Laudation for the DB Prize
Works of Stephen A. Ross: Some Highlights

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Professor Stephen A. Ross, MIT Sloan School

- Franco Modigliani Professor Finance and Economics, 1998–present
- Yale University, 1977–1998
- PhD (Harvard Economics) 1969
- BS (CalTech Physics) 1965
- born February 3, 1944

I am a student of Steve’s, which is probably the only reason I amounted to anything. I am proud to be associated with all of the wonderful fellow students of Steve’s. I was also Steve’s colleague at Yale for seven years and his co-author on a number of papers.
Papers

Steve is the greatest living finance scholar. Steve’s vitae lists more than 100 papers, most of which are published in top journals. These publications cover many areas, including:

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Steve’s works also include some papers that cross areas and are hard to classify, including interesting “big picture” topics such as Financial Marketing, Forensic Finance, and Behavioral Finance.
Some (but not all!) of Steve’s Pathbreaking Papers

Ross (AER 1973) - Agency Theory
Ross (JET 1976) - APT
Cox and Ross (JFE 1976) - Risk-neutral pricing
Ross (QJE 1976) - spanning with options
Ross (BellJ 1977) - Signalling and Capital Structure
Ross (JB 1978) - Arbitrage and Linear Pricing Rule (Fundamental Theorem of Asset Pricing)
Cox, Ross, Rubinstein (JFE 1979) - Binomial Option Pricing Model
Cox, Ingersoll, Ross (JF 1981) - Local Expectations Hypothesis
Cox, Ingersoll, Ross (Econometrica 1985a,b) - CIR model
Gibbons, Ross, Shanken (Econometrica 1989) - maximum-likelihood CAPM test
Steve’s broad influence

- Scholar
- Teacher
- Consultant
- Practitioner

amazing energy and enthusiasm!
Agency Theory


This paper introduced agency theory to economics and finance.

In the law, an agency relationship is one in which one person (the principal) hires another person (the agent) to perform some task. Because the principal and agent have different preferences about unobservable actions (for example over effort), there is a fundamental conflict that does not arise in the standard competitive model (in which all conflicts are internalized through the price system). Steve taught us that this conflict of interest is the fundamental problem in agency.
The Principal’s Problem

Choose a fee schedule $\phi(Y)$ and the agent’s optimal effort $e^*$ to maximize

$$EU_P(Y(e^*, \varepsilon) - \phi(Y(e^*, \varepsilon)))$$

subject to the agent’s participation constraint:

(i) $EU_A(\phi(Y(e^*, \varepsilon))) \geq U_R$

and incentive-compatibility of effort:

(ii) choosing $e = e^*$ maximizes $EU_A(\phi(Y(e, \varepsilon)))$. 
Big Contributions

• teaches to think of agency in terms of conflict of interest
• quantifies the trade-off between incentives and risk-sharing
• looks at efficient risk-sharing of linear contracts
• provides a widely-used standard framework for these models

More on the last item: although the paper predates the literature on refinements, this construction is a cunning choice that neatly sidesteps a potential problem (e.g. in subgame perfect equilibrium or perfect Bayes equilibrium) with nonexistence due to the fact that not all potential nonlinear contracts have a best response by the agent. Existence of a best response is implicit in the constraint.

A large literature has followed, including for example Holmstrom [BellJ 1979], a classic in its own right.
(a few) Arbitrage Pricing Theory (APT) Papers


APT Assumptions and SML

The Arbitrage Pricing Theory (APT) extends the CAPM to a theoretical model pricing multiple factors. Suppose risky asset returns are given by a factor structure

\[ x_i = \mu_i + \sum_{k=1}^{K} \beta_{ik} f_k + \varepsilon_i, \]

where \( \mu_i \) is the mean return on asset \( i \), \( f_k \) is a random mean-zero factor payoff, and \( \beta_{ik} \) is a constant giving the loading of asset \( i \) on factor \( k \), and \( \varepsilon_i \) is a mean-zero error term uncorrelated across assets. Then the APT asserts that there exists a shadow riskfree rate \( r^f \) (equal to the actual riskfree rate if there is a riskfree asset) and factor risk premia \( \lambda_k \) such that, for all \( i \),

\[ \mu_i = r^f + \sum_{k=1}^{K} \beta_{ik} \lambda_k. \]

This is the APT’s Security Market Line (SML).
Properties of the CAPM and APT

- Market-level risk is priced (CAPM and APT)
- Idiosyncratic risk is not priced (CAPM and APT)
- Diversification pays (CAPM and APT)
- single source of priced risk, implying 2-fund separation (CAPM or 1-factor APT)
- multiple sources of priced risk, implying K-fund separation (K-factor APT)

The “market model” version of the CAPM is formally subsumed by the 1-factor APT. The APT is the best theoretical justification of looking at common factors in stock prices that explain expected returns.
Origins of the APT: mutual fund separation

Steve (JET 1978) showed that having a factor structure for returns is a sufficient condition for $K$-fund separation (i.e., all risk averse agents would be happy to hold portfolios of the $K$ “mutual funds” instead of a general portfolio). Specifically, if the vector of asset payoffs per dollar invested in a one-period model are given by $x = (x_1, \ldots, x_N)$, then a sufficient condition for $K$-fund separation is the existence of portfolios $\theta_1, \ldots, \theta_K$, such that, for each $n$, there exists weights $w_{ik}$ such that

$$x_n = \sum_{k=1}^{K} w_{ik} \theta_k + \varepsilon_i$$

where $E[\varepsilon_i|\theta_1, \ldots, \theta_K] = 0$, plus an additional spanning condition. This is very close to the APT. Steve’s paper shows that this characterization is necessary as well for 2-fund separation, and shows the route for proving necessity for $K$-fund separation.
Absence of Arbitrage and the Linear Pricing Rule


Steve has argued that absence of arbitrage is the unifying theme for all of finance. The results in these papers (plus the Friend-Bicksler volume piece op. cit.), are summarized in the Fundamental Theorem of Asset Pricing and the Pricing Rule Representation Theorem.
Fundamental Theorem of Asset Pricing (FTAP)

Theorem (FTAP) The following are equivalent:

(i) Absence of arbitrage
(ii) Existence of a positive linear pricing rule that prices all claims
(iii) Existence of a hypothetical agent who prefers more to less and has an optimal portfolio

The equivalence of (i) and (ii) was the point of Steve’s landmark paper “A Simple Approach to the Valuation of Risky Streams.” That was the heavy lifting. I invented the name and adding the third property (iii) when teaching doctoral finance at Princeton in 1980 and 1981.
Pricing Rule Representation Theorem (PRRT)

When arbitrage pricing goes to work, it is useful in different forms in different contexts.

Theorem (PRRT) The following are equivalent:

(i) Existence of a positive linear pricing rule
(ii) Existence of consistent risk-neutral probabilities
(iii) Existence of a positive state-price density
(iv) Existence of positive state prices

The most famous of these is (ii), which is often called the martingale approach. I think many people do not know that this approach originated in Steve’s work, especially Cox-Ross [1978]. The state-price density (iii) is also known as the stochastic discount factor or pricing kernel.
Conclusion

Steve Ross has had a great influence on research and practice in finance. We have had a look at only a few of his important papers.
Epilogue: some current research topics of Ross’s student

Empirical Corporate: “Tobin’s Q does not Measure Performance: Theory, Empirics, and Alternative Measures” with Mitch Warachka

Investments Practice: “How to Squander Your Endowment,” with Zhenjiang Qin


k-fund separation: “Investor Preferences and Mutual Fund Separation,” with Fang Liu

http://phildybvig.com/somepapers.html