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Getting down to brass tacks: Is your organization really aligned?

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Chapter 3

You Get What You Pay For: CEO Compensation and the Inventory Rhombus

Causarum enim cognitio cognitionem eventorum facit (Knowledge of causes produces knowledge of results)

Cicero

Abstract

We provide the first empirical evidence of a relationship between an important organizational feature, the structure of executive compensation and inventory investments. The characteristics of compensation that we consider are the sensitivity of the chief executive officer's (CEO's) option portfolio to the stock price (SSP) and the sensitivity of the CEO's option portfolio to the stock return volatility (SSV), both of which are frequent subjects of media discussion. Our results highlight that CEO compensation affects inventory investment both directly and in multiple indirect ways. In particular, we find that a 20% increase in SSP is associated with a reduction in capital invested in inventory by approximately US$ 1.652M and that moving from the 20th to the 80th percentile in terms of SSP is associated with a reduction in capital invested in inventory by approximately US$ 22.6M. This finding confirms that CEOs whose compensation is more dependent on the stock price follow less risky strategies. We further reveal that a 20% increase in CEOs' SSV is associated with an increase in capital invested in inventory by approximately US$ 0.873M. This association corresponds to an increase of US$ 12.5M in capital invested in inventory when shifting from the 20th to the 80th percentile in terms of SSV and confirms that increasing SSV motivates risk-seeking behavior. Furthermore, we use the context of this study to show that the triangular interdependence among inventory investment, gross margin, and cost of goods sold (COGS), as proposed by past operations management (OM) research, also applies to manufacturing industries. We further develop this model by including sales effort and conceptualize the inventory rhombus.

3.1 Introduction

The appropriate design of incentives has been a major topic in academia and practice in recent decades (Dai and Jerath, 2013). As a result of stagnating share prices and the emergence of agency theory during the 1970s, there has been a movement to align executives' compensation with shareholders' interests (Currim et al., 2012). Since then, in the United States and nearly all other parts of the world, intense debates have taken place concerning the absolute amount of CEO compensation, its composition, and its effects on managers' decision-making. Consequently, over the last 20-30 years, the composition of CEO compensation packages has undergone substantial changes (Murphy, 2002; Frydman and Jenter, 2010).

Politicians and the media have recently voiced the criticism that executives are not held responsible for the consequences of their decisions. Therefore, a committee comprising the Federal Reserve, the Securities and Exchange Commission (SEC), the Federal Deposit Insurance Corporation, the Federal Housing Finance Agency, the National Credit Union Administration, and the Office of the Comptroller of the Currency is developing a rule that "[...] aims at eliminating bonus structures that could encourage the excessive risk taking [by requiring] [...] that bonuses should balance risk and rewards, be compatible with risk management practices and be supported by strong corporate governance" (Chon, 2014, p. 15). In a related press article, Wong (2014, pp. 1-2) states that the UK Corporate Governance Code is also being updated because "[...] an inordinate emphasis on financial incentives can contribute to damaging behavior, from manipulating reported earnings to underinvesting in activities critical to sustaining success."

Notably, although the emerging stream of behavioral operations particularly addresses human nature in decision-making processes, we are not aware of any study in the operations management (OM) field that has considered executive compensation as an explanatory variable of inventory investment, although decisions regarding inventory investments always require a careful trade-off between the risk of obsolescence and the risk of missing sales opportunities. Furthermore, OM theory states that a company's inventory investment is a function of sales and gross margin, which, in turn, are functions of price. Accordingly, we have reason to believe that if compensation schemes influence some or all of these determinants, there might also be several mediating mechanisms through which CEO compensation affects inventory investment. For example, Guay (1999) and Core and Guay (2002) show that increasing the degree to which CEO compensation depends on firms' stock price increases CEOs' risk exposure and hence induces them to forgo some positive present value projects, such as entering (small) new markets. Accordingly, we expect firms' inventory investments to decrease in expectation of lower mean demand, as predicted by the newsvendor (NV) model, if the degree to which CEO compensation is contingent on the stock price is increased.

In general, OM studies on the financial drivers of inventory investment are rare. For example, Gaur et al. (2005) find a negative correlation between gross margin and inventory turns, Rumyantsev and Netessine (2007b) find a positive correlation between margin and the inventory-to-COGS ratio, and Kesavan et al. (2010) assert the interdependence of inventory levels, gross margins, and COGS. Thus, we study a different financial aspect that potentially drives inventory/stocking decisions, namely, executive compensation. This analysis is critical because if executive compensation has direct and indirect effects on inventory levels, then our understanding of organizational processes, and particularly the drivers of inventory investment, may be myopic.

Furthermore, we use the context of our study to propose the incorporation of sales effort in econometric models when analyzing firm-level inventories. In this way, we capture the fact that in addition to gross margin and COGS, the sales effort of an organization (e.g., market research, corporate advertising, salesforce size) affects inventory investment, and vice versa. We conceptualize these interdependencies in the "inventory rhombus" and propose a simultaneous equation model to capture these endogenous feedback loops econometrically.

We use the context of U.S. public manufacturing companies to answer the question of whether CEO compensation affects inventory investment. The aspects of compensation that we consider are the sensitivity of CEOs' option portfolio to the stock price (SSP) and the stock return volatility (SSV). Based on existing OM theory, competing effects might be associated with an increase or decrease in SSP and SSV. We find that CEO compensation indeed has direct and multiple indirect effects on inventory investment. We identify the dominant of the competing hypotheses in the literature and show that an increase in SSP is associated with a reduction in inventory investment, while the effect of increasing CEOs' SSV increases the amount of capital invested in inventory – despite the presence of countervailing indirect effects. As such, our findings provide valuable insights into the complex dynamics in organizations and the effects of managerial incentives on inventory investment. We perform numerical experiments to substantiate the economic significance of our findings and perform various robustness tests based on previous OM research to reinforce the (statistical) validity of our findings.

The rest of the chapter is structured as follows: In §3.2, we provide an overview of the related literature. In §3.3, we conceptualize the inventory rhombus and present our hypotheses. In §3.4, we present the research setup, describe the data, and define the variables. In §3.5, we explain our estimation methodology, present the results, and perform several robustness checks. In §3.6, we discuss the implications and limitations of our work and propose directions for future research.

3.2 Literature Review

OM textbooks (e.g., Cachon and Terwiesch, 2013) extensively discuss models to determine optimal stocking and ordering quantities, the NV model and the economic order quantity (EOQ) being the most famous. This literature forms the basis of our theory. Furthermore, two streams of literature are relevant for our study: (1) the economics, finance, and marketing literature, which discusses the effect of CEO compensation on managerial decision-making, and (2) the growing body of OM literature, which uses publicly available data to analyze firm-level inventories.

3.2.1 CEO Compensation and Managerial Decision Making

The principal-agent (PA) problem between shareholders and executives has existed since the separation of corporate ownership from corporate control (Berle and Means, 1932; Frydman and Jenter, 2010). If shareholders cannot have perfect knowledge of CEOs' intentions and decisions, and if CEOs are self-interested, then CEOs are likely to pursue the maximization of their own utility at the expense of shareholders. Among others, Jensen and Meckling (1976) find that PA problems can be detrimental to firm value; however, these problems can be alleviated by carefully designing CEO compensation packages that align the interests of shareholders and managers.

Although equity-based compensation has become a standard motivational tool, research on the effects of various characteristics of executive compensation is fragmented. Through an examination of a sample of oil and gas producers, Rajgopal and Shevlin (2002) provide empirical evidence that CEOs with greater SSV are likely to invest in more risky projects. This finding is confirmed by Coles et al. (2006) based on a broad sample of firms covering various industries. The authors show further that greater CEO SSP provides an incentive to favor the implementation of less risky strategies, which is in line with the findings of Guay (1999). Cheng (2004) reveals a positive correlation between risky investments (R&D spending) and CEOs' annual option grants when the firm experiences an earnings decline or small loss and when the CEO approaches retirement, and Currim et al. (2012) show that an increase in equity-based compensation relative to the bonus leads to increases in advertising and R&D expenditures as a share of sales.

Also in the context of myopic management, research has established a relationship between management compensation and investment behavior. For example, Graham et al. (2005) survey top executives and conduct interviews to determine factors that drive earnings management and disclosure decisions. Of the respondents, 79.9% indicate that when facing a situation in which their company does not seem to meet the desired earnings, they would reduce discretionary spending, such as advertising and R&D. Additionally, 55.3% would delay the start of a new project even if this delay would lead to small mid- to long-term value losses. Furthermore, 39.1% would attempt to push products to their customers by providing incentives, implying that managers are willing to disrupt current processes to meet short-term financial targets. Based on their findings, Roychowdhury (2006) demonstrates that managers manipulate real activities – such as providing price discounts to temporarily increase sales, reducing discretionary expenditures, and inducing overproduction to report lower COGS, all of which are associated with inventory investments and potential future losses – to avoid reporting current profit declines that could hurt their own compensation. Similarly, Chakravarty and Grewal (2011) find that investors' expectations of financial performance induce managers to adjust marketing and R&D budgets. In a retail setting, Chapman and Steenburgh (2011) show that managers significantly intensify the use of and adjust the marketing mix to boost short-term earnings rather than decreasing advertising expenditures. However, the authors also provide evidence that managers are willing to sacrifice long-term firm value to meet short-term targets.

Overall, previous research suggests that CEO compensation has an effect on executives' risk preferences and, accordingly, affects operational, tactical, and strategic decisions. There is considerable evidence that CEOs' preferred strategies and actions often serve personal motives (and those of shareholders) but are not necessarily optimal for firms' long-term value.

3.2.2 Empirical OM Literature

Given the high practical relevance of inventory management, empirical research in OM has analyzed the development of inventory performance over time, linked various inventory metrics to financial performance, and determined drivers of inventory levels and inventory performance. In their pioneering work, Chen et al. (2005, 2007) investigate the development of firm-level inventories in the manufacturing and retailing industries and analyze whether abnormal inventories are indicative of abnormal stock returns. The authors reveal that inventory holdings mainly declined in the periods 1981-2000 and 1981-2004 and that firms with abnormally high inventories yield abnormally poor long-term stock returns. Whereas Chen et al. (2005) show that manufacturing firms with slightly lower-than-average inventory holdings (deciles 4 and 3) yield positive abnormal returns, Chen et al. (2007) do not find evidence of such a relationship for retailers and wholesalers. Building upon these findings, Steinker and Hoberg (2013) utilize a dataset of manufacturing firms over the period 1991-2010 and analogously demonstrate that abnormal stock returns monotonically decrease in abnormal year-over-year inventory growth and that abnormal stock returns increase in within-year inventory volatility.

Kesavan et al. (2010) and Kesavan and Mani (2013) explore the impact of inventory-related information on analysts' earnings and sales forecasts. Kesavan et al. (2010) find that including information on the cost of goods sold, inventory levels, and gross margins as endogenous variables in a sales forecast improves forecast accuracy, although analysts do not typically consider all of this information. Kesavan and Mani (2013) elaborate on the finding of analysts' failure to fully incorporate the information contained in past inventory and provide evidence for an inverted U-shaped relationship between abnormal inventory growth and one-year-ahead earnings, implying that inventories are necessary to capitalize on (additional) demand but become detrimental once they exceed a certain point. Eroglu and Hofer (2011) relate companies' inventory leanness to the return on sales and the return on assets. The authors also find that for most manufacturing industries the relationship between inventory leanness and financial performance is concave. In a recent study, Alan et al. (2014) find that inventory turnover predicts future stock returns of publicly listed U.S. retailers and that despite its predictive power, investors fail to incorporate inventory information into investment decisions. Hendricks and Singhal (2005a, 2009) use event studies applied to stock market and accounting data to study the effect of public announcements regarding operations on firm performance. The authors show that under- and oversupply lead to significant declines in both current and future stock returns and that announcements related to excess inventory, compared with product introduction delays and production disruptions, clearly have the greatest effect on the equity volatility of companies.

The literature that is most related to our work uses firm-level variables to explain inventory investments. In a study of 311 retail firms, Gaur et al. (2005) find that gross margin is negatively correlated with inventory turns, while capital intensity and sales surprise (the ratio of actual sales to expected sales) are positively related to inventory turnover. Rumyantsev and Netessine (2007b) test several hypotheses derived from classical inventory models in a cross-industry sample and find positive associations between the inventory-to-COGS ratio and the degree of demand uncertainty, lead time length, and gross margins; the authors further show that larger companies tend to have lower inventory levels but find only mixed evidence for the association between inventory holding costs and inventory levels.

Croson and Donohue (2003, 2006) study ordering behavior in a supply chain setting from a behavioral perspective. After controlling for operational causes of the bullwhip effect (e.g., batching, price fluctuation), they observe the persistence of the bullwhip effect, even when information on inventory levels is shared. These results imply that behavioral aspects and causes, which may be affected by incentive structures, must be taken into account when analyzing inventory investments. Analyzing the fiscal year-end effect, Lai (2007) finds that inventories are reduced by 10%, on average, in the fourth fiscal quarter and that the reduction of fiscal year-end inventories is the result of higher sales at lower margins. The author proposes that this behavior is induced by managerial incentives.

3.3 Conceptual Framework and Hypotheses

Inventory investment is a key asset for most firms, and its strategic and operational importance has been extensively discussed in the literature. Recent research shows that inventory investment, COGS, and gross margin are jointly determined (Kesavan et al., 2010; Kesavan and Mani, 2013; Jain et al., 2014). However, all of these variables are also affected by and may in turn affect sales efforts. We label the interdependence of these variables as the inventory rhombus. Because decisions regarding the budget allocation to and prioritization of each of these factors will commonly be approved by the CEO and assuming that CEOs have particular risk preferences that are dependent on the compensation schemes, as suggested by prior research, we expect CEO compensation to influence inventory investment directly and in multiple indirect ways.

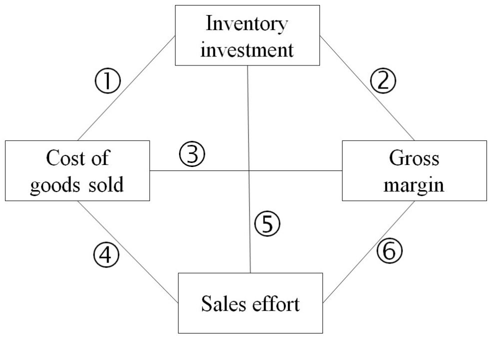
3.3.1 The Inventory Rhombus

We conceptualize the interdependence of inventory levels, gross margins, COGS, and sales effort to support the idea that our understanding of inventory investments may be fragmentary if sales effort is neglected in the empirical analysis of firm-level inventories. The triadic interdependence among inventory investment, gross margin, and COGS (links 1, 2, and 3, respectively, in Figure 3.1) has been proposed by Kesavan et al. (2010) and has since been considered the state-of-the-art model with respect to the analysis of inventory investment (Kesavan and Mani, 2013; Jain et al., 2014).

As predicted by the EOQ and the NV model, inventory levels are increasing in mean demand; vice versa, greater inventory levels may increase demand through the provision of higher service levels and greater product variety and stimulate demand by means of product pressure (link 1) (e.g., Balakrishnan et al., 2004). Inventory levels and gross margins (link 2) influence each other because having more products in stock increases the likelihood of (future) markdowns, whereas higher margins – as predicted by the NV model – increases the incentive for companies to hold more inventory (e.g., Cachon and Terwiesch, 2013). Because demand is a decreasing function of price, gross margin is negatively correlated with demand (approximated by COGS), whereas for a given inventory level, greater demand may allow for economies of scale in production and/or higher price enforceability in the market place and, thereby, increase margins (link 3) (Kesavan et al., 2010).

COGS and sales effort influence each other because according to standard marketing theory, increasing sales effort often increases demand (e.g., Hanssens et al.,

Figure 3.1: The inventory rhombus



2001), whereas greater demand either increases cash flows and hence enables firms to increase sales efforts, e.g., promotions (the "affordability" method of advertising budgeting (e.g., Joseph and Richardson, 2002)) or allows firms to reduce promotions owing to the market exit of a competitor, network effects, or other factors (link 4). In expectation of increasing future demand as a result of additional sales effort, companies may increase inventory investment (link 5), which is in line with classic inventory theory (Cachon and Terwiesch, 2013). Alternatively, owing to "abnormally" high or low inventory levels, managers may decide to intensify or reduce the adoption of marketing instruments (Sogomonian and Tang, 1993; Smith and Achabal, 1998). Finally, gross margins and sales effort are related because high gross margins may be enforceable in the market only if brand equity has been built up from intense marketing (Stahl et al., 2012) and/or customers' willingness to pay increases owing to better service, which is facilitated by a lower sales-representative-to-customer ratio. In contrast, a cost leadership strategy (low gross margins) may be realizable only if salesforce, advertising, and market research (i.e., sales efforts) expenses are reduced (link 6).

In addition to the aforementioned direct effects, there are $4 \times 4 \times (4 - 1) = 48$ potential indirect effects, for which we provide four selected examples to show the occurrence of these effects in practice. Because of lower-than-expected sales, companies may suffer from high inventories, which they clear out by cutting prices (links

1 → 2). This situation is described in a Wall Street Journal article from November 2010: "Sony and its TV rivals, Samsung Electronics Co. and LG Electronics Inc., have already said they expect price competition to be especially fierce this holiday season because manufacturers are sitting on excess inventory from aggressive growth targets" (Wakabayashi, 2010, p. 1). In the same article, an example of a path 1 → 3-effect is provided when Sony's CEO states that "[...] the company will again look to keep inventory levels low, even if that means forgoing some sales opportunities by not having enough supply [..]" to prevent recurring price cuts at the expense of margins. Advertising has also been suggested to overcome unexpectedly low sales that cause excess inventory, path 1 → 5. Following Blackberry's announcement of further financial disappointments and growing inventories due to decreasing sales, Jim Balsillie, the co-CEO of RIM (Research in Motion), stated "[...] that until the [new] Blackberry 10 phones arrive, RIM would start spending heavily on advertising and other promotions in the United States to attract buyers for the BlackBerry 7 phones, which were introduced during last year" (Austen, 2011, p. 6). Finally, in the automotive industry, path 4 → 1 → 2-causation was observed when Chrysler's demand increased significantly as a result of promotional campaigns and the economic recovery by the end of 2010. However, many customers postponed the purchase of a new vehicle "[...] because of the inventory shortages earlier this year [2010] that caused prices to rise" (Bunkley, 2011, p. 19).

These real-world observations provide some anecdotal justification for the specification of the inventory rhombus as depicted in Figure 3.1. The fact that causation seems to run in all directions between each of these variable combinations is important for the econometrical considerations that will be discussed in §3.4.3.

3.3.2 Executive Compensation and Inventory Investment

CEOs are responsible for the strategic task of effectively allocating limited resources to achieve a competitive advantage, which ultimately leads to superior financial performance. This task requires the simultaneous fulfillment of, and careful trade-off between, two processes: the creation of customer value (e.g., by innovating, producing, and supplying products to the market) and the appropriation of value in the market (i.e., capitalization) by isolating the firm from competitive forces through brand and reputation effects, advertising, distinctive service offers and network externalities, and so forth (Drucker, 1954; Mizik and Jacobson, 2003). Top executives who must make these decisions, which affect the firm's strategy and competitive positioning and, ultimately, financial performance, are compensated to a great extent based on stock options (Guay, 1999; Core and Guay, 2002; Coles et al., 2006; Frydman and Jenter, 2010). Therefore, it is not surprising that lower-level managers learn over time to submit tactical and operational plans that are aligned with the objectives and risk preferences of top executives and that are therefore more likely to be approved (Fama and Jensen, 1983; Joseph and Richardson, 2002). Consequently, although CEOs are not involved in day-to-day operations, their compensation schemes and intentions are reflected in the decisions and plans of lower-level managers, including decisions regarding pricing, sales effort, supply chain design, and inventory investment (Currim et al., 2012).

If shareholders cannot have perfect knowledge of the intentions and decisions of CEOs, and if CEOs are self-interested, they are likely to pursue the maximization of their own utility at the expense of shareholders (Berle and Means, 1932; Frydman and Jenter, 2010). The economic literature views the SSP of the CEO stock option portfolio as a balancing mechanism to align the interests of CEOs and shareholders because executives share gains and losses with shareholders (Guay, 1999; Core and Guay, 2002). However, increasing SSP also means that the CEO is exposed to more risk (McConnell and Muscarella, 1985; Guay, 1999; Core and Guay, 2002; Coles et al., 2006). Because CEOs tend to hold less diversified portfolios relative to shareholders (i.e., their total wealth is more dependent on the firm's financial performance), the relative exposure to risk will be greater for CEOs than for shareholders, such that it may be rational for executives to forgo some positive present value projects (Fama, 1980; Wu and Tu, 2007). Consequently, higher SSP may induce managers to implement less risky strategies, as suggested by Guay (1999) and Core and Guay (2002).

Based on OM theory, two opposing effects with respect to inventory investment could occur. On the one hand, a decision maker whose pay is more sensitive to changes in the stock price, and who therefore is more risk averse, may hedge against operational risks and the potential to miss sales opportunities by maintaining higher safety stocks and leverage less on concepts such as lean production and/or JIT practices that are known to increase the vulnerability of supply chains (Cachon and Terwiesch, 2013). On the other hand, a CEO whose pay is more sensitive to changes in the stock price might place substantial emphasis on the efficient management of inventories and thus focus on topics such as lean practices and supply chain information technology in order to hedge against the risk of obsolescence, thereby experiencing lower inventory investment. Therefore, we formulate two competing hypotheses (H):

H1a: The direct effect of greater SSP is associated with lower inventory investment.
H1b: The direct effect of greater SSP is associated with higher inventory investment.

To overcome the problem of executives forgoing some positive present value projects, they can be motivated to invest in more risky strategies by increasing CEOs' SSV, as shown by prior research (e.g., Guay, 1999; Rajgopal and Shevlin, 2002; Coles et al., 2006). However, based on our previous arguments, from the OM literature, the direct effect of inducing the CEO to be less risk averse on inventory investment is unclear. On the one hand, the decision maker might strive for operational efficiency gains by implementing modern inventory management practices and/or centralizing warehouses; these actions are typically associated with lower inventory investment. On the other hand, a risk- and opportunity-seeking CEO might engage in higher inventory investment as a consequence of product and/or market expansion strategies. Therefore, we formulate two competing hypotheses:

H2a: The direct effect of greater SSV is associated with lower inventory investment.
H2b: The direct effect of greater SSV is associated with higher inventory investment.

In addition to these opposing predictions regarding the direct effects of SSP and SSV on inventory investment, owing to the various indirect effects explained in § 3.3.1, it is difficult to predict the total effect of SSP and SSV on inventory investment. For example, Mizik (2010) finds that if executives' incentives are strongly tied to the stock price, CEOs place less emphasis on (risky) sales effort projects, such as promotions. Thus, if increased SSP (SSV) causes a decrease (increase) in sales effort, and if decreased (increased) sales effort induces managers to decrease (increase) inventory investment in expectation of lower (higher) demand, then the indirect effect of SSP (SSV) on inventory (through sales effort) would be negative (positive). However, if increasing SSP (SSV) simultaneously induces CEOs to increase (decrease), for example, gross margins – because they do not invest in small positive present value projects and, accordingly, margins increase on average – then increasing SSP (SSV) will indirectly lead to higher (lower) inventory investment, as predicted by the NV model.[1]

To make predictions regarding the effects of SSP and SSV on inventory investment, from the OM point of view, we are most interested in the total effect of these variables. However, because of the multitude of indirect effects and the ambiguity with regard to the direct effects of SSP and SSV on inventory investment, we again formulate two competing hypotheses for each of the measures, which are best investigated empirically:[2]

H3a: The total effect of greater SSP is associated with lower inventory investment.

H3b: The total effect of greater SSP is associated with higher inventory investment.

H4a: The total effect of greater SSV is associated with lower inventory investment.

H4b: The total effect of greater SSV is associated with higher inventory investment.

[1] Adjustments of SSP and SSV may also induce CEOs to initiate overproduction (Roychowdhury, 2006) to decrease COGS because under absorption costing, fixed overheads are allocated to the units sold. Hence, if products are not sold in the same period and are therefore accounted for as finished goods inventory (FGI), a portion of the fixed overheads will be assigned to the FGI rather than being directly and fully expensed as COGS.

[2] Due to space constraints, we do not develop hypotheses regarding each of the indirect effects.

3.4 Methodology

3.4.1 Description of the Data

We construct our data set by linking four sources of data: (i) First, we use information on executive compensation provided by the Standard & Poor's Execucomp database, which provides information on top executives' salary, bonus, and stock options from 1992 onward from Standard & Poor's S&P 500 LargeCap, S&P 400 MidCap, and S&P 600 SmallCap indices in the United States. To the best of our knowledge, this database has so far been utilized only by Swink and Jacobs (2012) in an OM context. (ii) To empirically analyze the hypothesized associations while controlling for firm-level financial characteristics that are known to influence inventory investment (Gaur et al., 2005; Rumyantsev and Netessine, 2007b; Eroglu and Hofer, 2011; Jain et al., 2014), we collect annual financial data from Standard & Poor's Compustat-North American database. (iii) In addition to firm-level financial characteristics, business cycles affect most of our variables. To control for macroeconomic growth as measured by the gross domestic product (GDP), we obtain annual values for GDP from the Bureau of Economic Analysis at the U.S. Department of Commerce. (iv) To calculate the current value of stock options held by CEOs, we collect annual risk-free rates based on Treasury securities from the website of the Board of Governors of the Federal Reserve System.

Our analysis focuses on the manufacturing, mining, and construction industries. Hence, we retain only companies that are assigned to the two-digit standard industrial classification (SIC) codes between 10 and 39 and exclude all other firms. To obtain our final sample, we validate our data and proceed as follows: In line with Guay (1999), we exclude CEOs from our sample if they own more than one-third of the focal firm's common stock because it is doubtful that such compensation schemes have been designed for contracting purposes. High inventory investments can also be caused by mergers and acquisitions (M&A). Because inventory investment is our key interest, we must control for these effects. We remove from our sample firm-years during which companies have been involved in major M&As using the Compustat footnote code "aquepsy_fn" (Hribar and Collins, 2002). Consistent with other empirical studies, we winsorize all variables at the .01-level to avoid biases caused by outliers and potentially erroneous data entries (Chen et al., 2005, 2007; Kesavan and Mani, 2013).[3] Our final sample comprises 1,398 companies and 15,943 observations and spans a period of 19 years (1992-2010).

3.4.2 Variable Operationalization

Throughout the chapter, we use the following notations to account for time-specific (fiscal year $t = 1, \ldots, 19$) and company-specific ($i = 1, \ldots, 1,398$) effects. Accordingly, for fiscal year t and firm i, we denote absolute inventory as INV_{it}; net sales as SAL_{it}; cost of goods sold as $COGS_{it}$; selling, general, and administrative costs as SGA_{it}; base salary as $BSAL_{it}$; total assets as TA_{it}; property, plant, and equipment as PPE_{it}; net income as NI_{it}; depreciation as DP_{it}; research and development expenditure as RD_{it}; market value as MV_{it}; and the LIFO reserve as $LIFO_{it}$. All of these figures are expressed in monetary terms at the end of a period.

In line with prior research (e.g., Kesavan et al., 2010), we operationalize gross margin as $GM_{it} \equiv SAL_{it}/(COGS_{it} - LIFO_{it} + LIFO_{i,t-1})$. We use selling, general, and administrative (SG&A) costs as a proxy for sales effort. SG&A costs are major non-production expenses that comprise sales staff, advertising, market research, distribution, and executive overhead. However, for some companies in the Compustat database, SG&A costs also include R&D expenses. Therefore, we remove these expenses from SG&A costs. Using SGA_{it} minus RD_{it} as a proxy for sales effort is grounded in the marketing science literature; in particular, Mizik and Jacobson (2007, p. 367) argue that analyses based on this operationalization "[...] can be expected to provide more powerful tests than an analysis based on a single marketing spending item (e.g., advertising), because it includes more expenditure items [...] that firms may seek to limit in an attempt to inflate earnings [...]" (see also Dutta

[3]Our results are not sensitive to these adjustments.

et al., 1999; Luo, 2008). Additionally, using SG&A costs as opposed to advertising expenses allows us to preserve a larger sample. Therefore, we define sales effort as: $SEF_{it} \equiv (SGA_{it} - RD_{it})$.

Because equity-based compensation, in the form of stock and stock options, has grown overproportionally in recent decades (e.g., Frydman and Jenter, 2010), CEOs' compensation has become much more sensitive to stock prices (Jensen and Murphy, 1990; Hall and Liebman, 1997; Coles et al., 2006). Among others, Guay (1999) shows that stock options in particular, but not stock holdings, have a significant effect on the sensitivity of CEOs' total compensation to stock price changes; therefore, they need to be managed with great caution.

An increase in the SSP of CEOs' option portfolio is viewed as aligning the incentives of executives with those of shareholders. As proposed by Core and Guay (2002), we define SSP as the change in the dollar value of CEOs' option portfolio per one percent change in the stock price. We employ sensitivity measures as opposed to an equity-to-bonus ratio, as performed by Currim et al. (2012),[4] because according to Core and Guay (2002, p. 616), "[...] proxies that fail to capture variation in options' characteristics [e.g., price-to-strike ratio] are likely to measure portfolio sensitivities with considerable error." To obtain estimates for SSP, we must first determine the current value of the options held by the CEO of firm i in year t, OV_{it}. Consistent with prior research, we use the Black and Scholes (1973) formula for the valuation of European call options as modified by Merton (1973) to account for dividend payouts to estimate the value of stock options (e.g., Guay, 1999; Core and Guay, 2002; Rajgopal and Shevlin, 2002; Coles et al., 2006):

$$OV_{it} = [SP_{it}e^{-d_{it}T_{it}}N(Z_{it}) - X_{it}e^{-r_tT_{it}}N(Z_{it} - \sigma_{it}\sqrt{T_{it}})], \quad (3.1)$$

where

[4] The authors measure the equity-to-bonus ratio as follows: Equity/Bonus=(stock options + restricted stock granted)/bonus.

SP_{it} = price of the underlying stock of firm i in year t,

d_{it} = natural logarithm of expected dividend yield over the life of the option of firm i based on year t,

T_{it} = time to maturity of the option [in years] for firm i based on year t,

N = cumulative probability function for the normal distribution,

Z_{it} = $\frac{ln(\frac{SP_{it}}{X_{it}})+T_{it}(\frac{r_t-d_{it}+\sigma_{it}^2}{2})}{\sigma_{it}\sqrt{T_{it}}}$,

X_{it} = exercise price of the option of firm i in year t,

r_t = natural logarithm of the risk-free interest rate in year t,

σ_{it} = expected stock return volatility over the life of the option of firm i based on information available in year t.

The sensitivity of a CEO's option portfolio of firm i in year t to a 1% change in stock price (SP) is then obtained by Equation (3.2):

$$SSP_{it} \equiv \frac{\delta OV_{it}}{\delta SP_{it}} * \frac{SP_{it}}{100} = e^{-d_{it}T_{it}} N(Z_{it}) * \frac{SP_{it}}{100}. \tag{3.2}$$

However, because all relevant information for newly granted stock options is disclosed only in annual proxy statements, extensive data collection from past proxy statements and careful determination of previously exercised and remaining stock options would be required. Accordingly, estimation of such "full information" sensitivities to stock price and stock price volatility would require proxy statements from the last ten years, if options are granted with ten-year maturities. Therefore, we employ the one-year approximation method derived by Core and Guay (2002), which has been shown to capture more than 99% of the variation in the option portfolio value and the sensitivities and has become the standard method of determining employee stock option portfolio values. This method requires only the most recent proxy statement and can summarized as follows:[5] "New option grant values and

[5]Detailed information regarding the computational details is provided in Core and Guay (2002) and Coles et al. (2013). For a recent application of this approximation method, see, e.g., Coles et al. (2014).

sensitivities are computed directly [as described above] because the proxy statement discloses all the inputs necessary for the Black-Scholes model. The proxy statement discloses separate information on exercisable and unexercisable previously granted options, and we treat these two types of options as two single grants. The exercise price of each 'grant' is derived from the average realizable value of the options, and we assume that unexerciseable options have a time-to-maturity that is three years greater than that of the exercisable option" (Core and Guay, 2002, p. 617).

As described in §3.3.2, PA problems, such as a CEO's greater risk aversion to projects than that of shareholders, can be alleviated through the careful inclusion of compensation components that reduce executives' risk aversion. Among others, Smith and Stulz (1985), Guay (1999), Core and Guay (2002), and Coles et al. (2006) suggest that increasing CEOs' SSV reduces the likelihood of CEOs passing up valuable projects. We again employ the one-year approximation method of Core and Guay (2002) and define SSV as the change in the value of a CEO's option portfolio associated with a .01 change in the annualized standard deviation of stock returns:

$$SSV_{it} \equiv \frac{\delta OV_{it}}{\delta STRV_{it}} * .01 = e^{-d_{it}T_{it}} N'(Z_{it}) * \sqrt{SP_{it}T_{it}} * .01, \tag{3.3}$$

where $STRV_{it}$ is the stock return volatility and N' is the normal density function.

After the change in accounting policy for the reporting of employee stock options by the Financial Accounting Standards Board (FASB) in 2006 (FAS No. 123R), Execucomp stopped providing information on stock return volatility, dividend yield, and the risk-free rate corresponding to the maturity level of the option, which are required to determine OV_{it}, SSP_{it}, and SSV_{it}. To avoid restricting our analysis to the pre-2006 period, we obtain these values by following the procedure suggested by Coles et al. (2013, pp. 2-8). The correlation of the Black-Scholes values reported in Execucomp for the pre-2006 period and those based on our estimates of risk-free rate, volatility, and dividend yield is 99.2%, suggesting high validity of the proposed methodology. Hence, we can confidentially use this method to obtain proxies of these values for the post-2005 period.

In addition to our main variables of interest, we use a number of control variables that are motivated by prior studies. Because CEOs with higher cash compensation, i.e., higher base salaries ($BSAL_{it}$), have more performance-independent money available outside the firm, they can invest in more diversified private portfolios. Therefore, CEOs with higher base salaries tend to be less risk averse, as their total wealth is less contingent on firm performance; thus, prior research recommends including base salary in econometric models to proxy for managers' level of risk aversion (Guay, 1999; Coles et al., 2006).

According to Rumyantsev and Netessine (2007b) and Jain et al. (2014), the inventory investment is – aside from other factors – a function of sales surprise and demand uncertainty. To obtain these variables, we compute the sales forecast for firm i in period t using the Holt-Winters forecasting approach, where the weighting parameters for each firm are chosen to minimize the in-sample sum-of-squared prediction errors for each time series (SF_{it}). Based on the forecast, we operationalize the sales surprise as: $SS_{it} \equiv SAL_{it}/SF_{it}$. To the best of our knowledge, there is no standard method of measuring demand uncertainty in the OM literature. Thus, because we use annual data, we take the absolute forecast error for each firm i and year t as proxy for demand uncertainty,[6] i.e., $DU_{it} \equiv ((SAL_{it} - SF_{it})^2)^{.5}$.

According to Gaur et al. (2005) and Rumyantsev and Netessine (2007b), investments in supply chain- and inventory-related infrastructure, such as information technology, that might reduce inventory investment are accounted for as fixed assets and should therefore be captured by an increase in capital intensity. In line with Jain et al. (2014), we operationalize capital intensity as $CI_{it} \equiv PPE_{it}/(TA_{it} - INV_{it})$ and include it in our model. Furthermore, the inventory investment may be affected by the firm's growth potential; therefore, we control for projected business growth, approximated by the ratio of the market value of equity to the book value of equity, GP_{it} (Fama and French, 1995; Hendricks and Singhal, 2009). Following resource-based theory and the "affordability principle", we define sales effort as a function

[6] In §3.5.2, we perform various robustness checks; among others, we operationalize $DU_{it} \equiv \frac{1}{k}\sum((SAL_{it} - SF_{it})^2)^{.5}$, where k is the sum of periods, and obtain qualitatively unchanged results.

Table 3.1: Summary statistics

			Standard Deviation			N	
Variables	Unit	Mean	Overall	Between	Within	Firms	Obs.
INV_{it}	US$ M	434.77	1,192.13	905.52	530.54	1,395	15,902
$COGS_{it}$	US$ M	2,760.66	11,086.52	8,083.27	4,809.69	1,398	15,939
GM_{it}	Percent	.22	6.83	3.16	6.20	1,398	15,931
SEF_{it}	US$ M	638.01	1,678.66	1,288.00	664.14	1,012	10,851
SSP_{it}	US$ K	177.62	437.31	219.65	370.34	1,382	12,342
SSV_{it}	US$ K	47.97	136.69	64.70	115.71	1,392	13,105
$BSAL_{it}$	US$ K	352.76	224.67	141.56	172.49	1,398	15,943
CI_{it}	Ratio	.32	.22	.21	.08	1,394	15,867
SS_{it}	Ratio	1.03	.2706	.0930	.2594	1,301	15,525
DU_{it}	US$ M	397.84	999.34	662.93	670.52	1,374	15,895
GP_{it}	Ratio	3.13	3.198	2.2027	2.445	1,398	15,935
GDP_{it}	US$ B	10,784.77	2,722.03	2,148.10	2,236.09	1,398	15,943
CF_{it}	US$ M	378.48	1006.03	753.46	480.90	1,397	15,900

of cash available (e.g., Joseph and Richardson, 2002), which is the rationale for controlling for cash flow ($CF_{it} \equiv NI_{it} + DP_{it}$) in the sales effort equation.

Finally, COGS, margins, inventory investment, and sales effort may be influenced by business cycles. Therefore, we control for macroeconomic growth as measured by GDP. We obtain annual GDP values, GDP_t, from the Bureau of Economic Analysis at the U.S. Department of Commerce and include these in the model. Table 3.1 provides the summary statistics of the variables in our study.

3.4.3 Model Specification

There are two major econometrical challenges in estimating the effects of SSP and SSV on inventory investment. First, recent empirical inventory research (e.g., Kesavan et al., 2010) and our discussion of the inventory rhombus (cp. §3.3.1) indicate that inventory investment is influenced by demand levels, margins, and sales effort but that inventory investment itself also influences these variables. The obvious conclusion from this discussion is that causation likely runs in both directions between each of the variable combinations; thus, the simultaneous determination of an equilibrium outcome is inevitable. As a result of the simultaneous determination, endogeneity occurs; this contemporaneous correlation between regressors and the error terms leads to inconsistency of the estimators if it is not explicitly controlled for (Baltagi, 2013). Second, in addition to the direct effects of SSP and SSV on inventory investment, we must account for multiple indirect effects through which inventory investment could be affected.

We employ the system of three simultaneous equations (3.4-3.6) introduced by Kesavan et al. (2010) and supplement this model by a sales effort equation (3.7) and the compensation-related variables. Following Gaur et al. (2005), Rumyantsev and Netessine (2007b), and Jain et al. (2014), we specify the equations in a log-multiplicative form, which has been shown to best fit the relationship between inventory metrics and a set of financial explanatory variables. We compute the natural logarithm of the relevant variables and denote these by their respective lowercase letters (e.g., $ln(COGS_{it}) = cogs_{it}$). Because prior research indicates that a firm's inventory investment, COGS, gross margins, and sales effort may also depend on unobserved firm-specific factors and may be subject to time-specific effects (e.g., trends), we include firm dummies (B_i, D_i, F_i, and J_i) and year dummies (T_r with $r \in [1, \ldots, 19]$) to account for unobserved heterogeneity between and within the firms.

Finally, all the dependent variables may be affected by firm-specific time-variant factors, such as brand strategy and strength or product variety, which cannot be measured directly with the data available; we proxy for these effects by including the respective lagged variables in each equation.

In line with past empirical OM research, in the inventory equation (3.4), we control for the cost of goods sold (cogs), gross margin (gm), capital intensity (ci), sales surprise (ss), demand uncertainty (du), growth potential (gp), and gross domestic product (gdp) (Gaur et al., 2005; Rumyantsev and Netessine, 2007b; Hendricks and Singhal, 2009; Jain et al., 2014). Additionally, we control for the inventory investment of the previous period ($inv_{i,t-1}$) to ensure that we capture only the change in inventory that results from CEO compensation. We supplement the above model with CEOs' sensitivity to the stock price (ssp) and CEOs' sensitivity to the stock return volatility (ssv) while controlling for the level of risk aversion by base salary (bsal) (Guay, 1999).

$$\begin{aligned} inv_{it} =& B_i + \alpha_{11} inv_{i,t-1} + \alpha_{12} cogs_{it} + \alpha_{13} gm_{it} + \alpha_{14} sef_{it} + \alpha_{15} ssp_{it} \\ &+ \alpha_{16} ssv_{it} + \alpha_{17} bsal_{it} + \alpha_{18} ci_{it} + \alpha_{19} ss_{it} + \alpha_{1,10} du_{it} \\ &+ \alpha_{1,11} gp_{it} + \alpha_{1,12} gdp_t + \tau_{1r} T_r + \epsilon_{it} \end{aligned} \tag{3.4}$$

$$\begin{aligned} cogs_{it} =& D_i + \alpha_{21} cogs_{i,t-1} + \alpha_{22} inv_{it} + \alpha_{23} gm_{it} + \alpha_{24} sef_{it} + \alpha_{25} ssp_{it} \\ &+ \alpha_{26} ssv_{it} + \alpha_{27} bsal_{it} + \alpha_{28} gdp_t + \tau_{2r} T_r + \epsilon_{it} \end{aligned} \tag{3.5}$$

$$\begin{aligned} gm_{it} =& F_i + \alpha_{31} gm_{i,t-1} + \alpha_{32} inv_{it} + \alpha_{33} cogs_{it} + \alpha_{34} sef_{it} + \alpha_{35} ssp_{it} \\ &+ \alpha_{36} ssv_{it} + \alpha_{37} bsal_{it} + \alpha_{38} gdp_t + \tau_{3r} T_r + \epsilon_{it} \end{aligned} \tag{3.6}$$

$$\begin{aligned} sef_{it} =& J_i + \alpha_{41} sef_{i,t-1} + \alpha_{42} inv_{it} + \alpha_{43} cogs_{it} + \alpha_{44} gm_{it} + \alpha_{45} ssp_{it} \\ &+ \alpha_{46} ssv_{it} + \alpha_{47} bsal_{it} + \alpha_{48} cf_{it} + \alpha_{49} gdp_t + \tau_{4r} T_r + \epsilon_{it} \end{aligned} \tag{3.7}$$

In the COGS equation (3.5), we include $cogs_{i,t-1}$ to control for time-variant firm specifics that affect COGS but for which we do not have direct measures, such as word-of-mouth and network effects. Additionally, we control for economic developments, as proxied by the gross domestic product (gdp), to separate these effects from the net effects of our main variables of interest. Because the design of CEO incentive schemes may also have an effect on COGS, as explained in §3.3.2, we further control for compensation-related metrics.

In the gross margin equation (3.6), we control for economic developments (gdp), which may require or allow for adjustments of margins. We include the compensation-related variables as controls because gross margin is considered to be one of the levers for CEOs to make earnings adjustments. In line with Jain et al. (2014), we add the lag of gross margin ($gm_{i,t-1}$) to the equation to control for unobserved time-variant firm-specific factors, such as brand equity.

Sales effort is a function of cash available (e.g., Joseph and Richardson, 2002). Thus, we include cash flow (cf) as a control variable in the sales effort equation (3.7). Because economic developments may also affect sales effort (e.g., Lamey et al., 2007), we control for the gross domestic product (gdp). To control for time-variant firm-specific factors, such as the marketing mix and brand strength, we include the lag of sales effort ($sef_{i,t-1}$) in (3.7). Finally, because prior research has shown that CEO compensation has an effect on sales/marketing effort (Currim et al., 2012), we add compensation-related metrics to the sales effort equation.

Some of the variables in this model exhibit significant firm size-related variance: larger firms have higher demand (cogs), carry more inventory (inv), spend more money on sales effort (sef), generate higher cash flows (cf), and exhibit larger absolute deviations from the forecast (du). This scale dependence could lead to spurious econometric effects. Thus, we follow the guidelines in Barth and Clinch (2009) and deflate the above variables by the market value of firm i in period t (MV_{it}).[7]

All of the above four equations and the system as such satisfy the order and rank conditions such that our model is identified (Greene, 2012). The direct effect of ssp and ssv on inventory investment is captured by the coefficient α_{15} and α_{16} in (3.4), on cogs by α_{25} and α_{26} in (3.5), on gross margin by α_{35} and α_{36} in (3.6), and on sales effort by α_{45} and α_{46} in (3.7).

3.5 Results

3.5.1 Original Model

The two-step endogeneity test (Wooldridge, 2013, pp. 534-538) confirms the expected presence of endogeneity in the inventory equation ($p < .01$), COGS equation ($p < .01$), gross margin equation ($p < .01$), and sales effort equation (p< .01).[8] To

[7] For a recent application of deflating scale-dependent variables by firms' market values in an OM context, see also Jain et al. (2014).

[8] For each potentially endogenous variable of each equation, we estimate the reduced form equation. Next, to test whether the assumed endogenous variables are uncorrelated with the error terms, we in-

control for the contemporaneous correlation between the regressors and the error terms, we estimate a simultaneous system of four equations and employ the error component two-stage least squares (EC2SLS) estimator derived by Baltagi (1981) and discussed in Baltagi and Liu (2009), which is a matrix-weighted average of the within and between estimates, where the weights depend on the respective variance-covariance matrices. The estimator exploits information from both sources available in panel data, within and across identities. Additionally, EC2SLS renders the estimates consistent and asymptotically efficient in the presence of error components. We follow Greene (2012, pp. 370-376) and estimate each equation individually. Additional robustness checks are provided in §3.5.2.

Table 3.2 provides the estimated coefficients of the four equations that constitute our model. We note at this point that the simultaneous dependence between each of the equations is confirmed by the significance of all the endogenous variables in each of the equations (rows 1-4 in Table 3.2). This fact, as well as the two-step endogeneity test and our theoretical elaborations in the context of the inventory rhombus, supports the appropriateness of specifying a simultaneous equation model. Panel A excludes the compensation-related variables to allow comparisons with past studies. As predicted by inventory theory, we find that inventory investment increases in mean demand (COGS) and gross margins. Both of the effects follow the predictions of the NV model (Cachon and Terwiesch, 2013). Higher sales effort is associated with an increase in inventory investment, which can be explained by the "pre-stocking behavior" of managers in anticipation of greater demand.

In line with prior research (Kesavan et al., 2010; Jain et al., 2014), we find that the COGS decreases in margins and increases in inventory investment. We attribute the former effect to the fact that demand is a decreasing function of the price. The latter effect results from higher service levels that may stimulate demand and hedge against lost sales. In line with marketing theory, we find that additional sales effort

clude the error terms of the reduced forms in the structural equations. After confirming that each of the assumed endogenous variables is indeed endogenous (as implied by the statistically significant error terms in each equation), we perform tests of the joint significance of the endogenous variables in each equation, which confirm the presence of endogeneity.

increases demand (COGS).

Higher inventory investment decreases the gross margin, which supports the findings of Kesavan et al. (2010), who argue that higher inventory investment increases the likelihood of obsolescence and hence induces companies to reduce prices to clear out stocks. Because demand is a function of price, higher sales typically come at the expense of margins, which is why margin decreases in COGS. As predicted by marketing theory, increasing sales effort provides better service for the customer and increases brand equity, which ensures that higher sales effort increases margins.

Finally, higher margins are associated with higher sales effort, which suggests that companies that have higher margins typically follow a business strategy that requires higher sales effort and service offerings. Companies with higher inventory levels may increase their sales effort to either sell out stocks or offer a more diversified product portfolio in a market that requires higher sales effort. We find that higher sales (COGS) lead to increases in sales effort; we attribute this finding to the fact that, by far, most of the companies spend a fixed percentage of their sales on marketing in each period (e.g., Fischer et al., 2011). In line with prior research, we find that cash flow has a positive effect on sales effort. We attribute this finding to the well-documented "affordability principle," which states that sales effort is a function of the cash available (e.g., Joseph and Richardson, 2002). As expected, the lagged variables in each equation significantly explain large proportions of the variances of the respective dependent variables.

Panel B adds the coefficients shown in rows 9-11 to the model, which represent the direct effect of CEOs' SSP, the direct effect of CEOs' SSV, and the additional control variable, CEOs' base salary (BSAL). In the full model, we also find that the estimation results are mostly in line with those of previous studies; among the control variables, capital intensity and demand uncertainty are positively associated with inventory investment. To hedge against demand uncertainty, firms maintain higher inventory levels; in line with Jain et al. (2014), we find a positive effect of capital intensity on inventory investment, which is driven by the fact that the measure includes investments such as additional warehouses that increase firm-level inventories while increasing responsiveness. We do not find support for a significant relationship between sales surprise and inventory investment (Gaur et al., 2005).[9] Against our intuition, projected business growth is negatively associated with inventory investment; we suspect that this effect is driven by the fact that firms with high growth potential invest in supply chain and information technology, which enables them to manage inventories more efficiently and to economize on scale effects.

With respect to CEO compensation, we find that SSP has a negative direct effect on inventory investment ($\alpha_{15} = -.0466, p < .01$), which provides support for Hypothesis 1a; all else being equal, a CEO whose incentive scheme is more strictly linked to the stock price maintains lower inventory levels. This result is in line with those of Fama (1980) and Wu and Tu (2007), who show that higher SSP increases CEOs' risk-exposure over-proportionally and, hence, may induce them to follow less risky strategies. The maintenance of higher inventory investment in expectation of increasing demand, perhaps resulting from the entering of new markets, presents great risk (e.g., obsolescence), which CEOs whose total wealth largely depends on a firm's stock price are not willing to take.

[9] In §3.5.2, we perform robustness checks with the conventional single-equation relative inventory model and find, in line with prior research, a negative and significant relationship between sales surprise and inventory investment.

Table 3.2: Model estimates

		Panel A							
		INV Equation		COGS Equation		GM Equation		SEF Equation	
No	**Variables**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
1	inv_{it}			.0855***	(.0099)	-.0062**	(.0024)	.0888***	(.0167)
2	$cogs_{it}$	.2586***	(.0187)			-.0369***	(.0035)	.2838***	(.0281)
3	gm_{it}	.3233***	(.0374)	-.6110***	(.0290)			.7645***	(.0560)
4	sef_{it}	.0380***	(.0115)	.0803***	(.0102)	.0209***	(.0024)		
5	$inv_{i,t-1}$	.6009***	(.0079)						
6	$cogs_{i,t-1}$			.6596***	(.0127)				
7	$gm_{i,t-1}$					.8873***	(.0071)		
8	$sef_{i,t-1}$							.4988***	(.0111)
9	ssp_{it}								
10	ssv_{it}								
11	$bsal_{it}$								
12	ci_{it}	.0869***	(.0087)						
13	ss_{it}	.0028	(.0043)						
14	du_{it}	.0382***	(.0093)						
15	cf_{it}							.1088***	(.0109)
16	gp_{it}	-.2704***	(.0110)						
17	gdp_{it}	-.4328***	(.0668)	-.0760***	(.0075)	-.0324*	(.0161)	.0086	(.0678)
18	$N_{obs.}$	5,471		4,976		5,663		4,875	
19	N_{firm}	737		730		877		755	
20	W/i R^2 (%)	63		49		38		61	
21	B/w R^2 (%)	94		95		93		87	
22	Tot. R^2 (%)	89		91		90		84	

Note. *$p < .1$ (two-tailed), **$p < .05$ (two-tailed), ***$p < .01$ (two-tailed). Standard errors (S.E.) are reported in parentheses below the parameter estimates.

Table 3.2: Model estimates (Cons.)

		Panel B							
		INV Equation		COGS Equation		GM Equation		SEF Equation	
No	**Variables**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
1	inv_{it}			.1049***	(.0115)	-.0063**	(.0024)	.0800***	(.0193)
2	$cogs_{it}$	.1615***	(.0207)			-.0369***	(.0035)	.2269***	(.0337)
3	gm_{it}	.1235***	(.0316)	-.8457***	(.0302)			.6698***	(.0664)
4	sef_{it}	.0579***	(.0113)	.1059***	(.0119)	.0209***	(.0024)		
5	$inv_{i,t-1}$	.6050***	(.0089)						
6	$cogs_{i,t-1}$			.6099***	(.0141)				
7	$gm_{i,t-1}$					.9354***	(.0086)		
8	$sef_{i,t-1}$							.4045***	(.0117)
9	ssp_{it}	-.0466***	(.0073)	-.1497***	(.0068)	.0017	(.0016)	-.1294***	(.0084)
10	ssv_{it}	.0267***	(.0060)	.0320***	(.0068)	-.0022*	(.0012)	.0357***	(.0055)
11	$bsal_{it}$	.1301***	(.0178)	.2771***	(.0154)	.0126***	(.0036)	.1275***	(.0178)
12	ci_{it}	.0899***	(.0097)						
13	ss_{it}	.0154	(.0161)						
14	du_{it}	.0417***	(.0106)						
15	cf_{it}							.0675***	(.0109)
16	gp_{it}	-.2743***	(.0122)						
17	gdp_{it}	-.5179***	(.0772)	-.3165***	(.0082)	-.0105	(.0164)	-.1038	(.0747)
18	$N_{obs.}$	4,325		3,977		4,284		3,873	
19	N_{firm}	725		708		729		729	
20	W/i R^2 (%)	64		54		39		69	
21	B/w R^2 (%)	95		96		98		89	
22	Tot. R^2 (%)	90		92		96		84	

Note. *$p < .1$ (two-tailed), **$p < .05$ (two-tailed), ***$p < .01$ (two-tailed). Standard errors (S.E.) are reported in parentheses below the parameter estimates.

In line with this argument, we find that SSV, which has been shown to motivate CEOs to take more risk (e.g., Core and Guay, 2002), has a positive and significant direct effect on inventory investment ($\alpha_{16} = .0267, p < .01$). This result provides support for Hypothesis 2b. The control variable for CEOs' "general" risk aversion, base salary, has a significant positive effect on inventory investment ($\alpha_{17} = .1301, p < .01$), implying that CEOs with higher performance-independent salaries are willing to engage in more risky projects that might require greater inventory investment (Guay, 1999).

The effect of SSP on COGS is negative and significant ($\alpha_{25} = -.1497, p < .01$). We follow the above argumentation and suspect that CEOs whose total wealth is more dependent on the stock price do not invest in small positive net present value projects, which is why they may forgo sales opportunities. Again, we find the opposite effect for SSV ($\alpha_{26} = .0267, p < .01$) and base salary ($\alpha_{27} = .2771, p < .01$), suggesting that higher SSV and lower general risk aversion (as proxied by base salary) induce CEOs to leverage on more risky sales projects.

We do not find a significant effect of SSP on gross margins ($\alpha_{35} = .0017, p > .1$), although we would have expected that CEOs whose compensation were strongly tied to the firm's stock price would not invest in "small positive" net present value projects, as implied by Guay (1999), and hence would experience – on average – higher gross margins. However, we find a negative and significant effect of SSV on gross margin ($\alpha_{36} = -.0022, p < .1$), which partially supports the above argument. A higher base salary, which reduces the CEO's financial dependence on firm performance, has a positive and significant effect on gross margin ($\alpha_{37} = .0126, p < .01$). We suspect that this effect might result from a lower risk aversion as a consequence of rather high performance-independent compensation (Guay, 1999), which induces CEOs to invest in highly risky projects that are associated with risk premiums.

Our results reveal that SSP has a negative effect on sales effort ($\alpha_{45} = -.1294, p < .01$); we attribute this effect to the risk that is associated with sales effort and marketing campaigns. We find the opposite (directional) effects of SSV ($\alpha_{46} = .0357, p < .01$) and base salary ($\alpha_{47} = .1275, p < .01$) on sales effort and argue, in line with findings of prior research (Mizik and Jacobson, 2007; Currim et al., 2012), that a CEO whose compensation is less dependent on the company's stock performance is more likely to invest in risky sales effort and marketing campaigns.

The coefficients presented in Table 3.2 are only the direct effects that we estimated in our model. Additionally, we must consider the indirect effects that arise from the concomitant changes in the endogenous variables as discussed in the context of the inventory rhombus; in fact, because inventory investment is our "overall" dependent variable, there are $5 \times (4 - 1) = 15$ indirect paths through which both SSP and SSV may have an effect on inventory investment. To calculate the size of the indirect effects and their respective significance levels, we follow the approach suggested by Preacher and Hayes (2008) and recently discussed in Malhotra et al. (2014) and Rungtusanatham et al. (2014). To test our hypotheses, we calculate the total effects, i.e., the aggregate of the direct and indirect effects. We employ a bootstrapping procedure to obtain estimates and significance levels that are based on stratified empirical sample distributions to ensure that the relative share of companies that belong to a particular industry group (two-digit SIC code) remains constant. For each of the estimated effects, we run 5,000 repetitions of the estimation. Table 3.3 summarizes the indirect and total effects of SSP and SSV on inventory investment through the various paths. In row (16) and row (32), we report the aggregate of the indirect effects and the total effects of SSP and SSV on inventory investment.

Table 3.3: Indirect and total effects of SSP and SSV on inventory investment

		Indirect effect			Total effect	
No	Paths	Indirect effects	Coefficient	S.E.	Coefficient	S.E.
1	ssp→cogs→inv	$\alpha_{25} * \alpha_{12}$	-.0252***	.0044	-.0616***	.0126
2	ssp→cogs→sef→inv	$\alpha_{25} * \alpha_{43} * \alpha_{14}$	-.0057***	.0017	-.0421***	.0119
3	ssp→cogs→sef→gm→inv	$\alpha_{25} * \alpha_{43} * \alpha_{34} * \alpha_{13}$	.0001	.0001	-.0364***	.0111
4	ssp→cogs→gm→inv	$\alpha_{25} * \alpha_{33} * \alpha_{13}$	-.0003	.0002	-.0368***	.0113
5	ssp→cogs→gm→sef→inv	$\alpha_{25} * \alpha_{33} * \alpha_{44} * \alpha_{14}$	.0029***	.0010	-.0336***	.0113
6	ssp→gm→inv	$\alpha_{35} * \alpha_{13}$	.0008***	.0003	-.0356***	.0107
7	ssp→gm→sef→inv	$\alpha_{35} * \alpha_{44} * \alpha_{14}$	-.0003**	.0001	-.0367***	.0111
8	ssp→gm→sef→cogs→inv	$\alpha_{35} * \alpha_{44} * \alpha_{24} * \alpha_{12}$	-.0000	.0000	-.0364***	.0112
9	ssp→gm→cogs→inv	$\alpha_{35} * \alpha_{23} * \alpha_{12}$	-.0003***	.0001	-.0376***	.0116
10	ssp→gm→cogs→sef→inv	$\alpha_{35} * \alpha_{23} * \alpha_{43} * \alpha_{14}$	-.0002**	.0001	-.0366***	.0110
11	ssp→sef→inv	$\alpha_{45} * \alpha_{14}$	-.0017**	.0007	-.0382***	.0112
12	ssp→sef→gm→inv	$\alpha_{45} * \alpha_{34} * \alpha_{13}$	-.0003	.0002	-.0368***	.0109
13	ssp→sef→gm→cogs→inv	$\alpha_{45} * \alpha_{34} * \alpha_{23} * \alpha_{12}$	.0001	.0001	-.0364***	.0113
14	ssp→sef→cogs→inv	$\alpha_{45} * \alpha_{24} * \alpha_{12}$	-.0023	.0016	-.0388***	.0112
15	ssp→sef→cogs→gm→inv	$\alpha_{45} * \alpha_{24} * \alpha_{33} * \alpha_{13}$	.0001	.0000	-.0364***	.0113
16	ssp→sum of ind. effects→inv	aggregate of ind. effects	**-.0238*****	.0065	**-.0703*****	.0104

Note. *$p < .1$ (two-tailed), **$p < .05$ (two-tailed), ***$p < .01$ (two-tailed). The indirect effects are calculated as by Preacher and Hayes (2008). The total effect is given by the aggregate of the indirect and direct effect. The standard errors (S.E.) and the test statistics are based on 5,000 bootstrapping repetitions.

Table 3.3: Indirect and total effects of SSP and SSV on inventory investment (Cons.)

		Indirect effect			Total effect	
No	Paths	Indirect effects	Coefficient	S.E.	Coefficient	S.E.
17	ssv →cogs→inv	$\alpha_{26} * \alpha_{12}$	.0048***	.0013	.0315***	.0105
18	ssv→cogs→sef→inv	$\alpha_{26} * \alpha_{43} * \alpha_{14}$	.0008*	.0004	.0275***	.0060
19	ssv→cogs→sef→gm→inv	$\alpha_{26} * \alpha_{43} * \alpha_{34} * \alpha_{13}$	-.0001	.0001	.0267***	.0061
20	ssv→cogs→gm→inv	$\alpha_{26} * \alpha_{33} * \alpha_{13}$	.0001	.0001	.0268***	.0060
21	ssv→cogs→gm→sef→inv	$\alpha_{26} * \alpha_{33} * \alpha_{44} * \alpha_{14}$	-.0006	.0004	.0260***	.0063
22	ssv→gm→inv	$\alpha_{36} * \alpha_{13}$	-.0004***	.0001	.0263***	.0060
23	ssv→gm→sef→inv	$\alpha_{36} * \alpha_{44} * \alpha_{14}$	-.0001	.0001	.0266***	.0058
24	ssv→gm→sef→cogs→inv	$\alpha_{36} * \alpha_{44} * \alpha_{24} * \alpha_{12}$	-.0001	.0001	.0267***	.0067
25	ssv→gm→cogs→inv	$\alpha_{36} * \alpha_{23} * \alpha_{12}$	-.0004**	.0001	.0269***	.0061
26	ssv→gm→cogs→sef→inv	$\alpha_{36} * \alpha_{23} * \alpha_{43} * \alpha_{14}$	.0001*	.0000	.0268***	.0054
27	ssv→sef→inv	$\alpha_{46} * \alpha_{14}$	.0012**	.0005	.0279***	.0097
28	ssv→sef→gm→inv	$\alpha_{46} * \alpha_{34} * \alpha_{13}$	.0002	.0002	.0269***	.0093
29	ssv →sef→gm→cogs→inv	$\alpha_{46} * \alpha_{34} * \alpha_{23} * \alpha_{12}$	.0001	.0001	.0267***	.0059
30	ssv →sef→cogs→inv	$\alpha_{46} * \alpha_{24} * \alpha_{12}$	.0006	.0006	.0242***	.0055
31	ssv →sef→cogs→gm→inv	$\alpha_{46} * \alpha_{24} * \alpha_{33} * \alpha_{13}$	-.0001	.0001	.0267***	.0060
32	ssv→sum of ind. effects→inv	aggregate of ind. effects	**.0105*****	.0031	**.0372*****	.0060

Note. *$p < .1$ (two-tailed), **$p < .05$ (two-tailed), ***$p < .01$ (two-tailed). The indirect effects are calculated as by Preacher and Hayes (2008). The total effect is given by the aggregate of the indirect and direct effect. The standard errors (S.E.) and the test statistics are based on 5,000 bootstrapping repetitions.

Both the aggregate indirect ($-.0238, p < .01$) and the total effect ($-.0703, p < .01$) of SSP on inventory investment are negative and significant, although there are competing indirect effects (row 5 and row 6). This provides further support for Hypothesis 3a. The aggregate indirect effect of SSV on inventory investment is positive and significant ($.0105, p < .01$). The total effect of SSV on inventory investment is also positive and significant ($.0372, p < .01$), despite the presence of competing indirect effects (row 22 and row 25). This result provides support for Hypothesis 4b and follows our discussion of the direct effect of SSV on inventory investment.

3.5.2 Robustness Tests

We check the robustness of our results along four dimensions: (i) we employ alternative variable specifications that have been used in prior research, including sales effort, sales forecast, and demand uncertainty; (ii) we test alternative specifications of the inventory equation, excluding some of the covariates in a stepwise manner; (iii) we employ alternative estimators, the three-stage least squares (3SLS), the generalized two-stage least squares random effects (G2SLS), and the fixed effects estimator; and (iv) we estimate a conventional single-equation relative inventory model to compare our results with past research.

Table 3.4 summarizes the results of our robustness checks along the dimensions (i) through (iii). For benchmarking purposes, row 1 displays the results of the original model. The accuracy of demand forecasts is crucial for the determination of inventory levels. Yet, when conducting empirical research, we cannot observe the true demand forecast. Therefore, we start our robustness checks with alternative specifications of the forecast, which affects the demand uncertainty (DU) and sales surprise (SS) measures. In our original model, we use the Holt-Winters forecasting approach. Because less advanced forecasting methods are today often applied in companies, we run our model again by using a simple exponential smoothing approach and set the smoothing parameter of the forecast to be $\alpha = .3$ (row 2) and $\alpha = .2$ (row 3).

While we use the absolute forecast error as a proxy for demand uncertainty in our original model, row 4 contains the results when we measure demand uncertainty as the mean absolute forecast error over all periods, $DU_{it} \equiv \frac{1}{k}\sum((SAL_{it} - SF_{it})^2)^{.5})$, where k is the sum of periods. Finally, row 5 shows the estimation results when we use SGA_{it}, rather than $SGA_{it} - RD_{it}$, as proxy for sales effort.

We exclude variables from the inventory equation in a stepwise manner to test alternative specifications; we exclude the sales surprise covariate (row 6), the demand uncertainty covariate (row 7), the growth potential covariate (row 8), and the capital intensity covariate (row 9). Finally, we summarize the results of applying alternative estimators to our model. Row 10 presents the results of a 3SLS estimation; 3SLS permits correlations among unobserved disturbances across several equations in the system. Additionally, we estimate our model by employing the G2SLS (row 11) and the fixed effects (row 12) estimators.

Across all of the eleven robustness tests described above, we confirm the negative direct, negative (aggregate) indirect, and negative (aggregate) total effect of SSP on inventory investment. Ten of the eleven tests confirm the positive direct effect of SSV on inventory investment. All of the eleven tests further confirm the positive and significant (aggregate) indirect and (aggregate) total effect of SSV on inventory investment. In sum, all of the 66 robustness tests confirm the coefficient sign of our original estimates, with only one exception of a nonsignificant effect. Overall, all of these robustness tests reinforce and confirm our main findings.

Table 3.4: Summary of robustness checks

	ssp			ssv			
No	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect	Robustness test description
							Original assumptions
1	-.0466***	-.0238***	-.0703***	.0267***	.0105***	.0372***	EC2SLS matrix-weighted estimator
							Alternative variable construction
2	-.0481***	-.0016*	-.0493***	.0285***	.0097***	.0383***	Exponential smoothing with $\alpha = .3$
3	-.0323***	-.0004**	-.0337***	.0283***	.0094**	.0377***	Exponential smoothing with $\alpha = .2$
4	-.0429***	-.0242***	-.0673***	.0257***	.0122**	.0379***	Mean abs. forecast error as proxy for DU
5	-.0241***	-.0240***	-.0524***	.0241***	.0096*	.0337***	SGA_{it} as proxy for sales effort
							Alternative specification for INV equation
6	-.0530***	-.0219***	-.0749***	.0240****	.0090***	.0330***	Without sales surprise covariate
7	-.0483***	-.0277***	-.0760***	.0267***	.0122**	.0389***	Without demand uncertainty covariate
8	-.0848***	-.0256***	-.1104***	.0434***	.0111***	.0545***	Without growth potential covariate
9	-.0512***	-.0278***	-.0790***	.0243**	.0121***	.0364***	Without capital intensity covariate
							Alternative estimators
10	-.0920***	-.0027**	-.0947***	.0234***	.0224***	.0458***	Three-stage least sq. (3SLS) estimator
11	-.0863***	-.0408*	-.1271***	.0042	.0582**	.0624***	Generalized two-stage least sq. estimator
12	-.0426***	-.0158***	-.0584***	.0536***	.0167*	.0704***	Fixed-effects estimator

Note. *$p < .1$ (two-tailed), **$p < .05$ (two-tailed), ***$p < .01$ (two-tailed). The indirect effects are calculated as by Preacher and Hayes (2008). The total effect is given by the aggregate of the indirect and direct effect. The test statistics are based on 5,000 bootstrapping repetitions.

Next, we test whether our results also hold in the traditional single-equation relative inventory investment model that has been utilized in prior empirical OM research. Following Rumyantsev and Netessine (2007b), we operationalize the relative inventory of firm i in period t as $RINV_{it} \equiv INV_{it}/COGS_{it}$. Conceptually, such a specification makes it difficult to capture the total effect of the compensation-related variables on inventory investment because the multitude of interdependencies, as discussed in the context of the inventory rhombus, cannot explicitly be measured. Nevertheless, we expect the directional effect of SSP and SSV to be the same as the direct and total effects of these variables that we observed in the four equation model: higher SSP leads to a reduction in inventory investment, while higher SSV is associated with an increase in inventory investment.

To verify these effects, we control for gross margin (GM_{it}), capital intensity (CI_{it}), sales surprise (SS_{it}), demand uncertainty (DU_{it}), and base salary ($BSAL_{it}$), and we estimate the effects of SSP and SSV on the relative inventory ($RINV_{it}$) by using the following log-log model in which the respective lowercase letters denote the natural logarithm of the focal variables (e.g., $ln(RINV_{it}) = rinv_{it}$):

$$\begin{aligned} rinv_{it} = &\alpha_1 gm_{it} + \alpha_2 ci_{it} + \alpha_3 ss_{it} + \alpha_4 du_{it} + \alpha_5 ssp_{it} + \alpha_6 ssv_{it} \\ &+ \alpha_7 bsal_{it} + F_i + \tau_{1r} T_r + \epsilon_{it}, \end{aligned} \tag{3.8}$$

where F_i and T_r are dummy variables to control for firm- and time-specific effects, respectively. We use a fixed effects estimator to allow the compensation-related variables to depend on other unobserved firm-specific factors that would cause a cluster-correlated error structure, and accordingly, we calculate robust standard errors that allow such an error structure.

Table 3.5 summarizes the estimation results for the relative inventory model. The first four columns provide the base model with the stepwise addition of the compensation-related metrics, SSP, SSV, and base salary. Columns (5) through (8) provide different robustness tests of the single-equation relative inventory model. In particular, column (5) adds the sales growth covariate as suggested by Rumyantsev and Netessine (2007b), which is measured as $SG_{it} \equiv (COGS_{i,t+1} - COGS_{it})/COGS_{it}$.[10] Column (6) shows the results when we remove the sales surprise covariate from the model; column (7) shows the results when we replace the covariate capital intensity with total assets as a proxy for firm size.[11] Finally, we supplement our results by using the generalized least squares estimator.

In the full model (columns 4-8), consistent with prior research and with the results of our main analysis, we find a positive and significant coefficient for gross margin, capital intensity, and demand uncertainty. However, we also find a significant positive coefficient for sales growth and total assets, which is in contrast to previous findings. For example, Rumyantsev and Netessine (2007b) use quarterly data and find a negative association between sales growth and relative and absolute inventory. The authors argue that companies do not immediately adjust inventories to increasing demand. We suspect that this effect might also be driven by (long) replenishment lead times and ordering policies. Because we use annual data, the likelihood that companies adjust their inventory levels to rather long-lasting sales growth increases, which is why we find a positive effect of sales growth on inventory investment. While past research has conceptualized total and fixed assets as proxies for firm size (larger firms can economize on scale effects in inventory management) and information technology that might reduce inventory investment, the measures also include investments such as additional warehouses, which increase firm-level inventories while increasing responsiveness. In line with Jain et al. (2014), we attribute the positive coefficient in our model to the latter argument.

[10] Alternative specifications, such as $COGS_{it}/COGS_{it-1}$ as a proxy for sales growth, do not substantially change the results.

[11] We also proxy for firm size by considering only long-term assets, as measured by $LTA_{it} \equiv TA_{it} - CA_{it}$, where CA are current assets. The results are qualitatively identical.

Table 3.5: Estimation results from the single-equation relative inventory model

	Original assumptions				Alternative specification			Alt. estimator
	Base model	+ssp	+ssv	+bsal	+Sales growth (sg)	-Sales surprise (ss)	Change total assets for ci	Generalized least squares
	1	2	3	4	5	6	7	8
gm	.7545***	.7649***	.7652***	.7332***	.7441***	.7220***	.6520***	.7295***
ci	.1101***	.1159***	.1195***	.1132***	.1147***	.1160***		.0731***
ss	-.0745***	-.0755***	-.0723***	-.0545***	-.0606**		-.0760***	-.0534***
du	.0042***	.0043***	.0053***	.0053***	.0025*	.0056**	.0045**	.0044**
sg					.0358***			
ta							.0742***	
ssp		-.0076***	-.0148***	-.0182***	-.0210***	-.0201***	-.0351***	-.0206***
ssv			.0109***	.0077**	.0081*	.0082**	.0085**	.0079**
bsal				.0338***	.0288***	.0394***	.0899***	.0414***
N_{obs}	13,088	9,973	9,422	9,422	9,414	9,422	9,437	9,422
N_{firm}	1,238	1,207	1,189	1,189	1,189	1,189	1,192	1,189
W/i R^2 (%)	16	16	17	17	18	17	17	17
B/w R^2 (%)	12	13	13	15	14	15	14	17
Tot. R^2 (%)	12	12	13	13	15	13	13	15

Note. $^{*}p < .1$ (two-tailed), $^{**}p < .05$ (two-tailed), $^{***}p < .01$ (two-tailed).

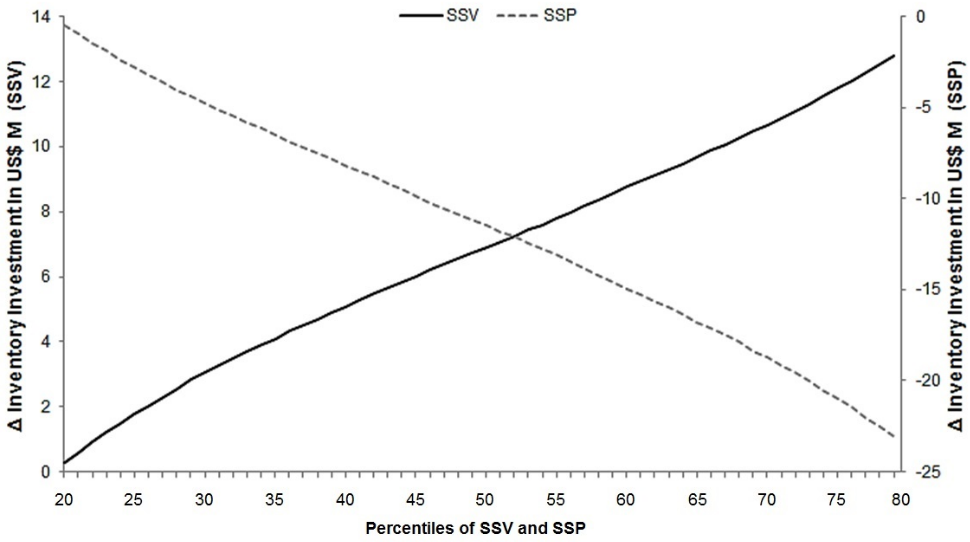
Across all full models, consistent with the estimates of our four-equation model, we find a negative and significant effect of SSP on the relative inventory investment. We also find again positive and significant effects of SSV and base salary on the relative inventory investment. In terms of magnitude, the coefficients are smaller than those obtained from our system estimation because the single equation model does not capture the feedback loops and indirect effects that – on average – amplify effect size, as shown in Table 3.3. Overall, the various robustness checks corroborate the validity of our main findings.

3.6 Implications and Discussion

Our results provide the first empirical evidence of a relationship between an important organizational feature, the structure of executive compensation, and inventory investments. The characteristics of executive compensation that we consider are the SSP and SSV of the CEO's option portfolio, both of which are frequent subjects of media discussion. Although there are well-established but competing arguments in the OM literature that imply a relationship between executive compensation and inventory investment, to date scholars have not examined whether this relationship indeed exists.

Applying econometric methods that control for the simultaneity of the equations in our model, we find that increasing SSP provides a strong incentive for managers to reduce inventory investment. Although there are competing (indirect) effects, we find that a 10% increase in SSP is associated with a lower average inventory investment of approximately 0.7%. An average firm in our sample (median) has an inventory investment of approximately US$ 118M. Hence, a 20% increase in SSP is associated with a reduction in capital invested in inventory of approximately US$ 1.652M. To substantiate the economic significance of our empirical results, we divide our sample into percentiles with regard to the CEOs' SSP. Moving from the 50th percentile to the 70th percentile - all else held constant - is associated with an increase in SSP by approximately 87% and, accordingly, with a reduction in capital

Figure 3.2: The effects of SSP and SSV on inventory investment



invested in inventory of US$ 6.9M, and vice versa. Considering that SSP increases by approximately 277% from its 20th percentile to its 80th percentile, the effect is economically significant (Δ inventory investment US$ 22.6M), as illustrated in Figure 3.2 (secondary vertical axis).

We further find that a 10% increase in SSV is associated with an increase in inventory investment of approximately 0.37% – despite the presence of multiple countervailing indirect effects. Accordingly, a 20% increase in SSV is associated with an increase in capital invested in inventory of approximately US$ 0.873M. Proceeding as above, moving from the 50th to the 70th percentile in terms of SSV is associated with an increase in SSV by approximately 85% and, accordingly, with an increase in inventory investment of approximately US$ 3.6M – all else held constant. From its 20th percentile to its 80th percentile, SSV increases by approximately 291%. This difference is associated with a change in inventory investment of US$ 12.5M, shown in Figure 3.2 (primary vertical axis).

These findings provide valuable insights into the complex dynamics in organizations and the effects of managerial incentives on inventory investments. The ceteris paribus analyses above indicate that the two elements of CEO compensation, the SSP and the SSV, both have a high economic impact on inventory investments. Therefore, operations managers, CEOs themselves, researchers, and compensation committees must all be aware of this impact and be able to estimate and manage it. Moreover, the finding that inventory, COGS, gross margin, and sales effort affect each other underlines the importance of a combined sales, marketing, and operations planning. Therefore, we urge and expect top managers to realize the importance of aligning their organizations across and beyond functional silos to improve the match between demand and supply. The results of our study are also of interest to operations managers. If their bonuses depend on inventory metrics, they should be aware of the fact that several of the causes of inventory buildup – and in particular the human one – lie outside their direct sphere of actions. Instead, they emerge from the design of CEO compensation schemes and their interconnection with the variables that comprise the inventory rhombus.

Our study also provides valuable insights for theory. We show that the triangular interdependent association between inventory investment, gross margin, and COGS as proposed by Kesavan et al. (2010) and Kesavan and Mani (2013) also holds for manufacturing industries. We further develop this model by including the sales effort measure and conceptualize the inventory rhombus, which answers the frequent call to strengthen the empirical dimension of OM research. The consideration of sales effort in the inventory model complements the scarce empirical research at the OM-marketing interface and might motivate more (empirical) OM scholars to stop considering demand as purely exogenous. Finally, despite the emerging stream of behavioral OM research that addresses human nature in decision-making processes, our study is the first to provide empirical insights into the effects of CEO compensation on inventory investment, a relationship that has been argued to exist in the context of phenomena such as "window dressing" and the "hockey stick effect" (e.g., Lai, 2007).

When designing executive compensation schemes, the various effects of SSP and

SSV must be carefully balanced and, in particular, be aligned with the risk profile of the organization; increasing SSP is – aside from decreasing inventory investment – associated with missing sales opportunities and less sales effort and might increase the likelihood of supply chain glitches, whose implications for financial performance are well documented by Hendricks and Singhal (2005a). At the same time, higher SSV comes with increased sales effort and higher COGS (demand), which are accompanied by higher inventory investment. Although these outcomes may seem desirable at first glance, higher sales effort and more inventories are typically associated with increased business risk. Awareness of this interdependence is thus essential to firm owners when adjusting SSP and SSV.

As only controlled experiments can unambiguously establish contemporaneous causality, there are two alternative explanations for the association between compensation characteristics and inventory investment. First, inventory investment could be interpreted as a cause of compensation characteristics. Although this is theoretically arguable, contractual agreements between CEOs and organizations would prevent annual adjustments of compensation schemes. Additionally, if this were the true chain of causality, we would expect the effects to be less contemporaneous and more lagged, which we did not find in our data. Second, both changes in SSP and SSV and in inventory investment could be caused by an omitted third variable, such as a time or firm characteristic or other firm-epoch economic variables. However, the inclusion of firm- and time-specific dummy variables in our model excludes the possibility of firm- and time-specific effects causing a spurious relationship; the most viable candidates that may cause changes to the SSP, SSV, and inventory investment are demand, gross margin, and sales effort, which are all interdependent and explicitly incorporated into our econometric model. Thus, although the two alternative interpretations may appear somewhat plausible, we feel confident about our interpretation.

Our study has limitations that must be acknowledged. First, although our data are rich compared with those of previous empirical studies on the effect of managerial compensation, we restrict our analysis to firms from the major three S&P

indexes. It is possible that the effect of compensation schemes on inventory differs for firms that do not meet the criteria to be listed on these indexes. Second, individual characteristics of CEOs for which we cannot control may have an impact on the proposed effects; for example, a CEO with an operations background may respond differently to increased SSP and have a different strategic focus compared with a CEO with a marketing background. Third, although the operationalization of our variables follows past studies, most of the variables remain proxies, which may be subject to some measurement error. Relaxing some of these restrictions and complementing the study with inter-industry comparisons provide opportunities for future research.