The Topology of Puerto Rico's Clean Energy Transition: A Qualitative Input-Output Approach

by

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Abstract

This research paper explores Puerto Rico's transition towards a clean energy economy, examining potential structural changes and economic impacts. The study focuses on analyzing inter-industrial relations within the productive structure before and after the energy transition, while also identifying gaps in the renewable energy value chain to highlight potential economic opportunities. Using the Input Output model and network techniques, the research investigates the evolving energy sector and its effects on the broader economy. By assessing the intersectoral linkages and structural changes, the study provides insights into the economic implications of the energy transition process. Through comprehensive data analysis and economic methods, the research aims to contribute to the understanding of the economic impacts of large-scale renewable energy deployment and offer recommendations for policy and decision-making. The findings serve as a resource for policymakers involved in Puerto Rico's energy transition and have broader relevance for similar initiatives worldwide.

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Introduction

Energy has played a vital role in the origin and evolution of industrial civilization and each stage has been characterized by a transition from one major fuel source to another (Timmons, Harris & Roach, 2014). Thus far, the global energy system has mostly relied upon fossil fuels – coal, oil, and natural gas - to produce energy and drive economic growth. However, the extensive use of fossil fuels has proven to lead to increased environmental pollution and economic deficits (Jelti et. al, 2021). Therefore, growing concerns about the current unsustainable levels of global carbon emissions and the threat of rapidly depleting fossil fuel reserves have forced policymakers to change strategies. The U.S. Energy Information Administration (EIA, 2019) projects a 50 percent increase in world energy consumption from 2018 to 2050; hence, making it an urgent situation for policymakers. Efforts to reduce carbon emissions are now focused on increasing the share of renewable energy (RE) – solar, wind, biomass, and nuclear - in energy production (Singh, Nyuur & Richmond, 2019). Considering that RE has the potential to mitigate environmental contamination and provide a more reliable energy supply it has become an important move towards a sustainable future. Through 2050 the EIA (2019) expects renewables to be the fastest-growing energy source, with consumption increasing by an average of 3.1 percent per year. qDuring this period, solar photovoltaic (solar PV) energy is expected to experience the largest growth, followed by wind and non-hydropower renewables (EIA, 2019).

Investments in RE transitions will not only impact industries directly involved in the RE value chain but also industries throughout the whole economic system considering the network of interactions that exist between markets and sectors (Guerra & Sancho, n.d.). Energy transitions also disrupt the multi-sectoral relationships within the economy as actors are

pressured to rearrange their interactions and activities or disappear completely (Matschoss & Repo, 2020). These shifts produce a non-linear change as inter-industrial relations are dynamic in nature. In the case of RE, the tangential economy is impacted through the demand for construction and maintenance of the renewable facilities and the demand changes for fossil fuels and grid electricity (Itoh & Nakata, 2004). Moreover, RE also presents socio-economic benefits in the form of industrial diversification, new value chain activities, and employment opportunities created from technology transfers (IRENA, 2014). In addition, the local manufacturing capacities of varying regions can affect the economic impacts derived from the rollout of RE technologies (Itoh & Nakata, 2004). Blazejczak emphasizes that structural changes resulting from RE transitions can generate risks and opportunities and to fully assess the economic impacts of these shifts the analysis needs to account for "the interrelated and counterbalancing effects in an economic system and needs to go beyond the aggregate level and provide insights on sectoral effects in the economy" (2014).

There is extensive research that investigates the macroeconomic effects of large-scale RE deployment, namely on variables such as value added, gross domestic product (GDP), welfare, and employment. These effects can be examined along any point of the RE value chain, which includes phases such as project planning, manufacturing, installation, grid connection, operation and maintenance, and decommissioning (IRENA, 2015). Nevertheless, the existing literature offers little to nothing in terms of understanding how the economic productive structure is impacted after an energy transition. At present, no studies have been conducted to assess these impacts in Puerto Rico (PR) although the island established unprecedented RE goals for electricity

production under the Public Energy Policy Law of Puerto Rico[1] of 2019 and was assigned approximately $10.5 billion in disaster recovery funds to reconstruct and repair PR's energy sector. To support the targets of the Public Energy Policy Law of Puerto Rico of 2019, the Final Integrated Resource Plan ("IRP") approved by the Puerto Rico Energy Bureau ("PREB") was developed and includes the processes to procure new renewable resources and battery energy storage. A central pillar of the latest IRP is to increase employment opportunities, economic growth, and attract economic development. The final IRP also has the undertaking of ensuring a reliable and sustainable electrical system is built, one that can respond quickly to unexpected events, such as hurricanes Maria and Irma from 2017. Said hurricanes wiped out the island's entire electric system and resulted in the longest electrical blackout in modern U.S. history (Puerto Rico Electric Power Authority [PREPA], 2020). Ultimately, investigating the economic impacts of the final IRP will be important not only because an unprecedented amount of funding will be injected into the economy, but because PR also faces its longstanding debt crisis. As of 2017, PR held approximately $74 billion in bond debt and $49 billion in unfunded pension liabilities (Kobre and Kim LLP, 2018). Given this unique circumstance, there is a clear need to understand what economic impacts the final IRP will have on the Island.

Under these conditions, PR becomes an ideal case to research: how can the transition process towards a clean energy economy, as proposed in the final IRP, potentially change Puerto Rico's economic productive structure? Therefore, the main objective of this research is to examine the potential structural change resulting from the energy transition and its economic

[1] Refer to Act 17-2019 (S. B. 1121)

impacts as the implementation of the final IRP progresses. Meanwhile, the secondary objectives are to: (1) analyze PR's inter-industrial relations within the productive network structure before and after the transition and (2) identify gaps in PR's RE value chain to highlight potential economic opportunities. Input Output (IO) models and network techniques have widely been applied to represent and analyze relational linkages of economic problems and will therefore be applied to study these objectives.

Ultimately, it is expected that investing in the transition process towards a clean energy economy in PR will result in an increase of intersectoral linkages. In addition, the shift will produce important structural changes which will be reflected in the network. Through this analysis we aim to provide a comprehensive picture of Puerto Rico's energy sector and how it can evolve throughout time, while also validating if the final IRP will support a strong economic system. The following sections of this paper are structured as follows: Section two presents the literature review. Section 3 describes the data and methodological aspects used. Section four discusses the research results focusing on the evolution of PR's productive network. Lastly, section five presents the main conclusions and recommendations.

Literature Review

Introduction

Globally, many countries have recognized the need to reduce our carbon emission levels as the threat to the planet has become more evident in recent years. Reducing carbon emission levels can be achieved through three channels: investing in RE technology, capturing the carbon that is emitted from the burning of fossil fuels and storing it, and increasing energy efficiency (EE) levels (Garrett, 2010). Policymakers have strongly supported expansive clean energy policies and increasing EE levels as strategies to mitigate climate change. The Environmental Protection Agency (EPA, 2011) defines clean energy as demand and supply side resources that satisfy energy demand with less pollution than that created by fossil-fuel sources. Clean energy sources include zero emissions sources such as renewables which are non-depleting energy sources used for electricity generation and typically include solar, wind, and geothermal energy (EPA, 2011).

In its 2019 International Energy Outlook, the EIA estimates in its reference case scenario (reflects current trends and relationships among supply, demand, and prices in the future), that RE will become the leading source of primary energy consumption by 2050, replacing petroleum and other liquids (a fossil fuel) as the predominant source. Moreover, in terms of electricity generation most of the growth in the EIA reference case is fueled by RE and natural gas, representing a share of total generation of approximately 70 percent in 2050 (2019). In addition, RE is expected to be the fastest growing source in terms of electricity generation, increasing approximately 3.6 percent per year between 2018 and 2050. Of this growth, wind and solar dominate and represent over 70 percent of related electricity generation capacity by 2050 (EIA, 2019).

In consideration of these outlooks there is a growing body of literature studying the economic effects of clean energy transitions which will be reviewed further ahead. Understanding these is of great importance because it can prove that limiting global warming effects does not have to come at the cost of accomplishing other socio-economic goals. Some key questions that arise from this debate are: What industries will gain from this energy transition, and which will lose? How will economic growth be impacted? Ultimately, the complete economic impact of RE expansion policies is a combination of the direct, indirect, and induced effects and is a result of what Blazejczak et al. (2014) calls "multiple interacting and counterbalancing mechanisms" in an economy. Many researchers have studied the overall economic effects of clean energy transitions mainly because RE expansion policies will only be supported if they can prove that they can benefit other socio-economic goals. Thus, in the remaining sections of this literature review we will examine research articles that have analyzed the economic impacts of RE expansion strategies while highlighting the modeling approach, results, and any other important considerations that could have altered the outcomes.

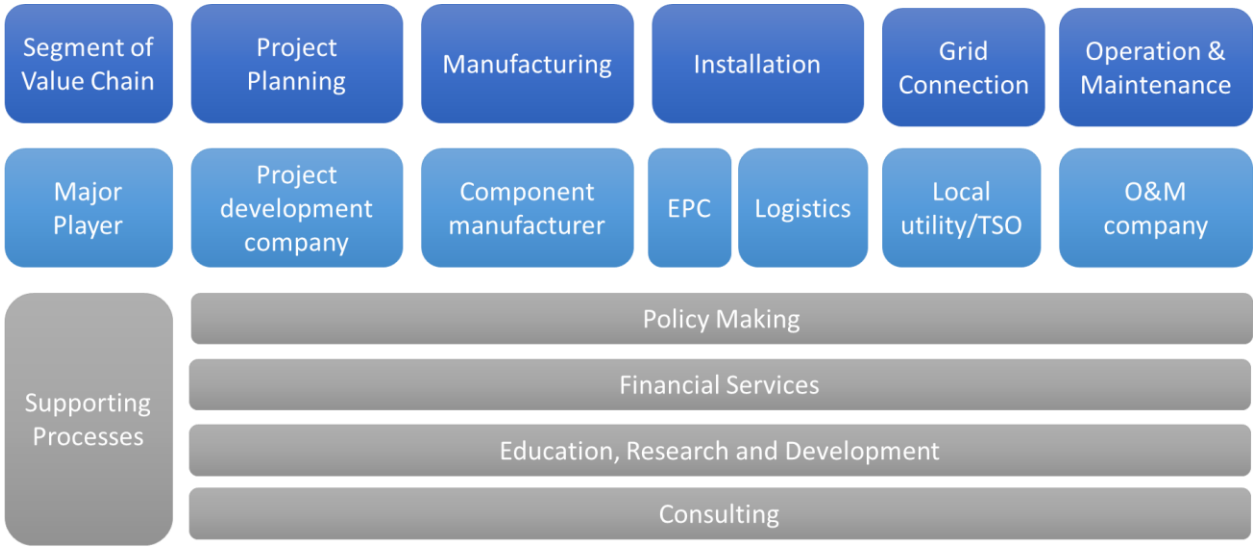
Economic Impact Assessment Studies

Among the existing literature that has assessed the economic impacts of RE expansion policies, many have focused on the effect this has had or can have on GDP and employment. Some studies recognize that analyzing sectoral shifts will be important as we transition from one energy system to another, considering that these will translate into sectoral employment gains and losses (sources). Blazejczak et al. understand that to fully assess the economic impacts of RE expansion strategies it is necessary to not only estimate aggregate level impacts but also the sectoral effects in an economy (2014).

To analyze these sectoral effects, it is important to identify what industries are involved in the process of RE expansion strategies. According to International Renewable Energy Agency (IRENA), for any given RE technology project, the main segments of the value chain can be divided into five which include: project planning, manufacturing, installation, grid connection, and operation, and maintenance (O&M) (see Figure 1). The lifecycle phases of a RE project do not differ much from that of conventional power plants and therefore, the companies or players involved in the process are also active in other industrial sectors (IRENA, 2014). As the deployment of RE grows, other industrial sectors, such as the suppliers of intermediate inputs will be impacted via inter-industry relations and ripple effects will be generated changing employment and growth levels across the economy. Furthermore, the changes in inter-industry relations will also translate to changes in the productive structure of the economy.

Figure 1

Segments of the Renewable Energy (RE) Value Chain (IRENA, 2015)



Another important aspect of assessing the economic impacts of clean energy investments is identifying a modeling approach that can quantify or characterize these impacts. Within the

revised literature there is mix of modeling approaches that have been employed, namely the IO approach (O'Sullivan and Edler, 2020; Lehr and Lutz, n.d.; Garrett, 2010; Aniello et al., 2019; Ulrich et al., 2012), the econometric approach (Hong, 2013; Blazejczak et al., 2014) and the Computable General Equilibruim model (Bohringer et al., 2012; Mu et al., 2018). Garrett (2010) notes that IO is an ideal model for understanding the economy wide impacts of RE expansion policies because it captures employment directly generated in companies producing a RE good or service as well as employment in companies tied to these throughout the supply chain. Meanwhile, Blazejczak et al. favors the econometric modeling approach when obtaining net effects because it is possible to account for feedback relations between various macroeconomic and sectoral variables, as well as across time and countries to draw a balance of the countervailing dynamics (2014).

Despite its frequent usage in the revised literature, IO models present a major limitation, and this is the absence of an IO vector that captures the clean energy industry. This limitation requires researchers to construct proxies for clean energy related activities. The literature goes about this task in different ways, but these are generally related to using external data gathered by means of a survey to build new vectors for clean energy industries and/or the disaggregation of exiting industries with clean energy components in order to reorganize them and explicitly create a clean energy industry (Garett, 2010). Garrett (2010) notes that because clean energy industries do not have unique industrial codes it is unfair to analyze them in a congruent manner with industries that do possess an industrial code.

O'Sullivan and Edler (2020) construct their own RE technology specific IO vectors to surpass the aforementioned limitation and do so by gathering information through company

surveys. The surveys were questionnaire-based interviews administered to leading companies in the RE market from 2004-2012 and were used in light of a lack of official sources that publish RE data. These surveys were able to capture information on the procurement and sale of intermediate goods from domestic and international sources which represented the input and output sections of the vectors. With this, they were able to create IO vectors for the installation area including 11 RE technologies; and these were then integrated into the existing IO table for Germany. The approach for the operation and maintenance (O&M) area was slightly different and instead its cost structure was defined as the weighted averages of exiting sectors for which the technological proximity of productions processes was similar (O'Sullivan and Edler, 2020).

Aniello et al. (2019) aimed to analyze the impact that the German Renewable Energy Act (EEG) would have on North Rhine-Westphalia's (NRW) economic performance and worked around the aforementioned limitation by using a hybrid approach. This approach allowed them to design a multi-regional input-output (MRIO) table for the German Federal States by firstly constructing a mock-up table using non-survey methods which served as the general framework of the table and contained preliminary estimates of its contents. Next, they improved the quality of the data by integrating information obtained through household surveys about income and expenditure as well as firm-level surveys about cost structure. Using this approach to construct their IO matrix they were able to conclude that the value-added effects in NRW resulting from investments in renewable energy facilities in 2011 produced mixed results. Specifically, that during the production phase of RE facilities there are positive effects, but these are one-off. However, during the operation phase of these facilities the effects are negative and stretch through the entire lifespan of the facility (Aniello et al., 2019).

Garrett (2010) uses the synthetic industry approach within the I-O model to estimate employment impacts from REEE industries. He states that using the synthetic industry approach allows for his research to analyze impacts for industries that are absent in the existing I-O model. As mentioned earlier, this is typically one of the biggest limitations to applying the I-O model when studying the impacts of renewable energy investments. This approach basically consists of gathering survey data about domestic and international purchases and sales, then decomposing the existing I-O tables to then integrate an REEE industry into the existing I-O tables. In addition, he notes that researchers have frequently gone about solving this problem by carrying out a large number of interviews to companies within the RE industry but that this method is impractical and generally does not provide sufficient survey data (Garrett, 2010).

Evidently, the construction of new vectors to represent the clean energy industry is a complex process and requires detailed data from other sources. The availability of this type of data could present another limitation for research analyzing the effects of clean energy investments on any type of indicator. Moreover, it is likely to see variations in the results of studies with similar topics due to differences in the data source and/or approach to build these new vectors. Although typically researchers have employed some form of external data to fill in this gap this investigation will employ the sub-approach of mapping each expenditure within PREPA's IRP to existing I-O vectors as is mentioned by Blyth, Spiers, and Gross (2014). Blyth et. al (2014) notes that this approach consists of estimating the annual operational expenses associated with a new RE investment and inputting these as a disruption to the final demands of the specific sectors that would be impacted. This mapping exercise should be done carefully in order to ensure the appropriate matching between activity expense and sector.

Methodology

IO tables represent a starting point to measure economic impact, identify inter-industrial relationships, and analyze the structure of an economy quantitatively or qualitatively. For this research the Qualitative Input Output Analysis (QIOA) approach will be applied to understand what industries could potentially be impacted by the energy transition process and highlight important characteristics of the productive structure before and after the transition. The analysis will be carried out on a network and sectoral or node level and Table 1 links the selected indicators to the evaluation criteria considered. Ultimately, the QIOA will offer important information regarding potential economic opportunities that can arise and will be useful for policy making in PR.

Table 1
I-O Indicators for Network and Sectoral analysis

	Network Level Metrics					Node Level Metrics	
Industrial policy should target sectors that:	**Digraph**	**Density**	**Diameter**	**Betweenness Centrality**	**Centrality Index**	**Coefficients Analysis**	**Intermediate Inputs/Production**
Belong to the productive structure core	X						
Belong to a community				X			
Have significant relationships on the demand side					X	X	
Belong to a tightly connected network (overall connectivity of the network)		X					
Belong to network with faster transmission capacity			X				
Are central to the transmission effects of the network/ occupies a strategic position in the network				X	X		
Have the capacity to transmit the impulses received in a signficant way						X	X

Note. Table created by the author to summarize the research methods employed in the study.

The data used for this analysis derives from two main sources: the first, PR's 2007 IO total transactions table published by the Puerto Rico Planning Board and the second, the US 2012 IO use table published by the Bureau of Economic Analysis (BEA). Both databases use the North American Industry Classification System (NAICS) to present inter-industry data. PR's IO matrix accounts for the flows of final and intermediate goods and services for 110 industries, meanwhile the US matrix presents this information for 405 industries. The aggregation of the industrial codes

in PR's matrix, as well as its outdatedness, represents a limitation for the analysis andd requires the need to complement the analysis with U.S data for the industries not found in PR's matrix.

To be used as a tool for economic impact analysis, the I-O tables were transformed into the direct requirements table. The direct requirements matrix, commonly denoted as matrix *A*, contains the inputs needed to produce one unit of output in any given industry of an economy. The elements of matrix *A* are the known as technical coefficients $a_{ij} = \frac{x_{ij}}{x_j}$ where x_{ij} represents the transaction between industry i and j, and x_j is the industry output produced by $x_j = \Sigma x_{ij}$. Therefore, the technical coefficients represent the dollar amount of an industry's output required directly by another industry to produce a dollar of their output.

Having constructed matrix A, the next step applied was an approach reviewed by Blyth, Spiers, and Gross (2014) to model the economy wide impact of a final demand disturbance (investments in RE) by mapping the investments of new activities to existing IO sectors. This mapping exercise focused on activities within all segments of the RE value chain, particularly those related to solar PV technology. This emphasis on solar PV is due to the final IRP prioritizing it as the energy resource to be used in PR's transition process. Subsequently, the associated sectors identified were verified within Puerto Rico's input-output matrix, and in case of nonexistence, their presence was validated in the US input-output table.

Network Analysis

QIOA has been applied to evaluate the relationships between industries in an economy to a point that allows for the mapping out of the entire economic system (Aroche, 2006). Network analysis, in the field of economics, uses QIOA as a foundation to connect IO tables with graphs that map industry relationships within the economy. To transform the IO table into this type of

graph industries must be plotted as vertices or nodes which are connected by edges or arcs (Aroche, 2006). Using this approach allows us to apply tools such as extraction methods, simulations, and network metrics which provide interpretations to the economic relationships that have been outlined. In terms of network metrics, there are a range of measurements frequently used in network analysis and these can be grouped into two main categories: group level and node level. The group level metrics employed to study the actual connections between the industries of the network are density, diameter, and betweenness. On the other hand, the node level metrics are the centrality index, coefficients analysis, and intermediate inputs and value added as a share of production. Each metric has a different meaning for the analysis and will provide insight on the dynamics of the network. The network analysis was limited to Puerto Rico since the productive structure of the United States is much larger and more complex. This complexity could make it difficult to draw meaningful conclusions from the analysis and, as a result, there would be little value added from including it.

Digraphs and Filters

To build a network using QIOA, the direct requirements matrix (matrix A) needs to be transformed into an Adjacency Matrix. This adjacency matrix is represented by a binary array "where an entry a_{ij} equal to 1 denotes a relationship between elements or vertices i and j and a null element in the matrix stands for absence of a link" (Aroche, 2006). These results are the product of having established a threshold for a filter that "defines the size of those intermediate demands that matter in the analysis of the economy, that is, those are the essential interindustry relationships" (Aroche, 2006). There are many ways to establish the filter (f) needed to arrive at the Adjacency matrix; however, the most common is using the average value of the a_{ij} entries in

the direct requirements matrix. Therefore, in our adjacency matrix w_{ij} =1 if a_{ij} >f for each sector and w_{ij} =0 otherwise.

Group Level Metrics for Analyzing Networks

The group level metrics employed to study the actual connections between the industries of the network are density, diameter, and betweenness. The following sections will describe each metric in detail and discuss how to interpret these in the context of the research.

Density and Diameter

The density metric refers to the overall connectivity of the network. In academic social networks it represents the degree of collaboration that takes place in the network (Arif, 2015). In our network the density metric can help us explain how connected the sectors within the solar PV value chain are to each other in terms of intermediate inputs. Density can be calculated by dividing the number of actual connections by potential connections or mathematically,

$$D = \frac{2m}{n(n-1)}$$

where m is the number of edges. D can lie within the range of 0 ≤ D ≤ 1, where 1 equals a fully connected network with the maximum number of edges, and a 0 represents a network with no edges at all.

Another important network level metric is diameter. When analyzing networks, it is common to analyze "paths" which are the fewest number of edges that you would have to go on to get from one node to another. The diameter represents the maximum path length or the

maximum degree of separation that exists in the network. It will essentially tell us how large the network is and in turn how long it would take transmission effects to be dispersed across the sectors within the solar PV value chain.

Betweenness Centrality

The betweenness centrality is a powerful metric in network analysis that provides insight into the importance of individual nodes in a network based on their ability to act as a bridge or intermediary in connecting other nodes. It measures the extent to which a node lies on paths between other nodes in a network. The calculation of betweenness centrality involves counting the number of shortest paths between all pairs of nodes in a network that pass through each node of interest, and then dividing this count by the total number of shortest paths between all pairs of nodes. Mathematically, betweenness centrality is calculated as follows:

$$x_i = \Sigma_{st} \frac{n_{st}^i}{g_{st}}$$

where n_{st}^i equals the number of shortest paths that pass between nodes s and t that pass through i and g_{st} equals the total number of shortest paths between s and i. In essence, betweenness centrality measures the proportion of shortest paths in the network that pass through a given node.

One way that betweenness centrality can be used in network analysis is to detect the emergence of communities. One commonly used algorithm for community detection based on betweenness centrality is the Girvan-Newman algorithm (Vélez, 2020). This algorithm works by

iteratively removing edges with the highest betweenness centrality, which has the effect of breaking the network into smaller components or communities. In that capacity, the betweenness centrality on a network level will be used to detect communities in Puerto Rico's productive structure.

Sectoral Analysis

To provide a more comprehensive understanding of the economic impacts of transitioning towards a renewable energy economy, as well as to characterize the sectors involved in this process, a sector or node level analysis was conducted alongside the network analysis. This analysis helped identify what industries within the solar PV value chain have significant relationships on the demand side, have the capacity to transmit the impulses received in a significant way, and occupy a strategic position within in the network. These results can provide important information to inform industrial policy during the energy transition process.

Demand and Supply Relationships

Studying the demand and supply relationships of the sectors involved in the solar PV value chain, and therefore the energy transition process, is crucial to understanding the overall economic impacts of the transition. By characterizing the sectors based on their demand and supply relationships, we can identify which sectors are most critical in driving the transition, as well as assess their transmission capacity. To obtain this information, PR's Technical Coefficients matrix and the US's Use table were used as inputs. For each sector the following figures were calculated for both the demand and supply side:

1. Number of total relationships: $\Sigma\ (a_{ij} > 0)$

where a_{ij} represents a technical coefficient in the matrix

2. Share of total relationships to total sectors in the matrix: $\frac{Number\ of\ total\ relationships}{Total\ Sectors\ in\ the\ matrix}\ X\ 100$
3. Number of total significant relationships: $\Sigma(a_{ij} \geq (\Sigma \frac{a_{ij}}{m*n})$

   where a_{ij} represents a technical coefficient in the matrix, m is the number of rows in the matrix, and n is the number of columns in the matrix.
4. Share of total significant relationships to total sectors in the matrix: $\frac{Number\ of\ total\ significant\ relationships}{Total\ sectors\ in\ the\ matrix}\ X100$

Based on these figures, each sector was ranked to identify those that have a high share of total relationships and significant relationships relative to the total sectors in the matrix.

Share of Intermediate Inputs and Value Added to Production

Examining the importance of different sectors in the economy and their roles in the production process is particularly relevant for sectors involved in a RE transition process. By analyzing which sectors are more dependent on intermediate inputs from other sectors and which sectors contribute more to value added in the production process, it is possible to identify sectors that may have a significant impact on the economy. This information can be used to develop strategies for managing the transition to renewable energy, such as identifying sectors that may require additional support or investment to ensure a smooth transition.

This information was calculated using the Total Transactions matrix for PR. The equations used to derive these coefficients are as follows:

$$II = \frac{Intermediate\ Inputs}{Production}\ X100$$

$$VA = \frac{Value\ Added}{Production}\ X100$$

Using these coefficients, each sector was ranked to identify those with a higher share of intermediate inputs as part of their production process. This is important for the energy transition process because changes in these industries can have ripple effects throughout the entire supply chain.

Centrality Index

In general, centrality metrics are used to identify what the most important vertices in a network are. One variation of this concept is the centrality index (CI) developed by Schnabal (1994). The CI was based on the idea that an industry is central to the economy if it is both highly connected to other industries and highly demanded by final consumers. This metric can be calculated with the following equation:

$$CI_i = \frac{In - Degree}{Out - Degree}$$

where In-Degree is the row-sum of industry i's input-output coefficients and Out-Degree is the industry's share of final demand.

A sector can be classified as sink, source or central. A $CI = 1$ identifies a Central Sector, $CI > 1$ a Sink Sector, and a $CI < 1$ a Source Sector. Sink sectors are industries that receive a large number of inputs but do not send many outputs to other industries and are considered to be users of inputs. On the other hand, source sectors send large amounts of output but do not receive many inputs from other industries, therefore being considered suppliers. Central sectors are those that are highly connected to other industries in the network both on the supply and use side. These sectors play a key role in the flow of goods and overall stability of the network.

Ultimately the CI will help highlight industries within the solar PV value chain with important relationships on the demand side, which are important to consider for industrial policy.

Betweenness Centrality

As previously mentioned, betweenness centrality is a metric that represents the number of the shortest paths that pass through a node. In other words, it represents how central an industry is to the transmission effects, or flow of information, of the network. Similarly, it captures the extent to which an industry occupies a strategic position or acts as a "bridge" within the network. Its importance of these type of sectors is highlighted by Arif (2015) who mentions that "the removal of nodes with high betweenness centrality result in breakdown of the information flow and the nature of connectivity in the network may change altogether" (p. 892). Therefore, in the context of this research, the betweenness metric will be used to understand if any of the sectors involved in the solar PV value chain hold strategic positions within the energy transition process and should therefore be targeted or strengthened during policy making.

Results and Analysis

In this section, we will explore the overall results of both the mapping exercise and the network analysis. The mapping exercise results provide a comprehensive overview of the associated NAICS codes, their specific mapping to activities within the RE value chain, and the verification of their presence in PR's IO matrix. Through these findings, we gain a deeper understanding of the economic implications and opportunities arising from the transition to renewable energy in PR. Furthermore, these results uncover valuable insights into the potential economic impact of RE investments and their integration into the local economy. To facilitate this exploration, Table 2 displays the NAICS codes associated with the mapped activities, while Table 3 highlights the reference NAICS codes and whether the corresponding sectors exist within Puerto Rico's IO matrix.

Table 2
Associated Industry Codes of the Value Chain Segments

Segment of Value Chain	Associated Industry NAICS Code (4-6 digits)
Project Planning	• *237210* - Land Subdivision • *237990* - Other heavy and civil engineering construction • *237130* - Power and communication line and related structures construction • *238910* - Site preparation contractors • *541370* - Surveying and Mapping • *522110* - Commercial Banking
Manufacturing	• *212230* - Copper, nickel, lead, and zinc mining • *331313* - Alumina refining and primary aluminum production • *331110* - Iron and steel mills and ferroalloy manufacturing • *327310* - Cement manufacturing • *3251* - Basic chemical manufacturing • *334413* - Semiconductor and related device manufacturing • *325998* - All other miscellaneous chemical product and preparation manufacturing • *221118* - Other electric power generation • *335313* - Switchgear and switchboard apparatus manufacturing • *335311* - Power, distribution, and specialty transformer manufacturing • *335312* - Motor and generator manufacturing (synchronous condenser) • *335911* - Storage battery manufacturing
Installation & Grid Connection	• *423810* - Construction and mining machinery and equipment merchant wholesalers • *334515* - Instrument manufacturing for measuring and testing electrical signals • *238120* - Structural steel and precast concrete contractors • *541330* - Engineering services
Operation and Maintenance (O&M)	• *221114 - Solar electric power generation*

Note. Table created by the author to provide a summary of relevant industries and their corresponding NAICS codes for the study.

Table 3

Input Output Matrix Corresponding to the Identified Industries of the Value Chain Segments

Associated Industry - NAICS Code (4-6 digits)	**NAICS Code Used as Reference**	**PR Input-Output Matrix**	**US Input-Output Matrix**
237210 - Land Subdivision	*237* – Heavy and Civil Engineering Construction	X	
237990 - Other Heavy and Civil Engineering Construction	*237* – Heavy and Civil Engineering Construction	X	
237130 - Power and Communication Line and Related Structures Construction	*237* – Heavy and Civil Engineering Construction	X	
238910 - Site Preparation Contractors	Not found	Not found	Not found
541370 - Surveying and Mapping	*5413* – Architectural, Engineering, and Related Services	X	
52211 - Commercial Banking	*52211* – Commercial Banking	X	
212230 - Copper, Nickel, Lead, And Zinc Mining	*212230* - Copper, Nickel, Lead, And Zinc Mining		X
331313 - Alumina Refining and Primary Aluminum Production	*331313* - Alumina Refining and Primary Aluminum Production		X
331110 - Iron and Steel Mills and Ferroalloy Manufacturing	*331110* - Iron and Steel Mills and Ferroalloy Manufacturing		X
327310 - Cement Manufacturing	*327310* - Cement Manufacturing		X
3251 - Basic Chemical Manufacturing	*3251* - Basic Chemical Manufacturing	X	
334413 - Semiconductor and Related Device Manufacturing	*334413* - Semiconductor and Related Device Manufacturing		X
325998 - All Other Miscellaneous Chemical Product and Preparation Manufacturing	*3259* – Other Chemical Product and Preparation Manufacturing	X	
221118 - Other Electric Power Generation	*2211* – Electric Power Generation, Transmission and Distribution	X	
335311 - Power, distribution, and specialty transformer manufacturing	*335311* - Power, distribution, and specialty transformer manufacturing		X
335312 - Motor and generator manufacturing (synchronous condenser)	*335312* - Motor and generator manufacturing (synchronous condenser)		X
335911 - Storage battery manufacturing	*335911* - Storage battery manufacturing		X

335313 - Switchgear and Switchboard Apparatus Manufacturing	***335313* - Switchgear and Switchboard Apparatus Manufacturing**		**X**
423810 - Construction and Mining Machinery and Equipment Merchant Wholesalers	*4238* – Machinery, Equipment, and Supplies Merchant Wholesalers		X
334515 - Instrument Manufacturing for Measuring and Testing Electrical Signals	*334515* - Instrument Manufacturing for Measuring and Testing Electrical Signals		X
238120 - Structural Steel and Precast Concrete Contractors	Not found	Not found	Not found
221114 - Solar Electric Power Generation	*2211* – Electric Power Generation, Transmission and Distribution	X	

Note. Table created by the author to provide a summary of relevant industries and their corresponding NAICS codes for the study.

Network Analysis

The identification of significant relationships among sectors is crucial for making informed industrial policy decisions. In the analysis of productive structures, not all relationships between sectors are equally important. To filter out weak connections and highlight the core of the productive structure, a filter is commonly applied. By focusing on the most significant relationships, policymakers can gain insights into the key sectors driving the economy and make informed decisions to promote economic growth and development. This analysis was conducted for the 2007 Total Transactions Matrix for Puerto Rico and is represented in graph 1. Moreover, the selected metrics of density and diameter were calculated for this network. Additionally, the communities for this network were plotted and the sectors within each community were listed in tables.

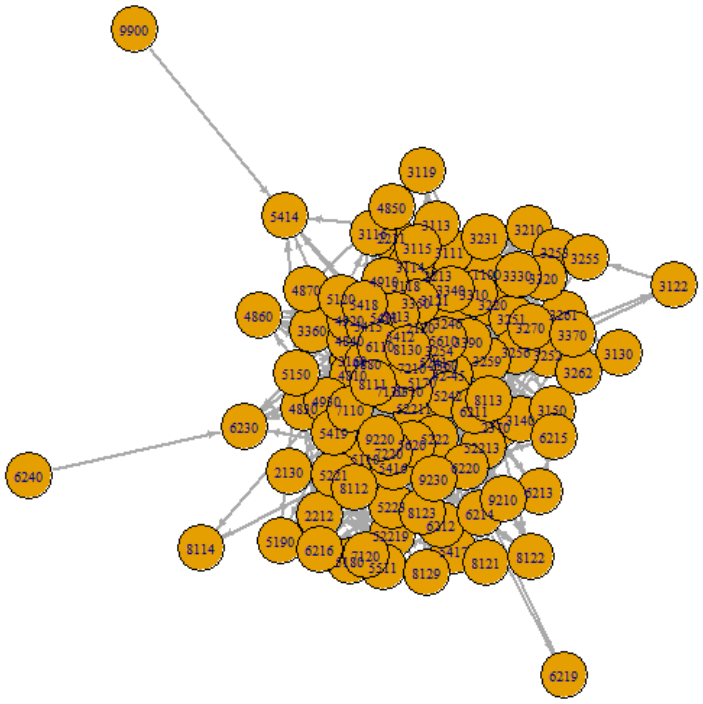
Graph 1 depicts the core of the total productive structure. Each industry is represented by their NAICS code while the arrows represent the direction of the relationships or connections between them. An outward arrow indicates that the first node is the source of a relationship or

flow towards the second node. On the other hand, an inward arrow points towards a node, indicating that the node is the recipient of a relationship or flow from another node.

Graph 1

Total Transactions Matrix Digraph

Puerto Rico, 2007



Note. Figure created by the author using data from Puerto Rico Planning Board (2007).

Network Metrics

Density and Diameter

The density metric measures the complexity of the economy and provides insights into the degree of interdependence between different sectors. This metric can have a value between zero and one, becoming denser as it approaches one. As can be observed, P.R.'s network density of approximately 0.09 is extremely low, indicating that the overall productive structure is not very complex, and its transmission capacity is poor. This also suggests that the economy has a lower level of interdependence between its sectors and that these are relatively siloed.

Moreover, that there are relatively few actual transactions between the different sectors or industries in the Puerto Rican economy, in comparison to the total number of possible transactions.

Overall, a density metric of 0.09 suggests that the Puerto Rican economy may have limited integration opportunities between sectors and may be vulnerable to shocks or disruptions in specific sectors. However, as large RE investments are being projected for PR this indicates opportunities for growth and diversification by developing linkages between different sectors to increase interdependence and complexity in the economy. In addition, it also presents the possibility to enhance the resilience and stability of the economy by spreading risk across sectors.

A diameter metric of 6 suggests that the productive structure in Puerto Rico is relatively well-connected, meaning that the flow of inputs and outputs between sectors is efficient and potentially able to adapt to changes.

Betweenness Centrality

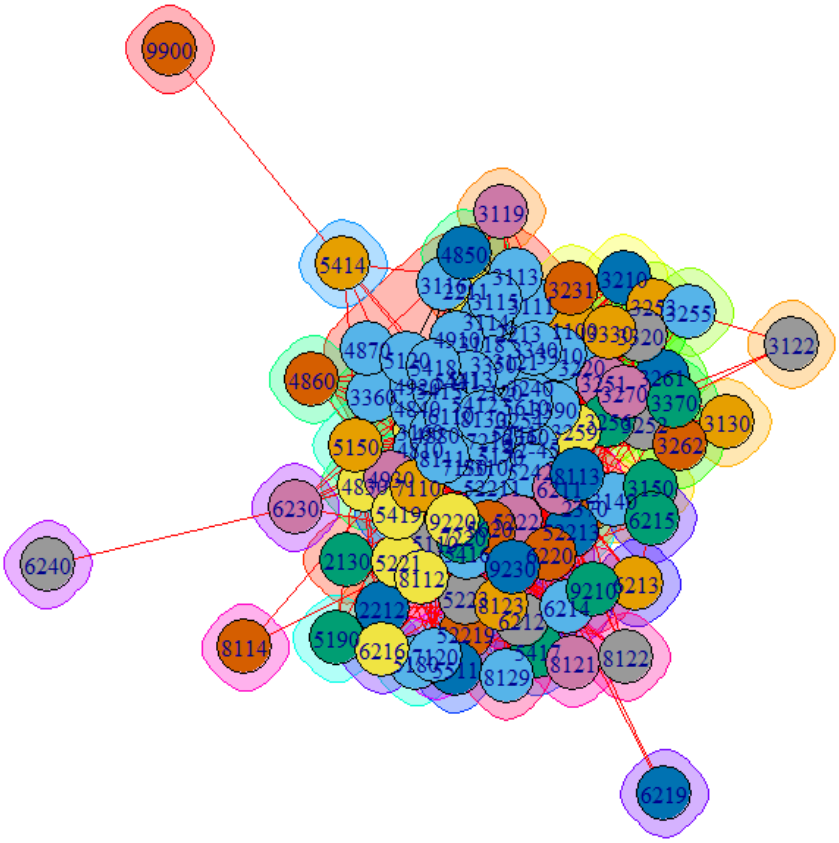
At a network level, the betweenness centrality metric is being used to detect whether there are communities within PR's productive structure and identify what sectors form part of these. Moreover, from a node level perspective, betweenness is being employed to understand if any of the sectors involved in the solar PV value chain hold strategic positions within the energy transition process. The result of running a community detection algorithm can be seen in Graph 2.

Graph 2

Betweenness Centrality

Total Transactions Matrix

Puerto Rico, 2007



Note. Figure created by the author using data from Puerto Rico Planning Board (2007).

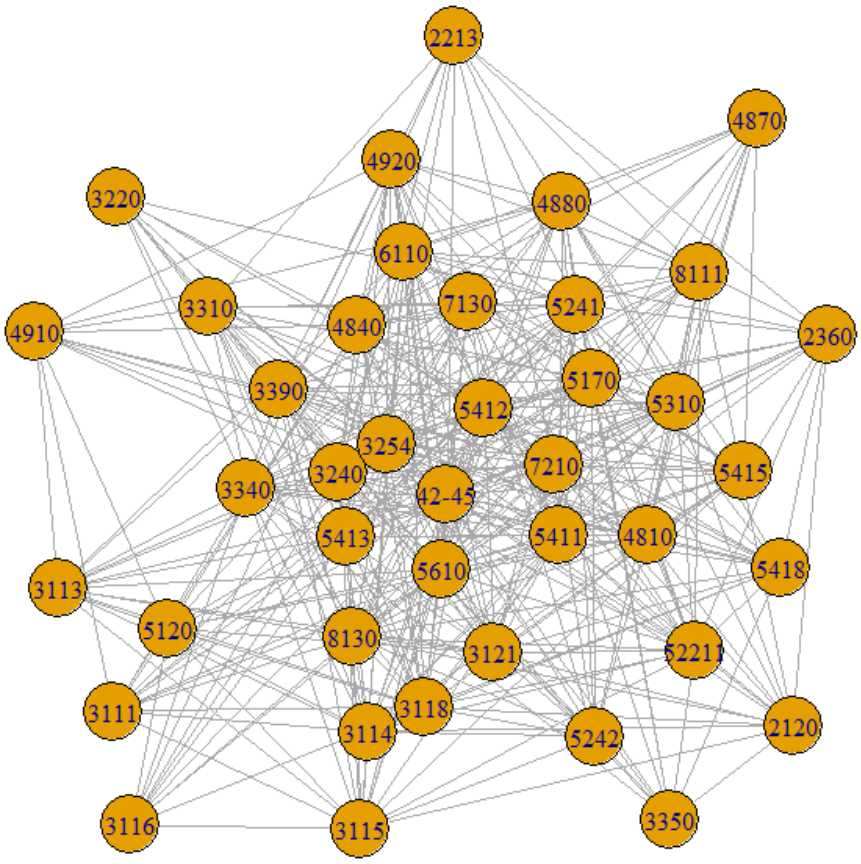
Upon examination, it can be noted that there is diversity in the relationships within the productive structure because of the range of colors that are present in the graph. However, the

dominance of blue color suggests that a community has been identified. Graph 3 was built to extract the sectors that form the community and are included in Table 4.

Graph 3

Community - Total Transactions Matrix

Puerto Rico, 2007



Note. Figure created by the author using data from Puerto Rico Planning Board (2007).

Table 4

Sectors Corresponding to the Identified Community

NAICS Code	Industry Name
212	Mining (except Oil and Gas)
2213	Water, Sewage and Other Systems
236	Construction of Buildings
3111	Animal Food Manufacturing
3113	Sugar and Confectionery Product Manufacturing
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing
3115	Dairy Product Manufacturing
3116	Animal Slaughtering and Processing
3118	Bakeries and Tortilla Manufacturing
3121	Beverage Manufacturing
322	Paper Manufacturing
324	Petroleum and Coal Products Manufacturing
3254	Pharmaceutical and Medicine Manufacturing
331	Primary Metal Manufacturing
334	Computer and Electronic Product Manufacturing
335	Electrical Equipment, Appliance, and Component Manufacturing
339	Miscellaneous Manufacturing
42-45	Retail Trade
481	Air Transportation
484	Truck Transportation
487	Scenic and Sightseeing Transportation
488	Support Activities for Transportation
491	Postal Service
492	Couriers and Messengers
512	Motion Picture and Sound Recording Industries
517	Telecommunications
52211	Commercial Banking
5241	Insurance Carriers
5242	Agencies, Brokerages, and Other Insurance Related Activities
531	Real Estate
5411	Legal Services
5412	Accounting, Tax Preparation, Bookkeeping, and Payroll Services
5413	Architectural, Engineering, and Related Services
5415	Computer Systems Design and Related Services
5418	Advertising, Public Relations, and Related Services
561	Administrative and Support Services
611	Educational Services
713	Amusement, Gambling, and Recreation Industries
721	Accommodation

8111	Automotive Repair and Maintenance
813	Religious, Grantmaking, Civic, Professional, and Similar Organizations

Note. Table created by the author based on a graph generated using data from Puerto Rico Planning Board (2007).

The community identified within Puerto Rico's productive structure includes a diverse set of industries spanning across 41 sectors, which represents 37 percent of the total sectors in the structure. The community is mostly composed of Service sectors (41%), followed by Manufacturing (34%), Transportation and Warehousing (12%), Finance and Insurance (7%), and Mining and Construction (5%). Furthermore, of the community that was identified, it was found that two of the sectors correspond to those that form part of the solar PV value chain, namely the Commercial Banking (52211) and Architectural, Engineering, and Related Services (5413) sectors. Finding these sectors within the community suggests that they may act as key intermediaries between other sectors in the value chain and indicates their potential high level of centrality and influence in regulating the flow of information and resources within the network.

Node Level Analysis

Inter-industry Relationships Analysis

Examining the characteristics of the inter-industrial relationships that each sector within the solar PV value chain holds can provide valuable insights into the structure and dynamics of the energy transition process. The following section analyzes the demand and supply side relationships for each of these sectors and highlights the range and significance of the relationships. The results are summarized in tables 5-6, while a comprehensive list of which industries these sectors have significant relationships with, on both the demand and supply side, can be found in the Appendix.

Demand Relationships

Table 5

Demand Relationships Summary

NAICS Code	Industry Name	# of Total Sectors in Matrix	# of Total Sectors with Relationships	Total Sectors with Relationships/ Total Sectors in Matrix (%)	# Significant Demand Relationsips	Total Significant Relationships / Total Sectors in Matrix (%)
2211	Electric Power Generation, Transmission, and Distribution	110	80	72.7%	9	8.2%
52211	Commercial Banking	110	74	67.3%	9	8.2%
334413	Semiconductor and related device manufacturing	405	233	57.5%	84	20.7%
3259	Other Chemical Product and Preparation Manufacturing	110	62	56.4%	10	9.1%
331110	Iron and Steel Mills and Ferroalloy Manufacturing	405	192	47.4%	66	16.3%
5413	Architectural Engineering and Related Services	110	49	44.5%	10	9.1%
237	Heavy and Civil Engineering Construction	110	43	39.1%	14	12.7%
331313	Alumina refining and primary aluminum production	405	126	31.1%	41	10.1%
4238	Machinery, Equipment, and Supplies Merchant Wholesalers	405	124	30.6%	56	13.8%
335312	Motor and generator manufacturing (synchronous condenser)	405	120	29.6%	60	14.8%
327310	Cement Manufacturing	405	102	25.2%	56	13.8%
3251	Basic Chemical Manufacturing	110	26	23.6%	17	15.5%
335911	Storage battery manufacturing	405	94	23.2%	53	13.1%
335311	Power, distribution, and specialty transformer manufacturing	405	93	23.0%	31	7.7%
335313	Switchgear and switchboard apparatus manufacturing	405	67	16.5%	31	7.7%
212230	Copper, Nickel, Lead, And Zinc Mining	405	66	16.3%	34	8.4%
334515	Instrument manufacturing for measuring and testing electrical signals	405	18	4.4%	18	4.4%

Note. Table created by the author using data from Puerto Rico Planning Board (2007).

Based on table 5, it can be observed that the Electric Power Generation, Transmission, and Distribution sector has the highest number of relationships on the demand side relative to the total sectors in the matrix (72.7%), followed by Commercial Banking (67.3%), and closely behind are the Semiconductor and Related Device Manufacturing (57.5%) and Other Chemical Product and Preparation Manufacturing (56.4%). These sectors have a high level of interconnectivity with other sectors in the economy, meaning that economic impacts within the sector can spread quickly and widely to others and its transmission capacity can have a larger ripple effect in the economy. Interestingly, of the industries with the highest number of

relationships on the demand side relative to the total sectors in the matrix, only the Semiconductor and Related Device Manufacturing sector also has a high ratio of significant demand relationships (20.7%). This indicates that changes in demand for semiconductors and related devices can have a significant impact on other industries that rely on these products. Furthermore, that the Semiconductor and Related Device Manufacturing sector is an important driver of the energy transition process and will play a critical role in the diffusion of the sustained economic impacts.

On the other hand, the sectors with lowest number of relationships relative to the total sectors in the matrix are Instrument Manufacturing for Measuring and Testing Electrical Signals (4.4%), Copper, Nickel, Lead and Zinc Mining (16.3%), and Switchgear and Switchboard Apparatus Manufacturing (16.5%). These sectors also have a relatively low percentage of sectors with significant relationships compared to the total number of sectors in the matrix. This suggests that their ability to transmit economic impacts to others is more limited and may be low.

Moreover, it can be observed that other than the Semiconductor and Related Device Manufacturing sector other sectors that have a high ratio of significant demand relationships are the Iron and Steel Mills and Ferroalloy Manufacturing (16.3%) and Basic Chemical Manufacturing (15.5%). These sectors have a higher capacity than others in the value chain to transmit economic impacts during the clean energy transition and are important drivers of this process. However, in the case of the Basic Chemical Manufacturing sector this transmission effect will not be spread very wide because it has a relatively low percentage of relationships relative to the total sectors in the matrix (23.6%).

In conclusion, this analysis highlights the importance of the Electric Power Generation, Transmission, and Distribution sector, as well as Commercial Banking, and Semiconductor and Related Device Manufacturing, the solar PV value chain due to their high level of interconnectivity on the demand side with other sectors in the economy. These sectors have a greater capacity to transmit economic impacts widely during the clean energy transition and could potentially play a critical role in the diffusion of sustained economic impacts. However, it is worth noting that some of the sectors with a high ratio of significant demand relationships, such as Iron and Steel Mills and Ferroalloy Manufacturing and Basic Chemical Manufacturing, have a relatively low percentage of relationships relative to the total sectors in the matrix. This suggests that although they have a higher capacity to transmit economic impacts, their transmission effect may be more limited in comparison to other sectors in the value chain. Therefore, it is important to focus on further enhancing the interconnectivity of these sectors with others in the value chain to increase their transmission capacity and maximize their economic impact. In general, this analysis provides insights into the dynamics of the solar PV value chain and can help policymakers identify opportunities to enhance its economic impacts.

Supply Relationships

Table 6

Supply Relationships Summary

NAICS Code	Industry Name	# of Total Sectors in Matrix	# of Total Sectors with Relationships	Total Sectors with Relationships/ Total Sectors in Matrix (%)	# Significant Supply Relationships	Total Significant Relationships / Total Sectors in Matrix (%)
3251	Basic Chemical Manufacturing	110	49	44.5%	9	8.2%
5413	Architectural Engineering and Related Services	110	48	43.6%	21	19.1%
52211	Commercial Banking	110	38	34.5%	9	8.2%
237	Heavy and Civil Engineering Construction	110	38	34.5%	7	6.4%
4238	Machinery, Equipment, and Supplies Merchant Wholesalers	405	137	33.8%	72	17.8%
334413	Semiconductor and related device manufacturing	405	124	30.6%	52	12.8%
331110	Iron and Steel Mills and Ferroalloy Manufacturing	405	117	28.9%	46	11.4%
335312	Motor and generator manufacturing (synchronous condenser)	405	109	26.9%	46	11.4%
327310	Cement Manufacturing	405	102	25.2%	63	15.6%
2211	Electric Power Generation, Transmission, and Distribution	110	27	24.5%	3	2.7%
335313	Switchgear and switchboard apparatus manufacturing	405	97	24.0%	53	13.1%
334515	Instrument manufacturing for measuring and testing electrical signals	405	94	23.2%	36	8.9%
335311	Power, distribution, and specialty transformer manufacturing	405	92	22.7%	52	12.8%
212230	Copper, Nickel, Lead, And Zinc Mining	405	90	22.2%	49	12.1%
331313	Alumina refining and primary aluminum production	405	86	21.2%	35	8.6%
335911	Storage battery manufacturing	405	80	19.8%	37	9.1%
3259	Other Chemical Product and Preparation Manufacturing	110	15	13.6%	7	6.4%

Note. Table created by the author using data from Puerto Rico Planning Board (2007).

Based on table 6, it can be observed that the three industries with the highest percentage of sectors with relationships on the supply side are Basic Chemical Manufacturing (44.5%), Architectural Engineering and Related Services (43.6%), and Commercial Banking (34.5%). Although the Basic Chemical Manufacturing sector has a relatively high percentage relationships relative to the total sectors within the matrix it has a low proportion of significant supply relationships (8.2%) meaning that may be opportunities to develop stronger partnerships and supply relationships in the industry, which could potentially increase its economic transmission

effect and fully maximize the industry's economic impact. On the other hand, the Architectural Engineering and Related Services sector has the highest number of significant supply relationships relative to total sectors in the matrix (19.1%). This suggests that this sector is an important player in the value chain and that it is heavily reliant on specific suppliers for its operations.

Following this sector in terms of the ratio of significant supply relationships are the Machinery, Equipment, and Supplies Merchant Wholesalers (17.8%) and Cement Manufacturing (15.6%) sectors. These sectors have a higher capacity to transmit economic impacts during the clean energy transition and are important drivers of this process. However, it is worth noting that the Cement Manufacturing sector has a relatively low percentage of sectors with relationships on the supply side (25.2%), indicating that there may be opportunities for this industry to further develop and expand its supply relationships.

There is a potential opportunity for Puerto Rico to further develop its Machinery, Equipment, and Supplies Merchant Wholesalers and Cement Manufacturing sectors to support the development of the RE transition. These industries could have a higher percentage of sectors with relationships, indicating that they have a strong potential to establish new relationships and supply chains.

On the other hand, the industries with the lowest percentage of sectors with supply relationships of the total sectors in the matrix are Other Chemical Product and Preparation Manufacturing (13.6%), Storage Battery Manufacturing (19.8%), and Alumina Refining and Primary Aluminum Production (21.2%). Overall, these three sectors appear to have relatively low

levels of interdependence with other sectors in the matrix and their transmission capacity is relatively lower compared to other sectors in the solar PV value chain.

Moreover, it can be observed that the industries with the lowest ratio of significant supply relationships are the Electric Power Generation, Transmission, and Distribution (2.7%), followed by Other Chemical Product and Preparation Manufacturing and Heavy and Civil Engineering Construction (both 6.4%). In other words, these sectors may have limited potential to support the energy transition process because it can be more challenging for them to develop new relationships.

Overall, the analysis of the supply-side relationships between industries within the solar PV value chain reveals important insights about their interdependence and transmission capacity. It suggests that to accelerate the RE transition process, it is important to focus on improving and strengthening supply relationships in industries that play a significant role in renewable energy production, such as with the Cement Manufacturing and Basic Chemical Manufacturing sector. Other sectors such as Architectural Engineering and Related Services are crucial players in the value chain and heavily reliant on specific suppliers, meaning that any changes in the sector can have ripple effects throughout the productive structure. Conversely, industries with low percentages of sectors with relationships and low ratios of significant supply relationships, such as Electric Power Generation, Transmission, and Distribution, may have limited potential to contribute to the energy transition on the supply side. In general, this analysis provides insights into the dynamics of the solar PV value chain and can help policymakers identify opportunities to enhance its economic impacts.

Coefficients Analysis

To understand the full economic impacts that could arise from the RE transition process it is important to analyze a breakdown of the production process for each sector within the value chain. Therefore, table 7 presents the share of each sector's share of intermediate inputs and value added in total production.

Table 7

Share of Intermediate Inputs and Value Added to Production

Sector #	NAICS Code	Industry Name	Intermediate Inputs/Production	Value Added/Production
1	2211	Electric Power Generation, Transmission and Distribution	62.29%	37.71%
2	3259	Other Chemical Product and Preparation Manufacturing	89.58%	10.42%
3	52211	Commercial Banking	72.69%	27.31%
4	237	Heavy and Civil Engineering Construction	62.14%	37.86%
5	5413	Architectural, Engineering, and Related Services	45.08%	54.92%
6	3251	Basic Chemical Manufacturing	33.30%	66.70%
7	331110	Iron and Steel Mills and Ferroalloy Manufacturing	80.12%	19.88%
8	331313	Alumina Refining and Primary Aluminum Production	77.21%	27.79%
9	335312	Motor and Generator Manufacturing	59.14%	40.86%
10	335911	Storage Battery Manufacturing	58.62%	41.38%
11	335311	Power, Distribution, and Specialty Transformer Manufacturing	58.53%	41.47%
12	335313	Switchgear and Switchboard Apparatus Manufacturing	56.56%	43.43%
13	212230	Copper, Nickel, Lead, and Zinc Mining	47.99%	52.01%
14	334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical	44.22%	55.78%
15	4238	Machinery, Equipment, and Supplies Merchant Wholesalers	38.88%	61.12%
16	327310	Cement Manufacturing	66.76%	33.24%
17	334413	Semiconductor and Related Device Manufacturing	25.81%	74.19%

Note. Table created by the author using data from Puerto Rico Planning Board (2007).

A high percentage of intermediate inputs in the production process means that a significant portion of the total production value is spent on purchasing goods and services from other businesses. This can indicate that the industry is heavily reliant on other industries for raw materials or components. These types of sectors are important for the energy transition process because changes in these industries can have ripple effects throughout the entire supply chain, affecting many other industries that provide them with intermediate inputs. Table 7 shows that the industries with the highest percentages of intermediate inputs/production are Other Chemical Product and Preparation Manufacturing (89.58%), Iron and Steel Mills and Ferroalloy Manufacturing (80.12%), and Alumina Refining and Primary Aluminum Production (77.21%). On

the other hand, the industries with the lowest percentages are Semiconductor and Related Device Manufacturing (25.81%), Architectural, Engineering, and Related Services (45.08%), and Machinery, Equipment, and Supplies Merchant Wholesalers (38.88%), indicating that these industries require fewer intermediate inputs.

In terms of value added/production, the industries with the highest percentages are Semiconductor and Related Device Manufacturing (74.19%), Basic Chemical Manufacturing (66.70%), and Machinery, Equipment, and Supplies Merchant Wholesalers (61.12%). These industries generate a high level of value added from their production processes may be less impacted by the RE transition process. In contrast, the industries with the lowest percentages are Iron and Steel Mills and Ferroalloy Manufacturing (19.88%), Alumina Refining and Primary Aluminum Production (27.79%), and Commercial Banking (27.31%), indicating that these industries generate lower levels of value added.

Centrality Index

Table 8 shows the distribution of sectors between the Source, Central, and Sink classifications for both PR's total transactions matrix and the US's use table. The centrality coefficient measures the importance of an industry within the value chain and is directly related to a sector's role as a demander or supplier of intermediate inputs. Source sectors typically supply inputs to other sectors in the value chain and have a lower centrality coefficient, meaning they have a less critical role in the overall structure and functioning of the value chain. On the other hand, sink sectors are typically demanders of inputs from other sectors and have a higher centrality coefficient, indicating a more critical role in the value chain. These sectors are more

likely to be affected by changes in other industries within the value chain, as they rely heavily on the input supplied by other sectors. Central sectors, which have a centrality coefficient value of 1, are those that are both significant demanders and suppliers of inputs in the value chain. These sectors play a critical role in the overall structure and functioning of the value chain and are highly influential in determining the performance of other industries within the chain.

Table 8

Classification of Sectors by Centrality Index

Matrix	Source	Central	Sink
Puerto Rico	3	1	2
United States	7	0	4
Total	**10**	**1**	**6**

Note. Table created by the author using data from two different sources:

Source A: Puerto Rico Planning Board (2007). Input-Output Total Transactions Matrix.

Source B: Bureau of Economic Analysis. (2012). U.S. Input-Output Use Table

In table 8 it is observed that most of the sectors involved in the solar PV value chain are classified as Source sectors, having a total of 10 out of 17 sectors. However, it is also evident that a significant portion of the sectors are classified as Sink, with 6 out of 17 sectors falling under this category. This classification indicates that these sectors rely heavily on other sectors within the value chain and are more susceptible to any disruptions or changes in the input supply. Hence, attention should be paid to these sink sectors during the transition to a clean energy economy because they play an important role in transmitting demand impulses to other sectors in the value chain. It should also be noted that there is a single sector that is classified as Central, indicating that it plays a critical role in connecting the upstream and downstream sectors of the

solar PV value chain. In the energy transition process, this sector would likely play a key role in coordinating and integrating the various activities across the value chain.

Table 9 shows the centrality index coefficients for each of the different industries within the solar PV value chain, categorized into source, center, and sink sectors.

Table 9

Classification of Sectors by the Centrality Index

Sector #	NAICS Code	Industry Name	Centrality Coefficient	Sector Type
1	2211	Electric Power Generation, Transmission, and Distribution	0.78	Source
2	237	Heavy and Civil Engineering Construction	0.64	Source
3	3251	Basic Chemical Manufacturing	1.00	Center
4	3259	Other Chemical Product and Preparation Manufacturing	0.06	Source
5	52211	Commercial Banking	5.40	Sink
6	5413	Architectural Engineering and Related Services	2.50	Sink
7	212230	Copper, Nickel, Lead, And Zinc Mining	0.61	Source
8	327310	Cement Manufacturing	0.25	Source
9	331110	Iron and Steel Mills and Ferroalloy Manufacturing	3.52	Sink
10	331313	Alumina refining and primary aluminum production	1.86	Sink
11	334413	Semiconductor and related device manufacturing	4.08	Sink
12	334515	Instrument manufacturing for measuring and testing electrical signals	0.50	Source
13	335311	Power, distribution, and specialty transformer manufacturing	0.29	Source
14	335312	Motor and generator manufacturing (synchronous condenser)	1.37	Sink
15	335313	Switchgear and switchboard apparatus manufacturing	0.49	Source
16	335911	Storage battery manufacturing	0.76	Source
17	423810	Construction and Mining Machinery and Equipment Merchant Wholesalers	0.36	Source

Note. Table created by the author using data from two different sources:

Source A: Puerto Rico Planning Board (2007). Input-Output Total Transactions Matrix.

Source B: Bureau of Economic Analysis. (2012). U.S. Input-Output Use Table

The Basic Chemical Manufacturing sector (3251) has a centrality coefficient of 1.00, indicating it is the most central industry in the solar PV value chain of those identified. This implies that it is the main hub where other industries converge, and it has a significant impact on the entire value chain. Other sectors that are important for the final stages of the value chain are the sink sectors with high centrality coefficients such as sectors 5, 6, 9, and 11 which have coefficients

ranging from 2.50 to 5.40. On the other hand, the source sectors (1, 2, 4, 7, 8, 12, 13, 15, 16, and 17) have lower centrality coefficients, ranging from 0.06 to 0.78. These industries play a more peripheral role, such as supplying raw materials, components, or services to other industries within the value chain.

In summary, the table highlights the critical industries and their roles within the solar PV value chain. It shows that some sectors are more central and have a more significant impact on the value chain than others.

Integrated Analysis

Based on the findings presented in the previous sections, Table 10 summarizes the characteristics of the sectors that should be considered as part of industrial policy strategies. In the case that a sector exhibits a particular characteristic, an X is marked in the corresponding cell of the table.

Table 10

Industry Evaluation Matrix

NAICS Code	Industry Name	Part of the core productive structure	Belongs to a community	Has significant relationships on the demand side		Transmits the impulses received in a signficant way	
				Sink	Central	Demand/Supply Coefficients	Intermediate Inputs/ Production
2211	Electric Power Generation, Transmission and Distribution	X					
3259	Other Chemical Product and Preparation Manufacturing	X					X
52211	Commercial Banking	X	X	X			
237	Heavy and Civil Engineering Construction	X					
5413	Architectural, Engineering, and Related Services	X	X	X		X	
3251	Basic Chemical Manufacturing	X			X	X	
331110	Iron and Steel Mills and Ferroalloy Manufacturing			X		X	X
331313	Alumina Refining and Primary Aluminum Production			X			X
335312	Motor and Generator Manufacturing			X			
335911	Storage Battery Manufacturing						
335311	Power, Distribution, and Specialty Transformer Manufacturing						
335313	Switchgear and Switchboard Apparatus Manufacturing						
212230	Copper, Nickel, Lead, and Zinc Mining						
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals						
4238	Machinery, Equipment, and Supplies Merchant Wholesalers					X	
327310	Cement Manufacturing					X	
334413	Semiconductor and Related Device Manufacturing			X		X	

Note. Table created by the author to summarize the findings of the study.

The analysis of inter-industrial presented in this study has identified several key sectors that are essential for the transition towards a clean energy economy in PR. The findings reveal that these are the Commercial Banking (52211) and Architectural, Engineering and Related Services (5413) sectors, which both form part of the core productive structure, belong to a community, and have significant relationships on the demand side. These sectors could potentially increase intersectoral linkages and generate significant structural changes. However, this analysis indicates that the Commercial Banking (52211) sector may require further development to effectively transmit the impulses received in a significant way, which an important characteristic for the sectors that should be considered as part of industrial policy strategies.

Similarly, other sectors that were revealed as being important for the transition process were the Iron and Steel Mills and Ferroalloy Manufacturing, Alumina Refining and Primary Aluminum Production, and Semiconductor and Related Device Manufacturing. These three meet the criteria of having significant relationships on the demand side as well as transmitting the impulses received in a significant way. However, because these sectors were analyzed using the US IO matrix they were not included as part of the network analysis, making it difficult to determine whether they belong to the core productive structure or are part of a community.

As can be seen in the appendix's Table 2.1 the Architectural, Engineering and Related Services (5413) sector has the potential to increase intersectoral linkages and generate significant structural changes due to its high level of intermediate input purchases from other sectors, particularly from the Pharmaceutical and Medicine Manufacturing (3254), Wholesale and Retail Trade (42-45), and Miscellaneous Manufacturing (339). This suggests that the sector is heavily

dependent on other industries and has a high potential to influence the demand side of these sectors. Furthermore, the sector's sales to other sectors indicate that it has a strong influence on the transmission effects of the network, particularly in the Insurance Carriers (5241), Construction of Buildings (236), Beverage Manufacturing (3121, and Real Estate (531) sectors.

Similarly, Table 2.2 in the appendix shows that the Commercial Banking (52211) sector has a high potential to increase intersectoral linkages and generate significant structural changes due to its significant intermediate input purchases from other sectors, particularly from the Non-depository Credit Intermediation (5222) and the Pharmaceutical and Medicine Manufacturing (3254). This indicates that the sector is also heavily dependent on other industries and has a strong influence on the demand side of these sectors. Moreover, the sector's sales to other sectors indicate that it is central to the transmission effects of the network, particularly in the Real Estate (531) and Construction of Buildings (236) sectors.

Additionally, the mapping of industries identified as part of the RE value chain to the IO matrix for PR has revealed some gaps and potential economic opportunities for local industry production during the transition process. This identification of previously overlooked economic opportunities is another important contribution of this research, as it has not been done before. By mapping industries in the RE value chain to the IO matrix for PR, 11 sectors (64.7% of the total identified sectors for the entire value chain) were found within the Manufacturing and Installation & Grid Connection segments of the value chain that were not part of PR's current production process. This suggests that these industries may not exist or may be so small that they are aggregated with another industry in PR's IO matrix. These findings highlight the potential for

developing these industries and expanding the local production process as part of the transition towards a cleaner energy economy in Puerto Rico.

While the results of this research identify important sectors for the transition to a clean energy economy in PR, they do not align with the literature review conducted. This may be due to the focus of the literature on measuring the impacts of clean energy transitions on employment and GDP, while our study focused on identifying key sectors for inter-industrial linkages and potential economic opportunities for local industry production during the transition process. Additionally, our analysis looked at the inter-sectoral relationships of industries within the RE value chain, which may have different implications for the overall economic impact of clean energy transitions than the studies reviewed in the literature. As such, our findings provide a unique perspective on the potential drivers of economic growth in PR's transition to a clean energy economy.

Conclusions and Recommendations

This research set out to address the pressing issue of how PR's economic productive structure could be affected by the transition towards a clean energy economy, as proposed in PREPA's final Integrated Resource Plan (IRP). Unlike prior studies that have focused on the effects of clean energy transitions on GDP and employment, this research took a unique approach by analyzing inter-industrial relationships and identifying gaps in the RE value chain, with a particular focus on solar PV technology. As a result, this study makes a valuable contribution to the existing body of work by exploring the potential economic impacts of this transition process and highlighting opportunities for growth and development.

The literature review conducted for this study consisted mainly of economic impact assessment studies that measured the impacts of clean energy transitions on economic variables such as employment and GDP. Although this research did not aim to measure the impacts of clean energy transitions on these variables, it was able to draw from these studies to identify a modeling approach that allowed to study intersectoral linkages and surpass the limitation of not having vectors for renewable energy within the data. By utilizing QIOA and applying a RE value chain framework, this research was able to identify the key sectors that are critical for the transition towards a clean energy economy in PR. Therefore, this research adds a new dimension to the existing literature by presenting an alternative approach that complements the existing studies, which may inform policymakers' decisions towards achieving a clean energy economy.

Within the IO analysis, this research employed two main methods: network analysis and a sector level analysis. These techniques were utilized to explore the productive structure of Puerto Rico's economy, as well as to identify and characterize the sectors involved in the clean

energy transition process. The network analysis allowed us to identify the most important sectors in terms of intersectoral linkages and their centrality in the economy. On the other hand, the sector-level analysis provided insights into the economic characteristics and relationships of specific sectors, allowing us to identify key sectors that could be considered for industry policy interventions.

Overall, the findings support the hypothesis that the transition towards a clean energy economy in PR can lead to an increase in inter-industrial linkages, producing significant structural changes and transforming inter-industrial interactions. Specifically, the network analysis suggests that even though currently the interdependence between sectors may be poor, the productive structure is relatively well-connected and has the potential to adapt to changes which is evidenced in the results of the diameter metric. In other words, even though the economy may have limited integration opportunities between sectors, the sectors that are present are well-connected and may be able to work together effectively in response to changes that can arise as part of the transition process. Moreover, the network analysis also suggests that the sectors within the identified community, specifically the two of which form part of the RE value chain, may play a crucial role in transforming and connecting the economy during the transition towards a clean energy economy. Specifically, these sectors may act as key intermediaries between other sectors in the value chain, indicating their potential high level of centrality and influence in regulating the flow of information and resources within the network. Therefore, these findings suggest that the productive structure has the potential to transform and become more interconnected during the transition towards a clean energy economy, leading to significant structural changes and inter-industrial linkages. The results of the sectoral analysis highlight the

Commercial Banking (52211) and Architectural, Engineering and Related Services (5413) sectors are the ones that could potentially increase intersectoral linkages and generate significant structural changes.

Moreover, this research highlighted the gaps found in PR's RE value chain, particularly in the manufacturing segment, suggesting that there are potential economic opportunities for local industry production which could support the energy transition process in PR. To fully realize the economic potential of the energy transition, PR's industrial policy could evaluate the possibility of promoting the development of industries that do not currently exist on the island. By doing so, a robust RE value chain can be established in PR, providing the necessary infrastructure and support for the transition to RE.

Based on the findings of this research, there are several recommendations for future research on the topic. Firstly, there is a need to gather more detailed data on the RE sector in PR which could be done via surveys, as suggested in the reviewed literature. This would allow for a more accurate analysis of the interindustry relationships of the sectors involved in the RE transition process. Secondly, future research could explore the potential economic impacts of the transition to a clean energy economy in PR by analyzing job creation, income generation, and GDP growth. This would provide a more comprehensive understanding of the potential benefits and challenges of transitioning to a clean energy economy in Puerto Rico. Thirdly, future research could also focus on studying the impacts of demand and supply shocks via simulations or compare Puerto Rico's energy transition and economic impacts to those of other countries or regions undergoing similar transitions to draw lessons and insights from other contexts.

Additionally, it is recommended that the Puerto Rico Planning Board updates the input-output tables to ensure more accurate analyses can be conducted. Regularly updating these tables will provide valuable insights for decision-making processes and assist in making informed policy decisions and resource allocation to support Puerto Rico's sustainable energy goals. Furthermore, the Planning Board should consider the possibility of creating satellite national accounts, similar to practices in other countries advanced in their renewable energy transitions. This approach would provide a comprehensive framework for measuring and analyzing the economic impact of renewable energy sectors, aiding in effective policy formulation and resource allocation.

In conclusion, this research has highlighted the importance of analyzing inter-industrial relationships and identifying gaps in the RE value chain to fully understand the potential economic impacts of the transition to a clean energy economy in PR. Ultimately, this emphasizes the criticality of understanding the complex interrelationships within energy systems, economic structures, and industrial networks in the context of the energy transition. These findings can help inform policy decisions and contribute to the ongoing dialogue on the economic impacts of the energy transition in PR.

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Appendix

Supply Relationships

Table 1.1

Heavy and Civil Engineering Construction – 237

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Wholesale and Retail Trade	42-45	83.13%
Pharmaceutical and Medicine Manufacturing	3254	7.44%
Justice, Public Order, and Safety Activities	922	2.21%
Other Depository Credit Intermediation	52219	1.69%
Construction of Buildings	236	1.59%
Hospitals	622	1.10%
Nondepository Credit Intermediation	5222	0.95%
	Grand Total	**98.13%**

Table 1.2

Basic Chemical Manufacturing – 3251

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Outpatient Care Centers	6214	39.15%
Waste Management and Remediation Services	562	23.25%
Basic Chemical Manufacturing	3251	21.34%
Machinery Manufacturing	333	3.94%
Heavy and Civil Engineering Construction	237	1.59%
Insurance Carriers	5241	1.48%
Electric Power Generation, Transmission and Distribution	2211	1.38%
Beverage Manufacturing	3121	1.20%
Telecommunications	517	1.16%
	Grand Total	**94.49%**

Table 1.3

Other Chemical Product and Preparation Manufacturing – 3259

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Computer and Electronic Product Manufacturing	334	30.92%
Electrical Equipment, Appliance, and Component Manufacturing	335	25.56%
Real Estate	531	20.30%
Commercial Banking	52211	10.42%
Basic Chemical Manufacturing	3251	5.28%
Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256	3.66%
Fabricated Metal Product Manufacturing	332	2.67%
	Grand Total	**98.81%**

Table 1.4

Commercial Banking – 52211

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Commercial Banking	52211	73.52%
Real Estate	531	7.00%
Construction of Buildings	236	5.47%
Activities Related to Credit Intermediation	5223	2.27%
Administration of Human Resource Programs	923	2.16%
Executive, Legislative, and Other General Government Support	921	1.66%
Administrative and Support Services	561	1.59%
Data Processing, Hosting, and Related Services	518	1.34%
Electrical Equipment, Appliance, and Component Manufacturing	335	1.26%
	Grand Total	**96.28%**

Table 1.5

Architectural Engineering and Related Services – 5413

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Insurance Carriers	5241	21.22%
Construction of Buildings	236	17.93%
Beverage Manufacturing	3121	10.51%
Real Estate	531	9.51%
Architectural, Engineering, and Related Services	5413	5.41%
Accommodation	721	4.04%
Computer and Electronic Product Manufacturing	334	3.47%
Miscellaneous Manufacturing	339	3.11%
Couriers and Messengers	492	2.60%
Justice, Public Order, and Safety Activities	922	1.91%
Petroleum and Coal Products Manufacturing	324	1.74%
Telecommunications	517	1.53%
Machinery Manufacturing	333	1.40%
Bakeries and Tortilla Manufacturing	3118	1.36%
Administration of Human Resource Programs	923	1.24%
Animal Food Manufacturing	3111	1.24%
Educational Services	611	1.17%
Fruit and Vegetable Preserving and Specialty Food Manufacturing	3114	1.14%
Legal Services	5411	1.02%
Air Transportation	481	0.96%
Dairy Product Manufacturing	3115	0.93%
	Grand Total	**93.44%**

Table 1.6

Electric Power Generation, Transmission and Distribution -2211

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Petroleum and Coal Products Manufacturing	324	49.89%
Electric Power Generation, Transmission and Distribution	2211	46.70%
Insurance Carriers	5241	1.14%
	Grand Total	**97.73%**

Table 1.7

Motor and generator manufacturing – 335312

ndustry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Motor and generator manufacturing	335312	12.90%
Other engine equipment manufacturing	333618	12.35%
Copper rolling, drawing, extruding and alloying	331420	6.29%
Turned product and screw, nut, and bolt manufacturing	332720	5.86%
ron and steel mills and ferroalloy manufacturing	331110	5.49%
Metal crown, closure, and other metal stamping (except automotive)	332119	4.85%
Motor vehicle gasoline engine and engine parts manufacturing	336310	4.40%
Ball and roller bearing manufacturing	332991	4.12%
All other miscellaneous electrical equipment and component manufacturing	335999	3.88%
Relay and industrial control manufacturing	335314	3.29%
Steel product manufacturing from purchased steel	331200	3.23%
Communication and energy wire and cable manufacturing	335920	1.76%
Management of companies and enterprises	550000	1.76%
All other miscellaneous manufacturing	339990	1.71%
Semiconductor and related device manufacturing	334413	1.42%
Speed changer, industrial high-speed drive, and gear manufacturing	333612	1.34%
Other electronic component manufacturing	33441A	1.27%
Mechanical power transmission equipment manufacturing	333613	1.27%
Machine shops	332710	1.22%
Household appliances and electrical and electronic goods	423600	1.18%
Power, distribution, and specialty transformer manufacturing	335311	1.11%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	1.09%
Paint and coating manufacturing	325510	0.97%
Paperboard container manufacturing	322210	0.93%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.89%
Other petroleum and coal products manufacturing	324190	0.78%
All other forging, stamping, and sintering	33211A	0.71%
Coating, engraving, heat treating and allied activities	332800	0.71%
Other Motor Vehicle Parts Manufacturing	336390	0.69%
Carbon and graphite product manufacturing	335991	0.69%
Clay product and refractory manufacturing	327100	0.68%
Nonferrous metal foundries	331520	0.62%
Electric Power Generation, Transmission and Distribution	221100	0.62%
Alumina refining and primary aluminum production	331313	0.58%
Ornamental and architectural metal products manufacturing	332320	0.55%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.52%
Noncomparable imports	S00300	0.52%
Other plastics product manufacturing	326190	0.37%
Ferrous metal foundries	331510	0.34%
Plastics material and resin manufacturing	325211	0.34%
nsurance agencies, brokerages, and related activities	524200	0.30%
Cutlery and handtool manufacturing	332200	0.27%
Postal service	491000	0.25%
Other real estate	531ORE	0.24%
Legal services	541100	0.21%
Wholesale electronic markets and agents and brokers	425000	0.21%
	Grand Total	**94.73%**

Table 1.8

Copper, nickel, lead, and zinc mining – 212230

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Petroleum refineries	324110	19.02%
Electric power generation, transmission, and distribution	221100	9.75%
Iron, gold, silver, and other metal ore mining	2122A0	7.35%
Tire manufacturing	326210	5.77%
Nonresidential maintenance and repair	230301	5.55%
Copper, nickel, lead, and zinc mining	212230	5.13%
Mining and oil and gas field machinery manufacturing	333130	5.11%
Natural gas distribution	221200	3.29%
Construction machinery manufacturing	333120	3.12%
Management of companies and enterprises	550000	2.98%
Material handling equipment manufacturing	333920	2.72%
Architectural, engineering, and related services	541300	2.50%
Other support activities for mining	21311A	2.36%
Other basic organic chemical manufacturing	325190	2.07%
All other chemical product and preparation manufacturing	3259A0	1.93%
Custom computer programming services	541511	1.55%
Insurance carriers, except direct life	5241XX	1.43%
Iron and steel mills and ferroalloy manufacturing	331110	1.22%
Legal services	541100	1.11%
Commercial and industrial machinery and equipment rental and leasing	532400	1.00%
Lime and gypsum product manufacturing	327400	0.94%
Other general purpose machinery manufacturing	33399A	0.93%
Industrial gas manufacturing	325120	0.90%
Services to buildings and dwellings	561700	0.88%
Pump and pumping equipment manufacturing	33391A	0.65%
Coating, engraving, heat treating and allied activities	332800	0.64%
Plate work and fabricated structural product manufacturing	332310	0.58%
Coal Mining	212100	0.50%
Insurance agencies, brokerages, and related activities	524200	0.47%
Paint and coating manufacturing	325510	0.40%
Petrochemical manufacturing	325110	0.37%
Turned product and screw, nut, and bolt manufacturing	332720	0.37%
Other financial investment activities	523900	0.37%
Waste management and remediation services	562000	0.35%
Lessors of nonfinancial intangible assets	533000	0.35%
Monetary authorities and depository credit intermediation	52A000	0.33%
Ground or treated mineral and earth manufacturing	327992	0.33%
Other petroleum and coal products manufacturing	324190	0.32%
Other Basic Inorganic Chemical Manufacturing	325180	0.30%
Full-service restaurants	722110	0.30%
Motor vehicle transmission and power train parts manufacturing	336350	0.29%
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	3363A0	0.27%
Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing	33351B	0.27%
Other Motor Vehicle Parts Manufacturing	336390	0.26%
Valve and fittings other than plumbing	33291A	0.26%
Other plastics product manufacturing	326190	0.23%
Machine shops	332710	0.21%
Noncomparable imports	S00300	0.21%
Storage battery manufacturing	335911	0.21%
	Grand Total	**97.47%**

Table 1.9

Iron and steel mills and ferroalloy manufacturing – 331110

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Scrap	S00401	28.30%
Iron and steel mills and ferroalloy manufacturing	331110	21.70%
Nonferrous Metal (except Aluminum) Smelting and Refining	331410	7.08%
Iron, gold, silver, and other metal ore mining	2122A0	6.76%
Coal mining	212100	6.70%
Electric power generation, transmission, and distribution	221100	3.26%
Other petroleum and coal products manufacturing	324190	2.40%
Steel product manufacturing from purchased steel	331200	1.56%
Lime and gypsum product manufacturing	327400	1.09%
Clay product and refractory manufacturing	327100	0.98%
Architectural, engineering, and related services	541300	0.97%
Ground or treated mineral and earth manufacturing	327992	0.85%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	0.77%
Natural gas distribution	221200	0.70%
Copper, nickel, lead, and zinc mining	212230	0.70%
Carbon and graphite product manufacturing	335991	0.68%
Coating, engraving, heat treating and allied activities	332800	0.66%
Securities and commodity contracts intermediation and brokerage	523A00	0.65%
Services to buildings and dwellings	561700	0.64%
Paperboard container manufacturing	322210	0.59%
Petroleum refineries	324110	0.54%
Alumina refining and primary aluminum production	331313	0.50%
Other durable goods merchant wholesalers	423A00	0.49%
All other miscellaneous professional, scientific, and technical services	5419A0	0.46%
Industrial gas manufacturing	325120	0.45%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.44%
Noncomparable imports	S00300	0.42%
Nonresidential maintenance and repair	230301	0.41%
Machine shops	332710	0.40%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.37%
Other Motor Vehicle Parts Manufacturing	336390	0.36%
Ferrous metal foundries	331510	0.33%
Monetary authorities and depository credit intermediation	52A000	0.33%
Synthetic rubber and artificial and synthetic fibers and filaments manufacturing	3252A0	0.33%
Relay and industrial control manufacturing	335314	0.31%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.30%
Special tool, die, jig, and fixture manufacturing	333514	0.27%
Management of companies and enterprises	550000	0.27%
Semiconductor and related device manufacturing	334413	0.24%
Wholesale electronic markets and agents and brokers	425000	0.24%
Lessors of nonfinancial intangible assets	533000	0.24%
Waste management and remediation services	562000	0.23%
Air transportation	481000	0.22%
Automotive repair and maintenance	811100	0.22%
Other basic organic chemical manufacturing	325190	0.21%
Other Basic Inorganic Chemical Manufacturing	325180	0.20%
	Grand Total	**95.77%**

Table 1.10

Alumina refining and primary aluminum production – 331313

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Electric power generation, transmission, and distribution	221100	24.47%
Alumina refining and primary aluminum production	331313	17.38%
Nonferrous Metal (except Aluminum) Smelting and Refining	331410	12.44%
Iron, gold, silver, and other metal ore mining	2122A0	9.68%
Carbon and graphite product manufacturing	335991	6.55%
Aluminum product manufacturing from purchased aluminum	33131B	5.57%
Coal mining	212100	1.53%
Semiconductor and related device manufacturing	334413	1.35%
Insurance agencies, brokerages, and related activities	524200	1.23%
Other petroleum and coal products manufacturing	324190	1.19%
Other Basic Inorganic Chemical Manufacturing	325180	1.17%
Machine shops	332710	1.06%
Nondepository credit intermediation and related activities	522A00	1.00%
Coating, engraving, heat treating and allied activities	332800	0.96%
Monetary authorities and depository credit intermediation	52A000	0.90%
Securities and commodity contracts intermediation and brokerage	523A00	0.82%
Natural gas distribution	221200	0.82%
Other Motor Vehicle Parts Manufacturing	336390	0.74%
Paperboard container manufacturing	322210	0.66%
Management of companies and enterprises	550000	0.66%
Insurance carriers, except direct life	5241XX	0.60%
Oil and gas extraction	211000	0.60%
All other chemical product and preparation manufacturing	3259A0	0.54%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.54%
Petroleum refineries	324110	0.52%
Services to buildings and dwellings	561700	0.48%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.46%
Other real estate	531ORE	0.40%
Nonresidential maintenance and repair	230301	0.34%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.32%
Turned product and screw, nut, and bolt manufacturing	332720	0.28%
Scrap	S00401	0.22%
Noncomparable imports	S00300	0.22%
Other fabricated metal manufacturing	332999	0.22%
Relay and industrial control manufacturing	335314	0.22%
	Grand Total	**96.10%**

Table 1.11

Semiconductor and related device manufacturing – 334413

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Management of companies and enterprises	550000	26.40%
Nonferrous Metal (except Aluminum) Smelting and Refining	331410	10.80%
Semiconductor and related device manufacturing	334413	9.08%
Legal services	541100	4.74%
Other Basic Inorganic Chemical Manufacturing	325180	3.90%
Electric power generation, transmission, and distribution	221100	3.85%
Other real estate	531ORE	3.07%
Other electronic component manufacturing	33441A	2.52%
Management consulting services	541610	2.46%
Employment services	561300	2.40%
Advertising, public relations, and related services	541800	2.21%
Warehousing and storage	493000	1.79%
Architectural, engineering, and related services	541300	1.47%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	1.27%
Noncomparable imports	S00300	1.23%
Household appliances and electrical and electronic goods	423600	1.10%
Plate work and fabricated structural product manufacturing	332310	0.99%
Ornamental and architectural metal products manufacturing	332320	0.95%
Electricity and signal testing instruments manufacturing	334515	0.94%
All other miscellaneous professional, scientific, and technical services	5419A0	0.93%
Accounting, tax preparation, bookkeeping, and payroll services	541200	0.92%
Industrial gas manufacturing	325120	0.80%
Services to buildings and dwellings	561700	0.73%
All other chemical product and preparation manufacturing	3259A0	0.72%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.69%
Monetary authorities and depository credit intermediation	52A000	0.53%
Investigation and security services	561600	0.50%
Business support services	561400	0.50%
Nonresidential maintenance and repair	230301	0.49%
Other support services	561900	0.49%
Lessors of nonfinancial intangible assets	533000	0.46%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.45%
Plastics pipe, pipe fitting, and unlaminated profile shape manufacturing	326120	0.42%
Wiring device manufacturing	335930	0.41%
Broadcast and wireless communications equipment	334220	0.40%
Machine shops	332710	0.37%
Motor and generator manufacturing	335312	0.34%
Data processing, hosting, and related services	518200	0.34%
Computer terminals and other computer peripheral equipment manufacturing	334118	0.33%
Waste management and remediation services	562000	0.32%
Electronic and precision equipment repair and maintenance	811200	0.27%
Automotive repair and maintenance	811100	0.26%
Metal crown, closure, and other metal stamping (except automotive)	332119	0.26%
Concrete pipe, brick, and block manufacturing	327330	0.26%
Wired telecommunications carriers	517110	0.26%
Facilities support services	561200	0.26%
Other Motor Vehicle Parts Manufacturing	336390	0.25%
All other miscellaneous electrical equipment and component manufacturing	335999	0.25%
Wholesale electronic markets and agents and brokers	425000	0.24%
Semiconductor machinery manufacturing	333242	0.21%
Plumbing fixture fitting and trim manufacturing	332913	0.20%
Wood kitchen cabinet and countertop manufacturing	337110	0.20%
	Grand Total	**95.25%**

Table 1.12

Electricity and signal testing instruments manufacturing – 334515

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Electricity and signal testing instruments manufacturing	334515	27.59%
Advertising, public relations, and related services	541800	12.16%
Warehousing and storage	493000	11.80%
Legal services	541100	10.82%
Accounting, tax preparation, bookkeeping, and payroll services	541200	5.41%
Management of companies and enterprises	550000	5.34%
Other electronic component manufacturing	33441A	2.70%
Data processing, hosting, and related services	518200	1.97%
Printed circuit assembly (electronic assembly) manufacturing	334418	1.95%
Relay and industrial control manufacturing	335314	1.54%
Computer terminals and other computer peripheral equipment manufacturing	334118	1.49%
Lessors of nonfinancial intangible assets	533000	1.41%
Semiconductor and related device manufacturing	334413	1.19%
Broadcast and wireless communications equipment	334220	1.10%
Electronic and precision equipment repair and maintenance	811200	1.09%
Other real estate	531ORE	0.85%
Noncomparable imports	S00300	0.76%
Management consulting services	541610	0.70%
Architectural, engineering, and related services	541300	0.64%
Employment services	561300	0.63%
Truck transportation	484000	0.61%
Wiring device manufacturing	335930	0.51%
Machine shops	332710	0.47%
All other miscellaneous professional, scientific, and technical services	5419A0	0.41%
Copper rolling, drawing, extruding and alloying	331420	0.41%
Other plastics product manufacturing	326190	0.36%
Turned product and screw, nut, and bolt manufacturing	332720	0.36%
Other Motor Vehicle Parts Manufacturing	336390	0.32%
Metal crown, closure, and other metal stamping (except automotive)	332119	0.31%
Securities and commodity contracts intermediation and brokerage	523A00	0.29%
Ornamental and architectural metal products manufacturing	332320	0.27%
Services to buildings and dwellings	561700	0.25%
Monetary authorities and depository credit intermediation	52A000	0.24%
Coating, engraving, heat treating and allied activities	332800	0.22%
Iron and steel mills and ferroalloy manufacturing	331110	0.22%
Custom computer programming services	541511	0.22%
	Grand Total	**96.59%**

Table 1.13

Power, distribution, and specialty transformer manufacturing – 335311

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Copper rolling, drawing, extruding and alloying	331420	15.53%
Iron and steel mills and ferroalloy manufacturing	331110	15.53%
All other miscellaneous electrical equipment and component manufacturing	335999	12.57%
Other petroleum and coal products manufacturing	324190	9.41%
Turned product and screw, nut, and bolt manufacturing	332720	7.07%
Wiring device manufacturing	335930	2.46%
Clay product and refractory manufacturing	327100	2.23%
Paint and coating manufacturing	325510	2.11%
Coating, engraving, heat treating and allied activities	332800	1.88%
Other electronic component manufacturing	33441A	1.80%
Communication and energy wire and cable manufacturing	335920	1.74%
Management of companies and enterprises	550000	1.59%
Power, distribution, and specialty transformer manufacturing	335311	1.54%
Household appliances and electrical and electronic goods	423600	1.48%
Petroleum refineries	324110	1.16%
Machine shops	332710	1.10%
Semiconductor and related device manufacturing	334413	1.07%
Paper mills	322120	1.01%
Valve and fittings other than plumbing	33291A	0.98%
Paperboard container manufacturing	322210	0.96%
Electric power generation, transmission, and distribution	221100	0.96%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	0.90%
Metal crown, closure, and other metal stamping (except automotive)	332119	0.75%
Other plastics product manufacturing	326190	0.72%
Insurance agencies, brokerages, and related activities	524200	0.70%
Plate work and fabricated structural product manufacturing	332310	0.64%
Wholesale electronic markets and agents and brokers	425000	0.58%
Ball and roller bearing manufacturing	332991	0.55%
Other fabricated metal manufacturing	332999	0.52%
Lessors of nonfinancial intangible assets	533000	0.49%
Nondepository credit intermediation and related activities	522A00	0.43%
All other forging, stamping, and sintering	33211A	0.43%
Monetary authorities and depository credit intermediation	52A000	0.41%
Postal service	491000	0.41%
Services to buildings and dwellings	561700	0.38%
Noncomparable imports	S00300	0.35%
Insurance carriers, except direct life	5241XX	0.35%
Securities and commodity contracts intermediation and brokerage	523A00	0.35%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.35%
Other real estate	531ORE	0.32%
Legal services	541100	0.32%
Natural gas distribution	221200	0.29%
Architectural, engineering, and related services	541300	0.29%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.29%
Nonresidential maintenance and repair	230301	0.26%
Advertising, public relations, and related services	541800	0.26%
Aluminum product manufacturing from purchased aluminum	33131B	0.23%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.23%
Cutlery and handtool manufacturing	332200	0.23%
All other chemical product and preparation manufacturing	3259A0	0.20%
Management consulting services	541610	0.20%
All other miscellaneous professional, scientific, and technical services	5419A0	0.20%
	Grand Total	**96.81%**

Table 1.14

Switchgear and switchboard apparatus manufacturing – 335313

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Motor and generator manufacturing	335312	12.90%
Other engine equipment manufacturing	333618	12.35%
Copper rolling, drawing, extruding and alloying	331420	6.29%
Turned product and screw, nut, and bolt manufacturing	332720	5.86%
Iron and steel mills and ferroalloy manufacturing	331110	5.49%
Metal crown, closure, and other metal stamping (except automotive)	332119	4.85%
Motor vehicle gasoline engine and engine parts manufacturing	336310	4.40%
Ball and roller bearing manufacturing	332991	4.12%
All other miscellaneous electrical equipment and component manufacturing	335999	3.88%
Relay and industrial control manufacturing	335314	3.29%
Steel product manufacturing from purchased steel	331200	3.23%
Communication and energy wire and cable manufacturing	335920	1.76%
Management of companies and enterprises	550000	1.76%
All other miscellaneous manufacturing	339990	1.71%
Semiconductor and related device manufacturing	334413	1.42%
Speed changer, industrial high-speed drive, and gear manufacturing	333612	1.34%
Other electronic component manufacturing	33441A	1.27%
Mechanical power transmission equipment manufacturing	333613	1.27%
Machine shops	332710	1.22%
Household appliances and electrical and electronic goods	423600	1.18%
Power, distribution, and specialty transformer manufacturing	335311	1.11%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	1.09%
Paint and coating manufacturing	325510	0.97%
Paperboard container manufacturing	322210	0.93%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.89%
Other petroleum and coal products manufacturing	324190	0.78%
All other forging, stamping, and sintering	33211A	0.71%
Coating, engraving, heat treating and allied activities	332800	0.71%
Other Motor Vehicle Parts Manufacturing	336390	0.69%
Carbon and graphite product manufacturing	335991	0.69%
Clay product and refractory manufacturing	327100	0.68%
Nonferrous metal foundries	331520	0.62%
Electric Power Generation, Transmission and Distribution	221100	0.62%
Alumina refining and primary aluminum production	331313	0.58%
Ornamental and architectural metal products manufacturing	332320	0.55%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.52%
Noncomparable imports	S00300	0.52%
Other plastics product manufacturing	326190	0.37%
Ferrous metal foundries	331510	0.34%
Plastics material and resin manufacturing	325211	0.34%
Insurance agencies, brokerages, and related activities	524200	0.30%
Cutlery and handtool manufacturing	332200	0.27%
Postal service	491000	0.25%
Other real estate	531ORE	0.24%
Legal services	541100	0.21%
Wholesale electronic markets and agents and brokers	425000	0.21%
	Grand Total	**94.73%**

Table 1.15

Storage battery manufacturing - 335911

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Nonferrous Metal (except Aluminum) Smelting and Refining	331410	63.27%
Other plastics product manufacturing	326190	3.91%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	3.86%
Iron and steel mills and ferroalloy manufacturing	331110	3.83%
Electric power generation, transmission, and distribution	221100	3.44%
Other Basic Inorganic Chemical Manufacturing	325180	2.10%
Management of companies and enterprises	550000	1.34%
Turned product and screw, nut, and bolt manufacturing	332720	1.21%
Synthetic dye and pigment manufacturing	325130	0.97%
Services to buildings and dwellings	561700	0.79%
Valve and fittings other than plumbing	33291A	0.74%
Plastics material and resin manufacturing	325211	0.63%
Other real estate	531ORE	0.58%
Paperboard container manufacturing	322210	0.58%
Lessors of nonfinancial intangible assets	533000	0.55%
Semiconductor and related device manufacturing	334413	0.55%
Nonresidential maintenance and repair	230301	0.55%
Noncomparable imports	S00300	0.53%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.50%
Plate work and fabricated structural product manufacturing	332310	0.50%
Natural gas distribution	221200	0.47%
Machine shops	332710	0.47%
Architectural, engineering, and related services	541300	0.42%
All other forging, stamping, and sintering	33211A	0.42%
Advertising, public relations, and related services	541800	0.39%
Storage battery manufacturing	335911	0.39%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.37%
Insurance agencies, brokerages, and related activities	524200	0.34%
Other fabricated metal manufacturing	332999	0.34%
Other Motor Vehicle Parts Manufacturing	336390	0.32%
Securities and commodity contracts intermediation and brokerage	523A00	0.32%
Metal crown, closure, and other metal stamping (except automotive)	332119	0.32%
Coating, engraving, heat treating and allied activities	332800	0.29%
Automotive repair and maintenance	811100	0.29%
Petroleum refineries	324110	0.29%
Waste management and remediation services	562000	0.26%
All other miscellaneous professional, scientific, and technical services	5419A0	0.24%
	Grand Total	**96.35%**

Table 1.16

Machinery, equipment, and supplies- 423800

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Management of companies and enterprises	550000	11.07%
Other real estate	531ORE	9.70%
Warehousing and storage	493000	4.44%
Advertising, public relations, and related services	541800	4.31%
Management consulting services	541610	3.93%
Nondepository credit intermediation and related activities	522A00	3.53%
Couriers and messengers	492000	3.42%
Accounting, tax preparation, bookkeeping, and payroll services	541200	2.80%
Electric power generation, transmission, and distribution	221100	2.34%
Postal service	491000	2.16%
Employment services	561300	2.15%
Insurance carriers, except direct life	5241XX	2.11%
Scenic and sightseeing transportation and support activities for transportation	48A000	2.10%
Legal services	541100	2.04%
Wireless telecommunications carriers (except satellite)	517210	1.78%
Wholesale electronic markets and agents and brokers	425000	1.73%
Business support services	561400	1.65%
Drugs and druggists' sundries	424200	1.64%
Services to buildings and dwellings	561700	1.54%
Plate work and fabricated structural product manufacturing	332310	1.50%
Monetary authorities and depository credit intermediation	52A000	1.31%
Commercial and industrial machinery and equipment repair and maintenance	811300	1.28%
Petroleum refineries	324110	1.25%
Other computer related services, including facilities management	54151A	1.19%
Other plastics product manufacturing	326190	1.13%
Wired telecommunications carriers	517110	1.10%
Computer systems design services	541512	1.01%
Air transportation	481000	1.01%
Architectural, engineering, and related services	541300	0.95%
Lessors of nonfinancial intangible assets	533000	0.89%
Professional and commercial equipment and supplies	423400	0.89%
Noncomparable imports	S00300	0.88%
Automotive equipment rental and leasing	532100	0.83%
Semiconductor and related device manufacturing	334413	0.82%
Speed changer, industrial high-speed drive, and gear manufacturing	333612	0.80%
Automotive repair and maintenance	811100	0.76%
Data processing, hosting, and related services	518200	0.63%
Investigation and security services	561600	0.61%
Nonresidential maintenance and repair	230301	0.56%
Commercial and industrial machinery and equipment rental and leasing	532400	0.55%
Full-service restaurants	722110	0.53%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.52%
Electronic and precision equipment repair and maintenance	811200	0.51%
Junior colleges, colleges, universities, and professional schools	611A00	0.50%
Printing	323110	0.50%
Other industrial machinery manufacturing	33329A	0.48%
Other engine equipment manufacturing	333618	0.44%
All other miscellaneous professional, scientific, and technical services	5419A0	0.43%
Household appliances and electrical and electronic goods	423600	0.42%
Other electronic component manufacturing	33441A	0.38%
Personal and household goods repair and maintenance	811400	0.37%
Motor vehicle transmission and power train parts manufacturing	336350	0.36%
Grocery and related product wholesalers	424400	0.36%
Specialized design services	541400	0.35%
Other nondurable goods merchant wholesalers	424A00	0.35%
Waste management and remediation services	562000	0.34%
Independent artists, writers, and performers	711500	0.34%
All other wood product manufacturing	3219A0	0.33%
Office administrative services	561100	0.33%
Limited-service restaurants	722211	0.32%
Other personal services	812900	0.29%
Other Motor Vehicle Parts Manufacturing	336390	0.29%
Paper Bag and Coated and Treated Paper Manufacturing	322220	0.29%
Truck transportation	484000	0.29%
Satellite, telecommunications resellers, and all other telecommunications	517A00	0.28%
Environmental and other technical consulting services	5416A0	0.27%
Other durable goods merchant wholesalers	423A00	0.26%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	333415	0.26%
Paperboard container manufacturing	322210	0.24%
Other support services	561900	0.24%
Software publishers	511200	0.22%
Accommodation	721000	0.20%
	Grand Total	**95.72%**

Table 1.17

Cement manufacturing - 327310

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Electric power generation, transmission, and distribution	221100	18.09%
Coal mining	212100	12.07%
Ground or treated mineral and earth manufacturing	327992	7.12%
Petroleum refineries	324110	6.80%
Natural gas distribution	221200	6.40%
Stone mining and quarrying	212310	6.31%
Cement manufacturing	327310	3.91%
Management of companies and enterprises	550000	2.26%
Architectural, engineering, and related services	541300	2.03%
Services to buildings and dwellings	561700	1.74%
Employment services	561300	1.68%
Other nonmetallic mineral mining and quarrying	2123A0	1.51%
Other durable goods merchant wholesalers	423A00	1.22%
Nonresidential maintenance and repair	230301	1.13%
Clay product and refractory manufacturing	327100	1.10%
Commercial and industrial machinery and equipment repair and maintenance	811300	1.04%
Other support services	561900	1.04%
Business support services	561400	1.04%
Coating, engraving, heat treating and allied activities	332800	1.04%
Investigation and security services	561600	0.98%
Machine shops	332710	0.90%
All other miscellaneous professional, scientific, and technical services	5419A0	0.78%
Glass and glass product manufacturing	327200	0.75%
Lime and gypsum product manufacturing	327400	0.69%
Commercial and industrial machinery and equipment rental and leasing	532400	0.67%
Automotive equipment rental and leasing	532100	0.67%
Automotive repair and maintenance	811100	0.61%
Noncomparable imports	S00300	0.58%
All other wood product manufacturing	3219A0	0.58%
Other Motor Vehicle Parts Manufacturing	336390	0.58%
Mineral wool manufacturing	327993	0.58%
Monetary authorities and depository credit intermediation	52A000	0.52%
Insurance agencies, brokerages, and related activities	524200	0.52%
Facilities support services	561200	0.52%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.49%
Insurance carriers, except direct life	5241XX	0.46%
Lessors of nonfinancial intangible assets	533000	0.46%
Specialized design services	541400	0.46%
Other petroleum and coal products manufacturing	324190	0.43%
Other fabricated metal manufacturing	332999	0.41%
Paperboard container manufacturing	322210	0.41%
Nondepository credit intermediation and related activities	522A00	0.38%
Semiconductor and related device manufacturing	334413	0.35%
Data processing, hosting, and related services	518200	0.35%
Other basic organic chemical manufacturing	325190	0.32%
Legal services	541100	0.32%
Turned product and screw, nut, and bolt manufacturing	332720	0.32%
Waste management and remediation services	562000	0.32%
Other real estate	531ORE	0.29%
Other Basic Inorganic Chemical Manufacturing	325180	0.29%
Accounting, tax preparation, bookkeeping, and payroll services	541200	0.26%
Air transportation	481000	0.26%
Computer systems design services	541512	0.26%
Scenic and sightseeing transportation and support activities for transportation	48A000	0.26%
Paperboard mills	322130	0.26%
Plastics material and resin manufacturing	325211	0.26%
Electronic and precision equipment repair and maintenance	811200	0.23%
Hardware manufacturing	332500	0.23%
Management consulting services	541610	0.23%
Advertising, public relations, and related services	541800	0.23%
All other chemical product and preparation manufacturing	3259A0	0.23%
Miscellaneous nonmetallic mineral products	327999	0.23%
Motor vehicle transmission and power train parts manufacturing	336350	0.20%
	Grand Total	**96.64%**

Demand Relationships

Table 2.1

Architectural Engineering and Related Services – 5413

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Computer and Electronic Product Manufacturing	334	42.61%
Retail & Wholesale Trade	42-45	14.96%
Pharmaceutical and Medicine Manufacturing	3254	13.07%
Architectural, Engineering, and Related Services	5413	11.99%
Telecommunications	517	2.98%
Miscellaneous Manufacturing	339	2.62%
Petroleum and Coal Products Manufacturing	324	1.23%
Educational Services	611	1.04%
Broadcasting (except Internet)	515	0.97%
Automotive Repair and Maintenance	8111	0.97%
	Grand Total	**92.44%**

Table 2.2

Commercial Banking – 52211

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Commercial Banking	52211	59.00%
Nondepository Credit Intermediation	5222	9.40%
Pharmaceutical and Medicine Manufacturing	3254	6.77%
Administrative and Support Services	561	4.40%
Petroleum and Coal Products Manufacturing	324	4.22%
Retail & Wholesale Trade	42-45	3.50%
Telecommunications	517	1.86%
Credit Unions	52213	1.36%
Mining (except Oil and Gas)	212	0.95%
	Grand Total	**91.45%**

Table 2.3

Basic Chemical Manufacturing – 3251

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Pharmaceutical and Medicine Manufacturing	3254	54.28%
Wholesale and Retail Trade	42-45	11.05%
Miscellaneous Manufacturing	339	7.53%
Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	5.29%
Basic Chemical Manufacturing	3251	5.01%
Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	3253	4.10%
Water, Sewage and Other Systems	2213	3.69%
Sugar and Confectionery Product Manufacturing	3113	3.15%
Nonmetallic Mineral Product Manufacturing	327	2.39%
Bakeries and Tortilla Manufacturing	3118	1.80%
	Grand Total	**98.29%**

Table 2.4

Other Chemical Product and Preparation Manufacturing – 3259

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Administrative and Support Services	561	27.70%
Paper Manufacturing	322	9.64%
Agriculture, Forestry, Fishing and Hunting	11	9.47%
Printing and Related Support Activities	3231	7.92%
Wholesale and Retail Trade	42-45	7.67%
Insurance Carriers	5241	5.96%
Furniture and Related Product Manufacturing	337	4.38%
Offices of Physicians	6211	3.87%
Advertising, Public Relations, and Related Services	5418	3.50%
Agencies, Brokerages, and Other Insurance Related Activities	5242	2.68%
Nondepository Credit Intermediation	5222	2.03%
Educational Services	611	1.80%
Computer Systems Design and Related Services	5415	1.66%
Mining (except Oil and Gas)	212	1.45%
Credit Unions	52213	1.41%
Drycleaning and Laundry Services	8123	1.22%
Commercial Banking	52211	1.17%
	Grand Total	**93.51%**

Table 2.5

Heavy and Civil Engineering Construction – 237

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Petroleum and Coal Products Manufacturing	324	32.48%
Pharmaceutical and Medicine Manufacturing	3254	28.67%
Wholesale and Retail Trade	42-45	11.56%
Real Estate	531	8.15%
Miscellaneous Manufacturing	339	2.59%
Primary Metal Manufacturing	331	1.51%
Offices of Physicians	6211	1.44%
Accommodation	721	1.38%
Nonmetallic Mineral Product Manufacturing	327	1.37%
Plastics Product Manufacturing	3261	1.17%
Hospitals	622	1.09%
Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256	1.08%
Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3252	0.95%
Beverage Manufacturing	3121	0.92%
	Grand Total	**94.36%**

Table 2.6

Electric Power Generation, Transmission and Distribution -2211

Industry Name	NAICS Code	Purchase from Sector/Total Purchase of Intermediate Inputs
Electric Power Generation, Transmission and Distribution	2211	48.60%
Computer and Electronic Product Manufacturing	334	10.11%
Insurance Carriers	5241	8.18%
Pharmaceutical and Medicine Manufacturing	3254	8.17%
Water, Sewage and Other Systems	2213	4.66%
Retail and Wholseale Trade	42-45	4.19%
Petroleum and Coal Products Manufacturing	324	3.92%
Mining (except Oil and Gas)	212	1.08%
Couriers and Messengers	492	0.94%
	Grand Total	**89.85%**

Table 2.7

Copper, nickel, lead, and zinc mining - 212230

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Copper, nickel, lead, and zinc mining	212230	3.71%
Industrial gas manufacturing	325120	1.06%
Synthetic dye and pigment manufacturing	325130	6.15%
Other Basic Inorganic Chemical Manufacturing	325180	1.21%
Paint and coating manufacturing	325510	0.34%
Iron and steel mills and ferroalloy manufacturing	331110	6.94%
Steel product manufacturing from purchased steel	331200	0.42%
Secondary Smelting and Alloying of Aluminum	331314	1.82%
Nonferrous Metal (except Aluminum) Smelting and Refining	331410	32.44%
Copper rolling, drawing, extruding and alloying	331420	0.64%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	4.45%
Spring and wire product manufacturing	332600	2.62%
Coating, engraving, heat treating and allied activities	332800	1.01%
Other fabricated metal manufacturing	332999	0.52%
Farm machinery and equipment manufacturing	333111	0.65%
Mining and oil and gas field machinery manufacturing	333130	0.44%
Aircraft engine and engine parts manufacturing	336412	0.28%
Wired telecommunications carriers	517110	0.83%
Data processing, hosting, and related services	518200	0.39%
Internet publishing and broadcasting and Web search portals	519130	2.80%
Architectural, engineering, and related services	541300	1.82%
Scientific research and development services	541700	0.78%
Investigation and security services	561600	1.99%
Services to buildings and dwellings	561700	2.48%
Waste management and remediation services	562000	0.68%
Performing arts companies	711100	2.13%
Other amusement and recreation industries	713900	6.41%
Accommodation	721000	0.57%
Electronic and precision equipment repair and maintenance	811200	1.02%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.41%
Personal care services	812100	5.04%
Other educational services	611B00	2.82%
Grantmaking, giving, and social advocacy organizations	813A00	1.26%
Civic, social, professional, and similar organizations	813B00	0.61%
	Grand Total	**96.72%**

Table 2.8

Iron and steel mills and ferroalloy manufacturing - 331110

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Iron and steel mills and ferroalloy manufacturing	331110	11.57%
Motor vehicle metal stamping	336370	7.59%
Plate work and fabricated structural product manufacturing	332310	6.21%
Steel product manufacturing from purchased steel	331200	5.97%
Ornamental and architectural metal products manufacturing	332320	3.80%
Other Motor Vehicle Parts Manufacturing	336390	3.05%
Material handling equipment manufacturing	333920	2.93%
Custom roll forming	332114	2.85%
Coating, engraving, heat treating and allied activities	332800	2.56%
Construction machinery manufacturing	333120	2.11%
Mining and oil and gas field machinery manufacturing	333130	2.10%
Farm machinery and equipment manufacturing	333111	1.97%
Metal crown, closure, and other metal stamping (except automotive)	332119	1.83%
Turned product and screw, nut, and bolt manufacturing	332720	1.82%
All other forging, stamping, and sintering	33211A	1.72%
Oil and gas extraction	211000	1.61%
Metal can, box, and other metal container (light gauge) manufacturing	332430	1.53%
Metal tank (heavy gauge) manufacturing	332420	1.53%
Aircraft manufacturing	336411	1.43%
Motor vehicle transmission and power train parts manufacturing	336350	1.34%
Fabricated pipe and pipe fitting manufacturing	332996	1.26%
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	3363A0	1.26%
Other fabricated metal manufacturing	332999	1.25%
Machine shops	332710	1.21%
Valve and fittings other than plumbing	33291A	1.08%
Other real estate	531ORE	0.98%
Wiring device manufacturing	335930	0.82%
Railroad rolling stock manufacturing	336500	0.81%
Ferrous metal foundries	331510	0.80%
Showcase, partition, shelving, and locker manufacturing	337215	0.79%
Fluid power process machinery	33399B	0.75%
Cutlery and handtool manufacturing	332200	0.75%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	333415	0.75%
All other miscellaneous manufacturing	339990	0.65%
Light truck and utility vehicle manufacturing	336112	0.58%
Other industrial machinery manufacturing	33329A	0.57%
Other rubber product manufacturing	326290	0.54%
Office furniture and custom architectural woodwork and millwork manufacturing	33721A	0.53%
Spring and wire product manufacturing	332600	0.45%
Other general purpose machinery manufacturing	33399A	0.45%
Turbine and turbine generator set units manufacturing	333611	0.45%
Military armored vehicle, tank, and tank component manufacturing	336992	0.44%
Nonresidential maintenance and repair	230301	0.43%
Machine tool manufacturing	333517	0.42%
All other transportation equipment manufacturing	336999	0.42%
Architectural, engineering, and related services	541300	0.41%
Travel trailer and camper manufacturing	336214	0.38%
Other nonresidential structures	2332D0	0.37%
Motor vehicle gasoline engine and engine parts manufacturing	336310	0.37%
Ball and roller bearing manufacturing	332991	0.36%
Power boiler and heat exchanger manufacturing	332410	0.35%
Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing	33351B	0.35%
Industrial mold manufacturing	333511	0.35%
Ship building and repairing	336611	0.33%
Switchgear and switchboard apparatus manufacturing	335313	0.32%
Other aircraft parts and auxiliary equipment manufacturing	336413	0.32%
Power, distribution, and specialty transformer manufacturing	335311	0.32%
Pump and pumping equipment manufacturing	33391A	0.31%
Motorcycle, bicycle, and parts manufacturing	336991	0.31%
Hardware manufacturing	332500	0.30%
Nonferrous metal (except copper and aluminum) rolling, drawing, extruding and alloying	331490	0.30%
Truck trailer manufacturing	336212	0.30%
Waste management and remediation services	562000	0.28%
Sign manufacturing	339950	0.27%
Household cooking appliance manufacturing	335221	0.26%
Heating equipment (except warm air furnaces) manufacturing	333414	0.25%
	Grand Total	**90.78%**

Table 2.9

Alumina refining and primary aluminum production – 331313

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Aluminum product manufacturing from purchased aluminum	33131B	45.78%
Nonferrous metal foundries	331520	9.11%
Metal can, box, and other metal container (light gauge) manufacturing	332430	8.78%
Alumina refining and primary aluminum production	331313	4.37%
Secondary Smelting and Alloying of Aluminum	331314	4.04%
Iron and steel mills and ferroalloy manufacturing	331110	2.25%
All other forging, stamping, and sintering	33211A	1.96%
Travel trailer and camper manufacturing	336214	1.62%
Machine shops	332710	1.36%
Valve and fittings other than plumbing	33291A	1.22%
Military armored vehicle, tank, and tank component manufacturing	336992	0.93%
Other household nonupholstered furniture	33712N	0.77%
Light truck and utility vehicle manufacturing	336112	0.76%
Other Motor Vehicle Parts Manufacturing	336390	0.72%
Cutlery and handtool manufacturing	332200	0.60%
Other general purpose machinery manufacturing	33399A	0.59%
Custom roll forming	332114	0.57%
Nonresidential maintenance and repair	230301	0.55%
Steel product manufacturing from purchased steel	331200	0.53%
Motor vehicle transmission and power train parts manufacturing	336350	0.45%
Office furniture and custom architectural woodwork and millwork manufacturing	33721A	0.45%
Ammunition, arms, ordnance, and accessories manufacturing	33299A	0.42%
Federal general government (defense)	S00500	0.42%
Material handling equipment manufacturing	333920	0.42%
Internet publishing and broadcasting and Web search portals	519130	0.42%
Architectural, engineering, and related services	541300	0.40%
Ornamental and architectural metal products manufacturing	332320	0.39%
Pump and pumping equipment manufacturing	33391A	0.39%
All other miscellaneous manufacturing	339990	0.39%
Institutional furniture manufacturing	337127	0.35%
Motorcycle, bicycle, and parts manufacturing	336991	0.34%
Guided missile and space vehicle manufacturing	336414	0.33%
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	3363A0	0.30%
All other wood product manufacturing	3219A0	0.30%
Wiring device manufacturing	335930	0.29%
Air and gas compressor manufacturing	333912	0.29%
Showcase, partition, shelving, and locker manufacturing	337215	0.29%
Industrial and commercial fan and blower and air purification equipment manufacturing	333413	0.27%
All other transportation equipment manufacturing	336999	0.27%
Motor vehicle gasoline engine and engine parts manufacturing	336310	0.26%
Metal crown, closure, and other metal stamping (except automotive)	332119	0.26%
	Grand Total	**94.11%**

Table 2.10

Semiconductor and related device manufacturing - 334413

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Aircraft manufacturing	336411	7.24%
Wired telecommunications carriers	517110	6.40%
Printed circuit assembly (electronic assembly) manufacturing	334418	4.01%
Wireless telecommunications carriers (except satellite)	517210	3.93%
Professional and commercial equipment and supplies	423400	3.73%
Light truck and utility vehicle manufacturing	336112	3.46%
Motor vehicle electrical and electronic equipment manufacturing	336320	3.00%
Electronic and precision equipment repair and maintenance	811200	2.95%
Semiconductor and related device manufacturing	334413	2.38%
Electronic computer manufacturing	334111	2.18%
Other nondurable goods merchant wholesalers	424A00	2.05%
All other retail	4B0000	1.82%
Motor vehicle and motor vehicle parts and supplies	423100	1.82%
Soft drink and ice manufacturing	312110	1.74%
Other durable goods merchant wholesalers	423A00	1.53%
Printing	323110	1.41%
Mining and oil and gas field machinery manufacturing	333130	1.22%
Household appliances and electrical and electronic goods	423600	1.20%
Computer systems design services	541512	1.15%
Computer storage device manufacturing	334112	1.04%
Ornamental and architectural metal products manufacturing	332320	1.02%
Custom computer programming services	541511	1.01%
Satellite, telecommunications resellers, and all other telecommunications	517A00	0.92%
Machinery, equipment, and supplies	423800	0.92%
Aluminum product manufacturing from purchased aluminum	33131B	0.89%
Toilet preparation manufacturing	325620	0.89%
Guided missile and space vehicle manufacturing	336414	0.81%
Plastics packaging materials and unlaminated film and sheet manufacturing	326110	0.78%
Automobile manufacturing	336111	0.76%
Other electronic component manufacturing	33441A	0.75%
All other miscellaneous electrical equipment and component manufacturing	335999	0.74%
Automotive repair and maintenance	811100	0.72%
Other basic organic chemical manufacturing	325190	0.71%
Breweries	312120	0.68%
Turned product and screw, nut, and bolt manufacturing	332720	0.64%
Turbine and turbine generator set units manufacturing	333611	0.59%
Plastics material and resin manufacturing	325211	0.59%
Material handling equipment manufacturing	333920	0.58%
Wineries	312130	0.56%
Machine shops	332710	0.56%
Electromedical and electrotherapeutic apparatus manufacturing	334510	0.52%
Search, detection, and navigation instruments manufacturing	334511	0.51%
All other chemical product and preparation manufacturing	3259A0	0.49%
Motor vehicle gasoline engine and engine parts manufacturing	336310	0.49%
Broadcast and wireless communications equipment	334220	0.49%
Sign manufacturing	339950	0.48%
Valve and fittings other than plumbing	33291A	0.48%
Nonstore retailers	454000	0.47%
Fluid power process machinery	33399B	0.45%
Other commercial and service industry machinery manufacturing	333318	0.43%
Pump and pumping equipment manufacturing	33391A	0.43%
Millwork	321910	0.40%
Soap and cleaning compound manufacturing	325610	0.40%
Iron and steel mills and ferroalloy manufacturing	331110	0.39%
All other miscellaneous manufacturing	339990	0.38%
Telephone apparatus manufacturing	334210	0.37%
Farm machinery and equipment manufacturing	333111	0.36%
Motor vehicle seating and interior trim manufacturing	336360	0.36%
Motor vehicle steering, suspension component (except spring), and brake systems manufacturing	3363A0	0.35%
Other engine equipment manufacturing	333618	0.35%
Steel product manufacturing from purchased steel	331200	0.35%
Glass and glass product manufacturing	327200	0.34%
Adhesive manufacturing	325520	0.34%
Office furniture and custom architectural woodwork and millwork manufacturing	33721A	0.34%
Software publishers	511200	0.33%
Construction machinery manufacturing	333120	0.33%
Other computer related services, including facilities management	54151A	0.33%
Other rubber product manufacturing	326290	0.32%
Coating, engraving, heat treating and allied activities	332800	0.31%
Pesticide and other agricultural chemical manufacturing	325320	0.30%
Wood kitchen cabinet and countertop manufacturing	337110	0.29%
Ready-mix concrete manufacturing	327320	0.29%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	333415	0.29%
Wiring device manufacturing	335930	0.28%
Lighting fixture manufacturing	335120	0.28%
Spring and wire product manufacturing	332600	0.28%
Surgical and medical instrument manufacturing	339112	0.27%
Air and gas compressor manufacturing	333912	0.27%
Paint and coating manufacturing	325510	0.27%
Health and personal care stores	446000	0.27%
Photographic and photocopying equipment manufacturing	333316	0.26%
Metal can, box, and other metal container (light gauge) manufacturing	332430	0.26%
Other fabricated metal manufacturing	332999	0.26%
Computer terminals and other computer peripheral equipment manufacturing	334118	0.25%
	Grand Total	**85.09%**

Table 2.11

Electricity and signal testing instruments manufacturing - 334515

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Electricity and signal testing instruments manufacturing	334515	28.45%
Analytical laboratory instrument manufacturing	334516	15.44%
Search, detection, and navigation instruments manufacturing	334511	13.69%
Watch, clock, and other measuring and controlling device manufacturing	33451A	10.91%
Industrial process variable instruments manufacturing	334513	6.56%
Other electronic component manufacturing	33441A	5.16%
Machine tool manufacturing	333517	3.78%
Totalizing fluid meter and counting device manufacturing	334514	3.43%
All other miscellaneous electrical equipment and component manufacturing	335999	3.37%
Semiconductor and related device manufacturing	334413	2.43%
Automatic environmental control manufacturing	334512	1.68%
Broadcast and wireless communications equipment	334220	1.24%
Optical instrument and lens manufacturing	333314	1.24%
Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing	33351B	0.79%
Other communications equipment manufacturing	334290	0.61%
Telephone apparatus manufacturing	334210	0.44%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.40%
Computer terminals and other computer peripheral equipment manufacturing	334118	0.37%
	Grand Total	**99.98%**

Table 2.12

Power, distribution, and specialty transformer manufacturing – 335311

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Lighting fixture manufacturing	335120	19.60%
Ammunition, arms, ordnance, and accessories manufacturing	33299A	12.89%
Millwork	321910	6.10%
Military armored vehicle, tank, and tank component manufacturing	336992	6.01%
Sign manufacturing	339950	5.23%
Other educational services	611B00	5.14%
Irradiation apparatus manufacturing	334517	4.57%
Federal general government (nondefense)	S00600	4.27%
Packaging machinery manufacturing	333993	4.01%
Motor and generator manufacturing	335312	3.27%
Industrial mold manufacturing	333511	2.92%
All other miscellaneous professional, scientific, and technical services	5419A0	2.92%
Facilities support services	561200	2.57%
Power, distribution, and specialty transformer manufacturing	335311	2.31%
Services to buildings and dwellings	561700	2.05%
Paint and coating manufacturing	325510	1.61%
Material handling equipment manufacturing	333920	1.39%
Office and commercial structures	2332A0	1.09%
Health care structures	233210	0.74%
Educational and vocational structures	233262	0.70%
Grocery and related product wholesalers	424400	0.61%
Other industrial machinery manufacturing	33329A	0.57%
Electromedical and electrotherapeutic apparatus manufacturing	334510	0.48%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	333415	0.44%
Accounting, tax preparation, bookkeeping, and payroll services	541200	0.44%
Management consulting services	541610	0.39%
Other general purpose machinery manufacturing	33399A	0.39%
Pump and pumping equipment manufacturing	33391A	0.35%
Office administrative services	561100	0.30%
Business support services	561400	0.26%
Professional and commercial equipment and supplies	423400	0.26%
	Grand Total	**93.86%**

Table 2.13

Motor and generator manufacturing - 335312

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Air conditioning, refrigeration, and warm air heating equipment manufacturing	333415	9.03%
Pump and pumping equipment manufacturing	33391A	7.39%
Motor and generator manufacturing	335312	5.13%
Material handling equipment manufacturing	333920	4.88%
Air and gas compressor manufacturing	333912	4.38%
Turbine and turbine generator set units manufacturing	333611	3.98%
Automotive repair and maintenance	811100	3.69%
Household laundry equipment manufacturing	335224	3.41%
Machine shops	332710	2.91%
Surgical appliance and supplies manufacturing	339113	2.83%
Other state and local government enterprises	S00203	2.61%
Small electrical appliance manufacturing	335210	2.58%
Other commercial and service industry machinery manufacturing	333318	2.37%
Nonresidential maintenance and repair	230301	2.24%
Other fabricated metal manufacturing	332999	1.90%
Power-driven handtool manufacturing	333991	1.68%
Architectural, engineering, and related services	541300	1.64%
Commercial and industrial machinery and equipment repair and maintenance	811300	1.54%
Farm machinery and equipment manufacturing	333111	1.52%
Other major household appliance manufacturing	335228	1.47%
Fluid power process machinery	33399B	1.47%
Industrial and commercial fan and blower and air purification equipment manufacturing	333413	1.46%
Machine tool manufacturing	333517	1.43%
Other industrial machinery manufacturing	33329A	1.39%
Surgical and medical instrument manufacturing	339112	1.23%
State and local government educational services	GSLGE	1.14%
Construction machinery manufacturing	333120	1.12%
Other state and local government enterprises	S00203	1.11%
Household refrigerator and home freezer manufacturing	335222	1.07%
Valve and fittings other than plumbing	33291A	1.03%
Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing	33351B	0.99%
Packaging machinery manufacturing	333993	0.96%
Other general purpose machinery manufacturing	33399A	0.91%
Other nonresidential structures	2332D0	0.81%
Residential maintenance and repair	230302	0.75%
Hardware manufacturing	332500	0.73%
Household cooking appliance manufacturing	335221	0.70%
Mining and oil and gas field machinery manufacturing	333130	0.69%
Other engine equipment manufacturing	333618	0.64%
Single-family residential structures	233411	0.60%
Aircraft manufacturing	336411	0.59%
Warehousing and storage	493000	0.59%
Other residential structures	2334A0	0.56%
Wireless telecommunications carriers (except satellite)	517210	0.52%
Semiconductor machinery manufacturing	333242	0.49%
Other Motor Vehicle Parts Manufacturing	336390	0.45%
Federal general government (nondefense)	S00600	0.43%
Scientific research and development services	541700	0.43%
Search, detection, and navigation instruments manufacturing	334511	0.42%
Speed changer, industrial high-speed drive, and gear manufacturing	333612	0.42%
All other miscellaneous electrical equipment and component manufacturing	335999	0.39%
Federal general government (defense)	S00500	0.38%
Power and communication structures	233240	0.36%
Educational and vocational structures	233262	0.32%
Electronic and precision equipment repair and maintenance	811200	0.31%
Semiconductor and related device manufacturing	334413	0.29%
Oil and gas extraction	211000	0.28%
Office and commercial structures	2332A0	0.27%
Other electronic component manufacturing	33441A	0.26%
Guided missile and space vehicle manufacturing	336414	0.26%
	Grand Total	**95.44%**

Table 2.14

Switchgear and switchboard apparatus manufacturing - 335313

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
All other miscellaneous professional, scientific, and technical services	5419A0	7.87%
Nonresidential maintenance and repair	230301	7.87%
Power and communication structures	233240	7.84%
Wireless telecommunications carriers (except satellite)	517210	7.57%
Other residential structures	2334A0	7.17%
Facilities support services	561200	6.93%
Federal general government (defense)	S00500	6.80%
Other nonresidential structures	2332D0	4.45%
Architectural, engineering, and related services	541300	3.53%
Switchgear and switchboard apparatus manufacturing	335313	3.52%
Single-family residential structures	233411	3.48%
Wired telecommunications carriers	517110	3.15%
Other plastics product manufacturing	326190	2.71%
Other engine equipment manufacturing	333618	2.61%
Relay and industrial control manufacturing	335314	2.23%
Office and commercial structures	2332A0	1.75%
Railroad rolling stock manufacturing	336500	1.63%
Data processing, hosting, and related services	518200	1.43%
Full-service restaurants	722110	1.27%
Educational and vocational structures	233262	1.21%
Accounting, tax preparation, bookkeeping, and payroll services	541200	1.21%
Transportation structures and highways and streets	2332C0	1.11%
Federal general government (nondefense)	S00600	0.86%
Office administrative services	561100	0.80%
Commercial and industrial machinery and equipment rental and leasing	532400	0.79%
Residential maintenance and repair	230302	0.74%
Business support services	561400	0.72%
Health care structures	233210	0.69%
Other state and local government enterprises	S00203	0.62%
Other Motor Vehicle Parts Manufacturing	336390	0.62%
Satellite, telecommunications resellers, and all other telecommunications	517A00	0.62%
Manufacturing structures	233230	0.54%
Employment services	561300	0.52%
Computer terminals and other computer peripheral equipment manufacturing	334118	0.50%
Scientific research and development services	541700	0.46%
Investigation and security services	561600	0.44%
Civic, social, professional, and similar organizations	813B00	0.44%
Limited-service restaurants	722211	0.40%
Commercial and industrial machinery and equipment repair and maintenance	811300	0.31%
	Grand Total	**97.39%**

Table 2.15

Storage battery manufacturing - 335911

ndustry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
.ight truck and utility vehicle manufacturing	336112	13.93%
3rain farming	1111B0	8.39%
Waste management and remediation services	562000	7.02%
:onstruction machinery manufacturing	333120	5.31%
;arm machinery and equipment manufacturing	333111	4.88%
)airy cattle and milk production	112120	4.53%
\utomotive repair and maintenance	811100	3.40%
\rchitectural, engineering, and related services	541300	3.37%
)ilseed farming	1111A0	3.26%
)ther state and local government enterprises	S00203	3.12%
Material handling equipment manufacturing	333920	2.92%
Heavy duty truck manufacturing	336120	2.80%
:hild day care services	624400	2.55%
)ther support activities for mining	21311A	2.42%
:omputer systems design services	541512	2.08%
)ther crop farming	111900	2.05%
\utomobile manufacturing	336111	2.01%
)rilling oil and gas wells	213111	1.91%
Motor vehicle and motor vehicle parts and supplies	423100	1.82%
'ower-driven handtool manufacturing	333991	1.67%
)ther real estate	531ORE	1.32%
'ruit and tree nut farming	111300	1.02%
;cientific research and development services	541700	0.98%
;tate and local government other services	GSLGO	0.84%
Management of companies and enterprises	550000	0.80%
\nimal production, except cattle and poultry and eggs	112A00	0.78%
3reenhouse, nursery, and floriculture production	111400	0.71%
/egetable and melon farming	111200	0.64%
ndividual and family services	624100	0.53%
;tate and local government educational services	GSLGE	0.52%
Nonstore retailers	454000	0.52%
;ervices to buildings and dwellings	561700	0.52%
Nonresidential maintenance and repair	230301	0.50%
\sphalt paving mixture and block manufacturing	324121	0.48%
Computer terminals and other computer peripheral equipment manufacturing	334118	0.46%
\ll other wood product manufacturing	3219A0	0.46%
\utomotive equipment rental and leasing	532100	0.46%
)ther financial investment activities	523900	0.46%
'ishing, hunting and trapping	114000	0.45%
Building material and garden equipment and supplies dealers	444000	0.45%
;tate and local government hospitals and health services	GSLGH	0.43%
'ood and beverage stores	445000	0.39%
3asoline stations	447000	0.37%
Hospitals	622000	0.34%
Motor vehicle and parts dealers	441000	0.30%
Residential maintenance and repair	230302	0.30%
)ther residential structures	2334A0	0.29%
Monetary authorities and depository credit intermediation	52A000	0.29%
Community food, housing, and other relief services, including rehabilitation services	624A00	0.27%
;torage battery manufacturing	335911	0.27%
Business support services	561400	0.27%
'oultry and egg production	112300	0.27%
Nondepository credit intermediation and related activities	522A00	0.27%
	Grand Total	**96.38%**

Table 2.16

Machinery, equipment, and supplies- 423800

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Other industrial machinery manufacturing	33329A	8.51%
Construction machinery manufacturing	333120	7.49%
Material handling equipment manufacturing	333920	7.38%
Mining and oil and gas field machinery manufacturing	333130	6.77%
Pump and pumping equipment manufacturing	33391A	4.98%
Valve and fittings other than plumbing	33291A	4.33%
Fluid power process machinery	33399B	3.67%
Other general purpose machinery manufacturing	33399A	3.64%
Other nondurable goods merchant wholesalers	424A00	2.73%
Professional and commercial equipment and supplies	423400	2.62%
Other durable goods merchant wholesalers	423A00	2.51%
Nonstore retailers	454000	2.22%
Farm machinery and equipment manufacturing	333111	1.96%
Machine tool manufacturing	333517	1.75%
Machinery, equipment, and supplies	423800	1.75%
Household appliances and electrical and electronic goods	423600	1.71%
Commercial and industrial machinery and equipment rental and leasing	532400	1.56%
Other engine equipment manufacturing	333618	1.56%
Air transportation	481000	1.53%
Truck transportation	484000	1.49%
Abrasive product manufacturing	327910	1.38%
Air and gas compressor manufacturing	333912	1.31%
Industrial mold manufacturing	333511	1.16%
Turbine and turbine generator set units manufacturing	333611	1.05%
Motor vehicle and motor vehicle parts and supplies	423100	1.02%
Ball and roller bearing manufacturing	332991	0.98%
Drugs and druggists' sundries	424200	0.98%
Cutting and machine tool accessory, rolling mill, and other metalworking machinery manufacturing	33351B	0.98%
Iron and steel mills and ferroalloy manufacturing	331110	0.95%
Industrial and commercial fan and blower and air purification equipment manufacturing	333413	0.95%
Heavy duty truck manufacturing	336120	0.80%
Special tool, die, jig, and fixture manufacturing	333514	0.80%
Soap and cleaning compound manufacturing	325610	0.76%
Mechanical power transmission equipment manufacturing	333613	0.69%
Packaging machinery manufacturing	333993	0.65%
Other textile product mills	314900	0.65%
Other plastics product manufacturing	326190	0.65%
Grocery and related product wholesalers	424400	0.65%
Other fabricated metal manufacturing	332999	0.62%
Petroleum refineries	324110	0.62%
Motor vehicle and parts dealers	441000	0.62%
Other basic organic chemical manufacturing	325190	0.55%
Grain farming	1111B0	0.55%
Other rubber product manufacturing	326290	0.44%
Electric power generation, transmission, and distribution	221100	0.44%
All other retail	4B0000	0.40%
Paperboard container manufacturing	322210	0.40%
Limited-service restaurants	722211	0.36%
Speed changer, industrial high-speed drive, and gear manufacturing	333612	0.36%
Automobile manufacturing	336111	0.33%
Plastics material and resin manufacturing	325211	0.29%
Printing ink manufacturing	325910	0.29%
Semiconductor machinery manufacturing	333242	0.29%
Hardware manufacturing	332500	0.25%
Industrial process furnace and oven manufacturing	333994	0.25%
Services to buildings and dwellings	561700	0.25%
	Grand Total	**93.93%**

Table 2.17

Cement manufacturing – 327310

Industry Name	NAICS Code	Sale to Sector/Total Sale of Intermediate Inputs
Electric power generation, transmission, and distribution	221100	18.09%
Coal mining	212100	12.07%
Ground or treated mineral and earth manufacturing	327992	7.12%
Petroleum refineries	324110	6.80%
Natural gas distribution	221200	6.40%
Stone mining and quarrying	212310	6.31%
Cement manufacturing	327310	3.91%
Management of companies and enterprises	550000	2.26%
Architectural, engineering, and related services	541300	2.03%
Services to buildings and dwellings	561700	1.74%
Employment services	561300	1.68%
Other nonmetallic mineral mining and quarrying	2123A0	1.51%
Other durable goods merchant wholesalers	423A00	1.22%
Nonresidential maintenance and repair	230301	1.13%
Clay product and refractory manufacturing	327100	1.10%
Commercial and industrial machinery and equipment repair and maintenance	811300	1.04%
Other support services	561900	1.04%
Business support services	561400	1.04%
Coating, engraving, heat treating and allied activities	332800	1.04%
Investigation and security services	561600	0.98%
Machine shops	332710	0.90%
All other miscellaneous professional, scientific, and technical services	5419A0	0.78%
Glass and glass product manufacturing	327200	0.75%
Lime and gypsum product manufacturing	327400	0.69%
Commercial and industrial machinery and equipment rental and leasing	532400	0.67%
Automotive equipment rental and leasing	532100	0.67%
Automotive repair and maintenance	811100	0.61%
Noncomparable imports	S00300	0.58%
Other Motor Vehicle Parts Manufacturing	336390	0.58%
Mineral wool manufacturing	327993	0.58%
All other wood product manufacturing	3219A0	0.58%
Facilities support services	561200	0.52%
Monetary authorities and depository credit intermediation	52A000	0.52%
Insurance agencies, brokerages, and related activities	524200	0.52%
Printed circuit assembly (electronic assembly) manufacturing	334418	0.49%
Insurance carriers, except direct life	5241XX	0.46%
Lessors of nonfinancial intangible assets	533000	0.46%
Specialized design services	541400	0.46%
Other petroleum and coal products manufacturing	324190	0.43%
Paperboard container manufacturing	322210	0.41%
Other fabricated metal manufacturing	332999	0.41%
Nondepository credit intermediation and related activities	522A00	0.38%
Semiconductor and related device manufacturing	334413	0.35%
Data processing, hosting, and related services	518200	0.35%
Legal services	541100	0.32%
Waste management and remediation services	562000	0.32%
Other basic organic chemical manufacturing	325190	0.32%
Turned product and screw, nut, and bolt manufacturing	332720	0.32%
Other real estate	531ORE	0.29%
Other Basic Inorganic Chemical Manufacturing	325180	0.29%
Paperboard mills	322130	0.26%
Plastics material and resin manufacturing	325211	0.26%
Accounting, tax preparation, bookkeeping, and payroll services	541200	0.26%
Computer systems design services	541512	0.26%
Air transportation	481000	0.26%
Scenic and sightseeing transportation and support activities for transportation	48A000	0.26%