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Dynamic portfolio choice with frictions ☆

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Abstract

We show how portfolio choice can be modeled in continuous time with transitory and persistent transaction costs, multiple assets, multiple signals predicting returns, and general signal dynamics. The objective function is derived from the limit of discrete-time models with endogenous transaction costs due to optimal dealer behavior. We solve the model explicitly and the intuitive solution is also the limit of the solutions of the corresponding discrete-time models. We show how the optimal high-frequency trading strategy depends on the nature of the trading costs, which in turn depend on dealers' inventory dynamics. Finally, we provide equilibrium implications and illustrate the model's broader applicability to micro- and macro-economics, monetary policy, and political economy.

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A fundamental question in financial economics is how to choose an optimal portfolio. Investors must choose their portfolio in light of the current risks, expected returns, and transaction costs of all available assets, as well as how often they can trade in the future and the future evolution of the risks and returns. This portfolio choice depends crucially on the future trading opportunities for several reasons: First, expected returns are driven by multiple economic factors that vary over time, leading to variation in the optimal portfolio.[1] Second, transaction costs imply that an investor must consider the portfolio's optimality both currently and in the future. Third, investors must decide how often to trade and how much to trade. A number of questions arise from these dynamic considerations: What is the difference between trading in markets that are open continuously versus discrete markets? How do transaction costs change when markets are open continuously rather than at discrete times? Why do high-frequency trading (HFT) firms and other investors trade continuously throughout the day when most existing models with transaction costs imply infrequent, lumpy trading? What are the implications for asset-price dynamics?

We provide a general and tractable framework to address these issues. First, to study portfolio choice for high- and low-frequency trading, we show how to formulate the problem in continuous time such that the objective function is a limit of discrete-time models in which transaction costs arise endogenously from dealer behavior. As a result, we clarify how transaction costs can be captured consistently for high- and low-frequency trades and how model parameters scale with time. Second, we solve the continuous-time model and derive a simple expression for the optimal high-frequency portfolio choice. The tractability of our framework contrasts with that of standard models in the literature based on proportional transaction costs.[2] These standard models are complex and rely on numerical solutions even in the case of a *single* asset with *i.i.d.* returns (i.e., no return predicting factors).[3] In contrast, our framework based on quadratic costs allows a closed-form optimal portfolio choice with multiple assets and multiple return-predicting factors. The assumption that transaction costs are quadratic in the number of securities traded is natural since it is equivalent to a linear price impact. Third, we show how the continuous-time solution obtains as the limit of optimal discrete-time portfolios. Fourth, we derive implications for equi-

[1] See, e.g., Campbell and Viceira (2002) and Cochrane (2011) and references therein.

[2] In discrete time, quadratic costs have been shown to provide tractability, and we rely in particular on Gârleanu and Pedersen (2013). In addition to introducing a continuous-time model, our contributions are to generalize the framework, consider a micro foundation for trading costs, derive the connection between discrete and continuous time, and provide equilibrium implications. See also Heaton and Lucas (1996) and Grinold (2006) who also assume quadratic costs, Glasserman and Xu (2013) who extend the model of Gârleanu and Pedersen (2013) to account for robust optimization, and Collin-Dufresne et al. (2014) who show how to linearize — and thus solve approximately — a more general and useful class of portfolio-choice models.

[3] There is an extensive literature on proportional transaction costs following Constantinides (1986). Davis and Norman (1990) provide a more formal analysis and Liu (2004) determines the optimal trading strategy for an investor with constant absolute risk aversion (CARA) and many independent securities with both fixed and proportional costs (without predictability). The assumptions of CARA and independence across securities imply that the optimal position for each security is independent of the positions in the other securities. Also, our paper is related to the literature on optimal trade execution (e.g., Perold, 1988; Bertsimas and Lo, 1998; Almgren and Chriss, 2000; Obizhaeva and Wang, 2006; Engle and Ferstenberg, 2007, and Gatheral and Schied, 2011), although this literature treats the total traded quantity as given exogenously while it is part of our solution.