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 X_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 $\tilde{X}_1$ this payoff per dollar invested in period 0: $\tilde{X}_1 = \frac{X_1}{P_0}$.

As in PST (2021), we have two sources of risk (uncertainty), $\tilde{M}_1$ a macroeconomic factor and $\tilde{C}_1$ 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:

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

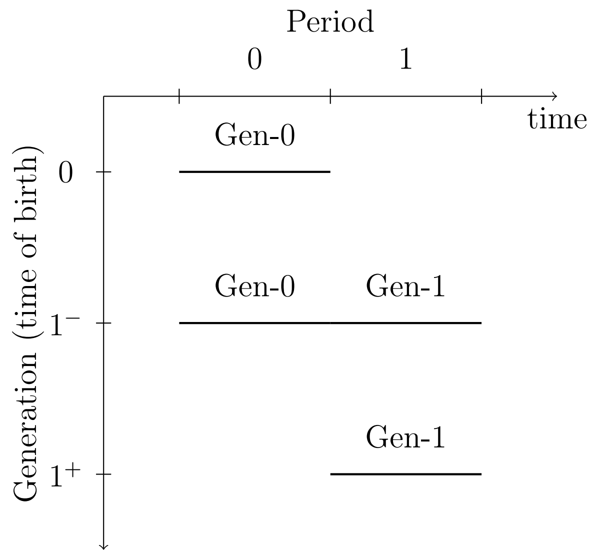

Figure 2.1: The One-Period Overlapping Generation Model

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:

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

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.

The price p_1 is calculated at 1^- when shocks associated with $\tilde{X}_1$ have been realized. Therefore, between 1^- and 1^+, the payoff is riskless (everything is known). Stockholders will receive the payoff at 1^+. The payoff is known at 1^-, so we can compute the price of the stock:

$$\tilde{P}_1 = \frac{\tilde{X}_1}{1 + R^e} \tag{2.3}$$

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

$$R^e = \mu_m \beta_m - \frac{D}{\gamma} \beta_c \tag{2.4}$$

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 $Gen-1$. 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^{-}:

$$\begin{aligned} \tilde{P}_1 &= \frac{\tilde{X}_1}{1-\frac{D}{\gamma}\beta_c} \\ &\approx \tilde{X} + \frac{\beta_c}{\gamma}D \end{aligned} \tag{2.5}$$

where we have followed the approximation from PST (2021)[1].

It's expected value when $Gen-0$ invested in period 0 was:

$$E_0(\tilde{P}_1) = E_0(\tilde{X}_1) + \frac{\beta_c}{\gamma}D \tag{2.7}$$

Because $\tilde{P}_1$ is the price of the payoff per unit of dollar invested in period 0, according to PST (2021), we have:

$$\begin{aligned} \tilde{P}_1 &= \frac{P_1}{P_0} \\ &= R_1 \end{aligned} \tag{2.8}$$

that is, P_1 is the (gross) return R_1 for $Gen-0$. So the unexpected change in price for the $Gen-0$ $\tilde{P}_1 - E_0(\tilde{P}_1)$ is in fact the unexpected return $R_1 - E_0(R_1)$:

[1]With $\rho_1 := \tilde{X}_1 - 1$ and $\rho_2 := \frac{\beta_c}{\gamma}D$, we have:

$$\begin{aligned} \frac{1+\rho_1}{1-\rho_2} &= \frac{(1+\rho_1)(1+\rho_2)}{1-\rho_2^2} \\ &\approx (1+\rho_1)(1+\rho_2) \\ &= 1+\rho_1+\rho_2+\rho_1\rho_2 \\ &\approx 1+\rho_1+\rho_2 \end{aligned} \tag{2.6}$$

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.

$$\begin{aligned}
R_1 - E_0(R_1) &= \tilde{X}_1 + \frac{\beta_c}{\gamma}D - E_0(\tilde{X}_1) - \frac{\beta_c}{\gamma}D \\
&= \tilde{X}_1 + \frac{\beta_c}{\gamma}D - E_0(\tilde{X}_1) - \frac{\beta_c}{\gamma}D \\
&= \tilde{X}_1 - E_0(\tilde{X}_1) \\
&= \beta_c\tilde{C}_1 + \varepsilon_1
\end{aligned} \tag{2.9}$$

2.1.2 Introducing the Discount Rate Channel

To model the discount rate channel, PST (2021) assume that the average perception of climate risk D shifts unpredictably from time 0 to time 1. We now have D_0 and D_1. At time 1^-, $Gen-0$ sell stocks to $Gen-1$ at price P_1, which depends on the average perception of climate risk of $Gen-1$, D_1 and the payoff $\tilde{X}_1$. 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:

$$P_1 = \tilde{X}_1 + \frac{\beta_c}{\gamma}D_1 \tag{2.10}$$

Taking the expectations:

$$E_0(P_1) = \tilde{X}_1 + \frac{\beta_c}{\gamma}E_0(D_1) \tag{2.11}$$

The unexpected return is now:

$$\begin{aligned}
R_1 - E_0(R_1) &= \tilde{X}_1 + \frac{\beta_c}{\gamma}D_1 - E_0(\tilde{X}_1) - \frac{\beta_c}{\gamma}E_0(D_1) \\
&= \tilde{X}_1 - E_0(\tilde{X}_1) + \frac{\beta_c}{\gamma}(D_1 - E_0(D_1)) \\
&= \beta_c\tilde{C}_1 + \varepsilon_1 + \frac{\beta_c}{\gamma}(D_1 - E_0(D_1)) \\
&= \beta_c(\tilde{C}_1 + \frac{1}{\gamma}(D_1 - E_0(D_1))) + \varepsilon_1
\end{aligned} \tag{2.12}$$

Chapter 3

Practical Implications of ESG Risks

PST 2022

3.1 Measuring ESG Risks

3.2 Exposure to ESG Risks