UNIVERSITY OF CALIFORNIA, SANTA BARBARA

DETERMINING THE EFFECTIVE FINANCIAL HARM OF THE UNIVERSITY OF CALIFORNIA SANTA BARBARA’S INVESTMENTS IN THE COAL INDUSTRY

A SENIOR THESIS SUBMITTED TO THE ENVIRONMENTAL STUDIES DEPARTMENT

BY

EMILY WILLIAMS

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Abstract:

This paper aims to determine the “effective financial harm” (EFH) attributable to UC Santa Barbara (UCSB) due to its investments in the coal industry. Effective financial harm assumes that by investing in a company, the investor is a partial owner of the company (either directly or indirectly) and therefore holds partial responsibility for the company’s actions and associated harms. Following such reasoning, UCSB has EFH with respect to its percent ownership in coal companies and the external costs associated with those companies. By conducting literature reviews on the external costs associated with coal production and utilization, and by quantifying in US$ the exact investment in the coal companies by the university, this paper aims to quantify UCSB’s EFH vis-à-vis its investments in stocks, bonds, and funds that support the coal industry. The paper finds that UCSB has a medium estimate EFH of $181,287 per year, with a range of $98,270 to $301,458.
History of Coal

Every technological advancement that modern society appreciates—be it the iPod, modern Western medicine, or agribusiness—would not have been had it not been for the discovery and exploitation of coal. When European societies finally discovered the potential use of coal as an energy source beyond heating, it permanently changed the path for industry. For what they had uncovered was a way to tap the incredibly densely packed energy stored in the little black carbon formation. It allowed Europeans to warm their houses and expand their cities; yet perhaps most important, it allowed for great industrial expansion and, thus, the industrial revolution.

In the early 1100s, the English were among the first to make such use of what they then called “sea coal.” Though with the extensive burning of the ‘sea coal,’ early-day England began to see the harmful effects of this troublesome fuel. Coal was prominent in many middle class homes, yet the well-to-do households would only burn it if their chimney was large enough to spread the smoke away from their home. Those who were not fortunate enough to have a chimney would find their homes coated in soot and fall into deep coughing spells. As coal made its way into the heart of London, the city grew black, its buildings coated in the grimy soot, and its air heavy with pollution. A few decades later, with the arrival of the bubonic plague, coal all but lost its presence in the household; the English lost their love for the black rock, as there was far too much a resemblance between the “buboes,” or boils, and a lump of coal.

Yet, as the 1700s brought the arrival of the industrial revolution, coal’s image changed significantly. By this time, it was easily extractable and there was extensive infrastructure in

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place to produce the commodity in mass quantities. Coal, with the quick, cheap (but dirty) power it provides, allowed for the enhancement of the steam engine, which truly powered the revolution. Western European ideas were propagated to the new world, and society witnessed an enormous amount of exploration and expansion. Indeed, were it not for coal, the industrial revolution would never have happened; had the revolution happened on the back of a different form of energy, it would have created a very different world than we have today².

As people immigrated to the United States in the 18th and 19th centuries, so did the industrial revolution, and thus, coal. Coal remained the main source of energy in those years, as well as a main source of wealth. Yet it wasn’t until the discovery, mass extraction, and utilization of oil and natural gas that coal was finally replaced as a central fuel and source of wealth. Though oil and natural gas would take center stage in the nation’s infrastructure and economy, King Coal still retains its place as the main producer of electricity³.

So why was coal so monumental in the development of the industrialized world? Today’s coal was made millions of years ago, when plant and animal matter was solidified under high pressure. As plants and animals decompose, they gradually release energy. Yet when that decomposition is buried by many layers of earth and pressurized under the earth’s enormous weight, aerobic decomposition cannot take place and the chemical energy remains in the layers. These layers are densely packed with energy, to the point that they have a much higher energy

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density than other sources, such as wood\textsuperscript{4}. This process of highly pressurized carbon matter solidifying or liquidizing, is how coal, oil and natural gas are formed—all fossil fuels\textsuperscript{5}.

Today coal remains the source of much of the world’s electricity production. In 2011, coal produced 42\% of the United States’ electricity, or 1.7 trillion kilowatt-hours of the 4 trillion kilowatt-hour yearly national consumption. This number is now slightly on the decline for two reasons: coal power plants are being retired with little new construction to replace them, and the discovery of natural gas reserves has led to cheaper electricity than electricity from coal\textsuperscript{6}. Most of the coal mined in the United States is used domestically, with only 5-12\% of it exported to other countries. Of the domestically-used coal, 92\% is used for energy generation, with the rest used for products such as cement. To process this large amount of coal, the United States has over 600 electricity-producing coal-fired plants, with over 1400 electricity generating units, which process over 800 million short tons of coal per year (1 short ton = 2000 pounds)\textsuperscript{7}. The reduction in the rate of coal production as seen in recent years is caused by the use of natural gas for a main source of electricity, with the newly-found technology of hydraulic fracturing, or “fracking” serving as a low internal cost source for the fuel. Although projections show that the percentage of electricity generated from coal may decline by 2035, the Energy Information Administration points out that coal use is projected to continue rising “in the absence of new policies to limit or reduce emissions of carbon dioxide and other greenhouse gases.”\textsuperscript{8} Such policies may be implemented, as can be seen by President Obama’s mandate for the EPA to look

\textsuperscript{7} EIA. “What is the role of coal in the United States?” Energy in Brief; Energy Information Administration. Last updated July 18, 2012.
\textsuperscript{8} EIA. “What is the role of coal in the United States?” Energy in Brief; Energy Information Administration. Last updated July 18, 2012.
into a carbon reduction plan, which would certainly affect the amount of electricity produced from coal. Yet, as the program has yet to be implemented, coal production is estimated to continue increasing to meet the country’s growing demand for energy.\footnote{Wald, Matthew L. “Energy Secretary Optimistic on Obama’s Plan to Reduce Emissions.” The New York Times. June 27, 2013.}

With such widespread and extensive use of coal, the world is paying today for the decisions made years ago. Between 1970 and 2004, there has been a 70% increase in greenhouse gas emissions, the majority of which are caused by burning fossil fuels, agriculture, and deforestation.\footnote{The National Academies. Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. Washington D.C.: National Academies Press, 2010, p. 249} The question remains as to whether or not new policies will be implemented to reduce greenhouse gases. There is much stirring today in the public media around the concept of climate change—whether or not it exists, what is causing it, and how to manage the problem. However, the scientific community is in near consensus that anthropogenic climate change (ACC) exists, with 0.7% of climate scientists rejecting it.\footnote{Cook, John. Nuccitelli, Dana. Green, Sarah. Richardson, Mark. Winkler, Barbel. Painting, Rob. Way, Robert. Jacobs, Peter. Skuce, Andrew. “Quantifying the Consensus on Anthropogenic Global Warming in the Scientific Literature.” Environmental Research Letters. 8, no. 2 (2013).} This figure shows that, of those scientists who have taken a position, 97.1% agree that climate change exists, and moreover that it is mostly anthropocentric in origin. This value is significant when compared to the percent of the general population who agree with or are skeptical of ACC. Sixty four percent of women and fifty six percent of men believe in ACC.\footnote{McCright, A.; Dunlap, R. “Cool dudes: The denial of climate change among conservative white males in the United States.” Global Environmental Change. Of interest to note is 48.4% of conservative white males who believe that global warming will not happen and ACC is a myth.} As consensus increases and more articles are published by the scientific community, people are beginning to accept that mining and burning coal creates unintended consequences for which society is not equipped to deal with. In fact, in a recent poll, 69% of respondents believe that climate change has caused the recent weather events...
in the United States.\textsuperscript{13} As the frequency of climate-associated disasters occurring on American soil increases, the American people are now more inclined to believe that there is indeed a change. Though it is true that no single climate-related disaster can be directly linked to climate change, it is known that as the rate of ACC increases, the occurrences of climate-related disasters increase. This may be better understood by considering the analogy of steroid usage and baseball. If a baseball player takes steroids, (s)he generally hits more home runs. While it is impossible to correlate a specific home run to steroid usage, one can still say that the likelihood of the player having hit the home run was increased by the steroid usage.\textsuperscript{14}

So where is the change coming from? According to the EPA, the “majority of greenhouse gases come from burning fossil fuels to produce energy,”\textsuperscript{15} and while other economic activity results in carbon dioxide and methane gas emissions, in order to mitigate the intensification of climate change, a shift in energy production must occur. Though the cost is relatively cheap when paying the electricity bill or filling up a tank of gas, the external costs associated with fossil fuels are much more than is included in the price tag. This holds especially true for coal. When a consumer pays her residential electric bill, she does not pay for the deforestation, mudslides, or increased rate of birth defects as caused by the practice of mountain top removal in Appalachia.\textsuperscript{16} The price a school pays to heat its classrooms with electric heaters does not reflect the hospital bills of children with aggravated cases of asthma due to their location downwind of a

\textsuperscript{14} NCAR UCAR. "Steroids, Baseball, and Climate Change: What do home runs and weather extremes have in common?" Atmos News. February 2012.
\textsuperscript{15} EPA. "Climate Change: Basic Information." Last modified June 27, 2013.
coal-fired plant\textsuperscript{17}. These costs as not included in the price tag are more commonly known as \textit{external costs}, or \textit{externalities}.

An \textit{externality} can be defined as “beneficial or negative effects that are not reflected in energy market prices…”\textsuperscript{18}, or “costs borne by people who are not parties to the transaction that imposes them.”\textsuperscript{19} Externalities, in the case of energy production and consumption, are caused by but not limited to the GHG emissions produced, subsidies used, and the ecosystems degraded by the fossil fuel industry. Externalities are in fact a type of market failure, as the market fails to distribute the cost of externalities on those responsible\textsuperscript{20}. In general, a market failure occurs when the distribution of goods and services in an economy is not efficient\textsuperscript{21}. Among the different fossil fuels, coal mining and burning as an industry has the greatest external costs\textsuperscript{22}. They are estimated at $345 billion for the year 2008, which was 2.7\% of the GDP for the year 2008\textsuperscript{23}.

As seen above, externalities most affect those societies that are far removed from the cause. Yet the question remains as to who is effectively responsible for the harm. In the case of externalities related to the coal industry, those most directly responsible are the coal companies. Yet what of those who are partial owners of these companies?

\begin{flushright}
\textsuperscript{17} The National Academies, "What you need to know about energy." Last modified 2013. http://needtoknow.nas.edu/energy/energy-sources/
\textsuperscript{23} 2008’s GDP was $12.88 trillion; “US Real GDP by Year.” Multpl. http://www.multpl.com/us-gdp-inflation-adjusted/table
\end{flushright}
The University of California

The University of California is California’s largest public university system in the United States, with 10 campuses, and over 220,000 students. Its office of the treasurer manages $77 billion in invested assets. However, despite the implementation of the California Public Records Act (CPRA) and its requirement that state-level public institutions disclose information, the exact holdings of endowments are difficult to access due to certain exemptions in CPRA. The UC Regents have been required to submit information in the past on their endowment holdings, yet are not always able to due to restrictions to not disclose proprietary information as they enter into investments with certain funds. This can be due to either concern for the value of the investments they make, or simply in order to discourage becoming involved in something that is “politically charged.”

The UC invests in multiple funds whose holdings are described as being “proprietary,” such as Adage Capital LC, and thus neither the UC Regents nor the firm makes public the contents of these holdings. With hundreds of such funds held by the university described as “proprietary,” transparency is a problem. While the funds for the UC system as a whole are difficult to access, funds for a specific campus are more transparent, such as those of UC Santa Barbara.

The University of California, Santa Barbara has over 21,000 students enrolled. As it is a large institution, its assets are mostly managed separately from those of the UC Regents. While UCSB does take some policy direction from the Regents, the UCSB Foundation’s policy does not require it to do so. UC-wide policies specify that individual campuses may have their own

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24 University of California, "It Starts Here: UC at the Frontier." Last modified February 12, 2007.
26 See Appendix B for more information.
27 UC Santa Barbara, "Our Campus." http://www.ucsb.edu/campus/
investment structure and endowment pools. The UC Santa Barbara Foundation has its own endowment pool, and has hired its own investment managers to determine which stocks, bonds and funds the endowment shall be invested in. The Foundation controls $112,777,312 worth of assets in various commingled funds and direct holdings.

As a progressive education institution, UC Santa Barbara places learning and community values at the forefront, as can be seen by its mission statement:

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Because teaching and research go hand in hand at UC Santa Barbara, our students are full participants in an educational journey of discovery that stimulates independent thought, critical reasoning, and creativity. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. Our commitment to public service is manifested through the creation and distribution of knowledge that advances the well-being of our state, nation, and world. All of this takes place within a living and learning environment like no other, as we draw inspiration, opportunity, and advantage from the beauty and resources of UC Santa Barbara's extraordinary location at the edge of the Pacific Ocean.

As can be seen by its mission statement, the university stresses the importance of studies and responsibilities which benefit the global society. However, if coal, which provides most of the world’s electricity, is responsible for large amounts of damage to the world, it must then be the job of institutions such as the university to think critically and creatively to come up with alternatives to “advance the well-being” of the state, nation and world, or at least do less harm.

30 UC Santa Barbara, "Mission Statement."
External Costs Associated with the Coal Industry

As coal is one of the older fuel sources for electricity, many researchers have analyzed the exact effects of coal on human health, ecosystems, pollution, and the global warming impact of the carbon dioxide it releases. Of the plethora of studies conducted, seven are examined in this thesis\textsuperscript{31}. These studies provide a comprehensive overview of external costs associated with coal.

The studied external costs associated with mining include the following:

- Methane emissions from mines
- Carcinogens in waste water
- Health burdens in the Appalachia
- Fatalities from transport
- Abandoned mine lands (AMLs)
- Subsidies
- Illness
- Death

The studied external costs associated with the burning of coal include the following:

- Land disturbance
- Decreased crop yields
- Forest health effects
- Aquatic system effects
- Climate change (loss of biodiversity, increased storms, etc.)
- Subsidies
- Other human health effects
- Mortality

Concern about the external costs caused by the energy sector has even led governments to support research in this area. Both the United States Federal Government (in its Energy Policy Act of 2005) and the European Commission (the executive body for the European Union which directs and imposes legislation) conducted research into the effects of the energy sector,

including the economic, political, human health, ecosystem, and climate harm caused by coal\textsuperscript{32}. It has since been estimated that coal-related externalities amount to 17.84$c/kWh\textsuperscript{33}. However there is a large disparity in the estimates of externalities due to uncertainty in determining coal’s effect on various sectors of society and the environment.

There are over 500 current active mining sites in the south-east of the US, which have been deemed responsible for degraded and otherwise polluted streams. These studies show that there is a significant loss of ecosystems, natural beauty, as well as the release of various chemicals and compounds the surrounding water sources\textsuperscript{34}. The external costs associated with mining generally only affect regional areas, such as the Appalachian Mountains and nearby communities. This is because the damages do not “migrate as easily as air pollution from burning does. Coal mining causes severe land disturbance, resulting in land that is degraded, leading to a reduction in biodiversity, an increase in toxicity, and the loss of important top soils.”

\begin{itemize}
    \item \textsuperscript{34} Ibid.
\end{itemize}
There are various methods employed for mining coal, such as strip mining, underground mining, and mountain top removal, as can be seen in Figure 1. Strip mining includes the removal of top soils for easily accessible coal. Surface mining is also associated with external costs. About 70% of coal mining is surface mining. This means that 70% of coal mined is done so by removing the top soils of land, including anything that may be growing in the topsoil. Ecosystem loss and degradation are difficult to quantify, let alone monetize, because of the great variability in biodiversity at various sites, as well as the uncertainty of what dollar amount should be applied to ecosystem conservation. Underground mining is a more traditional form, which makes use of shafts. Mountain Top Removal (MTR) is the process of removing the peak of a mountain in order to sift for the coal. The mountain top is then dumped down the sides of the mountain, burying flora, fauna, and their habitat, and ruining the overall aesthetic appeal of the mountain. Additionally, MTR uproots vegetation that would otherwise act as a carbon sink; it

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37 Ibid, p.78.
is thus responsible for a 17% increase in greenhouse gas emissions when considering the carbon that is released into the atmosphere from the decomposition of flora. Finally, nutrient-rich topsoil is often buried, which cuts off its oxygen supply, meaning that healthy decomposition can no longer take place\(^{39}\).

Coal mining can also lead to greater GHG emissions via the release of methane trapped in the coal beds. When the beds are tapped and mined, much of the methane is captured and flared off. Yet this is not always the case; estimates show that per every kWh produced from coal-fired power plants, there is an approximate 0.037 kg of CO\(_2\)-equivalent of methane released without being flared or captured\(^{40}\).

Impoundments, which are ponds of waste water from mining, pose a great threat to communities near mines, as they hold toxic water that sometimes leaks into the surrounding area. When coal is mined and processed, up to 50% of the material that treats the raw coal goes to waste in a slurry, and is then pumped into impoundments. The impoundments related to coal mining are near MTR sites, and contain carcinogens and other toxins exist in high concentrations in this water. These impoundments have been known to break and release toxins into the environment; in October 2000, a 72-acre impoundment in Kentucky gave way, creating environmental havoc\(^{41}\). Parts of the community were buried in over seven feet of coal sludge, and the water supply of over twelve communities was compromised\(^{42}\). Beyond accidents, mines often are associated with acid mine drainage—the acidic water runoff from either abandoned or

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\(^{39}\) Ibid, p.77.

\(^{40}\) Ibid, p.77, 80.


active mines, which is often heavily laced with heavy metals that kill biodiversity downstream. Acid mine drainage is considered the most adverse effect of coal on water quality. It often contains pyrite, which is a naturally occurring compound in coal seams. When pyrite reacts with water and air, it becomes acidic and toxic to biodiversity that both resides in the stream and drinks from the stream. In the Allegheny and Monongahela River Basins in Pennsylvania, 2,390 miles of streams were contaminated by acid mine drainage in 1980\textsuperscript{43}.

Working in and living within proximity to a coal mine has huge health implications. It has been found that communities have higher rates of diseases that are linked with the toxins emitted from the mines; communities near coal mines have higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease, hypertension, lung disease, and kidney disease\textsuperscript{44}. Additionally, there are great occupational hazards associated with mining, in which coal miners become ill or die. In 2007, there were 159 occupational illnesses reported, which are chronic illnesses as caused by the practice of mining\textsuperscript{45}. For miners, the most common and severe illness is black lung disease. Black lung disease is contracted by repeatedly inhaling the airborne debris from the mines. It has caused over 200,000 deaths since 1900. Many of those deaths are from the disease contracted years ago, yet the figure is still significant when compared with the 100,000 deaths caused by mining accidents\textsuperscript{46}.

\textsuperscript{44} Michael Hendryx, and Melissa Ahern, "Relations Between Health Indicators and Residential Proximity to Coal Mining in West Virginia," \textit{American Journal of Public Health}, 98, no. 4 (2008).
Subsidies are an externality often overlooked, both in coal mining and burning. As the government’s expenditure is not included in the price consumers pay directly for energy, it is by definition an external cost. Subsidies can come in the form of government handouts, through the implementation and funding of programs to do with the fossil fuel industry, or through not accounting for external costs. Government handouts include subsidies the Credit for Production of Nonconventional Fuels ($14.1 billion). Subsidies also act as positive feedback loops for externalities, as they can “affect the amount of an externality generated by an industry.” Such feedbacks are due to the fact that the fossil fuel companies can expand their operations when they have more money to operate with. Thus the oil, coal, and natural gas companies may extract and process more fuel with larger handouts, resulting in more external costs. The government has put a program in place which pays $438 million annually for the medical costs of coal miners with black lung disease. Yet subsidies need not be direct handouts or funding of programs. When governments do not put a price on carbon and fail to account for the external costs created by the industry, they are in fact subsidizing the externalities themselves.

As coal enters the next phase of its lifecycle, it imposes many more external costs. Several studies have monetized the effects of between 400 and 500 coal-fired plants in the United States, allowing for a comprehensive review of the external costs of coal-fired plants.

These studies indicate that externalities vary greatly across coal-plants, indicating high uncertainty when correlating concentrations of a pollutant with damages such as illness and global warming\textsuperscript{53}. This is due to differing atmospheric conditions and population densities across space, the various types of coal used, the age of a plant, and the implementation of pollution mitigation technologies. Because of how much the pollution of each plant varies, it is difficult to make generalizations of the effect of coal plants, as an institution may be only invested in the older, more polluting plants or the younger, cleaner plants. However, for the purpose of this study, averages will be used for each type of externality due to the difficulty of parsing out which plants the university invests in.

All studies utilized find that health impacts are the greatest immediate external cost of coal-fired plants\textsuperscript{54}. Emissions from fossil fuel burning plants have been shown to cause illness and

\textsuperscript{53} Uncertainty and Variability in Health-Related Damages from Coal-Fired Plants in the United States

even premature death. Epstein et al. found that there is a much higher concentration of respiratory illness as due to emissions within a 30-mile radius of a power plant, which further confirmed the hypothesis that close proximity to emissions cause disease. In these areas, there is an established link to increased rates of diabetes and kidney disease. There is also a high correlation between mortality and proximity to coal mining areas, as seen in Figure 2. The National Academies found that for every kWh of electricity produced from coal, there are 3.2 cents of external costs. 90% of that figure is associated with premature mortality. Epstein et al. found the effect on human health to amount to 5+ cents per kWh. When using the measure of the Value of Statistical Life (VSL), researchers estimate that in 2008 that there is a cost of $7.5 million US per life. The plant’s damages associated with pollution are largely due to the emission of the air pollutants SO₂, NOₓ, PM₂.₅, and PM₁₀. These heavily depend on the social cost of carbon chosen; this estimate uses a cost of $30 per ton of CO₂-eq. Particulate matter (PM) has the greatest cost associated; however, these four emissions are marked as the most polluting. All studies used the value of statistical life (VSL) in order to place a cost on illness and death. Another study, based in Toronto, Canada, found that daily there are approximately 8 excess hospital admissions in the city alone due to pollution in the form of fine particulates. Perhaps

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58 Ibid.
60 Ibid.
61 Toll From Coal, p.10.; Full cost...p.84; Hidden Costs, p.149; Uncertainty and Variability in Health-Related Damages, p.1005; ExternE, p.43.
the main culprit in human illness is that of fine particulates, microscopic particles that are emitted into the atmosphere from the combustion of coal. Normally, most particles would not cause chronic health problems. However, the PM types of concern—PM$_{2.5}$ and PM$_{10}$—are small enough to get lodged into the lung tissue and cause respiratory illness. More specifically, PM$_{2.5}$ is linked with “all-cause premature mortality, cardiovascular and cardiopulmonary mortality, as well as respiratory illnesses, hospitalizations, respiratory and lung function symptoms, and school absences.” The Clean Air Task Force cites that in 2010, 13,200 deaths were linked to PM pollution. The severity of this kind of emission is second perhaps only to the threat of global warming.

Modern day’s greatest challenge is climate change. The last decade was the warmest ever recorded: temperatures have increased by 1.3°F since 1990, leading to sea levels that have risen twice as fast in the past few decades as the years before. The climate change the world is experiencing today is caused by mostly anthropocentric emissions of greenhouse gases (GHGs); between the industrial revolution and 2004, there was a 70% increase in GHGs. The greenhouse gases emitted for the year 2011 were carbon dioxide (84%), methane (CH$_4$, 9%), nitrous oxide (N$_2$O, 5%), and fluoronated gases (e.g., CFC-22, 2%). These gases—once they are released by fossil fuel combustion, livestock, industrial processes—act as insulation for the earth’s atmosphere, letting visible radiation in but slowing down heat radiation escape. Thus the earth’s atmosphere experiences heat gain and warms. Of the four, carbon dioxide is the least

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potent, standardizing the index for global warming potentials (GWP). On that list, with carbon
dioxide having a GWP of 1, methane has a GWP of 25, and nitrous oxide has a GWP of 300.68

According to the IPCC, climate change has the power to affect water availability, the
composition of the various atmospheric levels, weather patterns, changes in the biosphere, and
water level changes in coastal areas (arctic summer sea ice is today 35% less than the 1950-1980
average). It also causes vast ecosystem loss through changing temperatures and water
availability.69 Many species of plants have evolved for a small range of ecosystem features.
However, with rapid changes predicted in temperature and weather, evolution will not
necessarily be able to allow species to adapt at a fast enough rate to prevent mass extinction. The
scenario of a 4.4 degree Celsius increase in mean global temperatures would reduce crop yields
significantly. Some areas in the world that are closer to the equator may benefit for a short period
of time, though drought, parasites, and severe weather fluctuations would eventually decrease
crop productivity in these areas.70 Additionally, water for human use is already affected by a
changing climate. For example, the glaciers in the Himalayas are quickly melting, faster than
glaciers in other areas of the world. These glaciers are the source of drinking water for including
many areas in China and India, the two most populous countries on Earth. According to Dr.
Vandana Shiva, a leader of the International Forum on Globalization, the rivers of the Himalayas
support “nearly half of humanity”71. The rate of desertification is also increasing, and in Latin

Institute for International Economics.
America, 50% of the agricultural land is expected to undergo salinization and desertification by 2050\textsuperscript{72}.

As projections vary as to how much and how quickly the climate will respond to changes in the atmosphere’s chemical composition, climate change is the most difficult external cost to quantify and monetize. Thus, when a study places a cost on the effects of climate change, there is a high level of uncertainty. Monetization efforts get their data from models that use the carbon dioxide equivalent (CO\textsubscript{2}-eq)\textsuperscript{73}. The models used to predict the ultimate effects of climate change on the world have various scenarios, in which different policies, feedback loops, and changing technology and material take place. The general consensus is that in 2100, the global monetary impact will be a 1-2\% loss in the world’s GDP\textsuperscript{74}.

\textsuperscript{72} IPCC, 2007. P.54.
\textsuperscript{73} Hidden Costs; Extern-E
\textsuperscript{74} Hidden Costs of Energy
Methodology

UCSB’s effective financial harm (EFH)—or the harm it would be responsible for were its ownership directly caused or influenced the external costs associated with coal—was determined. To do so, the following had to be quantified: the percent of each of the 15 coal companies UCSB owns via its investments; the external costs of coal in dollars per kWh or per ton of coal mined (also accounting for high, medium and low estimates); and the kWh or annual ton of coal produced by the company. These values were put into the following formulas for each relevant coal company:

To begin with, fifteen coal companies were considered as they have been identified by various nonprofit organizations as the most polluting and damaging coal companies.\(^7\)

\[^7\text{We Are Power Shift. “The Filthy Fifteen.”}\]

\[\begin{align*}
\text{Equation 1. Formulas used to determine EFH.} \\
\text{UCSB } EFH_{\text{burning}} &= \sum_{i=1}^{n} \left( \frac{\text{\$hi/med/low}}{\text{kWh coal produced}_i \times \text{UCSB } \% \text{ Ownership}_i} \right) \\
\text{AND} \\
\text{UCSB } EFH_{\text{mining}} &= \sum_{i=1}^{n} \left( \frac{\text{\$hi/med/low}}{\text{ton coal produced}_i \times \text{UCSB } \% \text{ Ownership}_i} \right) \\
\text{Total EFH for mining and burning } &= EFH_{\text{mining}} + EFH_{\text{burning}}
\end{align*}\]

Quantifying UCSB’s Percent Ownership of Coal Companies: In order to quantify UCSB’s EFH, UCSB’s percent ownership had to be quantified. This was done by determining:
1) UCSB’s dollar investment in each of the companies, and 2) the total worth of the company’s stocks.

In determining UCSB’s investments, data on UCSB’s holdings was obtained from Eric J Sonquist, UCSB Foundation’s Chief Financial Officer. The holdings were as of March 31, 2012\textsuperscript{76}. The holdings data included the dollar amount invested in each type of investment, or the Fair Market Value (FMV). For investments in funds, there were separate tables outlining the holdings within the specific funds. The tables outlining the specific holdings of fund were only available for mutual funds and separately managed accounts, but not for exchange traded funds over whose holdings the UCSB Foundation has no control. To determine the holdings of the exchange traded funds, their websites were visited and holdings downloaded; it was from there determined their exact holdings. However, hedge funds, due to their lack of transparency in holdings\textsuperscript{77}, were not analyzed, and are thus excluded from this study.

The FMV of UCSB’s investments had to then be determined. For the direct holdings, it was found what dollar amount was invested in the fifteen companies. For the funds, it was determined what percent of the total fund’s pool the coal company tranche made up. That percentage was then multiplied by UCSB’s dollar investment in that fund, to determine UCSB’s dollar investment in that specific company’s tranche within the fund. The dollar investments were added up for each of the fifteen companies, to give the Fair Market Value of Stocks Owned by UCSB as of March 31, 2012.

Next, the total value of each company vis-à-vis its stocks was determined. This data came from the U.S. Securities and Exchange Commission, or the SEC. Every company must file with the U.S. Securities and Exchange Commission (SEC) in a 10Q form, and report information on

\textsuperscript{76} Appendix C.  
\textsuperscript{77} Magnum Funds, "Advantages of Hedge Funds over Mutual Funds." Last modified 2011.
the profits, assets, and overall state of the company. The 10Q form has information on the stocks authorized, issued, and outstanding of a company. Authorized Stocks are the maximum number of stocks that are allowed to be created and then sold by a company; the company may not exceed this number when selling stocks without changing the limit. Stocks Issued are all those that are sold to investors. Stocks Outstanding are the ones that have not been repurchased by the company and thus still belong to the investors. More simply, the total issued shares are the sum of the total Stocks Outstanding plus the total treasury shares (owned by the company). From this form, the Stocks Outstanding were found for each of the fifteen companies, as it includes all outside ownership of the company. Though the SEC filings provide the number of outstanding shares available, they do not specify the FMV of these shares, which is their dollar worth. Generally, stocks are reported by the number issued rather than their dollar worth, as the dollar value fluctuates constantly due to the nature of the stock market. To determine the dollar worth of these stocks as of March 31, 2012, so that they could be compared to UCSB’s ownership, the dollar value was found on the New York Stock Exchange, or NYSE. The FMV was determined by taking the average of the high and low value on the NYSE for April 1, 2013 (the closest day available to when the holdings were recorded). This number, the FMV of all the shares of stock for each company, is referred to in this study as the Market Value of All Shares.

Finally, UCSB’s FMV of stocks owned for each company was divided by the total dollar worth of each of the companies from the Market Value of All Shares. This gives the percentage ownership of the companies.

**Calculating Each Company’s Production:** Next, each of the fifteen companies’ production had to be quantified. For the coal burning companies, the kWh produced for the year

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78 Appendix F.
2012 was determined; for the coal mining companies, the total tons of coal produced for 2012 was determined. For the coal-burning companies, their total electricity generating capacity was found (nameplate capacity) by referring to their webpages. It was then determined what percent of the total capacity for a given company was from its coal-fired plants. Then the capacity factor for the companies in 2012 was considered. The capacity factor is defined by the EIA as “the ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.” Because not every plant generates electricity all of the time, an estimation of total kWh produced must be adjusted down by multiplying nameplate capacity by the capacity factor. Yet, as 2012 was an anomaly of a year, its capacity factor was much lower than the years before. The average capacity factor for the previous years and EIA estimates for future years — 70% — was used instead. To determine the total tons of coal produced for the year from the mining companies, the figures were simply found on the companies’ websites.

**Dollar Cost of Externalities:** Finally, the externalities associated with each company had to be quantified in U.S. dollars. First, the coal companies were categorized into mining and burning companies by referring to the companies’ websites, in order to avoid double counting. The coal burning companies considered are American Electric, Ameren, Dominion, Duke, Edison International, First Energy, GenOn (now NRG), MidAmerican, Ppl, and Southern Company. The coal mining companies considered are Alpha Natural Resources, Arch Coal, Consol, Patriot, and Peabody.

External costs were then assigned to either burning or mining companies, with units of $/ton of coal mined or $/kWh produced. Literature was reviewed to estimate a range for costs

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79 U.S. EIA. s.v. “Glossary--Capacity Factor.”
80 EIA. “Annual Energy Outlook 2013.”
associated with each type of externality. To determine which category the external cost falls under, it had to be determined whether the cost was emitted upon extraction or upon burning. For example, toxic and greenhouse emissions as an externality are associated with coal burning companies, as the emissions are released upon burning\textsuperscript{81}. Costs associated with acid mine drainage, on the other hand, are assigned to coal mining companies\textsuperscript{82}. Some cost types were more difficult to determine (such as subsidies and ecosystem loss and degradation) as they can be assigned to both mining and burning, and are difficult to fully monetize the effects. In some cases, the same cost estimation was utilized by multiple papers, with conservative, medium, and all-encompassing estimates for the cost of the damage. However, as many studies did not specify whether the externality was due to mining or burning, this study is charged with deciphering which category the externality falls into.

External costs associated with mining were somewhat difficult to quantify, as many studies only looked at the costs associated with coal burning, and the ones that considered coal mining tended to monetize the costs per kWh, instead of per ton of coal mined. For example, the European Commission monetized the effects of coal mining on miners’ health—which included death, injuries, and disease—and quantified it in terms of millions of European Currency Units per kWh. However, the National Academies and the Clean Air Task Force only monetized effects to do with the emissions from burning coal.

The effects of coal mining on methane emissions from mines, carcinogens in waste water, health burdens in the Appalachia, fatalities from transport, abandoned mine lands


(AMLs), and subsidies were monetized by Epstein et al. Their estimations came from reviewing literature and drawing conclusions. For instance, in monetizing the effects of methane emissions from coal mines, they used the global warming potential of methane, the annual emissions, and the social cost of carbon dioxide. Additionally, when monetizing land disturbance, they used the social cost of carbon of $30 per ton of CO\textsubscript{2} equivalent, which measures the general expectations of harm associated with climate change per ton of CO\textsubscript{2}-equivalent\textsuperscript{83}. The European commission, when monetizing the effects on miner’s health, looked at respiratory issues as caused by radon and dust in the mines. They also monetized death in order to include it in the study\textsuperscript{84}.

The costs associated with burning were more complicated to estimate, as multiple studies monetized each externality. Five of the considered seven studies offered estimates for the dollar damage as caused by emissions. The costs associated with emissions took into account health burdens on the public, mortality, and hospitalizations. Estimates were provided by Epstein et al., The Clean Air Task Force, The National Academies, The European Commission, and Levy et al. The lowest estimate came from the National Academies, at $0.032 per kWh; the highest was estimated by Epstein et al. at $0.0954 per kWh. It is important to note that the National Academies’ estimate is much lower than that of Epstein et al. because the National Academies used a much lower estimate for the concentration-response curve between fine particulate matter and mortality\textsuperscript{85}. Of the five estimates provided by these studies aforementioned, two were chosen to determine the conservative, medium, and all-encompassing estimates: Epstein et al. and The


National Academies. This is because the two studies provided more detailed accounts of where the costs come from, and were more easily compared.

Climate change was monetized by The National Academies and Epstein et al. Both studies used the social cost of carbon, which is the “combined damages and benefits that will occur over many future years if an additional ton of greenhouse gas is emitted today.”

The social cost is difficult to quantify as it takes into account all effects that climate change and excess CO₂ in the atmosphere may have on human societies in the future and on a global scale. This number varies, as the emissions from each plant are variable depending on the plant’s age, type of coal used, and regulations in place. Some coal-fired plants—especially the older ones—emit far higher amounts of tons of CO₂ in the atmosphere as compared to their younger counterparts. The low, medium, and high estimates from The National Academies came from using social costs of carbon of $10, $30, and $100 per ton of CO₂-equivalent. Using the medium estimate, the National Academies calculated climate change damages at $0.03/kWh based on 2005. They are marginal damage values from greenhouse gas emissions normalized to the emission rates for electricity generation. Epstein et al. monetized climate change at $0.0315 per kWh for 2008, by taking into account the effects of N₂O, CO₂, extreme weather events, and black carbon. Their range for costs ran between 0.0106 $/kWh to 0.1071 $/kWh, depending on the social cost of carbon used.

Subsidies were quite difficult to compile, as many do not differentiate between mining and burning companies. Estimates were used from both the Energy Information Administration.
(EIA) and the Environmental Law Institute (ELI). These estimates had to be categorized between coal burners and miners. The EIA drafted a report on annual government subsidies, from which it could be determined which subsidy was specific to burning or mining companies.\(^89\) The second study, conducted by the Environmental Law Institute for the years of 2002-2008, had a more inclusive methodology and thereby a higher estimate than the EIA. Similarly, the estimate had to be divided between miners and burners. The categorization was done by consulting the study and determining which subsidy a) belonged to the coal industry and b) was granted to either mining or burning. However, some subsidies were not clearly defined as one or another. For example, the “Credit for Production of Nonconventional Fuels,” amounting to $14 billion dollars per year, has historically been used in the coal industry.\(^90\) This credit is for coal, oil and natural gas. As the exact amount that subsidizes coal is unknown, this study uses various estimates—one with none of the $14 billion going to coal, one with 25%, and one with 50%. The estimates were then broken into a low, medium, and high estimate for each subsidy. The detailed calculations are included in Appendix G.\(^91\)

In order to determine external costs associated with mining and burning, costs had to be in per ton or per kWh basis. Though some costs were reported in the literature as per kWh or per ton mined, some costs were an annual sum.\(^92\) Costs related to mining were per kWh or for the year, and had to be converted to per ton of coal mined. Epstein et al. normalized all costs to per kWh in 2008 dollars; external costs from burning were kept in this format, while external costs

\(^{91}\) Appendix G.
\(^{92}\) Epstein et al. used $ per kWh, as did the NRC, but subsidies were an annual cost (from EIA and ELI) as well as Extern-E.
from mining had to first be converted to annual 2008 costs, then to per ton of coal\textsuperscript{93}. The National Academies used per kWh in 2005, which did not need to be altered\textsuperscript{94}. As the subsidies were counted in 2007 and 2008 USD, the total tons of coal mined and the total kWh produced from coal had to be found in order to convert the figures to per kWh or per ton of coal mined basis. According to the EIA, there were 1,171.8 million short tons mined in 2008, and 1,968,838 million kWh produced. In 2007, there were 1,146.6 million short tons of coal mined, and 1,998,390 million kWh produced\textsuperscript{95}.

Knowing the cost per kWh or per ton of coal mined for each of the externalities, external costs were assigned to mining and burning companies by adding the values together. Three estimates were created—low, medium, and high. There is a large discrepancy between each of the estimates, due to the fact that many of the higher estimates took into account costs that were deemed by the other estimates as “difficult to quantify”\textsuperscript{96}.

**Putting It All Together**: Finally, the equation can be computed, thus determining UCSB’s EFH with respect to its investments in coal. The cost per kWh is multiplied by the total kWh produced by the specific company (following the same process for mining companies), which gives the cost associated with the company. That value is then multiplied by UCSB’s percent ownership, resulting in the EFH.

\textsuperscript{96} Full Cost of Coal; Hidden Costs of Energy; Extern-E
Results:

UCSB’s Percent Ownership of Coal Companies:

The FMV of UCSB’s investments can be seen in Table 1. For a more detailed account of how holdings were determined, refer to appendix E\textsuperscript{97}.

Table 1. UCSB’s Holdings in the fifteen coal companies.

<table>
<thead>
<tr>
<th>UCSB Holdings</th>
<th>MF + SMA</th>
<th>ETF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GSAM Global</td>
<td>American Fu</td>
<td>S&amp;P500</td>
</tr>
<tr>
<td>Alpha Natural Resources</td>
<td>$3,042.00</td>
<td>$3,042.00</td>
<td></td>
</tr>
<tr>
<td>Ameren Corporation</td>
<td>$5,864.40</td>
<td>$373.41</td>
<td>$6,052.94</td>
</tr>
<tr>
<td>American Electric Power</td>
<td>$18,518.40</td>
<td>$10,290.00</td>
<td>$28,808.40</td>
</tr>
<tr>
<td>Arch Coal Inc.</td>
<td>$1,713.60</td>
<td></td>
<td>$1,713.60</td>
</tr>
<tr>
<td>CONSOL Energy Inc.</td>
<td>$8,484.00</td>
<td>$6,052.94</td>
<td>$14,536.94</td>
</tr>
<tr>
<td>Dominion Resources</td>
<td>$33,798.60</td>
<td>$1,474.95</td>
<td>$35,273.55</td>
</tr>
<tr>
<td>Duke Energy</td>
<td>$12,606.00</td>
<td>$392.08</td>
<td>$13,005.08</td>
</tr>
<tr>
<td>Edison International</td>
<td>$14,453.40</td>
<td>$12,711.18</td>
<td>$27,164.58</td>
</tr>
<tr>
<td>FirstEnergy Corp.</td>
<td>$20,333.14</td>
<td>$1,213.57</td>
<td>$21,546.71</td>
</tr>
<tr>
<td>Mid-American Energy*</td>
<td>$128,217.00</td>
<td></td>
<td>$128,217.00</td>
</tr>
<tr>
<td>NRG Energy</td>
<td>$3,134.00</td>
<td></td>
<td>$3,134.00</td>
</tr>
<tr>
<td>Patriot Coal Corporation</td>
<td>$ -</td>
<td></td>
<td>$ -</td>
</tr>
<tr>
<td>Peabody Energy Corporation</td>
<td>$6,950.40</td>
<td>$6,052.94</td>
<td>$13,003.34</td>
</tr>
<tr>
<td>PPL Corporation</td>
<td>$10,173.60</td>
<td>$74.68</td>
<td>$10,248.28</td>
</tr>
<tr>
<td>Southern Company</td>
<td>$33,248.20</td>
<td>$82.15</td>
<td>$33,330.35</td>
</tr>
</tbody>
</table>

*Berkshire Hathaway is the holding company for Mid-American.

UCSB’s ownership of the companies can be seen in Table 2\textsuperscript{98}.

\textsuperscript{97} Appendix E.
\textsuperscript{98} “UCSB Ownership of Company” is the percentage ownership of the company in decimal points, not in %.
Table 2. UCSB’s percent ownership of the fifteen coal companies.

<table>
<thead>
<tr>
<th>Company</th>
<th>FMV per Share</th>
<th>Date of FMV</th>
<th>Total Shares of Company</th>
<th>Date of Shares</th>
<th>Approximate Value ($) of Company</th>
<th>UCSB Ownership of Company*</th>
<th>UCSB Ownership of Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Natural Resources</td>
<td>8.01</td>
<td>4/1/2013</td>
<td>232,000,000</td>
<td>12/31/2012</td>
<td>1,858,320,000</td>
<td>3042</td>
<td>0.00000164</td>
</tr>
<tr>
<td>Ameren Corporation</td>
<td>34.98</td>
<td>4/1/2013</td>
<td>241,586,534</td>
<td>1/31/2012</td>
<td>8,450,696,959</td>
<td>12290.75</td>
<td>0.00000145</td>
</tr>
<tr>
<td>American Electric Power</td>
<td>48.5</td>
<td>4/1/2013</td>
<td>486,045,098</td>
<td>3/31/2013</td>
<td>23,573,187,253</td>
<td>28808.4</td>
<td>0.00000122</td>
</tr>
<tr>
<td>Arch Coal</td>
<td>5.28</td>
<td>4/1/2013</td>
<td>212,250,000</td>
<td>5/27/2013</td>
<td>1,120,680,000</td>
<td>1713.6</td>
<td>0.00000153</td>
</tr>
<tr>
<td>Consol Energy Inc.</td>
<td>33.11</td>
<td>4/1/2013</td>
<td>228,129,467</td>
<td>12/31/2012</td>
<td>7,553,366,652</td>
<td>14536.94</td>
<td>0.00000192</td>
</tr>
<tr>
<td>Dominion Resources</td>
<td>34.11</td>
<td>4/1/2013</td>
<td>576,000,000</td>
<td>12/31/2012</td>
<td>19,647,360,000</td>
<td>47379.43</td>
<td>0.00000241</td>
</tr>
<tr>
<td>Duke Energy</td>
<td>72.32</td>
<td>4/1/2013</td>
<td>704,000,000</td>
<td>12/31/2012</td>
<td>50,913,280,000</td>
<td>27525.14</td>
<td>0.00000054</td>
</tr>
<tr>
<td>Edison International</td>
<td>50.35</td>
<td>4/1/2013</td>
<td>325,811,206</td>
<td>12/31/2012</td>
<td>16,404,594,222</td>
<td>27164.58</td>
<td>0.00000166</td>
</tr>
<tr>
<td>FirstEnergy Corp.</td>
<td>42.06</td>
<td>4/1/2013</td>
<td>418,216,437</td>
<td>5/6/2013</td>
<td>17,590,183,340</td>
<td>30020.83</td>
<td>0.00000171</td>
</tr>
<tr>
<td>Mid-American Energy</td>
<td>95</td>
<td>4/1/2013</td>
<td>75,000,000</td>
<td>12/31/2012</td>
<td>7,125,000,000</td>
<td>128217</td>
<td>0.000001800</td>
</tr>
<tr>
<td>NRG Energy</td>
<td>26.42</td>
<td>4/1/2013</td>
<td>323,165,879</td>
<td>2/21/2013</td>
<td>8,538,042,523</td>
<td>3134</td>
<td>0.00000037</td>
</tr>
<tr>
<td>Patriot Coal Corporation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Peabody Energy Corporation</td>
<td>20.83</td>
<td>4/1/2013</td>
<td>282,300,000</td>
<td>12/31/2012</td>
<td>5,880,309,000</td>
<td>13003.34</td>
<td>0.00000221</td>
</tr>
<tr>
<td>PPL Corporation</td>
<td>31.26</td>
<td>4/1/2013</td>
<td>592,339,687</td>
<td>4/30/2013</td>
<td>18,516,538,616</td>
<td>22354.16</td>
<td>0.00000121</td>
</tr>
<tr>
<td>Southern Company</td>
<td>46.71</td>
<td>4/1/2013</td>
<td>870,390,537</td>
<td>3/31/2012</td>
<td>40,655,941,983</td>
<td>51489.18</td>
<td>0.00000127</td>
</tr>
</tbody>
</table>

* This value came from the MFs, ETFs, and SMAs.
Calculating Each Company’s Production: Tables 3 and 4 present the results of each of the fifteen coal companies’ production.

**Table 3. The total kWh produced each year by each of the ten coal-burning companies studied.**

<table>
<thead>
<tr>
<th>Company</th>
<th>Total Generating Capacity (kW)</th>
<th>Generating Capacity from Coal Plants</th>
<th>Capacity Factor&lt;sup&gt;99&lt;/sup&gt;</th>
<th>Effective kW</th>
<th>Effective kWh per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP</td>
<td>38,000,000&lt;sup&gt;100&lt;/sup&gt;</td>
<td>23,700,000&lt;sup&gt;101&lt;/sup&gt;</td>
<td>0.7</td>
<td>16,590,000</td>
<td>1.453E+11</td>
</tr>
<tr>
<td>Ameren</td>
<td>15,800,000&lt;sup&gt;102&lt;/sup&gt;</td>
<td>10,285,800&lt;sup&gt;103&lt;/sup&gt;</td>
<td>0.7</td>
<td>7,200,060</td>
<td>6.307E+10</td>
</tr>
<tr>
<td>Dominion</td>
<td>27,000,000&lt;sup&gt;104&lt;/sup&gt;</td>
<td>8,370,000&lt;sup&gt;105&lt;/sup&gt;</td>
<td>0.7</td>
<td>5,859,000</td>
<td>5.132E+10</td>
</tr>
<tr>
<td>Duke</td>
<td>57,700,000&lt;sup&gt;106&lt;/sup&gt;</td>
<td>27,119,000&lt;sup&gt;107&lt;/sup&gt;</td>
<td>0.7</td>
<td>18,983,300</td>
<td>1.663E+11</td>
</tr>
<tr>
<td>Edison International</td>
<td>21,417,000&lt;sup&gt;108&lt;/sup&gt;</td>
<td>13,706,880&lt;sup&gt;109&lt;/sup&gt;</td>
<td>0.7</td>
<td>9,594,816</td>
<td>8.405E+10</td>
</tr>
<tr>
<td>First Energy</td>
<td>20,000,000&lt;sup&gt;110&lt;/sup&gt;</td>
<td>12,000,000&lt;sup&gt;111&lt;/sup&gt;</td>
<td>0.7</td>
<td>8,400,000</td>
<td>7.358E+10</td>
</tr>
</tbody>
</table>

<sup>99</sup> EIA. “Annual Energy Outlook 2013.”
<sup>100</sup> American Electric Power. “Power Generation.” http://www.aep.com/about/MajorBusinesses/PowerGeneration/
<sup>104</sup> Dominion. “About Dominion.” https://www.dom.com/about/index.jsp
<sup>110</sup> First Energy. “About Us.” https://www.firstenergycorp.com/content/fecorp/about.html
<sup>111</sup> First Energy. “Generation System.” https://www.firstenergycorp.com/content/fecorp/about/generation_system.html
<table>
<thead>
<tr>
<th></th>
<th>47,000,000112</th>
<th>17,084,000113</th>
<th>0.7</th>
<th>11,958,800</th>
<th>1.048E+11</th>
</tr>
</thead>
<tbody>
<tr>
<td>GenOn/NRG</td>
<td>47,000,000</td>
<td>17,084,000</td>
<td>0.7</td>
<td>11,958,800</td>
<td>1.048E+11</td>
</tr>
<tr>
<td>MidAmerican</td>
<td>8,087,000114</td>
<td>3,800,890115</td>
<td>0.7</td>
<td>2,660,623</td>
<td>2.331E+10</td>
</tr>
<tr>
<td>PPL</td>
<td>19,000,000116</td>
<td>7,410,000117</td>
<td>0.7</td>
<td>5,187,000</td>
<td>4.544E+10</td>
</tr>
<tr>
<td>Southern Company</td>
<td>45,740,000118</td>
<td>17,381,200119</td>
<td>0.7</td>
<td>12,166,840</td>
<td>1.066E+11</td>
</tr>
</tbody>
</table>

Table 4. The total tons of coal mined for the year 2012 by each of the five coal-mining companies studied.

<table>
<thead>
<tr>
<th>Mining (Tons)</th>
<th>Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Natural Resources</td>
<td>106,300,000¹²⁰</td>
</tr>
<tr>
<td>Arch Coal</td>
<td>134,400,000¹²¹</td>
</tr>
<tr>
<td>Consol</td>
<td>56,000,000¹²²</td>
</tr>
<tr>
<td>Patriot</td>
<td>25,000,000¹²³</td>
</tr>
<tr>
<td>Peabody (Appalachia)</td>
<td>140,000,000¹²⁴</td>
</tr>
<tr>
<td>Peabody (other)</td>
<td>38,000,000¹²⁵</td>
</tr>
</tbody>
</table>

**Dollar Cost of Externalities:** The external costs associated with mining and burning were found as can be seen in tables 5 and 6. Table 7 presents the total averaged adjustment of the low, medium and high estimates of external costs associated with burning companies and mining companies.\(^{126}\)

### Table 5. Total externalities associated with burning.

<table>
<thead>
<tr>
<th>Externality Type</th>
<th>Source</th>
<th>Case Year</th>
<th>Low (₵/kWh)</th>
<th>Mid (₵/kWh)</th>
<th>High (₵/kWh)</th>
<th>Low Cost</th>
<th>Mid Cost</th>
<th>High Cost</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damages from Burning</td>
<td>NRC</td>
<td>2007</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>3.54</td>
<td>3.54</td>
<td>3.54</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Damages from Burning</td>
<td>Epstein</td>
<td>2008</td>
<td>3.25</td>
<td>9.64</td>
<td>11.03</td>
<td>3.47</td>
<td>10.28</td>
<td>11.76</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Average Damages</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.505</td>
<td>6.91</td>
<td>7.65</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Climate</td>
<td>Epstein</td>
<td>2008</td>
<td>1.02</td>
<td>3.06</td>
<td>10.21</td>
<td>1.09</td>
<td>3.26</td>
<td>10.89</td>
<td>₵/kWh</td>
</tr>
<tr>
<td></td>
<td>NRC *</td>
<td>2007</td>
<td>1</td>
<td>3</td>
<td>10</td>
<td>1.11</td>
<td>3.32</td>
<td>10.07</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Average Climate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
<td>3.29</td>
<td>10.48</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Subsidies</td>
<td>EIA**</td>
<td>2007</td>
<td>4.57834E-05</td>
<td>0.001835799</td>
<td>0.003625814</td>
<td>0.04</td>
<td>0.23</td>
<td>0.43</td>
<td>₵/kWh</td>
</tr>
<tr>
<td></td>
<td>ELI</td>
<td>2008</td>
<td>0.001377109</td>
<td>0.001377109</td>
<td>0.001377109</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Average Subsidies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>0.195</td>
<td>0.295</td>
<td>₵/kWh</td>
</tr>
</tbody>
</table>

### Table 6. Total externalities associated with mining.

<table>
<thead>
<tr>
<th>Externality Type</th>
<th>Source</th>
<th>Case Year</th>
<th>Low ($/ton)</th>
<th>Mid ($/ton)</th>
<th>High ($/ton)</th>
<th>Low Cost</th>
<th>Mid Cost</th>
<th>High Cost</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Disturbance</td>
<td>Epstein</td>
<td>2008</td>
<td>0.046348788</td>
<td>0.139046364</td>
<td>2.858175257</td>
<td>0.05</td>
<td>0.15</td>
<td>3.05</td>
<td>$/ton</td>
</tr>
<tr>
<td>Methane Emissions</td>
<td>Epstein</td>
<td>2008</td>
<td>0.583789834</td>
<td>1.751369502</td>
<td>5.837898341</td>
<td>0.62</td>
<td>0.62</td>
<td>0.62</td>
<td>$/ton</td>
</tr>
<tr>
<td>Carcinogens in Water</td>
<td>Epstein</td>
<td>2008</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$/ton</td>
</tr>
<tr>
<td>Fatalities from Transport</td>
<td>Epstein</td>
<td>2008</td>
<td>1.54249872</td>
<td>1.54249872</td>
<td>1.54249872</td>
<td>1.64</td>
<td>1.64</td>
<td>1.64</td>
<td>$/ton</td>
</tr>
<tr>
<td>Abandoned Mining Lands</td>
<td>Epstein</td>
<td>2008</td>
<td>7.488720509</td>
<td>7.488720509</td>
<td>7.488720509</td>
<td>7.98</td>
<td>7.98</td>
<td>7.98</td>
<td>$/ton</td>
</tr>
<tr>
<td>Subsidies</td>
<td>EIA</td>
<td>2007</td>
<td>0.165707309</td>
<td>0.165707309</td>
<td>0.165707309</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>$/ton</td>
</tr>
<tr>
<td></td>
<td>ELI</td>
<td>2008</td>
<td>0.01938044</td>
<td>0.01938044</td>
<td>0.01938044</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>$/ton</td>
</tr>
<tr>
<td>Average Subsidies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>$/ton</td>
</tr>
<tr>
<td>Health Burdens in Appalachia</td>
<td>Epstein</td>
<td>2008</td>
<td>63.67368457</td>
<td>63.67368457</td>
<td>63.67368457</td>
<td>67.9</td>
<td>67.9</td>
<td>67.9</td>
<td>$/ton</td>
</tr>
</tbody>
</table>

\(^{126}\) For more information on how subsidies were estimated, please refer to appendix G. For more information on how mining costs were estimated, please refer to appendix H.
Table 7 Averaged externalities associated with mining and burning, as divided into low, medium, and high estimates.

<table>
<thead>
<tr>
<th>Type</th>
<th>Low Cost</th>
<th>Mid Cost</th>
<th>High Cost</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burning</td>
<td>4.705</td>
<td>10.395</td>
<td>18.425</td>
<td>₵/kWh</td>
</tr>
<tr>
<td>Mining</td>
<td>10.39</td>
<td>10.49</td>
<td>13.39</td>
<td>$/ton</td>
</tr>
<tr>
<td>Mining (Appalachia)</td>
<td>78.39</td>
<td>78.585</td>
<td>81.585</td>
<td>$/ton</td>
</tr>
</tbody>
</table>
Putting It All Together:

Equation 1 (as restated below) was then applied to the estimates and UCSB’s EFH was determined for the mining and burning companies (Tables 8 and 9).

\[
UCSB\ EFH_{burning} = \sum_{i=1}^{n} \left( \frac{\text{Low/med/low}}{\text{kWh}_{\text{coal}}} \times \text{kWh}_{\text{coal}} \text{produced}_i \times UCSB \% \text{Ownership}_i \right)
\]

AND

\[
UCSB\ EFH_{mining} = \sum_{i=1}^{n} \left( \frac{\text{Low/med/low}}{\text{ton}_{\text{coal}}} \times \text{ton}_{\text{coal}} \text{produced}_i \times UCSB \% \text{Ownership}_i \right)
\]

Total EFH for mining and burning = \( EFH_{\text{mining}} + EFH_{\text{burning}} \)

Table 8. UCSB’s EFH for burning companies.

<table>
<thead>
<tr>
<th>Company</th>
<th>Low</th>
<th>Med</th>
<th>High</th>
<th>Production</th>
<th>UCSB Ownership</th>
<th>Low</th>
<th>Med</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>1.45E+11</td>
<td>1.63696E-06</td>
<td>$</td>
<td>11,193</td>
<td>$</td>
</tr>
<tr>
<td>Ameren</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>6.31E+10</td>
<td>1.45441E-06</td>
<td>$</td>
<td>4,316</td>
<td>$</td>
</tr>
<tr>
<td>Dominion</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>5.13E+10</td>
<td>2.41149E-06</td>
<td>$</td>
<td>5,823</td>
<td>$</td>
</tr>
<tr>
<td>Duke</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>1.66E+11</td>
<td>5.40628E-07</td>
<td>$</td>
<td>4,230</td>
<td>$</td>
</tr>
<tr>
<td>Edison Internac</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>8.41E+10</td>
<td>1.65591E-06</td>
<td>$</td>
<td>6,548</td>
<td>$</td>
</tr>
<tr>
<td>First Energy</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>7.36E+10</td>
<td>1.70668E-06</td>
<td>$</td>
<td>5,909</td>
<td>$</td>
</tr>
<tr>
<td>GenOn/NRG</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>1.05E+11</td>
<td>3.67063E-07</td>
<td>$</td>
<td>1,809</td>
<td>$</td>
</tr>
<tr>
<td>MidAmerican</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>2.33E+10</td>
<td>1.79954E-05</td>
<td>$</td>
<td>19,734</td>
<td>$</td>
</tr>
<tr>
<td>PPL</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>4.54E+10</td>
<td>1.20725E-06</td>
<td>$</td>
<td>2,581</td>
<td>$</td>
</tr>
<tr>
<td>Southern Compa</td>
<td>0.04705</td>
<td>0.10395</td>
<td>0.18425</td>
<td>1.07E+11</td>
<td>1.26646E-06</td>
<td>$</td>
<td>6,351</td>
<td>$</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>68,494</td>
<td>$</td>
</tr>
</tbody>
</table>
Table 9 UCSB's EFH for mining companies.

<table>
<thead>
<tr>
<th>Mining EFH</th>
<th>Cost ($/ton)</th>
<th>UCSB EFH per Company</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Med</td>
</tr>
<tr>
<td>Alpha</td>
<td>10.39 10.49 18.425</td>
<td>106,300,000</td>
</tr>
<tr>
<td>Arch</td>
<td>10.39 10.49 13.39</td>
<td>134,400,000</td>
</tr>
<tr>
<td>Consol</td>
<td>10.39 10.49 13.39</td>
<td>56,000,000</td>
</tr>
<tr>
<td>Patriot</td>
<td>10.39 10.49 13.39</td>
<td>25,000,000</td>
</tr>
<tr>
<td>Peabody (Appalacia)</td>
<td>78.39 78.585 81.585</td>
<td>140,000,000</td>
</tr>
<tr>
<td>Peabody (Non-Appalacia)</td>
<td>10.39 10.49 13.39</td>
<td>38,000,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally, UCSB’s total EFH was found by summing the EFHs from the mining and burning companies (table 10).

Table 10 UCSB's total EFH.

<table>
<thead>
<tr>
<th>TOTAL UCSB EFH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>$ 98,270</td>
</tr>
</tbody>
</table>
Discussion of Results

As seen in the results section, UCSB’s annual EFH is estimated at $181,287, with a range of $98,270 to $301,458, for its investments in the fifteen most polluting and damaging coal companies. UCSB invested a total of $410,679.35 UCSB in the coal companies in March 2012. That means, when using the medium estimate, that for every dollar it invested, UCSB had an EFH of $0.44 for the year 2012. When considering UCSB’s EFH over a ten-year period, instead of just one year, the medium estimate jumps to $1,812,870, with the low at $982,700 and the high at $3,014,580.

UCSB’s overall percentage ownership of the fifteen coal companies is low; averaged, UCSB owns 0.000248% of each company. Yet considering UCSB’s very small ownership, and the high EFH of $181,287, the external costs associated with each company are very large. Using the medium estimate of external costs associated with burning (0.10395 $/kWh), the total external costs the ten coal-burning companies are responsible for in the year 2012 are $8.978x10^{10}, or $89.78 billion\textsuperscript{127}. Using the medium estimate of external costs associated with mining, the total external costs the five coal-mining companies are responsible for in the year 2012 are $1.478x10^{10}, or $14.78 billion. Together, the fifteen coal companies have annual external costs of $104.56 billion.

\textsuperscript{127} This number is derived from multiplying the medium estimate for the external cost of burning, or $0.10395, by the total kWh production of the ten companies for 365 days.
Conclusion:

Epstein *et al.* found that “accounting for the damages conservatively doubles to triples the price of electricity from coal per kWh generated.”\(^{128}\) According to the US EIA, in 2011, the levelized cost of conventional coal was $65.7/megawatthour, or $0.0657/kWh\(^{129}\). This paper found that the medium estimate for the cost is $0.10395/kWh, which is nearly double the levelized cost. The all-encompassing estimate this paper found of $0.18425/kWh is nearly triple the levelized cost, while the conservative estimate this paper found of $0.04705/kWh is near that of the levelized cost. In all cases, the external costs associated with the coal industry are significant when compared to the cost included in the price tag.

UCSB has a medium estimate of EFH of $181,287 per year, with low estimate of $98,270 and a high estimate of $301,458. Though not substantial when compared to the total external costs associated with the coal industry, it is impressive when considering the small percentage of the companies owned by UCSB. Though these figures provide a good estimate of the external costs associated with the industry, they cannot fully describe the external costs that are difficult to monetize. It is difficult to assign a monetary value to entities such as human lives and the environment, as well as the potential harm to future generations when considering climate change. As UCSB urges a “community…that is responsive to the needs of [the] multicultural and global society,” if one is to consider EFH, it is important to decide whether or not investments are under the jurisdiction of the mission statement, and thus the ideals, of the university.

\(^{128}\) Epstein *et al.* “Full Cost...” p. 93.
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Appendices:

Appendix A: Email Correspondence with Eric J. Sonquist, CFO of UCSB Foundation

(From Eric Sonquist, February 14th, 2013)
Hi Emily - sorry I have been out of the office in training on new financial systems this week.

GEP does not have a direct connection per se - however, it reflects one of many sources that generate funds for expenditure by UC. So in general terms, a drop in the investment portfolios of the UC Regents reduces payouts from GEP Funds to the campuses - and that in turn brings more pressure to meet operational expenses from other sources like tuition.

Probably the most direct connection is in the area of grad student fellowships as many departments use a mix of State General Funds and fellowships on top of financial aid to fund grad students.

Eric

Appendix B: email conversation with staff at the Treasurer’s Office of UCOP

(Emily Williams, 1/15/13)
Hello,

My name is Emily Williams and I am a 4th-year environmental studies major at UCSB. I chose to do my senior thesis on how we invest the money in the GEP.

I have been using the report on the GEP holdings as of December 31, 2011 (as found on the Treasurer of the Regent's website) to determine how the money is invested. The report has proved to be useful and clear when it comes to fixed income, security holdings. Yet I am having a hard time getting the access I need to the mutual I am unable to get access to many of the externally managed funds and private equity. When I visit the webpages of the firms who manage said funds, I find that I don't have access. For example, I tried to see for December 2011 what the holdings were of Adage Capital LC, yet I could not enter the site.

By any chance, does the Treasurer’s Office have such information? I am looking for a breakdown of each of the funds to see what the holdings of each fund is as of a certain date (namely, December 31, 2011). If so, could I somehow gain access to it? I am finding that my thesis is taking quite a bit more work than I had originally anticipated.

Thank you for your time. I eagerly await your response,

Emily Williams
(Robert Yastishak, 1/16/13)

Many times that information is proprietary and is not publically available. It is not information that we give out. Our websites have all of the information that can be disclosed. Bob
Appendix C: Holdings of the UCSB Foundation, as of March 31, 2012. Table is of investments that include coal company holdings; complete holding data available upon request.

### Assets as of March 31, 2012

<table>
<thead>
<tr>
<th>Investment Name</th>
<th>Type of Holding</th>
<th>Fair Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pimco Total Return Fund</td>
<td>MF</td>
<td>$15,192,497</td>
</tr>
<tr>
<td>Pimco High Yield Fund</td>
<td>MF</td>
<td>$6,923,798</td>
</tr>
<tr>
<td>Blended Equities and Fixed Income (75/25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Funds Capital Income Builder Fund</td>
<td>MF</td>
<td>$186,703</td>
</tr>
<tr>
<td>Equities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dow Jones US Real Estate Index Fund</td>
<td>ETF</td>
<td>$2,634,978</td>
</tr>
<tr>
<td>S&amp;P 500 Index Fund (SPDR)</td>
<td>ETF</td>
<td>$6,052,942</td>
</tr>
<tr>
<td>Vanguard MSCI Emerging Markets Index Fund</td>
<td>ETF</td>
<td>$5,230,964</td>
</tr>
<tr>
<td>Russell 3000 Value Index Fund (shares)</td>
<td>ETF</td>
<td>$3,497,199</td>
</tr>
<tr>
<td>Alternatives - Commodities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF3 Multi-Strategy Commodities Series 40</td>
<td>MF</td>
<td>$1,961,846</td>
</tr>
<tr>
<td>Equities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advisory Research</td>
<td>SMA</td>
<td>$3,359,933</td>
</tr>
<tr>
<td>DF Dent</td>
<td>SMA</td>
<td>$3,684,213</td>
</tr>
<tr>
<td>GSAM Global Dynamic Core</td>
<td>SMA</td>
<td>$23,322,633</td>
</tr>
<tr>
<td>Lord Abbott &amp; Co Non-US Equity</td>
<td>SMA</td>
<td>$6,317,645</td>
</tr>
<tr>
<td>Andron Capital</td>
<td>SMA</td>
<td>$1,362,541</td>
</tr>
<tr>
<td>Alternatives - Hedge Funds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farallon Capital Partners LP</td>
<td>FOF/COM</td>
<td>$5,089,980</td>
</tr>
<tr>
<td>GS Global Tactical Trading</td>
<td>FOF/COM</td>
<td>$6,007,800</td>
</tr>
<tr>
<td>GS Hedge Fund Opportunities</td>
<td>FOF/COM</td>
<td>$8,484,061</td>
</tr>
<tr>
<td>GS Investment Partners</td>
<td>FOF/COM</td>
<td>$3,305,975</td>
</tr>
<tr>
<td>GS West Street Partners 2007</td>
<td>FOF/COM</td>
<td>$2,298,571</td>
</tr>
<tr>
<td>Alternatives - Private Equity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GS Distressed Opportunities Fund IV LP</td>
<td>FOF/COM</td>
<td>$748,773</td>
</tr>
<tr>
<td>GS Mount Kellett Capital Partners</td>
<td>FOF/COM</td>
<td>$1,939,651</td>
</tr>
<tr>
<td>Fortress Credit Opportunities Fund (B) LP</td>
<td>FOF/COM</td>
<td>$1,428,025</td>
</tr>
<tr>
<td>Fortress Credit Opportunities Fund II (B)LP</td>
<td>FOF/COM</td>
<td>$946,456</td>
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<tr>
<td>GS Vintage Fund V LP</td>
<td>FOF/COM</td>
<td>$901,396</td>
</tr>
<tr>
<td>Oaktree Private Investment Fund 2010, LP</td>
<td>FOF/COM</td>
<td>$980,582</td>
</tr>
<tr>
<td>Cash</td>
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<td>$928,060</td>
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### Specific Holdings in Separately Managed Accounts (SMAs) by Investment Manager

<table>
<thead>
<tr>
<th>Stock Name and Symbol</th>
<th>Advisory Research Shares</th>
<th>FMV</th>
<th>FOF/COM Shares</th>
<th>FMV</th>
<th>GSAM Global Shares</th>
<th>FMV</th>
<th>Lord Abbott Shares</th>
<th>FMV</th>
<th>Andron Shares</th>
<th>FMV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha Natural Resources (NYSE: ANR)</td>
<td></td>
<td></td>
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<tr>
<td>Ameren Corporation (NYSE: AEE)</td>
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<tr>
<td>American Electric Power (NYSE: AEP)</td>
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</tr>
<tr>
<td>Arch Coal Inc. (NYSE: ACT)</td>
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<td></td>
<td></td>
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<tr>
<td>CONSOL Energy Inc. (NYSE: CNX)</td>
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<tr>
<td>Dominion Resources (NYSE: D)</td>
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<tr>
<td>Edison International (NYSE: EIX)</td>
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<tr>
<td>FirstEnergy Corp. (NYSE: FE)</td>
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</tr>
<tr>
<td>Mid-American Energy Holdings Company ***</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Patriot Cool Corporation (NYSE: PCX)</td>
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<tr>
<td>Peabody Energy Corporation (NYSE: BTU)</td>
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<tr>
<td>PPL Corporation (NYSE: PPL)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Company (NYSE: SO)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</table>

### Analysis of Equity Holdings on a Percent of Assets Basis

<table>
<thead>
<tr>
<th>Stock Name and Symbol</th>
<th>American Funds CIB Shares</th>
<th>FMV</th>
<th>Lionfund (CFI Multi-Strategy) Shares</th>
<th>FMV</th>
<th>PIMCO Total Return Shares</th>
<th>FMV</th>
<th>PIMCO High Yield Shares</th>
<th>FMV</th>
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</thead>
<tbody>
<tr>
<td>Alpida Natural Resources (NYSE: ANR)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>Ameren Corporation (NYSE: AEE)</td>
<td>0.20%</td>
<td>$337.41</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>American Electric Power (NYSE: AEP)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>Arch Coal Inc. (NYSE: ACT)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>CONSOL Energy Inc. (NYSE: CNX)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
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<tr>
<td>Dominion Resources (NYSE: D)</td>
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<td>$1,474.95</td>
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<tr>
<td>Duke Energy (NYSE: DUK)</td>
<td>0.21%</td>
<td>$392.68</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>Edison International (NYSE: EIX)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
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<td>$1,213.37</td>
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<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>Mid-American Energy Holdings Company ***</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
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</tr>
<tr>
<td>NRG Energy (NYSE: NRG)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
</tr>
<tr>
<td>Patriot Cool Corporation (NYSE: PCX)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
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</tr>
<tr>
<td>Peabody Energy Corporation (NYSE: BTU)</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
<td>$X</td>
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<tr>
<td>PPL Corporation (NYSE: PPL)</td>
<td>0.04%</td>
<td>$74.68</td>
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<td>$X</td>
<td>0.00%</td>
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<tr>
<td>Southern Company (NYSE: SO)</td>
<td>0.04%</td>
<td>$82.15</td>
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<td>$X</td>
<td>0.00%</td>
<td>$X</td>
<td>0.00%</td>
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</tr>
</tbody>
</table>
Appendix D: Email Correspondence with Eric J. Sonquist

(Emily Williams, 2/13/13)

Hi Eric!

I came across another thing I wanted to ask you, but this one has to do with my thesis. I have been looking at a list of coal companies to see which ones we invest in, but someone brought up the point of "subsidiaries." I realized that some of these companies operate under another name as well. When I started searching for subsidiaries of these companies, such as Duke Energy, I came across lists compiled by the U.S. Securities and Exchange Commission (for example, this one here: http://www.sec.gov/Archives/edgar/data/1326160/000119312510043083/dex21.htm).

When a company owns a subsidiary, does the subsidiary function as the parent company does? I'm wondering if I need to include these lists of hundreds of subsidiaries when I'm screening for the list of coal companies. I figure that if these subsidiaries are doing the same thing as their parent companies, I should include them.

(Eric Sonquist, 2/13/13)

Hi Emily,

This is a complex question....you can't even assume that subsidiaries are in the same business as the parent company because most multinational corporations run multiple businesses....oft times in totally unrelated fields.

As an example, if you look at the link you sent me, and review Duke Energy you can see that they have multiple investments in wind energy firms as well as fossil fuel based firms. In fact, they even own Duke Broadband which is probably an internet service company of some sort.

Also, remember this list only shows firms in which they have a controlling interest of 50%+. So you could have a firm that is not on your list of major coal producers that in fact has significant holdings in coal-producing firms (some of which are LLCs and not publicly traded) and you would not be seeing those.

I also think you will find that many of these subsidiaries are not publicly traded firms so they wouldn't even show up in a regular portfolio analysis. As privately held entities they might be start-ups that could be in the holdings of a hedge fund or private equity firm investment portfolio and we (as a single investor in a fund-of-funds structure) would not even know it.
So the reality is that, short of an incredible amount of research using a monstrous database, you
won't be able to penetrate to the subsidiary in a meaningful way. This is probably the stuff of a
PhD dissertation and the associated 5+ years of research. You might find that this work has been
done on a broader scale by social/business network theorists looking at corporate ownership
trends - I have no idea.

I don't know what percentage of total coal production worldwide is represented by the publicly
traded firms you identified the initial public information act request....but I would guess it is
significant. I think for your purposes, limiting yourself to major producers who are publicly
traded corporations is probably the only functional way to do the analysis - just make sure you
footnote your methodology so it is explicit that this is a subset of the full footprint of coal
producing firms (I think you should discuss the specific language of this with your faculty
advisor).

Hope this helps,
Eric

Appendix E: Calculating Tranches of Exchange Traded Funds (ETFs)

The holdings of the ETFs were not provided in the spreadsheet of the UCSB
Foundation’s holdings. Instead, they had to be found by researching the ETFs themselves. For
example, for the money invested in the Dow Jones, its website was visited and holdings data as
of March 31, 2012 downloaded. Then the fund was searched for holdings in the fifteen
companies. Percent ownership of each company was found for the entire fund itself and then
multiplied by the dollar ownership UCSB had of the fund, which would give the dollar
ownership of the particular company. The findings are listed in the table below.

<table>
<thead>
<tr>
<th>Dow Jones U.S. Real Estate Fund</th>
<th>S&amp;P 500 Index Fund</th>
<th>Vanguard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Value=$2,634,978</td>
<td>Total Value=$6,052,942</td>
<td>Total=$5,220,964</td>
</tr>
<tr>
<td>Percent</td>
<td>FMV</td>
<td>Shares</td>
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<td>0</td>
<td>0</td>
<td>7391960</td>
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</table>
Hi Eric!

I have been diligently working on my thesis, and I came across a few questions I hoped you could answer. When looking at the fair market value of a stock: how can I determine what percentage of the company that represents? Would I be dividing the FMV of the investment by the net worth of the company, or the value? (This is for trying to decipher what percent of, say, Arch Coal we own.)

Also, since we can't see into the hedge funds, would you say that it's a safe methodology to take the known holdings and extrapolate what percentage of the hedge funds are in the filthy 15 by using the percentage of the known holdings in the filthy 15?

Thank you for your help!

(Eric J. Sonquist, 5/13/13)

If you go to the pro forma reporting done to the SEC the company discloses the total number of shares that have been issued. You would use that as a the denominator and the number of shares UC owns as the numerator.

Hedge funds are a different beast - so you logic would not work. I would exclude all hedge funds and venture cap funds from the exercise.

Hope this helps,
Eric
Appendix G: Externalities Associated with Subsidies

<table>
<thead>
<tr>
<th>Burning Study</th>
<th>Subsidy Description</th>
<th>Year</th>
<th>Low (million $)</th>
<th>Medium (million $)</th>
<th>High (million $)</th>
<th>Total kWh or Tons</th>
<th>Low ($)/kWh or ton</th>
<th>Medium ($)/kWh or ton</th>
<th>High ($)/kWh or ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELI**</td>
<td>84-month amortization period for coal pollution control, p.9</td>
<td>2008</td>
<td>14.57</td>
<td></td>
<td></td>
<td>1,968,838</td>
<td>7.4003E-06</td>
<td>0.001790015</td>
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<td>Credit for Production of Nonconventional Fuels, p.7*</td>
<td>2008</td>
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<td>3524.25</td>
<td>7048.5</td>
<td>1,968,838</td>
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<td>2.48878E-05</td>
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<td></td>
<td>Exclusion of alternative fuels from fuel excise tax, p.8</td>
<td>2008</td>
<td>49</td>
<td></td>
<td></td>
<td>1,968,838</td>
<td></td>
<td>0.001790015</td>
<td>0.00358003</td>
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<tr>
<td></td>
<td>Credit for Clean Coal Investment, p.8</td>
<td>2008</td>
<td>26.57</td>
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<td>1,968,838</td>
<td>1.34953E-05</td>
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<td>Total</td>
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<td>4.57834E-05</td>
<td>0.001835799</td>
</tr>
</tbody>
</table>

EIA

| Refined coal alternative fuel production credit | 2007 | 2156 | 1,998,390 | 0.001078868 |
| Fuel and power systems                          | 2007 | 283  | 1,998,390 | 0.000141614  |
| Capital Gains Treatment of Royalties in Coal    | 2007 | 155  | 1,998,390 | 7.75624E-05  |
| Clean Coal Power Initiative                     | 2007 | 55   | 1,998,390 | 2.75222E-05  |
| Future Gen Advanced Clean Fuels                 | 2007 | 49   | 1,998,390 | 2.45197E-05  |
| 84-Month Amortization of Certain Pollution Control | 2007 | 27   | 1,998,390 | 1.35109E-05  |
| Credit for Investment in Clean Coal Facilities  | 2007 | 27   | 1,998,390 | 1.35109E-05  |
| Total                                           |      |     | 1,998,390 | 0.001377109  |

Mining ELI**

| Expensing advance mine safety equipment, p.9     | 2008 | 4.57 | 1,171.80  | 0.03899983    |
| Characterizing coal royalty payments as capital gains | 2008 | 140.86 | 1,171.80 | 0.120208227  |
| Exclusion of benefit payments to disabled miners | 2008 | 62.57 | 1,171.80 | 0.053396484   |
| Special rules from mining reclamation reserves, p.8 | 2008 | 22.71 | 1,171.80 | 0.01938044    |
| Total                                           |      |     | 1,171.80  | 0.196885134   |

EIA

| Exclusion of Special Benefits for Disabled Coal Miner | 2007 | 46   | 1,146.60  | 0.040118612   |
| Partial Expenseing for Advanced Mine Safety Equipment | 2007 | 9    | 1,146.60  | 0.007849294   |
| Unallocated                                       | 2007 | 135  | 1,146.60  | 0.117739403   |
| Total                                             |      |     | 1,146.60  | 0.165707309   |

* $14097 is the cost of the entire credit. Three different estimates were made as it is unknown how much goes to coal: 0%, 25%, and 50%.

**Values from the ELI are for the time period of 2002-2008, spanning 7 years. Values were divided by 7 to give an estimate for the annual cost.
Appendix H: Externalities Associated with Mining (original figures for cost estimates as from Epstein et al., 2008)

<table>
<thead>
<tr>
<th></th>
<th>Total Cost (Low)</th>
<th>Total Cost (Medium)</th>
<th>Total Cost (High)</th>
<th>Total tons of coal</th>
<th>Low Cost ($/ton)</th>
<th>Mid Cost ($/ton)</th>
<th>High Cost ($/ton)</th>
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</thead>
<tbody>
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<td>Land Disturbance</td>
<td>54,311,510</td>
<td>162,934,529</td>
<td>3,349,209,766</td>
<td>1,171,800,000</td>
<td>0.046349</td>
<td>0.139046</td>
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<td>Methane Emissions</td>
<td>684,084,928</td>
<td>2,052,254,783</td>
<td>6,840,849,276</td>
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<td>0.58379</td>
<td>1.75137</td>
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<tr>
<td>Carcinogens in Water</td>
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<td>0</td>
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<td>1,171,800,000</td>
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<tr>
<td>Fatalities from Transport</td>
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<td>1,807,500,000</td>
<td>1,807,500,000</td>
<td>1,171,800,000</td>
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<td>1.542499</td>
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<tr>
<td>Abandoned Mining Lands</td>
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<td>8,775,282,692</td>
<td>8,775,282,692</td>
<td>1,171,800,000</td>
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<tr>
<td>Health Burdens in Appalachia</td>
<td>74,612,823,575</td>
<td>74,612,823,575</td>
<td>74,612,823,575</td>
<td>1,171,800,000</td>
<td>63.67368</td>
<td>63.67368</td>
<td>63.67368</td>
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</table>
## Determining Subsidies for Coal Mining and Burning Companies

<table>
<thead>
<tr>
<th>Year</th>
<th>ELI</th>
<th>EIA</th>
<th>Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>84-month amortization period for coal pollution control, p.9</td>
<td>Refined coal alternative fuel production credit</td>
<td>expensing advanced mine safety equipment, p.9</td>
</tr>
<tr>
<td></td>
<td>Credit for Production of Nonconventional Fuels, p.7*</td>
<td>fuel and power systems</td>
<td>characterizing coal royalty payments as capital gains, p.7</td>
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<td></td>
<td>exclusion of alternative fuels from fuel excise tax, p.7</td>
<td>Capital Gains Treatment of Royalties in Coal</td>
<td>exclusion of benefit payments to disabled miners</td>
</tr>
<tr>
<td></td>
<td>Credit for Clean Coal Investment, p.8</td>
<td>Clean Coal Power Initiative</td>
<td>special rules for ining reclamation reserves, p.8</td>
</tr>
<tr>
<td>2008</td>
<td>102</td>
<td>2370</td>
<td>986</td>
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<td>170</td>
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<td><strong>Total</strong></td>
<td><strong>631</strong></td>
<td><strong>3026</strong></td>
<td><strong>2047.5</strong></td>
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<tr>
<td><strong>Low $ Cost (million)</strong></td>
<td><strong>102</strong></td>
<td><strong>2370</strong></td>
<td><strong>32</strong></td>
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<tr>
<td><strong>Medium $ Cost (million)</strong></td>
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<td><strong>170</strong></td>
<td><strong>986</strong></td>
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<tr>
<td><strong>High $ Cost (million)</strong></td>
<td><strong>186</strong></td>
<td><strong>61</strong></td>
<td><strong>438</strong></td>
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<th>Year</th>
<th>Low $ Cost (million)</th>
<th>Medium $ Cost (million)</th>
<th>High $ Cost (million)</th>
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<td>2008</td>
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<td>343</td>
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<td>2007</td>
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<td>84</td>
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<td>Amount</td>
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<td>Partial Expensing for Advanced Mine Safety Equipment</td>
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<td>Unallocated</td>
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* $14097 is the cost of the entire credit. Three different estimates were made as it is unknown how much goes to coal: 0%, 25%, and 50%.

**The Black Lung Disability Trust Fund is for the years 2002-2008, so the value was divided by 6 to obtain the annual cost. (p.16)