

Recursive Utility in Continuous Time

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Introduction

The [recursive preferences in a multiperiod economy](#) notebook derived the Epstein-Zin SDF (Epstein and Zin 1989) in discrete time by exploiting homotheticity and Euler's theorem. The key result was

$$m_{t+1} = \left[\beta \left(\frac{c_{t+1}}{c_t} \right)^{-1/\psi} \right]^\theta \left[\frac{1}{R_{t+1}^w} \right]^{1-\theta}, \quad \theta = \frac{1-\gamma}{1-1/\psi}.$$

Under power utility ($\psi = 1/\gamma$, so $\theta = 1$) the wealth return drops out entirely; under Epstein-Zin ($\theta \neq 1$) it enters as an independent pricing factor that captures the agent's concern for news about future investment opportunities.

Passing this result to continuous time requires some care. The discrete aggregator $V_t = [(1 - \beta)c_t^\rho + \beta\mu_t^\rho]^{1/\rho}$ of Kreps and Porteus (1978) and Epstein and Zin (1989) does have a heuristic limit when $\Delta t \rightarrow 0$, with $1 - \beta \approx \delta\Delta t$, but the raw limit carries a term proportional to the variance of the continuation value. Duffie and Epstein (1992b) show that an ordinally equivalent renormalization of utility removes this term, and that Epstein-Zin preferences in continuous time are characterized by a **stochastic differential equation** for the utility process, governed by a normalized aggregator $f(c, V)$. This object plays the role of the period felicity function in additive utility, but the continuation value V_t itself enters as an argument, separating risk aversion from intertemporal substitution at every instant.

This notebook develops stochastic differential utility (SDU), derives the continuous-time Epstein-Zin aggregator and consumption first-order condition, and explains how recursive utility modifies the stochastic discount factor relative to the additive case. The continuous-time limit is both mathematically elegant and economically important: it makes precise exactly when and how γ and ψ produce independent effects on asset prices.

The general theory here stops at the recursive-utility pricing kernel. A separate notebook, [Affine Recursive Utility in Continuous Time](#), applies these results to a one-factor affine-Gaussian state model and derives the local exponential-affine approximation for the value function and the SDF.

Stochastic Differential Utility

The Aggregator

In continuous time, the utility process V_t is defined implicitly by

$$V_t = E_t \left[\int_t^\infty f(c_s, V_s) ds \right], \quad (1)$$

where the function $f(c, v)$ is the **normalized aggregator**. Equation (1) is not a closed-form definition but a functional equation: V_t must be the process such that the stochastic integral representation holds simultaneously for every t . Define $M_t = V_t + \int_0^t f(c_s, V_s) ds$. The integral representation (1) implies $M_t = E_t \left[\int_0^\infty f(c_s, V_s) ds \right]$, which is a martingale. In a Brownian filtration, the martingale representation theorem guarantees that any square-integrable martingale is a stochastic integral with respect to $\mathbf{B}$, so $dM_t = \sigma_t^V \cdot d\mathbf{B}_t$ for some adapted process σ_t^V . Rearranging $dM_t = dV_t + f(c_t, V_t) dt$ yields the stochastic differential equation

$$dV_t = -f(c_t, V_t) dt + \sigma_t^V \cdot d\mathbf{B}_t, \quad (2)$$

where the drift is pinned down by the aggregator and the martingale part captures unpredictable revisions to the continuation value as new information arrives.

For additive utility with felicity $u(c)$ and discount rate δ , the aggregator is

$$f(c, v) = \delta(u(c) - v).$$

To see why (1) then reduces to the standard discounted utility representation, substitute into

the functional equation to get the fixed-point condition

$$V_t = E_t \left[\int_t^\infty \delta(u(c_s) - V_s) ds \right].$$

One can verify that $V_t = E_t \left[\int_t^\infty \delta e^{-\delta(s-t)} u(c_s) ds \right]$ solves this equation: the factor δ ensures that in steady state $V = u(c)$, so the continuation value has the same units as the felicity function itself.

Substituting $f(c, v) = \delta(u(c) - v)$ into (2) gives the additive utility SDE directly:

$$dV_t = \delta(V_t - u(c_t)) dt + \sigma_t^V \cdot d\mathbf{B}_t,$$

where the martingale term $\sigma_t^V \cdot d\mathbf{B}_t$ captures revisions to V_t driven by news about the future consumption path.

Epstein-Zin Aggregator

To specialize the aggregator to Epstein-Zin preferences, impose two conditions on f . First, require $f(c, v) = 0$ if and only if $v = c^{1-\gamma}/(1-\gamma)$: a constant consumption path c is a steady state precisely when the continuation value equals the CRRA value of c enjoyed forever. Inverting this condition defines the certainty-equivalent consumption

$$\hat{c}(v) = [(1-\gamma)v]^{1/(1-\gamma)},$$

the unique consumption level whose CRRA lifetime utility equals v . This power transformation requires $(1-\gamma)v > 0$, so along any admissible path the utility process must have the same sign as $(1-\gamma)$: $v > 0$ when $\gamma < 1$ and $v < 0$ when $\gamma > 1$.

Second, require f to respect CRRA scale invariance. Scaling all consumption by λ scales utility by $\lambda^{1-\gamma}$, so demand $f(\lambda c, \lambda^{1-\gamma} v) = \lambda^{1-\gamma} f(c, v)$. This homogeneity condition forces f to depend on c and v only through the ratio $c/\hat{c}(v)$, with the prefactor $(1-\gamma)v$ supplying the correct scaling:

$$f(c, v) = (1-\gamma)v \cdot g\left(\frac{c}{\hat{c}(v)}\right),$$

for some function g with $g(1) = 0$. The ratio $c/\hat{c}(v)$ measures how current consumption compares to its break-even level, and g determines how sensitively the drift responds to deviations from that benchmark. Parametrizing g as a CES function with elasticity $\psi > 0$ gives $g(x) = \delta(x^{1-1/\psi} - 1)/(1 - 1/\psi)$ and hence the Epstein-Zin normalized aggregator

$$f(c, v) = \frac{\delta(1 - \gamma)v}{1 - 1/\psi} \left[\left(\frac{c}{\hat{c}(v)} \right)^{1-1/\psi} - 1 \right]. \quad (3)$$

The two preference parameters enter through entirely separate objects: γ determines $\hat{c}(v)$, governing how the agent values uncertainty about future utility, while ψ determines the curvature of g , governing how the drift reacts to gaps between current and break-even consumption. This separation in the aggregator is precisely what additive utility cannot achieve, even though equilibrium allocations and prices still depend jointly on the solution for the value-function coefficient.

The same aggregator also follows heuristically from the discrete Epstein-Zin recursion, which shows that the CES form of g is not an extra assumption. Following the online appendix of Collin-Dufresne et al. (2016), write the recursion over a period of length dt as

$$U_t = \left[(1 - e^{-\delta dt}) c_t^{1-1/\psi} + e^{-\delta dt} (E_t[U_{t+dt}^{1-\gamma}])^{\frac{1-1/\psi}{1-\gamma}} \right]^{\frac{1}{1-1/\psi}},$$

and measure utility by $V_t = U_t^{1-\gamma}/(1 - \gamma)$, so that $U_t = \hat{c}(V_t)$ and the certainty equivalent of U_{t+dt} is exactly $\hat{c}(E_t[V_{t+dt}])$. Applying $\phi(x) = x^{1-1/\psi}/(1 - 1/\psi)$ to both sides and writing $G = \phi \circ \hat{c}$ gives

$$G(V_t) = (1 - e^{-\delta dt}) \phi(c_t) + e^{-\delta dt} G(E_t[V_{t+dt}]).$$

The argument of G on the right is a conditional mean, so a first-order expansion around V_t produces no variance term: with $1 - e^{-\delta dt} \approx \delta dt$, keeping terms of order dt yields $E_t[dV_t] = -f(c_t, V_t) dt$ with

$$f(c, v) = \delta \frac{\phi(c) - G(v)}{G'(v)}.$$

Since $G(v) = \hat{c}(v)^{1-1/\psi}/(1 - 1/\psi)$ and $G'(v) = \hat{c}(v)^{1-1/\psi}/[(1 - \gamma)v]$, this is exactly (3). Working with U_t directly would instead leave a term in the conditional variance of utility, which

is the term the normalization removes.

In the limit $\psi \rightarrow 1$, the CES function $(x^{1-1/\psi} - 1)/(1 - 1/\psi)$ converges to $\ln x$, giving

$$f(c, v) \xrightarrow{\psi \rightarrow 1} \delta(1 - \gamma)v \ln\left(\frac{c}{\hat{c}(v)}\right).$$

For additive utility $\psi = 1/\gamma$, so $1 - 1/\psi = 1 - \gamma$ and $\hat{c}^{1-\gamma} = (1 - \gamma)v$. Substituting into (3) gives

$$f(c, v) = \delta\left[\frac{c^{1-\gamma}}{1-\gamma} - v\right] = \delta(u(c) - v),$$

recovering the additive aggregator exactly. Under this normalization, the utility process V_t represents the average future felicity, which is the standard representation used to derive the Epstein-Zin SDF in continuous time.

The Bellman Equation

The agent maximizes V_0 by choosing a consumption plan $c_t \geq 0$ and a portfolio weight vector α_t . The investment opportunity set is time-varying: the short rate $r(\mathbf{z}_t)$, the vector of expected excess returns $\mu(\mathbf{z}_t) - r(\mathbf{z}_t)\mathbf{l}$, and the return volatility matrix $\sigma(\mathbf{z}_t)$ all depend on a state vector $\mathbf{z}_t$. Wealth therefore evolves as

$$dW_t = [W_t (r(\mathbf{z}_t) + \alpha_t'(\mu(\mathbf{z}_t) - r(\mathbf{z}_t)\mathbf{l})) - c_t] dt + W_t \alpha_t' \sigma(\mathbf{z}_t) d\mathbf{B}_t,$$

and $\mathbf{z}_t$ follows its own diffusion driven by the same Brownian motion, capturing the covariation between portfolio returns and shifts in investment opportunities:

$$d\mathbf{z}_t = \mu^z(\mathbf{z}_t) dt + \sigma^z(\mathbf{z}_t) d\mathbf{B}_t.$$

Then the HJB equation for stochastic differential utility is

$$0 = \sup_{c, \alpha} \{f(c, V(W, \mathbf{z})) + \mathcal{L}^{c, \alpha} V(W, \mathbf{z})\},$$

where $\mathcal{L}^{c,\alpha}$ is the Ito generator associated with the joint process $(W_t, \mathbf{z}_t)$. Expanding it explicitly,

$$\begin{aligned}\mathcal{L}^{c,\alpha}V &= V_W[W(r(\mathbf{z}) + \alpha'(\mu(\mathbf{z}) - r(\mathbf{z})\mathbf{1}) - c] + \frac{1}{2}V_{WW}W^2\|\alpha'\sigma(\mathbf{z})\|^2 \\ &\quad + (\nabla_z V)' \mu^z + \frac{1}{2}\text{tr}(\sigma^z(\sigma^z)' H_z V) + W(\nabla_z V_W)' \sigma^z \sigma(\mathbf{z})' \alpha,\end{aligned}$$

where $H_z V$ is the Hessian of V with respect to $\mathbf{z}$ and the last term captures the covariation between wealth and the state variables. Conjecturing that the value function is of the form $V(W, \mathbf{z}) = h(\mathbf{z}) W^{1-\gamma}/(1-\gamma)$ for some function $h > 0$ (Schroder and Skiadas 1999), homotheticity implies that optimal consumption is proportional to wealth: $c/W = \kappa(\mathbf{z})$. The key derivatives are

$$\begin{aligned}V_W(W, \mathbf{z}) &= h(\mathbf{z}) W^{-\gamma}, \\ V_{WW}(W, \mathbf{z}) &= -\gamma h(\mathbf{z}) W^{-\gamma-1},\end{aligned}$$

and

$$\nabla_z V(W, \mathbf{z}) = \frac{W^{1-\gamma}}{1-\gamma} \nabla_z h(\mathbf{z}).$$

Substituting the homothetic guess into the HJB separates the choice variables from the scale variable W . The first-order condition for current consumption is

$$f_c(c, V(W, \mathbf{z})) = V_W(W, \mathbf{z}),$$

which says that the marginal gain from an extra unit of current consumption must equal the shadow value of one more unit of wealth. Using the Epstein-Zin aggregator (3), this condition becomes, for $\psi \neq 1$,

$$\delta c^{-1/\psi} [(1-\gamma)V]^{1-1/\theta} = V_W, \quad \theta = \frac{1-\gamma}{1-1/\psi}.$$

To verify this, write $J = (1-\gamma)V$, so $\hat{c}(V) = J^{1/(1-\gamma)}$. Then

$$f(c, V) = \frac{\delta J}{1-1/\psi} \left[\left(\frac{c}{J^{1/(1-\gamma)}} \right)^{1-1/\psi} - 1 \right],$$

and differentiating with respect to c gives

$$f_c(c, V) = \delta c^{-1/\psi} J^{1-\frac{1-1/\psi}{1-\gamma}} = \delta c^{-1/\psi} J^{1-1/\theta}.$$

Differentiating with respect to v requires the chain rule through $\hat{c}(v)$. Since $\hat{c}(v) = [(1 - \gamma)v]^{1/(1-\gamma)}$, one has $d\hat{c}/dv = \hat{c}(v)/[(1 - \gamma)v]$, so $dx/dv = -x/[(1 - \gamma)v]$ where $x = c/\hat{c}(v)$. Applying this to (3):

$$f_v(c, v) = \frac{\delta(1 - \gamma)}{1 - 1/\psi} [x^{1-1/\psi} - 1] - \delta x^{1-1/\psi} = \delta \left[(\theta - 1) \left(\frac{c}{\hat{c}(v)} \right)^{1-1/\psi} - \theta \right]. \quad (4)$$

When $\theta = 1$ (power utility), $f_v = -\delta$ everywhere. When $\theta \neq 1$, f_v is state-dependent through the ratio $c/\hat{c}(v)$, which measures how far current consumption deviates from its break-even level. Along the optimal path this ratio has a simple form, derived below in (5).

After substituting $V = hW^{1-\gamma}/(1 - \gamma)$ and $V_W = hW^{-\gamma}$ into the FOC and collecting powers of W , one obtains, for $\psi \neq 1$,

$$\frac{c_t}{W_t} = \kappa(\mathbf{z}_t) = \delta^\psi h(\mathbf{z}_t)^{-\psi/\theta}.$$

Since $\hat{c}(V) = [hW^{1-\gamma}]^{1/(1-\gamma)} = h^{1/(1-\gamma)}W$, the ratio in (4) satisfies $(c/\hat{c})^{1-1/\psi} = \kappa/\delta$ along the optimal path, so

$$f_v(c_t, V_t) = (\theta - 1) \kappa(\mathbf{z}_t) - \delta\theta. \quad (5)$$

The extra discounting under recursive utility is therefore tied to the consumption-wealth ratio.

The portfolio first-order condition (differentiating the HJB with respect to α) gives the standard Merton decomposition:

$$\alpha^* = \underbrace{\frac{1}{\gamma} (\sigma(\mathbf{z})\sigma(\mathbf{z})')^{-1} (\mu(\mathbf{z}) - r(\mathbf{z})\mathbf{l})}_{\text{myopic demand}} + \underbrace{\frac{1}{\gamma} (\sigma(\mathbf{z})\sigma(\mathbf{z})')^{-1} \sigma(\mathbf{z})(\sigma^z)'}_{\text{hedging demand}} \frac{\nabla_z h(\mathbf{z})}{h(\mathbf{z})}. \quad (6)$$

The myopic component maximizes the instantaneous Sharpe ratio; the hedging component, as in Merton (1973), tilts the portfolio toward assets that co-vary with changes in investment opportunities. Risk aversion γ enters both terms directly, while the elasticity ψ enters only through $h(\mathbf{z})$: two specifications with the same γ and the same h yield identical portfolios.

Both policies depend on h , which is pinned down by substituting them back into the HJB. Along

the optimal path $(c/\hat{c})^{1-1/\psi} = \kappa/\delta$, so the aggregator is $f(c, V) = \theta(\kappa - \delta)V$. The two consumption terms f and $-cV_W$ then combine through $\theta - (1 - \gamma) = \theta/\psi$, and at α^* the portfolio terms reduce to a quadratic form. Dividing by $hW^{1-\gamma}/(1 - \gamma)$ removes W and leaves a partial differential equation in $\mathbf{z}$ alone:

$$0 = \frac{\theta}{\psi} \delta \psi h^{-\psi/\theta} - \theta \delta + (1 - \gamma) \left[r + \frac{1}{2\gamma} \mathbf{a}' (\boldsymbol{\sigma} \boldsymbol{\sigma}')^{-1} \mathbf{a} \right] + (\boldsymbol{\mu}^z)' \frac{\nabla_z h}{h} + \frac{1}{2} \text{tr} \left(\boldsymbol{\sigma}^z (\boldsymbol{\sigma}^z)' \frac{H_z h}{h} \right), \quad \mathbf{a} = \boldsymbol{\mu} - r\mathbf{1} + \boldsymbol{\sigma} (\boldsymbol{\sigma}^z)' \frac{\nabla_z h}{h}, \quad (7)$$

where every coefficient is evaluated at $\mathbf{z}$. The first term is $(\theta/\psi) \kappa(\mathbf{z})$, and it is the only term that is not polynomial in $\ln h$ and its derivatives, so the equation is nonlinear and in general must be solved numerically or approximately. Under power utility ($\theta = 1, \psi = 1/\gamma$) it reduces to Merton's equation, with leading term $\gamma \delta^{1/\gamma} h^{-1/\gamma}$. With a constant opportunity set, h is a constant and (7) becomes an algebraic equation for the consumption-wealth ratio:

$$\kappa = \psi \delta + (1 - \psi) \left[r + \frac{1}{2\gamma} (\boldsymbol{\mu} - r\mathbf{1})' (\boldsymbol{\sigma} \boldsymbol{\sigma}')^{-1} (\boldsymbol{\mu} - r\mathbf{1}) \right],$$

so better investment opportunities raise κ when $\psi < 1$ and lower it when $\psi > 1$. Schroder and Skiadas (1999) solve (7) exactly in the limit $\psi \rightarrow 1$, where $\kappa = \delta$, and Chacko and Viceira (2005) combine that exact case with a log-linear approximation for $\psi \neq 1$. The companion affine notebook solves (7) approximately by linearizing $h^{-\psi/\theta}$ around the steady state.

The Stochastic Discount Factor

General Form

For pricing, the key point is more subtle than under additive utility. In stochastic differential utility, the intertemporal marginal rate of substitution is not simply $e^{-\delta t} V_W$. The correct marginal-utility process, derived by Duffie and Epstein (1992a) and justified as the utility gradient by Duffie and Skiadas (1994), is

$$\Lambda_t = \Lambda_0 \exp \left(\int_0^t f_v(c_s, V_s) ds \right) \frac{f_c(c_t, V_t)}{f_c(c_0, V_0)},$$

and using the consumption FOC this can be written equivalently as

$$\Lambda_t = \Lambda_0 \exp\left(\int_0^t f_v(c_s, V_s) ds\right) \frac{V_W(W_t, \mathbf{z}_t)}{V_W(W_0, \mathbf{z}_0)}. \quad (8)$$

Only in the additive case, where $f_v = -\delta$, does the exponential reduce to the familiar $e^{-\delta t}$. For Epstein-Zin preferences, f_v is state dependent, so recursive utility contributes an additional discounting term through continuation-value sensitivity.

Differentiating (8) gives

$$\frac{d\Lambda_t}{\Lambda_t} = f_v(c_t, V_t) dt + \frac{dV_W(W_t, \mathbf{z}_t)}{V_W(W_t, \mathbf{z}_t)}.$$

With the homothetic guess $V_W = h(\mathbf{z})W^{-\gamma}$, Ito's lemma extracts the stochastic component of dV_W/V_W :

$$\left. \frac{dV_W}{V_W} \right|_{d\mathbf{B}} = -\gamma \boldsymbol{\sigma}_t^W \cdot d\mathbf{B}_t + \frac{(\nabla_{\mathbf{z}} h(\mathbf{z}_t))' \boldsymbol{\sigma}^Z(\mathbf{z}_t)}{h(\mathbf{z}_t)} \cdot d\mathbf{B}_t,$$

where $\boldsymbol{\sigma}_t^W = \boldsymbol{\sigma}' \boldsymbol{\alpha}_t^*$ collects the wealth-return volatilities. The drift follows from the envelope condition: differentiating the HJB with respect to W shows that the drift of dV_W/V_W equals $-r_t - f_v(c_t, V_t)$, which cancels the f_v term and leaves a drift of $-r_t$, as no-arbitrage requires. The SDF therefore satisfies

$$\frac{d\Lambda_t}{\Lambda_t} = -r_t dt - \underbrace{\gamma \boldsymbol{\sigma}_t^W}_{\text{wealth risk}} \cdot d\mathbf{B}_t + \underbrace{\frac{(\nabla_{\mathbf{z}} h)' \boldsymbol{\sigma}^Z}{h}}_{\text{opportunity risk}} \cdot d\mathbf{B}_t. \quad (9)$$

The first diffusion term prices wealth-return shocks exactly as under power utility. The second prices news about future investment opportunities through $\nabla_{\mathbf{z}} h/h$, the logarithmic sensitivity of the value-function coefficient to state-variable shocks. Its sign depends on how the state vector is defined. Since $V = hW^{1-\gamma}/(1-\gamma)$, news that raises continuation utility raises h when $\gamma < 1$ and lowers it when $\gamma > 1$.

Power Utility as a Special Case

Under power utility ($\psi = 1/\gamma$, so $\theta = 1$), $f_v = -\delta$ and (8) is the familiar $e^{-\delta t} V_W$ kernel. If, in addition, the opportunity set is constant, then $\nabla_z h = 0$ and (9) reduces to $d\Lambda_t/\Lambda_t = -r dt - \gamma \sigma^W \cdot d\mathbf{B}_t$. This is the power-utility SDF of the [Consumption-Based Asset Pricing](#) notebook, since consumption is then a constant fraction of wealth and σ^W is also the diffusion vector of consumption growth.

The Epstein-Zin SDF

The opportunity-risk term $(\nabla_z h)' \sigma^z / h$ in (9) is not specific to recursive utility: under power utility with $\gamma \neq 1$ and a stochastic opportunity set it is also nonzero, and it is the source of the intertemporal hedging premium of Merton (1973). What Epstein-Zin preferences with $\psi \neq 1/\gamma$ (so $\theta \neq 1$) change is the function h itself. Under power utility, h is determined by γ alone, so the price of opportunity risk is tied to the price of wealth risk. Under Epstein-Zin, h solves (7), which also involves ψ , so the two risk prices can be set separately. The state-dependent discount rate (5), $f_v = (\theta - 1)\kappa(\mathbf{z}_t) - \delta\theta$, varies with the state only when h does.

Under a constant opportunity set, f_v is constant and the same reduction of (9) holds regardless of ψ . In this case EZ and power utility with the same γ produce the same risk premia, and ψ matters only for the consumption-wealth ratio and, in equilibrium, the risk-free rate. The full separation of γ and ψ in asset prices requires a time-varying opportunity set so that $\nabla_z h \neq 0$. That is the continuous-time channel through which recursive utility prices news about future opportunities independently of γ , the counterpart of the wealth-return factor $1/R_{t+1}^W$ in the discrete-time SDF and of the separately priced news about future returns in Campbell (1993).

The companion notebook [Affine Recursive Utility in Continuous Time](#) implements this in a one-factor Gaussian model, where h takes an exponential-affine form and (9) yields closed-form risk prices.

References

- Campbell, John Y. 1993. "Intertemporal Asset Pricing Without Consumption Data." *American Economic Review*, 487–512.
- Chacko, George, and Luis M. Viceira. 2005. "Dynamic Consumption and Portfolio Choice with Stochastic Volatility in Incomplete Markets." *The Review of Financial Studies* 18 (4): 1369–402. <https://doi.org/10.1093/rfs/hhi035>.
- Collin-Dufresne, Pierre, Michael Johannes, and Lars A. Lochstoer. 2016. "Parameter Learning in General Equilibrium: The Asset Pricing Implications." *American Economic Review* 106 (3): 664–98. <https://doi.org/10.1257/aer.20130392>.
- Duffie, Darrell, and Larry G. Epstein. 1992a. "Asset Pricing with Stochastic Differential Utility." *The Review of Financial Studies* 5 (3): 411–36. <https://doi.org/10.1093/rfs/5.3.411>.
- Duffie, Darrell, and Larry G. Epstein. 1992b. "Stochastic Differential Utility." *Econometrica* 60 (2): 353–94. <https://doi.org/10.2307/2951600>.
- Duffie, Darrell, and Costis Skiadas. 1994. "Continuous-Time Security Pricing: A Utility Gradient Approach." *Journal of Mathematical Economics* 23 (2): 107–31. [https://doi.org/10.1016/0304-4068\(94\)90001-9](https://doi.org/10.1016/0304-4068(94)90001-9).
- Epstein, Larry G., and Stanley E. Zin. 1989. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework." *Econometrica* 57 (4): 937–69.
- Kreps, David M., and Evan L. Porteus. 1978. "Temporal Resolution of Uncertainty and Dynamic Choice Theory." *Econometrica* 46 (1): 185–200.
- Merton, Robert C. 1973. "An Intertemporal Capital Asset Pricing Model." *Econometrica* 41 (5): 867–87.

Schroder, Mark, and Costis Skiadas. 1999. "Optimal Consumption and Portfolio Selection with Stochastic Differential Utility." *Journal of Economic Theory* 89 (1): 68–126. <https://doi.org/10.1006/jeth.1999.2558>.