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Technological innovations and aggregate risk premiums ☆

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ABSTRACT

In this paper, I propose that technological innovations increase expected stock returns and premiums at the aggregate level. I use aggregate patent data and research and development (R&D) data to measure technological innovations in the U.S., and find that patent shocks and R&D shocks have positive and distinct predictive power for U.S. market returns and premiums. Similar patterns are also found in international data including other G7 countries, China, and India. These findings are consistent with previous empirical studies based on firm-level data, and call for further theoretical explanations.

1. Introduction

This paper examines the effect of aggregate technological innovations on expected market returns and premiums. In the finance literature, most attempts to explain the time series of market returns are based on macroeconomic and financial variables.[1] Since technological innovations are the main driving force for economic growth and fluctuations, they may provide valuable information about the dynamics of aggregate wealth from a distinct perspective.[2] The

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[1] An incomplete list includes the lagged returns (Fama and French, 1988a), the dividend–price ratio (Shiller, 1984; Campbell and Shiller, 1988; Fama and French, 1988b), the term spread and default premium (Fama and French, 1989), the relative bill rate (Campbell, 1990, 1991), the book-to-market ratio (Kothari and Shanken, 1997), the dividend–earnings ratio (Lamont, 1998), the aggregate consumption to wealth ratio (Lettau and Ludvigson, 2001), the share prices to gross domestic product (GDP) ratio (Rangvid, 2006), and the labor income to consumption ratio (Santos and Veronesi, 2006).

[2] Since Solow (1957), the economics literature has long recognized technology development as an important component of economic

empirical analysis suggests that, indeed, technological innovations are able to predict market returns and premiums in recent decades.

The existence of the time series predictability at the aggregate level can be attributed to several reasons: First, technological innovations raise the expected productivity and profitability of the representative firm. Second, technological innovations improve overall efficiency and reduce investment costs. Lastly, technological innovations work as options with returns more volatile than physical investments. Since the representative firm's expected stock returns equal expected investment returns,[3] they rise with more technological innovations. All these arguments imply a positive relation between technological innovations and expected market returns as well as premiums.

The hypothesis is empirically testable using patent data and research and development (R&D) data as proxies of technological innovations.[4] I note that patent data are more informative than R&D data in many aspects, but have rarely been considered in the finance literature.[5] First, patents are realized innovations ready to be utilized for business interests. Second, the territorial principle in patent laws makes patent data a more precise proxy of a nation's technological progress. Third, patents are the intangible assets most actively traded in intellectual property markets (Lev, 2001). As a matter of fact, the first exchange traded fund (ETF) based on patents, the Claymore/Ocean Tomo Patent ETF, was just launched on December 15, 2006.

I use total patents and accumulated industry R&D expenses in the U.S. to measure aggregate technology level, and use their growth rates to measure technological growth. Then, I detrend these two growth rates to estimate patent shocks and R&D shocks, as two proxies of technological innovations. Predictive regressions indicate that both patent shocks and R&D shocks have significant predictive power for the real and excess returns on the Standard and Poor's 500 (S&P500) index and the Center for Research in Security Prices (CRSP) value-weighted index, in both short and long horizons. The slope coefficients for lagged patent shocks and R&D shocks are positive with economic and statistic significance, and the associated t-statistics are not affected by the existence of other predictors. The adjusted R-squares of one-quarter ahead predictive regressions are well above 5%. These empirical findings survive several robustness checks, and suggest that technological innovations are able to explain a specific, substantial part of expected market returns and premiums. Moreover, consistent with my earlier argument, patent shocks are found to outperform R&D shocks in predictive ability.

I then extend the empirical analysis to available international data. Using China's patent data, I find that China's patent shocks significantly predict the real and excess returns on China's stock index. On the other hand, I examine the effect of R&D shocks on stock returns in Canada, France, Germany, India, Italy, Japan, and U.K. ("G6 plus India," henceforth). I find that country-specific R&D shocks are positively correlated with future market returns and premiums in all countries except France. The results from pooled regressions indicate that country-specific R&D shocks significantly predict market returns and premiums in G6 plus India. All these findings support the technology-driven predictability from an international perspective.

Note that technological innovations used in this study differ from the Solow (1957) residual in many aspects: First, the Solow residual contains all unexplained disturbances, and some of them (e.g., wars, oil crises, fiscal shocks, and natural disasters) are conceivably irrelevant to technological progress.[6] Second, the Solow residual includes both temporary and permanent shocks, while technological innovations mainly have permanent effects on the real economy. Third, the literature suggests a negative effect of the Solow residual on future market returns,[7] while technological innovations are found to positively correlate with future market returns in this study.

This study adds to the literature from three perspectives. First, previous studies focus on the relation between technological innovations and stock returns at the firm level (e.g., Pakes, 1985; Austin, 1993; Lev and Sougiannis, 1996; Deng, Lev, and Narin, 1999; Chan, Lakonishok, and Sougiannis, 2001), while I demonstrate the time series predictability of stock returns at the aggregate level. Second, I propose to use total patents and R&D expenses to measure aggregate technological innovations, which appear to be very effective predictors for market returns and premiums. Finally, I provide international evidence

(*footnote continued*)
dynamics. Technological progress comes from endogenous efforts (e.g., R&D expenses that generate inventions) and exogenous incidents (e.g., new discoveries due to accidents), and both types of advances are found to explain economic growth and fluctuations (e.g., Romer, 1986, 1990; Greenwood, Hercowitz, and Krusell, 1997, 2000). Moreover, Greenwood and Jovanovic (1999) and Hobijn and Jovanovic (2001) argue that the information-technology (IT) revolution caused global stock markets to drop in the 1970s and then rebound in the 1980s. Pastor and Veronesi (2008) propose that the adoption of uncertain technological revolutions drives stock price bubbles.

[3] The equivalence between investment returns and stock returns has been proved in Cochrane (1991) and Restoy and Rockinger (1994). Lately, Liu, Whited, and Zhang (2008) and Chen and Zhang (2009) show that such a relation provides a good description of the cross-section of expected stock returns.

[4] Griliches (1984, 1988) and many other studies find that these two data sets are able to explain economic growth. Moreover, there exist other technology statistics including the number of scientific journal articles (Price, 1963), the number of scientists and engineers (Gort, 1969), and the number of books published (Alexopoulos, 2006).

[5] Pakes (1985), Rossi (2005), Seru (2007), and Acharya and Subramanian (2008) are the only four to my knowledge, and the latter three focus on corporate finance issues.

[6] While Solow names all of the unexplained part of total production as "technical change," Denison (1967) points out the necessity of distinguishing technology shocks from non-technology shocks. Basu and Fernald (2002) also argue that productivity shocks and technology shocks are distinct concepts.

[7] For example, Balvers, Cosimano, and McDonald (1990) show that current output level correlates negatively with future market returns in a general equilibrium model. Kothari, Lewellen, and Warner (2006) find a negative relation between aggregate earnings surprises and subsequent market returns.