Supply Chain Management and Investment Risk

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Abstract

We use a behaviorally motivated risk-return optimization framework to shed light on the important link between global supply chain management and investors' risk-return choice. By improving the transparency and sustainability of the global supply chain, firms can reduce the probability of extreme losses, thus increasing investors' expected utility and asset valuations. In order to effectively address the growing risks firms face in their global supply chains, systemic change is required. Managers can facilitate this change by increasing transparency and sustainability of their supply chains, especially in the area of carbon emissions reduction.We outline existing programs and tools that are leading the way in this regard.

Keywords: Supply chain, ESG factors, risk, return

1. Introduction

The importance of supply chain management (SCM) in affecting a firm's operating and financial performance and creating economic value for its shareholders has long been recognized (Hendricks & Singhal, 2005;Hendricks & Singhal, 2003;Hertzel et al., 2008; Altay & Ramirez, 2010;Ou et al., 2010;Swink et al., 2010;Ellinger et al., 2011; Johnson & Templar, 2011; Mefford, 2011).We contribute to this literature by highlighting the role of sustainable and transparent SCM in reducing the volatility of expected asset returns as it is perceived by individual investors. When investors perceive lower asset risk, trade-offs between investor-specific behavioral volatility and expected asset returns improve thus increasing investors' expected utility and firms' valuations. Firms with the most sustainable and most transparent supply chainsare likely perceived as least risky and most valuable with the potential to replace the government as the safe haven in times of crisis.

Instead of using the variance of the return distribution, we focus on investor-specific behavioral volatility as developed by Davies and de Servigny (2012), henceforth DdS. A behavioral approach improves upon traditional financial models in that it offers a more realistic measure of asset volatility, taking into account non-normality of asset return distributions as well as important differences in how individual investors perceive asset risk. We use this approach to suggest that the risk-reducing effects of SCM on asset return distributions may help address concerns regarding the continued existence of a sovereign risk free asset. Instead of looking for alternative safe havens in gold or other commodities, investors might look to safer firms for a refuge from risk. Disclosing and improving firm risk profiles to make themobservable and valued by investors may also improve the signaling function of asset prices and returns. The resulting fund allocations are likely to not only increase investors' expected utility,but also improve the economy's ability to prosper and reduce the need for government crisis management.

The paper is organized as follows. The next section outlines the behaviorally motivated utility optimization framework in the context of the global economy in which observers question the assumption that sovereign debt will always be risk free, and shows that alternatives may be found. Section 3describes the need for a systemic (universal) shift towards sustainable and transparent SCM,if asset volatilities are to decline. Section 4 highlights the risks and costs of carbon as an example of areas on which supply chain managers may choose to focus. Section 5 concludes.

2. The Behaviorally Motivated Model

The recent financial crises in the U.S. and in Europe have renewed concerns about some of the assumptions built into generally accepted models of traditional finance theory, such as modern portfolio theory (MPT), the capital asset pricing model (CAPM), and the efficient markets hypothesis (EMH). In their search for better investment management practices, DdS identify three problems associated with the traditional MPT that need to be addressed. First, due to the great diversity of investors'attitudes towards risk, the risk-return framework needs to be completely subjective. Not only do investors differ with respect to their predictions of future return distributions, but they also differ with respect to their perceptions of the same future return distribution prediction. Second, the quadratic utility function employed by the traditional MPT displays increasing absolute risk aversion and increasing relative risk aversion, with especially the former being contrary to observed investor behavior. And, finally, the quadratic utility function implies that investors care only about the mean and variance of a given return distribution while ignoring all other moments. This assumption would make sense if all return distributions were Gaussian (normal), but most empirical tests conducted by DdSand others suggest this is not the case (see, for instance, Chapter 4 in DdS, and MSCI, Inc., 2009).Without abandoning MPT altogether, DdS suggest changes to the framework so that individual preferences are recognized, while behavioral biases and errors are understood yet excluded from the optimization process. In other words, the framework is built to optimize the rational long-term preferences of *individual*investors, and it allows for the fact that most asset returns are not normally distributed by recognizing asymmetries and fat tails.[1]

To improve upon the quadratic utility function used by the traditional MPT, DdS define utility as a function of log returns on initial wealth, and identify the exponential function as more suitable. A rational long-term utility function must be smoothly increasing in wealth (return) and exhibit concavity, because more is preferred to less and investors are averse to risk. The exponential function, beyond fulfilling all the requirements for a rational long-term utility function, is the only utility function that exhibits constant relative risk aversion (CRRA)and, therefore, decreasing absolute risk aversion (DARA) when log returns are used, which is more plausible given observed investor behavior. Utility, for the exponential function, is zero for zero returns, exponentially decreasing for negative returns, and increasing at a decreasing rate for positive returns. Thus the exponential utility function is consistent with an aversion to both negative skewness and fat tails in the return distribution. The risk aversion built into this utility function increases with lower degrees of the investor-specific risk tolerance.

The analysis of DdS then follows the traditional MPT in that the maximization of expected utility is replaced with a search for the optimal risk-return choice. This requires the decomposition of expected utility into two metrics, expected return and a risk measure that is independent of expected return. However, in the behaviorally motivated model of DdS, which abandons the unrealistic assumption of normally distributed asset returns, risk is no longer equal to the return variance.The higher distribution moments now matter. Furthermore, the behavioral risk measure, while consistent with rational long-term decision-making, is now subjective. In the traditional MPT, investor-specific subjectivity is limited to the individual investor's preferences regarding the trade-off between objective measures of expected return and variance. In contrast to the assumed "representative investor" of traditional finance theory, actual investors differ greatly with respect to their risk tolerance, which influences their perceptions of how risky a particular asset is. They may perceive different amounts of risk being associated with a given return variance, or with a given non-normal return distribution. Addressing these shortcomings of the traditional MPT, DdS add a behavioral component to the rational utility maximization framework and allow for non-normal return distributions with higher distribution moments. In their behaviorally motivated model, risk is defined as the investor-specific behavioral variance, σ_B^2, using the following approximation:[2]

$$\sigma_B^2 \approx \sigma^2 \left(1 - \frac{2\sigma}{3T}\,\text{skew} + \frac{\sigma^2}{3T^2}\,\text{kurtosis}\right) \tag{1}$$

[1] For purposes of this paper, we are concerned only with single-period optimizations. DdS also address the problem of dynamic rebalancing as new information is incorporated into the return distribution predictions over time, but this problem is beyond the scope of our paper.

[2] The formula is an approximation, because the much smaller effects on behavioral risk of the infinite number of higher moments of the distribution functions are ignored. See Chapter 5 in DdS (co-authored with Shweta Agarwal) for a derivation of this result.

where σ^2 is the return variance and T is the individual investor's degree of risk tolerance. Kurtosis, in this equation, is normalized by subtracting 3 so that skewness and kurtosis are zero when the return distribution is normal. In this special case, the behavioral risk measure equals the return variance, and the behaviorally motivated model converges to the traditional MPT.

The behavioral risk measure thus generalizes the optimization of the trade-off between expected return and risk, while retaining a focus on rational long-run investor preferences. This more general risk measure allows for differences among individual investors precisely where these differences arise. The variable T is inversely associated with both skewness and kurtosis, indicating that investors with high risk tolerance perceive little risk arising from the characteristics of return distributions that are represented by these two moments. Investors with low risk tolerance, on the other hand, exhibit a great deal of loss aversion, and tend to be very sensitive to relatively high probabilities that are attached to extreme losses or gains when return distributions are negatively skewed and leptokurtic. The degree to which risk perceptions are influenced by individuals'fearsand hopes varies greatly across investors, and this variety is incorporated in the behavioral variance measure.

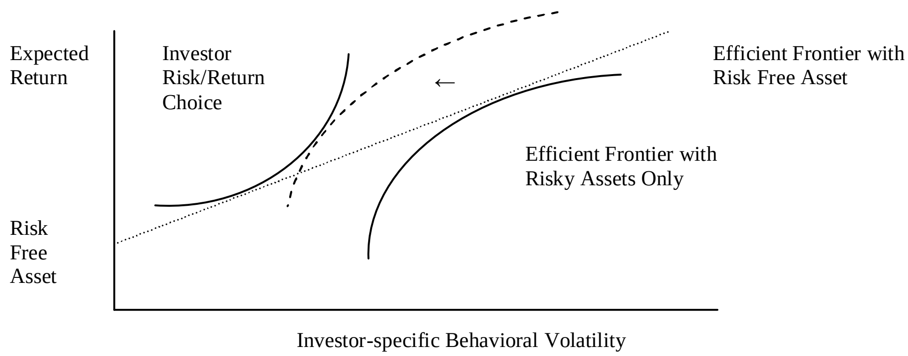
In the MPT, the assumed existence of a risk free asset allows investors to construct a portfolio with less risk than the efficient portfolio of risky assets offers. While this, in theory, is appealing, the MPT critically depends on the availability of a proxy for the risk free asset. Recent research has raised questions regarding the continued suitability of sovereign debt securities to serve in that role.Xiang and Qian (2012) and Damodaran (2010; 2008), for instance, discuss the causes and effects of a market perception that default by governments in the U.S. and Europe is no longer impossible.This perception may be explained with market participants' realization that advanced economies have experienced record increases in "fiscal stress" in recent years as documented by Baldacci et al. (2011).Rising sovereign debt levels combined with the sense that austerity measures are needed to contain them, have raised deflationary risks. The loss of credibility by the credit rating agencies in the wake of the 2007-2009 crisis has highlighted the difficulty of tracking these risks. While gold has, at times, been suggested as a substitute for sovereign debt, recent evidence does not support gold's use as a safe haven asset in the past, casting doubt on the metal's future ability to serve in that role (Joy, 2011).With a new proxy for the risk free asset not readily identifiable, a sense that nothing is risk free seems to be spreading (Sommer, 2011).

Damodaran (2010) predicts some possible consequences if investors are unable to identify an asset with a certain return: A reduced investor willingness to take risks would likely lead to lower asset prices. As a result, firms would borrow less and pay lower dividends. Inevitably, this would lower economic growth, which may be exactly what advanced economies need to help them stay within the nonnegotiable limits imposed by a finite planet (Jackson, 2011). Thus, the outcome would not necessarily be all negative. In fact, increased competition for reduced funding may improve the quality and lower the risk of the projects that are ultimately financed.

Some of the observed long-term trends suggest at least the possibility that this may be the direction in which we are heading (see, for instance, Table 1.10 on p. 27 and Table 6.1 on p. 186 in DdS). As the populations of the Western economies are aging, the demand for safe assets will increase even as the supply of safe assets appears to be shrinking. This creates an opportunity for borrowing entities (municipal governments and businesses) that, through "real economy" as opposed to "financial" innovation, are able to reduce the risk associated with a given expected rate of return (Doheny et al., 2012). Selected companies with the highest credit ratings have already benefitted from lower financing costs than the U.S. Treasury. Examples are the short-term yields of Exxon and Johnson and Johnson, which recently dipped below the yields of comparable U. S. Treasury securities(McGee & Burne, 2012).

An important area in which innovation can lower risk, as measured by the behavioral volatility, is management of the global supply chain.SCM has been shown to affect firms' risk, financial performance, and financing costs. Perceived reductions of firm risk would make corporate securities more attractive and lead to higher asset valuations (Ellinger et al., 2011; IBM Global Business Services, 2008; PricewaterhouseCoopers, 2008; Hendricks & Singhal, 2005;Hendricks & Singhal, 2003). Firms that improve their disclosure of relevant information and implement practices that lower the frequency and severity of losses associated with SCM,likely shift investors' efficient frontier to the left and allow investors to achieve risk-return combinations similar to those that would exist if a truly risk free asset were available (see Figure 1).

Figure 1: SCM May Improve Investors' Risk/Return Choice without a Risk Free Asset



To support the risk-reducing effects of "real economy"innovation, it may be necessary for firms, investors and consumers to make significant changes in long-established patterns of behavior, and for governments to facilitate these changes by creating the appropriate legal and regulatory infrastructure.The next section outlines the need for systemic change, and the steps that have already been taken in this direction with the universal adoption of a new focus on ESG (environment, social and governance) factors.

3. The Need for Systemic Change

The importance of identifying and managing risks in the supply chain - both the upside as well as the downside of uncertainty - has been widely recognized in the academic and professional literature (Doheny et al., 2012; Mefford, 2011; Rao & Goldsby, 2009; IBM Global Business Services, 2008; PricewaterhouseCoopers, 2008; Stauffer, 2003). Recent events, such as the earthquake and tsunami in Japan and Hurricane Sandy in the U.S. have heightened the sensitivities of investors to downside risk in the environment. Fires in Bangladeshi factories are examples of extreme social risks. Transparency enhances awareness and facilitates accountability. For firms, the United Nations Global Impact and Business for Social Responsibility (2010) offer some practical suggestions to help improve supply chain sustainability. More recently, researchers at the Massachusetts Institute for Technology have developed a "social network for supply chains" termed *Source map* that allows firms to connect with their suppliers and coordinate action in the event of crisis.

In order for global SCM to significantly reduce asset return volatilities - however measured - it is not enough for firms and investors to focus on supply chain sustainability and transparency. The behavior of all agents in the global economy will have to change simultaneously. Firms that disclose and reduce risk exposures in their global supply chains need investors to reward them with fund allocations, and they need consumers to make informed and responsible choices. To help investors and consumers identify responsible firms, government policy must formulate appropriate disclosure requirements that enhance transparency.Recent efforts by governments and economic agents all over the worldreflecta growing awareness that ESG (environment, social and governance) factors are critical drivers of our progress as a civilization. However, it is difficult to identify a set of practical recommendations for firms, investors, consumers and governments along these dimensions because of the great variety of approaches and the lack of generally accepted standards.

While standardized measures for ESG factors have yet to be developed, international organizations have launched initiatives to lay the foundation for global standards of operation and governance. In 1997, the Global Reporting Initiative (GRI) was created by the Coalition for Environmentally Responsible Economies (CERES) in conjunction with the United Nations Environment Programme (UNEP). GRI represents the first attempt at establishing a global framework for comprehensive reporting of the "triple bottom line," i.e. business results from a financial, environmental, and social perspective. Other prominent standards include the Caux Roundtable Principles, the Global Sullivan Principles, the OECD Guidelines for Multinational Enterprises, and the Bench Marks (Principles for Global Corporate Responsibility). The rising number of ESG initiatives worldwide reflects a growing global concern with these issues. Even greater awareness and more widespread action are needed.

In connection with the Carbon Disclosure Project, for instance, Topping (2012) and Jira and Toffel (2011) outline ways in which the disclosure of environmental information encourages changes in the practices and behavior of corporations, investors, regulators and other stakeholders.

The *Natural Capital Declaration*, The Cambridge Natural Capital Programme reports (2011a;2011b) and *The 2050 Criteria*published by the World Wildlife Fund (2012) all are manifestations of increasing levels of awareness among business leaders and investors regarding the immense sources of value associated withour ecosystems that, in the past, have been largely ignored. Emerging efforts aim to recognize and measure the value that the atmosphere, natural capital and biodiversity contribute to the sustainability of human life and health. This trend promises to reduce the environmental degradation and the destruction of natural habitats that, in the face of increasing population growth worldwide, threaten to result in resource shortages, price volatility, as well as elevated levels of climate and political risks.

Addressing social risks in the global supply chain is consistent not only with protecting and enhancing a firm's reputation and intangible asset value but, more broadly, is a requirement for sound labor relations and stable societies. Efforts to build a sound social infrastructure include, for instance, the California Transparency in Supply Chains Act of 2010 (SB 657), which aims to combat slavery and human trafficking. Doorey (2011) documents individual companies'assessments of the risks and benefits associated with factory disclosuresthataddress the use of sweatshops, child labor and other types of forced labor in their supply chains. Emerging and unresolved issues surrounding farm animal welfare are raised in Sullivan et al. (2012).These and similar efforts to broadly address social issues in firm decision-making share a concern that the goal of shareholder wealth maximization is often allowed to supersede the goal of preserving human life and health, which depend critically on the health of animals and our natural environment. In 2000, the *United Nations Global Compact* spelled out ten principles covering critical issues in the areas of human rights, labor, the environment and anti-corruption that, by now, have been signed and agreed upon by more than 10,000 participants from around the world.

As global population growth and increasing world consumption are expected to apply unrelenting pressures on societies and the planet, a realization is growing that we need a new social contract and a sincere concern for the common good (Ferenbach & Pinney, 2012; Reeves et al., 2012; Bekefi et al., 2006). If a more inclusiveapproachwith a view towards optimization for allis adopted, then disclosure and transparency of global supply chains become necessities.With supply chain dependencies no longer hidden from public view, financial gains for shareholders at the expense of other stakeholders will become increasingly difficult to achieve and justify. On the other hand, shareholders will be able to benefit from a reduction of previously hidden risks. One of the largest areas of uncertainty encompasses the physical, regulatory and political dimensions of climate risks. Important initiatives to report and address these risks have been launched, for example, by the Carbon Disclosure Project (CDP) with its Climate Disclosure Standards Board and its Supply Chain Program.

4. The Risks of Carbon

A particularlychallenging area of SCMthat promises opportunities for advancing systemic change, while simultaneously improving investors' risk-return choices, addresses the disclosure of carbon emissions and climate risk management. CDP's Supply Chain Program offers a standard global platform that facilitates reporting and collaboration for companies and their suppliers in efforts to reduce carbon emissions, reduce climate risks and generate savings from improved processes. In 2014, the program had more than 60 corporate members with more than 2,800 firms responding to the CDP's information request. A relatively large proportion of firms, 38%, have no reported processes for identifying and managing climate-related risks. Of the firms that have identified regulatory, physical, and other climate risks and report having a risk management system to address them, 78% integrate the issue into their overall risk management processes (CDP, 2014). The currently voluntary nature of this effort raises concerns about the quality of the reported information. At some point, this kind of information may be required, regulated, or emissions taxed nationally and/or globally. These possibilities imply a business exposure to potentially large contingent liabilities which most certainly need to be considered within a company-wide risk management system.

The Greenhouse Gas Protocol (GHG Protocol) defines three categories of emissions: Scope 1 covers direct GHG emissions from sources controlled by the company. Scope 2 accounts for GHG emissions from the generation of electricity purchased by the company. Scope 3 allows for the reporting of all other indirect emissions including supply chain activities. Scope 3 emissions may represent the largest category of emissions for some companies, and this may also be the one that is most difficult to track (World Resources Institute and World Business Council for Sustainable Development, 2011).

Sourcemap, the new social networking tool for managers, helps increase transparency of the entire supply chain to facilitate contingency planning to prepare for natural disasters or social unrest (Brown, 2013). It also helps measure carbon emissions at every stage and facilitates collaboration that can lead to savings.

Measurement and reductions of carbon emissions are important not only to reduce the long-term physical risks associated with climate change, but also the regulatory dimensions of climate risk. For instance, many firms that participate in the reporting of GHG emissions to CDP identify the following types of regulatory risks (CDP, 2013): Carbon taxes in high-energy jurisdictions, cap and trade schemes that raise operating costs due to the need to purchase allowances, fuel or energy taxes, environmental regulations that increase the costs of facility constructions, or emission reporting obligations that entail risks of enforcement action in the event of non-compliance. While most firms do not consider these risks an immediate threat, a longer-term approach to risk management justifies making emissions reduction a priority. Over time, the political will for regulatory intervention seems to be increasing (Environmental and Energy Study Institute, 2013), and so are estimates of the social cost of carbon which are used to determine the required magnitude of the regulatory impact.

The cost of carbon project, a joint effort by the Environmental Defense Fund, the Institute for Policy Integrity and the Natural Resources Defense Council (Howard, 2014), identifies a relatively large number of factors that were omitted in the most recent update of the social cost of carbon study by the Interagency Working Group (2013). The current average estimate of the social cost of carbon per metric ton of $CO_2$for 2015 is about $37 per year. The omissions, as the report points out, include hard-to-quantify impacts on a variety of market sectors, such as agriculture, forestry, fisheries, biodiversity, health, sea level rise, and the social stability of communities. Due to these omissions, the current social cost of carbon estimate should be considered to be a lower bound. If this lower bound were translated into a tax per metric ton of CO_2, the financial liability could be substantial, easily ranging in the hundreds of millions of dollars per year for a given firm based on currently reported Scope 1, 2, and 3 emissions. Clearly, managers face strong financial incentives to establish processes for regular reporting and emission reduction efforts along their entire supply chains, which frequently span multiple international jurisdictions. In the face of anticipated increases in carbon emissions and climate risks worldwide, investors are likely to pay very close attention to the extent to which this potential for risk reduction is realized by individual firms.

5. Summaryand Conclusion

A rapidly growing global population and rising levels of consumption are posing unprecedented threats to the atmosphere, the environment, communities, and governments. Successfully managing scarce resources, in the face of these ongoing challenges, requires major adjustments to traditional paradigms, concepts and management tools.Better informationdisclosure about ESG risks in business supply chains,and an increased awareness on the part of CEOs and Boards of Directors regarding their roles in protectingthe atmosphere and human rights,and valuing ecosystemsare important starting points. When progress along ESGdimensions is driven simultaneously by firms, investors, consumers and governments,better supply chains are likely toreduce behavioral volatilities and improve investors' risk-return choices, asset valuations and resource allocations. This kind of success iscriticalin an increasingly complex and interconnected worldthat faces the risks of climate change, in which every asset is risky and safe havens are temporary at best. Success may ultimately mean that the worst of all possible outcomes will have been avoided.

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