경영학석사학위논문

How Does Operational Risk in Supply Chain Affect Stock Returns? Role of Capacity Utilization in Reducing Income Volatility

공급사슬 내 영업위험이 기업 주가에 미치는 영향 : 이익변동성의 매개역할과 가동률의 조절효과를 중심으로

2017년 2월

서울대학교 대학원
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ABSTRACT

How Does Operational Risk in Supply Chain Affect Stock Returns? Role of Capacity Utilization in Reducing Income Volatility

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Knowledge and insights on supply chain operational risk is accumulating and consolidating rapidly. This study aims to fill in a relatively less explored area of supply chain risk by assessing the impact of operational risk on income volatility and stock returns. We present two sets of empirical findings. First, we compare operational risk across upstream and downstream industries. Compared with companies in downstream industries, those in upstream industries have little opportunity of outsourcing and have to commit to the long-term production resources for themselves. Our empirical tests show that upstream firms' operating income is more volatile and, as a result, their stock returns are lower compared to downstream firms. Second, in our attempt to better understand a channel through which operational risk affects stock returns, we find that high income volatility in upstream firms is attenuated when capacity utilization is high. In sum, our results suggest that operational risk in supply chain affects stock returns through limited production activities amplifying the impact of fixed costs on earnings stream.

Keywords: Supply chain performance, upstream industries, operational risk, income volatility, capacity utilization

Student Number: 2014-20493

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1. Introduction

Supply chain risk has been gaining increasing attention in recent years due to its potential negative impacts on shareholder value, sales, reputation, and relationships between customers and suppliers (Bode and Wagner, 2015; Hendricks and Singhal, 2003). Consequences of various disruptions and interruptions surrounding modern global supply chains caused by demand fluctuations, supply capacity changes and natural disasters have inspired much research efforts on sources, measurement, consequences, remedies as well as quantitative approaches regarding supply chain risks (Bode and Wagner, 2015; Tazelaar and Snijders, 2013; Guertler and Spinler, 2015; Hora and Klassen, 2013; Saldanha et al., 2013; Mitra et al., 2015; Wiengarten et al., 2016). The relationship between supply chain risk and the firm's operating and financial performance, with much emphasis on stock price, has been actively studied in the literature (Hendricks and Singhal, 2003; Hendricks and Singhal, 2005a & 2005b; Hendricks et al., 2009; Shafer and Yildirim, 2013). As a result, better understanding of aspects of supply chain risk is rapidly accumulating along with efforts on consolidation of recent findings (Lewis, 2003; Seshadri and Subrahmanyam, 2005; Sodhi et al., 2011; Heckman et al., 2015; Fahimnia et al., 2015).

On the other hand, most works on supply chain risks have tended to take a holistic perspective on the supply chain. Sources, consequences and remedies of supply chain risks have been explored from the perspective of the entire supply chain, or of a "focal" firm, which frequently locates in the downstream of supply chain.[1] Outside of the literature on supply chain risk, there have been notable exceptions. For example, Crook and Combs (2007) investigated possible asymmetric benefit distribution among supply chain members, depending on relative bargaining power use. Xue et al. (2014) examined how the asymmetry in power distribution along the supply chain affects quantity, retail price, consumer surplus, and each supply chain member's profitability. Kim and Henderson (2015) studied the effects of a supplier's and a customer's dependency on a focal firm's benefits and risks in triadic supply chain relationships that might be asymmetric. This research stream suggests that investigation into possible asymmetric impacts of supply chain risks on its members is deemed to be a natural extension. In this paper, we study asymmetric supply chain operational risk among its members (i.e., upstream firms vs. downstream firms) and present large sample analyses with respect to its impact on financial performance.

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[1] "Upstream" and "downstream" refer to a company's location in the supply chain. The closer to the end user a firm is, the further downstream it can be classified as. For example, in oil and gas industry, upstream companies identify oil and natural gas deposits and engage in the extraction, while oil refiners represent the downstream element of the oil and gas supply chain.

Our study hinges on the premise that upstream firms in supply chains are exposed to a greater operational risk than downstream firms. First, as referred as the bullwhip effect, the amplified propagation of information uncertainty distortion towards upstream creates many adverse effects on upstream firms (Lee et al., 1997; Lee and Whang, 2002). Second, upstream firms are usually restricted from opportunities for outsourcing compared to downstream firms, despite that outsourcing is an effective means of mitigating operational risk by enhancing cost elasticity (Holzhacker et al., 2015).

We expect that the operational risk in supply chain materializes to volatility in operating performance. We thus begin by documenting the association between asymmetric operational risk in supply chain and income volatility. In so doing, we refer to accounting and finance literature on operating leverage, a given firm's proportion of fixed costs out of all costs (Mandelker and Rhee, 1984; Zhang, 2005; Garcia-Feijoo and Jorgensen, 2010; Chen et al., 2010; Novy-Marx, 2011). When the degree of operating leverage (DOL) is high, even a small change in company revenues will result in a large change in operating income since most costs are fixed rather than variable. In other words, a firm with high DOL is likely to exhibit low cost elasticity and high volatility of operating income. For this reason, DOL has been a popular indicator of operational risk.[2] We expect that the asymmetric supply chain risk (upstream vs. downstream) well captures a significant variation of operating leverage hindering flexible operations of a firm, hence materializing into financial performance.

Based on a comprehensive dataset of Korean listed companies for the periods from 1981 to 2013, we document the followings. First, we find that the volatility of operating income is on average larger for upstream industries than downstream industries after controlling for size, growth, and financial leverage. Our empirical results also show that the stock return is relatively lower in upstream industries than in downstream industries and suggest that such unfavorable market reaction in upstream industries is caused partially by their larger income volatility.

Second, we investigate the role of capacity utilization regarding whether it amplifies the upstream's operational risk, establishing a possible source of the asymmetric magnitude in the operational risk along the supply chain. As we have observed in the US automobile manufacturing industry, excess capacity often results in a devastating loss and possibly a complete

[2] Whereas the term "operational risk" is frequently used in operations management literature, "operating risk" is a more standard term in accounting and finance. We employ the term "operational risk" for consistency throughout this paper.

failure.[3] The following is excerpted from the 2011 annual report (Part I Risk Factors) of General Motors, one of the Detroit Big Three companies.

> *"The global automotive industry is highly competitive, and overall manufacturing capacity in the industry exceeds demand. Many manufacturers have relatively high fixed labor costs as well as significant limitations on their ability to close facilities and reduce fixed costs. Our competitors may respond to these relatively high fixed costs by attempting to sell more vehicles by adding vehicle enhancements, providing subsidized financing or leasing programs, offering option package discounts or other marketing incentives, or reducing vehicle prices in certain markets. ... These actions have had, and are expected to continue to have, a significant negative effect on our vehicle pricing, market share, and operating results, and present a significant risk to our ability to enhance our revenue per vehicle."*

As indicated in the above excerpt, we argue that capacity-oriented fixed costs materialize as a crucial operational risk particularly when there is a considerable amount of excess capacity.

Our empirical results suggest that higher income volatilities as well as lower stock returns in the upstream industries are substantiated when the

[3] Examples of the failure on managing operational risk are not scant in non-manufacturing industries, too. For instance, many large air-carriers went through bankruptcy protection periods because of their large fixed costs and low-cost competitors' wresting market share. Blockbuster was delisted out of the capital market for the similar reason.

capacity utilization level is low. Low levels of capacity utilization implicate that the excess capacity cost can be detrimental because the downside risk in the operating leverage is likely to materialize provided with greater unutilized resources. Thus, investors become more concerned about the higher income volatility (i.e., the higher operating leverage) when the firm does not utilize its capacity effectively.

This research contributes to the literature in two important aspects. First, to our knowledge, there has been no empirical research dealing with risk transferring between upstream and downstream industries in the operational risk context. Whereas supply chain risk literatures have evaluated the overall performance of a specific supply chain relation, we classify the industries into upstream versus downstream and contrast the two groups' performances. Second, we are able to employ capacity utilization data of the listed Korean manufacturing firms as Korean regulation mandates them to disclose the maximum production capacity and the actual utilization level. Using the data, we find that capacity utilization is an important source of income volatility and the stock market incorporates this information in assessing upstream industries' operational risk.

In Section 2, we provide relevant literature review. In Section 3, we describe the objectives of this study and discuss the theories pertinent to our research questions to develop hypotheses. Section 4 presents the sample and the research methodology, followed by our empirical results in section 5. Finally, section 6 concludes the study with implications for practitioners and academics and future research avenues.

2. Literature Review

2.1. Supply chain operational risk

Supply chain risk can be categorized in many different ways and perspectives (Christopher and Peck, 2004). For example, Thun and Hoenig (2011) distinguished between internal and external supply chain risks that encompass purchasing, demand and environmental whereas Guertler and Spinler (2015) subdivided supply chain risk into supply, demand, product and process risks. Recently, there is growing attention to the operational risk (Hora and Klassen, 2013; Mitra et al., 2015; Guertler and Spinler, 2015; Heckmann et al., 2015). Because operational risk reflects the complexity, uncertainty and diversity of risk sources that are valid for supply networks; operational risk is considered a better conceptual basis for the notion of supply chain risk compared to financial risk which is understood as market, credit, currency and liquidity risk (Heckman et al., 2015).

In addition, operations management area is now encouraging quantitative analysis employing rigorous proxies for supply chain risk (Finke et al., 2010; Heckmann et al., 2015; Mitra et al., 2015; Fahimnia et al., 2015). Prior studies in accounting and finance have also utilized the DOL concept in the context of cost elasticity since a cost structure with less operating leverage, i.e., a lower proportion of fixed costs, offers companies flexibility (Banker et al., 2014). In this paper, setting up operating income volatility as a quantitative measure of operational risk, we examine whether operational risk is higher in the upstream than the downstream and whether the operational risk mediates the upstream industries' low stock return performance.

2.2. Sources of operational risk for upstream firms: demand uncertainty & outsourcing

Drawn from operations management and other management literatures, we consider two sources of operational risk for upstream firms: demand uncertainty and lack of outsourcing opportunity. First, demand uncertainty may lead upstream players in supply chains to a disadvantageous position. Lee et al. (1997), Lee and Whang (2002), and Chen and Lee (2012) analyze the bullwhip effect, both empirically and theoretically, that demand information distortion being exaggerated towards the upstream can cause longer lead time and lower supply chain efficiency for the upstream players[4]. Particularly, Garavelli (2003) suggests that the bullwhip effect translates into business uncertainty, cost rigidity, and operational risk in the upstream stages of the supply chain.

Also, the literature relates outsourcing opportunities to the operational risk. Various advantages of outsourcing in terms of lower manufacturing costs, reduced investment in plant and equipment, capacity flexibility, enhanced focus on core competencies and promotion of suppliers' competition has long been widely documented across multiple areas of management (D'Aveni and Ravenscraft, 1994; Gilley and Rasheed, 2000; Lei and Hitt; 1995; Quinn, 1992; Bettis et al., 1992; Beach et al., 2000; Harrigan, 1985; Kotabe and Murray, 1990; Prahalad and Hamel, 1990). Also, globalization in business has been a major source of operational risk in supply chain as it extends the scope and complexity of supply chains (Chopra and Sodhi, 2004; Narasimhan and Talluri, 2009; Guertler and Spinler, 2015). It is generally accepted that the outsourcing strategy benefits

[4] The bullwhip effect prevails for a majority of firms along the supply chain (Bray and Mendelson, 2012) and it can arise in various relationships: between a retailer and a manufacturer or between a manufacturer and its supplier. (Lee et al., 1997).

more provided with tighter supply chain integration (SCI), while some recent studies introduce into this relation several contingency factors such as product complexity, complexity of business environment, uncertainty and other country level variables (Kim, 2009; van der Vaart et al., 2012; Wiengarten et al., 2016).

In the context of supply chain, upstream industries are characterized by limited outsourcing options, which is one of the most common policies for risk mitigation (Holzhacker et al., 2015; Chen and Xiao, 2015; Wiengarten et al., 2016), for the following reason. Upstream industries consist mostly of manufacturers of parts and interim goods as well as of natural raw-material providers. In such case, an upstream firm must invest in manufacturing facilities but have little opportunity of outsourcing due to the inherent nature of its operation whereas downstream firms can easily adopt a flexible multiple-sourcing strategy to mitigate risk (Chen and Xiao, 2015). As mentioned in Section 1, outsourcing converts some fixed costs into variable costs, thereby improves cost elasticity, lowers DOL and mitigates operational risk.

In this regard, we anticipate that operational risk is higher for upstream firms, which is signified by low cost elasticity and high volatility of operating income.

2.3. Impact of supply chain operational risk on operating and stock performances

Besides negative impacts on intangible and/or indirect aspects of a firm such as brand equity, relationship, safety and spillover effects, tangible and direct adverse impacts of supply chain risk on stock and operating performances have been widely verified. Hendricks and Singhal (2005a & 2005b) exhibited the direct negative impact of supply chain disruption on either stock (stock price and equity risk) or operating performances (operating income, return on sales and return on assets). On the other hand, the low-risk anomaly phenomenon, where firms with a low stock return volatility outperform firms with a high stock return volatility has been analyzed for some time in accounting and finance (Baker et al., 2011; Dutt and Humphery-Jenner, 2011; Shafer and Yildrim, 2013). Particularly, Dutt and Humphery-Jenner (2011) showed that high volatility stocks exhibit lower operating returns, which was deemed a possible reason why high volatility stocks earn lower stock returns. Combining these results, one can establish a chain of association among operational risk, operating performance, stock volatility and stock return.

3. Theoretical development and hypotheses

3.1. Maintained Assumption: transfer of operational risk in a supply chain relation

This study emphasizes adverse environmental factors upstream industries have to deal with. As discussed in Section 2.2, downstream player benefits from the enhanced cost flexibility on wages and other perk payments by divestiture of committed resources and transfers demand uncertainty risk to the upstream player via bullwhip effect. However, such downstream advantages are often realized at the cost of upstream disadvantages from outsourcing contracts. Taper integration strategy (Rothaermel et al., 2006) suggests that the outsourcers may suffer from outsourcing strategy: while external sourcing is likely to increase a firm's flexibility in the short term, it also increases its path dependence in the use of external sources. As the firm loses its internal capability to perform certain value chain activities, it becomes increasingly dependent on its external partners to perform those activities (Bettis et al., 1992; Lei et al., 1996; Rothaermel et al., 2006).[5] In contrast, this study focuses on the

[5] The hold-up problem literature also suggests that downstream companies can appropriate more surpluses from the supply-chain collaboration when upstream companies undertake

implication of the transfer of committed costs, which penalizes only one side (upstream companies) of the contracting parties. We address this issue utilizing the concept of operating leverage.

Following the logic in Section 1 and Section 2.1, we expect that low flexibility, represented by low cost elasticity due to the limited resource outsourcing opportunity faced by upstream firms is likely to cause greater operational risk in upstream industries, which translates into higher volatility of operating earnings:

Assumption 1 (A1). *Income is more volatile for upstream firms than for downstream firms.*

3.2. Stock performance across supply chains & the mediation effect of income volatility

Based on discussions in Section 1 and Section 2.3, we predict that higher operational risk and its consequential income volatility of upstream firms are associated with stock performances, specifically rendering low stock return. Thus, we hypothesize that companies in upstream industries

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investment which does not carry business opportunities outside the relation (Klein et al., 1978; Hart, 2009).

are operating in more challenging circumstances than downstream industries, and consequently, their stock performance is lower.

Hypothesis 1a (H1a). *Stock-return is lower for upstream industries than for downstream industries.*

Among multiple disadvantages hindering the upstream firms' value creation as discussed, we focus on the impact of operational risk and predict that the greater income volatility stemming from the innate nature of upstream operations plays a critical role in the relation between upstream industry and lower stock return.

Hypothesis 1b (H1b). *Income volatility mediates the upstream industries' lower stock returns.*

3.3. Implication of capacity utilization in understanding the operational risk

Next, we investigate how the capital market assesses the operational risk (operating income volatility) in association with the capacity utilization:

lower stock returns. Our first hypothesis is derived based on our maintained assumption that the operational risk (i.e., upfront cost commitment) is detrimental to the firm value. However, leaning toward higher fixed costs can be valuable when the market demand is growing. Expanding manufacturing capability will boost the income generation with increasing sales. The high operating leverage becomes problematic only when sales decline substantially. That is, the nature of operational risk is the *downside* risk.[6]

We anticipate that the downside risk in the operating leverage materializes seriously when the firm does not utilize its capacity effectively. Low levels of capacity utilization are likely to indicate that the excess capacity cost can devastate the business. Thus, we propose that investors will view the higher income volatility (i.e., the higher operating leverage) as a concern only when the capacity utilization level is low. On the other hand, when an upstream firm is operating near its full capacity, the excess capacity cost caused by sales decrease is not threatening the business as significantly as when the firm's capacity utilization is low. Thus, we hypothesize that upstream industries are not penalized in their stock

[6] Banker et al. (2014) note “Higher downside risk means that only unfavorable demand realizations become more likely, which not only increases the variance of demand, but also reduces the *mean* of demand.”

performance compared to downstream industries insofar as the capacity utilization is high enough.

It is interesting to contrast the role of capacity utilization in the context of Hendricks et al. (2009) with that of ours. Hendricks et al. (2009) verified that operational slack in the form of excess capacity measured by sales over assets, level of inventory and cash to cash cycle is effective in mitigating the negative stock market reaction to supply disruption. On the other hand, we hypothesize that higher income volatilities as well as lower stock returns in the upstream industry, in which operational risk is demand-oriented in nature, are substantiated only when the capacity utilization level is low. In other words, low capacity utilization plays an auspicious role when the risk originates from the supply side since the excess capacity mitigates the downside risk of supply shortage whereas it plays an adverse role when the risk comes from demand side since it amplifies the downside risk of demand fall.

Hypothesis 2 (H2). *Upstream industry's disadvantage in terms of operational risk and its negative impact on stock returns are greater (smaller) when the utilization level is low (high).*

4. Research Design

4.1. Estimation Models

First, we use equation (1) to verify our maintained assumption that the upstream industries are subject to higher income volatilities.

$$IV_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t} \qquad (1)$$

The dependent variable $IV_{i,t}$ is defined as the standard deviation of the ratio of operating income to sales over the past five years (from t-5 to t-1) for firm i.[7] $Upstream_{i,t}$ is 1 if the company i for period t belongs to the upstream industries, 0 otherwise. According to our assumption, β_1 is expected to be positive. We include three control variables: $Growth_{i,t}$ = ratio of market value of equity to book value of equity for firm i at the end of the period t; $Size_{i,t}$ = log of market value of equity for firm i at the beginning of the period t; $Leverage_{i,t}$ = ratio of debt to asset for firm i at the beginning of the period t.

To examine H1a, we test equation (2) and see if there is disadvantage in generating returns for upstream industries (negative β_1). $Return_{i,t}$ is defined as the market-adjusted buy-and-hold stock return over

[7] When we obtain the standard deviation over three and four years instead of five, our empirical results do not change. When we increase the number of years beyond five in calculating the *IV* variable, the coefficient estimates have the same signs but the statistical significance reduces.

fiscal year *t* for firm *i*. We include the market value of equity, the book-to-market ratio, and financial leverage to control the return performance following the traditional literature in earnings response coefficient and the Fama-French three factor model.

$$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t} \qquad (2)$$

Our next interest is whether the income volatility mediates the negative relationship between *Upstream* and *Return* variables. As in H1b, we predict that the greater income volatility stemming from the innate nature of upstream operations plays a critical role in the relation between upstream industry and lower stock return. To test this mediation effect, we employ a "path analysis" where *Upstream* has both direct and indirect effects on stock returns.

$$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \beta_2\ IV_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t} \qquad (3)$$

Although it is not shown in equation (3), our path analysis includes the path from *Upstream* to *IV* and we show the magnitude of indirect effect through the income volatility in the result section.

Our second hypothesis reexamines the above relationships for the different levels of capacity utilization. Thus, we split the sample into two groups, high and low capacity utilization, and test equations (2) and (3) to see whether the coefficient estimates differ between the two sup-samples. Figure 1 summarizes the path analysis framework.

4.2. Industry classification

To test our hypotheses, we construct a dichotomous variable according to which industry group a company belongs to: upstream industry groups versus downstream industry groups. Based on Fama-French 48 industry classification, we evaluate each industry with respect to the closeness between the industry and the end-customers. When the industry is located closely to (remote from) the end-customers, we classify it as downstream (upstream) industry.[8] In supply-chain, upstream suppliers are providing raw materials, parts, and intermediary goods; whereas downstream participants take care of final consumer goods. For instance, manufacturers in the Computers industry assemble hard disks, memory chips and LCDs that have been produced by the Chips suppliers. Using such sequential linkages generally accepted in the supply-chain relation literature,

[8] To our knowledge, prior studies identify upstream and downstream firms in a specific supply chain relation but there is no established method of classifying overall industries into the two groups of upstream and downstream. We note that Kenessey (1987) postulates U.S. economy into four activities at the two-digit SIC level: primary, secondary, tertiary, and quaternary activities where primary (tertiary and quaternary) activities overlap our upstream (downstream) industries and secondary activities involve both upstream and downstream.

we classify into the upstream industry group Agriculture, Chemistry, Rubber and plastics, Textiles, Building material, Steel, Fabricated products, Machinery, Oil, Chips electronic equipment, paper, and boxes; and into the downstream industry group Food, Soda, Beer, Smoke (Tobacco), Toys, Fun, Books, Household, Clothes, Medical equipment, Drugs, Construction, Electronic equipment, Autos, Aircraft, Ships, Guns, Utilities, Telecommunication, Personal and business services, Computers, Laboratory equipment, Transportation, and Wholesale.[9]

5. Empirical Results

5.1. Sample Selection

We collect data from three public sources, KISVALUE, FnGuide, and FSS, to obtain the data relevant to our research hypotheses including capacity utilization in particular. First, KISVALUE provides Korean firms' financial statement database. KISVALUE is operated by NICE Information Service Company which also provides credit rating and credit information for the public. Next, FnGuide provides Korean aggregated analysts' reports as well as firms' financial information. KISVALUE and FnGuide are

[9] Industry names follow the Fama French 48 industry classification.

widely used for academic research purpose in Korea. We obtain financial information such as incomes and book values from the KISVALUE, and stock prices and betas from FnGuide. The sample period of the study is from 1981 to 2013 because the two databases provide the data from 1981. We drop the samples with missing values, and truncated 1% of the data. Sample observations are restricted to manufacturing industry, since the definition of upstream and downstream firms is not suitable for the supply chain of other industries.

Capacity utilization data are generally hard to obtain since they are proprietary information to the firm. In Republic of Korea, however, manufacturing firms listed in the stock market are required to report capacity utilization levels in their annual reports. Financial Supervisory Service (FSS), the governing authority of Korea, regulates the capacity utilization disclosure policy. Thus, we obtain capacity utilization rates from Korean Financial Supervisory Service (FSS) database.

5.2. Empirical Results

Table 1 reports summary statistics of our main and control variables. The income variability (IV), our proxy for operational risk, has the mean value of 5.5% and the standard deviation of 6.4% implying that firms carry fixed costs and the relative portion of fixed costs varies across firms. The average capacity utilization rate is 80.8% after winsorizing it at 1%.[10] In Panels B and C, we separately report descriptive statistics of our upstream and downstream sub-samples. The univariate analysis shows that stock returns are on average lower in upstream industries than in downstream industries, the difference is statistically significant at the 1% level. Income volatility is also higher for the upstream industries at the 5% significance level, whereas capacity utilization does not differ significantly between the upstream and downstream sub-groups. We note that this equality of capacity utilization assures that there is no systematic association between the capacity utilization and the dichotomy of upstream vs. downstream—thus our results on the second hypothesis are not driven by possible endogeneity.

[Insert Table 1 here.]

Table 2 presents Pearson correlations among our main variables. First, stock return and income volatility are negatively correlated as conformation of the adverse impact of income volatility on returns. Also,

[10] With the 1% winsorization, the capacity utilization level ranges from 15% to 153% which seem still unusual. As robustness tests in our analyses, we have changed the winsorization cutoffs from 2% to 5% and obtained very similar results. We also truncated the extreme values at 1% to 5% and the results remained unchanged.

consistent to our predictions, the upstream industry indicator is negatively correlated with returns but has a positive association with income volatilities. Finally, the correlation between the upstream indicator and capacity utilization is insignificant.

[Insert Table 2 here.]

Table 3 presents the results from multivariate analyses controlling for growth, firm size, and leverage. Our OLS regression analysis, with standard errors clustering on firm and year, shows that the coefficient estimate on the *Upstream* indicator variable is 0.1031 (significant at 1% level) which indicates the income volatility of the upstream industries is on average 7.9% greater than that of the downstream industries. The results are consistent to our premise that upstream manufacturers are committed to the fixed resources and hence bear greater operational risk. As to the controls, the market to book ratio (*Growth*) and the debt to asset ratio (*Leverage*) have significantly positive coefficients, indicating that the operating income is more volatile for growing firms and those with high financial leverage.

When we restrict our sample into 7,212 observations having capacity utilization data, we find that capacity utilization level is an important factor explaining income volatility. First, the intercept term is significantly positive only for the low capacity utilization circumstances. Because the fixed cost from employing manufacturing facilities gets spread over production units, its impact on the operating leverage dwindles as a firm utilizes more portion of capacity. Therefore, the higher income volatility under the lower capacity utilization can be understood in terms of the general notion of operating leverage. Moreover, the coefficient of the upstream indicator for the low capacity utilization subsample (0.1855) is almost twice larger than for the other subsample (0.1032). This result indicates that our dichotomous industry classification in relation to the operational risk is meaningful only in case the capacity utilization level is low.

[Insert Table 3 here.]

Next, we present empirical results on our first hypothesis that upstream industries are disadvantageous in stock return performance due to the operational risk. Moreover, we anticipate that such negative relationship between the *Return* variable and the *Upstream* indicator can be mediated by *IV*, the operating income volatility. As shown in Panel A of Table 4, we find that the average stock return over the sample period is lower for the upstream industries than the downstream industries. The coefficient on *Upstream*, β_1, is –2.26 which is significant at 1% level. The negative correlation between upstream industries and stock returns holds after controlling the control variables commonly adopted in the literature of the return models.

In H1b, we conjecture that low stock returns for upstream firms are attributable to their rigid cost structure—high operational risk—to some extent. Therefore, we construct a path analysis, equation (3) to examine such potential mediation effect of the upstream participants' commitment to fixed costs on their inferior returns. Panel B of Table 4 provides the estimation results. On one hand, as opposed to Panel A, β_1 turns out to be insignificant although it still gets a negative estimate. On the other hand, the *Upstream* variable indirectly influences stock returns through the income volatility: the coefficient estimate of *Upstream* on *IV* is 0.1147 and that of *IV* on *Return* –9.478 while the control variables remain about the same in their estimates. Thus, we conclude that the lower stock return performance of upstream firms than downstream firms is mainly caused by income volatility proxying for operational risk.

[Insert Table 4 here.]

We lastly present the empirical tests on our second hypothesis as for the implication of capacity utilization in understanding the association between stock return and operational risk. Panel A of Table 5 report empirical results when we estimate equation (2) for two sub-samples, low versus high capacity utilization groups.[11] The β_1 estimate is −4.1778 for the low high capacity utilization group. However, we find that upstream and downstream industries do not differ in stock returns when the capacity utilization is high. These results suggest that upstream industries are subject to poorer return performance only when the capacity utilization is low.[12] That is, as far as the capacity utilization is reasonably high, the downside risk of operating leverage in the upstream industries is not materializing beyond that of the downstream industries: the upstream versus downstream industry dichotomy is no crucial concern of the shareholders.

[Insert Table 5 here.]

Panel B of Table 5 presents empirical results from the path analysis. Similarly to the full sample analysis, the upstream industries' direct impact on the return in the lower capacity utilization subgroup disappears as the income volatility variable mediates the *Upstream* and *Return* association. In

[11] Table 5 reports the result when we divide the sample observations based on the median capacity utilization level by year and industry. The results remain the same when we divide the sample based on the capacity utilization over the entire observations.

[12] Our expectation is robust when firms are categorized into three groups (low, middle, high) based on capacity utilization rate. The high capacity utilization group continues to have no impact of *Upstream* while the middle and low groups show the significantly lower returns of the upstream industries.

addition, the coefficient on the IV←Upstream path is significantly greater for the low capacity utilization group (0.1720) than for the high group (0.0729) at the 5% confidence level. In short, our results show that upstream industries experience greater operational risk due to the nature of supply-chain positioning, which is adversely reflected in the capital market, and that the operational risk is of more concern given the lack of capacity utilization.

5.3. Additional Tests

In our main hypothesis tests we document that the extent to which upstream industries yield lower stock returns than downstream industries depends on income volatility as well as capacity utilization. Because stock returns reflect the investor's belief on the future cash flows, our earlier findings may also have implication on stock return volatility. Because the upstream companies' earnings are more volatile due to its intensive commitment to the fixed assets, capital market participants are likely to form various opinions on the value implication of earnings information: therefore, we expect stock return volatility is greater in upstream industries than downstream. To address this question, we first test whether or not earnings information given higher operational risk in upstream industries leads to more diversified interpretation among investors. Furthermore, as shown in our main empirical analysis, an important operational environment that creates investors' concern is the low level of capacity utilization. Thus, we examine whether or not capacity utilization involves in stock return volatility as well.

Skinner (1989), Bushee and Noe (2000), Landsman and Maydew (2002), and DeFond et al. (2007) examine the earnings information content by means of stock return volatility. First, following Landsman and Maydew (2002), we define abnormal stock return volatility (*Retvol*) as u_{it}^2/σ_i^2, where $u_{it} = R_{it} - (\alpha_i + \beta_i R_{mt})$, R_{it} is the raw return of firm *i* for day *t*, and R_{mt} is the equal weighted return of market for day *t*. α_i and β_i are firm *i*'s market model parameter estimates and σ_i^2 is the variance of firm *i*'s market model adjusted returns, each of which is calculated during the period *t*–345 to *t*–20 and *t*+20 to *t*+345.[13] While Lamdsmand and Maydew (2002) include in their model only the main variables of interest, we adopt controls variables from Bushee and Noe's (2000) return volatility model.[14]

[13] The adjustment by σ_i^2 is in the spirit of a heteroskedasticity adjustment, where the stock's return variance is assumed proportional to that of the market (Skinner 1989).

[14] Because this research uses Korean company data, some control variables used in Bushee and Noe (2000) are not available. The unavailable variables in this study are S&P stock

$$Retvol_{it} = \beta_0 + \beta_1\, IV_{it} + \gamma_j \sum_{j=1}^{8} Controls_j + \varepsilon_{it} \tag{4A}$$

$$Retvol_{it} = \beta_0 + \beta_1\, IV_{it} + \beta_2\, Upstream_{it} + \beta_3\, Upstream_{it} \times IV_{it} + \gamma_j \sum_{j=1}^{8} Controls_j + \varepsilon_{it} \tag{4B}$$

The eight control variables are: $MRET_{it}$ = market adjusted buy-and-hold stock return measured over a year's time; $TVOL_{it}$ = average monthly trading volume relative to total shares outstanding; MV_{it} = log of the market value of equity; LEV_{it} = ratio of debt to assets; EP_{it} = ratio of income before extraordinary items to market value of equity; BP_{it} = ratio of book value of equity to market value of equity; DP_{it} = ratio of dividend to market value of equity; SGR_{it} = percentage change in annual sales.

Panel A of Table 6 presents the results from the benchmark model including the income volatility variable (equation 4A) and the extended model with the upstream indicator and its interaction with *IV* to examine the impact of upstream versus downstream positions (equation 4B). We find that *Retvol* is commensurate with *IV* in consistent to our prediction. However, when we include *Upstream* and *Upstream**IV*, we find that the positive association between income and return volatilities exists only in the upstream side. The coefficient estimate on the interaction term is 9.10 at the

rating, S&P index dummy, and percentage ownership by transient, dedicated, and quasi-indexer institutions relative to total shares outstanding.

1% significance level but the *IV* variable is no longer significant[15]. Thus, it suggests that earnings volatility is of concerns to investors in upstream industries but downstream investors appear to be little worried about the operational risk.

[Insert Table 6 here.]

Panel B of Table 6 shows the result when the capacity utilization is added in equation 4B. The negative coefficient estimate, –0.063, on the three-way interaction term indicates the stronger positive association between *Retvol* and *Upstream**IV* along the lower capacity utilization. We interpret that the investors in the upstream industry companies have more disperse judgment on the earnings information particularly when the capacity utilization level is low. In other words, some upstream investors can interpret the slack capacity given the higher operating leverage as a future threat of earnings deterioration but others may perceive it as an opportunity of expeditious earnings growth. Such opposing interpretation, however, seems mute in downstream industries and even in upstream industries as far as there is no significant amount of excess capacity. In short,

[15] The coefficient estimate and its significance presented in the text are when we define *IV* as the standard deviation of past five year operating earnings. As in Panel A of Table 6, the results are the same when IV is defined based on past three or four year operating earnings.

the result is consistent with our earlier findings in that the capacity utilization is one of the crucial factors that distinguish the upstream industries from the downstream with regard to the income volatility and operating leverage.

6. Conclusion

The operational risk has been one of the focal research topics in the supply chain management literature in recent years. Although substantial amount of knowledge on this topic is accumulating and consolidating, there also remain unexplored issues such as asymmetric operational risk along the supply chain positioning. This study examines the association between operational risk and stock returns, comparing it between upstream and downstream industries. While theories of cost accounting suggest that commitment to larger amount of fixed resources should lead to higher risk in realization of operating income, there has been no scrupulous empirical research addressing its implication on business particularly with respect to the supply chain relation. Relying on the fact that companies in upstream industries are (i) subject to greater risk from demand uncertainty, (ii) less capable of exploiting outsourcing strategy, and (iii) inevitably led to the commitment to long-term production resources, we examine that upstream firms' operating income is more volatile and their stock returns are lower compared to downstream firms. Our empirical results reveal that the operational risk plays an important role in explaining the lower returns of upstream industries.

In addition, we extend the operational risk concept to the capacity utilization. Because the operational risk substantiates through adverse demand conditions, it is meaningful to investigate whether the relation between income volatility and stock performance depends on the level of capacity utilization. Consistent to our prediction, the main results hold only when the capacity utilization level is lower than its median value in our sample. This result is complementary to previous findings of Hendricks et al. (2009) with regard to the role of capacity utilization. Low capacity utilization (holding larger slack resources) can have a positive impact on the upstream when the uncertainty originates from the supply side disruptions whereas, as we document here, it can devastate the supplier's profit when the uncertainty pertains to the customer market.

Our study contributes to the literature in two important aspects. First, there is no prior study, to the best of our knowledge, which compares upstream and downstream industries in the operational risk context. Departing from the supply chain risk literatures that have evaluated the overall performance of a specific supply chain relation in response to the supply chain interruption and disruption, we classify the industries into upstream versus downstream and contrast the two groups' performances. The significantly higher income volatility in upstream firms validates the use of this simple dichotomy to proxy for operational risk in supply chain. Second, by virtue of the capacity utilization data of the Korean manufacturing firms, we put forward to the literature that capacity utilization is an important source of income volatility and the stock market incorporates this information in assessing upstream industries' operational risk.

We note, as a potential future research avenue in extension of this study, that return volatility is another interesting subject. For instance, we anticipate that returns would be more volatile in upstream companies especially when capacity utilization is low. It is because investors are likely to form different opinions to the greater extent when they observe higher operating leverage with lower capacity utilization, again due to the downside risk.

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Figure 1. Research framework

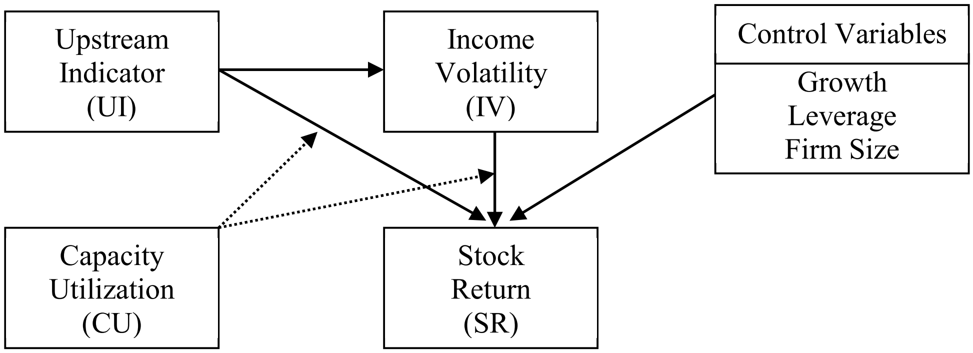

Table 1. Descriptive statistics

Panel A. Full sample (N=7,591)

Variable	Mean	STD	Q1	Median	Q3
Return	-3.939	69.527	-42.114	-14.888	17.490
IV	0.055	0.064	0.021	0.034	0.061
Capacity Utilization (%)	80.757	19.248	71.099	83.804	93.000
Growth	1.131	1.118	0.500	0.802	1.346
Size	18.658	1.428	17.693	18.485	19.356
Leverage	0.463	0.200	0.310	0.468	0.609

Panel B. Upstream industry sub-sample (N=4,764)

Variable	Mean	STD	Q1	Median	Q3
Return	-5.699	68.232	-43.346	-15.870	16.777
IV	0.056	0.063	0.022	0.036	0.064
Capacity Utilization (%)	80.503	18.933	70.735	83.321	92.343
Growth	1.069	1.017	0.470	0.768	1.307
Size	18.697	1.422	17.759	18.527	19.349
Leverage	0.467	0.197	0.324	0.470	0.611

Panel C. Downstream industry sub-sample (N=2,827)

Variable	Mean	STD	Q1	Median	Q3
Return	-0.974	71.570	-40.590	-13.833	19.059
IV	0.053	0.065	0.019	0.031	0.056
Capacity Utilization (%)	81.185	19.764	71.813	84.973	93.852
Growth	1.236	1.263	0.554	0.851	1.412
Size	18.591	1.436	17.573	18.417	19.371
Leverage	0.455	0.206	0.289	0.463	0.603

1. Definition of variables:
   - *Upstream* $_{i,t}$ = 1 if the company *i* for period *t* belongs to the upstream industries, 0 otherwise.
   - *Return* $_{i,t}$ = market-adjusted buy-and-hold stock return measured over a year's time for firm *i* in period *t*.
   - *IV* $_{,t}$ = standard deviation of five-year operating income for firm *i* in period *t*.
   - *Growth* $_{i,t}$ = ratio of market value of equity to book value of equity for firm *i* at the end of the period *t*.
   - *Leverage* $_{i,t}$ = ratio of debt to asset for firm *i* at the beginning of the period *t*.
   - *Size* $_{i,t}$ = log of sales for firm *i* at the beginning of the period *t*.
   - *Capacity utilization* $_{i,t}$ = ratio of actual manufacturing performance to practical capacity for firm *i* in period *t*.
2. All variables are truncated at 1% and 99%.

Table 2. Pearson correlation between model variables

	Upstream	Return	IV	Capacity	Growth	Size	Leverage
Upstream							
Return	-0.033***						
IV	0.023**	-0.118***					
Capacity	-0.017	0.064***	-0.197***				
Growth	-0.072***	0.206***	0.270***	-0.069***			
Size	0.036***	0.067***	-0.342***	0.193***	-0.107***		
Leverage	0.030***	-0.013	0.057***	0.064***	0.100***	0.283***	

*,**,*** : Statistical significance at 10%, 5% and 1% two-tailed levels, respectively.

Table 3. Income volatility of upstream industries against downstream industries (A1)

$$IV_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t}$$

Variables	Predicted Sign	Full Sample	Subsamples by Capacity Utilization: Full Sample	Low capacity utilization	High capacity utilization
Intercept		1.311***	0.763**	1.752***	-0.280
		(5.30)	(2.02)	(3.42)	(-0.71)
Upstream	+	0.103***	0.151***	0.185***	0.103**
		(3.27)	(3.51)	(3.27)	(2.05)
Growth	+	0.152***	0.177***	0.173***	0.180***
		(13.19)	(9.21)	(6.71)	(8.69)
Size	-	-0.271***	-0.243***	-0.300***	-0.184***
		(-20.50)	(-11.96)	(-10.92)	(-8.60)
Leverage	+	0.616***	0.357***	0.497***	0.206*
		(9.02)	(3.66)	(3.84)	(1.77)
N		16,291	7,212	3,600	3,612
Adjusted R^2		0.2646	0.1929	0.2356	0.1518

1. Definition of variables:

- $IV_{i,t}$ = standard deviation of five-year operating income for firm i in period t.
- $Upstream_{i,t}$ = 1 if the company i for period t belongs to the upstream industries, 0 otherwise.
- $Growth_{i,t}$ = ratio of market value of equity to book value of equity for firm i at the end of the period t.
- $Size_{i,t}$ = log of sales for firm i at the beginning of the period t.
- $Leverage_{i,t}$ = ratio of debt to asset for firm i at the beginning of the period t.

2. All variables are truncated at 1% and 99%.

3. The table presents OLS coefficient estimates and t-statistics (in parentheses).

4. *,**,*** : Statistical significance at the 10%, 5% , 1% two-tailed levels, respectively.

Table 4. Stock return performance of upstream industries against downstream industries (H1)

Panel A. H1a (Direct effect)

$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t}$

Variables	Predicted Sign	Coefficient Estimates
Intercept		-96.013*** (-11.21)
Upstream	-	-2.262** (-2.02)
Growth	+	11.552*** (15.53)
Size	+	5.658*** (12.44)
Leverage	-	-38.350*** (-14.65)
N		16,291
Adjusted R^2		0.14741

Panel B. H1b (Mediation effect)

$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \beta_2\ IV_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t}$ (path analysis)

Paths	Coefficient Estimates
Return ← Upstream	-1.404 (-1.40)
IV ← Upstream	0.115*** (7.71)
Return ← IV	-9.478*** (-17.98)
Return ← Growth	13.693*** (27.81)
Return ← Size	3.665*** (9.71)
Return ← Leverage	-35.072*** (-15.17)
N	16,233
Chi-Square (Pr > Chi-Square)	5121.7406 (<.0001)

1. Definition of variables:

- *Return* $_{i,t}$ = market-adjusted buy-and-hold stock return measured over a year's time for firm *i* in period *t*.
- *Upstream* $_{i,t}$ = 1 if the company *i* for period *t* belongs to the upstream industries, 0 otherwise.
- *Growth* $_{i,t}$ = ratio of market value of equity to book value of equity for firm *i* at the end of the period *t*.
- *Size* $_{i,t}$ = log of sales for firm *i* at the beginning of the period *t*.
- *Leverage* $_{i,t}$ = ratio of debt to asset for firm *i* at the beginning of the period *t*.

2. All variables are truncated at 1% and 99%.

3. The table presents OLS coefficient estimates and t-statistics in parentheses.

4. *,**,*** : Statistical significance at the 10%, 5% , 1% two-tailed levels, respectively.

Table 5. Mediation effect of income volatility conditioning on capacity utilization (H2)

Panel A. Direct effect

$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t}$

Variables	Predicted Sign	Capacity Utilization	
		Low	High
Intercept		-111.620***	-109.355***
		(-7.03)	(-6.98)
Upstream	-	-4.178**	0.131
		(-2.05)	(0.06)
Growth	+	10.802***	11.963***
		(6.63)	(7.55)
Size	+	6.355***	5.396***
		(7.52)	(6.90)
Leverage	-	-31.811***	-20.296***
		(-6.09)	(-3.45)
N		3,600	3,612
Adjusted R^2		0.1897	0.1137

Panel B. Mediation effect

$Return_{i,t} = \beta_0 + \beta_1\ Upstream_{i,t} + \beta_2\ IV_{i,t} + \Sigma\beta_j\ Control\ j_{i,t} + Error_{i,t}$ (path analysis)

Path	Capacity Utilization	
	Low	High
Return ← Upstream	-2.312	1.400
	(-1.10)	(0.66)
IV ← Upstream	0.172***	0.073***
	(5.63)	(2.59)
Return ← IV	-8.618***	-9.087***
	(-7.54)	(-7.31)
Return ← Growth	13.434***	13.974***
	(12.49)	(13.15)
Return ← Size	4.656***	4.259***
	(5.64)	(5.30)
Return ← Leverage	-30.400***	-20.440***
	(-5.66)	(-3.72)
N	3,340	3,598
Chi-Square	1292.4433	1090.8456
(Pr > Chi-Square)	(<.0001)	(<.0001)

1. Definition of variables:

- *Return* $_{i,t}$ = market-adjusted buy-and-hold stock return measured over a year's time for firm *i* in period *t*.
- *IV* $_{i,t}$ = standard deviation of five-year operating income for firm *i* in period *t*.
- *Upstream* $_{i,t}$ = 1 if the company *i* for period *t* belongs to the upstream industries, 0 otherwise.
- *Growth* $_{i,t}$ = ratio of market value of equity to book value of equity for firm *i* at the end of the period *t*.
- *Size* $_{i,t}$ = log of sales for firm *i* at the beginning of the period *t*.
- *Leverage* $_{i,t}$ = ratio of debt to asset for firm *i* at the beginning of the period *t*.
- *Capacity* $_{i,t}$ = ratio of actual manufacturing performance to practical capacity for firm *i* in period *t*.

2. Samples are bisected using the rank of capacity utilization rate. The capacity utilization rate is ranked by each year.

3. All variables are truncated at 1% and 99%.

4. The table presents MLE coefficient estimates and t-statistics in parentheses using path analysis.

5. *,**,*** : Statistical significance at the 10%, 5% , 1% two-tailed levels, respectively.

Table 6. Return Volatility (additional tests)

Panel A. Mediation effect of the upstream industry

Model: $Retvol_{i,t} = Upstream_{i,t} + IV_{i,t-1} + Upstream_{i,t} {*}IV_{i,t-1} + MRET_{i,t} + TVOL_{,t} + MV_{i,t} + Leverage_{i,t} + EP_{i,t} + BP_{,t} + DP_{i,t} + SGR_{i,t}$

Variables	Benchmark (STD of five-year income)	STD of five-year income	STD of four-year income	STD of three-year income
Intercept	1.416***	0.843***	0.897***	0.893***
	(14.66)	(7.23)	(7.65)	(7.62)
IV	0.986***	0.708	-0.610	-0.743
	(2.66)	(0.70)	(-0.65)	(-0.91)
Upstream		-0.066*	-0.107***	-0.118***
		(-1.70)	(-2.61)	(-2.89)
Upstream*IV		2.194*	3.368***	3.620***
		(1.75)	(2.84)	(3.35)
MRET	0.000*	0.000**	0.000**	0.000**
	(1.89)	(2.05)	(1.97)	(2.05)
TVOL	4.886***	3.181***	3.212***	3.161***
	(7.66)	(3.94)	(3.95)	(3.90)
Size	-0.064***	-0.025***	-0.026***	-0.026***
	(-8.75)	(-3.12)	(-3.21)	(-3.20)
Leverage	0.315***	0.355***	0.336***	0.350***
	(5.94)	(5.39)	(5.09)	(5.30)
EP	0.288***	0.267***	0.270***	0.272***
	(3.78)	(2.98)	(2.99)	(3.04)
BP	-0.065***	-0.019**	-0.020*	-0.020*
	(-5.90)	(-1.74)	(-1.86)	(-1.92)
DP	-0.003***	-0.002***	-0.002***	-0.002***
	(-5.04)	(-2.74)	(-2.8)	(-3.04)
SGR	0.000	-0.000	-0.000	-0.000
	(-0.35)	(-1.34)	(-1.06)	(-0.92)
N	3,999	2,302	2,302	2,302
Adjusted R^2	0.0648	0.0633	0.0654	0.0662

Panel B. three-way interaction with capacity utilization

Model: $Retvol_{i,t} = Upstream_{i,t} + IV_{i,t-1} + Upstream_{i,t} * IV_{i,t-1} + Capacity_{i,t} * Upstream_{i,t} * IV_{i,t-1} + Capacity_{i,t} + MRET_{i,t} + TVOL_{,t} + MV_{i,t} + Leverage_{i,t} + EP_{i,t} + BP_{,t} + DP_{i,t} + SGR_{i,t}$

Variables	STD of five-year income	STD of four-year income	STD of three-year income
Intercept	0.756***	0.792***	0.747***
	(5.58)	(5.87)	(5.61)
Upstream	-0.124***	-0.109***	-0.066*
	(-3.02)	(-2.67)	(-1.71)
IV	-0.836	-0.666	0.667
	(-1.02)	(-0.70)	(0.66)
Upstream*IV	9.102***	7.680**	6.770**
	(3.11)	(2.53)	(2.08)
CapU	0.002*	0.001	0.001
	(1.69)	(1.32)	(1.21)
CapU*Upstream*IV	-0.063**	-0.051	-0.055
	(-2.00)	(-1.53)	(-1.51)
MRET	0.000**	0.000**	0.000**
	(2.05)	(1.97)	(2.05)
TVOL	3.118***	3.182***	3.151***
	(3.85)	(3.91)	(3.90)
Size	-0.025***	-0.026***	-0.025***
	(-3.02)	(-3.06)	(-2.97)
Leverage	0.341***	0.328***	0.346***
	(5.15)	(4.94)	(5.23)
EP	0.272***	0.269***	0.268***
	(3.03)	(2.98)	(2.98)
BP	-0.019*	-0.019*	-0.018
	(-1.81)	(-1.76)	(-1.63)
DP	-0.002***	-0.002***	-0.002***
	(-3.10)	(-2.86)	(-2.76)
SGR	-0.000	-0.000	-0.001
	(-0.89)	(-1.04)	(-1.32)
N	2,302	2,304	2,305
Adjusted R^2	0.0409	0.0381	0.0384

1. Definition of variables:

- $Retvol_{i,t}$ = standard deviation of daily return. Event window is [-1, 3] including the earnings announcement date in period t.
- $Upstream_{i,t}$ = 1 if the company i for period t belongs to the upstream industries, 0 otherwise.
- $IV_{i,t}$ = standard deviation of three-year/four-year/five-year operating income for firm i in period t for each model.
- $Capacity_{i,t}$ = ratio of actual manufacturing performance to practical capacity for firm i in period t.
- $MRET_{i,t}$ = market-adjusted buy-and-hold stock return measured over a year's time for firm i in period t.
- $TVOL_{i,t}$ = average monthly trading volume relative to total shares outstanding measured over the period t.
- $Size_{i,t}$ = log of market value of equity for firm i at the beginning of the period t.
- $Leverage_{i,t}$ = ratio of debt to asset for firm i at the beginning of the period t.
- $EP_{i,t}$ = ratio of income before extraordinary items to market value of equity for firm i in period t.
- $BP_{i,t}$ (= $Growth_{i,t}$) = ratio of book value of equity to market value of equity for firm i at the end of the period t.
- $SGR_{i,t}$ = percentage change in annual sales for firm i in period t.

2. All variables are truncated at 1% and 99%.

3. The table presents OLS coefficient estimates and t-statistics in parentheses.

4. *,**,*** : Statistical significance at the 10%, 5% , 1% two-tailed levels, respectively.

요약(국문초록)

본 연구는 공급사슬 내 영업위험이 이익변동성과 주가에 어떠한 영향을 미치는 지를 분석한다. 또한 공급사슬 내 영업위험이 이익변동성과 주가에 영향을 미치는데 있어 가동률의 영향을 분석한다. 연구결과는 다음과 같다. 첫째, 영업위험이 높은 상부 산업은 하부 산업에 비해 이익변동성이 높고, 따라서 주가성과가 더 낮다. 이는 상부 산업은 하부 사업에 비해 아웃소싱의 기회가 제한되므로 설비투자 및 고정원가의 부담을 지게 되고 이것이 높은 영업위험으로 이어진다는 점에서 이해할 수 있다. 둘째, 가동률이 높을 경우로 한정했을 경우, 높은 이익변동성은 상부 산업의 낮은 주가성과를 설명하는데 있어 효과적이다. 이는 영업위험이 하방 위험의 성격을 가지고 있다는 점에서 이해할 수 있다. 본 연구는 공급사슬 내 기업들 간에 전가되는 영업위험에 대한 실증 연구결과를 제공한다.

주요어: 공급사슬성과, 상부 산업, 영업위험, 이익변동성, 가동률

학번: 2014-20493