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論文内容要旨

The economic damage from unanticipated disasters could increase in the future because of the worsening effects of climate change. The IPCC described many observed changes in the Earth's climate, including those affecting the atmospheric composition, global average temperature, and ocean conditions, and it forecasts increased, large-scale changes in the ecosystem. Consequently, climate-induced disasters are expected to increase over time. Therefore, to protect ourselves now and in the future, we must address the issue of climate change.

Within this context, this dissertation comprises three studies. First, in Chapter 2, it analyzes the markets' reactions to the effect of natural disasters. From a financial perspective, the effective resource allotment, even after the shock of a devastating disaster has subsided, is an important factor in understanding market reactions. We employ an event study analysis to compare the market reactions for two devastating earthquakes that occurred in Japan: the Great East Japan earthquake and the Great Hanshin Earthquake. By employing event study analysis, we are also able to investigate the shock to stock prices in relation to disasters in the existing literature. However, the

number of samples is relatively limited, and earlier studies may display a bias in favor of the industrial sector. These two factors might not be crucial to investigate a localized event; however, the Great East Japan Earthquake and the subsequent nuclear power plant disaster extensively affected not only Tohoku but also Japan as a whole and the rest of the world. Hence, a more comprehensive scale must be adopted. For these reasons, this study selects a large sample of stock prices to evaluate the effect of the catastrophic earthquake on Japan's industrial sectors.

From this analysis, we found that the damage from the disasters had a statistically significant impact on the stock prices of several sectors. The results show that in 9 sectors and 18 sectors, the effects are statistically significant for the Great Hanshin Earthquake and the Great East Japan Earthquake, respectively. We also found that these sectors could be separated into five groups (i.e., Group One to Group five) using the empirical results. That is, these sectors could be separated based on the effects of the damage to the stock price, whether statistically significant, negative or positive, and whether the effects were short term (i.e., t = 0 to 5) or long term (i.e., t = 10, 20, and 30). We summarize the results of these five groups after each disaster.

In the case of the Great Hanshin Earthquake, three sectors are included in the first group (i.e., negative impact in the long term): *Transport Equipment*, *Electric Power & Gas*, and *Retail Trade*. The *Construction* and *Security & Commodity Futures* sectors are included in the second group (i.e., positive impact for long term). The *Pulp & Paper* and *Rubber Products* sectors are classified into the third group (i.e., negative impact for the short term). There are no sectors included in the fourth group (i.e., positive impact for the short term). The *Glass & Ceramics Products* and *Iron & Steel* sectors are included in the fifth group (i.e., positive and negative impact).

In the case of the Great East Japan Earthquake, the *Electric Power & Gas*, *Air Transportation*, *Wholesale Trade*, and *Real Estate* sectors are included in the first group. There are no sectors included in the second group. There are nine sectors classified in the third group: *Foods*,

Pharmaceutical, *Machinery*, *Transport Equipment*, *Land Transportation*, *Information & Communication*, *Retail Trade*, *Banks*, and *Service*. There are three sectors in the fourth group: *Glass & Ceramics Products*, *Iron & Steel*, and *Nonferrous Metals*. The fifth group includes the *Construction* and *Electric Appliances* sectors.

We found the *Electric & Gas* sector included in the first group for both events. The market might expect a decrease in electricity and gas production, which causes the profits from this sector to decrease. However, the reasons for a decrease in electricity and gas production may differ for the two events. In the case of the Great Hanshin Earthquake, the decrease in the demand for electricity and gas may be due to the damage to the manufacturing plants in the other sectors. In the case of the Great East Earthquake, there might be additional reasons. For instance, there is uncertainty regarding the compensation cost by the electric power company and/or the government because the effect of the release of radioactive material on humans and on the other sectors is unknown in the long term.

The remaining sectors are not included in the same group for both disasters. Hence, a market will effectively react to economic conditions even if the disaster is unanticipated and devastating. Additionally, several sectors do not indicate statistically significant results for either event. For example, the *Marine Transportation*, *Oil & Coal Products*, *Chemicals*, and *Textile & Apparels* sectors do not indicate statistically significant results. This finding implies that, on average, the stock prices for these sectors did not deviate from the expected returns. Therefore, the stock prices of these sectors are less sensitive to the events of an earthquake. Finally, we conclude from these empirical results that a disaster affects the stock prices of several sectors in the Japanese market through the actions of the investors. The results show different effects on the stock prices of the Japanese industrial sectors.

In Chapter 3, it employs a cost-benefit analysis to investigate the economic validity for fuel cell vehicle (FCV) and all-electric vehicle (EV) diffusion. The transport sector accounts for

approximately 19% of global energy use and 23% of energy-related carbon dioxide (CO_2) emissions, for which shares will likely rise in the future. Energy use and CO_2 emissions related to transportation are expected to increase nearly 50% by 2030 and more than 80% by 2050.

In this context, we investigate the economic validity for FCV and EV diffusion by employing cost-benefit analysis. We obtain the data of two alternative fuel vehicles from an interview with an automobile maker in Japan. Considering uncertainties, we applied a sensitivity analysis to the cost-benefit ratios. These scenarios consist of the following: progress in the speed of alternative vehicle production, the increase ofCO_2 abatement cost, gasoline price increase, and the target year for the alternative vehicle diffusion. In summary, the results show that the diffusion of FCV is not economically feasible until 2110, even if the purchase cost of FCV is decreased to that of ICEs vehicle. On the other hand, the diffusion of EV might be possible as soon as 2060, considering the increase of gasoline price and the CO_2 abatement cost.

The major obstacles to the widespread use and commercialization of FCV are the high purchase (or production) cost, unsatisfactory durability, and poor transient performance of FCVs. Therefore, fundamental innovation is needed to produce a significant cost reduction and improve relative FCV performance compared to ICE. In addition, the government must promote the development of such fundamental technological development. From this study, some kind of hybridization of fuel cells with other energy storage devices such as batteries and ultracapacitor would be preferable for a long period of time, realistically. For example, the Toyota FCHV fuel cell vehicle uses a NiMH battery pack as the secondary energy source, and the Honda FCX fuel cell vehicle uses ultracapacitors as an energy buffer to achieve powerful, responsible driving. As in FCVs, the electric battery is one of the major obstacles to diffusion of EVs. Major progress of technology is required to reduce the production costs and improve the battery performance.

Finally, Chapter 4 examines the performance of Socially Responsible Investment (SRI)

funds. Many people base their investment decisions on financial criteria. However, an increasing number of institutional and other investors and others require additional information. In 1960, a type of financial behavior known as SRI, or ethical investment, arose from the mid-20th century political climate of social awareness for the environment, civil rights protection, distrust of nuclear energy, and similar concerns. Currently, SRI funds choose investments based not only on financial criteria but also on environmental, social and governance criteria, so these investments reflect ethical values. Therefore, through financial activity, the expansion of SRI funds could help to sustain a society that supports economic growth and alleviates environmental issues. Nonetheless, SRI funds are financial products and therefore need to incorporate not only social and environmental performance but also profit performance. In other words, rather than relying on ethical investment only, SRIs rely on portfolios that combine attractive profit/risk ratios with appropriate returns for society.

A significant amount of empirical literature posits relationships between corporate social performance and various financial performance measures. The empirical SRI literature can be divided into three types of studies. The first type focuses on SRI market indices; it compares the performance of SRI indices, such as the Dow Jones Sustainability Index (DJSI), and the FTSE4Good Index with that of stock market indices, such as Standard & Poor's 500 (S&P500) and the FTSE100. The second type of study is based on an event study, which examines if an environmentally troubled company suffers from a lower market valuation following the news of such an environmental and societal impactful event. The third type focuses on mutual fund performances and compares individual SRI mutual funds and conventional funds by analyzing their financial returns and Sharpe and/or alpha ratios.

This study belongs to the third type. We provide a robust comparison of mutual fund performance by employing a nonparametric estimation method known as the "dynamic mean-variance model for evaluating mutual funds" that can address fund returns and risks

simultaneously. Considering the recent interest in firms' actions in relation to environmental problems such as climate change, we analyze the EF. This study investigates the performance of socially responsible investments and environmentally friendly funds in the U.S., EU, and Japan using data spanning 2000 to 2009. SRI and EF funds are compared to conventional funds.

In this paper, socially responsible investments and environmentally friendly funds in the U.S., EU, and Japan were empirically analyzed using a nonparametric methodology. SRI and EF funds were compared to conventional funds. We apply dynamic mean-variance model using shortage function.. We contribute to the literature on SRI in three ways: 1) our analysis considered performances in the risk-adjusted sense, 2) we measured efficiency using only applicable funds, not benchmarks, and 3) it can define each fund's "projection" on the efficient production frontier to not only locate ill-performing (inefficient) funds but also to determine the degree and causes of their inefficiencies.

In summary, we found that SRI funds outperformed conventional funds in all regions. Many previous studies have shown that SRI fund performances were statistically insignificant or that SRI funds underperformed conventional funds. Similarly, environmentally friendly funds have not performed as well as SRI, but have performed in manners equal or superior to conventional funds. We showed that the use of a dynamic mean-variance model for evaluating mutual funds might usefully complement the traditional method. The results were in line with those of Jensen's alpha, and our methodology was able to provide clear implications for risk-adjustment, return-orientation, and time dimensions.

From these three analyses, i.e., market reaction to unanticipated and devastating disasters, investment decisions concerning benefits and costs for environmental policy and indirect investment with respect to profit and social and environmental performance, this paper demonstrates the comprehensive role of environmental economics for a sustainable future.

論文審査結果の要旨

伊藤豊の提出した博士論文は投資を軸として持続可能な開発に向けて重要と思われる内容について、3つの実証研究の結果をまとめたもので、全5章からなる。

第1章は博士論文の総括がされており、本研究の背景を述べ、各研究の意義と目的について示している。

第2章では阪神大震災と東日本大震災を事例とし、株式市場が災害下においてどのような反応を示すのかをイベント・スタディ分析を用いて検証している。災害やテロ、汚染物質の排出などが株式市場へもたらす影響の分析は海外において行われているが、特定の産業に偏ったものが多く、また、日本においては災害が株式市場に与える影響についての実証的な分析はほとんどされていない。本研究はその点において株価データの得られる日本の企業をすべて用いて産業ごとの比較、検証を行っている点でより包括的な検証をしており、この分野の研究に対して意義のある結果を示したと言える。

第3章では電気自動車（EV）と燃料電池自動車（FCV）の普及の社会的な妥当性についての検証である。日本においては、温室効果ガスを削減するための対策として、環境負荷のより少ない自動車の普及を目標としているが、EVやFCVは現状において生産コストが高いことやインフラの整備できていないことも等もあり、これらの普及が社会的に望ましいのかは検証されていない。そこで本論文ではガソリン自動車からEVとFCVに乗り換えが行われた場合をそれぞれ仮定し、それに必要となるコスト（乗り換え費用と維持費、インフラの建設費と維持費）と、得られる便益（CO_2とNOxの排出量とガソリン消費量の削減効果）を比較し、それらの普及が社会全体でみた場合に望ましいのか検証している。CO_2の削減費用とガソリン価格、自動車の製造コストの要素に関してはそれぞれ3つのシナリオを用いて長期的な不確実性を考慮している。また自動車に関するデータは企業へのヒアリング調査から得られたデータを使用しており、より現実的な検証を行っている点で、これまでの研究にはない新規性と独自性がある。

第4章では社会的責任投資（SRI）ファンドと環境ファンドの運用パフォーマンスの検証を行っている。企業の社会的、環境的な評価も加味して投資を行うこれらの2つのファンドの運用パフォーマンスが他のファンドより優れていれば、投資家に選ばれるインセンティブとなり、環境や社会に貢献しうる企業がより評価されていく可能性がある。本研究は生産性分析の手法をファイナンスに応用したモデルを用いてEU、米国、日本の市場を対象にファンドのカテゴリーごとにパフォーマンスの比較を行い、SRIファンドとEFファンドのパフォーマンスが優れていることを示している。ここで使用したモデルは、先行研究で多くみられるような、1）単純な収益率のみの比較で、リスクを考慮していない、2）インデックスと比較されており包括的な比較ができていない、といった問題を考慮することが可能なモデルであり、より現実的な評価を行っている点で優れた研究である。

第5章ではこれら三つの実証研究の結果をあらためて示し、本博士論の意義をまとめている。

上記の研究は環境問題を投資の観点から包括的なアプローチで分析、検証を行っており、独自性も高く、学術的に優れた研究であり、博士要件を十分に満たす内容であると考える。よって，本論文は博士(環境科学)の学位論文として合格と認める。