

PENNSYLVANIA'S BAD BET

WHY SHELL DIDN'T
SAVE APPALACHIA
WITH PLASTICS

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The Ohio River Valley Institute is an independent, nonprofit research and communications center founded in 2020. We equip the region's residents and decision-makers with the policy research and practical tools they need to advance long-term solutions to some of Appalachia's most significant challenges. Our work includes in-depth research, commentary, and analysis, delivered online, by email, and in-person to policy champions, emerging leaders, and a range of community partners.

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Executive Summary

In November 2022, over ten years after Shell's first public announcement of site selection for the project, and after five years of construction, Shell Chemical Appalachia Polymers¹ opened its ethane cracker plant in Beaver County, Pennsylvania. The plant, which refines ethane, a natural gas liquid, into plastic pellets used to produce single-use plastics, was heralded as the beginning of a plastics industry renaissance in Appalachia. At least one local economic development organization estimated it would support nearly 600 direct employees and could generate 11,000 jobs in the Pittsburgh area. [\(1\)](#)

Now, just over one year since production officially began, the plant has been mired in problems. The facility exceeded its allotted pollution limits within months of operating and repeated flaring has deepened air quality and health concerns of Beaver County residents. Furthermore, the plant seems to have fallen short so far in generating the economic benefits promised to residents, as Beaver County continues to trail the state across most economic metrics. [\(2\)](#) This poor economic and environmental performance comes despite Shell receiving billions of dollars in state and local tax exemptions that carry an opportunity cost for taxpayers—namely, that alternative uses of the funds could have been used to grow the regional economy in more direct ways, such as to support small businesses, improve workforce development, or develop projects within industries that already have a strong history, complete with supply chains, in the region.

Why did Pennsylvania's leaders in the 2010s decide to bless Shell with such generous tax incentives? A deeply flawed economic impact study conducted by professors at the Robert Morris University (RMU) School of Business in 2014 and a follow-up study published in 2021 provided rationale for these tax incentives. [\(3\)](#) The goal of this report is to offer a critique of these studies, which largely went unchallenged at the time. The first study was published nearly two years after the State Assembly passed two large subsidies for the project, and just before Shell completed its purchase of the site chosen years before. Both studies were used to justify

¹ Unless specifically noted otherwise, 'Shell' is used throughout the report to refer to Shell Chemical Appalachia, LLC.

an “investment” of billions of dollars in Shell’s plan on the premise that the return-on-investment for taxpayers would be positive. It is, unfortunately, unlikely to be so.

Foremost, the circumstances in which the RMU team was solicited to do the economic study are murky. None of the authors' curriculum vitae list any previous professional experience doing economic analysis work within the petrochemical industry. We will likely never understand Shell’s choice of authors to evaluate the project, especially given that so many field experts would have been available from other major universities both in Pittsburgh and throughout Pennsylvania.

The study was billed as an independent analysis by a university team and branded with RMU’s logo, but the study is not currently published on RMU’s website. Seemingly no record of its release by RMU exists. Correspondence with two of the RMU authors revealed that the study is the property of Shell and, thus, could not be shared with the authors of this report. Indeed, the 2014 report cover page does note that the report was financed by and prepared for Shell. The study was widely cited in media outlets in 2014, but does not appear online despite considerable search effort.

The fact that the 2014 economic study was used to justify billions of dollars of public subsidy that had already been granted to the project by the Pennsylvania General Assembly over two years earlier and is not easily accessible to the public raises serious academic and ethical concerns. For instance, a follow-up study from an RMU team co-authored by two of the 2014 report authors was released in 2021. [\(4\)](#) This 2021 report does not adequately explain the methodology used to forecast tremendously positive benefits of the Shell petrochemical project, and instead refers readers to their 2014 report—which is generally unavailable. At best, citing one’s own private and publicly inaccessible work is academic malpractice, equivalent to asking serious readers to blindly trust the authors. At worst, it is a purposeful omission designed to discourage valid criticism of the study—and there is plenty of valid criticism.

The criticism of the RMU studies can be divided into four categories:

1. It uses methodology that is not appropriate for long-term economic forecasting. The authors use commercially available economic modeling software from

IMPLAN to conduct what is known as *input-output analysis*. While this analysis is widely used in industry, and can be valuable in some instances, it is inappropriate for long-term economic forecasting. The IMPLAN models make a series of inherent assumptions, some of which may be bad assumptions for this particular project, which involves considerable pollution and external costs. Additionally, tax subsidies provide Shell with competitive advantages over other local businesses for workers and materials. In essence, the input-output model excludes prices—meaning that it wrongfully assumes that Shell's use of land, labor and capital are readily available and do not impact other local businesses in the region. The assumptions of input-output models are more thoroughly detailed in **Table 1** of this report.

2. The RMU study's impact analysis completely omits consideration of the costs of billions of dollars in public subsidy. It is untenable to conduct a fair cost-benefit analysis and not consider the costs at all. The Shell facility receives considerable exemptions from local property taxes—revenue that would otherwise go to public services such as schools. Additionally, Pennsylvania seemingly won the project over nearby states by creating a raw material tax credit that directly subsidizes the ethane inputs for Shell's facility. Having raw materials subsidized is a massive advantage for Shell, and this tax credit was likely needed to make the plant a profitable endeavor in the first place.
3. The authors of the RMU study used a non-standard 40-year timeline to project benefits, which is highly unrealistic within the petrochemical industry. The positive forecast for the regional economy thus implausibly assumes no global market shifts, no consumer attitude shifts around single-use plastics, no political and regulatory changes, and no need to re-invest capital for upkeep or modifications to the facility for four decades. Other ethane cracker facilities in the US have used 15-year timelines for projections and evaluation.

4. The RMU study utilizes incorrect industry classification codes for the project. Essentially, previous criticisms aside, even if both 1 and 2 were not valid criticisms, the RMU authors used the methodology incompetently. The code the authors used misclassified the Shell plant, as noted in a critique by Penn State Professor Emeritus David Passmore, which causes their economic model to use inflated parameters and thus overestimate the economic benefits. [\(5\)](#)

For a variety of reasons, this report finds that the RMU studies present residents of the region with an inadequate evaluation of the true economic prospects of Shell's plant. Hidden costs, including environmental degradation, chronic healthcare costs to residents due to air pollution, and declining home values near a large plastics plant, as well as the cost of what else could have been done with some of the subsidy money, are not considered. Nor does the study consider the offsetting impact of Shell's facility crowding out investment from other local businesses by driving up construction wages and material and land prices. As a result, the RMU study does not project a **net** benefit to the region's jobs—it presents an "all gravy" estimate.

This should be a cautionary tale for policymakers who are constantly presented with overly-rosy economic development projects by private companies using faulty methodologies. This is particularly true in Appalachian communities, where residents have been misled, forgotten, and fed false promises by extractive industries for the better part of a half-century. Better questions have to be asked by leaders before making decisions with public funds and the onus to thoroughly demonstrate economic benefits should be on the company seeking tax incentives. It is not enough to take anyone's word for it without a deeper understanding of how companies and analysts arrive at their predictions. After all, as the adage goes, if something seems too good to be true, then it probably is.

In terms of economic growth, there are alternatives. Investments in workforce development, education, resident quality of life, environmental conservation, and high-multiplier small business activity, where more money remains locally instead of in out-of-state corporate headquarters, have been shown to give regions a "bigger bang for their buck." [\(5\)](#) It is the hope of this report that current and future policymakers will learn from the past and avoid making another bad bet.

Background

In 2012, Pennsylvania legislators [created a unique](#) tax credit that would eventually be used to support the Shell Chemical Appalachia Polymers plant, located in Monaca, Pennsylvania. The Pennsylvania Resource Manufacturing Tax Credit subsidizes raw materials used in Pennsylvania. In Shells' case, this new law offered a \$2.10 per barrel credit on ethane and helped make the state a competitive location for Shell's so-called "ethane cracker" plant, which began operation in late 2022—nearly a decade after the passage of tax credit legislation and six years after the company made its "Final Investment Decision" (FID) in mid-2016. The Resource Manufacturing Tax Credit alone was estimated at the time to save Shell potentially \$1.65 billion over 25 years in raw materials, until 2042 when the credit expires.

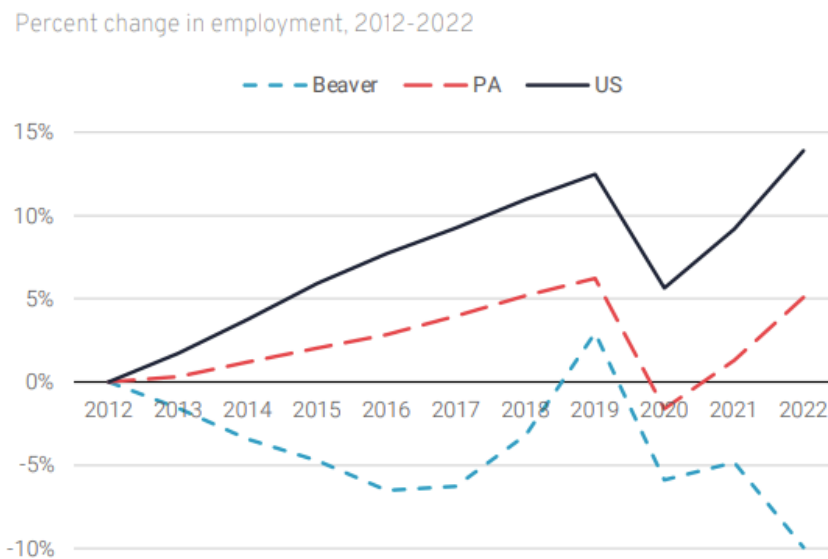
In addition to the tax credit for its raw material, Shell received additional benefits through the Keystone Opportunity Expansion Zone (KOEZ) program. This was an expansion of a tax incentive program originally established in the late 1990s and designed to attract businesses to the state with major tax breaks and potentially even tax-free status. Shell was approved for the KOEZ benefits in 2013, which exempts it from state corporate income tax, local real estate property taxes, state and local sales taxes and occupancy tax. [\(6\)](#) Additionally, Shell was offered a grant award of up to \$10 million from the Pennsylvania First Program to assist with site development. These generous financial incentives were, like all economic development strategies, predicated on the Shell plant supporting thousands of jobs during the construction and operational phases of the plant and helping to grow western Pennsylvania's economy.

The startup of the Beaver County, PA ethane cracker facility has been, at best, rocky. Described as "technical niggles" by Shell's CEO Wael Sawan, operational hiccups and mishaps have caused flaring and excessive discharges of volatile organic compounds (VOCs). [\(7\)](#) Shell has received 13 notices of violations for exceeding emissions limits and was fined \$10MM by the Pennsylvania Department of Environmental Protection (DEP) last May. [\(8\)](#) The plant received an "F-grade" from Moms Clean Air Force after review by numerous organizations including Three Rivers Waterkeeper, Clean Air Council, Breathe Project, and Earthworks. [\(9\)](#) It is well documented that health effects from such quantities of pollution create major non-market, unaccounted costs for residents of the region. Such costs include medical bills, a loss of

environmental quality, a potential loss of local eco-tourism, and depreciated home values due to the proximity to a large point-source of pollution.

Vast quantities of toxic pollution aren't the only challenge that the project faces. After posting a \$1.4 billion full-year loss in 2022 (based on adjusted earnings), Sawan, who became CEO of Shell in January 2023, has begun a strategic financial review of the company's chemical and energy assets throughout the world. (10) It is likely that the so-called "ethane cracker" plant in Beaver County will be a part of this review. Several studies have been conducted to evaluate the economic impact of the facility, demonstrating underwhelming results for policymakers desperate for a regional turnaround. A previous report by the Ohio River Valley Institute in June 2023 found that GDP, population, and employment in Beaver County have lagged the state of Pennsylvania and the nation since the announcement and startup of the facility. (2) A key figure from that report is reproduced below in **Figure 1**, illustrating that not only has Beaver County lagged in job growth during the construction and startup of the ethane cracker, but the county has not yet economically recovered from the COVID-19 pandemic relative to Pennsylvania and the US

Figure 1: Beaver County Job Growth Relative to PA and US, 2012-2022



Source: Reproduced from “Updated: A Cautionary Tale of Petrochemicals from Pennsylvania”, Ohio River Valley Institute, 2023. Data originally from US Bureau of Labor Statistics (BLS).

Given that jobs, including those promised during the construction phase, have so far failed to materialize and that Shell itself has signaled a review the financial feasibility of its own chemical business model, it is fair to wonder whether how and why the company received such a massive tax incentive package from the State of Pennsylvania to subsidize its investment and operation in the region. As this report will show, much of the justification for the project and its large subsidization at the expense of Pennsylvania taxpayers was driven by a singular report conducted by members of Robert Morris University's (RMU) business school who had no prior experience in the petrochemical or plastics industries and had little experience with analyzing the spillover impact of economic development projects. Presented to legislators and the public frequently, their overly-rosy jobs projections from a 2014 study were based on faulty assumptions, questionable methodology that ignores the potential for offsetting economic spillover effects and, in some cases, were based on job estimates seemingly given directly to them by Shell itself.

This report aims to examine some of the bad assumptions underpinning the original RMU analysis that supported the economics of the Shell ethane cracker plant in Beaver County and concludes that, given major changes in the global economy as well as Shell's delayed and logistically fraught startup, Pennsylvania residents are unlikely to see a positive return on investment of their billions in public subsidies.

How the Beaver County Ethane Cracker Came to Be

Shell first became active in the Marcellus Shale region when Shell Western E&P Inc. (SWEPI) acquired a privately held company called East Resources in 2010. This was near the beginning of what is commonly known as the "fracking boom," when a revolution in drilling technology drastically accelerated natural gas investment and production in the US. This development represented a huge potential boon for the chemical industry, since natural gas and oil provide raw materials for chemicals such as plastics precursors. The abundance of new, cheap feedstock quickly spurred interest in an ethylene cracker plant in the region to produce chemicals. Shell Oil President Marvin Odum specifically mentioned the possibility in 2011,

saying “...With this investment (an ethylene cracker), we would use feedstock from the Marcellus to locally produce chemicals for the region and create more American jobs. As an integrated oil and gas company, we are best-placed in the area to do this.” (11) Notably, as this report will explore, the global markets for both raw inputs and plastics have significantly changed over the last decade. Shell announced it had signed a land option to acquire the site in Beaver County from the Horsehead Corporation for a potential ethylene plant in March 2012.

When multi-billion-dollar investment projects—such as the ethane cracker—are considered by corporations, it typically sets off a frenzy of competition among politicians in different regions to “win” the project in the hope that it will bring jobs and dollars to their area. Sometimes termed a “race to the bottom” by economists, states and municipalities compete by offering increasingly generous tax exemptions to companies, which are then able to “shop” for the best deal with little concern for economic efficiency. (12) There is perhaps no better public example of this than Amazon’s “HQ2” contest in 2018, where cities bid for the facility by offering generous tax abatement deals to the company. Brookings noted at the time that there was little evidence that luring companies with tax incentives helps spur job creation. Only 3% to 14% of estimated jobs created in a typical state come from out-of-state relocations each year, despite \$45 billion in annual spending on local tax incentives. (13-15).

By February 2012, fresh off the Great Recession, similarly intense competition had sprung up between Pennsylvania, Ohio, and West Virginia for Shell’s proposed ethylene cracker project. One news outlet tracking fossil fuel activity in the region proclaimed that “the governors of WV, PA and OH are all dreaming and scheming for the siting of a major new chemical industry in their State.” (16) Pennsylvania would eventually win the project. The state legislature approved and amended two major tax incentive programs for Shell’s benefit. These are discussed in detail below.

The Keystone Opportunity Zone Eliminated Shell’s State & Local Taxes

The Keystone Opportunity Zone (KOZ) is a tax incentive program established by the Pennsylvania Legislature in 1998 to help revitalize distressed communities. Tax abatements, such as the KOZ, are a cornerstone of traditional economic development policy designed—in

theory—to create jobs and grow incomes by encouraging private investment in blighted areas.

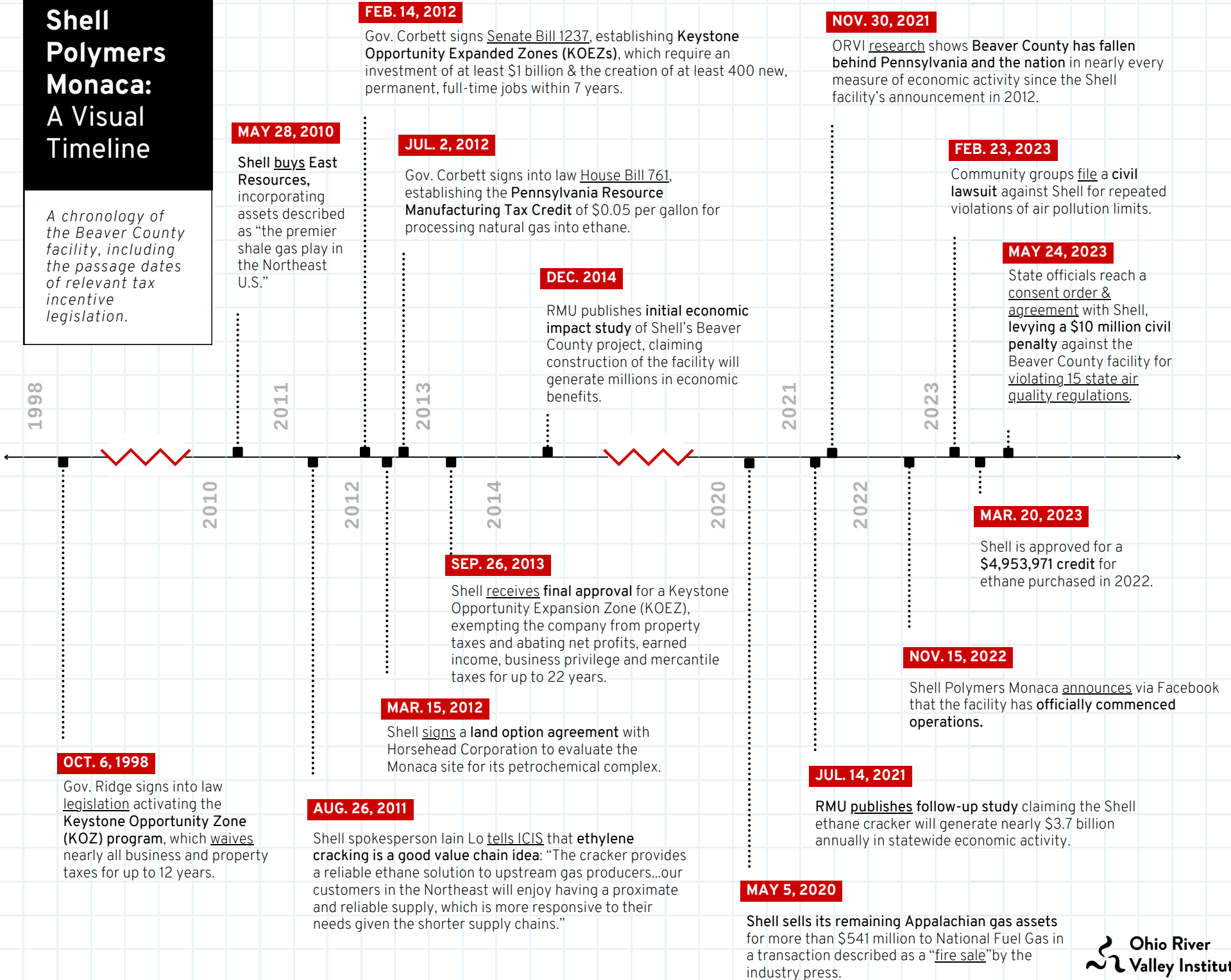
The KOZ program can exempt businesses from the following taxes:

- State corporate income taxes
- Capital stock foreign franchise taxes
- Personal income taxes
- State sales and use taxes
- Local earned income/net profit taxes
- Business occupancy taxes
- Local real property taxes
- Local sales and use taxes
- Mercantile and business privileges taxes

Effectively, the KOZ can exempt a business from all state and local taxes. What makes the Shell ethane cracker project unique, however, is that the state legislature expanded the KOZ the month before Shell announced the option to acquire the property in Beaver County where it would site the project. The following page presents a visual timeline of the Beaver County facility from conception to present, including the passage dates of relevant Pennsylvania tax incentive legislation.

Shell Polymers Monaca: A Visual Timeline

A chronology of the Beaver County facility, including the passage dates of relevant tax incentive legislation.



Signed by then-Governor Tom Corbett on Valentine's Day 2012, [Senate Bill 1237](#) expanded the KOZ program to include larger parcels of land meeting specified requirements. These sites were known as KOEZ's (Keystone Opportunity *Expansion* Zones). The requirements for designation included an investment of at least \$1 billion and creation of at least 400 **new**, permanent, full-time jobs within seven years.² These requirements immediately made the site Shell was considering in Beaver County, beginning in 2011, eligible for inclusion in the newly expanded version of the tax incentive program. Shell took out an option to buy the site the following month and applied for designated KOEZ status by the end of that year, in December 2012.

The KOEZ program is supposedly a 'ground up' initiative where local communities designate a Zone for approval by the State, but given the timing of its passage and Shell's application, it appears that the process for the Shell project was top-down. Local taxing authorities who rely in part on the foregone property tax revenue from the project were apparently not in the loop when the State Assembly passed the February 2012 amendments to the KOZ legislation. This includes both Potter Township and Central Valley School District. One article from 2012 noted that "the Senate's move to expand the KOZ, and the political hoopla around Shell choosing Pennsylvania, leaves Potter Township (population 600) as the final stop in securing Shell's move to the state. This essentially turns the normal KOZ designation process on its head." Rebecca Matsco, one of Potter's three township supervisors at the time, was quoted as saying that "We weren't part of the process. We have seen no paperwork, no language. We have not had transparency." [\(17\)](#) The Pennsylvania Assembly's rushed passage of Senate Bill 1237 to expand the KOZ program, seemingly in part for Shell's benefit, also superseded an existing tax incentive program in Potter Township that would have given the local community more control and would not have fully exempted property taxes that the

² Emphasis is added here by the authors to underscore that the KOEZ requirement of "new" jobs is ambiguous and hard to measure in reality from a net economic perspective. As this report highlights, there is little evidence to suggest that jobs created by the facility have in fact been **net new to the county**, which would be a requirement to positively influence net economic growth. It is unlikely that the jobs were net new, since Shell cannot control the loss of other jobs in the region, but the language is misleading. It is very likely that Pennsylvania and Beaver County taxpayers ultimately paid to subsidize Shell to **offset** other regional job loss, which is one reason that the forecasted "all positive" economic prosperity from the facility has failed to materialize. This is a common problem with the input-output model projections commonly used to justify major subsidies for economic development projects.

township and local schools rely on. State Senator Tim Solabay, sponsor of Senate Bill 1237, said he “didn’t know the site for the Shell plant already had a local tax designation that would be more beneficial to Potter Township.” Nonetheless, he said, passing the KOZ expansion bill was the right thing to do. “It’s true that things don’t always get followed through the way they should,” he said. “But you try to make the best decision. The voters put their trust in us to make the best opportunities possible.” [\(17\)](#)

Shell ultimately agreed to a Payment In Lieu Of Property Taxes (PILOT) to the local taxing authorities of 110% of the amount paid in 2011 by the Horsehead Corporation, the company that then occupied the site Shell was evaluating. Horsehead Corporation operated a zinc smelter at the site at the time of the KOEZ application, employing about 650 people in 2013, according to the Beaver County Economic Development Authority. [\(18\)](#) Horsehead gave its required 60-day Worker Adjustment and Retraining Notification (WARN) notice in October 2013 to notify its employees of its intent to shut down the facility in 2014, and sold the site to Shell in 2015. [\(19\)](#) Importantly, the PILOT Shell ultimately paid fails to capture any potential *increase* in property value of Shell’s acreage. Effectively, it locks Shell’s payments at the 2011 levels of its predecessor. Even in a best-case scenario, were the ethane cracker to generate dramatic gains in property value, local taxing authorities would be frozen out and prevented from realizing any increases in taxable property value on the site.

The Ethane Feedstock Tax Credit

After Shell optioned the site in Beaver County, the Pennsylvania State Assembly upped the ante for other states in the region by including the Pennsylvania Resource Manufacturing Tax Credit in a series of Omnibus Amendments to the Tax Reform Code of 1971. This Act, now known as Public Law 751, No. 85, [was passed as House Bill 761](#). The details of the credit are contained in Article 17-G of the Act. It provides a tax credit of \$.05/gallon for ethane purchased and used in manufacturing of ethylene in Pennsylvania by a qualified taxpayer. There is no stated cap on the amount of ethane that can be purchased to generate the credit, nor is there a stringent requirement that the ethane be sourced from Pennsylvania gas production. The credit can be used to offset up to 20% of the qualified taxpayer’s tax liability in a given year, with the exception of payroll taxes. If not used by the qualified taxpayer, it can be “assigned or

transferred” to other qualified businesses for use in offsetting up to 50% of state and local taxes.

On March 20, 2023, Shell was approved for a \$4,953,971 credit for ethane purchased in 2022. Since its designation as an Expansion Opportunity Zone under the KOEZ program essentially exempts it from most state and local taxes already, this credit is available for transfer to other parties. The Act provides that the credits be offered first to businesses “upstream” or “downstream” of the ethylene facility before being offered to other types of businesses. This would effectively allow some of the businesses that would otherwise be paying state and local taxes to offset up to half of their liabilities.

The amount of the potential credit is substantial. Assuming a 96,000 barrel a day estimate for ethane feedstock consumption, 10 months annual operating time, and a 21-year term (2022-2042) for the credit yields over \$60 million a year, or a total of nearly \$1.3 billion in 2023 dollars, in effective feedstock “discounts” for the facility. This provides a large competitive advantage in an industry where feedstock costs are the primary cost of ethylene production. At the time the subsidy was enacted into law, ethane at the primary market hub in Mont Belvieu, Texas, was selling for \$0.35/gallon. The \$0.05/gallon subsidy would represent a 14% discount.

Although programs that provide exemptions from various state and local taxes, loans, and grants are relatively common incentives offered to industries in many states, this analysis was unable to find any other program in the nation that provided such a massive benefit to ethylene producers. As the following sections of this report discuss, this potential reduction in the tax benefits to be generated from spinoff industries resulting from this legislation was not identified or estimated in either of the RMU studies.

Bad Assumptions, Bad Studies, and The Race to the Bottom

How did Shell manage to garner so much political support—to the point of establishing new subsidies—for its ethane cracker facility in Beaver County? The most plausible answer is that the project promised to deliver a large number of new jobs to the region and kickstart a so-called “plastics boom.” This type of thinking is common in economic development practice where politicians believe that establishing an “anchor” facility will attract upstream and

downstream businesses to the region because of potential gains in efficiency due to co-location. One often disregarded fact is that, while co-location of other businesses may be the most market-efficient decision, tax incentives offered by one state do not occur in a vacuum. While Shell receives subsidies to locate in Pennsylvania, its upstream and downstream suppliers and customers may receive similar tax benefits to locate elsewhere that compensate for any inefficiencies due to being further away from the ethane cracker in Beaver County. In essence, almost all states and cities offer market-distorting tax incentives to “win” business site location decisions, but the economic benefits of these decisions partially relies on other states and cities not further distorting markets with their own incentives. It is precisely the fact that everyone attempts to play the same game that creates what economists term the “race to the bottom,” where most of the states and cities fail to realize the benefits promised by such large public subsidies and tax incentives.

The ethane cracker plant in Beaver County was another such project that was presented to the public and to local officials as a tremendous economic opportunity. Numerous studies were used to generate job estimates in support of the project. It is important to note that all of these economic studies were published *after* 2012, when legislation enabled the Shell facility to qualify for substantial tax breaks and an unprecedented feedstock tax credit. That public financing described in the previous section was a vital factor in the company’s decision to locate the plant in Pennsylvania, according to Shell’s managers. [\(20\)](#)

The studies citing potential economic benefits of petrochemical plants or expanded petrochemical manufacturing operations were conducted by many industry organizations, including the American Chemistry Council, IHS Markit, and two Shell-financed studies by Robert Morris University (RMU) professors. The findings from these studies were widely circulated and cited by advocates for the petrochemical projects in the region, but rarely critiqued or challenged in real time. The RMU studies in particular contained significant methodological flaws and questionable economic assumptions that render their final conclusions suspect.

What the RMU Economic Studies Got Wrong

In 2014, an RMU study funded by Shell titled "Economic Impact Analysis: Proposed Petrochemical Facility in Beaver County, Pennsylvania" was widely cited by trade publications and local media outlets. (3) The report concluded that the construction of the facility would bring millions of dollars in economic benefits to Beaver County.³ According to one of the report's authors, the study was used by Shell as part of its application for subsidies to the state government of Pennsylvania. A follow-up study entitled "Updated Economic Impact Analysis: Petrochemical Facility in Beaver County, Pennsylvania" was released in 2021. (4) The second study was also funded by Shell and conducted by a second Robert Morris University research team that included two authors from the original 2014 study. Some assumptions and findings in the 2014 report were used as the basis to support assumptions made in the second report, despite the referenced original report data and findings no longer being publicly available.

The initial RMU study in 2014 was commissioned by Shell with the intent to be an independent analysis of the ethane cracker facility's regional economic impact. As noted, this study was not actually published until two years after the initial tax subsidy legislation had been approved by the Pennsylvania legislature. The study was conducted by a team of professors from the RMU School of Business who, as best as can be discerned, had no prior experience or major research publications in the petrochemical industry or in economic analysis of site selection.

The RMU study used a technique known as input-output (I-O) modeling, which is among the most common techniques used in economic development practices. These models are used to "project" the number of jobs a potential large new business investment will create for a regional economy, despite the fact that net economic projection is not what the technique was originally intended to be used for. The technique has been aptly described by David Passmore, a Professor Emeritus at Pennsylvania State University, as an "accounting exercise, not an

³ The authors of this report attempted to receive the full original 2014 report from the RMU research team, the RMU librarian, Shell, and journalists who cited the report and were unsuccessful. Because Shell financed the report, its authors were not permitted to release the full report independently. Shell's Investor Relations department noted that all publicly available information regarding the report, if available to the public, would be posted on its website. The report is not available on Shell's website as of this writing.

application of economics.” (21) The two most common I-O models are those found in software sold commercially by IMPLAN and RIMS which is used by the US Bureau of Economic Analysis (BEA). IMPLAN was used by the RMU authors.

I-O models generally overestimate the positive effects of large business openings because they rely on a series of simplifying assumptions to produce their results. **Table 1** presents a concise summary of some of these assumptions. (22)

Table 1. Key Assumptions of Input-Output Models that Can Bias Job Estimates

Model Assumptions:	Description:	How it impacts job estimates:
No price or wage effects for materials and workers	In markets, prices direct money and investment to the highest-value use. When a large shock occurs to a local economy, such as the construction and opening of a new mega-project, this can drive up prices for construction materials and labor (wages) by diverting them to the mega-project. Prices are not included in common I-O models, so they have no way to account for how rising wages and prices impact <i>other</i> businesses in the area.	When the price of materials or wages to local workers go up, it may cause other businesses to change plans for their own future investments. Smaller businesses may be priced out of hiring additional workers due to wage competition from the subsidized mega-project. As a result, there is likely an offsetting effect on the economy where the mega-project is located. Even though the mega-project creates direct jobs, it crowds out some jobs that would have been created anyway, absent the mega-project. The I-O thus overestimates, and results in the total job change, not the net job change for the region.
Constant returns to scale	I-O models typically assume that there are constant returns to scale for the mega-project. This means that an X% increase (or decrease) in their labor or inputs results in exactly an X% increase (or decrease) in their production.	This assumption ignores that for many operations, productivity is not constant. For instance, if a new local company is asked to supply Shell with inputs for the ethane cracker plant, it likely will not have the ability to instantly meet Shell's need without scaling up first. As a result, Shell may also use other non-local companies to fulfill its supply chain needs, reducing the number of indirect jobs it supports in the local economy. The I-O model does not capture this.
National, not regional, productivity values	I-O models assume linkages between industries. For instance, it might take 500 pounds of steel to produce 1 automobile. These linkages are national averages and do not account for the fact that some regions may be more efficient at producing automobiles due to more modern assembly facilities or may produce a make and model of automobile that requires less/more steel. Additionally, government regulations around safety, wages, or taxes may exist between different regions, states, and cities that influence productivity.	This assumption creates a “one-size fits all” model when the reality of business is more complicated. For example, if the price of steel rises, automakers may shift their production processes to alternative materials and substitute for steel. The productivity parameters of I-O models, which also lack prices, do not allow for this type of substitution in response to market changes and do not account for better (or worse) technology differences between regions. As a result, they may either over- or underestimate the number of workers needed at a mega-project site. Since firms often build new facilities to include the latest technology, I-O models most often overestimate the number of workers needed at a new facility.

<p>Perfectly elastic factors of production and no constraints</p>	<p>I-O models assume that if a new mega-project site needs a factor of production, such as workers, then those workers will appear in the region. If the region cannot directly supply them, then workers will migrate to the region.</p> <p>Additionally, I-O models assume that land is not a constraint. In some areas, such as rural areas, this may be a reasonable assumption. In more densely populated areas or in areas with strict land-use regulations this is not a reasonable assumption.</p>	<p>Similar to the “no prices” assumption of I-O models, this assumption ignores the impact that mega-projects have on the cost of labor (wages) and land prices.</p> <p>In reality, mega-projects compete for a limited pool of workers in the region with pre-existing local businesses. Even if more workers will migrate to the region, that process will take time. Additionally, if workers for a multinational corporation like Shell are forcibly transferred to the region by the company, they may not be the type of worker who will settle in the region long-term by buying property, paying taxes, or sending children to schools.</p> <p>Land prices impact other businesses in the region, such as farmers who may wish to expand and drive up the price of homes. This is of particular concern in areas where housing affordability is already a major concern.</p>
<p>No externalities or negative spillovers, like pollution, health costs, or declining housing values</p>	<p>I-O models do not account for any externalities, or side-effects, of mega-projects. This includes environmental and health costs to residents if a project emits large amounts of pollution, such as the Shell ethane cracker facility.</p>	<p>Because the cost to the public to clean up pollution or the damage done by the pollution that is paid for later (such as individual medical bills) is not factored into the economic impact analysis, the analysis appears more positive than it is. While a project might generate dollars for the local economy through employee income, it also may cost residents in ways unaccounted for by I-O models.</p> <p>Additionally, if a project is near homes it may have a hidden cost in the form of lower home values as fewer prospective buyers wish to buy property near a major industrial site.</p> <p>As a result, the I-O model overestimates the benefit to the region from the jobs a mega-project might create.</p>
<p>No better uses of foregone tax revenue</p>	<p>Economic impact studies that utilize I-O models do not account for alternative uses of tax dollars and how those uses might benefit the local economy.</p>	<p>This again overestimates the economic benefit of a mega project. The I-O model does not compare mega-projects to the true counterfactual—what the community might have done with the tax revenue or subsidy money instead of giving it to the corporation. For instance, if local schools received more revenue they may help attract more families to the region. Or, tax dollars could start a small business incubator that delivers more local economic impact than a large multinational corporation that supports operations out-of-state.</p>

The collection of assumptions presented in **Table 1** are not clearly addressed by the RMU studies that underpinned the rationale for the Shell facility in Beaver County. In fact, in the 2014 study the authors provide a list of assumptions in Exhibit A on page 19 of their report. [\(3\)](#)

The RMU explicitly assumes:

1. A five-year construction phase that does not overlap with the operating phase.
2. The site employs 400-500 workers directly

3. Shell's projected construction employment is correct
4. 100% of construction employees are Pennsylvania residents
5. 80% of construction workers and 90% of ethane cracker employees reside in the 10 county region of Southwest Pennsylvania.
6. There is enough construction labor mobility in the region to provide adequate labor
7. The multipliers and underlying accounting tables from IMPLAN are reliable

As Table 1 details, Assumptions 6 and 7 are built into most I-O models and the reality of such assumptions is debatable. Assumption 7, as this report will explore in a later section, was likely not reasonable given the national nature of such accounting tables and productivity parameters for the plastics industry are not necessarily applicable in Appalachia—a region where transportation of feedstock and product is more geographically difficult than, say, the Gulf Coast, for plastics producers. Additionally, as thoroughly detailed in Table 1, the assumption that IMPLAN multipliers were sufficient essentially acknowledges that the RMU study does not account for offsetting negative, or “crowding out,” effects on other businesses or residents in the region, such as higher prices for land, labor, or material and that there were no externalities such as pollution, health effects, or home price effects.

Assumption 2 notes that the total number of direct positions estimated “during the steady-state operations was anticipated to be in the range of 400 to 500” for the Shell site.⁴ This is actually a net loss of 150 to 250 jobs compared to the number of employees that were at the site before the zinc smelter was shut down, but meets the 400 minimum required for the site to qualify for 15 years of KOEZ tax exemptions. The exemption assumes that the jobs created by the Shell plant are considered to be “new” jobs since the site was cleared and the new plant didn't begin operations until 2022. Classifying a job as “new” is tricky. While individual county level data are unavailable for the specific industries related to the construction and operation of the ethane cracker due to non-disclosure from the US Bureau of Labor Statistics, it is true that Beaver County as well as the entire ten-county region that the RMU study examines lost jobs between 2015 and 2022. Beaver County specifically **lost** 2,296

⁴ In this study **direct jobs** refers to jobs created by the company primarily responsible for building and operating the project. **Indirect jobs** refers to the number of jobs created within the supply chain, upstream and downstream, by the project. **Induced jobs** refers to the jobs in the broader regional economy that are supported by direct and indirect workers spending income on goods and services in unrelated industries.

net total jobs – nearly five times the number of “new jobs” estimated to be created by Shell. The RMU study presents estimates of large dollar figures from estimated wages and additional income tax collected on the construction and operation income from the project and, per Assumption 7 above, assumes that these wages and tax revenues will support broader economic growth through economic multipliers. This has clearly not been the case, with a net job loss of thousands in Beaver County and the region at large during the plant’s construction and operation phases. The best-case scenario would be that the projected positives from the 2014 RMU study have made things “less bad” than they might have otherwise been—a far cry from stimulating true, sustainable economic growth for the residents of the area. As this report has noted, there are a multitude of reasons why broader economic growth has not materialized despite the substantial investment by Shell and the massive public subsidies supporting the project. Namely, the methodology used to project the economic benefits is an “all gravy” methodology that fails to account for offsetting financial and economic effects such as declining home values impacting property taxes or other business investment being crowded out due to competition with the ethane cracker project for labor, land and material.

The RMU Study Doesn't Consider the Opportunity Cost of Public Money

Strikingly, RMU studies do not refer at all to the KOEZ program or the feedstock cost subsidy, which combined to redirect millions of taxpayer dollars to the Shell project. Nor does it show a deduction of the taxes that are exempt for 22 years from its estimates of the tax revenues that would come into Beaver County. In this sense, the 2014 study’s projected positive tax revenues for the county are almost meaningless, since they are not a **net** projection that incorporates the exemptions given to Shell, including potentially lost revenue for local services and schools.

Another key consideration is that the RMU studies do not really compare apples to apples. The study methodology essentially estimates the forty-year economic benefit of the plant for the region and the state of Pennsylvania and then compares that to the economic conditions at the time of the report’s publication. This is a false comparison since, in reality, the money provided to Shell through the KOEZ and feedstock subsidy could be put to alternative uses that grow the economy, create jobs, and improve the quality of life for residents.

Effectively, the RMU study leaves the billions in cumulative public funds over 40 years off of the liability side of the accounting ledger in its analysis. This is perhaps the most egregious flaw of the study. If Shell were receiving no tax exemptions, then while the RMU assumptions could still be debated, it may be a much more reasonable set of estimates. However, the exclusion of any consideration of whether alternative uses of the billions in public funds might generate job creation in the region with fewer of the potential negative spillovers largely invalidated the estimates if the goal was to help decision-makers determine whether the ethane cracker plant was the best economic development strategy for the region.

One example alternative could have been to use public money to establish small business grants and incubators in the region. It is well documented in economic research that the economic multipliers for small businesses are substantially higher than large mega-projects. [\(5, 23-25\)](#) One reason why is that for multinational corporations, most of the high-paying, high-skill jobs, such as financial services, C-suite executives, or technology services, are located out-of-state at corporate headquarters. Additionally, larger corporations tend to leverage economies of scale and utilize national and international supply chains. This is not the case, generally, for small businesses or local start-ups, who use local supply chains more heavily and rely on locally based (or regionally based) workers. Another possible use of public funds could have been expanding worker retraining. Given that the region was a net job-loser in the 2015-2022 period, investing in workforce development for higher multiplier jobs, such as technology or high-demand skilled trades, may have also produced positive economic spillovers for the region. The concepts fall in line with an increasing call for economic development strategies that focus on quality of life. [\(26\)](#)

The RMU Estimates Don't Consider Pre-Existing Plastics Jobs

One of the key parts of the I-O jobs multiplier was an implicit assumption that more plastics manufacturing business would be created in the region to use the polyethylene from the Shell plant. The High Density PolyEthylene (HDPE) and Linear Low Density PolyEthylene (LLDPE) produced by the Shell facility are primarily used in consumer products like food packaging, bottles, trash bags, and containers. Notably, most of these types of products fall into

the disposable, “single-use” category that is increasingly subject to bans over concerns around pollution. As we will discuss, given that the study assumes a 40-year operational timeline for the ethane cracker but doesn't account for broader consumer attitudes and demand toward single-use plastics, the study likely overestimates the economic impact in the long run.

Other types of higher value plastic products, such as medical supplies and masks, and building materials such as PVC pipe require additional types of chemical “ingredients” that this plant doesn't make. The Shell project essentially allows existing plastics conversion businesses to potentially source their raw materials from a closer location rather than creating new materials that would support product line expansions. Some of the production will replace material produced at the former Sunoco ethylene plant at Marcus Hook, which was closed due to a fire in 2009. The I-O model used to justify the economic benefits of the plant inherently assumes that new indirect jobs will be created by the co-location of new plastics industry activity nearby the plant.

There is a potential freight savings, however, for pre-existing local plastics manufacturers, by having their raw materials produced locally. A 2017 IHS study about the prospects for petrochemical business expansion in Appalachia does an admirable job of estimating these freight savings, but also notes that Shell will likely have to discount their material in the early years due to competition from other suppliers with a wider choice of materials, and might need to export in spite of the market demand being greater than what they can produce. [\(27\)](#) IHS also notes that the cost of doing business in Appalachia is basically the same as the Gulf Coast, so the main selling point for regional ethylene producers is freight. Polyethylene pellets are very lightweight and not directly hazardous.

Ultimately, the feedstock tax credit is likely the key differentiator for ethylene production in the region, and it appears to offset most of the payroll cost of the direct jobs created by the plant. After removing the jobs from downstream manufacturing that already exist using raw materials from other locations, and considering offsetting taxes, it looks like the “net” for the State is an environmental negative with limited potential upside.

A 40 Year Time Horizon is Unrealistic

The RMU report uses a 40-year timeframe to calculate the economic benefits of the ethane cracker, as measured by total output, value added, labor income and state and local taxes. The Pennsylvania tax credits for feedstock consumption are slated to run from 2017 to the end of 2042 (21 years from the time the Shell plant actually began operations). The US Internal Revenue Service classifies chemical manufacturing as eligible for depreciation over only 9.5 years. Mechanical engineering experts who specialize in analyzing useful productive life of industrial assets note that “...many major components for power generation and petrochemical production were originally designed for only ten to 15 years of service.” [\(28\)](#) Given this, it is also notable that the Thai company PTTGC, which was considering a similar ethylene plant in Ohio during the time the Shell project was under construction, used a 15-year project lifespan when it analyzed a similar project for its Thailand operations. [\(29\)](#) This project was to build Thailand’s first ethane-based ethylene cracker back in the 1980s.

Although these facilities can and do operate for much longer than ten or 15 years, they require periodic major maintenance and replacement of costly critical components. These replacement investments require a new assessment of the economic conditions at the time. The challenges facing the virgin plastics industry in future years make it likely that the operating life of the Shell facility will be closer to the 22 years that are covered by the subsidies rather than the 40 years projected by RMU. Given the emphasis on greenhouse gas reduction and the fact that newly announced ethylene facilities, such as INEOS in Antwerp and Dow in Canada, are changing their designs to use electricity and reduce carbon emissions, it’s likely this facility would need significant changes to operate past the 2050 target for “net zero.”

Even the developers of the IMPLAN software, which the RMU study relied upon, noted that its software is not suitable for long-term forecasting. [\(21\)](#) Static input-output modeling simply cannot account for changing supply and demand scenarios in a global industry, and especially in an industry as volatile as petrochemicals.

The RMU Study Uses the Incorrect Industry Classification

The RMU report misclassifies Shell's petrochemical complex as a "Petrochemical Refineries" industry instead of a "Plastic Resin Manufacturing" industry within the IMPLAN software. This incorrect categorization likely inflated the potential economic impact.

The misidentification of the Shell petrochemical facility potentially led to unrealistically high estimates of economic benefits, according to Passmore, who provided an example. Petroleum Refineries generated \$7.2 million of output per worker, while Plastic Resin Manufacturing produced \$2.1 million of output per worker in 2020, according to their respective North American Industry Classification System (NAICS), which the US Census Bureau uses to categorize industries. While output by worker is an admittedly crude measure, the estimates of some economic benefits could have been overstated more than three-fold, Passmore noted. The market value of refined products is much higher than commodity plastic resin.

Conclusion:

In November 2022, Shell Chemical Appalachia Polymers opened its ethane cracker plant in Beaver County, Pennsylvania. Generous tax incentives were offered to the company, incentives that were crucial to the company's decision to move forward with a multi-billion petrochemical plant in Pennsylvania.

In the year since production officially started, the plant has been mired in problems. It has reported 26 malfunctions and received 13 notices of violation from the Pennsylvania Department of Environmental Protection. Given the Shell plant's public health and environmental impact in its first year of operation, it is time to consider whether the return-on-investment for Pennsylvania taxpayers has been positive.

It is also time to revisit two studies that have been cited to justify the tax incentives—in particular, two economic impact studies conducted by professors at Robert Morris University (RMU) School of Business, in 2014 and 2021, that were funded by Shell and appeared to support Pennsylvania leaders' decision to provide tax subsidies to the plant.

Though they were largely unchallenged when they were published, these RMU studies were deeply flawed. The RMU studies:

- relied on methodology, known as *input-output analysis*, that is not appropriate for long-term economic forecasting;
- failed to consider costs, including hidden environmental costs and opportunity costs;
- applied a 40-year time period to the project's economic benefits, which is beyond industry standards; and
- misclassified the Shell plant, thereby overestimating potential economic benefits.

These flaws in the RMU studies provided an inaccurate view of the economic benefits that might be created by the Shell plant. It deprived decision-makers and the public of a true evaluation of the economic prospects of Shell's plant.

This is a cautionary tale. As the true costs of the Shell plant come to light, policymakers would be wise to think twice about economic development project analyses funded by private companies seeking tax subsidies. Overly-rosy forecasts that don't explicitly consider costs have been used to justify expensive, taxpayer-funded projects by extractive industries in Appalachia. Leaders charged with allocating public funds must have a deeper understanding of how companies and analysts—especially those funded by companies seeking tax incentives—arrive at their rosy forecasts.

Policymakers must seek alternative economic development models that can provide broad-based, local economic benefits, like investments in workforce development, education, resident quality of life, environmental conservation, and high-multiplier small business activity. Policymakers that rely solely on industry-funded studies make bad bets. Pennsylvania residents deserve better.

References

1. Deto R. Shell cracker plant begins operation in Beaver County. TribLive [Internet]. 2022. Available from: <https://triblive.com/local/regional/shell-cracker-plant-begins-operation-in-beaver-county/>.
2. de Place E, Stone J. Updated: A Cautionary Tale of Petrochemicals from Pennsylvania. 2023 June.
3. Clinton S, Foreman S, Litzinger P, Minutolo MC. Economic Impact Analysis: Proposed Petrochemical Facility in Beaver County, Pennsylvania. 2014 December.
4. Clinton S, Minutolo MC, O'Roark B. Updated Economic Impact Analysis: Petrochemical Facility in Beaver County, Pennsylvania. 2021 April.
5. Tsvetkova A, Partridge M, Betz M. Self-employment effects on regional growth: a bigger bang for a buck? *Small Business Economics*. 2019;52:27-45.
6. Stonesifer J. Tax breaks given to Shell Chemicals 'essential' in attracting company to Beaver County. Times Online [Internet]. 2016. Available from: <https://www.timesonline.com/story/business/energy-resource/2016/06/19/tax-breaks-given-to-shell/18567370007/>.
7. Shell. Q1 2023 Earnings Call Transcript 2023 [updated May 8, 2023. Available from: <https://seekingalpha.com/article/4601509-shell-plc-shel-q1-2023-earnings-call-transcript>.
8. Shapiro Administration Secures \$10 Million Payment from Shell, Including \$6.2 Million for Local Community to Resolve Air Quality Violations [press release]. May 24 2023.
9. Fink RC. Shell's Ohio River Valley Cracker Plant Gets an "F" Grade 2023. Available from: <https://www.momscleanairforce.org/shells-cracker-plant-in-the-ohio-river-valley-gets-an-f-grade/>.
10. Pérez IGa. Shell Reviews Its Chemical Business as Performance Lags 2023. Available from: <https://www.bnnbloomberg.ca/shell-reviews-its-chemical-business-as-performance-lags-wsj-1.1931710>.
11. Lerner I. Shell's new ethylene cracker in Appalachia may be the first of several. Independent Commodity Intelligence Services [Internet]. 2011. Available from: <https://www.icis.com/explore/resources/news/2011/08/29/9488406/shell-s-new-ethylene-cracker-in-appalachia-may-be-the-first-of-several/>.
12. Mast E. Race to the Bottom? Local Tax Break Competition and Business Location. *American Economic Journal: Applied Economics*. 2020;12(1):288-377.

13. Liu A. Landing Amazon HQ2 isn't the right way for a city to create jobs. Here's what works instead 2018. Available from: <https://www.brookings.edu/articles/landing-amazon-hq2-isnt-the-right-way-for-a-city-to-create-jobs-heres-what-works-instead/>.
14. Mazerov M, Leachman M. State Job Creation Strategies Often Off Base 2016. Available from: <https://www.cbpp.org/research/state-job-creation-strategies-often-off-base>.
15. Florida R. Handing Out Tax Breaks to Businesses Is Worse Than Useless. Bloomberg City Lab [Internet]. 2017. Available from: <https://www.bloomberg.com/news/articles/2017-03-07/business-incentives-are-ineffective-and-wasteful>.
16. Nicholas D. Special Report on Possible Ethane Cracker Plants in WV, PA and OH. FrackCheckWV [Internet]. 2012. Available from: <https://www.frackcheckwv.net/2012/02/01/special-report-on-possible-ethane-cracker-plants-in-wv-pa-and-oh/>.
17. Samuel L. Potter Township: The forgotten player in bringing Shell Oil to PA. PublicSource [Internet]. 2012. Available from: <https://www.publicsource.org/potter-township-the-forgotten-player-in-bringing-shell-oil-to-pa/>.
18. Spanik J, editor Beaver County's Natural Gas Opportunity. Pittsburgh Regional Alliance; 2013 October.
19. Horsehead Corporation's Monaco Property Sold to Shell [press release]. June 15 2015.
20. Frazier R. Shell's ethane cracker, a mammoth plastics plant near Pittsburgh, begins operations. State Impact Pennsylvania [Internet]. 2022. Available from: <https://stateimpact.npr.org/pennsylvania/2022/11/15/shells-ethane-cracker-a-mammoth-plastics-plant-near-pittsburgh-begins-operations/>.
21. Passmore D. Notes from Pittsburgh [Internet] 2022. Available from: <https://davidpassmore.github.io/blog/ec/2022-04-26-robertm/>.
22. Partridge M, Messenger N. A Bigger Bang Approach to Economic Development. 2023 September 20.
23. Acs ZJ, Sanders MWJL. Knowledge spillover entrepreneurship in an endogenous growth model. *Small Business Economics*. 2013;41:775-95.
24. Birch D. Job creation in America: How our smallest companies put the most people to work.

University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. 1987.

25. Acs ZJ. How is Entrepreneurship Good for Economic Growth? *Innovations: Technology, Governance, Globalization*. 2006;1(1):97-107.
26. Austin JC, Weinstein A, Hicks M, Wornell E. Improving quality of life -not just business- is the best path to Midwestern rejuvenation. 2022 January 26.
27. IHSMarket. Prospects to Enhance Pennsylvania's Opportunities in Petrochemical Manufacturing. 2017.
28. Middleton C, Townsend RD, editors. An Overview of Remaining Life Assessment Methods for High Temperature Components Operating in the Power and Petrochemical Industries. *CORROSION* 98; 1998 March.
29. [Anon]. Feasibility Study Report for Ethylene and Vinyl Chloride Monomer Plants in the Kingdom of Thailand. 1981 April.
11. Mazerov M, Leachman M. State Job Creation Strategies Often Off Base 2016. Available from: <https://www.cbpp.org/research/state-job-creation-strategies-often-off-base>.
12. Florida R. Handing Out Tax Breaks to Businesses Is Worse Than Useless. Bloomberg City Lab [Internet]. 2017. Available from: <https://www.bloomberg.com/news/articles/2017-03-07/business-incentives-are-ineffective-and-wasteful>.
13. Nicholas D. Special Report on Possible Ethane Cracker Plants in WV, PA and OH. FrackCheckWV [Internet]. 2012. Available from: <https://www.frackcheckwv.net/2012/02/01/special-report-on-possible-ethane-cracker-plants-in-wv-pa-and-oh/>.
14. Samuel L. Potter Township: The forgotten player in bringing Shell Oil to PA. PublicSource [Internet]. 2012. Available from: <https://www.publicsource.org/potter-township-the-forgotten-player-in-bringing-shell-oil-to-pa/>.
15. Spanik J, editor Beaver County's Natural Gas Opportunity. Pittsburgh Regional Alliance; 2013 October.
16. Horsehead Corporation's Monaco Property Sold to Shell [press release]. June 15 2015.
17. Clinton S, Foreman S, Litzinger P, Minutolo MC. Economic Impact Analysis: Proposed Petrochemical Facility in Beaver County, Pennsylvania. 2014 December.

18. Clinton S, Minutolo MC, O'Roark B. Updated Economic Impact Analysis: Petrochemical Facility in Beaver County, Pennsylvania. 2021 April.
19. Passmore D. Notes from Pittsburgh [Internet]2022. Available from: <https://davidpassmore.github.io/blog/ec/2022-04-26-robertm/>.
20. Partridge M, Messenger N. A Bigger Bang Approach to Economic Development. September 20 2023.
21. Acs ZJ, Sanders MWJL. Knowledge spillover entrepreneurship in an endogenous growth model. *Small Business Economics*. 2013;41:775-95.
22. Birch D. Job creation in America: How our smallest companies put the most people to work. University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. 1987.
23. Acs ZJ. How is Entrepreneurship Good for Economic Growth? *Innovations: Technology, Governance, Globalization*. 2006;1(1):97-107.
24. Tsvetkova A, Partridge M, Betz M. Self-employment effects on regional growth: a bigger bang for a buck? *Small Business Economics*. 2019;52:27-45.
25. Austin JC, Weinstein A, Hicks M, Wornell E. Improving quality of life -not just business- is the best path to Midwestern rejuvenation. 2022 January 26.