ESG Risks

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2.1 Cash-Flows and Discount Rate Channels

Pastor *et al.* (2021) propose a simple one-period (period 0 and 1) overlapping generation (OLG) model to study the impact of climate risk on asset prices, through both the cash-flows and discount rate channels. To make it possible, PST (2021) splits the time 1 between 1^- and 1^+, close to each other.

In the OLG model, there are two generations, $Gen-0$ and $Gen-1$. $Gen-0$ borns at time 0 and invests in the stock of a firm. It dies at the beginning of period 1 (1^-). $Gen-1$ borns at the beginning of period 1 (1^-) and dies at the end of period 1 (1^+). $Gen-0$ sells the stock to $Gen-1$ at the beginning of period 1 (1^-). Figure 2.1 shows the timeline of the model.

2.1.1 Cash-Flows Channel

We denote π_1 the payoff (profit) by the firm in period 1. It is known at 1^- (the beginning of period 1) but received at 1^+ (the end of period 1). We denote X_1 this payoff per dollar invested in period 0: $X_1 = \frac{\pi_1}{P_0}$.

As in PST (2021), we have two sources of risk (uncertainty), $\tilde{M}$ a macroeconomic factor and $\tilde{C}$ a climate risk factor. Those factors correspond to an unanticipated state of the world. For example, we could have C to be a carbon tax. In that case:

$$\tilde{C}_1 = C_1 - E_0(C_1) \tag{2.1}$$

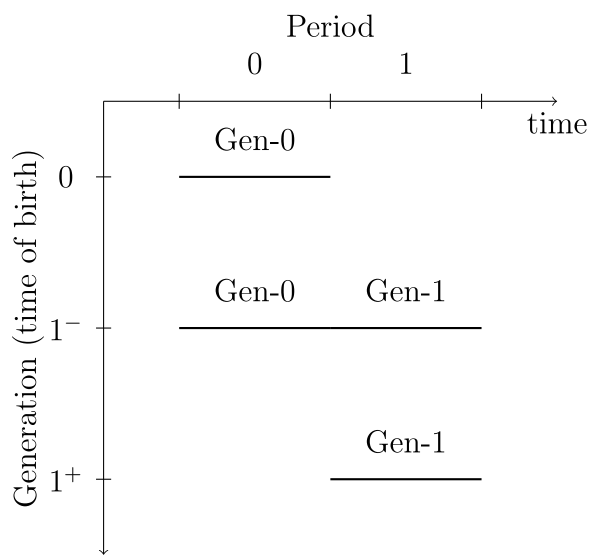

Figure 2.1: The One-Period Overlapping Generation Model

is interepreted as the difference between the expected carbon tax $E_0(C_1)$ and the realized carbon tax C_1. These shocks occurs at 1^-.

The unexpected payoff in period 1 is:

$$X_1 - E_0(X_1) = \beta_m \tilde{M}_1 + \beta_c \tilde{C}_1 + \varepsilon_1 \tag{2.2}$$

where β_m and β_c are the sensitivities of the payoff to the macroeconomic and climate risk factors, respectively, and ε_1 is the idiosyncratic shock to the payoff.

Example 1. Suppose an investor in $Gen - 0$ invests in a stock with $P_0 = 100$ million USD and expects a profit $E_0(\pi_1) = 120$ million USD. Thus, the expected payoff per dollar invested at the beginning of the period is calculated as:

$$E_0(X_1) = \frac{E_0(\pi_1)}{P_0} = \frac{120}{100} = 1.2 \tag{2.3}$$

The investor expects to earns a return of 20% on the investment at the end of the period.

However, two major unexpected events occur between period 0 and period 1:

1. Macroeconomic Changes ($\tilde{M}_1$): The economy undergoes a downturn worse than expected, represented by $\tilde{M}_1 = -0.05$ (a 5% negative shock).

2. Climate Risk ($\tilde{C}_1$): The government imposes a higher-than-anticipated carbon tax, leading to $\tilde{C}_1 = 0.03$ (a 3% additional cost).

We assume that the idiosyncratic shock is equal to 0.

We know that the sensitivity of the firm's profits to economic and carbon tax shocks are $\beta_m = 0.5$ and $\beta_c = -0.3$, respectively. Note that a negative β_c means that higher carbon taxes reduce profits for the firm.

The unexpected payoff is calculated as:

$$X_1 - E_0(X_1) = (0.5 \times -0.05) + (-0.3 \times 0.03) = -0.034$$

Thus, the actual payoff per dollar invested deviates from the expected by -0.034, resulting in an actual payoff per dollar of:

$$X_1 = 1.2 - 0.034 = 1.166 \tag{2.4}$$

In dollars terms, this translates into an actual end-of-period profit of:

$$\pi_1 = X_1 \times P_0 = 1.166 \times 100 = 116.6 \tag{2.5}$$

instead of the expected 120 million USD.

The price p_1 is calculated at 1^- when shocks associated with X have been realized. Therefore, between 1^- and 1^+, the payoff is riskless (everything is known). Stockholders will receive the payoff at 1^+. We compute the price of the stock:

$$P_1 = \frac{X_1}{1 + R^e} \tag{2.6}$$

where R^e is the excess expected return from PST (2021):

$$R^e = \mu_m \beta_m - \frac{D}{\gamma} \beta_c \tag{2.7}$$

with γ the investor risk aversion parameter, D the average investor sensitivity to climate risk, and μ_m the expected return on the market. As PST (2021), we assume the risk free rate $r_f = 0$, $\beta_m = 0$ and the investor risk aversion parameter γ and the firm sensitivity to climate risk β_c doesn't change between $Gen-0$ and $Gen-1$. Figure **??** shows the price of the stock sensitivity to β_c, D and γ.

We assume for the moment that the average investor sensitivity to climate risk D doesn't change between $Gen-0$ and $Gen-1$. We have the payoff for $Gen-0$ at 1^-:

$$\begin{aligned} P_1 &= \frac{X_1}{1-\frac{D}{\gamma}\beta_c} \\ &\approx X_1 + \frac{\beta_c}{\gamma}D \end{aligned} \tag{2.8}$$

where we have followed the approximation from PST (2021)[1].
Figure 2.2 shows the price of the stock sensitivity to β_c, D, γ and X.
It's expected value when $Gen-0$ invested in period 0 was:

$$E_0(P_1) = E_0(X_1) + \frac{\beta_c}{\gamma}D \tag{2.10}$$

So the unexpected change in stock price for the $Gen-0$ is:

$$\begin{aligned} P_1 - E_0(P_1) &= X_1 + \frac{\beta_c}{\gamma}D - E_0(X_1) - \frac{\beta_c}{\gamma}D \\ &= X_1 + \frac{\beta_c}{\gamma}D - E_0(X_1) - \frac{\beta_c}{\gamma}D \\ &= X_1 - E_0(X_1) \\ &= \beta_c\tilde{C}_1 + \varepsilon_1 \end{aligned} \tag{2.11}$$

[1]With $\rho_1 := X_1 - 1$ and $\rho_2 := \frac{\beta_c}{\gamma}D$, we have:

$$\begin{aligned} \frac{1+\rho_1}{1-\rho_2} &= \frac{(1+\rho_1)(1+\rho_2)}{1-\rho_2^2} \\ &\approx (1+\rho_1)(1+\rho_2) \\ &= 1+\rho_1+\rho_2+\rho_1\rho_2 \\ &\approx 1+\rho_1+\rho_2 \end{aligned} \tag{2.9}$$

where the approximation are ρ_2^2 and $\rho_1\rho_2$ are small. The assumptions are valid when ρ_1 and ρ_2 are small.

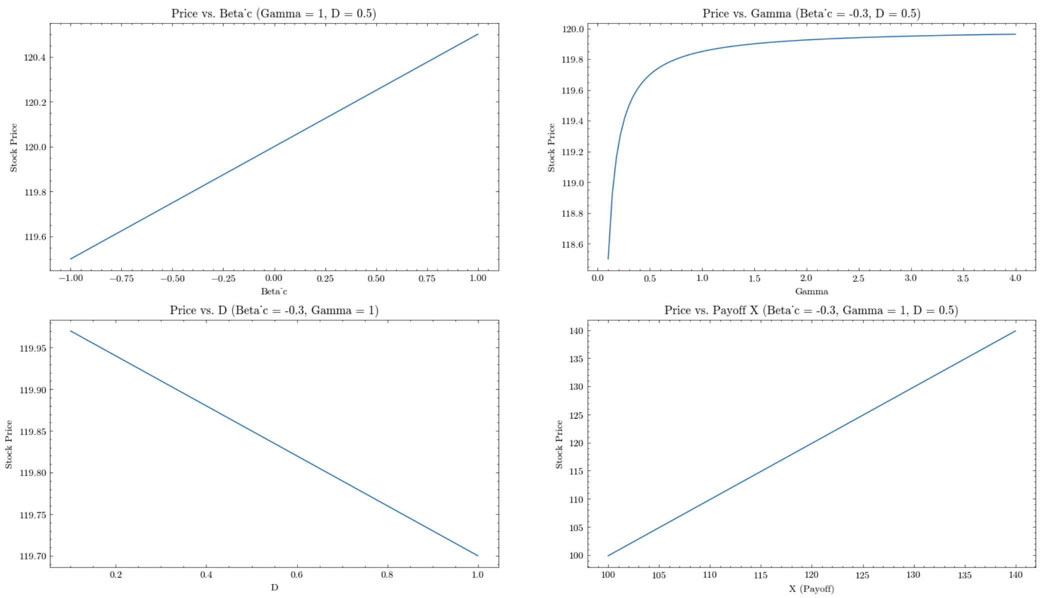

Figure 2.2: Price of the stock as a function of β_c, D, γ and X

Example 2. Continuing our previous example, but with $\beta_m = 0$. We have then the unexpected loss in stock price to be:

$$\begin{aligned} P_1 - E_0(P_1) &= \beta_c \tilde{C}_1 + \varepsilon_1 \\ &= -0.3 \times 0.03 + 0 = -0.009 \end{aligned} \tag{2.12}$$

With the shock $\tilde{C}_1 = 0.03$, the investor in $Gen - 0$ will suffer a loss of 0.9% in the stock price.

2.1.2 Introducing the Discount Rate Channel

To model the discount rate channel, PST (2021) assume that the average investor sensitivity to climate risk D shifts unpredictably from time 0 to time 1. At time 1^-, $Gen - 0$ sell stocks to $Gen - 1$ at price P_1, which depends on the average sensitivity to climate risk of $Gen - 1$, D_1 and the payoff X_1. This setting maintains single-period payoff uncertainty but allows risk stemming from from climate risk to enter via both cashflows and discount rates channels.

The price P_1 is now:

$$P_1 = X_1 + \frac{\beta_c}{\gamma} D_1 \tag{2.13}$$

Taking the expectations:

$$E_0(P_1) = X_1 + \frac{\beta_c}{\gamma} E_0(D_1) \tag{2.14}$$

The unexpected loss in stock price is now:

$$\begin{aligned} P_1 - E_0(P_1) &= X_1 + \frac{\beta_c}{\gamma} D_1 - E_0(\tilde{X}_1) - \frac{\beta_c}{\gamma} E_0(D_1) \\ &= X_1 - E_0(X_1) + \frac{\beta_c}{\gamma}(D_1 - E_0(D_1)) \\ &= \beta_c \tilde{C}_1 + \varepsilon_1 + \frac{\beta_c}{\gamma}(D_1 - E_0(D_1)) \\ &= \beta_c(\tilde{C}_1 + \frac{1}{\gamma}(D_1 - E_0(D_1))) + \varepsilon_1 \end{aligned} \tag{2.15}$$

Chapter 3

Practical Implications of ESG Risks

PST 2022

3.1 Measuring ESG Risks

3.2 Exposure to ESG Risks