Academic Peer Review of

"The Economic Impact of the Proposed Copper World/Rosemont Mine Complex on the Greater Tucson Area Economy"

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August 8, 2024

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I. Introduction

How will Pima County's residents benefit from Hudbay's proposed Copper World copper mining project? What harms will they suffer? Are the social and economic benefits large enough to offset the social, economic, and environmental costs? Economic science is well equipped to answer these questions. To this end, there is by now a large, peer-reviewed academic literature advising how to measure the benefits and costs of mining activity to nations, regions, and local communities.

The proposed Copper World project has been estimated to generate significant returns to Hudbay's lenders and shareholders. Once the project is approved and ready for construction the net value created is estimated to be between $771 million and $1.1 billion in present value terms.[1] Each dollar invested in the project will on average return 19.2% per year on a compounded basis for the remaining mine life.[2]

This is the business case for the project. Save the Scenic Santa Ritas is a group of 3,000 citizens "fighting to protect the Santa Rita Mountains from the devastating effects" of the planned Hudbay Copper World open-pit mining project on "the wild mountains that we love," arguing that the environmental costs of the mine outweigh benefits from the mine. The group recently commissioned economist Thomas Power and geologist Donovan Power of Power Consulting to analyze the socio-economic impact, i.e., the costs and benefits, of the proposed mine on the population in the greater Tucson area. Should the greater Tucson area similarly oppose the mine? Power Consulting's report, "The Economic Impact of the Proposed Copper World/Rosemont Mine Complex on the Greater Tucson Area Economy" (the "Power report") produces a list of benefits and costs associated with the project, mainly but not exclusively limiting their accounting to those occurring within Pima County, the county in which Tucson resides. While the Power report does not provide an opinion on whether the benefits of the mine to this community outweigh the costs, they tenor of the report would suggest that the community's "rational economic decision would be to oppose Hudbay's Copper World Project."

Thomas Power, the lead author of the study, is a Princeton-trained Ph.D. economist who has long advocated that traditional economic cost-benefit analyses of mining projects have placed

[1] "NI 43-101 Technical Report: Phase I Pre-feasibility Study and Updated Mineral Resource Estimates, Copper World Project" ("NI 43-101 PFS"), Hudbay, July 1, 2023, p. 22-1. Canadian mining firms are under specific scrutiny by Canadian securities regulators in order to protect investors from misleading public disclosures of technical information. An NI 43-101 report is a government-mandated technical report that must be issued by firms listed on Canadian stock exchanges when communicating technical information to the investing public. The format and contents of the report are set by Canadian securities regulators. The report must be prepared by a Qualified Person, a qualification that is also regulated by Canadian securities regulators. At the time the technical report is filed with securities regulators the Qualified Person must sign and file a corresponding Certificate that states, among other things, "that, at the effective date of the technical report, to the best of the qualified person's knowledge, information, and belief, the technical report, or part that the qualified person is responsible for, contains all scientific and technical information that is required to be disclosed to make the technical report not misleading." National Instrument 43-101 Standards of Disclosure for Mineral Properties, May 9, 2016.

[2] NI 43-101 PFS, op cit.

insufficient emphasis on the negative cultural and environmental impacts associated with mining.[3] This is a reasonable concern, as traditional economic analyses tends to limit their quantification of costs and benefits to those that are "marketed." Marketed costs and benefits have measurable quantities and market prices. But "non-marketed" costs and benefits should also be considered, even though possibly difficult to quantify. A major non-marketed cost of mining is environmental degradation at and in the immediate vicinity of the mine. Environmental degradation is non-marketed because environmental amenities are not typically priced by society and considered a cost in a mine's business case for development.[4]

I have been asked by Hudbay Minerals Inc. to comment on the economic merits of the Power report, with a particular emphasis on methodology. I have no direct or indirect financial, personal, or other involvement with Hudbay, now or in the past, and am therefore independent of the company. My biographical sketch is appended to this report.

After careful review I find that the Power report has not applied reasonable economic methods or analyses in its assessment of costs and benefits of the Copper Mine project to the Pima County community. The estimation of costs and benefits is incomplete, failing to consider both important benefit impacts and important cost impacts. References to existing literature on mining costs and benefits, from which inferences about the costs and benefits of the Copper World project are made, are dated and selective. Where the report conducts original analyses of costs and benefits of the Copper World project these are based on ill-defined premises that are not well stated or justified. The methods used when original data analysis is undertaken are lacking in empirical validity and do not meet standard academic practice. The report smacks of advocacy that downplays the economic benefits and accentuates the economic and environmental costs associated with the project.[5] As such, the report is of little use to a community and government wishing to rationally assess the costs and benefits of the proposed Copper World mining project.

In the remainder of this report I provide the basis for these conclusions.

II. Defining the Task at Hand

Being a quantitative science, an economic investigation of costs and benefits of an activity like mining must consider the bounds of the problem under examination. Those bounds have several facets.[6]

[3] https://www.powereconconsulting.com/about/. His resume with a list of authored works, last updated in 2010, can be found at https://www.powereconconsulting.com/vita/TMP%20VITA%202008.pdf.
[4] The inclusion of environmental costs in the planning process is instead passed on to governmental regulatory bodies for societal consideration when issuing permits to operate.
[5] This is not the first time that a report by Power Consulting has been accused of advocacy. See BBC Research & Consulting, "Socioeconomic Effects Technical Report – 2020 Update, Resolution Mine Environmental Impact Statement," September 14, 2020, p. 1.
[6] For a guide to appropriate cost-benefit analysis of mining projects, see Abelson, Peter, "Cost-Benefit Evaluation of Mining Projects," *Australian Economic Review* 48.4 (2015), 442-452.

1. **Who is the Affected Community?**

The first task is to determine the *social and spatial bounds* of the analysis. Such bounds could include the globe, a nation, a region, or a community proximate to the mining operation. The bounds serve to guide and parameterize the study.

Setting bounds at the outset of the study is important because the outcome of the analysis will depend on those bounds. Typically, the more proximate the bounds of the analysis are to the economic activity the higher the likelihood that costs outweigh benefits, as demonstrated by what has been called NIMBYism.[7] For example, one can imagine that a cost-benefit analysis of the net benefits of a new interstate highway would be negative if one limited the analysis to the neighborhood in which the highway was being routed, but positive if one considered the regional benefit to having a new transportation corridor and reduced traffic congestion. Likewise, with mining projects, the harvesting of metals from beneath the earth's surface produces a product that has value to society as a whole, as indicated by its price, but whose environmental costs are largely limited to the surrounding community. Limiting the analysis to only those negatively affected by environmental degradation proximate to the mine site is likely to result in costs that outweigh the benefits to that community.

The Power report has selected the approximately 1 million citizens of Pima County, the county in which the proposed mine is located, as the bounds for the analysis. A measurement of benefits and costs would then be limited to the benefits from the project that accrue to only these 1 million citizens, and the costs that similarly accrue to only these 1 million citizens. There is no scope for assessing the net benefits of the project to the other 6.4 million citizens of Arizona, or the nation as a whole, or the globe. The distinction therefore rules out any assessment of the benefits of adding to the national or global copper supply to satisfy the transition to renewable energy, for example.

The selection of measurement at the county level has the benefit that in the United States counties collect a relatively uniform set of economic statistics upon which economic analyses can be based. Any unit of measurement smaller than the level of a county limits empirical comparisons.

2. **What Do We Measure?**

Having determined who to include in our measurements, the next step is to determine *what* to measure. While measuring costs and benefits to Pima County sounds reasonable, determining what exactly to include in those measurements is

[7] NIMBY stands for Not in My Back Yard.

philosophically complex. Economic science is anthropocentric, focusing on humans and their well-being. How does one measure the aggregate well-being of the 1 million citizens of Pima County? And how does one measure the effect of the Copper World mining project on that aggregate well-being?

There are entire books written on this subject.[8] Focusing first on well-being, happiness might be a reasonable target. Despite economists' desire to use mainly market-based measures of well-being, there is ample economic literature on happiness and its measurement. Freedom from poverty, freedom from tyranny, access to quality education, access to local environmental amenities, and access to social programs may also be reasonable measures of well-being. Institutions like the United Nations collect and compare such measures across nations.[9] Because all of these are difficult to measure, however, especially at the county level, economists tend to focus on monetary measures of well-being, such as disposable wage and non-wage (i.e., investment) income, since income allows citizens to pursue their pleasures, avoid poverty and destitution, and even take actions such as buying indoor air filters to prevent exposure to environmental degradation. The provision by government of free or discounted services must then be priced and added to income, as these are equivalent to additional income through which such services can be purchased in the market. Additional county-level tax revenues from a project would thus be added to income under the assumption that such revenues would enable increased social programs or equally reduce the tax burden on income. Increased state level revenues may also flow back to the county, either as enhanced social programs or as reduced state income and sales tax rates, and these must be added as benefits as well.[10]

The next decision is how to aggregate across individuals. If a proposed activity would cause the impoverishment of half of the community but would financially enrich the other half, how would one assess the net effect of the community? Is a simple adding up of the loss of income to those who are harmed and the gains in income to those who flourish satisfactory? Aggregation has bedeviled economists for decades. Usually, however, an assessment of averages, as in per-capita income, is selected because of its ease of measurement.

The final decision is in what units to measure the effect of the proposed project on the well-being of the selected community. The usual decision is to convert costs

[8] See, for example, https://unstats.un.org/unsd/broaderprogress/pdf/How%27s%20life%20-%20Measuring%20well-being.pdf.

[9] The most well-established of these is the Human Development Index, a measure of the ability of a nations' citizens to live a long and healthy life, be knowledgeable, and have a decent standard of living. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.

[10] A study of state-level government receipts of resource tax revenues finds that states with higher revenues have decreased income and sales tax rates. James, Alexander, "US State Fiscal Policy and Natural Resources," *American Economic Journal: Economic Policy* 7.3 (2015), 238-257.

and benefits into monetary terms, as a present value of cost and benefit flows over the life of the program. Benefits are usually already in monetary terms, but costs are not. Economists have many accepted techniques for translating non-marketed costs in this type of cost-benefit analysis into the same monetary units as benefits are measured, such that a net benefit or cost, in monetary terms, can be determined.

Many impact analyses stop short of converting benefits and cost into a single numeraire (e.g., dollars) so that benefits and costs can be directly compared. Instead, they enumerate relevant benefits and costs separately.[11] Benefits could include additional regional employment, wage income, GDP, and tax receipts, both directly from the mining operation and indirectly through stimulated or knock-on effects called multipliers. Corporate social responsibility programs by the mining firm can also provide additional services beneficial to the community. Costs can include increased economic volatility in the region due to commodity price movements that affect employment and fiscal revenue flows, effects of tourism and recreation, water pollution, air pollution, inward or outward migration, impacts on property values, water scarcity, reduced agricultural lands, increased crime, lost cultural artifacts and heritage, and disturbances to the visual horizon. The community is then left to assess its preferences over these listed benefits and costs in coming to a decision as to whether it will support or reject the mining project.

The Power report has no discussion of what to measure and why the measures it selects are useful and appropriate. It haphazardly selects jobs and taxes as benefits, ignoring wage earnings, GDP and GDP growth. It selects housing prices, out-migration, environmental amenities, reductions in non-mining economic activity, water scarcity, and truck traffic as costs. There is no uniform monetization of the measured benefits and costs such that they can be compared or aggregated into a net benefit assessment.

3. **Over What Time Period Do We Measure?**

The development and operation of a mining project takes decades. The Copper World project is planned to undergo 3 years of construction, followed by 20 years of production and 5 years of closure. A second phase of mining could extend the mine life an additional 28 years.[12] Measurement of costs and benefits would reasonably be estimated on a pro-forma basis for the duration of the project.

[11] See BBC 2020, op cit., and W.P. Carey School of Business, Arizona State University, "The Florence Copper Project: Economic and Fiscal Impact," March 1, 2024.
[12] NI 43-101 PFS, op cit., p. 2-1.

Benefits and costs may, however, continue after the project ceases. Consider, for example, the possibility that the project's tax payments to the community allows the construction of a new school. The duration of the school's benefits to the community would outlast the duration of the project. Should only the current tax receipts during the project's life be counted, or should the continuing benefit to the community after the project ends also be counted? Or, conversely, if environmental damage is permanent, should that not also be considered?

The Power report does not comment on the period of analysis. In certain instances it defaults to the 20 year life of the project when taking data from the project's technical reports. The technical report in fact determines that there will be activity at the site for 55 years even if the expanded mine plan is not undertaken.[13]

4. **How Do We Account for Uncertainty in Measurement?**

Benefits and costs from a proposed mining project must be estimated based on technical and socio-economic studies. These projections are typically expected or average outcomes, around which variance will occur. Economists hold that individuals are risk averse, meaning that they prefer certainty to uncertainty. Benefit-cost analysis must account for uncertainty associated with the projections of benefits and costs.

The Power report mentions future copper price uncertainty and uncertainty about the future mining plan, but does not assess or quantify the impact of this uncertainty on the benefits and costs of the project.

III. Accepted Empirical Techniques for Implementing the Task at Hand

The next step in a study of costs and benefits is to implement the assessment of the selected benefit and cost outcomes over the selected community for the selected period of analysis.

Since the Power report fails to declare a unit of assessment and period of assessment, it embarks on this part of the task in a disjointed and unmethodical manner. I will comment on individual aspects of the report below, but I first outline five widely accepted empirical techniques for assessing the prospective impacts of mining on surrounding communities.

1. **Input-output Analysis**

The gold standard for measuring direct prospective impacts of a new economic activity like a mining project on a specific community is input-output analysis.

[13] Ibid, p. 22-8.

Input-output analysis was developed in the 1970s to account for the direct, indirect, and induced effects of a project or activity on a community. Its development is credited to economist Wassily Leontief, who was awarded the Nobel Prize in economics in 1973 for his work.

Input-output analysis can measure expected changes in total economic activity, GDP (also known as value added), employment, wages and salaries (i.e., income), and government tax revenues in a selected community in response to the initiation of a project by using actual measured relationships between existing businesses and suppliers of inputs to those businesses within that specific community. It is commonly applied to assess regional impacts of mining activity.[14] It does not measure non-marketed costs such as environmental degradation, but provides a basis of benefits from which such costs can be compared.

The Power report does not consider or implement this methodology, even though Power Consulting has used the technique in estimating direct and secondary effects of the Resolution Copper mine in nearby Superior, AZ.[15]

2. **Computable General Equilibrium Analysis**

Computable General Equilibrium (CGE) modeling of direct prospective regional project impacts on a specific community is a recognized and popular version of input-output analysis that includes negative feedback effects arising from changes in equilibrium prices. It also allows for the intertemporal dynamics of a project, such as construction and then production, as well as the negative impact of environmental accidents during production.[16]

The Power report does not consider or implement this methodology.

3. **Econometric Estimation**

Econometric estimation techniques test historical relationships between the variable of interest and an economic activity at a local, regional, or national level via analysis of historical data patterns. These estimations are then used to project

[14] See, for example, Ejdemo, Thomas, and Patrik Söderholm, "Mining Investment and Regional Development: A Scenario-based Assessment for Northern Sweden," *Resources Policy* 36 (2011), 14-21.
[15] BBC Research & Consulting, op cit. BBC classifies the Power Consulting work as "advocacy analyses," and classifies its own estimation as an "independent, third-party assessment."
[16] See, for example, Törmä, Hannu, Susanna Kujala, and Jouko Kinnunen, "The Employment and Population Impacts of the Boom and Bust of Talvivaara Mine in the Context of Severe Environmental Accidents – A CGE Evaluation," *Resources Policy* 46 (2015), 127-138.

the impact of a new economic activity on a selected community.[17] The technique is less reliable that direct input-output or CGE analysis because tested average relationships across other communities do not necessarily reflect the specific relationship in the study at hand due to geographical and social differences across communities.

Most of the econometric studies identifying historical costs and benefits of mining projects on local communities focus on rural communities in developing economies. Of relevance here is the impact of the Copper World project on an urban community. I am aware of only two econometric studies that include estimated impact of mining on urban communities in the United States. The first is a 2011 study of the annual per capita personal income growth in 3,092 counties in the United States.[18] Counties with higher wages in mining, agriculture, forestry, fishing, and other resource industries on average had statistically slower income growth from 1980 to 2005 than counties with lower resource earnings after controlling for other factors that could cause differences in income growth across counties. Income in counties in Arizona that had increased earnings from resource industries, however, exhibited faster growth, bucking the national trend. The study did not estimate whether the effect is different in urban versus rural counties.[19]

The tendency for slower economic growth in communities or countries with substantial natural resource industries has come to be known as the Resource Curse. Subsequent analysis has determined that the previously measured slower growth is a statistical mirage related to short-run contractions of the resource sector over the measurement period and should not be of concern for long-run growth in economies dependent on resource extraction.[20]

A second study examines the role of entrepreneurship on the rate of urban employment growth in US cities.[21] Entrepreneurship has long been held to be beneficial to economic growth in cities.[22] Cities with more entrepreneurship did

[17] See, for example, Moritz, Thomas, Thomas Ejdemo, Patrik Söderholm, and Linda Wårell, "The Local Employment Impacts of Mining: An Econometric Analysis of Job Multipliers in Northern Sweden," *Mineral Economics* 30 (2017), 53-65.
[18] James, Alexander, and David Aadland, "The Curse of Natural Resources: An Empirical Investigation of U.S. Counties," *Resource and Energy Economics* 33 (2011), 440-453. The US has 3,144 counties. 52 of these were omitted from the study because of missing data.
[19] It did, however, control for the fact that urban counties may have different earnings growth than rural counties for reasons other than natural resource production. The estimate of the impact of natural resource growth on production is net of these other reasons for differences in growth.
[20] James, Alexander, "The Resource Curse: A Statistical Mirage?" *Journal of Development Economics* 114 (2015), 55-63.
[21] Glaeser, Edward L., Sari Pekkala Kerr, and William P. Kerr, "Entrepreneurship and Urban Growth: An Empirical Assessment with Historical Mines," *Review of Economics and Statistics* 97.2 (2015), 498-520.
[22] Chinitz, Benjamin, "Contrasts in Agglomeration: New York and Pittsburgh," *American Economic Review Papers and Proceedings,* 51.2 (1961), 279-289.

indeed have stronger employment growth from 1982 to 2002.[23] Of relevance to Copper World, cities with more mining projects within 500 miles of the city in 1900 had less subsequent entrepreneurship and as a result less employment growth due to mining's assumed crowding out of entrepreneurial activity. The inference here is that the Copper World project may inhibit long run growth in Pima County employment by suppressing entrepreneurial activity within the county.[24] This effect points to my earlier suggestion that a time frame must be adopted over which to measure benefits and costs, and that the appropriate time frame may well extend beyond the mine's life.

Studies of the effect of increased oil and gas extraction on U.S. county welfare, on the other hand, find positive effects. In one study increased oil and gas production in U.S. counties increases cumulative local welfare and wages, while decreases in oil and gas extraction had the opposite effect.[25] In a second study oil-abundant counties in Texas, Louisiana, and Oklahoma had higher employment, higher population growth, higher per capita income, and better infrastructure than neighboring counties that did not have oil production.[26] While oil and gas production is not the same as mining production, an accounting for measurable economic costs and benefits tends to show that increased extractive activity has a positive overall effect on a county. From this, negative non-marketed costs must be deducted to deduce overall net benefits.

4. **Survey-based Methods**

Another direct measure of benefits and costs of mining in an urban area is a survey of urban residents' opinions about a new mining operation. Are residents in favor of or opposed to the new Copper World mine? It is evident that the 3,000 members of the Save the Scenic Santa Ritas Association are opposed to the mine, but what of the other 997,000 residents of Pima County? A survey would answer that question. The Power report did not undertake such a survey.

In the absence of a direct survey a proxy survey may provide useful. Utah's Salt Lake City is approximately the same size as Tucson, and Rio Tinto's Kennecott mine is visible in the community and has an effect on locals. Survey responses from 628 randomly selected Salt Lake City residents about a hypothetical new

[23] Glaeser et al., op cit.
[24] If this is the case, the appropriate policy response by Pima County governance is to use some of the mine tax revenue to incentivize local entrepreneurial activity such that this negative effect is offset. The Glaeser et al. study is careful to point out that the decline in entrepreneurship does not mean mining is harmful overall to a city; "mines over the long haul presumably yielded plenty of economic benefits as well" (p. 518).
[25] Allcott, Hunt, and Daniel Keniston, "Dutch Disease or Agglomeration? The Local Economic Effects of Natural Resource Booms in Modern America," *Review of Economic Studies* 85 (2015), 695-731.
[26] Michaels, Guy, "The Long Term Consequences of Resource-Based Specialisation," *Economic Journal* 121 (2010), 31-57.

mine within their community with 16 possible attributes, both positive and negative, found that amongst positive attributes job creation was most important; residents preferred a mine that created 900 jobs and no increase in income for all local residents as opposed to 600 jobs and a $200/month increase in income for all local residents.[27] The result is surprising given that 300 jobs is relatively minor relative to the size of the community related to $200 million per month in additional community income across all residents. Residents were also more receptive to a mine that provided independent and transparent information on potential impacts of the mine, infrastructure improvement (transportation, education, human services, and internet via corporate social responsibility programs and local tax revenues), a mine distant from homes, and a mine that does increase local incomes to some degree as opposed to one that does not.

In terms of costs, respondents were most concerned with increases in housing costs, air pollution, noise pollution, and crime.

Proposed mine attributes and effects that were statistically significant but of lessor import included mine life, traffic increase, land pollution, labor shortages for other businesses, water pollution, population increase, and the governmental permit approval decision making mechanism. Demographically, male and older residents with higher levels of education and income are more likely to approve of a new mining project relative to the status quo, though the individual attributes of the mine are much more important than demographic makeup in whether it gains acceptance from the community.

Figure 3 from that study is reproduced below. The vertical axis is the DCM (discrete choice model) coefficient, a coefficient that numerically indicates the importance of the attribute. The positive attributes score between 0.5 and 1.0, while the negative attributes score between -1.0 and -1.5. This indicates that survey participants are more attuned to the negative attributes from the proposed project than the positive attributes from the project. All of the attributes listed are statistically significant (horizontal axis).

[27] Que, Sisi, Kwame Awuah-Offei, Liang Wang, V. A. Samaranayake, Nathan Weidner, and Shaochun Yuan, "Individual Preferences for Mineral Resource Development: Perspectives from an Urban Population in the United States," *Journal of Cleaner Production* 189 (2018), 30-39.

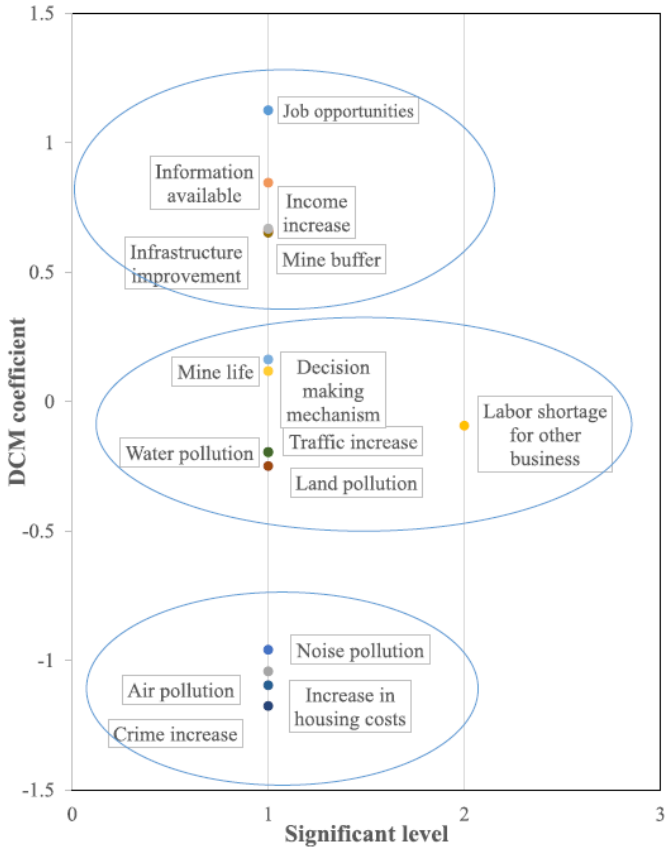

Fig. 3. Discrete choice model result.

The Power report estimates several of these positive and negative aspects of the Copper World project and infers Pima County residents' opinions on these without surveying the residents, and without using as an inference the responses to a proposed mine project by these Salt Lake City residents. In fact, the Power report dismisses as largely irrelevant to Pima County residents the job growth estimated to be result from the project because of its small number of new jobs (430) relative to the size of the county economy. The survey evidence from the Salt Lake City study indicates that this inference is probably incorrect.

5. Multiplier Analysis

The final empirical technique is multiplier analysis, which takes the output of other input-output, CGE, or econometric analyses of the impacts of other mining projects and computes various multiplier effects that can then be applied to other benefit-cost analyses in the same region. For example, Moritz et al. (2017) estimate that in northern Sweden if the number of jobs in mining increases by 10

an additional 8.5 jobs are created in other industries in the same municipality.[28] The jobs multiplier here would be 1.85.[29]

In multiplier analysis the estimated multiplier is specific to the region and time period of analysis, and the application of this same multiplier to other regions (in this case, other Swedish municipalities) would provide only a rough approximation of the total job effect of a new mining venture. Applying the same multiplier to Pima County in the United States would be inappropriate.

The Power report does not directly estimate a jobs multiplier or any other multiplier for the Copper World mining project using any of the above techniques. Rather, it references mining multipliers from other studies and infers that the Copper World project would create similar multipliers. One study it cites, of industrial mineral mines in LaSalle County, Illinois, determines a multiplier in that county of 2.41.[30] Another cited study, in Australia, found local mining multipliers that were statistically no different from 1 (indicating no secondary employment effects) in some economic sectors and as high as 1.5 in others.[31] The overall mining jobs multiplier in mining regions was 1.4. A study for the Resolution Copper Mine in Superior, AZ, estimated a regional jobs multiplier of 2.44 and a labor income multiplier of 1.88. The study further estimated the multiplier effect for the town of Superior alone, and for each of Pinal, Gila, Graham, Maricopa, and Pima Counties. The larger the area of analysis, the larger the multiple because more knock-on effects are included.

The Power report uses these three multiplier estimates only to challenge Hudbay's estimate that the 430 direct jobs at the mine would create up to 3,000 secondary jobs with Pima County, a multiplier of 8.[32] It does not use them to independently assess the potential job growth associated with the proposed mining project. Nor does it conduct an original analysis of the multiplier effects of the Copper World

[28] Moritz et al (2017), op cit. Moritz et al., in stating the multipliers in their analysis, refer to this as a 0.85 multiplier.
[29] See https://blog.implan.com/understanding-implan-multipliers for other examples of multiplier calculations. A multiplier of less than one would indicate that the project on net destroys jobs in the community.
[30] Harger, Brian, "Economic Impact Analysis, The LaSalle County Mining Industry," Center for Governmental Studies at Northern Illinois University, March 2015. Industrial mineral mining in the study includes construction aggregates (sand, gravel, crushed stone), silica sand, and cement manufacturers. It does not include copper mines.
[31] Fleming, David A., and Thomas G. Measham, "Local Job Multipliers of Mining," *Resources Policy* 41 (2014), 9-15. The sectors that had statistically significant local multiplier employment effects were: wholesale trade; accommodation and food services; transport, postal and warehousing; financial and insurance services; rental hiring and real estate services; and services not otherwise specified. The Power report draws attention to the fact that the reported multiplier on arts and recreation services is less than one, indicating job loss in that sector as a result of mining job growth. That result has a large standard error associated with its estimation and is not statistically significant. The appropriate interpretation of the result would be that there is no statistically significant multiplier effect in that sector.
[32] NI 43-101 PFS, op. cit., p. 1-18. The Power report curiously identifies this multiplier as 7.

mine on Pima County. I will comment further on this criticism of Hudbay's multiplier analysis later in the report.

IV. The Power Report's Implementation of the Task at Hand: Irrelevant Analyses

The Power Report does not define what benefits should be measured, how they should be measured, or over what time period they should be measured. Rather, it presents a scattered series of observations.

I begin by identifying the six Power report observations that are irrelevant to the task at hand.

1. **Copper is Not a "Critical Mineral"**

   Hudbay, in making the business case to its investors, has stated that the copper produced at the Copper World is a key element in the global decarbonization effort and the shift to renewable energy sources.[33] It expects its on-site copper cathode production to be sold entirely to domestic copper consumers to meet the growing demands for copper in the U.S.[34]

   The Power report takes issue with any inference by Hudbay as to the criticality of copper supply for the U.S., stating that copper is not "critical" to the green energy revolution. Criticality is a definition that indicates that the mineral serves an essential function in the production of energy transition technologies. The Power report criticizes the U.S. Department of Energy's analysis that copper is "near critical" in the medium term given that the US Geological Survey does not classify copper as critical as of its latest (2023) report on critical minerals.

   Whether or not copper is critical for the green energy transition is irrelevant to a benefits analysis limited to Pima County. It is, rather, a national policy planning concern regarding production incentives, trade protections, and other policy measures.

2. **Copper World's Copper Concentrates Will Be Shipped to China for Refining**

   Along this same line, the Power report takes issue with Hudbay's "made in America" branding of copper to be produced at the Copper World project. The Power report estimates that copper concentrates produced at the mine will likely be shipped to China for refining. The ultimate destination for refining of the

[33] https://hudbayminerals.com/united-states/default.aspx.
[34] Ibid.

Copper World concentrate is irrelevant to a cost-benefit analysis of the project to Pima County other than through the benefit of new jobs necessary to ship the product and the environmental cost of increased truck traffic to ship the concentrate.

3. Most of the Money Generated by the Project Does Not Stay in the Community

The Power report claims that most of the money generated by mining projects does not stay in the community. While I am skeptical of the word "most," it is true that in return for fronting the $1.7 billion in capital cost necessary to develop and construct the mine, mill, and leach plant, profits generated by the mine are returned to shareholders in compensation for their investment – the community has no rightful claim on these profits. But this is an irrelevant fact that holds for any investment in a local community by an outside agent. What is pertinent for a benefit analysis is taxes paid to local government, mine inputs purchased locally that stimulate local employment, and upward pressure on housing markets that enriches existing homeowners.

4. Competition for Water

The Power report draws attention to the fact that Colorado River flows are dropping. It reviews the Colorado River Compact, Arizona's Groundwater Management Act, and The Central Arizona Project, none of which it links to Pima County's water needs. The Copper World Project will not draw from the Colorado River, but from wells on the western side of the Santa Rita Mountains that tap the upper Santa Cruz Basin. The main draw on water is the sulfide concentrator, which, after taking into account recycled water, will draw an average of 5,100 acre-feet (1.7 billion gallons) of water per year from underground wells over the mine's life. For comparison, Tucson Water delivers nearly 30 billion gallons of water each year to its 722,000 customers, a blend of groundwater and Colorado River water.[35]

The Power report identifies water scarcity and use in Arizona in general, making broad remarks as to the mine's use of water interfering with other existing water rights, threatening public safety, and threatening public interest and welfare as local wells dry up. It speculates that municipal wells around the proposed mine, including specifically in the towns of Green Valley, Sahuarita, Vail, and Corona de Tucson, would have less water available. There is no direct or indirect

[35] https://www.tucsonaz.gov/Departments/Water/Water-Quality/Water-Quality-Monitoring/Drinking-Water-Distribution-System. The city draws approximately 104 acre-feet per year from the Colorado River, equivalent to 1% of the city's annual water consumption, and stores some of this for future use. https://www.kgun9.com/news/local-news/the-future-of-water-for-tucson-and-marana-residents.

evidence presented that water shortages will fall on these Pima County residents, and nor on other residents of Pima County, and so the speculation as to competition for water is irrelevant.

5. Productivity Improvements in Mining Have Lowered Mining Employment

The Power report notes that productivity at mining operations from 1860 to 2010 has lowered the amount of labor needed to mine and process a tonne of rock, resulting in "a huge loss of jobs." It is curious that the development of highly mechanized mining equipment that removes workers from dangerous mining activities and improves worker productivity and worker wages would be considered a negative factor in an economic impact assessment of mining. By the Power report's reasoning, were miners to use picks and shovels to mine at Copper World, the project would be a more beneficial activity within a community because it would take 100 times more workers to mine the copper at the Copper World mine than is planned.[36]

The analysis is in any event irrelevant. The fact is that the proposed Copper World mine, with its use of modern mechanized mining and processing equipment, will generate 430 full-time jobs over its mine life, and it is this quantity that is injected into the cost-benefit analysis.

6. Taxes to State and Federal Governments

In a benefit-cost analysis of the project to Pima County, direct and induced tax payments to state and federal governments are largely irrelevant, as only a small portion of those payments will be directed back to government services provision in Pima County. The Power report's analysis of the project's projected tax payments to state and federal government as "trivial" is therefore irrelevant to the task at hand. If it wanted to include flows to state and federal governments as a benefit it should assess the extent to which these flows will generate benefits for Pima County residents.

V. The Power Report's Implementation of the Task at Hand: Broad Inferences About Costs and Benefits of Mining

The Power report's analysis begins with the proposition that mining has on average negatively affected nearby communities worldwide, and also in Arizona. It infers, but never directly claims, that as a result Pima County will be harmed by an increase in mining activity.

[36] The 100 times factor is cited in the Power report, p. 20.

In making the first point the Power report refers to a single 2002 study on the effect of mining on economic growth in nonmetropolitan areas.[37] I noted earlier that most studies of mining impacts focus on nonmetropolitan areas because these are most susceptible to negative impacts from mining. That study qualitatively reviews 19 prior analyses, some empirical, some anecdotal, of the outcomes of poverty, unemployment, and income in mining-intensive nonmetropolitan regions in the United States vs. comparable nonmetropolitan regions that are not mining-intensive.[38] The Power report notes that in the 19 studies' results negative impacts of mining were twice as likely to be estimated as positive impacts of mining. It is not clear why the Power report would cite this study of non-metropolitan outcomes to infer the effect of the Copper World mine on the welfare of citizens in Pima County, an urban county. Moreover, the 19 studies' outcomes vary systematically by region. In the West, where Pima County is located, the majority of outcomes are favorable.[39] The Power report does not note this distinction in inferring how mining might affect Pima County. In my opinion this 2002 study of trends is of limited use in inferring how modern mining operations would impact Pima County.

The Power report then conducts its own study of trends, compiling data on growth in total income, labor earnings, per capital income, and population from 1980 to 2010 in what it identifies as 100 mining counties in the United States. It compares that growth with growth in these same indicators in 3,000 counties that it did not identify has mining counties. It finds that the indicators in the mining counties grew more slowly than in the non-mining counties, though it appears to report only the selected time periods over which these negative results occurred.

Economists frequently conduct this type of analysis, but in a formal econometric approach that controls for other factors that can affect growth. The Power report's analysis in not an econometric approach, but instead a simple comparison of averages. It is not, therefore, a reliable statistical analysis and would not survive peer review at any academic economic journal.

The Power report adds to his comparison of averages gratuitous statements about coal mining's negative impact that are irrelevant to an analysis of copper mining's contribution to Pima County. It notes that coal-county unemployment and poverty rates are unusually high. Coal production in the United States has dropped by 54% between 2005 and 2020, with mines shutting down and laying off their labor force.[40] This has had a negative impact on coal counties, and this negative impact skews any inference that mining counties in general have higher unemployment and poverty rates.

It ends this summary of negative impacts by comparing growth of various economic outputs in several mining counties in Arizona with growth in Payson County, Pima County and the US overall, and notes the former have grown more slowly than the latter. The analysis compares simple averages without controlling for the many other factors that are known to cause urban centers to growth faster than rural centers. The analysis would not withstand peer review as

[37] Freudenburg, William R., and Lisa J. Wilson, "Mining the Data: Analyzing the Economic Implications of Mining for Nonmetropolitan Regions," *Sociological Inquiry* 72.4 (2002), 549-575.
[38] Ibid.
[39] Ibid, Table 2.
[40] https://www.arc.gov/wp-content/uploads/2021/04/Coal-and-the-Economy-in-Appalachia_Q4_2020-Update.pdf.

being informative to any analysis of the likely impact of mining on Pima County. Formal statistical techniques must be used in any serious study of mining's impact on regional economic growth.[41] It may be that mining has caused rural mine-based counties in Arizona to tend to have slower growth, but this provides little to no useful information as to how Pima County would respond to increased mining activity within the County.

VI. The Power Report's Implementation of the Task at Hand: Estimation of Benefits

The Power report limits its analysis of actual, measurable benefits in Pima County to two impacts, job creation and tax revenues.

1. **Direct Job Creation**

   Communities appear to view job creation as a positive aspect of a proposed mining project.[42] Benefits may include direct employment of unemployed individuals within the county, job growth and additional employment in other sectors through multiplier effects, and increasing regional wages due to increased demand for labor. The Copper World prefeasibility study estimates that 430 permanent operating jobs will be created at the mine, with an additional 3,000 secondary jobs created within Arizona. It does not estimate how many of these secondary jobs would be located in Pima County.

   The Power report considers Hudbay's assertion that 430 new jobs will be created, and recognizes that mining employment in Pima County has higher pay than non-mining employment. One of the Power report's concerns is that these jobs will not be filled by Pima County residents.

   Whether these direct and secondary jobs will be filled by and therefore benefit current Pima County residents has not been determined through any economic analysis.[43] Multiplier analysis simply tallies up jobs created in a region, and does not identify who will fill those jobs. It may be that workers will relocate to Pima County to take up these jobs, or they may commute to Pima County. Whether this

[41] See, for example, the peer-reviewed studies referenced in Section III.3 above.
[42] Que et al., op cit.
[43] One must be careful with the analysis here. New jobs in the mining industry are a combination of skilled and unskilled workers. A skilled or unskilled worker may move from their existing job at firm A into the new mining job. Firm A may then hire a worker from firm B to move to Firm A. Firm B then hires a worker from Firm C, and so on. Firm C may well be outside of Pima County, so that while the mining job is filled by a Pima County resident, no new jobs are created within the County. With unemployment rates currently near the natural rate, it is unlikely that the 430 new jobs will be filled by unemployed workers from Pima County. Competition for labor is a negative impact that I mention later in the report.

would be counted as a benefit to Pima County (in terms of increase wage spending and multiplier effects within the county), or whether the population growth would be counted as a cost, has also not been determined. I infer from the Power report that jobs taken up by non-Pima County residents would not be counted as a positive benefit to Pima County.

There has been limited empirical analysis of the effect of increased mining activity on employment uptake by county residents. In a study of coal mining counties in Kentucky, Ohio, Pennsylvania, and West Virginia, increased coal production in a county led to increased employment of coal workers within that county and increased earnings per worker, along with increased employment of workers in other sectors.[44] In-migration filled some of the increased job opportunities, with most of this being prime-aged men who had previously left the county due to poor job prospects returning to their place of birth.[45] It is reasonable to assume that at least some of the 430 new job opportunities associated with the Copper World project, along with secondary job increases in other sectors, will benefit current and possibly returning former residents of Pima County in terms of new jobs and increased earnings.

Another concern of the Power report is that there may be a net *loss* of jobs in Pima County as a result of a decrease in net in-migration to the county due to lost environmental amenity services associated with the mining project. The thinking here is that newcomers bring with them large amounts of passive income, which is spent in the service sector and drives up the demand for service sector jobs. The essence of this argument is that there is a negative jobs multiplier effect that could cause a new mining venture like the Copper World project to reduce overall jobs in the region. I am not aware of any study that shows that new mining activity in a region reduces the total number of jobs in that region via a negative multiplier effect. The proposition is therefore not only speculative, but unsupported by historical patterns in mining communities in the United States.

The Power report's additional concern with job creation is that the direct and secondary effects in terms of both numbers of jobs and total employment earnings are trivial in terms of Pima County overall employment and earnings. This is a strange stance to take. By this reasoning no economic activity in Pima County that creates 430 well-paying jobs should be viewed as being significantly beneficial to the county. It is also contrary to Dr. Power's previous concerns that the worst place for a new mining project to be undertaken is in a rural area where the mining activity will dominate employment and economic activity in the area.[46]

[44] Black, Dan, Terra McKinnish, and Seth Sanders, "The Economic Impacts of the Coal Boom and Bust," *Economic Journal* 115 (2005), 449-476.
[45] Ibid.
[46] https://www.youtube.com/watch?v=eM8eusGGiCk&ab_channel=JPRennquist.

Under this logic it is beneficial that the Copper World project will not turn Pima County into a mining mono-economy because of the project's small size relative to the overall county economy. And yet now Dr. Powers is arguing that a new mining project in an urban area creates too few jobs relative to total employment to have meaningful benefit to the region. This type of inconsistency of analysis is what causes the report to smack of advocacy.

The Power report is also concerned with copper price volatility and the fact that the Copper World project may not be sustained for the entire planned project life. If the mine temporarily or permanently shuts prior to the exhaustion of the copper ore the increased jobs will be lost. There is ample economic evidence of booms and busts in the mining industry causing job increases and job decreases, respectively, within a region.[47]

It is true that copper prices are volatile, and that mines plan for operations based on what they view as an average or expected price over the project's duration. If prices rise, the mine may expand its orebody and increase production as more ore becomes economic. If prices fall, it may shorten the planned mine life or reduce output. These actions will cause direct job opportunities to rise and fall. There is no industry that is not subject to economic volatility. California silicon chip maker Intel is eliminating 15,000 jobs in the face of manufacturing problems and competition. The US tech sector as a whole shed 260,000 jobs in 2023. Mineral economists generally believe that copper prices will rise in real terms in the long-run due to increasing scarcity given its fixed geological supply in a growing world. The possibility of Copper World direct job creation not being fulfilled at a constant level of 430 due to temporary or permanent shut down during the planned project life is minimal, but not impossible.

On balance, the Power report is inappropriately dismissive of the potential direct job creation from the Copper World project. High-paying job creation is an important benefit from new mining activity, and will likely be a main driver of considerations by Pima County residents as to their acceptance or rejection of the Copper World project.

2. Secondary Job Creation

The Power report is dismissive of Hudbay's assertion that up to 3,000 secondary jobs will be created in Arizona. Employment multipliers are dependent on the region included, with a larger multiplier the larger the region. In Australia, each new mining job creates an additional seven jobs across the country, for a

[47] Black et al. 2015, op cit., and Weber, Jeremy G., "How Should We Think About Environmental Policy and Jobs? An Analogy with Trade Policy and an Illustration from U.S. Coal Mining," *Review of Environmental Economics and Policy* 14.1 (2020), 44-66.

multiplier of 8.[48] But it only creates 1.4 jobs in the mining locality itself.[49] Hudbay is suggesting a multiplier of 8 within Arizona, which is considerably higher than regional mining project multipliers found in the literature cited above and cited in the Power report but not out of line with national multiplier effects.

The task at hand is to estimate secondary job creation within Pima County. The correct way for the Power report to estimate this is through direct, formal analysis using a reliable technique like input output analysis. In the absence of that, the best indicators of secondary job creation are studies of regional job multipliers at other mines in Arizona. The study for the Resolution copper mine in Superior, AZ estimates a jobs multiplier of 2.44 across several surrounding counties. The study for the Florence copper project in Pinal County estimates an Arizona jobs multiplier of 5.9. It is not unreasonable that with Tucson proximate to the Copper World mine, and with nine operating mines within a 125 mile radius of Tucson, Tucson is well positioned to supply most of the inputs required for the mine. While a jobs multiplier of 8 is high, it cannot not be ruled out as possible.

3. Local Property Taxes

Hudbay estimates that it will pay $247 million in property taxes over the mine life. The Power report notes that half of property taxes go to support K-12 education, and that because of the State's education equalization system some of that spending will be directed out of Pima County and towards school districts with lower property values. These concerns with the benefits of property tax payments are valid.

What is not valid, once again, is the Power report's trivialization of property tax payments by comparing it with Pima County's total property tax intake of $1.44 billion. By this measure, any new economic venture that generates $12.35 million in property taxes per year would be seen as having little to no benefit to Pima County.

VII. The Power Report's Implementation of the Task at Hand: Benefits Not Analyzed

The Power report does not estimate and monetize several important benefits that will accrue from this mining project.

[48] Fleming and Measham, op cit., p. 13.
[49] Ibid. Mining localities are measured as Australian "Local Government Areas," which are roughly equivalent to counties in the United States.

1. **Economic Diversification**

   The addition of a substantial copper mining project to a rural or developing country community can often serve to destabilize existing economic activity and cultures. Because of the large size of Pima County's economy relative to the size of the Copper World mine, the addition of new copper mining output to Pima County would serve to beneficially diversify the economy, which is largely dependent on aerospace/defense, the University of Arizona and affiliated private sector R&D firms, tourism and Canadian snowbirds wintering in Tucson, and retirees. Diversification reduces volatility in GDP, earnings, and employment, de-risking the economy to the benefit of Pima county residents.

2. **Wage Earnings and GDP**

   Increases in wage earnings and regional GDP, both direct and secondary, are benefits that are usually tracked in regional economic impact studies. Because mining jobs tend to be high-paying jobs, wage earnings can be a more relevant benefit that counting job growth alone.

3. **Additional Direct Taxes**

   The project is estimated to pay $55 million in state severance taxes over its life. In Arizona state severance taxes are directed back to counties based on their populations. Pima County will as a result receive a substantial portion of these taxes. It would also receive a portion of the projected $113 million in state income taxes paid by the mine through the state's Urban Revenue Sharing Fund. Because of its incomplete analysis of taxes directed to Pima County the Power report underestimates the direct tax benefits of the project to Pima County residents.

4. **Secondary Taxes**

   A proper analysis of economic impacts would include estimation of incremental sales taxes paid to Pima County government by employees, incremental employee income taxes funneled back to the county, and incremental employee property taxes from employees who take up residence in the county.[50] The Power report considers only taxes directly paid by the mine, ignoring these secondary taxes. A complete analysis of tax benefits would have included estimation of secondary taxes accruing to Pima County for the benefit of its residents.[51]

[50] Local governments also charge their own sales tax on top of the state sales tax. See https://www.library.pima.gov/content/sales-tax-rates-in-tucson-and-pima-county/.
[51] For an example of how this is done, see BBC Research and Consulting, op cit, and W.P. Carey Business School, op. cit.

5. Economic Impacts During Phase I Mine Construction

Construction jobs would be created during the mines' initial three-year construction period, as well as when the leach plant is built in year 4 of operations. The Power report ignores benefits to Pima County of direct and secondary job creation during the construction period.

6. Economic Impacts After Phase I Mine Closure

Hudbay estimates that closure and post-closure activities will take place from project year 20 to year 52. These activities include job and spending effects that would benefit Pima County. The Power report ignores economic impacts of closure and post-closure activities at the project.

7. Economic Impacts of a Possible Phase II Operation

The Phase I mine plan limits operations to the extraction of copper ore on Hudbay's current private landholdings over a 20 year period. Phase II, which would extract additional copper from nearby federal lands, would extend the mine life by an additional 28 years. While the Phase II operation has not been assessed for economic feasibility, the benefits and costs of the extended operation should weigh as a consideration of the proposed project. With a main concern about mining operations being their relatively short life and their consequent boom then bust effect on a community, the prospect of increased mine life would add heavily to the benefit column of the analysis. The Power report ignores the possibility of a Phase II operation.

8. Sustained Economic Benefits or Costs

It is likely that the impact of a mining operation to a community continues after the operation ceases. Continued benefits include the significant and positive productivity spillovers that have been measured to occur between the mining sector and non-resource sectors.[52] It is not only the multiplier effects from mining to other sectors of the economy during the mining project that matter, but any permanently increased productivity in these sectors that mining creates. Offsetting this is the possibility that mining activity crowds out entrepreneurial activity in Tucson.[53] This would be a permanently negative effect on growth and citizen welfare. The Power report is devoid of such analyses.

[52] Bjørnland, Hilde C., and Leif A. Thorsrud, "Boom or Gloom? Examining the Dutch Disease in Two-Speed Economies," *Economic Journal* 126 (2015), 2219-2256.
[53] Glaeser et al., op cit.

One the other hand, mining activity permanently scars the landscape and will cause permanent environmental degradation. This effect is appropriately captured in present value terms via reductions in house prices proximate to the mine site, as estimated in the Power report. In this sense the Power report attempts to take into account the permanent damage to the environment as a result of the project, but not the present value of ongoing benefits that would extend to the local economy once mining ceases.

VIII. The Power Report's Implementation of the Task at Hand: Estimation of Costs

The Power report appropriately considers environmental degradation associated with mining as a cost to Pima County. It divides these costs into two categories, direct effects of converting natural landscape to a mining operation, and secondary effects caused by mining activity that make the area a less attractive place to live. Direct effects can and should be monetized to facilitate comparison with monetized benefits from a mining project.[54] The Power report makes no attempt to quantify and monetize the negative environmental impacts it identifies other than of land disturbance and dust emissions on housing prices. This is a severe failing of the report, as it renders the analysis largely unusable in terms of evaluating the net socio-economic impact of the project.

1. Direct Effect: Degraded Natural Landscapes and Public Lands

The Power report considers that the Copper World mine will be constructed on private land within or adjacent to ecologically and socially important public lands that are the foundation of the area's recreation and visitor economy. It asserts that the mine will degrade the natural environment and block access to the Santa Rita Mountains. It will destroy known jaguar habitat, cause some hiking trails to be closed and others to be rerouted, and alter dark sky viewing. The report argues that based on the size of the outdoor recreation sector in Arizona, Pima County residents and tourists are particularly interested in the outdoor recreation opportunities in the county and value them highly. None of these effects are quantified in terms of quantity or amenity value, which would be a normal course of action in a cost-benefit analysis, other than through reduced housing prices for homes near the mine (see below).

I agree that mining degrades the natural environment. Open pits and waste piles are visible for miles. The land becomes inaccessible to the public for safety

[54] Abelson, op. cit., Damigos, D., "An Overview of Environmental Valuation Methods for the Mining Industry," *Journal of Cleaner Production* 14 (2006), 234-247.

reasons. The area of operation of the mine is a 27,721 acre package, or 43 square miles. This is equivalent to a 6.5 mile by 6.5 mile square, a substantial land holding. That land will already be off limits to hiking, but the operation of the mine will cause additional visual disturbances that will impact hikers on trails in the vicinity of the mine. I have seen no direct evidence to support the claims made in the Power report that the mine will block access to the Santa Rita Mountains, destroy known Jaguar habitat, and cause some hiking trails to close or be rerouted.

2. Direct Effect: Roads and Traffic

The mine will truck copper concentrate and copper cathode to buyers. Concerns include road dust creation, metal contamination due to spillage from concentrate loads, and paving of currently unpaved roads. These concerns are largely captured in decreased property values (see below), and to include them as a separate cost would be to double count them.

3. Direct Effect: Competition for Water

The Power report speculates that if the mine interferes with natural water flows or pumps enough water from underground aquifers to diminish underground water supplies, both people and wildlife will suffer. None of these effects are quantified, and I have noted above that the Power report's claims of competition for water are exaggerated.

4. Direct Effect: Property Values

Survey-based methods have shown that urban community residents are concerned that new mining activity and the direct and secondary jobs it creates could push up housing costs (both rental and purchase prices).[55] The Power report takes the opposite approach, with concern that the Copper World mine will lower housing costs in Pima County, and specifically in the four communities closest to the mine due to lost nearby environmental amenities. This is a valid concern for existing property owners, whose housing wealth would be negatively impacted, and for the local government that relies on property taxes to fund local services.

In order to quantify the effect, the Power report cites three reports that study the effect of mining projects on house prices. It identifies these as "the best available analogous peer-reviewed science." They are not.

[55] Que et al., op. cit.

The first, a peer-reviewed analysis of households near 6,000 mining sites in Chile, shows that household rental prices in cities drop by between 18% and 26% in when new mining activities like Copper World commence.[56] The second is a non peer-reviewed undergraduate student thesis at the University of Texas, Knoxville that examined house prices in 1,154 counties in thirteen US states with high surface coal mining activity.[57] It finds that the addition of an additional surface coal mine to the average county decreases aggregate home value by between 0.34% and 1.7%. A third study estimated that the degradation in house prices in Green Valley, AZ due to impairment of view due to mining activity at the Sierrita and Pima open pit copper mines is $5,000.[58] Average consumer loss due to dust pollution is $13,000. The Power report's concern for degradation in housing prices in the four communities nearest the proposed mine site is therefore appropriate.

The Power report takes Kim and Harris's estimates of costs of mining on property values and air quality, inflates them to 2022 dollars, and applies them to the community of Corona de Tucson (a loss of $105.68 million), and then to the Copper World communities (a loss of $1.4 billion). It applies the Rivera finding of decreased house prices to the Copper World Communities (a loss of $1.36 billion to $1.97 billion). It applies the Williams finding to Pima County as a whole (a loss of $355 million to $1.7 billion). It concludes that the mine's impact on property values would more than offset what the Power report estimates to be the $222 million in annual earnings from direct and secondary jobs created by the mine.

The problem with this analysis is three-fold. First, it ignores other recent peer-reviewed empirical work studying the issue that has used more sophisticated empirical techniques than those in the papers the Power report cites.[59] Second, impacts on home values decrease the further a mine is from the affected community. Kim and Harris, for instance, assume that only households within 5 miles of a mining site are affected by dust, and only those up to 10 miles from the

[56] Rivera, Nathaly M., "Is Mining an Environmental Disamenity? Evidence from Resource Extraction Site Openings," *Environmental and Resource Economics* 75 (2020), 485-528.
[57] Williams, Austin, "The Impact of Surface Coal Mining on Residential Property Values: A Hedonic Pricing Approach," University of Tennessee, Knoxville, May 2011. The study did not include counties in Arizona.
[58] Kim, Hyo-Sun, and DeVerle Harris, "Air Quality and View Degradations doe to Copper Mining and Milling: Preliminary Analysis and Cost Estimates for Green Valley, Arizona," *Nonrenewable Resources* 5.2 (1996), 91-201.
[59] Neelawala, Prasad, Clevo Wilson, and Wasantha Athukorala, "The Impact of Mining and Smelting Activities on Property Values: A Study of Mount Isa City, Queensland, Australia," *Agricultural and Resource Economics* 57 (2012), 60-78. Fitzpatrick, Luke G., and Christopher Parmeter, "Data-Driven Estimation of Treatment Buffers in Hedonic Analysis: An Examination of Surface Coal Mines," *Land Economics* 97.3 (2021), 528-547. Malikov, Emir, Yigou Sun, and Diane Hite, "(Under)Mining Local Residential Property Values: A Semiparametric Spatial Quantile Autoregression," *Journal of Applied Econometrics* 34 (2019), 82-109. Kolala, Chomba, Maksym Polyakov, and James Fogarty, "Impacts of Mining on Property Values in Kalgoorlie-Boulder, Western Australia," *Resources Policy* 68 (2020).

mine are affected by a view of the tailings dam.[60] Homes closer to the Fimiston open-pit gold mine in Western Australia, known locally as the super pit, have lower property values than those 6 to 7 kilometers away.[61] The effect of surface coal mines on house prices in two counties in Ohio and Pennsylvania show that the effect dissipates for homes more than 2.3 km from the mine site.[62] Williams suggests that houses farther from a mine site would be less affected than a house within 1 mile of the site. The Power report's extrapolation of the Kim and Harris, Williams, and Rivera estimates to surrounding communities and the city of Tucson does not account for the fact that the proposed mine is more than 5 miles away from Vail, Green Valley, and Sahuarita and 28 miles from Tucson. The calculated losses will as a result be overstated. Third, the estimates of lost property and amenity values are stock, or wealth, concepts, reflecting a present value loss from all future environmental harms from the mine. Earnings from new jobs are a flow benefit, occurring each year. Stock ($) and flow ($/yr.) benefits cannot be compared without converting them into common units. The Power report fails to undertake this conversion.

5. Indirect Effect: Population Growth and In-migration Offsets of Mine Jobs

Pima County has had net in-migration over the past few decades, mainly through movement of retirees to the sunbelt. Retirees bring with them a demand for services and spending of passive income on goods that generates growth in a region, while at the same time not competing for jobs. As such, in-migration is viewed by the Power report as beneficial to Pima County.

The Power report asserts that mine activity makes Pima County a less attractive place to live due to decreased environmental amenities, with decreases in in-migration or an increase in out-migration. It then proposes that this change in migration would equate to a decrease in jobs within the county, and makes various estimates of associated job losses and earnings losses that would outweigh the direct and secondary job creation from the mine.

The assumption in the Power report is contrary to multiplier analyses of mining and job growth. I am aware of no empirical study that estimates that the introduction of a new mining operation in an urban area reduces the total number of jobs in that area, as would be reflected in a regional job multiplier of less than one. Yet that is what the Power report is suggesting may occur in the greater

[60] Kim and Harris, op. cit., p. 98.
[61] Kolala et al., op cit.
[62] Fitzpatrick and Parmeter, op cit. The Neelawala et al. (op cit.) study of mining and smelting activities on property values in Australia limited the zone of impact to a 4 kilometer radius. Another study found that house prices more than 10 miles from a large Ohio limestone mine were not impacted by the mine (Malikov et al., op cit.).

Tucson area. The proposition is speculative and unlikely to be a relevant cost that should be taken into consideration.

IX. The Power Report's Implementation of the Task at Hand: Costs Not Analyzed

There are several costs relevant to the introduction of a new mining operation in Pima County that are not considered by the Power study.

1. **Increased Vehicle Traffic**

   The workers at the Copper World mine are likely to commute from nearby communities and from Tucson. Increased vehicle traffic was a statistically significant, if minor, concern in a survey of residents of Salt Lake City.[63]

2. **Increased Crime**

   Increased crime associated with a new mining project was a statistically significant, major, concern in a survey of residents of Salt Lake City.[64] The shale energy boom in the United States caused increased rates of crime in energy-rich counties.[65] The possibility of increased crime in Pima County and the cost of increased policing to control crime is a cost worthy of consideration.

3. **Housing Shortages and High Rental Prices**

   While the Power study anticipates lower rental prices as a result of lost environmental amenities, this is likely to occur, if at all, only within several miles of the mine site. To the extent that the increase in direct and secondary jobs draws migrants to Pima County, and particularly to the south side of the county near to the mine site, housing shortages and high rental prices may occur there. This is most likely to be particularly acute during the project construction stages where there may be a particularly large influx of migrant construction workers. Members of a coal mining community in Australia listed housing shortages and high rental prices as a major concern associated with a boom in coal mining in the early 2000s.[66] The possibility of housing shortages and higher rental prices takes a toll

[63] Que et al., op cit.
[64] Que et al., op cit.
[65] James, Alexander, and Brock Smith, "There Will Be Blood: Crime Rates in Shale-Rich U.S. Counties," *Journal of Environmental Economics and Management* 84 (2017), 125-152.
[66] Rolfe, John, Bob Miles, Stewart Lockie, and Galina Ivanova, "Lessons from the Social and Economic Impacts of the Mining Boom in Bowen Basin 2004-2006," *Australasian Journal of Regional Studies* 13.2 (2007), 134-153.

on the renters in the community, while homeowners benefit as their home equity increases. The cost-benefit study should consider and evaluate these tradeoffs.

4. Labor Shortages for Other Businesses

Where the increase in direct and secondary jobs is not met by in-migration, existing businesses will have to compete for labor. Labor shortages were a statistically significant concern in the Salt Lake City study and for residents of a coal mining community in Australia.[67] Multiplier analyses of mining projects do show that some sectors may shrink as a result of labor shortages. It is not clear how these losses should be traded off against growth in other sectors. Nevertheless, negative impacts like this may turn communities against a proposed mining project.

5. Crowding Out of Entrepreneurial Activity

Entrepreneurship is important to modern urban growth. Mining may inhibit entrepreneurship by drawing otherwise entrepreneurial talent away from their original pursuits and into the mining and downstream sectors.[68] This would then slow urban growth. The effect does not rule out that mines may be beneficial to an urban area for other reasons, but does suggest that considerations of reduced urban entrepreneurship should be taken into account.

[67] Ibid, Que et al., op cit.
[68] Glaeser et al., op cit.

Biography

Graham A. Davis, Ph.D., is President of Davis Economics Group, Inc., a mineral economics consulting firm located in Boulder, Colorado. He is Professor Emeritus of Mineral Economics at the Colorado School of Mines, where he was a full-time faculty member from 1993 to 2017. His academic research includes investigations of the impact of mining on developing nations. He has applied this research in consulting assignments for multilateral organizations like the Inter-American Development Bank, the World Bank, the United Nations, and the World Trade Organization. Prior to academia he worked as a Metallurgical Engineer at major and small-scale metal mines in Africa and Canada.

He is a Qualified Person under Canadian National Instrument 43-101 ("NI 43-101," a standard designed to ensure accurate mineral resource and mineral reserve reporting for mining companies listed on Canadian stock exchanges) and hold professional membership status in both the Society for Mining, Metallurgy, and Exploration ("SME") and the Australasian Institute of Mining and Metallurgy ("AusIMM"). He us a Valuer under the SME Standards and Guidelines for Valuation of Mineral Properties, a Qualified Valuator under The CIMVAL Code for the Valuation of Mineral Properties ("CIMVAL"), and a Specialist under the Australasian Code for the Public Reporting of Technical Assessments and Valuations of Mineral Assets ("VALMIN"). In 2014, he was awarded the SME's Mineral Economics Award "for research and teaching on modern methods of valuing and evaluating undeveloped mineral resources and the role of minerals on economic development." Dr. Davis is Associate Editor of the *Journal of Commodity Markets* and a member of the Editorial Board of *Resources Policy*, two peer-reviewed journals that publish academic papers related to the economics of natural resources.

Dr. Davis received a Ph.D. in Mineral Economics from Pennsylvania State University, an MBA from the University of Cape Town, and a BS in Metallurgical Engineering from Queen's University at Kingston.