

Cost of Fossil Fuel Divestment for Public Pension Funds of New York State and Colorado¹

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I. Introduction

1. The fossil fuel divestment movement encourages investors to “take a stand” against climate change by selling the holdings of fossil fuel companies in their portfolios “to stigmatize the fossil fuel industry” and deprive these firms of capital. A growing economic literature finds, by contrast, that fossil fuel divestment is little more than a political statement; it has little or no effect on the targeted companies while creating additional costs and lower risk-adjusted returns for investors.²

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. See Daniel R. Fischel (2015) “Fossil Fuel Divestment: A Costly and Ineffective Investment Strategy” (concluding that the cost of divestment was 0.5 percent per year on a risk-adjusted basis, and demonstrating that these annual losses add up to a 23 percent reduction in the value of a divested portfolio over a 50-year period). See also Bradford Cornell (2015) “The Divestment Penalty: Estimating the Costs of Fossil Fuel Divestment to Select University Endowments” (estimating losses from potential divestment actions at five large U.S. university endowments, and concluding that, on a weighted average basis, fossil fuel divestment would cost these endowments approximately 0.23 percent per year). See also Hendrik Bessembinder (2016) “Frictional Costs of Fossil Fuel Divestment” (estimating the costs of divestment related to transaction costs from selling divested securities and buying substitute securities, and ongoing research costs of maintaining compliance with a divestment goal, and concluding that these costs alone reduce the value of a university endowment divested of fossil fuel securities by between two percent and twelve percent over a twenty-year period). See also Hendrik Bessembinder (2017) “Fossil Fuel Divestment and Its Potential Impacts on Students, Faculty and Other University and Pension Stakeholders” (estimating the costs of divestment are equivalent to hundreds or thousands of dollars in increased university tuition and 5-7% reductions in monthly pension benefits).

2. In 2017, we released a report that quantified the reduction in risk-adjusted returns that would be caused by divestment at large U.S. public pension funds, including the California Public Employees' Retirement System (CalPERS), which is the largest public pension fund in the United States, as well as public pension funds of New York City, Chicago, and San Francisco.³ Using data on these funds' 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. We found that when a pension fund divests from coal, oil, and natural gas, the annual cost of divestment averaged 0.15% across the funds we studied, with a range between 0.05% to 0.27% per year. When the pension fund also divests from utilities, then the annual cost of divestment averaged 0.20% per year, and ranged from 0.09% to 0.27%. These lost returns are large in dollar terms. For instance, for CalPERS, the estimated cost of divestment would translate into a loss of \$210 million per year when divesting from coal, oil, and natural gas, and \$289 million per year when also divesting from utilities.

3. Of course, the magnitude of the costs of divestment depends on the particular holdings of a pension fund. In this study, we extend our previous work by analyzing the cost of divestment for two additional pension funds that have recently been the subject of debate regarding divestment: the New York State Common Retirement Fund and the Colorado Public Employees' Retirement Association (PERA). For example, New York State Governor Andrew Cuomo has recently announced that he supports fossil-fuel divestment by the state's pension

3. Daniel R. Fischel, Christopher R. Fiore, and Todd D. Kendall (2017) "Fossil Fuel Divestment and Public Pension Funds."

Exhibit A

Public Pension Funds Analyzed

Pension Fund	Most Recently Reported Portfolio Value (\$MM)
New York State Common Retirement Fund	\$ 192,411
Colorado PERA	\$ 43,649

Sources: Respective pension funds.

fund.⁴ In addition, 350.org has announced that it will “kick the fossil fuel divestment movement in Colorado into overdrive...”⁵ The most recent total portfolio values of these pensions are provided in Exhibit A. We have obtained detailed data on specific equity securities holdings for these two funds, so that our cost estimates can be closely tailored to actual fund holdings.

4. 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 0.15 percent per year lower for Colorado PERA and 0.16 percent per year lower for New York State. The broader divestment approach (targeting utilities as well as coal, oil, and gas) led to risk-adjusted returns that were 0.22 percent per year lower for Colorado PERA and 0.23 percent per year lower for New York State. Thus, these two funds are similar to the funds we analyzed in our previous report in terms of the impact of fossil fuel divestment.

4. See, “New York Governor Seeks Fossil-Fuel Divestment, But Comptroller Has Other Plans,” *Wall Street Journal*, December 27, 2017, <https://www.wsj.com/articles/new-york-governor-seeks-fossil-fuel-divestment-but-comptroller-has-other-plans-1514404668>.

5. See, <https://350colorado.org/promoting-solutions/divest-invest/>

5. These costs of divestment are substantial in dollar terms. For Colorado PERA, the expected annual cost of divestment is \$36 million (narrow divestment approach) or \$50 million (broader divestment approach), which would constitute, at current funding levels, 2.2 percent or 3.0 percent of employer contributions to this fund, respectively.⁶ For the New York State fund, the expected annual cost of divestment is \$136 million (narrow divestment approach) or \$198 million (broader divestment approach), which would constitute, at current funding levels, 3.6 percent or 5.2 percent of employer contributions to this fund, respectively.⁷ The costs of divestment also add up over time. We estimate that over the past 50 years, on a risk-adjusted basis, Colorado PERA would have suffered a 7.36 percent loss due to the narrower divestment approach, and a 10.12 percent loss due to the broader divestment approach. This amounts to \$470 billion for the narrower divestment approach and \$646 billion for the broader divestment approach. Similarly, New York State would have suffered a 7.53 percent loss due to the narrower divestment approach, and a 10.76 percent loss due to the broader divestment approach. This amounts to \$1.1 trillion for the narrower divestment approach and \$1.5 trillion for the broader divestment approach. These are funds that would be unavailable to pension recipients and which would have to be made up in some way, either with lower pension payouts, or through taxpayer bailouts.

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

6. Colorado PERA “Comprehensive Annual Financial Report” For the Year Ended December 31, 2017, at pp. 60-61 (indicating employer contribution of \$1,645,104,000).

7. New York State and Local Retirement System, Office of the New York State Comptroller, “2017 Comprehensive Annual Financial Report,” at p. 40 (indicating employer contribution of \$3,798,738,000).

II. Calculation of Divestment Costs

7. For each fund, we sought the most recent detailed information on equity holdings available.⁸ For the New York State Common Retirement Fund, this information was provided in publicly available reports from the fund, and for the Colorado PERA, it was sent to us by the fund upon request. Appendix B provides more details on the pension holdings data utilized for this study.

8. 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 (“SIC”).⁹ 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.

9. 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 New York State Common Retirement Fund, we were able to identify an SIC code for 84.6 percent of the holdings, and for Colorado PERA, we were able to identify an SIC for 99.9 percent of holdings. Holdings lacking an SIC were dropped from the analysis.

10. We then analyzed historical returns to these holdings over the 50-year period 1968 to 2017. However, if we were to analyze the past returns of the actual securities held by

8. 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.

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

Exhibit B

Industry Classification of Pension Funds' Equity Holdings

Pension Fund	Equity Portfolio	Amount Classified into Sectors	Percent Classified into Sectors
New York State Common Retirement Fund	\$ 101,423,239,339	\$ 85,767,773,779	84.6%
Colorado PERA	\$ 23,055,373,069	\$ 23,031,213,033	99.9%

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 a 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.

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 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.¹⁰

11. 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-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 New York State,

10. 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
Annual Diversification 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]
New York State Common Retirement Fund	7.00%	17.65%	6.96%	17.95%	6.85%	17.65%	0.16%
Colorado PERA	7.99%	17.25%	7.99%	17.59%	7.83%	17.25%	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 ©2018 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

the average annual excess return is 7.00 percent and the standard deviation is 17.65 percent.¹¹

For Colorado, the average annual excess return is 7.99 percent and the standard deviation is 17.25 percent.

12. 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,¹² and a “broader” divestment that also includes utilities.¹³ As discussed elsewhere in the literature, divestment advocates differ in their opinions on which companies are “fossil fuel” companies and should be targeted for divestment;¹⁴ hence, it is reasonable to consider alternative approaches to divestment.

11. 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 $\sqrt{12}$.

12. SIC 1200-1399 and 2900-2999.

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

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

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]
New York State Common Retirement Fund	7.00%	17.65%	7.00%	18.24%	6.77%	17.65%	0.23%
Colorado PERA	7.99%	17.25%	8.05%	17.86%	7.77%	17.25%	0.22%

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 ©2018 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

13. 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 New York State fund, the average annual excess return for the “narrow” divested portfolio (Exhibit C-1) is 6.96 percent and the standard deviation is 17.95 percent, and in the case of the “broader” divestment (Exhibit C-2), the average annual excess return is 7.00 percent and the standard deviation is 18.24 percent. For the Colorado fund, the average annual excess return for the “narrow” divested portfolio (Exhibit C-1) is 7.99 percent and the standard deviation is 17.59 percent, and in the case of the “broader” divestment (Exhibit C-2), the average annual excess return is 8.05 percent and the standard deviation is 17.86 percent.

14. 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.¹⁵ This is reported in columns 5 and 6 of Exhibits C-1 and C-2.

15. 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. For both funds, narrow and broader divestments are costly. For narrow divestment, the risk-adjusted diversification cost of divestment is 0.15 percent for Colorado and 0.16 percent for New York State. For broader divestment, the risk-adjusted diversification cost of divestment is 0.22 percent for Colorado and 0.23 percent for New York State.

16. 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 is \$36 million per year for Colorado and \$136 million per year for New York State. For the case of broad divestment, the cost is \$50 million per year for Colorado PERA and \$198 million per year for New York State.

17. 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 of each portfolio would have been in 2017, had the fund invested the current value of its equity portfolio in 1968. In other words, these calculations reflect actual equity returns over the past 50 years, applied to the current value of the equity portfolio. For Colorado, after 50 years, the divested portfolio value is 7.4 percent lower in the

15. 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.

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
New York State Common Retirement Fund	\$ 85,768	0.16%	\$ 136	7.53%	\$ 1,062,016
Colorado PERA	\$ 23,031	0.15%	\$ 36	7.36%	\$ 469,719

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, 1968-2017, taken as a percent of the Non-Divested Portfolio. The analysis assumes that the portfolio value on January 1, 1968 is given by the Portfolio Value

[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, 1968-2017. The analysis assumes that the portfolio value on January 1, 1968 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 ©2018 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

narrow divestment case and 10.1 percent lower in the broad divestment case, compared with the value of the equivalent non-divested portfolio. This amounts to \$470 billion for the narrow divestment case and \$646 billion for the broad divestment case. For New York State, after 50 years, the divested portfolio value is 7.5 percent lower in the narrow divestment case and 10.8 percent lower in the broad divestment case, compared with the value of the equivalent non-divested portfolio. This amounts to \$1.1 trillion in the narrow divestment case and \$1.5 trillion in the broad divestment case. 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.¹⁶

16. Taxpayers are already beginning to pay substantial sums to close pension deficits. For instance, Colorado recently passed a reform bill that requires the state to contribute an additional \$225 million per year to PERA. Colorado PERA press release, “Colorado PERA Reform Legislation Signed by Governor Hickenlooper,” <https://www.copera.org/news/colorado-pera-reform-legislation-signed-governor-hickenlooper>. See also Richard W. Johnson, Owen Haaga, and Benjamin G. Southgate (2016) “Understanding the growth in government contributions

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
New York State Common Retirement Fund	\$ 85,768	0.23%	\$ 198	10.76%	\$ 1,516,327
Colorado PERA	\$ 23,031	0.22%	\$ 50	10.12%	\$ 646,205

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, 1968-2017, taken as a percent of the Non-Divested Portfolio. The analysis assumes that the portfolio value on January 1, 1968 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, 1968-2017. The analysis assumes that the portfolio value on January 1, 1968 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 ©2018 Center for Research in Security Prices (CRSP), The University of Chicago Booth School of Business.

18. 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

to New York State’s public pension plans,” Urban Institute, <https://www.urban.org/sites/default/files/publication/81221/2000805-Understanding-the-Growth-in-Government-Contributions-to-New-York-State%E2%80%99s-Public-Pension-Plans.pdf> (“Nationally, contributions by state and local governments to public employee retirement plans increased 133 percent in inflation-adjusted dollars between 2002 and 2014. In New York State, by contrast, total government contributions increased 609 percent over the same period, the second-largest increase in the nation.”).

transactions.¹⁷ 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.

19. Therefore, this study shows that the same conclusion from our previous study applies to the New York State Common Retirement Fund and Colorado PERA: divestment from fossil fuels results in a substantial shortfall in investment performance.¹⁸

17. See, Bessembinder (2016) "Frictional Costs of Fossil Fuel Divestment" (concluding that, "[o]verall, I estimate a total cost to endowments over 20 years due to the frictional costs of divestment that range between approximately 2 and 12 percent of the endowment's value.").

18. Other studies that evaluate the effect of fossil fuel divestment for pensions also find that divestment can have large costs to pension funds for additional reasons beyond those discussed in this report. As noted above, there are transaction and monitoring costs of divestment. See Bessembinder (2016), *supra*. As another example, a study conducted by Global Analytic Services, Inc. and commissioned by the Suffolk County Association of Municipal Employees finds that when one replaces fossil fuel assets with "green" assets, losses from divestment are between \$29.4 million and \$48.9 million in the year following divestment and between \$188.8 million and \$303.2 million in the five years following divestment. See, Global Analytic Services (2017): "Fossil Fuel Divestment Impact on New York State Pensions," <https://www.politico.com/states/f/?id=00000160-4cb2-d9e9-a365-efff1cdf0001>. This study studies the impact of divestment on these stocks in isolation, and does not measure the cost of diversification as we do.

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 former member of the Board of Governors of the Becker Friedman Institute at the University of Chicago and a former 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. New York State Common Retirement Fund

A detailed list of holdings is available online as of March 31, 2017. Holdings are divided into the following asset classes: Domestic and International Equity, Commingled Stock Funds, Global Fixed Income, Mortgage Holdings, Real Estate Investments, Short-Term Investments, and Alternative Investments Assets. We analyzed the portfolio of Domestic and International Equity, and Commingled Stock Funds. Assets were considered to be classified as funds by the pension if there were listed as Commingled Stock Funds. All securities identified as Real Estate Investment Trusts were removed from the analysis, and the resulting portfolio totaled approximately \$101.4B in market value.

2. Colorado Public Employees' Retirement Association (PERA)

We received the complete list of equity holdings as of December 31, 2016 directly from the pension fund. All securities identified as Real Estate Investment Trusts were removed from the analysis, and the resulting portfolio totaled approximately \$23.1B in market value.