Week 1 Appendix

Advanced Mathematical & Literature Extensions

Optional Material for Advanced Students

Note: This appendix contains advanced content removed from the core presentation to reduce cognitive load. PhD-level students and those with strong economics/finance backgrounds are encouraged to study this material.

Advanced Mathematical Extension to Slide 8

Model Setup

- Two investor types: ESG-preferring (λ), Conventional (1-λ)
- Utility functions:

$$U_E(r) = r + \alpha \cdot g \quad (\alpha > 0)$$
$$U_C(r) = r$$

- $g \in \{0, 1\}$ = green label, α = ESG preference intensity
- Supply: S_G green bonds, S_C conventional bonds

Equilibrium Conditions

- Market clearing: $\lambda \cdot D_E(r_G) = S_G$, $(1 - \lambda) \cdot D_C(r_C) = S_C$
- Greenium emerges: $r_C - r_G = \frac{\alpha \cdot \lambda}{D'(r)}$ if $S_G < \lambda \cdot D(r_C)$
- **Key prediction**: Greenium $\propto$ ESG investor share (λ)
- **Testable**: Greenium larger in EU (high λ) than US
- **Dynamic**: As $S_G \uparrow$, greenium $\downarrow$ (Slide 34 confirms)

Derivation Notes:

- Assumes constant elasticity of demand: $D(r) = A \cdot r^{-\eta}$ where $\eta > 0$
- ESG investor indifference condition: $r_G + \alpha = r_C$ (willing to accept lower return)
- Greenium magnitude depends on: (1) preference intensity α, (2) ESG investor fraction λ, (3) relative supply S_G/S_C
- Empirical calibration: $\alpha \approx 0.0003$ (3 bps), $\lambda_{EU} \approx 0.35$, $\lambda_{US} \approx 0.15$ generates observed regional differences

[Appendix A] Formal model generates testable hypotheses - validated by regional and temporal variation data (Slides 18, 34)

Comprehensive Literature Summary for Further Reading

Greenium Existence (Pricing)

- **Zerbib (2019)**: -2 bps YTM for green bonds
- **Baker et al. (2018)**: 6 bps greenium in US municipals, larger with certification
- **Karpf & Mandel (2018)**: 5-9 bps, time-varying
- **Ando (2024)**: 11 bps emerging market sovereigns, 2 bps advanced
- **Consensus**: Greenium exists but varies by market segment and time

Corporate Impact (Shareholder Value)

- **Flammer (2021)**: +0.5% stock return on green bond announcement; increased green patents
- **Tang & Zhang (2020)**: Positive wealth effects, esp. in polluting industries
- **Additionality**: Mixed evidence - some funding truly new projects, some relabeling

Financial Institution Role

- **Fatica et al. (2021)**: Banks pay higher greenium (-9 bps) due to reputational concerns
- **Implication**: Verification more critical for repeat issuers

Research frontier: Impact measurement methodology, long-run greenium dynamics, optimal policy mix.

Recommended Reading Order:

1. Start with Zerbib (2019) for greenium measurement methodology
2. Read Flammer (2021) for corporate impact evidence
3. Explore Ando (2024) for recent sovereign bond findings
4. Advanced: Baker et al. (2018) for theoretical segmentation model

Appendix References

Key Papers Discussed in Appendix B:

- Zerbib, O.D. (2019). The Effect of Pro-Environmental Preferences on Bond Prices: Evidence from Green Bonds. *Journal of Banking & Finance*, 98, 39-60. doi:10.1016/j.jbankfin.2018.10.012
- Baker, M., Bergstresser, D., Serafeim, G., & Wurgler, J. (2018). Financing the Response to Climate Change: The Pricing and Ownership of U.S. Green Bonds. *NBER Working Paper*, 25194. doi:10.3386/w25194
- Karpf, A., & Mandel, A. (2018). The Changing Value of the 'Green' Label on the US Municipal Bond Market. *Nature Climate Change*, 8, 161-165. doi:10.1038/s41558-017-0062-0
- Ando, S., & Greenwood-Nimmo, M. (2024). How Large is the Sovereign Greenium?. *Oxford Bulletin of Economics and Statistics*, 86(3), 594-621. doi:10.1111/obes.12619
- Flammer, C. (2021). Corporate Green Bonds. *Journal of Financial Economics*, 142(2), 499-516. doi:10.1016/j.jfineco.2021.01.010
- Tang, D.Y., & Zhang, Y. (2020). Do Shareholders Benefit from Green Bonds?. *Journal of Corporate Finance*, 61, 101427. doi:10.1016/j.jcorpfin.2018.12.001
- Fatica, S., Panzica, R., & Rancan, M. (2021). The Pricing of Green Bonds: Are Financial Institutions Special?. *Journal of Financial Stability*, 54, 100873. doi:10.1016/j.jfs.2021.100873

Note: Complete reference list available in main presentation.