



ECONOMIC IMPACT OF DOWNSTREAM GAS DEVELOPMENT IN WEST VIRGINIA

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Executive Summary

Natural gas production in West Virginia has grown rapidly over the last decade as hydraulic fracturing has opened up new gas reserves in the shale formations underlying the state. Despite the rapid growth of natural gas production in the state over the last decade, West Virginia has been slow to see growth in downstream industries—those that rely on natural gas as inputs to their production processes.

Downstream gas development has the potential to provide significant economic value if West Virginia can capture this development within its borders. In this report, we explore the potential impact of downstream natural gas industries on the West Virginia economy. To estimate the economic impact of downstream natural gas development, we take a two-pronged approach. First, we identify those industries nationally that require large amounts of natural gas in their production process. We then choose three of these industries that have the greatest potential for development within West Virginia. Second, we estimate the economic impact of a typical establishment in each of these industries based on national average employment and wages. From these estimates, we derive an overall potential economic impact.

Quantifying the economic potential of an industry with limited presence in the state can be difficult. There is little publicly available data detailing operating costs and employment in these industries, and it is hard to predict how much of the potential economic activity will locate within West Virginia's borders. To assess the potential economic impact we have made several simplifying assumptions, which are detailed in the report.

Based on our analysis, we identify the top three industries to focus on for this analysis as:

- Plastics Material and Resin Manufacturing
- Petroleum Refineries
- Petrochemical Manufacturing

We estimate the total potential economic impact from the top three natural gas downstream industries to be between \$5.5 and \$8.0 billion (see Table 7). We estimate the potential direct employment to be between 1,500 and 2,200 jobs, with an additional 5,000 to 7,500 to come in secondary industries, for a total employment impact of approximately 6,600 to 9,600 jobs.

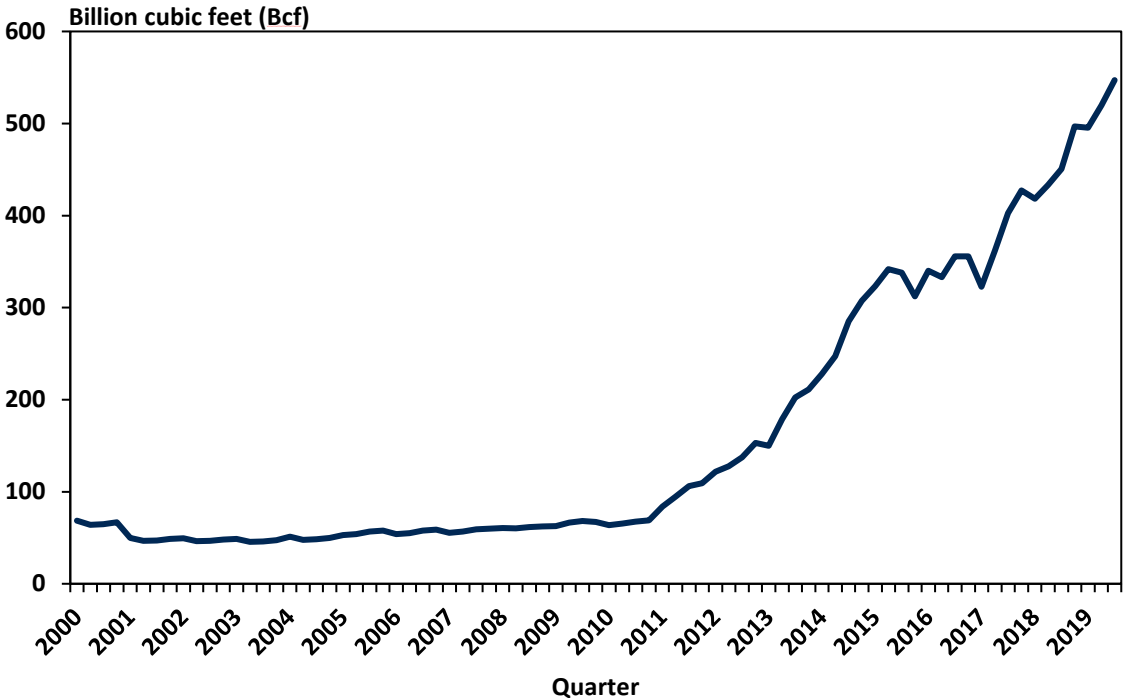
Table 1: Annual Potential Economic Impact from Natural Gas Downstream Industries

Type of Impact	Direct	Indirect and Induced	Total
Output (\$, billions)	4.6–6.7	0.9–1.3	5.5–8.0
Employment (jobs)	1,500–2,200	5,079–7,449	6,579–9,649
Employee Compensation (\$, millions)	210–309	281–411	491–720
Local Property Tax Revenue (\$, millions)	21–31	12–17	33–48
All Other State Tax Revenue (\$, millions)	14–20	17–26	31–46

1 Introduction

Natural gas production in West Virginia has grown rapidly over the last decade as hydraulic fracturing has opened up new gas reserves in the shale formations underlying the state. As shown in Figure 1, natural gas production has grown from approximately 265 billion cubic feet (Bcf) in 2010 to more than 1.8 trillion cubic feet (Tcf) in 2018, a gain of nearly 600 percent. Production growth continued to be strong through 2019, as production was up about 20 percent over the same period the previous year.

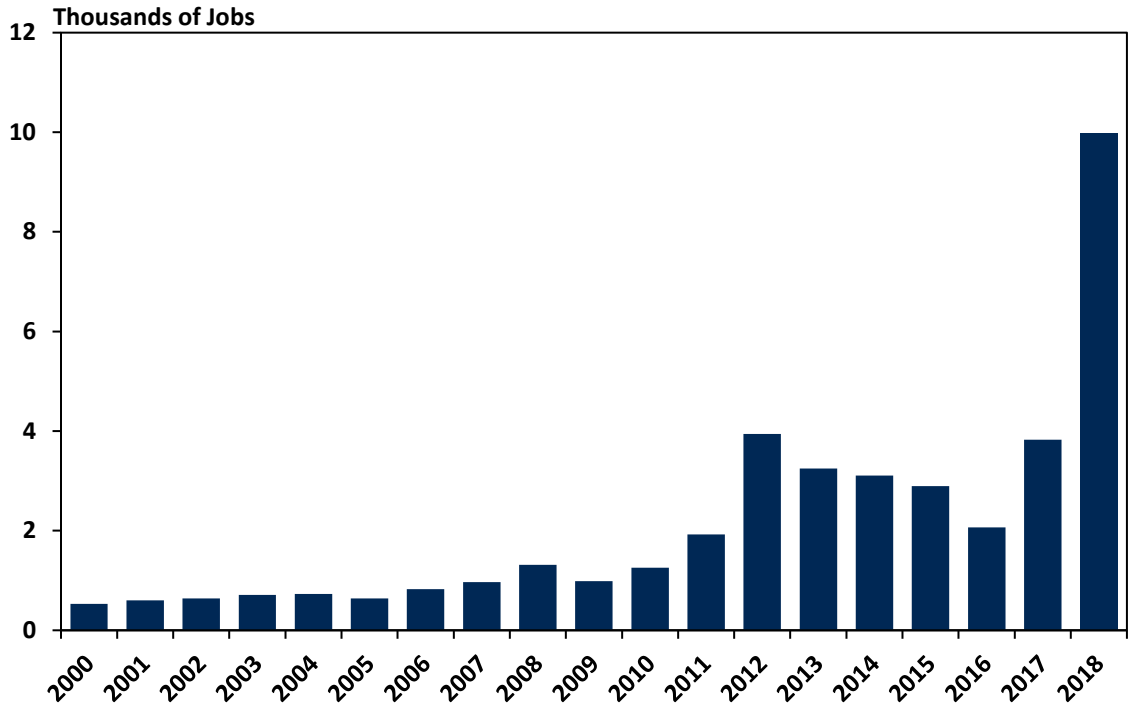
Figure 1: West Virginia Natural Gas Production



Source: US Energy Information Administration

Despite the rapid growth of natural gas production in the state over the last decade, West Virginia has been slow to see growth in downstream manufacturing industries—those that rely on natural gas as inputs to their production processes. During this same period, construction of an ethane cracker plant is underway in Pennsylvania and a second plant is likely to be built in Ohio. These states also have more than 11 gigawatts of new baseload natural gas electric generating capacity currently planned. In West Virginia, much of the natural gas-related growth has been in midstream industries, primarily pipeline transportation. As shown in Figure 2, employment in pipeline construction increased nearly five-fold in the last two years, from 2,068 jobs in 2016 to 9,976 jobs in 2018. However, this construction is largely due to large interstate pipeline projects that have the goal of moving gas outside the state for consumption rather than for use in manufacturing in-state.

Figure 2: West Virginia Pipeline Construction Employment



Source: US Bureau of Labor Statistics

Downstream gas development has the potential to provide significant economic value if West Virginia can capture this development within its borders. In this report, we explore the potential impact of downstream natural gas industries on the West Virginia economy. To estimate the economic impact of downstream natural gas development, we take a two-pronged approach. First, we identify those manufacturing industries nationally that require large amounts of natural gas in their production process. We then choose three of these industries that have the greatest potential for development within West Virginia. Second, we estimate the economic impact of a typical establishment in each of these industries based on national average employment and wages. From these estimates, we derive an overall potential economic impact.

2 Identifying potential natural gas downstream industries

In order to understand the potential market for West Virginia-produced natural gas, we begin our analysis by identifying the largest consumers of natural gas nationally. The largest purchasers tend to be those industries with the greatest amount of square footage that require heating, such as households, government, schools, and hospitals. Natural gas is also used extensively for electric power generation. However, since this analysis is interested in those sectors that use natural gas as a feedstock into their production process, we have limited the industries considered only to those in the manufacturing sector.

In Table 2, we list all of the industries that purchased more than \$250 million of natural gas either directly from producers or from distributors in 2012, the latest year available. These data come from in the US Bureau of Economic Analysis Input-Output Accounts, which are derived from the US Census Bureau's Economic Census. The I-O Accounts provide detailed data of sales between industries in the US economy and is the standard dataset for determining the economic impact of changes in the national economy.

Table 2: Top US Natural Gas Consuming Industries

Industry	Purchases (\$, millions)
Petroleum refineries	540,414
Petrochemical manufacturing	4,986
Other petroleum and coal products manufacturing	2,971
Other basic organic chemical manufacturing	2,490
Fertilizer manufacturing	1,681
Other Basic Inorganic Chemical Manufacturing	705
Iron and steel mills and ferroalloy manufacturing	639
Paper mills	626
Paperboard mills	596
Plastics material and resin manufacturing	360
Glass and glass product manufacturing	253

Source: US Bureau of Economic Analysis

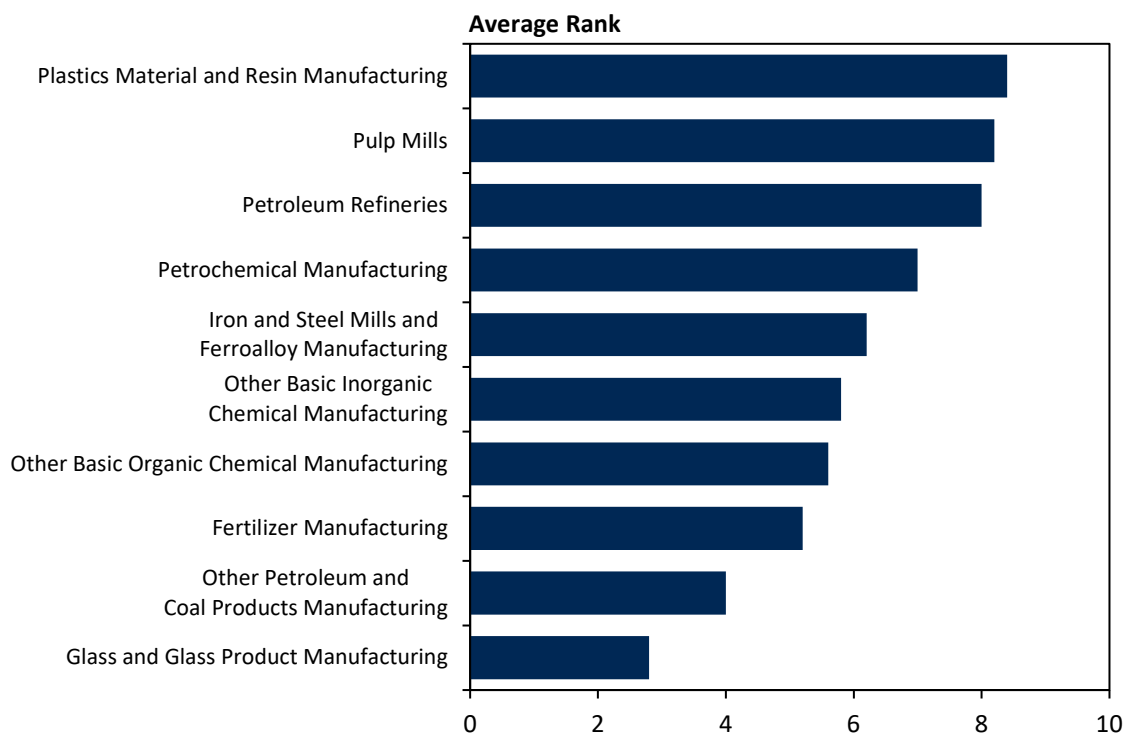
The largest consumer of natural gas by a large margin is the petroleum refineries industry, which purchases more than \$540 billion of natural gas each year. This industry encompasses a range of businesses that refine raw natural gas and natural gas liquids into gasoline, hydrocarbons, and other petroleum products that are purchased, in turn, by nearly every other industry in the economy. The industry has a wide variation in terms of firm size, including multi-billion dollar plants—such as the Shell ethane cracker plant in Pennsylvania, for example—and small local fractionation operations. The

remaining industries are significantly smaller and all primarily use natural gas in their production processes either as a chemical feedstock or through burning the gas for its heat content.

To narrow down this list of industries, we attempted to identify those industries that West Virginia may be able to attract and that fit with the state’s existing industrial composition. We apply five criteria to determine industries that already have a sizable presence in the state, and where West Virginia has a reasonable competitive advantage compared to neighboring states. We ranked the 11 industries above according to the following criteria:

- Location quotient¹
- Location quotient growth
- Shift-share analysis²
- Overall US employment growth
- Average wages

Figure 3: Industry Rankings



Source: Author Calculations

¹ LQ is a measure of how concentrated employment is in a region compared to the national average.

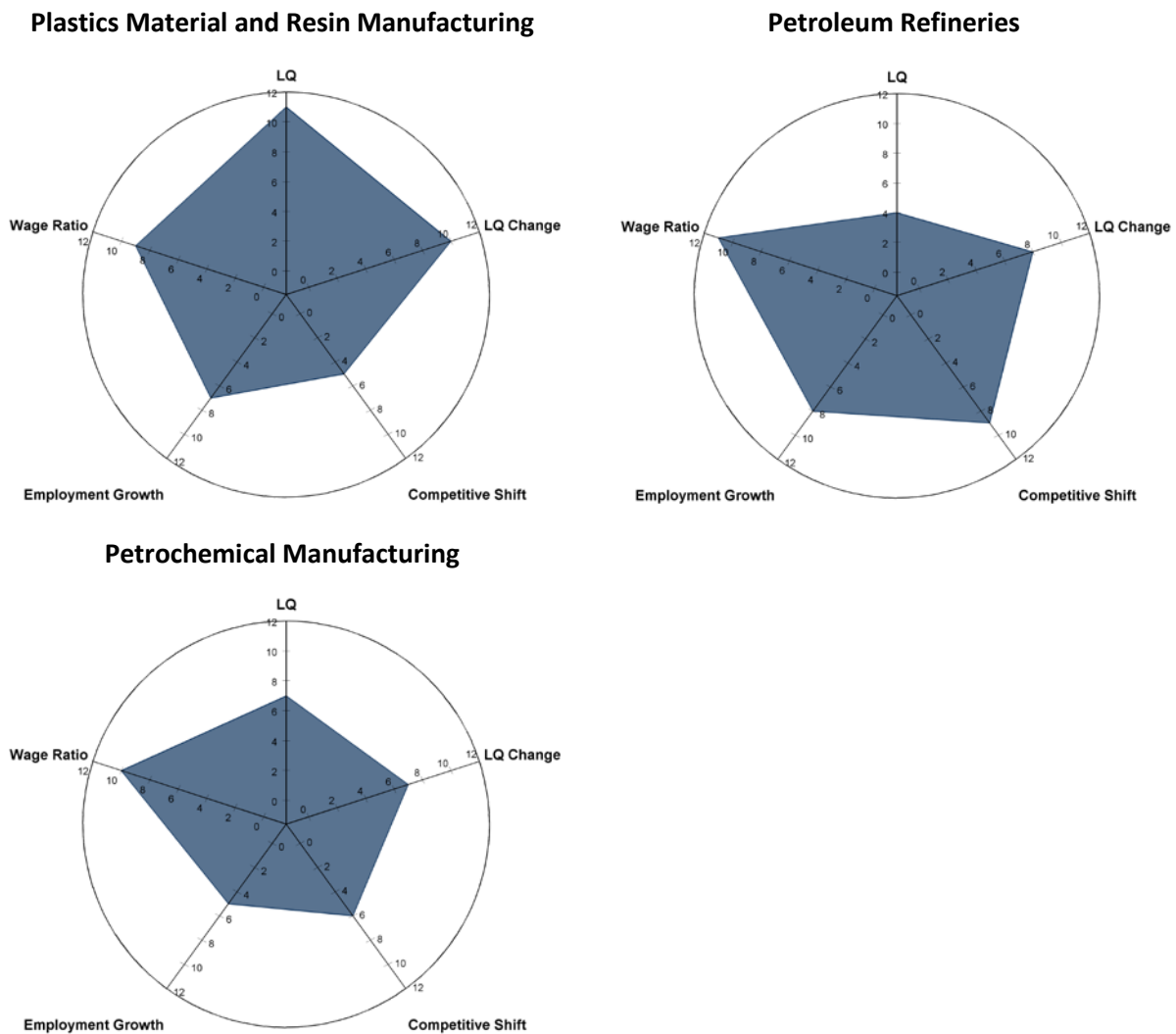
² Shift-share measures the competitive advantage of an area.

We then limited our analysis to those industries with a current West Virginia employment above 250 workers. Following these criteria, we identify the top three industries to focus on for this analysis:

- Plastics Material and Resin Manufacturing
- Petroleum Refineries
- Petrochemical Manufacturing

In Figure 4, we summarize the industry characteristics for the three industries chosen in the rankings. All of these industries have a sizable employment base in West Virginia and high wages. As shown by the LQ, the Petroleum Refineries industry is less clustered in the state currently, but has been growing in importance, as seen by the change in LQ. Petrochemical Manufacturing is lower ranked in employment growth, as this industry has seen employment declines nationally since 2007.

Figure 4: Industry Target Rankings



3 Industry Profiles

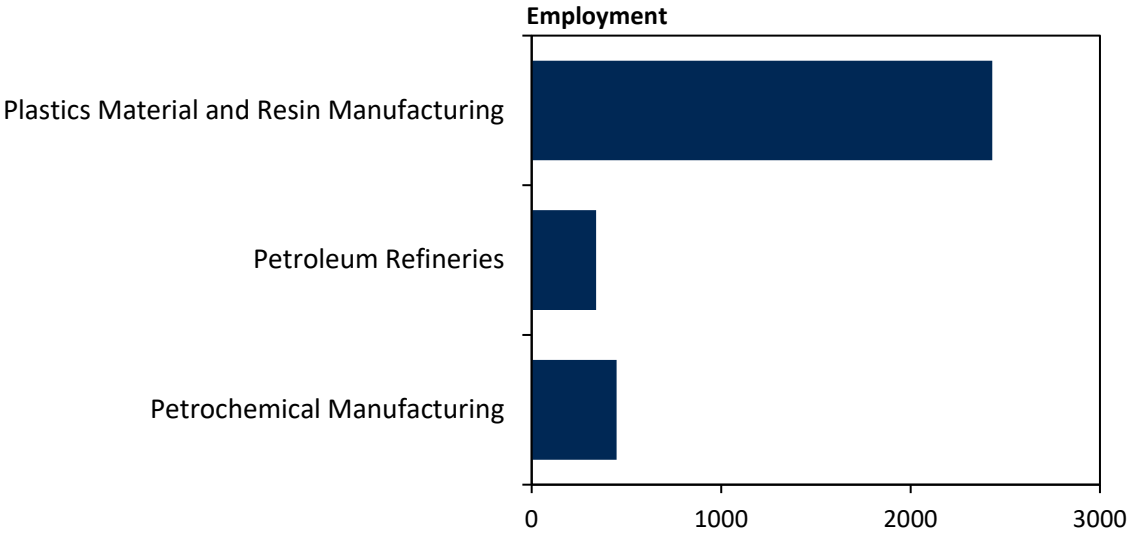
In this section, we provide a brief profile of the three industries that were identified in the previous section as having the highest growth potential within West Virginia. For each industry, we examine employment, wages, and location quotient, which is a measure of industry concentration.

Of the three industries, Plastics Material and Resin Manufacturing has the largest employment presence in the state (see Figure 5). More than 2,400 people were employed in the industry on average in 2018. The Petroleum Refineries industry employs about 340 people, and Petrochemical Manufacturing employs about 450 people.

While all three industries pay well above the average West Virginia wage of \$43,000, both the Petrochemical Manufacturing and Plastics Material and Resin Manufacturing industries pay higher than \$100,000 in average wages (see Figure 6). Workers in the Petroleum Refineries industry earn approximately \$84,000 annually.

Both the Plastics Material and Resin Manufacturing industry and Petrochemical Manufacturing industry are highly concentrated in West Virginia. The Plastics Material and Resin Manufacturing industry has a location quotient (LQ) above 9 (see Figure 7), indicating that the industry’s share of total employment in West Virginia is nine times that of the share nationally. Petrochemical Manufacturing has an LQ greater than four. The Petroleum Refineries industry is not as highly concentrated, with an LQ of 1, indicating that the level of employment in West Virginia is similar to the national average.

Figure 5: West Virginia Employment



Source: US Bureau of Labor Statistics

Figure 6: West Virginia Average Wages

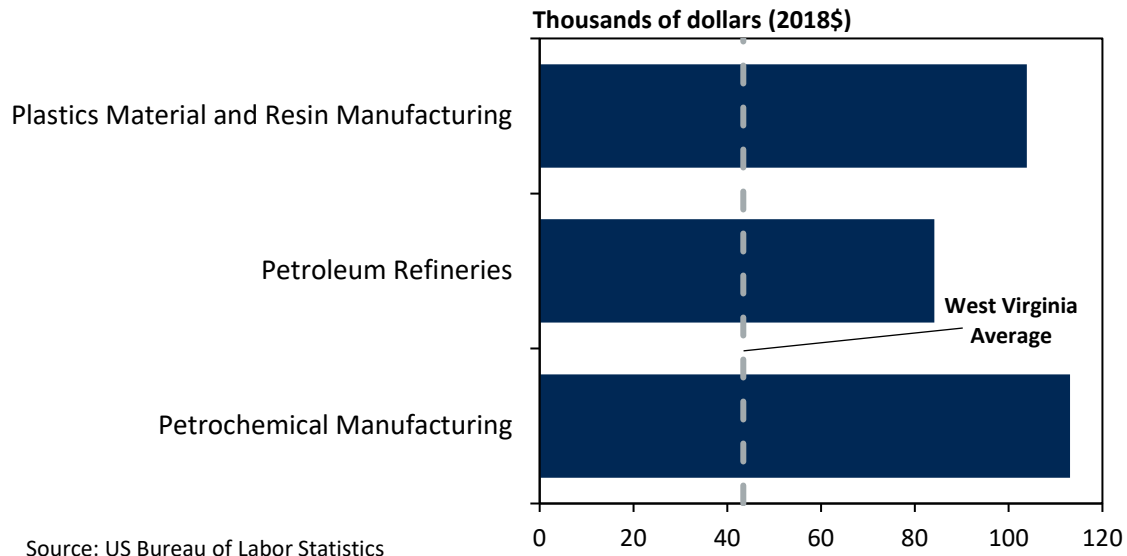
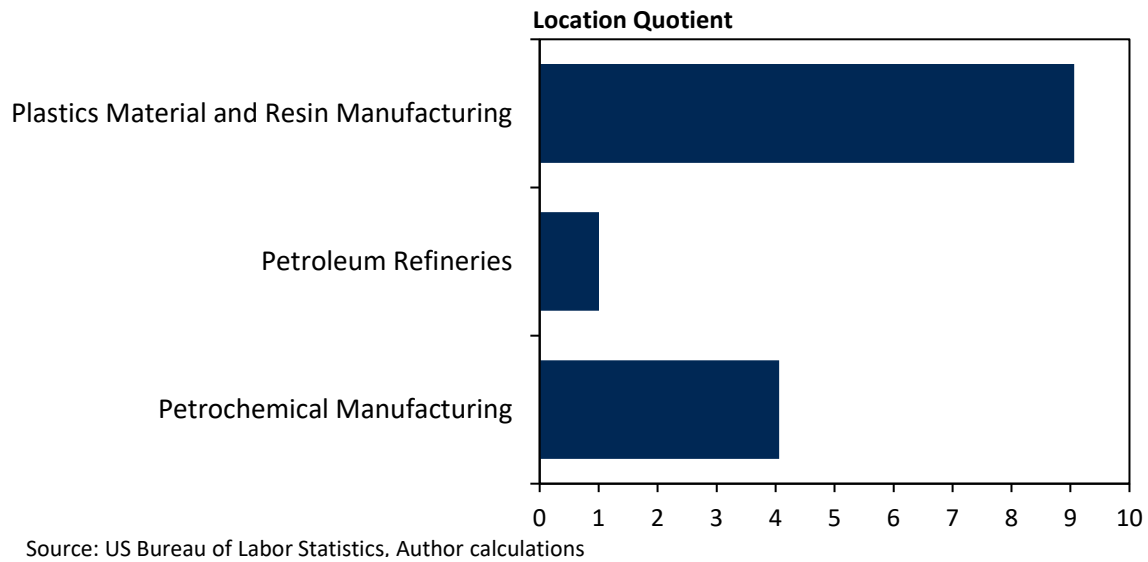


Figure 7: West Virginia Location Quotient



4 Economic Impacts

Estimating the economic impact of an industry that is not well-established in West Virginia is a difficult task. There is little publicly available data detailing the operating expenditures and employment levels of large manufacturing facilities. Also, it is difficult to predict the degree to which suppliers will move to the state to service the primary industries we have identified here.

Given these difficulties, we have made several assumptions regarding the impacts of the three industries under consideration. First, we assume that the manufacturing plants that locate in West Virginia will be similar to the average employment size for manufacturing plants nationally. Second, we assume that the level of output per worker, also known as worker productivity, will be equal to the national average. Lastly, we assume that commuting patterns will be similar to the state average, thus the number of workers who work at the manufacturing plants will live in the state at rates similar to those of other industries.

In this section, we provide a range of potential impacts for each industry based on average employment at a single large-scale facility. Data on employment comes from the US Bureau of Labor Statistics Quarterly Census of Employment and Wages. We estimate the employment ranges by dividing the total employment in each industry by the number of establishments based on counties and states that have a high level of large-scale manufacturing plants in each industry. The employment ranges we use in this analysis are detailed in Table 3.

Table 3: US Average Employment per Establishment

Industry	Employment per Establishment Range
Plastics Material and Resin Manufacturing	100–150
Petrochemical Manufacturing	100–200
Petroleum Refineries	400–500

Source: US Bureau of Labor Statistics, Author Calculations

To estimate the economic impact of a representative establishment in these industries, we apply a detailed model of the West Virginia economy that outlines how trade-flows among industries interact with key economic indicators such as employment, income, output, and tax revenue.³ The expenditures associated with operational spending at the firms are referred to as the direct economic impact. However, the total economic impact of these activities is not limited to the direct impact, but also includes the secondary economic impacts accrued as those initial direct expenditures are re-spent throughout the rest of the economy.

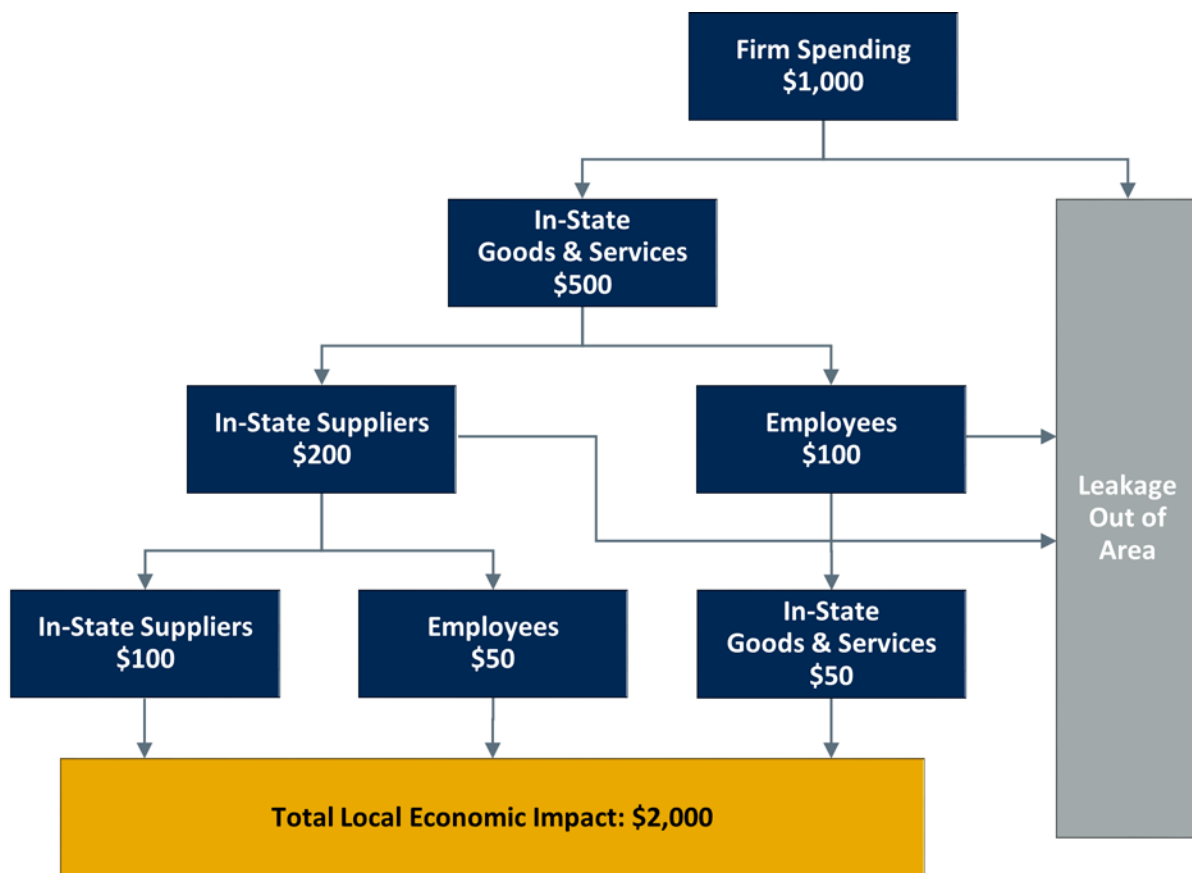
For example, to support its operations, each firm will purchase items such as materials, utilities, office products, professional services, etc., from suppliers in West Virginia. Because of the increased demand for these inputs, local suppliers will increase their production correspondingly, and their subsequent

³ This study was conducted using the IMPLAN modeling software, an industry-standard input-output model of the economy. More information about IMPLAN can be found at <http://www.implan.com>.

suppliers will increase production, etc. This additional economic activity is referred to as indirect impacts. In addition, the companies and their suppliers employ numerous workers, part of whose income will be spent in the West Virginia economy, which generates additional output, income, and employment. This activity is referred to as induced impacts.

These indirect and induced impacts together form what is known as the “multiplier effect.” The original stimulus to the economy from the firms’ expenditures is re-spent multiple times through the rest of the state’s economy. At each stage, some of the expenditures “leak” out of West Virginia as they are spent outside of the state. The combined direct impact and secondary impacts together constitute the total economic impact of the operational expenditures of the firms in these industries. These multipliers and leakages are depicted in Figure 8.

Figure 8: Economic Impact Flow



For this study, we consider the economic impact of each firm in terms of output, employment, employee compensation, and select state and local tax revenue. We estimate the impact using what is known as “economic contribution analysis,” which assesses the total value of the plant to the state’s economy, including the secondary indirect and induced impacts. For this type of analysis, we estimate the economic impact if the plant were newly added to the local economy, with the implicit assumption that the addition of this company would not affect the trade relationships between suppliers. We have not attempted to assess the potential impact of the construction of the plant, but instead focus only on the annual operation of these new businesses.

4.1 Plastics Materials and Resins Manufacturing Industry

West Virginia has a highly developed cluster in the Plastics Materials and Resins Manufacturing industry, with multiple producers centered in the Parkersburg and Charleston metropolitan areas. The average size of an establishment in this industry in West Virginia was approximately 160 workers. However, firm sizes in other major supplying regions nationally suggest that the typical size may be somewhat smaller than this figure. For this reason, we chose the somewhat conservative employment range of 100 to 150 workers.

A firm of this size can be expected to generate between \$129 million and \$193 million in direct output, with an additional secondary output of between \$36 million and \$54 million, for a total economic impact of between \$165 million and \$247 million.

This industry generates an employment multiplier of greater than 3, meaning that the activity generates more than two additional jobs in secondary industries for every job in the primary industry. Our estimate shows that the direct jobs would result in between 211 and 316 additional workers in indirect and induced impacts, for a total employment impact of between 311 and 466 workers. Workers directly employed are estimated to earn between \$14 million and \$21 million in income, with an additional \$11 million to \$16 million generated in secondary industries.

A plant this size can be expected to return approximately \$3 million to \$4 million in total tax revenue to the state, split roughly evenly between direct impacts and indirect and induced impacts.

Table 4: Annual Economic Impact: Plastics Materials and Resins Manufacturing Industry

Type of Impact	Direct	Indirect and Induced	Total
Output (\$, millions)	129–193	36–54	165–247
Employment (jobs)	100–150	211–316	311–466
Employee Compensation (\$, millions)	14–21	11–16	25–37
Local Property Tax Revenue (\$, millions)	0.6–0.9	0.4–0.7	1.0–1.5
All Other State Tax Revenue (\$, millions)	0.9–1.3	0.7–1.0	1.5–2.3

Notes: Output, Employee Compensation, and Tax Revenue are measured in 2019 dollars. Tax Revenue impact includes sales, personal income, property, and corporation net income taxes.

4.2 Petrochemical Manufacturing Industry

West Virginia has approximately 500 workers in the petrochemical industry. However, these establishments tend to be smaller and play a more supportive role in the local economy. In order to understand the potential size of large-scale petrochemical manufacturing, we use average employment totals from Texas and Louisiana, where much of the larger plants are located.

Our analysis of these locations indicates that the average large-scale petrochemical manufacturing plant employs between 100 and 200 workers. Based on average worker productivity measures, this translates to between \$563 million and \$1.1 billion in annual direct expenditures. Direct employee compensation falls between \$14 million and \$28 million, and firms can be expected to pay approximately \$2 million to \$5 million in state and local taxes.

Expenditures in supplier industries and households constitutes between \$110 million and \$220 million if output, for a total annual economic impact of between \$673 million and \$1.3 billion. Employment in secondary industries totals between 553 and 1,106 jobs annually, for a total employment impact of between 653 and 1,306 jobs. Total tax revenue falls between \$6 million and \$11 million, with between \$2 million and \$5 million coming from primary industries and the remainder coming from secondary impacts.

Table 5: Annual Economic Impact: Petrochemical Manufacturing Industry

Type of Impact	Direct	Indirect and Induced	Total
Output (\$, millions)	563–1,126	110–220	673–1,346
Employment (jobs)	100–200	553–1,106	653–1,306
Employee Compensation (\$, millions)	14–28	30–61	44–89
Local Property Tax Revenue (\$, millions)	1.5–2.9	1.4–2.7	2.8–5.6
All Other State Tax Revenue (\$, millions)	0.9–1.9	1.9–3.8	2.8–5.7

Notes: Output, Employee Compensation, and Tax Revenue are measured in 2019 dollars. Tax Revenue impact includes sales, personal income, property, and corporation net income taxes.

4.3 Petroleum Refineries Industry

While West Virginia does not have a large petroleum refining industry, it has been a growing sector since the development of the state’s shale gas resources. However, because the industry encompasses a wide range of activities, it is difficult to determine an average employment size for the industry.

As with Petrochemical Manufacturing, we rely on data from Texas and Louisiana to understand the potential employment in this industry. Employment per establishment data from counties with well-developed large-scale refinery capacity indicate that a typical refinery plant employs between 400 and 500 people. As an example, according to news reports⁴ the Shell ethane cracker in Beaver County, PA, is expected to employ approximately 600 workers at full capacity.

⁴ See for example Downing, Bob, “Shell’s \$6 billion ethane cracker in western Pennsylvania will also impact Ohio, West Virginia.” Akron Beacon Journal, June 7, 2016. Retrieved from <https://www.ohio.com/akron/business/shell-s-6-billion-ethane-cracker-in-western-pennsylvania-will-also-impact-ohio-west-virginia>; and Litvak, Anya, “Shell cracker plant in Beaver County to provide 600 jobs when it opens.” Pittsburgh Post-Gazette June 7, 2018. Retrieved from <http://www.post-gazette.com/powersource/companies/2016/06/07/Shell-says-Marcellus-cracker-is-a-go-ethane-beaver-county-pennsylvania-pittsburgh/stories/201606070131>.

Given standard worker productivity figures, a typical refinery of this size would produce between \$2.7 billion and \$3.4 billion in annual economic activity. According to US BEA data, approximately three-quarters of the refinery’s intermediate expenditures are spent on natural gas and natural gas liquids as a feedstock to the refining process. Our economic model is based on the assumption that this gas would not be extracted except for the presence of the ethane cracker. In this case, this assumption is incorrect, as much of the gas in our region likely would be extracted, but it would be transported by pipeline to crackers in other areas. In order to isolate the economic impact of the ethane cracker plant itself, we have eliminated local purchases of natural gas from this analysis. To the extent that a cracker plant located in the region would generate additional demand for natural gas, the impact could be larger than our estimate. Thus we consider this to be a lower-bound estimate for the impact of a large-scale cracker plant.

As shown in Table 6, we estimate a large-scale refinery would generate between \$3.1 billion and \$3.9 billion in total economic impact, with between \$400 million and \$500 million coming in secondary industries. Refineries also have extremely high employment multipliers. Though the plant would be expected to directly employ 500 workers at the high end, secondary employment could total more than 3,000 workers, for a total employment impact of between 2,819 and 3,524 jobs annually. Direct compensation would total between \$59 million and \$74 million, for an average compensation of nearly \$150,000 per worker. Total compensation for these employees and those in secondary industries would be between \$200 million and \$250 million. We estimate a refinery would generate approximately \$33 million to \$41 million in state and local tax revenue on an annual basis.

Table 6: Annual Economic Impact: Petroleum Refineries Industry

Type of Impact	Direct	Indirect and Induced	Total
Output (\$, billions)	2.7–3.4	0.4–0.5	3.1–3.9
Employment (jobs)	400–500	2,419–3,024	2,819–3,524
Employee Compensation (\$, millions)	59–74	141–176	200–250
Local Property Tax Revenue (\$, millions)	13.7–17.1	5.8–7.2	19.5–24.3
All Other State Tax Revenue (\$, millions)	4.5–5.6	8.8–10.9	13.3–16.5

Notes: Output, Employee Compensation, and Tax Revenue are measured in 2019 dollars. Tax Revenue impact includes sales, personal income, property, and corporation net income taxes.

5 Potential Market Size

In the above sections, we detailed the potential economic impact of individual plants in the three industries of interest. However, it is also important to understand the potential size of the overall market for these manufacturing industries in order to estimate the total potential impact on the state's economy. As stated above, it is difficult to predict how the market for these commodities will change over the near future as the low cost of natural gas feedstock in the region reorganizes national and international supply chains. In this section, we provide what we consider to be a best-case-scenario estimate for the potential market in the state.

We base our analysis on a 2017 study by the American Chemistry Council (ACC) that examined the potential impact of a new petrochemical cluster in the Appalachian Region—consisting of West Virginia, Kentucky, Pennsylvania, and Ohio.⁵ In this study, the ACC posits a scenario where the region becomes a significant hub in the petrochemical sector on the scale of the Gulf Coast region. As an example, the study assumes the four-state region garners an increase in the Plastics Materials and Resins Manufacturing industry of approximately \$13 billion in output, which constitutes approximately 16 percent of total US output in the industry. Similarly, in the Petrochemical Manufacturing industry, the study assumes an increase of \$4.9 billion, which is 3 percent of US output in the industry. The ACC study does not break out potential gains in the refining industry, but assumes that five world-class cracker plants will be built within the four-state region.

The ACC study does not break out impacts for each of the four states. In order to assess the potential impact in West Virginia, we assume that the estimates above will be allocated approximately in proportion to the share of natural gas production in the four states. Based on data from the US Energy Information Administration, West Virginia produced approximately 17 percent of total natural gas output in the four-state region in 2018. Using this proportion, we assign the following impacts to West Virginia:

- One of the five ethane cracker plants
- One new Petrochemical Manufacturing plant
- 10 new Plastics Materials and Resins Manufacturing plants

Using these assumptions, we estimate the total potential economic impact from the top three natural gas downstream industries to be between \$5.5 and \$8.0 billion (see Table 7). Of this total, between \$4.6 billion and \$6.7 billion would come from direct expenditures, with the remainder in secondary industries. We estimate the potential direct employment to be between 1,500 and 2,200 jobs, with an additional 5,000 to 7,500 to come in secondary industries, for a total employment impact of approximately 6,600 to 9,600 jobs. Employee compensation would total between \$210 million and \$309 million directly, with an additional \$281 million to \$411 million in indirect and induced impacts, for a

⁵ Economics & Statistics Department. "The Potential Economic Benefits of an Appalachian Petrochemical Industry." American Chemistry Council. May 2017. <https://www.americanchemistry.com/Appalachian-Petrochem-Study/>

total compensation impact of between \$491 million and \$720 million. Tax revenue is estimated to be between \$64 million and \$94 million, split approximately evenly between local and state governments.

Table 7: Annual Potential Economic Impact from Natural Gas Downstream Industries

Type of Impact	Direct	Indirect and Induced	Total
Output (\$, billions)	4.6–6.7	0.9–1.3	5.5–8.0
Employment (jobs)	1,500–2,200	5,079–7,449	6,579–9,649
Employee Compensation (\$, millions)	210–309	281–411	491–720
Local Property Tax Revenue (\$, millions)	21–31	12–17	33–48
All Other State Tax Revenue (\$, millions)	14–20	17–26	31–46

6 Conclusion

Our analysis of the potential economic impacts from downstream natural gas development indicates that the primary industries in the sector would provide substantial gains in economic output and employment in West Virginia. The top three industries identified above are characterized by high incomes that lead to large employment multipliers. Our estimate of the total potential impact of these industries is between \$5.5 and \$8.0 billion. As a comparison, total GDP in West Virginia in 2017 was \$73 billion. At the low end of our estimate for the total market size, the gains to the economy would constitute approximately 7.5 of the state's GDP.

The single largest potential impact would come from the construction of an ethane cracker plant or other large-scale petroleum refinery. Given that two cracker plants have already been announced in the region, it may be difficult for firms to justify construction of additional capacity in West Virginia over the near term. However, though these plants are not within the state's borders, they are still likely to have large spillover effects into West Virginia. The cracker plants and their suppliers are likely to employ hundreds of local residents and serve as hubs for additional development in the region through their supply chain relationships. The hydrocarbons produced in these plants also provide the feedstock for a number of different types of manufacturing, including the two other industries identified in our analysis as good prospects for development in West Virginia. The addition of even a small number of average-sized plastics or petrochemical manufacturing plants would be a major contributor to the state's economy.

There are some limitations to this analysis. First, the assumption in section 5 of the potential for 10 new Plastics Materials and Resins Manufacturing plants is extremely large. The addition of these plants would nearly double the size of this industry in West Virginia. Second, the economic impact multipliers found in this study are extremely high because the Petroleum Refineries industry is a highly capital intensive industry, and thus has a very high level of output per worker. Our economic model accounts for regional leakages, but it is likely that any plant of the magnitude considered here will draw suppliers from across a wider geographical region than usual, thus spreading secondary impacts farther outside the state's borders than may be accounted for in the model. Third, we have assumed that permanent workers and contractors at the petrochemical plant will reside in West Virginia at similar rates as other commuters, and thus spend the majority of their household income in the state. It is likely that any plant will draw from a labor pool in neighboring states, particularly if the plant is located near the state border. Thus, induced impacts may be somewhat lower than our estimate. Lastly, our estimate does not account for how quickly these industries will become established in the state. It is likely to take many years, if not decades, for these impacts to be fully realized.

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