An EZ way to evaluate assets

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Abstract

We incorporate Epstein-Zin preferences in an exchange economy with background risk and examine the effect of inequality on the equity risk premium. When agents have preference for late resolution of uncertainty, inequality increases the premium for low income uncertainty and increases the premium for large income uncertainty.When agents have preference for early resolution of uncertainty, inequality increases the equity premium even the level of income uncertainty is large. Our results suggest that the interplay of timing of resolution of uncertainty with the background risk are the cause for the positive relationship of inequality with the premium.

Keywords: asset pricing; equity premium; time preferences; consumption; wealth inequality; background risk

JEL Codes: G11, G12, D11, D31, D90

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1 Introduction

The consumption-based asset pricing model (CCAPM) with the simple power utility specification has been criticized for its ability to explain observed asset pricing anomalies, such as the high equity premium, the high volatility of stock returns and the countercyclical variation in the equity premium (Grossman and Shiller 1981; Shiller 1982; Mehra and Prescott 1985; Kandel and Stambaugh 1990). One source of criticism is the restrictive nature of this type of utility, as it links risk aversion with the elasticity of intertemporal substitution (EIS) making one the reciprocal of the other and implying that the marginal utility of consumption at any date is independent of consumption at all other dates, even at very low levels of consumption.

Revisions and elaborations of asset pricing theory include the implementation of recursive utility models, such as in Kreps and Porteus (1978) and Epstein and Zin (1989, 1991), which are based on the notion that agents have an intrinsic preference towards resolution of uncertainty over time. Some agents might prefer to resolve uncertainty earlier than later. This class of preferences disentagles the coefficient of risk aversion from the elasticity of intertemporal substitution (EIS), providing a framework towards the resolution of several asset pricing anomalies. The long-run risk model of Bansal and Yaron (2004) is able to replicate quite well the observed equity risk premium and risk free rate, as long as the agents have a strong preference for early resolution of uncertainty; however this setup has also been characterized by empirical difficulties (Beeler and Campbell, 2012).

A strand of literature, which has become relatively popular lately, suggests that inequality, either in income or wealth, can potentially explain asset pricing anomalies. Inequality has increased almost steadily in the last forty years (Atkinson et al., 2011; Piketty and Saez, 2014), and, most importantly, it has risen substantially since the period the first equity premium puzzle papers were written (Mehra and Prescott, 1985; Weil, 1989). Therefore it is not surprising that several economists have focused on the relationship between inequality and asset pricing. The findings are mixed. Several researchers (Constantinides and Duffie, 1996; Brogaard et al., 2015; Christou et al, 2021) show a positive relationship between inequality and the equity premium, while others (Dumas, 1989; Favilukis, 2013; Gârleanu and Panageas, 2015; Toda and Walsh, 2020) predict a negative relationship. Gollier (2001), in his seminal study, shows that the impact of inequality on

the premium will be positive if agents exhibit absolute risk tolerance and negative if agents exhibit convex absolute risk tolerance.

Our paper attempts to add to the inequality-asset pricing nexus literature, by investigating how the decoupling of the elasticity of intertemporal substitution (EIS) from risk aversion affects the relationship between inequality and equity premium in an incomplete market setting. Inequality does not affect asset pricing in complete markets, unless the utility function of agents captures the concavity of the absolute risk tolerance (Gollier, 2001). Therefore we introduce an element of market incompleteness in our economy, known as background risk, which is defined as a risk that cannot be insured or avoided. In the real world, markets are incomplete. Certain risks, by their very nature, cannot be diversified. Aggregate risks, as they affect all pool members equally, are, to an extent, fundamentally non-tradable and therefore uninsurable. Moreover, different types of frictions, such as informational asymmetries or problems in enforcing risk-sharing agreements, might be preventing the realization of a complete market (Attanasio and Davis, 1996). Sources of background risk have been identified in literature and include, among others, human capital (Bodie, Merton and Samuelson, 1992; Koo, 1995; Viceira, 2001; Cocco et al., 2005), housing wealth (Cocco, 2005; Flavin and Yamashita, 2002; Yao and Zhang, 2005) and private business wealth (Heaton and Lucas; 2000a, 2000b). A more recent empirical study by Fagereng et al. (2018) focuses on human capital as source of the background risk and shows that its importance regarding portfolio heterogeneity varies greatly, as it is large for the poor and negligible for the wealthy.

As in Gollier (2001) and Ahn et al. (2015), we examine a simple Arrow-Debreu exchange economy with agents that live two periods. A two-period model is flexible and allows us to investigate equilibrium by using various combinations of assumptions, despite its limitations. All agents exhibit Epstein Zin preferences, implying the disentanglement of the relative risk aversion from the elasticity of intertemporal substitution (EIS). EIS shows how the marginal rate of substitution between the current and the future consumption reacts to changes in the risk-free rate, holding the lifetime utility constant. Therefore EIS implies time aversion and the timing of resolution of income uncertainty becomes important. Lastly, we introduce wealth inequality through a mean-preserving transfer of endowment and a background risk is present.

We run calibrations and according to our findings, wealth inequality can significantly affect the equity risk premium in our economy. When EZ agents have a preference for late resolution of uncertainty, wealth inequality decreases the equity risk premium. On the other hand, when agents have a preference for early resolution of uncertainty, wealth inequality increases the equity risk premium. Our findings suggest that the shape of the absolute risk tolerance of the agents (concave or convex) is linked with the type of time preferences the agents exhibit. The intuitive mechanism relies on theoretical findings by Gollier (2001) and Eeckhoudt et al. (2005). Specifically, for inequality to increase the premium in an unequal economy, a concave absolute risk tolerance is required, which can be achieved through the presence of a low level of background risk. Moreover, the reason that inequality increases the premium for agents that have a preference for early resolution of uncertainty, even for high levels of background risk is because, in this case, time-diversification of risk is allowed and plays a similar role with further reduction of the background risk.

The rest of the paper is organized as follows. Section 2 describes the methodology.; Section 3 presents and discusses the results and Section 4 concludes.

2 Methodology

2.1 Model

We consider a simple Arrow-Debreu exchange economy with a single perishable good. There is a large number of n agents, $i = 1, 2, ..., n$ in the economy, who live for two periods, indexed by 0 and 1 respectively. To keep the model simple, we assume that all agents have identical preferences and the same subjective discount factor β. They also have the same attitude towards risk and consumption smoothing over time. The economy is characterized by the von Neuman-Morgenstern utility function u on consumption at each period, increasing ($u' > 0$), twice continuously differentiable and strictly concave ($u'' < 0$).

Wealth inequality is introduced through a mean preserving transfer of endowment. In the first period there is no uncertainty and agent i receives an endowment equal to w_{i0}. In the second period there is uncertainty, characterized by S possible states of the world, indexed by $s = 0, 1, ...s, ...S$ and the agent receives a bundle of contingent claims $w_{i1}, ..., w_{is}, ..., w_{iS}$ with likelihood $\{p_s\}_{s=1}^{S}$.

The average endowment can be written as

$$z_s = \sum_{i=1}^{n} \frac{1}{n} w_{is}$$

.

We assume one spot market for present consumption and S contingent markets for future consumption in the S states of the world. The competitive prices in the spot and in the futures markets in the S different states of the world are denoted with π_0 and π_s respectively, where π_0 is the price to be paid at $t = 0$ for the delivery of 1 unit of the good, while π_s is the price of a security that pays off 1 unit of consumption only if state s occurs. Market incompleteness is introduced through a non-hedgeable background risk $\widetilde{y}$, bounded from below. Moreover, $E(\widetilde{y}) = 0$ so that the non-hedgeable income is a pure risk.

Agents exhibit Epstein and Zin (1989, 1991) preferences. Adopting the formulation of Ahn et al. (2015) and adapting it to include background risk, the saving-portfolio problem becomes

$$V_i = max \left[(C_{i0} + \widetilde{y})^{\rho} + \beta \Big(\sum_{s=1}^{S} p_s (C_{is} + \widetilde{y})^{1-r} \Big)^{\frac{\rho}{1-r}} \right]^{\frac{1}{\rho}} \tag{1}$$

s.t.

$$\pi_0 (C_{i0} - w_{i0}) + \sum_{s=1}^{S} \pi_s (C_{is} - w_{is}) = 0, \tag{2}$$

where r is the coefficient of relative risk aversion, $\rho = 1 - \frac{1}{1-\psi}$, and ψ is the elasticity of intertemporal substitution (EIS).

The competitive equilibrium should satisfy the following set of necessary and sufficient conditions:

$$\Omega^{\frac{1}{\rho}-1} (C_{i0} + \widetilde{y})^{\rho-1} = \lambda_i \pi_0, \;\; i = 1, \dots n \tag{3}$$

$$\beta\frac{1-r}{\rho}\Omega^{\frac{1}{\rho}-1}\left[\frac{\rho}{1-r}\Phi\right]^{\frac{\rho}{1-r}-1}p_s(C_{is}+\widetilde{y})^{-r}=\lambda_i\pi_s,\ \ i=1,\dots n,\ \ s=0,\dots s,\dots S \tag{4}$$

and

$$\sum_{i=1}^{n}\frac{1}{n}C_{is}=z_s \tag{5}$$

where

$$\Omega=\left[(C_{i0}+\widetilde{y})^{\rho}+\beta\left[\sum_{s=1}^{S}p_s(C_{is}+\widetilde{y})^{1-r}\right]^{\frac{\rho}{1-r}}\right]$$

and

$$\Phi=\sum_{s=1}^{S}p_s(C_{is}+\widetilde{y})^{1-r}$$

Equations (3) and (4) correspond to the first order conditions of the maximization problem of agent i. The term λ_i is the lagrangian multiplier associated with agent i's budget constraint. Equation (5) is the market clearing condition associated to the market for state-claims s and implies that for $s=0$, the good cannot be transferred to the next period (i.e. perishable). Through conditions (3)-(5) we can get the optimal portfolio choice of agent i. In the appendix section of the paper, we provide a transformation of the equation system to partially overcome the difficulty of deriving closed form equilibrium with our EZ utility function.

The relative price of a risky asset with respect to bonds, Π, is evaluated as follows:

$$\Pi=\frac{\sum_{s=1}^{S}\pi_s z_s}{\sum_{s=1}^{S}\pi_s} \tag{6}$$

The risk free asset provides one unit of consumption good at $t=1$ with probability 1. The price to be paid at $t=0$ for that asset will be

$$\frac{1}{R}=\frac{\sum_{s=1}^{S}\pi_s}{\pi_0} \tag{7}$$

where R is the gross risk-free rate.

2.2 Calibrations

In our model economy, and despite its simplicity with EZ preferences, there is no closed-form expression for its equilibrium, which is also the case for several incomplete market general equilibrium models. Therefore, we rely on a numerical method to derive the consumption-investment choices and asset prices. The parameters used for our study are summarized in Table 1. We examine a simple macroeconomic uncertainty. Period $t = 1$ consists of two states of the world. State 1 is defined as the recession state and state 2 is defined as the growth state. In state 1, the consumption per capita is reduced by 1% ($z_1 = 0.99$), with a probability of 62%. In state 2 the consumption per capita is increased by 6% ($z_2 = 1.06$) with a probability of 38%. Our qualitative results do not depend on the probability of a recession exceeding 50%, nor on the particular values of the growth rate of the consumption per capita in each state.

Table 1: Baseline Parameterization

Parameters		**Values**
Probabilities		
p_1	Probability of realization of recession	62%
p_2	Probability of realization of growth	38%
Wealth Distribution		
h	Coefficient of variation of wealth	0, 0.5
Individual Preference		
β	Time discount factor	0.98
r	Coefficient of relative risk aversion	2
ψ	Elasticity of intertemporal substitution	0.1, 0.2, 0.5, 0.7, 1
Income per capita		
z_0	Average income at period 0	1
z_1	Average income at state 1	0.99
z_2	Average income at state 2	1.06
Background Risk		
k	Labor income risk	$[0, 0.30]$

Finance literature uses a variety of coefficients, ranging from 1 to 10. However, Chetty (2006) examines a series of labor supply studies and finds a mean estimate close to 1 and an upper bound

equal to 2. For our calibrations, we set a coefficient of relative risk aversion equal to 2.

Market incompleteness is introduced through a non-hedgeable labor income risk. To keep things simple, we assume that this background risk $\widetilde{y}$ is distributed as $(-k, 1/2; +k, 1/2)$. Parameter k is the standard deviation of the growth of labor income and ranges from 0 to 30%.

In terms of wealth inequality, we consider a simple wealth distribution with two equally weighted classes, poor and rich, as in Heaton and Lucas (1996) and Gollier (2001). The poor are endowed with a share of $1 - h$ of the GDP per capita in each state, and the rich are endowed with the rest $1 + h$. The parameter h is at the same time the standard deviation and the coefficient of variation of the wealth distribution. In the unequal economy, the poor are endowed with 50% of the GDP per capita while the rich are endowed with 150% of the GDP per capita.

Regarding the elasticity of intertemporal substitution ψ, the literature has not reached a consensus about its magnitude. Hansen and Singleton (1982), Guvenen (2009) and Vissing-Jorgensen (2002) estimate ψ to be larger than 1. Barsky et al. (1997) and Campbell (1999) provide estimates well below 1. Bansal and Yaron (2004) consider 1.5 for ψ, and Gomes and Michaelides (2008) set (endogenous) stock market non-participants' ψ to be 0.1 and participants' to be 0.3. Epstein et al. (2014) argue that investors have unrealistically high willingness to pay for early resolution for ψ equal to 1 or 1.5 and r equal to 7.5 or 10. On the other hand, Weil (1989, 1992) has shown that a very low value for the EIS implies an implausible behavior of the risk-free rate. To acknowledge this diversity for the EIS, we choose a wide range of values consistent with the literature.

For comparison purposes, all parameters of Table 1 with the exception of the EIS are intended to match Gollier's (2001) parameters.

3 Results and Discussion

Per Gollier's (2001) findings, when economic agents are indifferent to their temporal resolution of uncertainty, taking into account wealth inequality can cause only a marginal improvement in the equity premium, and only if the uninsurable income risk is low. Our calibrations show that Gollier's (2001) argument can be extended with Epstein-Zin preferences and inequality and that the value for the equity premium can approach its historically observed level. The integral part of

our analysis is how the background risk and the timing of resolution of uncertainty come into play in our setting.

Whether agents have a preference for early or late resolution of uncertainty is a question that can be better examined through empirical work. On the experimental side of the finance literature, Cheung (2016) offers an extensive methodological survey of elicitation of time preferences and concludes that it is difficult to make definitive recommendations regarding the relationship of concavity between risk and time preferences. Brown and Kim (2014) reveal, through their experiment, that most agents have a preference for early resolution of uncertainty and have relative risk aversion coefficient greater than the reciprocal of EIS, a result consistent with predictions of the recursive utility class of models.

On the other hand Meissner and Pfeiffer (2022) find through their experiment that agents weakly prefer early resolution of consumption uncertainty, but with considerable heterogeneity. Some subjects have a strong preference for early resolution, 40% of subjects are indifferent, while almost no subjects prefers late resolution. The differences with Brown and Kim's (2014) paper can be attributed to the different measures of preferences for resolution of uncertainty, as well as to the use of consumption as incentive, instead of monetary payments. However, even though most experimental papers find that individuals typically prefer early resolution of uncertainty, these studies do not control for the instrumental value that early resolution could have.

All figures show the equity premium as a function of the background risk (k), in an egalitarian ($h = 0$) and in an unequal ($h = 0.5$) setting. As is known from literature, in complete markets with CRRA agents (linear absolute risk tolerance), the distribution of wealth has no effect on asset prices. That is because in this type of preferences, the absolute risk tolerance is linear. This result is extended for EZ preferences, given that they are a generalization of time-additive CRRA preferences. Therefore, and per our calibrations, when there is no background risk in the economy, inequality has no effect on asset pricing.

Next, we focus on what happens with presence of a background risk and in cases with different timing of resolution of uncertainty. Specifically, in Figure 1 we examine how the premium changes in economies where agents prefer late resolution of uncertainty ($r < 1/\psi$). We look at low values

of EIS, and specifically 0.1 and 0.2. We find that for lower background risk, inequality produces a higher premium and for a higher level of background risk, inequality produces a lower premium.

In Figure 2, EIS is equal to 0.5, which implies that the EZ setting reduces to a CRRA case and agents have no preference for late or early resolution of uncertainty ($r = 1/\psi$). Qualitatively, the results are similar as with agents that prefer late resolution of uncertainty. For low background risk inequality raises the premium and for high background risk, inequality reduces the premium. The main difference is that for late resolution of uncertainty the premium not only is not marginal, but it can approach its historically observed level. In Figure 3 we look at EIS equal to 0.7 and 1, which corresponds to agents that prefer early resolution of uncertainty ($r > 1/\psi$). As is shown, inequality raises the equity premium even for a large background risk. Our results are consistent with theory as, the lower the EIS, the higher the equity premium that is generated (Weil, 1989). Our results also extend previous findings from literature as the higher the EIS, and therefore the larger the preference for early resolution of uncertainty, the more likely that inequality will raise the premium in an economy with a large background risk.

An intuitive explanation can be sought to two theoretical findings. The first theoretical finding refers to the concavity of the absolute risk tolerance of agents. The negative effect of an idiosyncratic uninsurable income risk on the degree of tolerance towards the independent portfolio risk is lower for the poor and larger for the wealthy agents, implying that the absolute risk tolerance of the wealthy is less adversely affected by background risk. This condition is true if the background risk is small and the utility of the agents is HARA or hyperbolic absolute risk aversion utility (Gollier 2001), which nests CRRA utilities. The second theoretical finding provides the intuitive mechanism on why inequality raises the premium even for a large level of background risk (Figure 3). Specifically, when earlier resolution of uncertainty is expected consumers reduce their precautionary savings, because risks that are realized earlier can be dispersed over more periods (Eeckhoudt et al. 2005). Therefore earlier resolution of uncertainty time-diversifies the risk, implying a reduction of the background risk.

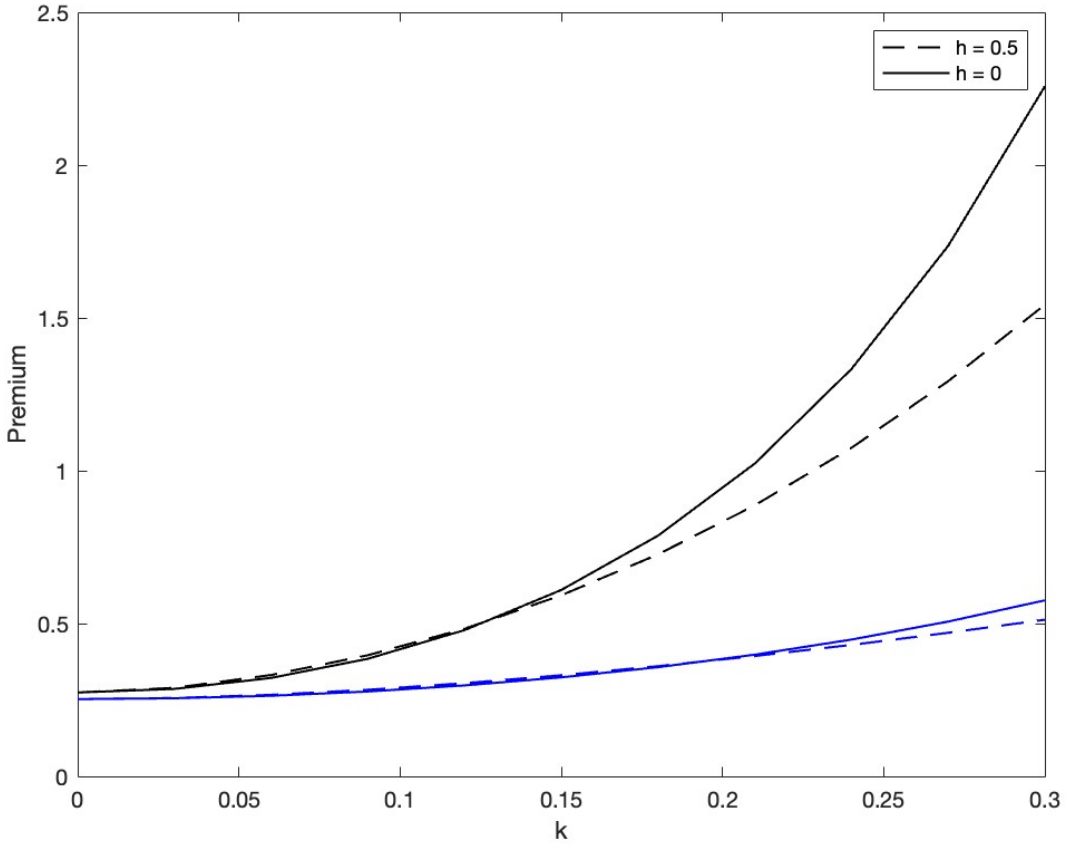

Figure 1: The equity premium (in % per year) as a function of the background risk. The economy consists of two equally weighted classes of wealth (poor and rich). The plain (dashed) lines are for the egalitarian (unequal) economy. For EIS, we have as follows: Black: $\psi = 0.1$, Blue: $\psi = 0.2$.

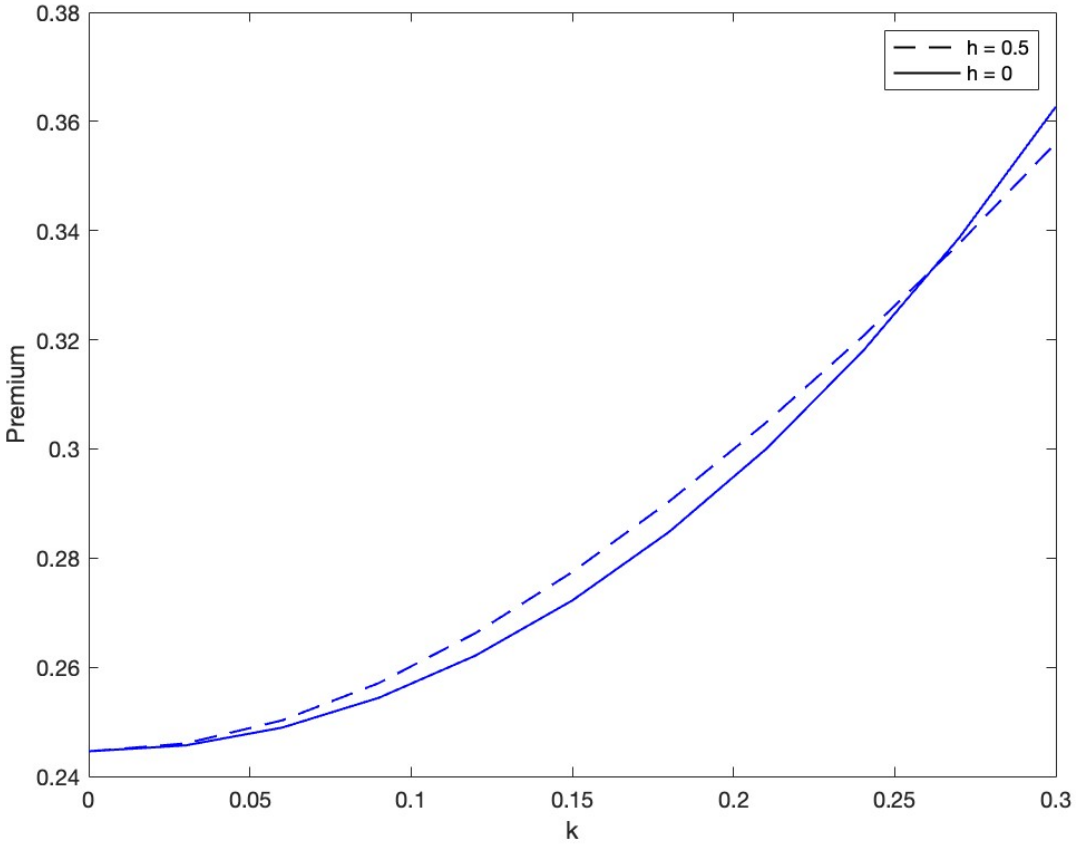

Figure 2: The equity premium (in % per year) as a function of the background risk. The economy consists of two equally weighted classes of wealth (poor and rich). The plain (dashed) lines are for the egalitarian (unequal) economy. For EIS, we have as follows: Blue: $\psi = 0.5$

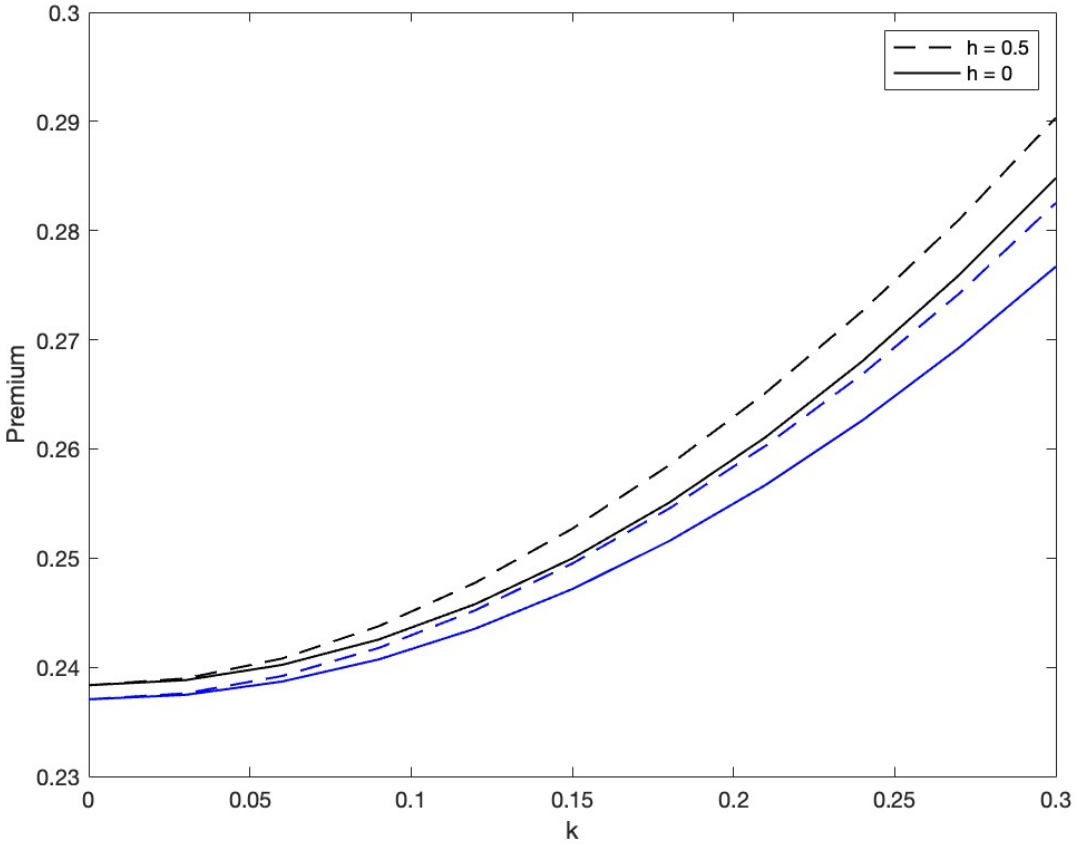

Figure 3: The equity premium (in % per year) as a function of the background risk. The economy consists of two equally weighted classes of wealth (poor and rich). The plain (dashed) lines are for the egalitarian (unequal) economy. For EIS, we have as follows: Black: $\psi = 0.7$, Blue: $\psi = 1$.

4 Conclusion

This paper examines how the relationship of inequality, Epstein-Zin preferences and background risk can affect the equity premium. We find that a departure from an egalitarian economy reduces the equity risk premium when agents have a preference for late resolution of uncertainty and the level of background risk is sufficiently high. We also observe that when agents have preference for early resolution of uncertainty, wealth inequality increases the equity risk premium. Our findings suggest that the timing of resolution of uncertainty in an economy with background risk can cause a positive relationship between wealth inequality and equity premium.

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Appendix

We apply a simple transformation to our system, so that we overcome the difficulty of deriving closed-form equilibrium.

Denote

$$C_{i0} + \widetilde{y} = \widetilde{C}_{i0}, \quad C_{is} + \widetilde{y} = \widetilde{C}_{is},$$

transforming V_i to[1]

$$V_i = \max_{C_{i0}, C_{is}} \left[\widetilde{C}_{i0}^{\rho} + \beta \left(\sum_{s'=1}^{S} p_{s'} \widetilde{C}_{is'}^{1-r} \right)^{\frac{\rho}{1-r}} \right]^{\frac{1}{\rho}} := \max_{C_{i0}, C_{is}} F^{\frac{1}{\rho}} \left(\widetilde{C}_{i0}, \widetilde{C}_{is} \right).$$

[1]Hereinafter, we use s as a free index to recognize the parameters C_{is}. In order to avoid any confusion with indexes, we will use s' to indicate the summation index.

Since the maximization problem is split for each i, we will not indicate the range of i every time.

We can state that

$$\max_{C_{i0},C_{is}} \cdot = \max_{\widetilde{C}_{i0},\widetilde{C}_{is}} \cdot.$$

and since F is non-negative, we conclude that[2]

$$\operatorname{argmax} F^{\frac{1}{\rho}} = \operatorname{argmax} F.$$

Therefore, the i^{th} Lagrangian will have the form

$$\mathcal{L}_i\left(\lambda_i;\widetilde{C}_{i0},\widetilde{C}_{is}\right) = \widetilde{C}_{i0}^{\rho} + \beta\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho}{1-r}} - \lambda_i \cdot \left[\pi_0\left(C_{i0}-w_{i0}\right) + \sum_{s'=1}^{S}\pi_{s'}\left(C_{is'}-w_{is'}\right)\right].$$

The system of necessary conditions will then be

$$\frac{\partial \mathcal{L}_i}{\partial \widetilde{C}_{i0}} = \rho \cdot \widetilde{C}_{i0}^{\rho-1} - \lambda_i \cdot \pi_0,$$

$$\frac{\partial \mathcal{L}_i}{\partial \widetilde{C}_{is}} = \beta \cdot \frac{\partial}{\partial \widetilde{C}_{is}}\left[\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho}{1-r}}\right] - \lambda_i \cdot \pi_s,$$

where

$$\begin{aligned}\frac{\partial}{\partial \widetilde{C}_{is}}\left[\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho}{1-r}}\right] &= \frac{\rho}{1-r}\cdot\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho+r-1}{1-r}} \cdot p_s \frac{\partial \widetilde{C}_{is}^{1-r}}{\partial \widetilde{C}_{is}} = \\ &= \frac{\rho\cdot p_s}{1-r}\cdot\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho+r-1}{1-r}} \cdot (1-r)\,\widetilde{C}_{is}^{1-r-1} = \\ &= \rho\cdot p_s\cdot\left(\sum_{s'=1}^{S} p_{s'}\widetilde{C}_{is'}^{1-r}\right)^{\frac{\rho+r-1}{1-r}} \cdot \widetilde{C}_{is}^{-r}.\end{aligned}$$

[2]This can be easily proved by taking into account that for any non-trivial $f:\mathbb{R}\to\mathbb{R}$ and $n\geq 1$, f and f^n share the same stationary points. Indeed, the chain rule provides $\frac{df^n(x)}{dx} = n\cdot f^{n-1}(x)\cdot f'(x)$ where $f^{n-1}\not\equiv 0$.

Thus, the i^{th} system of constraints becomes

$$\begin{cases} \rho \cdot \widetilde{C}_{i0}^{\rho-1} - \lambda_i \cdot \pi_0 = 0 \\ \beta \cdot \rho \cdot p_s \cdot \left(\sum_{s'=1}^{S} p_{s'} \widetilde{C}_{is'}^{1-r} \right)^{\frac{\rho+r-1}{1-r}} \cdot \widetilde{C}_{is}^{-r} - \lambda_i \cdot \pi_s = 0 \\ \pi_0 \left(C_{i0} - w_{i0} \right) + \sum_{s'=1}^{S} \pi_{s'} \left(C_{is'} - w_{is'} \right) = 0 \end{cases} \tag{8}$$