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Pessimism toward climate disasters and asset prices: A quantitative investigation

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Abstract

This paper explores the pricing of economic risks from climate change in financial markets. Unlike previous models that treat climate change-induced disasters as independent and identically distributed events, our model uses a Markov stochastic process to account for disaster persistence and incorporates subjective probabilities to reflect investors' ambiguity aversion. We find that pessimistic assessments of climate disaster risks lead to significantly higher risk premiums and lower risk-free rates, even if the intertemporal elasticity of substitution is lower than 1. This study contributes to the literature on climate change and asset pricing by emphasizing the role of subjective probability and offering quantitative evaluations within a recursive utility framework.

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1 Introduction

We examine how economic risks from climate change are priced in financial markets. Barro (2015) models climate change-induced economic damage as disasters following an independent and identically distributed (IID) process and analyzes the impact of climate change risk on asset prices. Our model differs from Barro (2015) in three key ways: (i) Disaster risks follow a Markov process rather than an IID process; (ii) investors base their decisions on subjective probabilities, and (iii) intertemporal elasticity of substitution (IES) is assumed to be reasonably low.

Based on various observations, we assumed that climate disasters exhibit some persistence. For instance, Yang et al. (2022) and Qiu et al. (2023) found that droughts reduce hydropower generation and increase thermal and greenhouse gas emissions, resulting in economic damage. These findings suggest that environmental factors contribute to recurring economic damage. Therefore, we adopted a Markov process rather than an IID process.

As Barro (2015) pointed out, historical disasters lack environmental components. Consequently, our model incorporated subjective probability assessments instead of relying solely on objective probabilities. This approach follows Suzuki (2014) and Liu (2022), who explored the impact of persistent disaster uncertainty and learning on asset prices. Our max-min expected utility assumption reflects an investor with extreme ambiguity aversion.[1]

IES values of one or higher are common in the asset pricing literature, as in Nakamura et al. (2013) and Bansal et al. (2014), and Barro (2006, 2009, 2015). Saito and Suzuki (2014) note that a persistent disaster model with IES much lower than one can lead to negative equity premiums. Epstein et al. (2014) argue that high degrees of relative risk aversion (RRA) and IES values overstate preferences for early risk resolution, and Havránek (2015) concludes that values above 0.8 are inconsistent with empirical evidence. Recently, Suzuki and Yamagami (2024) analytically demonstrate that a persistent disaster model with IES slightly lower than one can generate significant equity premiums.[2] Thus, we set the IES to 0.8.

We calculated asset prices assuming that the expected damage from climate change aligns with Nordhaus (1994a, 1994b) and Pindyck's (2019) survey results. Our findings indicate that climate change risk generates significantly high risk premiums and low risk-free rates when investors assess climate disaster risks pessimistically. This creates a risk premium more than 1% higher than the IID risk assumption for the same expected damage scale. Considering the Nordhaus survey was in 1994, climate change risks may have been priced in the market for decades. If so, the results suggest that climate change risk may have, at least partially, solved the equity

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[1] Klibanoff et al. (2015) and Ju and Miao (2012) propose a smooth ambiguity model. When ambiguity aversion is exceptionally high, the model coincides with a max-mini utility that considers only the worst scenario. Skiadas (2013) showed that such a smooch ambiguity model converges to a single scenario subjective expected utility model in continuous time. However, Suzuki (2018) proposed a smooth ambiguity model that can consider multiple scenarios in the continuous-time version. In contrast to such models of subjective probability, this paper focuses on the max-mini utility for analytical tractability. It also discusses the implications for asset prices under Markov processes, which can easily handle differences between pre-and post-disasters.

[2] Suppose a disaster occurs and is likely to persist for several years. Right after the disaster, there are two opposing effects on the equity prices. A lower expected future dividend decreases the price-dividend ratio, while a higher demand for saving due to lower expected future consumption raises the price-dividend ratio. Saito and Suzuki (2014) pointed out that if the IES is sufficiently smaller than one, the latter effect dominates and equity prices rise immediately after a disaster. In a pre-disaster period, equity holdings serve as insurance against reduced consumption during disaster periods. As a result, the unconditional equity risk premium decreases. However, Suzuki and Yamagami (2024) demonstrated that if the IES is lower than one but close enough to one, stock prices still fall after a disaster, and the unconditional equity risk premium still takes a significantly high value.

premium puzzle originally proposed by Mehra and Prescott (1985). In addition, according to Pindyck's (2019) estimation, the welfare loss from climate disasters is quite significant. We consider a policy that reduces the economic damage from climate change by suppressing the trend output growth rate. Then, we demonstrate that such climate policy significantly improves the welfare evaluated by the certainty equivalent consumption growth.

Our study relates to Karydas and Xepapadeas (2022), who focused on models with an IES of one, which we relaxed. Benmir et al. (2021) considered habit formation and climate risk, whereas our model emphasized subjective probability. Olijslagers and van Wijnbergen (2024) employ a continuous-time asset pricing model with ambiguity aversion to evaluate the social cost of carbon.

2 Model

2.1 The time series properties of risks

We consider an economy in which a representative investor consumes fruits from a single Lucas tree. We use C_t and Y_t to denote consumption and output, respectively, in period t. We consider a closed economy in which $C_t = Y_t$ holds.

There are three types of risk: Recession, macroeconomic disaster, and ambiguous climate change-induced disaster. The first and second shocks are standard and follow an IID stochastic process. The third shock is unfamiliar. However, for analytical tractability, we assume a two-state Markov process. The two states, $s_t \in \{n, d\}$, are the normal and damage states, respectively.

Output depends on the state in which the economy is in: $Y_t = Y(s_t)$. The stochastic process for the logarithm of the output is:

$$\ln Y(s_{t+1}) - \ln Y(s_t) = g + \epsilon_{t+1} + \ln(1-b_m)u_{t+1} + \ln(1-b)v(s_{t+1})$$

g is a trend growth rate, ϵ_{t+1} is a IID normal shocks with a distribution of $N(0, \sigma^2)$, b_m denotes the scale of the macroeconomic disaster, and u_{t+1} is a IID disaster shocks. A macroeconomic disaster, such as financial crises or major wars, occurs in period $t+1$ ($u_{t+1} = 1$) with a probability of π. Otherwise, $u_{t+1} = 0$. b denotes the scale of climate change-induced economic damage. If there is a damaged state in period t+1 (i.e., $s_{t+1} = d$), $v(s_{t+1}) = 1$, otherwise (i.e., $s_{t+1} = n$), $v(s_{t+1}) = 0$. In the current state s, the state d occurs in the next period with a probability of ϕ_s. We denote the probability measure $\psi = \{\phi_n, \phi_d\}$. The stationary probability of the economy being in a state d is $\tilde{\phi} = \phi_n/(1 - \phi_d + \phi_n)$.

2.2 Asset prices

We employ the following utility recursion:

$$V_t = \frac{\left[C_t^{1-\theta} + e^{-\rho}\left\{(1-\gamma)E_t^* V_{t+1}\right\}^{\frac{1-\theta}{1-\gamma}}\right]^{\frac{1-\gamma}{1-\theta}}}{1-\gamma}$$

where $E_t^* V_{t+1}$ denotes the expectation operator under the probability measure ψ^*, which is defined as

$$\psi^* \equiv \arg\max_{\psi} E_t^* \left[V_{t+1} \right].$$

In other words, investors have max-min expected utility, as proposed by Gilboa and Schmeidler (1989). Klibanoff et al. (2005) show the max-min expected utility is the limiting case of extremely strong ambiguity aversion. In this case, the stochastic discount factor is written as:

$$m_{t+1} = \exp\left(-\rho \frac{1-\gamma}{1-\theta}\right) \left[\frac{Y(s_{t+1})}{Y(s_t)}\right]^{-\theta \frac{1-\gamma}{1-\theta}} (R_{t+1}^e)^{\frac{\theta-\gamma}{1-\theta}}$$

where R_{t+1}^e denotes the return on the market portfolio. The first-order condition for the intertemporal optimization with respect to asset prices is

$$1 = E_t^* \left[m_{t+1} R_{t+1}^i \right], \tag{1}$$

where R_{t+1}^i denotes a return of any arbitrary assets i.

We assume that the stochastic process follows a Markov process. In this case, the asset prices and returns are functions of the state variable s. The risk-free rate R_s^f, is

$$R_s^f = \frac{1}{E_s^*[m_{t+1}]}.$$

The unconditional risk-free rate is $R^f = (1-\tilde{\phi})R_n^f + \tilde{\phi} R_d^f$.

The price of the Lucas tree in state s is $P(s)$. By using the price-dividend ratio in each state s, defined as $\omega(s) \equiv P(s)/Y(s)$, we can represent the ex-post return on equity as one moves from state s to s' as follows:

$$R_{ss'}^e = \frac{Y(s')}{Y(s)} \frac{\omega_{s'}+1}{\omega_s}.$$

From (1) and the above definition, we derive the following equation:

$$\omega_s = E_t^* \left[\frac{m_{ss'} Y(s')}{Y(s)} (\omega_{s'}+1) \right]$$

$$\Leftrightarrow \omega_s = E_t^* \left[e^{-\rho \frac{1-\gamma}{1-\theta}} \left(\frac{Y(s')}{Y(s)} \right)^{1-\gamma} (\omega_{s'}+1)^{\frac{1-\gamma}{1-\theta}} \right]^{\frac{1-\theta}{1-\gamma}}$$

We can use this equation to compute the price-dividend ratio in each state.

The expected rates of return on equity can be written as follows:

$$\begin{aligned} R_n^e &= (1-\phi_n) E_n^*[R_{nn}^e] + \phi_n E_n^*[R_{nd}^e] \\ R_d^e &= (1-\phi_d) E_d^*[R_{dn}^e] + \phi_d E_d^*[R_{dd}^e] \end{aligned}$$

where $E_s^*[\cdot]$ denotes a subjective expectation operator conditional on the information set at the state s. The unconditional expected equity returns are: $R^e = (1-\tilde{\phi})R_n^e + \tilde{\phi} R_d^e$. The unconditional expected equity premium is: $\Pi = R^e - R^f$.

2.3 Welfare

Considering investors who assume a worst-case climate change scenario, it is necessary to derive a value function. Let $U_t \equiv V_t/u_t$ be the welfare to utility ratio, where $u_t \equiv C_t^{1-\gamma}/(1-\gamma)$. The welfare-to-utility ratio in state s, U_s, can be calculated using the following recursion:

$$U_s = \left\{ 1 + \exp(-\rho) E_d^* \left[\left(\frac{Y(s')}{Y(s)} \right)^{1-\gamma} U_{s'} \right]^{\frac{1-\theta}{1-\gamma}} \right\}^{\frac{1-\gamma}{1-\theta}}. \tag{2}$$

Thus, unconditional welfare can be calculated as follows:

$$V = \frac{(1-\tilde{\phi})U_n + \tilde{\phi} U_d (1-b)^{1-\gamma}}{1-\gamma}.$$

We evaluate the welfare in terms of the certainty equivalent consumption growth, ζ. Suppose that the output (consumption) growth takes a constant value of $Y(s')/Y(s) = \exp(\zeta)$. In this case, the welfare-to-utility ratio takes a constant, and then $U = (1-\gamma)V$ holds. Introducing $\exp(\zeta)$ into (2) obtains

$$U^{\frac{1-\theta}{1-\gamma}} = 1 + \exp\left[-\rho + (1-\theta)\zeta\right] U^{\frac{1-\theta}{1-\gamma}}.$$

Therefore, the certainty equivalent consumption growth, ζ, is written as follows:

$$\zeta = \frac{1}{1-\theta} \left[\rho + \log \left(\frac{U^{\frac{1-\theta}{1-\gamma}} - 1}{U^{\frac{1-\theta}{1-\gamma}}} \right) \right].$$

3 Numerical exercise

3.1 Baseline parameters

Following Barro (2006), we assume a time discount rate of $\rho = 0.03$, a trend growth rate of $g = 0.025$, a probability of macroeconomic disasters of $\pi = 0.03$, and a scale of disasters of $b = b_m = 0.25$. We use an RRA of $\gamma = 5$, standard in asset pricing literature. Following Havránek (2015) and Suzuki and Yamagami (2024), we set IES at $\theta^{-1} = 0.8$. In addition, to clarify the role of IES in determining asset price, we compute the cases of low $\theta^{-1} = 0.6$ and high 2.0 value of IES.

3.2 Calibrating climate risks

There is no consensus regarding the economic damage caused by climate change; Stern et al. (2006) estimate it could be 5% to 20% of global output, while Tol and Yohe (2006) argue it is likely closer to 5%. Some studies suggest subjective estimates. For instance, Nordhaus (1994a, 1994b) asked experts about the probability of damage of 25% or more to global production if a certain degree of temperature occurs by 2090 or 2175. The most serious scenario (Scenario C) in Nordhaus (1994a, 1994b) is the damage from a six-degree rise in temperature by 2090. According to Table 7.2 of Nordhaus (1994b, 153), the average subjective probability is 17.5%.

Pindyck (2019) also estimated the probability of climate change causing severe economic damage through a survey of experts. The results show that the likelihood of causing damage of 25% or more to GDP by 2066 is 20.8%, which is very high.[3]

Following Nordhaus's (1994a, 1994b) estimates, we estimate the frequency at which production that considers climate change falls by more than 25% compared with production that does not consider climate change. The current period is taken to be 1990 because Nordhaus (1994a, 1994b) was published in 1994. The year 2090 is approximately 100 years later. By generating 100 random variables, we calculated output in 2090 under two stochastic processes, one without economic damage from climate change ($\phi_n = \phi_d = 0$) and one with ($\phi_n > 0, \phi_d > 0$); then, we calculated the ratio of the two simulated outputs. We repeated this 100,000 times to estimate the frequency at which production considering climate change decreases by more than 25% compared to production that does not consider climate change. Using the same procedure, we calculated ϕ_n and ϕ_d, consistent with Pindyck's (2019) calculations.

Suppose the probability of climate change-related disasters is set at 0.755% ($\phi_n = 0.0075, \phi_d = 0.0075$) or 1.68% ($\phi_n = 0.0168, \phi_d = 0.0168$), the frequency at which production falls by 25% or more in 100 years or in 50 years are 17.5% or 20.8%. Then, we reduce the probability of occurrence ϕ_n while raising the persistence probability ϕ_d, keeping the frequency of a fall in output by more than 25% in the case of climate change damage constant at around 17.5% or 20.8%.[4]

3.3 Numerical results

3.3.1 Baseline case: Nordhaus (1994a, 1994b)

Panel A is the results under the calibration parameters following Nordhaus (1994a, 1994b). Panel A1 of Table 1 summarizes the numerical results when the IES is set to 0.8. Column (a) presents the results without macroeconomic or climatic disasters. The risk-free asset interest rate is 6.10% and the equity risk premium is small at 0.21%. Mehra and Prescott (1985) found an observed risk premium of 6.18% for the U.S. economy from 1889 to 1978, while Fama and French (2002) concluded a risk premium of 4.32% for the U.S. from 1951 to 2000. The model without disasters failed to explain the observations. Column (b) shows the results for macroeconomic disasters in the IID based on Barro (2015). Considering disaster risks with low probability and significant damage results in a high-risk premium and a low risk-free rate. Here, the risk-free interest rate and the equity risk premium are 2.64% and 2.46%, respectively. Columns (c)–(h) show results considering climate disaster risks with expected damage of the same size as estimated by Nordhaus (1994b). Column (c) assumes that climate disasters are also IID ($\phi_n = \phi_d$), while Columns (d) to (h) assume that they are persistent ($\phi_d > \phi_n$). When climate disasters are IID (Column (c)), the interest rate is 1.74%, and the equity risk premium is 3.06%. In any case, the consideration of climate disasters results in a lower risk-free rate and higher risk premium.

Let us now examine the quantitative implications of changes in the subjective risk perception of climate disasters. In Columns (e) to (h), the probability of occurrence is lower and the probability of persistence is higher, whereas the expected damage scale remains constant. The

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[3] Calculated based on the log-normal distribution (mean -2.446, standard deviation 1.476) in Table 6 in Pindyck (2019).

[4] We found that Barro's (2015) assumption is somewhat higher than Nordhaus (1994a, 1994b) results; Barro (2015) gives a 3% probability of a macroeconomic disaster occurring and a 1% probability of a climate change-related disaster occurring; under Barro's assumptions ($\phi_n = 0.01, \phi_d = 0.01$), the frequency at which production falls by 25% or more is 26.5%.

risk-free rate is lower, and the equity risk premium is higher. For example, Column (f) shows an occurrence probability of 0.0047 and a persistence probability of 0.3292 with a risk-free rate of 0.28% and an equity risk premium of 4.07%, close to actual values. Columns (g) and (h) show that the risk-free rate has a negative value but the equity premium is even more significant. Investors assess the subjective probability based on the worst-case scenario. The table shows welfare worsens in persistent cases compared to IID cases, even if the expected damage is constant. Therefore, investors with the max-min expected utility would expect disasters to be more persistent. Thus, a climate disaster reduces the risk-free rate considerably and raises the equity risk premium.

Panel A2 of Table 1 summarizes the numerical results when the IES is 2.0. The results for columns (a), (b) and (c) are similar to those for IES=0.8. Also, columns (d) to (h) show that the risk premium increases and the risk-free rate decreases as the persistence probability increases. The difference is that the risk premium increase is much more severe than when IES is 0.8. For example, in the case of IID for climate change risk (column (c)), the risk-free rate is 1.403, and the risk premium is 3.049. Under the more persistent scenario (column (d)), the risk-free rate is -0.660, and the risk premium is 5.646, which is quite large. The reason for this is the movement of the price-dividend ratio. When IES is 2.0, the price-dividend ratio in state d falls more sharply than in state n. As a result, the decline in the return on the equity at the time of the occurrence of state d is emphasized. As a result, investors demand a high-risk premium for equity investment. In this way, a high IES value forces a risk premium for the persistence of disaster risk. However, as we have already mentioned, there are empirical and theoretical concerns about such a high IES.

Panel A3 of Table 1 summarizes the numerical results when the IES is set to 0.6. The results for columns (a), (b) and (c) are similar to those for IES of 0.8 and 2.0. However, the results for columns (d) to (h) show that the risk premium decreases as the persistence probability increases. For example, when the climate change risk is IID (column (c)), the risk premium is 3.065. Under the scenario where persistence is high (column (d)), the stock risk premium falls to 2.784. This is due to the movement in the price-dividend ratio. When IES is 0.6, the price-dividend ratio in state d is much higher than in-state n, which offsets the decline in the stock return at the time of state d. Therefore, equity investment becomes a low risk in a disaster. These are the effects that Saito and Suzuki (2014) and Suzuki and Yamagami (2024) theoretically discussed. Note that there are no values in column (h). Under these probabilities, the transversality condition is not satisfied, the stock price diverges, and there is no competitive equilibrium.

3.3.2 Extreme case and policy intervention: Pindyck (2019)

Panel B of Table 1 shows results under the calibration parameters following Pindyck (2019), which shows a more pessimistic view of the economic damage from climate change than Nordhaus (1994a, 1994b). Thus, we also examine the effect of policy intervention on asset prices and welfare. Panel B of Table 1 summarizes the numerical results when the IES is 0.8. Columns (a) and (b) are the same for the case under Palen A1. Columns (c)–(e) show results considering climate disaster risks with expected damage of the same size as estimated by Pindyck (2019). Column (c) assumes that climate disasters are IID ($\phi_n = \phi_d$), but the probability is relatively high at 1.68%, while Columns (d) to (h) assume that they are persistent ($\phi_d > \phi_n$). When climate disasters are IID (Column (c)), the interest rate is 0.694%, and the equity risk premium is 4.431%. In any case, considering climate disasters results in a lower risk-free rate and higher risk premium. Both the risk-free rate and the equity risk premium are broadly consistent with empirically valid figures. Here, a marginal increase in the persistence probability and a marginal reduction in the occurrence probability would reduce both the risk-free rate and the equity risk premium, as Suzuki and Yamagami (2024) show. However, column (e) shows the risk-free rate is -3.931% and the equity risk premium is 6.018%. These are less empirically valid. The pessimistic assessment of climate change-derived economic damage results in a risk-free rate that is too low and a risk premium that is too high.

Given that climate change may strongly impact asset prices and welfare, we consider that the government can implement the following policy. Suppose the government can limit the economic damage caused by climate disasters by limiting the pollution emitted. However, such a policy would suppress economic activity, and the trend growth rate would decline. The stationary expected output growth rate is $\bar{g} \equiv g - \pi b_m - \tilde{\phi} b$. Let us consider an alternative g' and b' that achieve the same stationary expected output growth rate; $\bar{g} = g' - \pi b_m - \tilde{\phi} b'$. That is, b' and g' such that $b' = (g' - g + \tilde{\phi} b)/\tilde{\phi}$ holds. In this way, the government can keep the stationary expected output growth rate constant and, in exchange for suppressing the trend growth rate, suppress the damage caused by disasters.

Columns (f)-(h) show the asset price results from implementing policies that reduce the scale of damage from climate disasters instead of curbing emissions and reducing the trend growth rate by 0.5% each. A reduction in the scale of damage increases the risk-free rate and decreases the equity risk premium. It is interesting to note here that welfare improves despite the decrease in the trend growth rate. Specifically, the certainty equivalent consumption growth rate is 1.3% when the climate change disaster is IID (column (c)). If the damage is persistent (column (e)), the certainty equivalent consumption growth rate would be -7.4%, which is extremely low. However, if a 1-1.5% reduction in trend growth rate could reduce the scale of damage from 25% to 19% or 16%, the certainty equivalent consumption growth rate would improve markedly to -0.7% or 0.9%. This hypothetical exercise suggests that if the subjective assessment of climate change-derived economic damage were huge, policies that reduce climate change-derived damage at the expense of current economic activity could benefit investors.

4 Conclusion

Our model advances the understanding of how climate disasters affect asset prices by employing subjective probabilities, a Markov process, and extreme ambiguity aversion. Based on Nordhaus's (1994a, 1994b) survey results, we quantitatively find that pessimistic views on climate disaster risk lead to high-risk premiums and low risk-free rates, thus increasing the risk premium. Moreover, the risk premium in our model is more than 1% higher than under the IID assumption. This result highlights the importance of considering investors' perceptions of climate risk.

In addition, we also examine the results based on a more recent survey on subjective damage estimates by Pindyck (2019) and further discuss the scope of policy interventions. The results show that climate change risk can potentially have a huge impact on asset prices, and its welfare-impairing effects are significant. At the same time, the results also showed that the welfare-improving effects would be substantial if the government could control the scale of damage caused by climate disasters in exchange for a reduction in the trend growth rate.

Table 1: Asset Price Results

Panel A: Nordhaus (1994a, b)

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	disaster	No	Macro	Macro + Climate					
	ϕ_n	0.0000	0.0000	0.0076	0.0050	0.0048	0.0047	0.0045	0.0040
	ϕ_d	0.0000	0.0000	0.0076	0.2900	0.3218	0.3292	0.3595	0.4340
A1	$R_f(\%)$	6.104	2.642	1.742	0.807	0.398	0.276	-0.287	-1.504
$IES = 0.8$	$R_e(\%)$	6.317	5.106	4.801	4.551	4.394	4.343	4.063	3.034
	$R_e - R_f(\%)$	0.212	2.464	3.059	3.743	3.996	4.066	4.35	4.538
	ω_n	27.242	30.631	31.643	34.386	36.317	36.999	41.165	70.693
	ω_n	27.242	30.631	31.643	37.538	40.659	41.697	47.714	87.062
	ζ: C.E.growth	0.024	0.024	0.020	0.010	0.004	0.002	-0.0082	-0.047
A2	$R_f(\%)$	4.196	1.990	1.403	-0.660	-1.825	-2.180	-3.9180	-9.1447
$IES = 2.0$	$R_e(\%)$	4.404	4.438	4.452	4.986	5.241	5.316	5.6725	6.7029
	$R_e - R_f(\%)$	0.209	2.448	3.049	5.646	7.066	7.496	9.5904	15.8475
	ω_n	55.367	38.337	35.509	30.400	28.349	27.792	25.4092	20.3235
	ω_n	55.367	38.337	35.509	25.613	22.859	22.168	19.3867	14.1075
	ζ: C.E.growth	0.024	0.024	0.020	0.010	0.004	0.003	-0.0050	-0.0274
A3	$R_f(\%)$	7.1793	3.0060	1.931	1.511	1.5233	1.556	1.979	
$IES = 0.6$	$R_e(\%)$	7.3939	5.4786	4.996	4.295	3.8186	3.651	2.661	
	$R_e - R_f(\%)$	0.2146	2.4726	3.065	2.784	2.2953	2.095	0.682	
	ω_n	21.1801	27.5405	29.834	37.647	45.9010	49.728	98.015	
	ω_n	21.1801	27.5405	29.834	47.710	62.5750	69.147	148.711	
	ζ: C.E.growth	0.0242	0.0242	0.020	0.010	0.0040	0.002	-0.010	

Panel B: Pindyck (2019)

		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	disaster			Macro + Climate			+ Policy		
$IES = 0.8$	g			0.0250	0.0250	0.0250	0.0245	0.0240	0.0235
	b			0.2500	0.2500	0.2500	0.2201	0.1901	0.1602
	ϕ_n			0.0168	0.0130	0.0090	0.0090	0.0090	0.0090
	ϕ_d			0.0168	0.2200	0.4700	0.4700	0.4700	0.4700
	$R_f(\%)$			0.694	-0.178	-3.931	-1.462	0.2718	1.237
	$R_e(\%)$			4.431	4.229	2.087	3.105	3.860	4.266
	$R_e - R_f(\%)$			3.738	4.407	6.018	4.551	3.588	3.028
	ω_n			32.951	35.231	135.923	57.512	40.307	34.750
	ω_n			32.951	36.814	162.706	67.096	45.394	37.708
	ζ: C.E.growth			0.013	0.011	-0.074	-0.035	-0.007	0.009

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