Prize Citation for 9th Stephen A. Ross Prize in Financial Economics Awarded by Foundation for Advancement of Research in Financial Economics (FARFE)

The 9th Ross Prize has been awarded to "Technological Revolutions and Stock Prices," written by Lubos Pastor and Pietro Veronesi, both from the University of Chicago. The award-winning paper, published in the *American Economic Review* in 2009, makes two important contributions. First, it develops a framework to analyze the asset pricing implications of "technological revolutions" – large-scale adoptions of new technologies. Second, at a broader level, it highlights how carefully separating systematic and idiosyncratic uncertainty, and understanding what drives their joint dynamics, can offer a new perspective on asset price formation.

Asset price dynamics during technological revolutions often feature an initial bubble-like increase in stock prices, followed by a decline accompanied by high volatility. Such a pattern occurred during the Internet boom of the 1990s, the biotech revolution of the 1980s, the electronics boom in the 1960s, and others before that. More recently, it may be emerging again with the artificial intelligence stock rally. Understanding the source of these asset pricing dynamics presents a challenge to financial economists. There are also important implications beyond the financial market, when we think about the effect that financial markets may have on the allocation of resources in the real economy. Against the tendency to attribute such boom-bust asset pricing patterns to market irrationality, Pastor and Veronesi (2009) show that these patterns can be consistent with fully rational behavior. Such behavior can also explain the time-series and cross-sectional dynamics of stock volatility and betas during technological revolutions. The key insight is that large-scale adoption of new technology changes the nature of risk, from idiosyncratic in early stages to systematic in later stages. This shift occurs as agents in the economy learn about the new technology, which drives the timing of its wide-scale adoption and generates asset pricing dynamics related to the change in discount rates.

The paper obtains these insights in a simple and elegant general equilibrium framework, featuring classic ingredients from macroeconomics and financial economics. In the model, a representative risk-averse agent is deciding, over time, whether to switch from an old technology with known productivity to a new one with uncertain productivity. Since switching is costly and irreversible, the agent initially prefers to experiment by adopting the new technology on a small scale. This experimentation allows the agent to learn about the new technology's productivity over time. During this stage, there are two types of firms in the market: "new economy" firms, which have adopted the new technology but constitute a small fraction of the economy, and "old economy" firms, which continue using the old technology but may switch in the future.

As the agent learns about the new technology, the agent either refrains from large-scale adoption if the news is unfavorable (then, no technological revolution occurs) or adopts it on a large scale once the agent's belief about its productivity becomes sufficiently high (marking the end of the technological revolution). In the latter scenario, asset pricing dynamics are driven by two simultaneous effects. The first is the cash flow effect: as positive information about the productivity of the new technology emerges, this cash

flow news drives stock prices up. The second is the discount rate effect. Initially, the risk associated with the new technology is mostly idiosyncratic, as it is adopted on a small scale with a low likelihood of widespread adoption. However, as positive news accumulates, the probability of large-scale adoption increases, making the risk increasingly systematic. As a result, discount rates remain low early on, but gradually rise toward the end of the technological revolution. Both effects are stronger for new economy firms, which are more exposed to the new technology.

Initially, the cash flow effect dominates, driving a bubble-like rise in asset prices for new economy firms (while the limited cash flow effect for old economy firms prevents bubble-like behavior for them). Importantly, this price increase is unexpected by investors in real time, so the bubble-like behavior is partly due to ex post selection bias: Researchers study technological revolutions with the hindsight that they took place, but investors living through revolutions do not know whether the new technologies will eventually be widely adopted. Over time, the discount rate effect strengthens, eventually leading to a price decline. This decline is especially pronounced for new economy firms, which have higher market betas due to their greater exposure to the technology. Beyond explaining the boom-bust asset price level dynamics, this mechanism generates a variety of additional predictions about the dynamic patterns in asset price volatility and betas. In particular, a key prediction is that the market beta of new technology firms should rise sharply before the end of the revolution.

Complementing the model, the authors conduct an empirical analysis of asset prices during the spread of railroad (1830–1861) and internet (1992–2005) technologies in the US, showing that the empirical patterns closely match the model's predictions. Importantly, the model's ability to explain not only price levels but also the dynamics of market betas provides strong support for their mechanism, distinguishing it from behavioral models.

A common alternative explanation for technology-driven stock market booms is an irrational extrapolation by investors that creates stock price bubbles at such times (for example, Kindleberger (1978); Greenwood, Shleifer, and You (2019); and Bastianello and Fontanier (2024)). In contrast, Pastor and Veronesi make an important point by showing how a bubble-like price pattern can emerge even in a market with fully rational investors. While this framework does not refute the possibility of irrational extrapolation contributing to market movements, understanding the possibility of these price patterns within a fully rational framework is critical to assess the extent to which irrational extrapolation may contribute to them. The paper belongs to a literature that challenges the use of behavioral arguments to explain puzzling financial-market phenomena, demonstrating that learning channels can rationalize many of them. Pastor and Veronesi (2009a) provide a review of some of these papers.

The paper also relates to an earlier literature that links technological innovations to asset prices. For example, Greenwood and Jovanovic (1999), Hobijn and Jovanovic (2001), and Laitner and Stolyarov (2003) explore mechanisms by which innovation causes the stock market to drop without resorting to assumptions of irrationality. Yet, unlike the award-winning paper, they do not address the bubble-like pattern and they do not relate the pattern to the important feature of technology being adopted on a large scale and becoming a systematic risk.

Following the award-winning paper, the finance literature continued to explore the role of innovation for both the aggregate stock market and the cross-section of stock returns. Like Pastor and Veronesi (2009), papers along these lines advance the production-based asset pricing approach that seeks to derive the properties of stock returns from the underlying productive possibilities and investment decisions of firms. A key example of a paper that focuses on the role of technological innovation in this literature is Kung and Schmid (2015), who present a model in which persistent movements in R&D drive persistent movements in productivity growth, which are a source of systematic risk within the long-run risk paradigm of asset pricing of Bansal and Yaron (2004). Another example is Kogan, Papanikolaou, and Stoffman (2020), who argue that innovation can destroy the value of incumbent public companies even while creating new wealth for entrepreneurs owning private companies, and that shareholders are willing to own growth stocks in part because they hedge against displacement risk. Both these papers build on the insights of Pastor and Veronesi (2009) that innovation can be systematically risky and that innovative new-economy firms may have different risk exposures from established old-economy firms.

Pastor and Veronesi's award-winning paper continues to be relevant today given new technological innovations, such as the artificial intelligence revolution, and the associated stock market booms. Their insights have also been linked to the adoption of cryptocurrencies in the recent work of Cong, Li, and Wang (2021) that attempts to shed light on the price patterns of these new assets. Pastor and Veronesi's (2009) insights also helped guide empirical research on the dynamic relation between firms' cash flows and stock returns across industries, as exemplified by the work of Hoberg and Phillips (2010) who find that market betas increase and idiosyncratic risk decreases after industry booms.

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