

Fossil Fuel Divestment and Public Pension Funds¹

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June 2017

I. Introduction

1. The fossil fuel divestment movement promises that the problem of climate change can be ameliorated if investors in certain companies refuse to hold the securities of those companies in their portfolios. In 2015, Professor Fischel, an author of this report, released a study examining this claim from an economic and financial perspective.² Based on well-accepted economic theory and the academic literature studying previous divestment attempts, the study concluded that fossil fuel divestment has minimal or no environmental impact because it is highly unlikely to affect the production or distribution of fossil fuels on the part of targeted companies. Moreover, not only is fossil fuel divestment ineffective, it is also costly to investors.

2. In particular, based on a 50-year retrospective sample period, the study found that an optimal equity portfolio including fossil fuel stocks outperforms a portfolio of equal risk that is divested of energy stocks by an average of 0.5 percent per year.³ These annual losses add up to a 23 percent reduction in the value of a divested portfolio over a 50-year period.⁴ This loss

1. Our qualifications are described in Appendix A. We have been assisted in preparing this report by other members of Compass Lexecon's professional staff. This study has been commissioned and financed by the Independent Petroleum Association of America (IPAA).

2. Daniel R. Fischel (2015) "Fossil Fuel Divestment: A Costly and Ineffective Investment Strategy".

3. *Id.* ¶ 24. Before adjusting for differences in risk, the divested portfolio underperforms the non-divested portfolio by 0.7 percent per year.

4. *Id.*

from divestment is due to the simple fact that a divested portfolio is suboptimally diversified, as it excludes one of the most important sectors of the economy. In fact, the diversification benefits of the energy sector exceed those of any other major sector of the economy.

3. These costs of diversification are in addition to other costs discussed in the study, including transaction costs from selling divested securities and buying substitute securities, and ongoing research costs of maintaining compliance with a divestment goal.⁵ Bessembinder (2016) estimates these additional costs for a sample of universities, and concludes that they are substantial, reducing the value of a university endowment divested of fossil fuel securities by between two percent and twelve percent over a twenty-year period.⁶

4. The previous study by Prof. Fischel focused on an optimally-weighted equity-only portfolio, but as stated in that study, actual portfolios vary in composition, and hence, vary in the costs of divestment. Therefore, although the basic fact that fossil fuel divestment generates losses as a consequence of suboptimal diversification is unassailable, estimates of these losses can vary depending on the actual portfolio composition. Cornell (2015) estimated these losses from potential divestment actions at five large U.S. university endowments, and concluded that, on a weighted average basis, fossil fuel divestment would cost these endowments approximately 0.23 percent per year.⁷

5. Likely as a consequence of these and other substantial costs, most of the major universities that have considered divestment have rejected it,⁸ or at best implemented it in a very

5. *Id.* ¶ 6.

6. Hendrik Bessembinder (2016) “Frictional Costs of Fossil Fuel Divestment”.

7. Bradford Cornell (2015) “The Divestment Penalty: Estimating the Costs of Fossil Fuel Divestment to Select University Endowments,” ¶ 8.

8. Schools that have rejected divestment include Harvard University, Princeton University, Columbia University, MIT, New York University, and the University of Michigan. For a more complete list, *see* <http://divestmentfacts.com/category/what-theyre-saying/>

limited fashion.⁹ Given the apparent failure to convince university endowments to divest, advocates appear to be increasingly turning to state and local public pension funds. The same basic economics of diversification and other costs of divestment apply to pension funds as well as they apply to university endowments. In fact, the California Public Employees' Retirement System (CalPERS) recently said the following:¹⁰

Divestment, as an active investment decision, represents a form of active risk-taking that must be considered, first and foremost, within the context of the Board's fiduciary duty. As a mature, cash-flow negative system, CalPERS is obligated to seek out and implement the portfolio construction methods that best serve our mission – the sustainable delivery of promised benefits. In efficient markets, however, limiting the opportunity set for investments has generally been shown to have a detrimental effect on performance.

6. Of course, the magnitude of the costs of divestment depends on the particular holdings of a pension fund. The purpose of this study is to analyze the costs of lost diversification due to fossil fuel divestment for major U.S. public pension funds. A key advantage of studying pension funds is that detailed data on specific securities holdings is often available, so that cost estimates can be more closely tailored to actual fund holdings. By contrast, specific holdings of university endowments are often not public information, and hence, proxies must be used. For this study, we considered 11 major U.S. public pension funds, including the largest state pension fund (CalPERS) and all of the major funds for the municipalities of New York City, Chicago, and San Francisco, as reported below.

9. Schools that have implemented divestment in a limited fashion include Stanford University, Georgetown University, and the University of Maine.

10. <https://www.calpers.ca.gov/docs/board-agendas/201702/invest/item06b-00.pdf>

Exhibit A

Public Pension Funds Analyzed

Pension Fund	Most Recent Reported Portfolio Value (\$MM)
CalPERS	\$ 299,760
<i>New York City</i>	
Teachers' Retirement System	\$ 63,652
Police Pension Fund	\$ 34,930
Fire Department Pension Fund	\$ 11,341
NYCERS	\$ 55,945
Board of Education Retirement System	\$ 4,728
<i>Chicago</i>	
Policemen's Annuity & Benefit Fund	\$ 2,371
LABF	\$ 1,141
Firemen's Annuity & Benefit Fund	\$ 797
MEABF	\$ 4,289
<i>San Francisco</i>	
Employees' Retirement System	\$ 20,428
Total	\$ 499,382

Sources: Respective pension funds.

7. Using data on these funds' current holdings, we estimated the returns on the same or similar holdings over the past 50 years, and compared them with the returns over that period from an otherwise identical portfolio, stripped of stocks targeted by divestment advocates. In particular, we considered divestment of all coal, oil, and natural gas companies, and then separately considered a broader divestment that also included utility companies.

8. A divested portfolio may differ from a non-divested portfolio not only in terms of its average return, but also in terms of riskiness. Therefore, to estimate the cost of lost diversification alone, we adjusted the divested portfolio to match the risk profile of the non-divested portfolio. With that adjustment, the narrower divestment approach (divesting only coal,

oil, and gas companies) led to risk-adjusted returns that were, depending on the specific pension fund, between 0.05 percent and 0.27 percent per year lower. The weighted average across the 11 funds was a reduction in risk-adjusted returns of 0.15 percent per year. The broader divestment approach (targeting utilities as well as coal, oil, and gas) led to risk-adjusted returns that were, depending on the specific pension fund, between 0.09 percent and 0.27 percent per year lower, with a weighted average across the 11 funds of 0.20 percent per year lower.

9. These costs of divestment add up over time. We estimate that over the past 50 years, on a risk-adjusted basis, the weighted average portfolio of the 11 funds would have suffered a 7.1 percent loss due to the narrower divestment approach, and a 9.3 percent loss due to the broader divestment approach. The expected loss due to fossil fuel divestment for particular funds varies, but we estimate that all 11 funds will suffer a shortfall as a consequence of divestment. For example, the estimated loss over 50 years for CalPERS is 6.9 percent in the narrow divestment approach and 9.4 percent in the broader divestment approach, which respectively amounts to \$2.3 trillion and \$3.1 trillion. For the group of 11 funds as a whole, the estimated losses over 50 years are \$3.8 trillion in the narrow divestment approach, and \$4.9 trillion in the broader divestment approach. (As noted above, there are also additional costs to divestment, including transaction costs and compliance costs, that serve to further reduce the value of divesting pensions.) These are funds that will be unavailable to pension recipients and which will have to be made up in some way, either with lower pension payouts, or through taxpayer bailouts.

10. Many public pension funds in the U.S. are currently deeply underfunded. The 100 largest public pensions in the U.S. are funded below 70 percent, and total unfunded

liabilities are approximately \$1.25 trillion.¹¹ Particularly given this situation, anything that reduces expected returns on pension investments, as fossil fuel divestment would, is likely to directly harm pension benefits and increase the likelihood of taxpayer bailouts.

11. The following section describes our methodology in detail and provides estimates of the losses that would be imposed upon specific pension funds due to divestment.

II. Calculation of Divestment Costs

12. For each of the 11 funds, we sought the most recent detailed information on equity holdings available.¹² For seven funds, this information was provided in publicly available reports from the fund, or was sent to us by the fund upon request.¹³ For four funds, information was available regarding portfolio allocation to various asset classes, but not specific holdings within those classes.¹⁴ In these cases, we proxied for the specific holdings of the pension fund by using the holdings of the largest U.S. mutual funds with the same benchmarks that were identified by the pension as benchmarks for each asset class.¹⁵ Appendix B provides details on a pension fund-by-pension fund basis regarding the availability of data on specific holdings and the use of benchmark mutual fund proxies for specific holdings when necessary.

13. For each equity holding of a given pension fund, we identified an industry for the company that issued the security by assigning to each holding a standard industry code

11. See, “Moody’s: U.S. states’ FY 2015 net pension liabilities reach \$1.25 trillion, with more growth to come,” Moody’s Press Release, October 6, 2016. See also, “2016 Public Pension Funding Study,” Milliman White Paper.

12. We included common stock, preferred stock, and warrants in the analysis, but excluded REITs, even though these are sometimes classified by the pension funds as equity.

13. This was the case for CalPERS, New York City Employees’ Retirement System, New York City Board of Education Retirement System, Chicago Laborers’ and Retirement Board Employees’ Annuity and Benefit Fund, Chicago Fireman’s Annuity and Benefit Fund, Chicago Municipal Employees’ Annuity and Benefit Fund, and the San Francisco Employees’ Retirement System.

14. This was the case for the New York City Teachers’ Retirement System, New York City Police Pension Fund, New York City Fire Department Pension Fund, and Chicago Policemen’s Annuity and Benefit Fund.

15. This is similar to the methodology used by Cornell (2015), *supra*.

("SIC").¹⁶ In some cases, pension funds hold mutual funds or exchange traded funds ("ETFs") which include stocks from many companies in many industries. In these cases, we replaced the mutual fund or ETF in the pension fund's portfolio with the specific holdings of that mutual fund or ETF as of the most recent date for which data are available prior to the date of the pension fund holdings information. Each of these specific holdings was then assigned an SIC code as described above.

14. Exhibit B reports the total value of equity holdings for each of the pension funds, and the total value of all holdings for which we were able to identify an SIC. Overall, for the 11 funds as a whole, we were able to identify an SIC for 92.1 percent of all holdings by value.¹⁷ Holdings lacking an SIC were dropped from the analysis.

15. We then analyzed historical returns to these holdings over the 50-year period 1966 to 2015. However, if we were to analyze the past returns of the actual securities held by the pension, two problems would arise: First, not all stocks currently held by the funds exist continuously throughout the sample period. As a result, the analysis of returns many years into the past would result in stocks currently held by the pension being dropped from the sample. Second, analyzing the past returns of securities in the current portfolio would result in "survivorship bias," in which the companies that failed during the sample period would be omitted from the analysis. Hence, instead, for each stock and for each month throughout the

16. SIC codes were identified through Capital IQ using the stock's CUSIP or ISIN when available, or the name of the stock.

17. SIC code 6798 is associated with Real Estate Investment Trusts, and, as noted above, all securities classified in this SIC code were eliminated from the analysis. Furthermore, SIC codes 6722 and 6726 are associated with open-end and closed-end funds, respectively. As noted above, we attempted to identify the specific holdings of these funds and classify each of those specific holdings into an SIC. If holdings were not available for assets with these two codes, they were determined to be unclassified. In addition, assets that were classified as funds by the pension itself, but for which holdings were not available, were also determined to be unclassified.

Exhibit B
Industry Classification of Pension Funds' Equity Holdings

Pension Fund	Equity Portfolio	Amount Classified into Sectors	Percent Classified into Sectors
CalPERS	\$ 150,230,914,537	\$ 145,420,720,481	96.8%
<i>New York City</i>			
Teachers' Retirement System	\$ 11,507,149,221	\$ 10,299,384,153	89.5%
Police Pension Fund	\$ 16,985,124,953	\$ 16,238,551,231	95.6%
Fire Department Pension Fund	\$ 5,098,113,691	\$ 4,888,100,748	95.9%
NYCERS	\$ 35,640,863,975	\$ 26,391,786,575	74.0%
Board of Education Retirement System	\$ 3,057,967,874	\$ 2,543,588,391	83.2%
<i>Chicago</i>			
Policemen's Annuity & Benefit Fund	\$ 1,222,807,486	\$ 1,179,070,523	96.4%
LABF	\$ 593,803,410	\$ 593,792,583	100%
Firemen's Annuity & Benefit Fund	\$ 498,912,194	\$ 497,714,796	99.8%
MEABF	\$ 1,962,751,715	\$ 1,951,763,893	99.4%
<i>San Francisco</i>			
Employees' Retirement System	\$ 8,950,397,480	\$ 7,078,109,498	79.1%
Total	\$ 235,748,806,535	\$ 217,082,582,871	92.1%

Notes: Equity portfolio lists the total market value of equity securities held by the pension. Amount Classified into Sectors refers to the market value of securities for which it was possible to assign an SIC code. Percent Classified into Sectors shows Amount Classified into Sectors as a percent of the Equity Portfolio.

Sources: Respective pension funds; Capital IQ; Morningstar

sample period, we calculated the value-weighted return of all stocks in the CRSP database in the same industry sector as the stock. These returns therefore proxy for the returns a fund would earn by holding a portfolio similar to what it holds today.¹⁸

16. Through this methodology, we were able to calculate the historical average return and standard deviation (a measure of riskiness) to each pension fund's equity portfolio over a 50-

18. On some dates, there were no stocks in CRSP that matched the four-digit SIC code of a particular stock. In that case, we matched by the first three digits of the SIC code. If there were still no such stocks, then we matched the stock to all stocks with the same first two digits. Finally, if no such stocks were available, we matched the stock to all stocks in the same ten-sector classification given on Kenneth French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken_french/data_library.html.

Exhibit C-1
Average Annual Cost of Divestment Due to Lost Diversification
Narrow Divestment Approach: Coal, Oil, and Natural Gas

Pension Fund	<i>Non-Divested Portfolio</i>		<i>Divested Portfolio</i>		<i>Divested Portfolio (Risk-Adj.)</i>		Annual Cost of Divestment
	Average Excess Return	Standard Deviation	Average Excess Return	Standard Deviation	Average Excess Return	Standard Deviation	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
CalPERS	7.39%	16.84%	7.38%	17.15%	7.25%	16.84%	0.14%
<i>New York City</i>							
Teachers' Retirement System	7.69%	17.72%	7.56%	18.03%	7.43%	17.72%	0.27%
Police Pension Fund	8.09%	17.16%	8.09%	17.41%	7.97%	17.16%	0.11%
Fire Department Pension Fund	8.20%	17.48%	8.25%	17.85%	8.07%	17.48%	0.13%
NYCERS	7.67%	17.26%	7.66%	17.61%	7.51%	17.26%	0.16%
Board of Education Retirement System	7.62%	17.36%	7.61%	17.73%	7.45%	17.36%	0.17%
<i>Chicago</i>							
Policemen's Annuity & Benefit Fund	7.83%	17.40%	7.87%	17.75%	7.72%	17.40%	0.12%
LABF	7.94%	17.93%	7.95%	18.07%	7.89%	17.93%	0.05%
Firemen's Annuity & Benefit Fund	7.56%	17.96%	7.58%	18.23%	7.47%	17.96%	0.08%
MEABF	7.64%	17.72%	7.64%	17.98%	7.53%	17.72%	0.11%
<i>San Francisco</i>							
Employees' Retirement System	7.75%	16.95%	7.75%	17.31%	7.59%	16.95%	0.16%
Weighted Average	7.53%	17.00%	7.52%	17.31%	7.38%	17.00%	0.15%

Notes:

[1] The Narrow Divestment Approach divests from SIC Codes 1200-1399, and 2900-2999.

[2] Excess return is the annual return of the portfolio less the 3-month secondary market Treasury bill rate.

[3] The Divested Portfolio is a result of removing the divested assets from the Non-Divested Portfolio. The Risk-Adjusted Divested Portfolio allocates a fraction of the portfolio to treasury bills so that the standard deviation of the portfolio matches the standard deviation of the Non-Divested Portfolio.

[4] The Annual Cost of Divestment is the average excess return of the Non-Divested Portfolio less the average excess return of the Risk-Adjusted Divested Portfolio.

Sources: Respective pension funds; Federal Reserve Bank of St. Louis (FRED); Capital IQ; Morningstar; Calculated based on data from CRSP US Stock and Index Databases ©2017 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

year period. These are reported in the first two columns of Exhibits C-1 and C-2, and reflect the best available estimate of the expected future returns to similar portfolios. For the 11 pension funds as a whole, the average annual excess return is 7.53 percent and the standard deviation is 17.0 percent.¹⁹

19. Excess return is the return minus the 3-month secondary market Treasury bill rate. To calculate the average annual excess return for a particular stock, we subtracted the Treasury bill rate from each month, quoted on a monthly basis, from the monthly return of the stock. Then, we found the average of the excess return over all months in the sample, and annualized this average by multiplying by 12. Similarly, the standard deviation was found by finding the standard deviation of excess returns over all months in the sample, and then by multiplying by $\sqrt{12}$.

Exhibit C-2
Average Annual Cost of Divestment Due to Lost Diversification
Broad Divestment Approach: Coal, Oil, Natural Gas, and Utilities

Pension Fund	<i>Non-Divested Portfolio</i>		<i>Divested Portfolio</i>		<i>Divested Portfolio (Risk-Adj.)</i>		Annual Cost of Divestment
	Average Excess Return	Standard Deviation	Average Excess Return	Standard Deviation	Average Excess Return	Standard Deviation	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
CalPERS	7.39%	16.84%	7.47%	17.50%	7.19%	16.84%	0.20%
<i>New York City</i>							
Teachers' Retirement System	7.69%	17.72%	7.56%	18.03%	7.43%	17.72%	0.27%
Police Pension Fund	8.09%	17.16%	8.14%	17.56%	7.96%	17.16%	0.13%
Fire Department Pension Fund	8.20%	17.48%	8.32%	18.07%	8.04%	17.48%	0.16%
NYCERS	7.67%	17.26%	7.79%	18.04%	7.45%	17.26%	0.22%
Board of Education Retirement System	7.62%	17.36%	7.72%	18.13%	7.39%	17.36%	0.23%
<i>Chicago</i>							
Policemen's Annuity & Benefit Fund	7.83%	17.40%	7.96%	18.07%	7.67%	17.40%	0.17%
LABF	7.94%	17.93%	8.01%	18.29%	7.85%	17.93%	0.09%
Firemen's Annuity & Benefit Fund	7.56%	17.96%	7.64%	18.48%	7.43%	17.96%	0.13%
MEABF	7.64%	17.72%	7.71%	18.25%	7.49%	17.72%	0.15%
<i>San Francisco</i>							
Employees' Retirement System	7.75%	16.95%	7.89%	17.76%	7.53%	16.95%	0.22%
Weighted Average	7.53%	17.00%	7.61%	17.64%	7.33%	17.00%	0.20%

Notes:

[1] The Broad Divestment Approach divests from SIC Codes 1200-1399, 2900-2999, and 4910-4939

[2] Excess return is the annual return of the portfolio less the 3-month secondary market Treasury bill rate

[3] The Divested Portfolio is a result of removing the divested assets from the Non-Divested Portfolio. The Risk-Adjusted Divested Portfolio allocates a fraction of the portfolio to treasury bills so that the standard deviation of the portfolio matches the standard deviation of the Non-Divested Portfolio

[4] The Annual Cost of Divestment is the average excess return of the Non-Divested Portfolio less the average excess return of the Risk-Adjusted Divested Portfolio

Sources: Respective pension funds; Federal Reserve Bank of St. Louis (FRED); Capital IQ; Morningstar; Calculated based on data from CRSP US Stock and Index Databases ©2017 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business

17. We then calculated similarly the average return for “divested” versions of each pension fund portfolio. We considered two types of divestments: a “narrow” divestment excluding only stocks in the coal, oil, and natural gas industries,²⁰ and a “broader” divestment that also includes utilities.²¹ As discussed in Professor Fischel’s previous study, divestment advocates do not come close to agreeing with each other on which companies are “fossil fuel” companies and should be targeted for divestment;²² hence, it is reasonable to consider alternative approaches to divestment.

20. SIC 1200-1399 and 2900-2999.

21. SIC 1200-1399, 2900-2999, and 4910-4939.

22. Fischel (2015), *supra*, ¶¶ 30-31.

18. The third and fourth columns of Exhibits C-1 and C-2 report the average annual return and standard deviation for the narrow and broader divested portfolios, respectively. For the 11 pension funds as a whole, the average annual excess return for the “narrow” divested portfolio (Exhibit C-1) is 7.52 percent and the standard deviation is 17.3 percent. In the case of the “broader” divestment (Exhibit C-2), the average annual excess return is 7.61 percent and the standard deviation is 17.6 percent.

19. As shown in Exhibits C-1 and C-2, a divested portfolio is, on average, riskier than a non-divested portfolio. In order to compare the divested and non-divested portfolios on an apples-to-apples basis, we adjusted the divested pension fund portfolios for differences in riskiness that occur when the composition of a portfolio changes. In particular, we scaled the mean and standard deviation of each divested portfolio by the same factor that makes the standard deviation of the divested portfolio equal to the standard deviation of the equivalent non-divested portfolio.²³ This is reported in columns 5 and 6 of Exhibits C-1 and C-2.

20. Finally, we compared the average annual historical return of each pension fund with the average return of the risk-adjusted equivalent divested pension fund. This is the expected cost of fossil fuel divestment due to lost diversification benefits, and it is reported in column 7 of Exhibits C-1 and C-2. In all cases, both narrow and broader divestment is costly. For narrow divestment, the risk-adjusted diversification cost of divestment ranges between 0.05 percent per year for the Chicago Laborers’ and Retirement Board Employees’ Annuity and Benefit Fund and 0.27 percent per year for the New York City Teachers’ Retirement System. For broader divestment, the risk-adjusted diversification cost of divestment ranges between 0.09 percent per year and 0.27 percent per year for the same two pension funds.

23. Scaling the mean and standard deviation by the same factor essentially amounts to investing a portion of the portfolio in 3-month Treasury bills and the remaining portion in the unadjusted divested portfolio, with precise weights chosen so that the volatility of the risk-adjusted divested portfolio matches the volatility of the original non-divested portfolio.

21. Overall across all 11 funds, the weighted average risk-adjusted diversification cost of divestment is 0.15 percent for narrow divestment and 0.20 percent for broader divestment.

22. Exhibits D-1 and D-2 show how these costs translate into real dollars each year. The average annual cost of divestment in dollars in the case of narrow divestment ranges from more than \$324,000 for the Chicago Laborers' and Retirement Board Employees' Annuity and Benefit Fund to \$210 million for CalPERS. For the case of broad divestment, the cost of divestment ranges from more than \$518,000 to \$289 million for these same funds, respectively.

23. These losses also add up quickly over time to dramatically reduce the value of a pension fund. Exhibits D-1 and D-2 also show the cost of fossil fuel divestment for each fund over 50 years by determining what the value each portfolio would have been in 2015, had the fund invested the current value of its equity portfolio in 1966. In other words, these calculations reflect actual equity returns over the past 50 years, applied to the current value of the equity portfolio. On average across these 11 funds, after 50 years, the divested portfolio value is 7.1 percent lower in the narrow divestment case and 9.3 percent lower in the broad divestment case, compared with the value of the equivalent non-divested portfolio.

24. The total expected loss over 50 years for these 11 pension funds due to fossil fuel divestment is \$3.8 trillion in the narrow divestment case, and \$4.9 trillion in the broad divestment case. CalPERS in particular, being the largest of the pension funds we considered, would be expected to lose \$2.3 trillion in the narrow divestment case, and \$3.1 trillion in the

Exhibit D-1
Divestment Shortfall Over 50 Years (\$MM)
Narrow Divestment Approach: Coal, Oil, and Natural Gas

Pension Fund	Annual Cost of Divestment		Cost of Divestment over 50 years		
	Portfolio Value	Return Shortfall	Current Dollar Shortfall	Percent Shortfall	Dollar Shortfall
CalPERS	\$ 145,421	0.14%	\$ 210.336	6.90%	\$ 2,313,271
<i>New York City</i>					
Teachers' Retirement System	\$ 10,299	0.27%	\$ 27.370	12.25%	\$ 313,070
Police Pension Fund	\$ 16,239	0.11%	\$ 18.472	5.44%	\$ 280,535
Fire Department Pension Fund	\$ 4,888	0.13%	\$ 6.427	6.26%	\$ 100,009
NYCERS	\$ 26,392	0.16%	\$ 41.453	7.45%	\$ 502,519
Board of Education Retirement System	\$ 2,544	0.17%	\$ 4.294	7.98%	\$ 50,267
<i>Chicago</i>					
Policemen's Annuity & Benefit Fund	\$ 1,179	0.12%	\$ 1.376	5.59%	\$ 18,033
LABF	\$ 594	0.05%	\$ 0.324	2.65%	\$ 4,329
Firemen's Annuity & Benefit Fund	\$ 498	0.08%	\$ 0.418	4.03%	\$ 4,554
MEABF	\$ 1,952	0.11%	\$ 2.168	5.33%	\$ 25,125
<i>San Francisco</i>					
Employees' Retirement System	\$ 7,078	0.16%	\$ 11.524	7.72%	\$ 149,358
Total	\$ 217,083	0.15%	\$ 324.162	7.10%	\$ 3,761,071

Notes:

[1] The Narrow Divestment Approach divests from SIC Codes 1200-1399, and 2900-2999.

[2] Portfolio Value is the Amount Classified into Sectors, given by Exhibit B.

[3] Annual Return Shortfall is the Annual Cost of Divestment in Exhibit C-1. Current Dollar Shortfall is obtained by applying this cost to the portfolio value.

[4] The Percent Shortfall over 50 years is calculated as the difference between the Non-Divested and Risk-Adjusted Divested Portfolio after the 50 year period, 1966-2015, taken as a percent of the Non-Divested Portfolio. The analysis assumes that the portfolio value on January 1, 1966 is given by the Portfolio Value listed above.

[5] The Dollar Shortfall over 50 years is calculated as the difference between the Non-Divested and Risk-Adjusted Divested Portfolio after the 50 year period, 1966-2015. The analysis assumes that the portfolio value on January 1, 1966 is given by the Portfolio Value listed above.

Sources: Respective pension funds; Federal Reserve Bank of St. Louis (FRED) Capital IQ; Morningstar; Calculated based on data from CRSP US Stock and Index Databases ©2017 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

Exhibit D-2
Divestment Shortfall Over 50 Years (\$MM)
Broad Divestment Approach: Coal, Oil, Natural Gas, and Utilities

Pension Fund	Annual Cost of Divestment		Cost of Divestment over 50 years		
	Portfolio Value	Return Shortfall	Current Dollar Shortfall	Percent Shortfall	Dollar Shortfall
CalPERS	\$ 145,421	0.20%	\$ 289.133	9.37%	\$ 3,140,972
<i>New York City</i>					
Teachers' Retirement System	\$ 10,299	0.27%	\$ 27.370	12.25%	\$ 313,070
Police Pension Fund	\$ 16,239	0.13%	\$ 21.455	6.30%	\$ 324,686
Fire Department Pension Fund	\$ 4,888	0.16%	\$ 7.728	7.49%	\$ 119,596
NYCERS	\$ 26,392	0.22%	\$ 57.890	10.26%	\$ 692,150
Board of Education Retirement System	\$ 2,544	0.23%	\$ 5.829	10.69%	\$ 67,309
<i>Chicago</i>					
Policemen's Annuity & Benefit Fund	\$ 1,179	0.17%	\$ 1.957	7.87%	\$ 25,389
LABF	\$ 594	0.09%	\$ 0.518	4.21%	\$ 6,885
Firemen's Annuity & Benefit Fund	\$ 498	0.13%	\$ 0.634	6.07%	\$ 6,865
MEABF	\$ 1,952	0.15%	\$ 2.994	7.29%	\$ 34,390
<i>San Francisco</i>					
Employees' Retirement System	\$ 7,078	0.22%	\$ 15.771	10.42%	\$ 201,663
Total	\$ 217,083	0.20%	\$ 431.280	9.34%	\$ 4,932,975

Notes:

[1] The Broad Divestment Approach divests from SIC Codes 1200-1399, 2900-2999, and 4910-4939.

[2] Portfolio Value is the Amount Classified into Sectors, given by Exhibit B.

[3] Annual Return Shortfall is the Annual Cost of Divestment in Exhibit C-2. Current Dollar Shortfall is obtained by applying this cost to the portfolio value.

[4] The Percent Shortfall over 50 years is calculated as the difference between the Non-Divested and Risk-Adjusted Divested Portfolio after the 50 year period, 1966-2015, taken as a percent of the Non-Divested Portfolio. The analysis assumes that the portfolio value on January 1, 1966 is given by the Portfolio Value listed above.

[5] The Dollar Shortfall over 50 years is calculated as the difference between the Non-Divested and Risk-Adjusted Divested Portfolio after the 50 year period, 1966-2015. The analysis assumes that the portfolio value on January 1, 1966 is given by the Portfolio Value listed above.

Sources: Respective pension funds; Federal Reserve Bank of St. Louis (FRED) Capital IQ; Morningstar; Calculated based on data from CRSP US Stock and Index Databases ©2017 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

broad divestment case, over 50 years due to fossil fuel divestment. These are amounts that would be unavailable to pay to pension recipients, and as a consequence, pensions would either need to pay less to pensioners or else seek other sources of funds, such as taxpayer bailouts, to compensate for the losses due to divestment.

25. The costs estimated above are solely those attributable to lost diversification benefits for the equity portion of these pension funds' portfolios. There are likely to also be costs from lost diversification when a fund divests its non-equity holdings as well, including corporate bonds, alternative strategy holdings such as hedge funds or private equity, and other investments. Moreover, as discussed above, these diversification costs of fossil fuel divestment are only one category of costs that a pension fund would incur. In addition, there are transaction costs from selling fossil fuel securities (and replacing them with other securities), such as the bid-ask spread and the price impact of trades, as well as commissions that may be owed on transactions. There are also likely to be ongoing compliance costs to maintain a pension fund's adherence to their pledged standard of fossil fuel divestment. All of these costs are in addition to the substantial costs of fossil fuel divestment for pension funds we estimated above.

26. Of course, other pension funds besides the 11 we discuss here may have different holdings, and hence, different costs of divestment. But these data show that the costs of divestment are likely to be substantial in any case. Overall, fossil fuel divestment very likely has no environmental benefits and only serves to penalize public pension funds at a time when these funds desperately need higher returns to cover their current and future obligations.

Appendix A: Qualifications

Professor Daniel R. Fischel

I am President of Compass Lexecon, a consulting firm that specializes in the application of economics to a variety of legal and regulatory issues. I am also the Lee and Brena Freeman Professor of Law and Business Emeritus at The University of Chicago Law School. I have served previously as Dean of The University of Chicago Law School, Director of the Law and Economics Program at The University of Chicago, and as Professor of Law and Business at The University of Chicago Graduate School of Business, the Kellogg School of Management at Northwestern University, and the Northwestern University Law School.

Both my research and my teaching have concerned the economics of corporate law and financial markets. I have published approximately fifty articles in leading legal and economics journals and am coauthor, with Judge Frank Easterbrook of the Seventh Circuit Court of Appeals, of the book *The Economic Structure of Corporate Law* (Harvard University Press, 1991). Courts of all levels, including the Supreme Court of the United States, have cited my articles as authoritative.

I have served as a consultant or adviser on economic issues to, among others, the United States Department of Justice, the United States Securities and Exchange Commission, the National Association of Securities Dealers, the New York Stock Exchange, the Chicago Board of Trade, the Chicago Mercantile Exchange, the New York Mercantile Exchange, the United States Department of Labor, the Federal Deposit Insurance Corporation, the Resolution Trust Corporation, the Federal Housing Finance Agency, and the Federal Trade Commission.

I am a member of the Board of Governors of the Becker Friedman Institute at the University of Chicago and an Advisor to the Corporate Governance Project at Harvard University. I am also a former member of the Board of Directors of the Center for the Study of

the Economy and the State at The University of Chicago, and former Chairman of the American Association of Law Schools' Section on Law and Economics. I have testified as an expert witness in multiple proceedings in federal and state courts across the country.

Christopher R. Fiore

I am a Vice President at Compass Lexecon, where I have been employed since 2012. In this role, I have applied financial and economic analysis to a variety of legal and regulatory matters. Prior to joining Compass Lexecon, I received my Ph.D. in Economics from Yale University, where I specialized in financial economics, macroeconomics, and applied econometrics, and served as a teaching assistant in a variety of economics courses. I also hold a bachelor's degree in economics and mathematics from the University of Rochester, as well as a bachelor's degree in classical guitar performance from the Eastman School of Music. I have also previously worked as an intern at the Federal Reserve Board of Governors. I continue to conduct research, and have published articles in academic finance journals.

Todd D. Kendall

I am an Executive Vice President at Compass Lexecon. Prior to joining Compass Lexecon in 2008, I served for five years on the faculty of the economics department at Clemson University, and taught in the undergraduate, professional, and economics Ph.D. programs at that university. I have published more than a dozen articles in academic economics journals and collected volumes on the topic of applied economic theory, and which employ statistical and econometric methods.

I have been employed at Compass Lexecon since 2008, during which time I have consulted on a wide range of regulatory, litigation, merger and other business matters, and

testified in court as an expert witness. I received a bachelor's degree in mathematics from the University of Chicago in 1998 and a doctorate in economics from the University of Chicago in 2003.

Appendix B: Data sources for individual pensions

1. CalPERS

A detailed list of holdings is available online.²⁴ Holdings are divided into the following asset classes: Cash Equivalents, Debt Securities, Domestic REITs, International REITs, Domestic Equity, International Equity, Derivatives, Real Estate, Private Equity, Infrastructure, and Forestland. We have analyzed the portfolio of Domestic Equity and International Equity, totaling approximately \$150.2B in value.

2. *New York City Teachers' Retirement System*

Information about holdings as of June 30, 2016 of the funds available through the Teachers' Retirement System is available online.²⁵ Six different funds are listed: Pension Fund, Diversified Equity Fund, Bond Fund, International Equity Fund, Inflation Protection Fund, and Socially Responsive Equity Fund. We analyze the Pension Fund, but detailed holdings are not available for this fund. Of the fund's \$62.1B in market value, \$11.5B is invested in a mutual fund that tracks the EAFE Index. To proxy for the holdings of this fund, we found the holdings of the largest U.S. mutual fund, by AUM, which lists the MSCI EAFE Index as its benchmark.

24. See, "2014-2015 Annual Investment Report," <https://www.calpers.ca.gov/docs/forms-publications/annual-investment-report-2015.pdf>

25. See, "Investment Portfolios, June, 30, 2016," <https://www.trsnyc.org/ASPENMemberPro/WebContent/publications/financialReports/investmentPortfolio.pdf>

3. *New York City Police Pension Fund*

The Annual Financial Report of the Police Pension Fund is available online.²⁶ The report contains a list of broad investment funds that the pension invests in, with performance benchmarks. Since the pension does not provide detailed holdings, the holdings of the largest U.S mutual funds with those benchmarks as their own benchmarks were used as proxies for the holdings of the funds.

4. *New York City Fire Department Pension Fund*

The broad classification of holdings is available online as of June 30, 2016, in the “Monthly Performance Review” document.²⁷ The document contains a list of broad investment funds that the pension invests in, with performance benchmarks. Since the pension does not provide detailed holdings, the holdings of the largest U.S mutual funds with those benchmarks as their own benchmarks were used as proxies for the holdings of the funds.

5. *New York City Employees’ Retirement System*

We received holdings directly from the pension fund, divided into equity and fixed income holdings. The fund further classified equity holdings into the following categories: Common Stock, Common Stock Unit, Depository Receipts, Limited Partnership Units, Mutual Funds, Non-Security Asset-Stock, Preferred Stock, Real Estate Investment Trust, Rights, and Warrants. All securities identified as Real Estate

26. See, “Police Pension Fund, A Pension Trust Fund of the City of New York, for fiscal years ended June 30, 2016 and June 30, 2015,” <http://www.nyc.gov/html/nycppf/downloads/pdf/CAFR%202016.pdf>

27. See, “Monthly Performance Review, June 2016,” <https://comptroller.nyc.gov/wp-content/uploads/documents/PDF-Package-Fire-8.2016-Monthly-Performance-Review-Material-10.0-Version.pdf>

Investment Trusts were excluded from the analysis, and the resulting portfolio had market value totaling \$35.6B. Assets were considered to be classified as funds by the pension if they were listed as part of one of the following categories: Mutual Funds, Limited Partnership Units, or Non-Security Asset-Stock.

6. *New York City Board of Education Retirement System*

We received holdings directly from the pension fund, divided into equity and fixed income holdings. The fund further classified equity holdings into the following categories: Common Stock, Common Stock Unit, Depository Receipts, Limited Partnership Units, Mutual Funds, Non-Security Asset-Stock, Preferred Stock, Real Estate Investment Trust, Rights, and Warrants. All securities identified as Real Estate Investment Trusts were excluded from the analysis, and the resulting portfolio had market value totaling \$3.06B. Assets were considered to be classified as funds by the pension if they were listed as part of one of the following categories: Mutual Funds, Limited Partnership Units, or Non-Security Asset-Stock.

7. *Chicago Laborers' & Retirement Board Employees' Annuity & Benefit Fund*

We received detailed holdings as of 11/23/2016 directly from the pension, but market values are as of 10/31/2016. Holdings are divided into two asset classes: Equities and Fixed Income. Equities are further classified into the following sub-categories: Common Stock, Funds – Common Stock, Funds – Equities ETF, Other Equity Assets, Preferred Stock, Rights/Warrants, and Stapled Securities. Assets were considered to be classified as funds by the pension if they were listed as part of one of the following categories: Funds – Common Stock and Funds – Equities ETF.

8. *Chicago Fireman's Annuity and Benefit Fund of Chicago*

We received holdings as of 9/30/2016 directly from the pension. The list of holdings did not divide the holdings into asset classes, so we eliminated keywords that suggested that the holding could be a part of a non-equity asset class. The process left a portfolio with value of \$498.9M, short of the \$533.5M cited by the fund as the value of its equity.²⁸

9. *Chicago Municipal Employees' Annuity and Benefit Fund of Chicago*

We received detailed holdings of the pension as of August 2016. The holdings are divided into the following asset classes: Equity, Fixed Income, Real Estate, Venture Capital and Partnerships, Other Assets, Derivative Offsets, Hedge Funds, Recoverable Taxes, Cash and Cash Equivalents, and Adjustments to Cash. We analyzed the equity portfolio, which had market value of approximately \$2.0B. Equities were further classified into the following categories: Common Stock, Preferred Stock, Stapled Securities, Rights/Warrants, Equity Derivatives – futures, and Funds – Equities ETF. Assets were considered to be classified as funds by the pension if they were classified as: Funds – Equities ETF.

10. *Chicago Policemen's Annuity & Benefit Fund*

28. See, "Firemen's Annuity and Benefit Fund of Chicago, Asset Allocation and Performance, September 30, 2016," <http://www.fabf.org/PDF/Financial/Asset/09-30-2016.pdf>

The broad allocation of the pension fund is available online.²⁹ The broad asset classes are: U.S. Equity, Non-U.S. Equity, Fixed Income, Global Asset Allocation, Private Equity, Hedge Funds, Real Estate, Real Assets, Infrastructure, and Cash. The total value of U.S. equity is \$589.3M and the total value of Non-U.S. Equity is \$633.5M. Benchmarks were provided for each of these two asset classes, and the holdings of the largest U.S. mutual funds by AUM citing those benchmarks as its own benchmarks were used as proxies for the holdings of the U.S. Equity and Non-U.S. Equity asset classes.

11. San Francisco Employees' Retirement System

We received equity and fixed income holdings directly from the fund. Equity holdings included Real Estate Investment Trusts, so we eliminated any holding with key words "REIT" or "REAL ESTATE". The equity portfolio we analyzed totaled \$9.0B in value.

29. See, "Policeman's Annuity and Benefit Fund of Chicago, Performance Update as of September 30, 2016," <http://www.chipabf.org/ChicagoPolicePension/PDF/Investments/Performance.pdf>