TERMINATION RISK AND SUSTAINABILITY

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As the Emperor said " *Everything is proceeding as I have forseen*"

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ABSTRACT

This paper examines optimal behavior of companies and investors in businesses that have uncertain termination dates at which they will stop doing business. It is shown that intuitively and in simple models that such businesses will underinvest to avoid stranding assets when termination occurs. As supply is reduced, output prices and stock prices will rise. It is argued that this characterizes fossil energy firms, investors and even countries. A consequence of this behavior is that many "sustainable" funds are underperforming as they are underweighting the energy sector. Nevertheless, today's high fossil energy prices provide a strong incentive to decarbonize. However better policies could lead to even better outcomes.

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INTRODUCTION

In 2022 fossil energy prices and stock returns rose dramatically and stock market portfolios designed to be sustainable underperformed the broad market. From a climate perspective this appears to be an unfortunate outcome. This white paper will suggest why the underlying risks associated with climate change are in fact the cause of this outcome and will discuss whether this should be interpreted as good or bad news for climate mitigation. It also raises the question of whether there are now or were in the past better policies to mitigate climate risk.

LONG RUN RISK

A bad event that has some probability of occurring is called a risk. When this is far in the future we call it a long run risk. Climate change is a good example of long run risk. We see evidence of climate change all around us but science and common sense make it clear that the damages from climate change are likely to be much greater in the future than we see now. However, many of these damages are uncertain in their location, severity and timing. Thus, these are naturally thought of as long run risks and in particular they are long run physical risks. The literature on climate change also identifies transition or regulatory risks as risks that will result from efforts to mitigate climate change. The risk to a firm is that society will impose laws, regulations or other approaches to decarbonization that will create winners and losers and that this firm is a loser. Being such a loser is a long run risk where much of the uncertainty may be whether political bodies or the private sector will act and if so what form these will take.

I would like to begin this analysis with a simple example that motivates the results I will describe. Consider the strategies available to the owner of a luxury beach front hotel. In an uncertain number of years, sea level rise will completely destroy this property. Thus, it is an example of a stranded asset with a random termination point. If the best estimate of the terminal date is relatively soon, it would be foolish to carry out an expensive remodel that would have a payoff period in excess of the lifetime of the hotel. A smarter strategy would be to reduce long horizon investment and allocate the revenue to better projects. If there are multiple hotels facing the same choices, then a shortage of beach front luxury hotels may develop. As a consequence of this inward supply shift and reductions of cost, the price of hotel stays should rise and the profits should also rise.

What should investors do in this example? If they invested in the hotel before sea level rise was predicted, then their investment must fall with the news. However new investors can expect profits and payouts until the end when they will drop to zero leaving the hotel and its land as worthless stranded assets. If they sell their position in the hotel, the buyer will recognize the same factors so the price will be low and the return temporarily high. The stock price should still reflect the present discounted value of payouts over the short and uncertain time period and probably a substantial risk premium. The stock price will still fluctuate based upon changes in demand for beach front vacations and changes in the expected termination date.

A similar set of choices face the owners of fossil energy companies. In this case the risk is primarily transition risk rather than physical risk and so the risk incorporates politics rather than simply nature. It is unclear how decarbonization of the economy will be achieved but there is little doubt that we will have to do this one way or another unless the science is very wrong. Managers and investors and politicians will be forced by the escalation of physical damages, to confront this problem. The terminal date is thus highly uncertain but it must be part of corporate and investor planning.

GOVERNMENT DECARBONIZATION STRATEGIES

There are various ways climate mitigation can impact fossil energy companies. These might be considered alternative long run risk scenarios. The outcomes will depend upon the choices made by governments.

Conceptually, governments can decarbonize in three stylized policies.

1. They can tax fossil energy emissions and this policy is in place for some sectors in the EU as the EU Emission Trading System. The UK and California have such institutions and in a much more limited way so does New England through RGGI. These all are cap and trade systems which allow trading of emission allowances and even futures on them. Many other countries have systems ready to go with various specific features. Some are emission taxes and some are tradable emission allowances. Effectively, carbon taxes put a wedge between the price that consumers pay for fossil energy and the price that producers receive for producing the energy. Thus, when such a tax is instituted, consumer prices should increase and producer prices decrease. However, it is not so simple as this because the tax could be shifted either upstream to suppliers or downstream to consumers. The net effect is typically higher fossil energy prices but lower profits to the fossil energy companies and therefore lower stock prices.
2. A second strategy is subsidizing renewables. In this case, the cost of energy to consumers will fall and the demand for energy as a whole will rise. Fossil energy prices must fall to compete and profits of fossil energy companies will decline as will stock prices. This is the strategy implemented in the Inflation Reduction Act of the Biden administration. It provides substantial stimulus to the energy sector through

increasing the quantity and lowering the price of renewables which will hurt the fossil energy sector.

3. The third strategy is to regulate emissions. This has been used in many countries. Vehicle emission standards and building standards are good examples. We now see laws stating that by a certain date in the future no fossil energy vehicles can be sold in California or in China. In this case, the prohibition of some emissions will raise the price of remaining emissions and close substitutes. The net effect of restricting supply is often an increase in price and profits and stock prices.

The net effect of each of these policies is to reduce the amount of emissions but some come with increasing prices of fossil energy and others with decreasing fossil energy prices. Some lead to rises in fossil energy stock prices and others declines.

The government has another option - do nothing and hope the private sector will stop climate change. The most likely response by the private sector is from the capital markets which could shrink lending to and investing in fossil energy companies. In this case also, fossil energy will shrink but its profits and energy prices may rise. There could also be incentives implemented by consumers who want to buy green products or workers who want to work for green companies. Each of these incentives relies on private responses to collective goals and consequently the effectiveness is hard to forecast.

In reality, all four of these approaches are likely to be present in any situation. Government inactivity will surely precede any political mitigation and one form of policy response is unlikely to be comprehensive so other strategies will be needed for particular sectors or jurisdictions.

From this casual analysis it seems clear that as climate risk rises, in one way or another, fossil energy will decline in importance and will leave stranded assets. It will be optimal for fossil energy companies to reduce their long-term investment and shrink their supply curves. Thus, even before any government policy is implemented, we might expect to see the private sector response which leads to higher energy prices and profits. Data from 2022 suggests that this is exactly what we are seeing.

CAN FOSSIL ENERGY COMPANIES TURN GREEN?

If fossil energy companies do indeed believe that there is a date at which their business will terminate, perhaps they will shift their investment into renewable energy projects. This is certainly possible and is widely viewed as a socially desirable outcome. However it is not clear that it is preferable from a social welfare point of view to simply giving the cash flows to the investors until they finish.

Possibly fossil energy companies have special synergies with renewable energy projects. However, they are located in very different places and the transmission of oil and gas is completely different from electricity. There is no drilling or exploration needed for renewable projects but there is battery technology and high tech solar and wind devices. It is not clear that any of the fossil energy personnel or technology is relevant to the renewable projects.

If a fossil energy company takes on green projects, then it will be unclear whether sustainable investors will choose to invest in the blended technology or not. It may also be difficult for such companies to qualify for subsidies for renewable energy. Thus the cost of capital for fossil energy to develop renewable energy projects is likely to be higher than for stand-alone renewable projects which could benefit from the various forms of green finance subsidies.

A natural solution is for fossil energy companies to start new subsidiaries to carry out the renewable energy projects and spin them off on their own with an IPO or other ways to enter the public or private market. In this case the new company competes on its own but often with the fossil energy company as a major investor.

A TERMINATION RISK MODEL

In this next section a stylized version of this long run risk argument is put into a model. This model is called a Termination Risk Model because the risk is that of termination of the business and capital. The key feature is that the sector will face a demand function that goes to zero at time T which is the termination time. This may be for any of the reasons described above. The question of whether prices or profits rise is a result of the method and implementation of decarbonization policy.

Firms will naturally choose to invest in projects which increase its ability to produce output. The amount invested must be related to the value of the product. At the margin, the last dollar invested should yield at least a dollar of output. Letting p be the price of the product (fossil energy) relative to the price of capital and assuming no monopoly power, then in economic language the marginal physical product of capital, (MPP_K), should equal 1/p. Thus, investment should satisfy

$$MPP_K * p = 1 \qquad (1)$$

This relation however is only correct if capital lasts only one period. Typically, however capital lasts many years and gradually depreciates. Hence this formula applies when a firm has only one period left to operate. The model in this section develops investment strategies for businesses with finite lifetimes.

Consider an economy with a consumption good which can also be used for investment. There are J competitive firms which all produce a second good, which we will call fossil energy. The quantity produced, q, is described by production functions

$$q_j = a_j f_j\left(k_j\right), \quad j = 1,\ldots,J \tag{2}$$

where each f is increasing, differentiable and strictly concave in capital, *k*. Capital accumulates from investment in a traditional fashion according to

$$\begin{aligned} &k_{j,t} = \delta k_{j,t-1} + i_{j,t} \quad for\ j = 1,\ldots,J,\ t = 1,\ldots,T,\ hence \\ &k_{j,s} = \delta^{s-t+1} k_{j,t-1} + \delta^{s-t} i_{j,t} + \delta^{s-t-1} i_{j,t+1} + \ldots + i_{j,s} \quad for\ s = t,\ldots,T \end{aligned} \tag{3}$$

where δ is the depreciation rate and *i* is investment.

To recognize the finite lifetime of these firms, aggregate demand, Q_t , is zero after termination date T. This is a very stylized assumption and could occur in many ways. For example, regulators or firms themselves could make binding commitments to a netzero emissions target at T. This could be done by regulation or by a punitive emissions tax. Alternatively, either government or the private sector could mobilize a massive renewable energy project that is completed at T. If this is substantially cheaper than fossil energy, then effectively demand will disappear. Firms could also commit to reach net zero targets at time T.

Before T is reached, the demand function for Q can evolve and will depend monotonically upon the price of fossil energy. There is often a belief that the demand for fossil energy is highly inelastic, however the elasticity could be substantially bigger if there are alternative energy sources. Markets are assumed to clear each period.

$$\sum_{j=1}^{J} q_{j,t} = \sum_{j=1}^{J} a_j f_j\left(k_{j,t}\right) = Q_t \tag{4}$$

The important decision variable for each firm is the choice of *i*. In a deterministic model, the future demand and price are known so the solution for investment is simply to set the present discounted value of the marginal product equal to 1. If γ is the discount rate then

$$\left[\sum_{s=t}^{T} \gamma^{s-t} * \delta^{s-t} * p_s * a_j * f_j{}'\left(k_{j,s}\right)\right] = 1 \quad \forall t = 1,\dots,T \;\; j = 1,\dots,J \tag{5}$$

This condition terminates at T since the marginal product has no value after T. This means that the capital has no value and is therefore stranded. One can add some residual value of the capital but that would not change the relation very much. This expression can be used to see the consequences of changes in Q and changes in T. Since all the terms in square brackets are non-negative, a reduction in T will mean that the left side is lower unless *p* is higher or *f′* is higher. Higher *f′* results from lower *k* and higher *p* also results from lower *k.* Thus, when the time to termination gets shorter, investment will decrease and prices will increase. This is a leftward shift in the aggregate supply curve and the elasticities will determine the quantity decline and price increase that results.

Next, consider an increase in Q. This will coax out new investment by increasing the price and increasing k which will reduce the marginal product. It is simply a rightward shift in aggregate demand. Thus, increased demand for fossil energy leads to higher prices and higher investment. Interestingly, if Q increases for one period which is close to T the quantity response will be smaller than if this period is long before T. In the period with a positive shock to Q, fossil energy prices will rise and investment will rise increasing output. In the subsequent periods without the demand shock, the capital stock will remain elevated leading to increased output and lower prices. If the demand shock occurs late, then there will be less output increase over the remaining periods.

UNCERTAINTY

Uncertainty makes exact solutions more difficult to compute. In general, investment would be chosen to maximize Expected Discounted Value of cash flows. In this model cash flows are *p*f(k)-i* hence the firm should choose today's investment to solve the problem

$$\max_{i_t} E_t u_j \left(\sum_{s=t}^{T} (\gamma\delta)^{s-t} p_s a_j f'(k_s) - \gamma^{s-t} i_s \right) \tag{6}$$

In this expression, u_j is the utility function of the decision maker for firm *j*. In this expression, not only is T is uncertain but so is the path of prices and quantities. Suppose that when T=T*, some particular future date, then the optimization of i_t can be solved to give i_t^*. If it turns out that T<T*, then the strategy starting with i_t^* will overinvest and as a consequence, p will be too low and the value of the terminal stranded asset will be too high. If on the other hand, T>T*, then the firm will under invest leading to higher prices and profits and less capital stranded after T. It is better to err on the side of underinvesting. This shows that the solution to (6) will be conservative in that it will behave as if the terminal date is closer than its actual expected value. Furthermore, assuming the utility function exhibits risk aversion, the solution for a known T will also be underinvestment relative to a risk neutral solution. This is consistent with the rational expectation that under uncertainty, the firm will underinvest relative to the deterministic solution.

EQUITY PRICES

Long run risks occur in many financial and non-financial applications and generally incur a risk premium. Equity investors in firms that face termination risks face similar long run risks. In a well-functioning market, equity prices are based upon the present discounted value of expected cash flows as well as a risk premium. Since cash flows before T will rise and cash flows after T are simply the returns on cash net of liabilities, the stock price will go to zero if all the profits are returned to investors by T. This might appear as an investment disaster, but investors in this case would be appropriately compensated for taking this risk.

Fossil energy companies have another choice. They can invest in renewable energy projects directly with the revenue from fossil projects. This an alternative to returning the earnings to shareholders and letting them invest it in renewables. From an efficiency perspective the choice depends upon whether fossil energy has a particular advantage in making such investments. For many similar transitions, the market rewards firms that leave the investment choice to the investors. Hence rising dividends and buybacks might be the efficient approach to this transition. See Bloomberg: Money Stuff: Oil Companies Give Back the Cash by Matt Levine(May 9,2023) and Bentham et al(2022) for a nice discussion of this choice.

Returns above this level may best be interpreted as increases in Q and/or T. In the fossil energy market, it is easy to see that the global demand for fossil energy from markets other than Russia has increased. In addition, it is certainly possible that the expected shutdown date for these industries has moved further into the future. The rise in energy prices and energy stocks thus has a simple explanation that still leads ultimately to decarbonization.

EMPIRICAL EVIDENCE

There is substantial empirical evidence that this termination model is consistent with behavior of the fossil energy sector. A congressional oversight committee investigated fossil energy misinformation. In their December 2022 report they say:

The fossil fuel industry's failure to make meaningful investments in a long-term transition to cleaner energy is particularly outrageous in light of the enormous profits these companies are raking in at the expense of consumers—including nearly $100 billion in combined profits for Exxon, Chevron, Shell, and BP in just the last two quarters

This criticism is that they did not invest in renewables which I have asserted might not be their role. In fact, they did not invest in their own business either as suggested by Goldman's report in March 2022:

> *Primary energy capex fell 35% over the past decade*
>
> *Seven years of hydrocarbon under-investment (2015-21) and an ongoing focus on de-carbonization mean this energy investment cycle will be different.*

The evidence for underinvestment is clear in data on drilling rigs for exploration and development of fossil energy as shown in Figure 1. The lowest point in active US drilling rigs for oil and gas, for offshore and for Canada occurs in approximately October of 2020, the pandemic year. The series show some recovery in 2021-2022 but only for oil is it substantial and even there the recovery is much weaker than other peaks in the series. And now, all the series have turned down again in 2023. This is a physical measure of capital expenditure which illustrates the model. Even as demand denoted by Q increases with the Ukraine war, the rise in investment is modest compared with past increases. Delays in implementing decarbonization also should give positive signals but these effects are muted too.

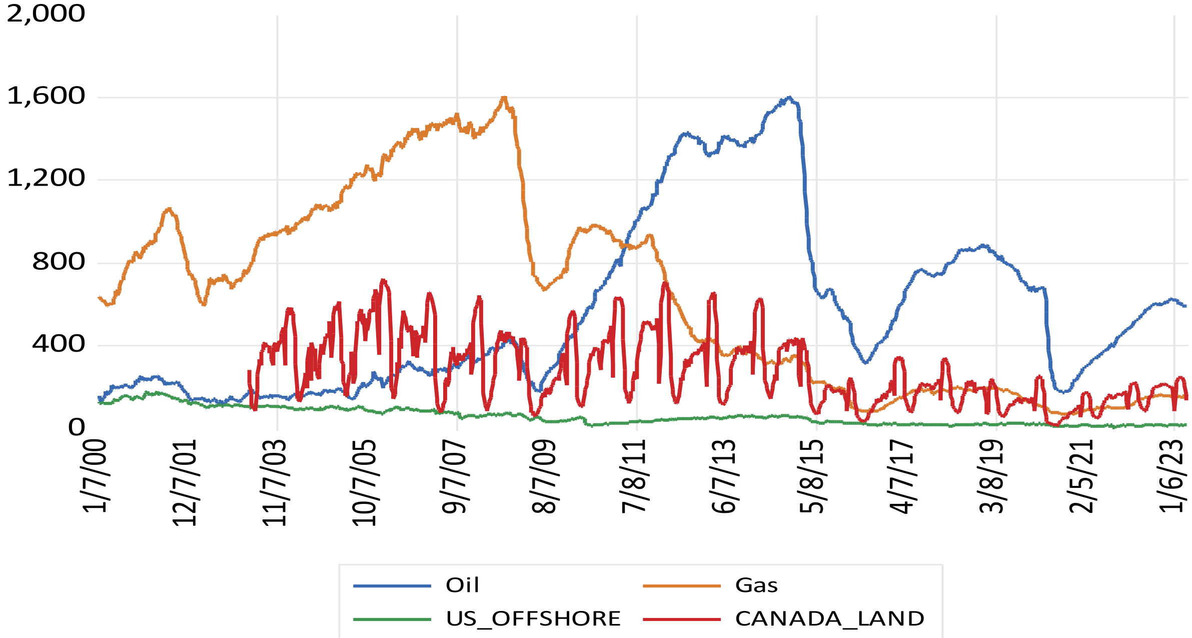

Figure 2.
Baker Hughes data on active rotary oil and gas rigs in North America

The stock market also appears to recognize the early termination concept. When earnings rise temporarily, the stock price may only respond partially since this is not evidence that earnings will be higher in the long run. Thus, the price/earnings ratio for fossil energy is expected to be low. The data shows that it is the lowest of any sector and in March 2023 this is just 6.4. Even though earnings increased 41% over the last 5 years, they are only predicted to rise by 9% over the next 5 years as shown in the Figure 2 from finviz.

No.	Name	Market Cap	▲P/E	Fwd P/E	PEG	P/S	P/B	P/C	P/FCF	EPS past 5Y	EPS next 5Y	Sales past 5Y	Change	Volume
1	Energy	3323.87B	6.44	7.94	0.68	0.71	1.47	9.62	8.43	41.34%	9.46%	13.75%	3.14%	423.38M
2	Basic Materials	1932.26B	10.93	15.52	3.01	1.33	1.84	11.16	20.88	19.47%	3.63%	12.04%	0.52%	314.97M
3	Financial	8595.3[illegible]B	14.31	11.25	1.65	2.31	1.45	0.52	11.10	10.92%	8.65%	7.93%	2.58%	1.41B
4	Industrials	4624.3[illegible]B	19.89	16.16	1.66	1.68	3.70	14.47	29.17	11.97%	12.01%	6.55%	1.28%	400.83M
5	Utilities	1406.[illegible]6B	21.65	3.34	2.61	1.69	1.24	34.19	64.67	5.43%	8.28%	6.28%	-1.79%	109.87M
6	Consumer Cyclical	6003.[illegible]2B	22.73	20.27	1.75	1.41	3.77	8.98	41.73	12.91%	13.00%	21.47%	2.44%	1.26B
7	Communication Services	5675.[illegible]2B	22.92	16.26	1.57	2.33	2.47	13.40	34.76	13.95%	14.62%	15.20%	2.31%	461.49M
8	Consumer Defensive	3618.1[illegible]B	23.36	20.46	3.23	1.19	4.20	22.99	74.28	6.31%	7.23%	5.70%	-0.02%	208.08M
9	Healthcare	7245.85B	25.18	17.03	2.81	1.92	3.93	12.39	30.34	10.78%	8.97%	14.44%	0.65%	838.99M
10	Real Estate	1405.29B	25.74	26.78	2.69	4.02	1.96	22.65	40.76	13.91%	9.58%	12.32%	-0.24%	251.42M
11	Technology	12285.77B	29.49	20.86	2.29	4.16	4.96	16.37	37.43	20.24%	12.87%	15.72%	1.09%	1.19B

Figure 2

Price Earnings Ratios on March 11, 2023 from finviz.

IMPLICATIONS OF THIS MODEL

This model of termination risk applies naturally to companies that face transition or physical risk from climate change or other widely appreciated slow moving risks.[2] It also applies to companies that supply or buy products from such companies. It also applies to investors who hold assets linked to such companies such as banks or pension funds. It also applies to countries.

From asset pricing theory, equities exposed to long run risk are less desirable than ones that are not, everything else being equal. Consequently, their price should be lower and their expected return higher. This is simply a risk premium as has been documented empirically by Bolton and Kacperczyk(2020) for climate risk and by Giglio et al(2021) for coastal real estate.

[2] Other examples of terminated firms and industries include Kodak, Smith Corona, Blockbuster, RCA Victor, Video Recorders, Punch Cards, Floppy Disks, CDs, dot matrix printers, and many others.

A striking example of this type of long run risk is Russia. It is probably clear to the Russian government, that their fossil energy sector is likely to decline in value over the next decade or so. The natural public policy is therefore to reduce investment and channel funds into other sectors with better long run prospects. This is however, not the policy that Russia followed. They invaded Ukraine in a costly and inhumane war in an effort to expand and diversify their economy. Presumably they recognized that their war would be more successful now than later when Europe was more self sufficient through renewable energy investments. Probably they also realized that by restricting supply, the price of their energy products would rise to pay for the war. To some extent, all of this happened except that the NATO and Ukrainian alliance was able to make sanctions moderately effective and the Ukrainian military quite effective.

Other striking examples are in the Middle East. Saudia Arabia has sold a small fraction of ARAMCO to the global stock market and can use the proceeds to diversify the Saudi economy. Other Middle Eastern countries are following related paths to build other strengths for their economies.

Many developed and some emerging market economies suffered dramatic increases in inflation partly as a result of this same phenomenon. The rise of energy prices that is predicted by this long run risk model has clearly occurred. This is a strong contributor to inflation. In addition, high energy prices have led to long delays in supply chains and big increases in costs. The effects of high energy costs gradually lead to higher costs for almost all sectors of the economy. In so far as the Ukraine war is due to climate risk, the complex relation between China and Russia and the deterioration in relations between the US and China may also be partly attributed to climate change. This acceleration of deglobalization has also led to rising costs as firms scramble to build new supply chains and bring production back from overseas.

SUSTAINABLE INVESTING

The private sector response to the long run risk of climate change and decarbonization has surprised sustainable investors. Many sustainable investment products are focused on either hedging climate change risk or taking a position that the market has underpriced climate change risk. Such funds typically underweight firms that will fare badly from climate change and overweight those that are better prepared. This is often translated into shorting fossil energy stocks and taking long positions in companies better prepared such as renewable energy firms or types of technology that should perform well.

The investment performance of 2022 however did not reward such strategies. The inflation which is in part due to energy price increases, precipitated rising interest rates in most countries and led to broad stock market declines. Sustainable investors missed the benefits of the energy rise and exaggerated the losses from the broad market declines. This has precipitated a great deal of criticism of sustainable investing.

IS CLIMATE MITIGATION FAILING?

Although sustainable investments are not performing well, there are reasons to believe that the global response to climate change is positive. It is quite clear that policies such as a carbon tax or regulatory prohibition should increase the price of fossil energy. In fact, this is one of the key factors in decarbonization. If consumers can avoid paying the high cost of emissions heavy merchandise, then they will be helping to reduce emissions. This is not only true of consumers; businesses will also seek to reduce their energy budget by using cheaper renewables or more efficient processes or changing the product line. Thus, the high price of fossil energy is good from a climate mitigation point of view. Furthermore, the fact that this rise in fossil energy prices is due to reducing supply by fossil energy firms and countries is also positive from a climate mitigation point of view.

The shortage of fossil energy also has a positive effect on investment in renewable energy. New projects are being rushed through approval processes and projects already in development are being accelerated.

The rise in interest rates in an effort to slow the growth of global economies is also a positive feature of climate mitigation even though it may also be a negative from a consumer point of view. The emission of greenhouse gasses is closely related to the rate of growth of the economy so a slowdown in output is also a slowdown in emissions. During the pandemic, emissions were substantially reduced but have recovered as the economy recovered.

Climate mitigation is always cast as a cost to be borne today that will be amply repaid in the future. However the exact tradeoff between now and the future has been highly controversial with hundreds of articles arguing over the discount rate and prediction of damages. Nevertheless, all such mitigation proposals impose short run costs and the question then is whether the long run benefits are sufficient to justify these costs. Nordhaus(2000),(2008), Stern(2006), Weitzman(2007), Pindyck(2019), Giglio et al(2021) and many other papers discuss methodologies and findings. Closely related is the observation by Danzig(2022) among others, that climate mitigation is especially harmful to low income consumers. This is a finding of the climate justice research.

The future will reveal the benefits of such action but the costs can be adjusted by better policies. The short-term costs could have been minimized if governments had acted swiftly and effectively. If a carbon tax had been comprehensively implemented, then the same increase in energy prices would have led to substantial government revenues rather than simply higher equity values for fossil energy investors. These government revenues could have been used to reduce other regressive taxes or to further speed mitigation and thus reduce expected physical risks. This was a missed opportunity. But it is still available for implementation as part of the climate policy response. The high profitability of fossil energy companies makes this potentially a good time for such a policy. The war in Ukraine however might make this a bad time to tax emitters that may be needed for the war effort.

CLIMATE HEDGE PORTFOLIOS

A natural investment strategy is to put a portion of investors' portfolio into a climate hedge. This hedge should increase in value if climate risk increases and decrease when climate risk declines. This can be accomplished by overweighting assets that will do well in a bad climate scenario and underweighting or shorting assets that will do badly in this scenario. While it is easy to propose such a portfolio, the details are difficult to implement. See Engle et. al. (2020). Often ESG data is used to construct such portfolios even though the quality of the data is widely considered to be inadequate. Alternatively, statistical approaches can be used to determine winners and losers when there is news about climate severity. This is applied in Engle et al.(2020) and Denard et al.(2023). A hedge portfolio should appreciate in value when there is news that climate risk has increased.

In the context of this terminal risk model, it is natural to consider news about T. How long will a company or industry survive? When there is news that T is getting shorter, then exposed companies will see stock prices decline because of the reduction in periods of operation. The decline will be mitigated by reduced investment costs and rising output prices. If there is no price on carbon emissions the stock prices and dividends may rise temporarily but the net effect should remain negative. If there is a price on carbon emissions, the effects will be stronger and produce government revenue that can reduce future taxes or provide other public goods.

CONCLUSION

The rise in energy prices and appreciation of energy stocks is often viewed as evidence of the failure of sustainability. It has led to underperformance of a majority of "sustainable" funds. However, it is argued in this paper that this is a natural consequence of the inevitability of policies to mitigate climate change. Consequently, these events should be interpreted as evidence that the private market does indeed recognize that climate change is real and must be addressed. In fact, the consequences of private sector decarbonization are quite similar to the consequences to be expected from implementation of an optimal carbon tax. Fossil energy prices are high encouraging conservation, and fossil energy firms are preparing for termination. The key difference is that the profits from this process are channeled to investors bearing the risk of climate change rather than governments who could use the proceeds to reduce other regressive taxes or accelerate decarbonization.

Sustainable portfolios should still have climate hedge characteristics even though they temporarily underperformed conventional diversified portfolios. If climate risk continues to increase, the results for sustainable investors should improve relative to unhedged investors.

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