

Post-acquisition inventory levels

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Abstract

Merging companies typically anticipate inventory reductions through pooling of inventory, higher purchasing power or elimination of planning uncertainties in a wider supply chain. In contrast, companies appear to experience an inventory build-up in the quarters after an acquisition. This is the first attempt that I am aware of to develop an understanding for when, how and why the inventory build-up occurs. The research gap is addressed in this work with four research questions. (1) Does the phenomenon of inventory build-ups after mergers exist? (2) When does the inventory build-up occur and does it persist after the post-merger integration? (3) What happens in the post-merger integration and why does the inventory build-up occur? (4) Which companies are affected the most by the inventory build-up?

Creating awareness and understanding of the inventory build-up is important because companies may take wrong assumptions when deciding on their next acquisition. The additional inventory positions constitute an implicit premium to the deal value. Unrealistic expectations in the inventory development can affect post-merger integration when companies focus on the wrong actions. Therefore, decision makers should have well founded reasons when they anticipate inventory reductions.

The research gap is addressed in this work with four research questions, based on data comprising 926 U.S. mergers in the period 1978-2009. Financial data for four quarters before and eight quarters after the merger is retrieved from Standard & Poor's Compustat database.

I compare average inventory levels before and after the merger to show a substantial increase in inventory levels. A more detailed analysis of quarterly inventory growth rates shows when the inventory build-up occurs. Inventory responsiveness is used as a measure that reflects inventory growth adjusted for revenue growth. For a sub-sample of 58 deals, I decompose inventory into raw material, work in progress and finished goods. I use a least square dummy variable regression to show which companies are likely to experience strong inventory build-up.

The results of this study confirm that the inventory build-up exists. Mean inventory levels increase by \$ 99.4 million or 21.6% in the first year after the merger. The higher inventory levels are not reverted in the second year after the merger as mean inventory increases to 35.3% above pre-merger level. The inventory build-up happens in the first and second quarter after the merger when inventory growth rates peak at 7.9% and 6.9% respectively. Revenue growth can partially explain the inventory build-up. However, other factors including operational changes in supply and production play a role. Companies that typically experience high growth in inventory levels operate in high volume businesses and target smaller companies for acquisitions.

Keywords merger, acquisition, M&A, inventory, supply chain

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1 Introduction

The belief that M&A creates value is widely accepted. However, most of the created value is distributed to the target's shareholders. This leaves the acquirer's shareholders with no or only little gains. Bradley, Desai and Kim (1988) found that mergers in the period 1963-1984 increased the combined stock market valuation of the merging entities by 7.4% on average. However, the majority of the wealth was allocated through the acquisition premium to the target's shareholders. Andrade, Mitchell and Stafford (2001) found that in the period 1973-1998, stock market returns for merging companies in the U.S. improved by 0.4% on average. Again, the target shareholders captured most of the wealth. Other research suggested that mergers are not able to significantly improve operating performance and cast doubt on the ability of mergers to realize synergies (Healy, Palepu and Ruback (1992), Ghosh (2001), Powell and Stark (2005)). One important conclusion from the research on M&A synergy creation is that acquiring companies face challenges to systematically realize synergies beyond the acquisition premium.

Why then do companies engage in M&As? M&A promises the opportunity to quickly create capabilities that are not available and that can not be created within the company. Therefore successful mergers are often critical to make a company's strategy work. But if these capabilities improve long-term firm performance, why is this not reflected in the shareholder value of the acquiring firm? This paper is set out to reconcile this seeming contradiction between low M&A value creation and its vast popularity by arguing that operational and, in particular, inventory considerations matter. In particular I will argue that strategic and operational synergies can be outweighed by operational inefficiencies. These inefficiencies are a product of the ongoing transformation process as the target firm resources are being integrated into the acquirer's supply chain. This paper focuses on the problem of inventory buildup - one of the possible damages that occur upon the merger.

One idea for making M&A more successful comes from supply chain practitioners. Herd, Saksena and Steger (2005), Finley and Bonno (2012), and Tompkins (2012) promoted the idea that the supply chain involvement is essential for M&A success. In many cases supply chain was the largest source of cost synergies, accounting for up to 30-50% of the total cost savings. Acquiring companies are likely to overpay when they estimate the synergy potential too high. However, accurate estimation of the synergy potential requires the understanding of subject matter experts. For instance, the consolidation of distribution networks is often identified as a saving potential in a merger with geographical overlap. However, individual distribution centers may be critical in ensuring service levels and fast delivery. Their close-downs may result in loss of customers that are not willing to wait for their delivery.

Supply chain management is critical to make the deal work in the post-merger integration. The consolidation of production and logistics facilities often necessitates asset transfers and changes in the layout of facilities. Supply chain experts are essential to manage the transition and avoid operational disruptions. Disruptions in customer deliveries can be especially severe during the post-merger integration when customers are already concerned that their needs may be compromised in the pressure to realize cost synergies. The first 100 days often entail the biggest decisions, as the uncertainty in the merging organizations creates a window of opportunity for change. To make the right decisions concerning the supply chain and to get the realization of supply chain synergies on the right track, key people need to understand the deal rationale and plan for the future supply chain before the implementation starts. Therefore, early involvement of supply chain experts is essential for merger success.

In practice, however, supply chain management receives little to no attention during pre-deal strategy decisions, deal making and planning of the new organization. Only in the post-merger integration, the supply chain gains importance as it is expected to deliver synergies that often represent a significant share of the total synergies.

The supply chain perspective on M&A is a vivid part of the discussion among supply chain experts and in some M&A deals a key driver for success. In contrast, it has received little attention in academia. Häkkinen et al. (2004) surveyed M&A decision makers and found that logistics and supply chain topics were perceived to be an important motive and enabler for synergies. However, studies of supply chain performance in the post-merger period show that it is often poor. Zhu, Boyaci and Ray (2011) analyzed changes in supply chain performance for horizontal mergers with an event study methodology. They found that in the year after the merger, the inventory period became longer, gross margin on inventory decreased and inventory grew faster than did revenue. Similar observations were made by Langabeer (2003) who found deteriorating supply chain performance in a sample of 400 mergers in the pharmaceutical and chemical industries. Saraan and Srari (2008) and Srari, Bertonec, Fleet and Gregory (2010) employed case studies as an alternative research approach. Their aim was to illustrate frequent post-merger activities to capture operational synergies and to highlight the vital role of inventory and supply chain management in mergers and acquisitions.

An important conclusion from the academic research is that the performance in inventory-related metrics deteriorates after a merger. This finding is troubling as merging companies frequently expect net working capital synergies, which include reduction in the inventory position.

Acquiring companies have good reasons to anticipate such synergies. Anupindi and Bassok (1999) and Cachon (2003) found the benefits of inventory pooling through combination

of safety stocks. Merging companies could pool inventory through the consolidation of warehouses and distribution centers. Economies of scale could lead to more efficient storage and inventory handling practices. Häkkinen et al. (2004) and Schweiger and Lippert (2005) noted that the higher purchasing power of the combined entity could improve the negotiation position when bargaining on delivery terms with suppliers, such as delivery lead times or vendor managed inventory. Singh (2009) and Bernile and Lyandres (2010) analyzed the benefits of vertical mergers. For instance, planning uncertainty and buffer stocks may be reduced by optimization across a larger supply chain.

The expectation to reduce inventory levels after acquisitions stands in contrast to observations of actual inventory development. The key contribution of this study is to clearly establish that the phenomenon of inventory build-ups following acquisitions exists. This is the first attempt that I am aware of to develop an understanding for when, how and why the inventory build-up occurs. The research gap is addressed in this work with four research questions, based on data comprising 926 U.S. mergers in the period 1978-2009. (1) Does the phenomenon of inventory build-ups after mergers exist? (2) When does the inventory build-up occur and does it persist after the post-merger integration? (3) What happens in the post-merger integration and why does the inventory build-up occur? (4) Which companies are affected the most by the inventory build-up?

Creating awareness and understanding of the inventory build-up is important because companies may take wrong assumptions when deciding on their next acquisition. The additional inventory positions constitute an implicit premium to the deal value. Unrealistic expectations in the inventory development can affect post-merger integration when companies focus on the wrong actions. Therefore, decision makers should have well founded reasons when they anticipate inventory reductions.

The initial list of 3590 deals is retrieved from SDC M&A database. Acquiring and target company need to be publicly traded and regularly report quarterly financial data including their inventory position. Financial data for four quarters before and eight quarters after the merger is retrieved from Standard & Poor's Compustat database. The final sample includes 926 companies. 499 of the targeted companies are in the high tech manufacturing industry, 224 in process manufacturing, 144 in trade and 59 in mining and construction. Companies in the finance, service and transport and utilities industries are not included in the sample as they do not have relevant inventory positions.

I compare average inventory levels before and after the merger to show a substantial increase in inventory levels. A more detailed analysis of quarterly inventory growth rates shows when the inventory build-up occurs. Revenue is a main driver for inventory development. Extraordinary revenue growth after the acquisition may be an explanation for the extraordinary inventory growth. I devise inventory responsiveness to measure the

growth in inventory that exceeds revenue growth. The analysis of quarterly inventory responsiveness shows in which quarters inventory growth can not be explained by revenue growth. For a sub-sample of 58 deals, more detailed inventory data is available. The decomposition of inventory may unfold other reasons for the inventory build-up. Increasing raw material inventory indicates challenges in transition and change of suppliers. Changes of work in progress inventory can be caused by an extension of the product portfolio or creation of new bottlenecks by higher capacity utilization and close-downs. An increase in finished goods inventory suggests anticipated revenue growth as the goods need to be made available to the customer. Certain companies are likely to experience stronger inventory growth after an acquisition. I use a least square dummy variable regression to assess the correlation of inventory build-up and company characteristics. The dependent variables is measured through inventory growth after post-merger acquisitions and through inventory growth adjusted for revenue growth. The company characteristics include gross margin, inventory turnover, capital intensity, acquirer and target size.

The results of this study confirm that the inventory build-up exists. Mean inventory levels increase by \$ 99.4 million or 21.6% in the first year after the merger. The higher inventory levels are not reverted in the second year after the merger as mean inventory increases to 35.3% above pre-merger level. The inventory build-up happens in the first and second quarter after the merger when inventory growth rates peak up to 7.9% and 6.9% respectively. The difference to long-term average growth rate at 4.1% is statistically significant. Revenue growth is part of the explanation for the inventory build-up. Revenue growth can account for inventory growth in the second quarter after the merger. However, in the first quarter inventory growth of 7.9% is significantly higher than revenue growth of -0.8%. The decomposition of inventory indicates that operational changes in the supply and production network are part of the explanation of inventory build-ups. Companies that typically experience high growth in inventory levels operate in high volume businesses and target smaller companies for acquisitions.

The first research question seeks to confirm that the phenomenon of inventory build-ups after mergers exists. The comparison of mean inventory levels shows an increase from \$837.9 million in the four quarters before the merger to \$937.3 million in the four quarters following the merger. The increase of \$99.4 million corresponds to a 21.6% increase of mean pre-acquisition inventory and is statistically significant. The increase in inventory levels persists in the second year after the merger. The mean inventory level lies at \$993.3 million, which is \$155.5 million above pre-merger average. These results confirm that inventory levels increase significantly after mergers. Moreover, the increase is persistent over time which indicates that it is caused by fundamental changes in the business rather than temporary disturbances that may occur during post-merger integration.

The second research question concerns the timing of the inventory build-up. The average inventory growth lies at 4.1% per quarter across all firm quarter observations. Inventory growth rates peak in the first and second quarter at 7.9% and 6.9% respectively. These averages are significantly different from the long-term average across all quarters. These findings corroborate that the inventory build-up phenomenon is closely connected to the post-merger integration. The timing of the inventory build-up goes hand in hand with the 100 days axiom in post-merger integration described by Srari, Bertonecclj, Fleet and Gregory (2010) and Herd, Saksena and Steger (2005). Acquiring companies typically strove to make key decisions and changes as early as possible to utilize the window of opportunity for change and to build up momentum for the post-merger integration.

The third research question looks at the reasons behind the change in inventory levels. Revenue growth and operational changes in supply and production network are main reasons for the inventory build-up. Increasing sales often means expanding into new geographic areas, into new customer segments or introducing a new product. All of these steps are related to creating additional inventory. Merging companies often aim to boost their sales growth through these or similar actions. I compare inventory and revenue growth in a metrics called inventory responsiveness (Rumyantsev and Netessine; 2007). In the first quarter after the merger, revenue growth is at -0.8% and can not explain inventory growth at 7.9%. However, in the second quarter after the merger, 5.2% revenue growth is the main driver for inventory growth of 6.9%. Revenue growth is one piece of the inventory build-up puzzle.

I am able to track changes in specific inventory types for a subsample of my data. I find that it is work in progress that is strongly affected by M&A activity. For many merging companies, the acquisition seems to initiate a fundamental change in the operations that necessitates higher work in progress inventory. For instance, bottlenecks in production can occur when volumes reach a capacity limit or when close downs reduce the available capacity as part of the merger. An extension of the product portfolio may require to store a larger variety of intermediate products. Raw material inventory grows even stronger, reaching an increase of 13.8% in the first quarter. Although the effect is not statistically significant, companies seem to face challenges when changing suppliers to gain synergies or when maintaining relationship with key suppliers. The companies in the sub-sample do not build-up additional finished goods inventory. Revenue growth is not able to account for higher inventory levels. This may be due to the small sample size and the nature of these businesses. As they report detailed inventory decomposition, inventory management is likely to be an important part of their business that is also closely followed by shareholders.

The fourth research question examines which companies are likely to experience higher inventory growth. The regression analysis exhibits that companies that operate in high volume businesses and target smaller companies for acquisitions typically experience higher inventory build-ups.

Inventory build-up is negatively correlated to the size of the target company at statistically significant levels. When choosing a 50% larger target, acquiring companies can expect a 0.3%-points smaller cumulative average growth rate of inventory in the first year after the merger. For the median company holding \$ 837.9 million in inventory before the merger, this implies \$ 2.5 million lower inventory build-up. Smaller targets are likely to receive less management attention as their impact tends to be smaller. The integration may be carried out with less rigor and control leading to a higher inventory build-up.

Companies that typically experience high growth in inventory levels operate in high volume businesses. Inventory turnover is positively correlated with inventory build-up with a coefficient of 0.30. Inventory turnover is a measure of efficiency with higher values signifying the ability to produce more at same inventory levels or to produce same levels with a lower inventory position. Higher efficiency implies higher inventory growth. For instance, an increase in quarterly inventory turnover from 2.3 to 2.5 is associated with an additional inventory build-up by 0.2% or \$ 1.9 million for an average company.

After looking at the relationship between inventory growth and M&A, I study the link between inventory responsiveness and M&A. The dependent variable is replaced by a measure of inventory growth adjusted for revenue growth. Target size and inventory turnover are not significant explanatory variables in these regressions. However, acquirer size exhibits a negative and statistically significant relation. Larger acquiring companies appear to have superior capabilities and resources to manage and integrate their acquisitions.

Companies in the retail and wholesales industries experience above average inventory build-ups. I presume that trade companies have stronger incentives to ensure customer deliveries and therefore choose to hold additional inventory. This is because trade companies operate closer to the end customer who may have better possibilities and lower barriers to switch to competitors when delivery performance declines as a result of post-merger integration.

The remainder of this paper is organized as follows. Section 2 contains a review of the existing literature. It consists of three subsections comprising event study analyses of post-acquisition inventory metrics, surveys and case studies on supply chain perspective in M&A, and studies that involve mathematical programming. Section 3 develops the hypotheses to address the four research questions. Section 4 describes the data and methodology. Section 5 analyses the empirical results and compares them to earlier studies. Section 6 concludes the main findings, practical implications and provides ideas for future research.

2 Literature review

Despite the extensive research on M&A (Tuch and O'Sullivan; 2007), there is little literature that analyses changes in inventory and inventory related topics under the supply chain or operations research. In recent years, the supply chain aspects in M&A has gained interest among researchers and the following paragraphs introduce the relevant literature. The first sub-section of the literature review contains three articles that employ empirical analysis to assess changes in inventory based performance metrics. The second section aims to provide a broader view on operations and supply chain functions and their role in M&A. The third section gives a view on a related research stream in operations management. Theoretical studies use mathematical programming models to assess synergy potential in the combination of supply chains.

2.1 Event study analyses of post-acquisition inventory metrics

Zhu, Boyaci and Ray (2011) examined the change of inventory based supply chain metrics in horizontal mergers between 1997-2006. Their analysis did not show improved performance when comparing pre- and post-merger performance for the average company, but rather deteriorating performance in several areas: The inventory period of the median company increased by 2%, indicating that the merged company operated less efficiently. The gross profit return on inventory decreased, meaning that the companies earned less profit for each dollar invested to inventory. Inventory levels of the median company increased by 12% while sales grew only by 9%, meaning that the merging companies needed to stock up additional inventory. This development persisted in the second year after the merger: Inventory was 20% higher than prior to the acquisition and revenue growth lacked behind at 17%. The inventory growth effect in the first and in the second year were found to be significantly different from zero at the 1% level when performing a Wilcoxon sign rank test for differences in medians. For the second year, the difference of inventory growth and revenue growth (denoted as inventory responsiveness) was 2%-points which was statistically significant at the 5% level.

The authors retrieved a sample of 487 U.S. deals from the SDC M&A database for which financial data were available on a quarterly basis. Quarterly financial data was retrieved from Standard & Poor's Compustat database to compare median average performance in the four quarters before to four quarters after the merger. The change in performance could be driven by industry trends. To account for the potential effect, the authors benchmarked the merging firm with the industry average and with their closest rival firm. Industry averages were calculated as medians from a industry classification based on three digit SIC codes (Standard Industry Identifier). Merging firms grew inventory levels by 12% from the year before to the year after the merger. In comparison, the industry adjusted inventory growth was evaluated at -15% meaning that the industry median company grows

inventory 15% faster than the merging company. The authors analyzed that the merging firms were able to operate their inventory more efficiently. However, merging companies were not able to translate the efficiency into profit. Gross margin returns on inventory were clearly below the industry median level. The authors acknowledged that the difference could be driven by differences in company size. An alternative matching procedure for rival performance took company size into consideration in addition to industry. Rival adjusted inventory growth was 3%. Thus the rival firm grew inventory 3% slower than the merging firm. That translated into better inventory turnovers for the rival adjusted firms, as they had more efficient inventory practices. The authors suggested that rival firms were able to gain a competitive advantage when their closest competitors go through a merger.

In the further analysis, Zhu, Boyaci and Ray (2011) grouped their sample according to the change in return on assets (ΔROA) to create a sub-sample for the quarter of companies with the highest increase in ΔROA . This sub-sample of merging firms was able to increase the inventory turnover and improve the gross margin earned on inventory investments. To analyze the effect of supply chain performance on profitability in a merger, the authors conducted a regression analysis. They employed a number of operational metrics: ΔGPM (gross profit margin), ΔSOA (sales on assets), ΔIP (inventory over cost of goods sold) and ΔINV (inventory). By regress them on the dependent variable ΔROA , the authors found significant, positive relationships for all variables. While the regression can not identify causalities, it potentially suffers from multi-collinearity. The explanatory variables are derived from a small set of financial metrics including multiple times sales, costs of goods, and inventory.

The paper is a good starting point to shed light into post-acquisition inventory performance as the authors identify deteriorating inventory performance. However, the authors dilute the message by packaging the analysis in metrics derived from actual inventory levels and venturing into a quest for synergy gains.

Langabeer (2003) found that mergers led to lower supply chain performance after the merger. The research focused on companies in the pharmaceutical and chemical companies (SIC code 2800-2899) that conducted mergers between 1990-2000. This time period was characterized by high merger activity in the respective industry. The sample included 400 deals from the SDC mergers and acquisition database. Financial data for the years before and after the merger year were retrieved from Lexis-Nexis. To deepen the analysis beyond financial metrics, supply chain data was retrieved from Hoovers database. The data included the number of shipments for each company: The total number of shipments in the industry was split to the companies in the sample according to a company's relative share of revenue. The authors make the underlying assumption that the size and value of shipments are similar across the industry. However, companies can split their deliveries

into smaller batches to create a competitive advantage through superior delivery performance. The authors employed factor analysis to construct one metric for supply chain performance that comprises inventory turns, finished goods inventory level and operating margin. Pre-merger supply chain performance lay at 0.23 and deteriorated to 0.01. The difference in means was found to be statistically significant at the 5% level.

In the further analysis, deal value was used as a proxy for merger volume and intensity. Higher deal values were found to be negatively correlated with post-merger supply chain performance. Inventory turns per year, operating margin, capacity utilization and number of employees per shipment decrease for higher deal values. And costs per shipment and finished goods inventory increased with the deal value. Overall, the analysis showed that higher deal values tend to result in lower post-merger supply chain performance.

In a subsequent paper, Langabeer and Seifert (2003) analyzed the relationship of post-merger integration and profitability. Although, the article misses a sufficient description of the employed data and methodologies, it is quoted in the relating literature and therefore the findings are reviewed briefly in the following. Supply chain performance was measured by a similar set of metrics including inventory levels, inventory turnover, cost per shipment and employees per shipment as a proxy for labor productivity. The authors chose return on assets and operating margin as measures for merger success. An ordinary least squares (OLS) regression analysis showed that lower inventory levels and higher inventory turns were associated with better financial performance. In addition, the authors developed a proxy for the speed at which a company could complete the integration process. Companies that were able to integrate faster, were found to perform better in financial terms and the ones that spent two and more years on the integration had negative operating margins. The authors concluded for M&A to be a questionable value creation strategy because the supply chain and financial performance were likely to deteriorate after the merger.

Langabeer and Seifert (2003) saw the underlying reason for deteriorating supply chain performance in the separated responsibilities in the pre- and post-merger phases. The pre-merger planning, assessing and negotiating was dominated by finance and planning groups. However, operations and supply chain were expected to execute the deal on an operational level. During the integration, substantial challenges occurred that were not accounted for in the merger planning and that could put the merger success at stakes. The authors employed case studies and anecdotal evidence to support their claim. For instance, they cited the acquisition of Robson Foods by Colonel Foods. The acquirer failed to integrate the supply chains due to distinctively different strategic focus: Colonel Foods pursued a low cost strategy with control of its own warehouses, truck fleet and logistic department which allowed the company to pursue a low cost strategy. In contrast, Robson Foods had outsourced the entire logistics focusing its efforts on a premium

product offering. The failure to integrate the supply chains contributed to the resolution of the merger after 1.5 years and led to the resignation of the vice president logistics. The authors concluded that early and active involvement of supply chain representatives was the key to a fast and successful merger integration.

An key insight from the existing event study research is that inventory levels appear to increase significantly after an acquisition. Zhu, Boyaci and Ray (2011) employed metrics for supply chain performance that were based on inventory levels. Average inventory levels increased by 12% from the year before to the year after the merger. Langabeer (2003) found declining performance for a supply chain measure that combined into one metric inventory turns, finished goods inventory level, and operating margin. However, the contribution to the understanding of the inventory build-up is very limited. Langabeer (2003) investigated the relationship of deal values and post-merger supply chain performance and found it to be negatively correlated. Larger target companies appear to be more difficult to integrate.

Zhu, Boyaci and Ray (2011) and Langabeer and Seifert (2003) made an effort to link supply chain performance to financial performance and overall merger success. Such a relationship is appealing. Herd, Saksena and Steger (2005), D'Avanzo, Lewinski and Wassenhove (2003) and Finley and Bonno (2012) promoted the idea that strong and early supply chain involvement was critical for merger success. However, the provided evidence may not be sufficient. The analysis in both papers was based on regression analysis which may indicate correlation but not causality.

2.2 Surveys and case studies on supply chain perspective in M&A

The event studies introduced in the previous section are limited in creating insights for the reasons of change and into the decision making process. Alternative research designs such as surveys and case studies can provide a deeper understanding and develop guidance for inventory development after an acquisition. The following paragraphs introduce the relevant literature.

Häkkinen et al. (2004) surveyed key decision makers of 257 Finnish and Swedish manufacturing companies. The authors found that logistic was perceived to play an important role in M&A: Logistics was considered an important motive for M&A and a key enabler to achieve other motives. The sample of deals between 1995-2001 was drawn from website information from KPMG Sweden and the Finnish business magazine Talouselama. Questionnaires were send out to the management of 257 acquiring companies, which in total

conducted 484 deals in the period. The response rate was 12%. The authors analyzed synergy potential and realization across corporate functions including sourcing, manufacturing, distribution as well as sales, R&D, IT, administration and finance. The scope of logistics included sourcing, manufacturing and distribution areas. The authors employed Spearman rank order correlations to link survey results with deal characteristics. 40% of the survey respondents regarded logistic synergies as an extremely important or important merger motive. Logistics synergies were rated third after product/ market extension and geographical extension. Realizing logistics synergies was perceived as neither difficult nor easy by most respondents, although logistic synergies appeared to be harder to realize than synergies in finance, administration or IT.

The hypothesis that capturing synergies was easier for smaller targets is not supported. No significant effects were found. On the contrary, realizing synergies in sourcing was found to be more difficult for smaller targets. The absolute synergy potential was lower for smaller targets, thus attracting less management attention. The lack of management attention could result in too little effort and support being put into integration. Higher expected synergies led to higher levels of integration in distribution, sales, R&D. For distribution the relationship was statistically significant. A high level of expected synergies in distribution had strong, positive relationships with the degree of the integration in all other functions except finance. Realizing distribution synergies often involved the reorganization of the distribution network which entailed an integrated effort from all functions. The analysis showed that closer levels of integration increased the chances to realize synergies. This finding held for most functions, but also applied across functions. In particular, realizing synergies in manufacturing became easier with a higher degree of integration in IT, R&D and finance.

The authors introduced a basic framework for structuring and illustrating logistic issues in an acquisition. The framework started from impacting factors including similarities, complementarities, geographical overlaps, relative size, pre-merger quality of process, and acquirers experience. The factors were used to assess logistic structures and processes in sourcing, manufacturing, and distribution. While the authors highlighted the multiple use cases of the framework in evaluating combination potential, levels of integration or realized synergies, the actual process for evaluation remained open.

Srai, Bertonecelj, Fleet and Gregory (2010) proposed a basic framework for an operations management perspective on M&A. The framework was called operations process maps and aimed to illustrate frequent post-merger activities to capture operational synergies. From operations perspective, the principal stages in M&A were identification of value creation drivers, initial operations assessment, development of operations strategy and value delivery. The authors observed a research gap regarding the operational activities in synergy realization. The research was based on the insights from 24 case studies and

refined in interviews with executives and industry experts.

In the operations process map, identification of value creation drivers was based on strategic objectives and led to the selection and review of potential target companies. The outcomes of the initial operations assessment was compared to strategic objectives and value creation drivers. For promising targets, assessment proceeded to the development of an operations strategy. The components of an operations strategy included value delivery plan, risk management, and formal due diligence. If the assessment was successful, the acquisition proceeded to negotiation and eventually to execution. The negotiation phase was used to set up an implementation plan and team. During the execution, the value delivery plan was implemented sequenced to the first 100 days, the first year and the transition to business as usual after about three years. The authors emphasized the generic nature of the framework as it applied to all observed M&A cases. The starting point for the involvement of different stakeholders and the time lines of phases were omitted as they were typically extremely case sensitive.

The operations process map lay down the generic process for value creation through operational synergies. The first phase aimed at identification of value creation drivers and was studied in a related paper by Bertoneclj and Kovač (2007). The fourth phase concerning value delivery and frequent activities were analyzed by Srαι, Bertoneclj, Fleet and Gregory (2010) and Saraan and Srαι (2008). Srαι, Bertoneclj, Fleet and Gregory (2010) highlighted the need for further research on phase 2 and 3 which comprise the initial operations assessment and operations strategy.

Bertoneclj and Kovač (2007) analyzed a subsample of 9 M&A cases and introduced hard and soft key success factors for value contribution in M&A. While each factor contributed by its own, the key to more successful acquisitions was taking a balanced approach that incorporates all factors at an early stage. In particular, the authors argued that except for the competent management team, the soft success factors were frequently neglected. The lack in attention towards organizational learning, intellectual capital, a joint organizational culture, and effective communication resulted in the neglect of human aspect and ultimately in the failure of many deals. Hard success factors were thorough acquisition research and due diligence, sufficient financial resources, realistic synergy estimates, and accurate integration planning. They represented the financial side of M&A. Managers often focused on the financial factors and the deal went off track when the soft factors did not match. The authors suggested that all factors should be considered in an early stage of the merger process.

Srαι, Bertoneclj, Fleet and Gregory (2010) investigated the value delivery for different M&A motives and for actions taken towards value realization. The most frequent motives were improved network access including market, product and technology, and improved

network efficiency in supply, production and route to market. Contrary to the authors expectations, the taken actions did not depend on the underlying motive. A possible explanation was the multitude of motives typically at play in an acquisition. The most frequent actions in purchasing included supplier re-selection, harmonization of specifications and purchasing policies. For an individual factory typical actions comprised changes in outsourcing, production line redeployment, know-how transfer and equipment investments for production task changes and for technology upgrades. Frequent changes in the production network concerned production tasks and geographic dispersion. Many M&A cases included actions changing the route to market with the aim to exploit of joint distribution channels, change in inventory policies, and rationalization of warehousing and distribution.

Saraan and Srari (2008) used a subsample of five case studies to develop and introduce a framework and determine the sequence of actions. The significance and sequence of operational actions depended on geographic and product overlaps among the merging companies. For instance, mergers with a regional but with no product overlap typically focused on customer service within the first 100 days and then started exploiting market access opportunities and integration of business processes. Long-term action to should be completed within three years were the integration of distribution, sales and service network. In contrast, M&A integration with a product but without a geographic overlap would start by assessing the manufacturing technology and processes. The first year focused on planning the integration, reviewing opportunities for outsourcing and integration of product development. Long-term actions were the integration of manufacturing technologies, best practice transfers in production and group-wide material planning. For cases of geographic and product overlap, the authors suggested for the first year to determine a procurement strategy and capacity planning across all sites. Long-term actions were the realization of economies of scale in procurement and production, rationalization of production networks and the ERP integration.

Summarizing, the surveys and case studies showed that supply chain was perceived as an important factor in M&A and in particular in post-merger integration. However, in many deals the role of supply chain management is neglected. Häkkinen et al. (2004) and Srari, Bertonecelj, Fleet and Gregory (2010) identified the research gap and initiated the development of supply chain and operational frameworks. The frameworks have proven useful in delivering insights into what happens in the supply chain during post-merger integration. Häkkinen et al. (2004) identified interdependencies among integration and synergy realization in different departments. Closer levels of integration increased the chances of synergy realization within and across different functions. Realizing synergies in manufacturing became easier with a higher degree of integration in IT, R&D and finance. Srari,

Bertoncelj, Fleet and Gregory (2010) highlighted the importance of the first 100 days in post-merger integration which is a central element in the argument for earlier supply chain involvement in deal making. The authors found that the actions to integrate operations of the merging companies did not depend on the merger motive. However, Saraan and Srai (2008) showed that the significance and sequence of operational actions depended on geographic and product overlaps among the merging companies.

2.3 Studies that involve mathematical programming

Mathematical programming models represent a related research stream from operations research. Research in this area typically aims to solve theoretical optimization problems through linear programming. Some scholars employed mathematical models to quantify supply chain synergies in various M&A settings. These studies may be helpful in determining the synergy potential of individual merger cases. Accurate estimates of the synergy potential are important to avoid overpaying on the deal premium and to set the right focus areas in post-merger integration. However, this study aims to establish whether companies actually manage to realize synergies. Therefore, the research stream focused on mathematical programming in reviewed only briefly.

Xu (2007) pointed out synergies from consolidating supply chains as a major motive for the recent merger wave in the 2000s. As the realization of these synergies proved to be challenging in practice, the author developed mathematical programming models to estimate and analyze synergies from supply chain consolidation. The multi-period model varied the fit of company characteristics like product structure and distribution network and estimates improvements in supply chain performance of the merged company. The analysis showed that most synergies originated from lower logistic costs through reductions in the number of trucks. Achieving the full synergy potential required the supply chain manager to work with short planning horizons.

Nagurney (2009) proposed a model to quantify potential operational synergies from a horizontal merger. The model was novel in embedding the company into a network of other companies. In the network, manufacturing, distribution and logistics functions of acquirer and target company could be modeled as one system. This facilitated a better understanding of the interaction of the company characteristics in each function and allowed assessing the impact on operational synergies. Mathematical programming models helped to properly assess potential supply chain synergies prior to the merger.

3 Hypotheses

In the following section, I introduce five hypotheses and their underlying reasoning. The first research question concerns the existence of the inventory build-up phenomenon and is addressed in hypothesis 1. For the second research question, the timing of the inventory build-up is analyzed in hypothesis 2. The third research question looks at reasons for the inventory build-up. Hypothesis 3 looks at revenue as a driver of inventory. For hypothesis 4, I decompose inventory into raw material, work in progress and finished goods to identify underlying drivers of inventory growth. The fourth research question investigates which type of company is more likely to experience high inventory growth after mergers. Hypothesis 5 evaluates the relationship of five company characteristics to inventory build-up.

An important insight from the literature review in section 2.1 is that inventory levels appear to increase significantly after an acquisition. Zhu, Boyaci and Ray (2011) employed metrics for supply chain performance that were based on inventory levels. Average inventory levels increased by 12% from the year before to the year after the merger. Langabeer (2003) found declining performance for a supply chain measure that combined into one metric inventory turns, finished goods inventory level, and operating margin. The first step is to establish clearly that the phenomenon of increasing inventory levels exists.

Hypothesis 1. *Post-acquisition inventory is significantly higher than pre-acquisition inventory.*

The second research question deals with the timing of the inventory build-up. Most merger execution activities are completed within the second year after the merger. Srari, Bertonec, Fleet and Gregory (2010) described three phases in post-merger integration. The most important decisions are taken within the first 100 days after the merger announcement. In the first year, the value delivery occurs. In the last step, operations return to business as usual. Recent research by Langabeer (2003) and Zhu, Boyaci and Ray (2011) followed post-merger performance for one and two years respectively. Post-merger integration often involves fundamental changes in the way the two companies operate. Finley and Bonno (2012) and Srari et al. (2010) described restructuring of production and distribution footprint, re-allocation of production, creation of shared services and consolidation of inbound and outbound logistics as typical changes. I claim that these changes can create a need for higher inventory levels. For instance, a close-down of production facilities aims to increase capacity utilization which may create bottlenecks in production and logistics that result in higher inventory positions. Devos, Kadapakkam and Krishnamurthy (2009) and Häkkinen et al. (2004) showed that revenue synergies are a common motive for mergers. I argue that revenue growth is likely to necessitate inventory growth. For instance, this is the case when the acquiring company makes the target company's

products available through its distribution channel to boost sales. For these reasons, I expect the inventory build-up to persist beyond the post-merger integration.

An alternative argumentation is that temporary inventory buffers are a mitigation strategy against disturbances during post-merger integration. Finley and Bonno (2012) mentioned poor product quality and slack fill rates that could affect customer delivery. Competitors were keen to prey on disturbances as they try to gain customers that were concerned by the changes the merger. In this case, the inventory build-up would be temporary and inventory levels would return to lower levels after the completion of the merger. I believe that this is a weaker argument. Waters and Waters (2003) and Tang (2006) described risk monitoring, pro-active inventory management and planning of mitigation actions as effective strategies against operational disturbances. While companies seem to have several options to mitigate disturbances, revenue growth and cost reduction through restructuring are two of the most prevalent motives for mergers.

Hypothesis 2. *The average inventory levels of merging companies are significantly higher in the second year after the merger compared to the year before the merger.*

The third research question investigates reasons for the inventory build-up. Companies strive to minimize their inventory to reduce capital costs and signal that they operate efficiently. There are three reasons why companies still hold inventory. Those reasons are holding inventory as part of the replenishment cycle to facilitate production and sales to customers, holding inventory as a buffer stock against risks and uncertainty in demand, and holding excess inventory due to operational inefficiencies.

Devos, Kadapakkam and Krishnamurthy (2009) cited revenue synergies as a frequent motive for mergers. Srαι, Bertoneelj, Fleet and Gregory (2010) found market, product and technology access to be among the most frequent motives. And a survey conducted by Häkkinen et al. (2004) showed that the respondents see product/ market extension and geographic roll up as the two most important merger motives. Revenue synergies are likely to create a need for higher inventory to make the new product available or to start selling in a new market or geography. Rumyantsev and Netessine (2007) showed that on the long-term companies are able to grow their inventory at similar rates as revenues. The authors employed a metric called inventory responsiveness, which is calculated as quarterly inventory growth less quarterly revenue growth. Positive (negative) numbers express that inventory grows faster (slower) than revenues. Zhu, Boyaci and Ray (2011) employed a similar metric and observed that inventory grew on average 1% faster than revenues after the merger. I argue that revenue growth is a main reason for the inventory build-up. Therefore, inventory and revenue growth should be very similar through all quarters.

Hypothesis 3. *Merging companies grow revenue at similar rates as inventory in the quarters following an acquisition.*

Inventory can be decomposed into raw material, work in progress, and finished goods. Each type of inventory fulfills a dedicated purpose. I claim that the development of the different inventory types allows conclusions on the underlying reasons for the inventory build-up.

Srai, Bertoucelj, Fleet and Gregory (2010) cited supplier re-selection, harmonization of specifications and purchasing policies to be among the most frequent actions in the purchasing department during post-merger integration. Merging companies have incentives to build-up raw material inventory when they are concerned that these cause temporary disruptions to their supply or continuous disadvantages such as longer lead times or lower reliability of supply deliveries. For instance, Sagner (2012) described that conflicting interests with the merging party may render a key supplier unavailable. Binding supplier contracts could limited the synergy potential. In addition, temporary increases of raw material inventory may be desirable when supply certainty is impaired by changes in the production setup. I believe that these negative effects are likely to outweigh potential inventory synergies from the merger. Häkkinen et al. (2004) and Schweiger and Lippert (2005) noted that the higher purchasing power of the combined entity can improve the negotiation position when bargaining on delivery terms with suppliers. However, the synergies evolve mostly from transport cost and purchase prices reductions while raw material inventory is likely to be used as a buffer against adverse effects.

Hypothesis 4a. *The inventory build-up occurs in work in raw material inventory.*

The purpose of work in progress inventory is to maintain and facilitate a smooth production. A buildup in work in progress inventory would indicate a fundamental change in the production and logistics setup which necessitates higher inventory. Finley and Bonno (2012) and Srai et al. (2010) described such changes to include restructuring of production and distribution footprint, re-allocation of production, creation of shared services and consolidation of inbound and outbound logistics. Srai, Bertoucelj, Fleet and Gregory (2010) added changes in outsourcing, production line redeployment, know-how transfer and equipment investments for production task changes and for technology upgrades to the list. I argue that these changes can create a need to hold higher inventory levels. For instance, a close-down of production facilities targets at increased capacity utilization which may create bottlenecks in production and logistics that result in higher inventory positions. Bottlenecks in production may also occur when the merging company is able to increase its volumes to an extent that limitations of the equipment are reached. An extension of the product portfolio may require to hold on stock a larger variety of intermediate products. Potential problems in the post-merger integration would become visible in a pile-up of work in progress inventory. Tompkins (2012) stated facilities and technologies as potential constraints for merger integration. For instance, fundamentally

different production and IT systems could make supply chains incompatible.

Hypothesis 4b. *The inventory build-up occurs in work in progress inventory.*

The primary purpose of finished good inventory is to ensure product availability and on-time customer deliveries throughout the distribution network. Merging companies can have an interest to increase finished good inventory if they anticipate demand growth. Persuading new customers often involves offering additional services, such as on-demand deliveries or promising no stock-outs. The argumentation line is in line with hypothesis 3. If revenue growth is a main driver for inventory growth, than this should reflect in particular in finished goods inventory.

Hypothesis 4c. *The inventory build-up occurs in finished goods inventory.*

The fourth research question examines which companies are likely to experience higher inventory growth. The following hypothesis examines the relationship of inventory build-up with gross margin, inventory turnover, capital intensity, acquirer and target size.

Zhu, Boyaci and Ray (2011) employed gross margin return on inventory (GMROI) as a measure of supply chain performance. GMROI reflects how much money a company is able to earn for each dollar invested into inventory. Companies can improve their GMROI performance by increasing their gross margin or by increasing their inventory turnover. This describes a strategic choice each company faces to generate returns through high profitability or through high volumes. Companies that target a high gross margin typically have a premium offering that allows them to charge relatively higher prices. The premium offering may entail logistic services such as fast delivery, high availability of spare parts and guarantees for no stock-outs. Providing the logistic services often requires special arrangements and expertise in logistics and inventory management. Therefore, I argue that companies with a high gross margin are better prepared to manage their inventory efficiently and will experience lower inventory build-ups.

Hypothesis 5a. *Gross margin is negatively correlated with the build-up of above average inventory.*

Continuing the argumentation from hypothesis 5a, companies that do not chose to generate returns through a premium offering by default opt to operate in a high volume business. Naturally, there may be companies that try to occupy the middle ground and provide a medium priced offering if they see sufficient demand. However, I believe that these cases can be neglected as the competitive environment forces companies to make a clear strategic choice. The companies that go into the volume business are likely to have higher inventory turnovers as they can utilize their capacity more efficiently. Due to the high volumes, the effect of any adverse changes such as longer lead times or disturbances will be magnified. Therefore, I argue that companies with high inventory turnover are associated with higher inventory build-ups.

Hypothesis 5b. *Inventory turnover is positively correlated with the build-up of above average inventory.*

Capital intensity is a proxy for infrastructure investments such as IT systems, production plants, transportation equipment and warehousing. Higher developed IT systems may plan better for future demand uncertainty and optimize production plans accordingly. Better infrastructure in plants and equipment enables to execute the plans accurately and efficiently. I claim that higher capital intensity is linked to superior inventory management that reduces the needs for inventory build-up after a merger.

Hypothesis 5c. *Capital intensity is negatively correlated with build-up of above average inventory.*

Larger companies can afford more advanced analytics and inventory management tools that help them cope with operational changes. With superior tools and the ability to dedicate resources to an acquisition, larger companies may find it easier to integrate an acquisition and avoid creation of additional inventory. Larger companies are also more likely to be serial acquirers. Hayward (2002) showed that serial acquirers are able to learn from their mistakes and on average can achieve better M&A performance. I expect larger acquirers to generate lower inventory build-ups.

Hypothesis 5d. *The size of acquiring company is negatively correlated with the build-up of above average inventory.*

Larsson and Finkelstein (1999) and Häkkinen et al. (2004) found that smaller targets were likely to receive less management attention. After the deal was closed, top management attention diverted and the integration was carried out with less rigor and control. I argue that smaller target companies are associated with higher inventory build-ups. I believe that the negative effect of low management attention for small targets outweighs the positive effect that stems from smaller targets being easier to integrate. Smaller targets typically have a smaller number of production sites and warehouses and are likely to not have a multitude of different IT systems. Although they may appear to be easier to integrate, I believe that the contrary is the case. Management underestimates the challenges in integration smaller targets and diverts its attention to bigger topics. I argue that a higher inventory build-up can be a negative outcome from lower management attention. This argumentation is in line with findings by Langabeer (2003). Their analysis showed that deal values and post-merger supply chain performance are negatively correlated. Larger target companies appear to be more difficult to integrate.

Hypothesis 5e. *The size of target company is negatively correlated with the build-up of above average inventory.*

4 Data and methodology

The first subsection describes the employed data and offers descriptive statistics for the sample. The second subsection reviews the methodology used in the analysis section. And the third subsection gives an overview to the variables and introduces descriptive statistics.

4.1 Sample data

This section describes the used data sources, processing of the data, and illustrates sample characteristics in descriptive statistics. The sample is drawn from a population of mergers in the period 1978-2009 that is available from the Securities Data Corporation SDC M&A database. Companies from the financial industry are excluded because their low comparability with conventional companies (Standard Industry Classification SIC codes 6000 - 6999). The initial sample covers 5289 deals. I impose additional conditions to ensure a significant impact on the business operations. The deal needs to be completed and the acquiring company needs to obtain at least a 33.3% share in the target company, representing a controlling interest. I exclude any deals involving a company buying its own shares, e.g. acquisitions of remaining interest.

Accounting data is retrieved from the Standard & Poors Compustat database through the Wharton Research Data Service (WRDS). The databases SDC and Compustat use different primary keys to identify companies. In 489 cases it is not possible to match the codes of either the acquiring or the target company leading to the exclusion of the observation. In particular, SDC uses historical CUSIP codes while Compustat uses GVKEY as a company identifier. While GVKEY uniquely identifies a specific company at any point in time, the historical CUSIP code of a company changes to reflect changes in the financing structure. The Center for Research in Security Prices (CRSP) tracks historical CUSIPs. I access CRSP through the Wharton Research Data Service (WRDS) to match historical CUSIPs and GVKEYs. In addition, I perform a manual check for the company name to identify GVKEYs not included in CRSP. In doing so I account for name changes with publicly available information on the internet. For 3590 deals identified from SDC, it is possible to match the CUSIP and GVKEY identifiers. Deals are excluded when missing accounting data in the period from four quarters before to eight quarters after the merger of either the target and the acquiring company. Several firms are excluded because the financial data needs to be available on quarterly level for the analysis. For 1345 deals, quarterly financial information is available for both acquiring and target firm. I still exclude industries in for which inventory do not play a significant role, transport and utilities, services and public administration. The final sample covers 926 deal. Table 1 illustrates the split by acquirer industry and 15 in the appendix for the split by target industry.

Table 1: Data availability and sample size by industry of the acquiring firm

	Retrieved from SDC database	Acquirer data available	Target data available	Data available for both	Deals included in sample	% of total in sample
Mining and Construction	267	110	155	67	59	6.4
Process manufacturing	563	409	387	284	252	27.2
High tech manufacturing	1083	850	714	561	478	51.6
Transport and Utilities	484	200	300	127	0	0.0
Trade	331	228	222	154	137	14.7
Services	862	242	515	152	0	0.0
Total	3590	2039	2293	1345	926	100.0

The table shows the number of deals by industry of the acquiring firm, based on one-digit SIC codes. Deals were excluded from the original sample due to missing data for the acquiring or target firm. In addition, deals with firms in the service, and transport and utilities industries were excluded because inventory does not play a significant role for them.

The following financial items are collected from the Compustat database: total assets (data item: ATQ), inventory (INVTQ), net sales (SALEQ), cost of goods sold (COGSQ), and operating income before depreciation (OIBDPQ). In total I retrieve 14 quarters of accounting data: five quarters before the merger, eight quarters after the merger, and the quarter of the merger itself. The four quarters before the merger are a comparison period for pre-merger level of performance. For the post-merger period, I analyze two years after the date when merger became effective. The idea that post-merger activities are concentrated on the weeks and months immediately after closing the deal is very prominent in academia and in practice. Srari, Bertonec, Fleet and Gregory (2010) described three phases in post-merger integration: The first 100 days often entailed the biggest decisions, as the uncertainty in the merging organizations created a window of opportunity for change. The second phase was called value delivery and occurred within the first year after the merger. The execution was completed by the third phase in which the organization returned to business as usual. Herd, Saksena and Steger (2005) supported this idea. They propose that supply chain leaders were actively involved in earlier phases before the change of control to ensure that their function can take a head start in capturing supply chain synergies.

Table 2 describes the merger intensity in the sample over the years 1978-2009. The number of mergers has increased over the decades and mergers are concentrated over time in merger waves. In the late 70s and early 80s, the number of observations per year ranges between 1-7. Merger intensity peaks in the late 80s with 26 observations in 1986 and in 1989. Martynova and Renneboog (2008) characterized these mergers as driven by the deregulation in the financial industry and innovation of electronic technologies.

Table 2: Number and average size of acquisitions by year, in \$ million

Year	Number of observations	Mean inventory level	Mean total assets	Inventory as % of total assets
1978	2	384.0	1562.8	22.5
1979	1	4397.0	40988.0	10.7
1980	3	832.0	3531.9	29.4
1981	5	928.8	3972.0	26.1
1982	7	817.7	4579.1	20.5
1983	6	703.4	3620.4	20.0
1984	23	703.9	4589.5	21.5
1985	21	857.8	4344.2	21.8
1986	26	359.8	2142.2	19.1
1987	25	973.6	6639.7	18.6
1988	25	954.2	6535.9	22.1
1989	26	898.6	4353.6	21.7
1990	17	517.6	2477.9	25.1
1991	15	439.7	2540.5	12.6
1992	11	225.3	943.6	18.5
1993	23	306.4	2490.3	17.0
1994	27	577.7	3176.8	20.2
1995	32	563.2	4278.4	16.9
1996	46	631.7	3198.5	18.3
1997	62	635.9	4772.4	17.5
1998	71	672.9	4711.3	15.8
1999	70	825.9	8018.7	13.3
2000	73	783.7	6470.9	15.5
2001	52	731.7	6797.3	15.2
2002	28	1270.6	8391.7	19.3
2003	28	587.4	7318.2	12.8
2004	31	1108.3	6577.9	14.0
2005	35	950.1	15737.1	11.1
2006	36	1449.1	16715.3	11.7
2007	46	724.1	7421.3	11.3
2008	27	1604.3	21370.3	8.6
2009	26	2392.6	38750.1	9.1
Total	926	837.9	7646.7	16.1

The table shows the number of mergers, their mean average inventory and assets per year in the sample period 1978-2009. Inventory and assets are shown for the pro-forma combined entity of acquiring and target company.

These mergers were characterized by an increase of hostile takeovers, leveraged buyouts and going private transactions. There was an increasing share of smaller deals as small and medium sized companies started acting as buyers and big corporations divested from their inefficient business areas.

The merger market cools down in the early 90s and the number of observations in the sample decline to 11 in 1992. The next merger wave issues in the following years and peaks in the years 1998-2000 with over 70 mergers per year. Acquiring companies sought to acquire strategic combinations that could create synergies and fight off the tougher competition. There was also an increasing shares of cross-border deals. All sizes of companies and all industries showed high activity in this merger wave. This is reflected in the combined assets of acquiring and target company. In earlier years, mean total assets in most years ranged between between \$ 2000-4500 million. After 1997, the average combined assets are above \$ 4700 million for all years.

The merger wave ends with the burst of the dot-com bubble. In 2002 and 2003, the number of mergers in the sample is down to 28. The most recent merger wave occurred 2004-2007. The sample shows a maximum of 46 observations in 2007. These mergers were driven by excess liquidity and low financing rates. The average combined assets peak up to over \$ 15000 million in the late 2000s with the maximum of \$ 38750.1 million in 2009. The increasing size of merging companies is also reflected in the joint inventory position. The average inventory for most years before the 2000s is below the average of \$ 837.9 million. In the late 2000s the average inventory increases to over \$ 1000 million in most years. This increasing assets and inventory of the merging entities pose an challenge to post-merger integration. With size the complexity and interconnections of supply chain operations increases. This emphasizes the need for stronger supply chain involvement to make post-merger integration successful as proposed by Herd, Saksena and Steger (2005) and Finley and Bonno (2012).

A prominent explanation for mergers being clustered into waves is that they are caused by industry shocks, such as financial deregulation and technical innovation in the 1980s. In this case, the change in profitability after a merger may be over-ridden by industry or economy wide trends. Therefore, performance needs to be adjusted by industry performance. For instance, Healy, Palepu and Ruback (1992) proposed to adjust the merging company's operational performance by comparing to its closest rivals. Operational performance and profitability may well be affected by industry shocks such as financial deregulation or oil price changes. However, they are unlikely to affect the medium to long-term inventory development. Therefore, I do not adjust of industry or rival performance when analyzing the post-acquisition inventory development.

Table 3 shows the average inventory levels for acquiring and target company before the

Table 3: Average inventory levels by industry before the merger, in \$ million

	2 digit SIC code	Number of observations	Mean inventory level	% of total assets	Median inventory level	% of total assets
<i>Panel A: Average inventory position of acquiring company by industry</i>						
Mining	10-14	46	404.3	4.4	48.2	2.8
Construction	15-17	13	813.1	54.4	531.1	60.6
Food and kindred products	20	35	1075.2	19.9	813.2	21.9
Paper	26	21	1062.4	11.1	518.6	11.2
Printing and publishing	27	19	101.6	7.8	46.5	6.2
Chemicals	28	129	1236.4	11.9	511.0	10.4
Other process manufacturing		48	694.0	20.7	231.1	20.3
Primary metal industries	33	26	535.5	16.2	246.0	17.3
Industrial machinery	35	100	761.5	14.5	296.9	13.2
Electronics	36	123	460.7	16.2	82.2	15.0
Transportation equipment	37	35	1400.5	17.1	723.9	14.9
Instruments and related products	38	124	439.7	14.5	124.9	13.3
Other high tech manufacturing		70	234.1	20.1	131.7	18.6
Wholesale - durable goods	50	27	640.4	31.1	243.7	34.9
Wholesale - nondurable goods	51	20	1293.9	26.4	476.8	29.7
General merchandise stores	53	20	2968.1	37.6	2755.6	35.0
Food stores	54	17	862.9	28.3	521.4	32.0
Eating and drinking places	58	17	87.8	5.6	7.6	2.7
Other retail trade		36	1028.4	34.6	214.0	37.1
Total	926	926	762.7	17.4	225.7	14.1
<i>Panel B: Average inventory position of target company by industry</i>						
Mining	10-14	47	156.5	9.9	7.4	2.9
Construction	15-17	12	30.1	6.4	0.5	0.4
Food and kindred products	20	38	236.3	12.2	6.3	10.5
Paper	26	20	78.5	15.6	36.0	12.8
Printing and publishing	27	16	36.6	11.8	8.0	2.4
Chemicals	28	99	94.4	11.1	9.5	6.5
Other process manufacturing		51	112.1	14.6	17.9	10.8
Primary metal industries	33	19	61.5	12.8	7.1	12.0
Industrial machinery	35	110	81.3	15.1	6.2	13.8
Electronics	36	135	35.4	14.7	5.8	11.4
Transportation equipment	37	21	92.9	11.2	16.6	4.7
Instruments and related products	38	147	61.8	11.5	4.4	5.5
Other high tech manufacturing		67	41.6	15.8	9.5	12.8
Wholesale - durable goods	50	35	67.6	16.3	5.4	10.3
Wholesale - nondurable goods	51	17	34.0	20.3	5.6	12.7
General merchandise stores	53	10	66.2	17.8	33.5	16.7
Food stores	54	14	67.3	17.5	20.8	13.8
Eating and drinking places	58	15	9.2	9.5	4.7	6.2
Other retail trade		53	44.0	16.7	11.7	10.9
Total	926	926	75.2	13.6	8.1	8.8

The table shows mean inventory levels and inventory as % of total assets over the four quarters before the merger (q-4 - q-1). Industries are defined based on two-digit SIC codes. Industries with a low number of observations are grouped together in other segments.

merger. The split by industry is determined by the two-digit primary SIC code. It shows substantial differences in the number of mergers and the size of inventory position held by the average company. Acquiring companies hold on average \$762.7 million in inventory which is more than ten times as much as acquiring firms \$75.2 million. For median averages, the difference is even bigger with acquiring companies holding \$22.7 million and target companies holding \$8.1 million in inventory. Acquiring companies also tend to hold higher inventory as a % of total assets. Their mean percentage lies at 17.4% compared to 13.6% for target companies. This indicates that acquiring companies have either less efficient inventory holding practices or they operate in a more complex, geographically extended supply chain that necessitates holding additional inventory.

The majority of companies in the sample are in the manufacturing industry (742 out of 926 deals). 482 deals were initiated by firms in high tech manufacturing (SIC codes starting with 3) and 260 deals were executed by acquiring firms in the process manufacturing industry (SIC codes starting with 2). Companies in instruments and related products are with 147 deals most active in initiating deals, followed by electronics with 135 deals. The two industry segments are characterized by below average inventory levels for acquiring and target companies. While all manufacturing companies have incentives to minimize their inventory position to avoid capital holding costs and signal efficient processes, companies producing instruments and electronics often have additional incentives. For instance, computer hardware and electronic components tend to rapidly lose value due to constant innovation and development of new and better products.

Among the acquiring companies, there are 145 companies in trade industry which are characterized by high average inventory levels (SIC codes starting with 5). General merchandise stores hold mean inventory of \$1746.1 million and business in the wholesale of nondurable goods hold \$1394.6 million, making these industry segments clearly the ones with highest inventory positions compared to other segments. With the exception of eating and drinking places, trade companies also hold above average inventory as a % of revenue positions. Trading companies are expected to hold high inventory positions. Product availability is a crucial factor for stable revenues and customer loyalty. Holding additional inventory is a tool to ensure timely delivery and constant availability of products. Surprisingly, target companies in many trade industry segments appear to hold below average inventory levels. The mean target companies in wholesale of durable goods hold \$67.6 million in inventory, food stores hold \$67.3 million and general merchandise stores hold \$66.2 million, which are all below the mean of the entire sample of \$75.2 million. A potential explanation is that trading companies are acquired due to their superior inventory management practices.

For the definition of the merger date, I follow Zhu, Boyaci and Ray (2011). The merger date is determined by the time when the merger becomes effective. This is the moment when the acquiring company gains control over the target entity. The post-merger integration can be initiated including operational changes that are likely to affect inventory levels. In contrast, most M&A studies employ the announcement date. The announcement date is more appropriate which is the correct date when observing stock market reactions rather than operational changes.

Absolute accounting numbers affected by inflation over time. To make pre- and post-merger data comparable, I deflate all accounting metrics to 2009 dollars. I use quarterly inflation data from St. Louis FED FRED.

Extreme outliers can result in distorted estimates. To improve the robustness of results I winsorize the accounting data (specify what is winsorized) at the 1% level at both tails. That means that the 1% of the observations at either tail of the observation are transformed into the value at the 1% and 99% percentile respectively. Winsorization results in more robust estimates.

4.2 Descriptive statistics

The previous section summarized the data collection and sample characteristics. The following section presents descriptive statistics, as well as definitions and descriptions of key variables.

Table 4 shows key financial data in the four quarters before the merger in four panels: Data describing acquiring firms, target firms, the pro-forma combined firm, and further company descriptives derived from the data. Panel A shows that the mean average acquiring firm holds \$6676.5 million in assets and generates \$1778.4 million in revenue per quarter. That makes the average acquiring firm about seven times the size of the average target firm as the comparison to panel B makes visible. The average target firm holds \$970.2 million in assets and generates \$239.0 million in revenue per quarter. In terms of inventory, the difference is even more distinct as the average acquiring firms holds about ten times the inventory of the average target firm.

Due to the relatively small size of target companies, the pro-forma combined entity is dominated by the acquiring firm. Potential changes in the post-merger integration to the acquirer's operations are likely to be reflected to a stronger extent. Larger companies are likely to have several business units with varying degree of integration amongst each other. Changes in another business units during the post-merger integration can affect the development of inventory development. Special attention is attributed to the quarterly development of inventory growth in table 7. It shows that inventory growth peaks

Table 4: Key metrics for sample description, \$ million

Defintion		Mean	Median	Standard deviation
<i>Panel A: Average for acquiring firms</i>				
Inventory		762.7	225.7	1366.1
Assets		6676.5	1558.2	15399.0
Revenue		1778.4	436.8	4036.4
Costs of goods sold		1107.9	252.9	2991.8
<i>Panel B: Average for target firms</i>				
Inventory		75.2	8.1	298.6
Assets		970.2	118.2	3747.3
Revenue		239.0	33.0	898.6
Costs of goods sold		169.3	18.5	687.8
<i>Panel C: Average for pro-forma combined firm</i>				
Inventory		837.9	287.0	1419.9
Assets		7646.7	2168.2	16716.3
Revenue		2017.3	584.2	4208.8
Costs of goods sold		1277.2	345.3	3099.1
<i>Panel D: Derived metrics for company descriptives</i>				
Inventory turnover	Costs of goods sold/ Inventory	2.3	1.3	5.9
Gross margin	(Revenue-COGS)/ Revenue	0.4	0.3	0.2
Capital intensity	Revenue/ Total assets	4.3	3.6	2.9

The table shows mean and median of key financials before the merger (q-4 - q-1). Panel A shows averages for the acquiring firm, Panel B for the target firms and Panel C for both firm combined. Panel D shows metrics that are derived from the pro-forma combined financials in Panel C. These metrics serve as explanatory variables in the regression analysis.

in the first and second quarter after the merger, giving support to the hypothesis that the observed inventory effect is really related to changes in the post-merger integration.

Panel C of table 4 shows statistics for the pro-forma combined entity of acquiring and target firm which is created by adding up data for acquiring and target company. The mean average revenue per quarter lies at \$2017.3 million. The median average is considerably lower and lies at \$584.2 million. Together with the standard deviation of 4208.8, this indicates that the size of companies in the sample varies remarkably. The sample is skewed positively which means that a over-proportional share of companies are smaller than the mean average with a small number of especially large companies. The pattern is typical as most companies are small and medium enterprises and only few grow to become multi-national corporations.

Panel D displays three metrics that are derived from the financial metrics of the pro-forma combined entities. The metrics include inventory turnover, gross margin and capital intensity. Together with measures for the size of acquiring and target firm, the metrics are used as explanatory variables for the regression analysis. For acquirer and target size, I use the natural logarithm \ln of mean assets to linearize their relationship. See section 4.3 Methodology for the formulation of the regression models.

The average pro-forma combined company has an inventory turnover of 2.3 per quarter, which means that it needs to replenish its average inventory position 2.3 times per month to keep its operations running. Inventory turnover is calculated as the ratio of costs of goods sold over inventory. Higher values indicate superior performance as the company is able to use its inventory more efficiently. An alternative definition for inventory turnover calculated the ratio of revenue over inventory. As all inventory with the exception of some finished goods are valued in the balance sheet at costs, the definition using costs of goods sold is more accurate. A benefit of using revenue in the calculation of inventory turnover is that the interpretation is slightly more intuitive. Inventory turnover then measures investment into inventory required to generate the company's revenue. More efficient companies need to invest less to achieve the same results.

Inventory turnover is the inverse of inventory period, another standard supply chain measure. Inventory period measures the average time inventory lie on stock before they are being used in production or sold. The gross margin of the average company in the sample is 0.4. For each dollar in revenue that the company generates, approximately 60% are spend on costs of goods sold and 40% are left over to pay fixed costs and for profit. Gross margin percentage is a common measure for a company's profitability. Companies with higher profitability typically target a premium segment of the market. The value proposition to premium customers often involves additional services including fast delivery, instant availability of spare parts or the promise to avoid stock-outs. Offering the services may involve the creation of additional inventory and securing the continuance of the services during the post-merger integration is essential for a successful merger.

Capital intensity is measured as assets over revenue. The average company has a capital intensity of 4.3. It to reflect the amount of investments required from a company to generate its revenues. In this study, capital intensity is used as a proxy for tools and infrastructures that are available to a company. For instance, investments into IT tools, warehouses and transportation systems will enter the balance sheets as fixed assets. The investments are likely to improve the company's ability to manage its inventory and predict demand. Through that, the investments are likely to also affect the inventory development during post-merger integration.

Table 5 shows the decomposition of inventory types into raw material, work in progress and finished goods. While the entire sample consists of 926 deals, only a fraction reports

Table 5: Decomposition by inventory type, \$ million

	Number of observations	Mean	Median	Standard deviation
Total inventory entire sample	926	919.1	309.3	1532.6
Total inventory with inventory decomposition	58	1126.4	562.6	1393.0
Raw material inventory	63	295.9	140.3	367.3
Work in progress inventory	58	265.0	117.7	401.3
Finished good inventory	74	617.2	295.1	821.1

The table shows average inventory levels decomposed to inventory types: raw material, work in progress and finished goods. Only a small sub-set of companies reports decomposition of inventory.

the decomposition of inventory. For 65 deals, data on quarterly raw material levels is available for both acquiring and target company. For 63 deals, work in progress has been reported and for 77 deals the finished good inventory.

Companies that report inventory decomposition have higher averages inventory with a mean average of \$1126 million compared to \$919 million for the entire sample. However, the standard deviation of inventory is lower, with the mean average at 1393.0 compared to 1532.6. Although the companies that report inventory decomposition have higher inventory levels, they are able to run their operations in a smooth and balanced manner. As elaborated in section 3 Hypotheses, each type of inventory serves a distinct purpose and the development of each inventory type can give cues on what happens during post-merger integration with inventory. The purpose of finished good inventory is to secure availability of products and timely delivery of customer orders. Finished good inventory is typically found in distribution warehouses and on the way to the end customer. Finished goods account for the biggest share in total inventory (54.8%) and changes will have a bigger impact on total inventory development than for the other types of inventory.

Raw material and work in progress make up for the remaining inventory in almost equal shares, with mean averages of \$295.9 million and \$265.0 million respectively. The purpose of raw material inventory is to buffer against potential disruptions in sourcing that can be caused by late or bad deliveries by suppliers. Work in progress inventory is held to ensure a smooth production and balancing of bottlenecks. Out of all reasons to hold inventory, demand uncertainty is the most difficult to plan in advance and can have the most severe impact of sales. This explains why companies on average hold most of their inventory in finished goods. It also can explain that the standard deviation in inventory increases from 367.3 for raw material, to 401.3 for work in progress, and up to 821.1 for finished good inventory.

4.3 Methodology

The previous sections reviewed the sample data and descriptive statistics. The following section concerns methodologies used to analyze the four research questions outlined in the introduction.

The first research question intends to confirm the existence of the phenomenon of inventory build-up during the post-merger integration period. I compare average inventory levels and quarterly inventory growth rates of the merging companies before and after the merger. First, I calculate mean and median average inventory levels in the four quarters before the merger q-4 to q-1 and in the four quarters after the merger Q1 to Q4. The difference of the two numbers is the increase of inventory above pre-deal average. My methodology is comparable to Andrade, Mitchell and Stafford (2001) and Ghosh (2001). To test for statistical significance in differences from zero, I employ student's t-test for means. For medians, I employ the Wilcoxon sign rank test. This test is a non-parametric and distribution free test. It does not require standard distribution of the population. The test procedure takes the absolute difference of pre- and post-value, orders the values from smallest to largest and ranks them by assigning 1 to the smallest value. The test statistic is calculated as the absolute value of the sum of the signed ranks.

Second, I verify whether the inventory build-up persists or reverts in the second year after the merger. I compare average pre-merger inventory levels in q-4 to q-1 to the averages in the second year after the merger Q5 to Q8. I repeat the testing procedure by taking differences and testing for differences from zero with student's t-test for means and with Wilcoxon sign rank for medians. If the effect is reverted in the second year, the inventory build-up would be driven by temporary motives connected to the post-merger integration. A sustainable increase in inventory indicates a fundamental change in the business. The phenomenon of inventory build-up after a merger is established if inventory levels are significantly higher after the merger and if the higher inventory levels are not reverted in the following year.

Studies that analyzed changes in stock market valuation often used a time horizon of several years to analyze long-term effects of an acquisition. For instance, Ghosh (2001) looked at three years following the merger date and Healy, Palepu and Ruback (1992) even at five years. In contrast, studies that looked at operational metrics often used shorter time horizons. Zhu, Boyaci and Ray (2011) used one year before and two years after to compare inventory-related metrics before and after the merger. Langabeer (2003) used only one year before and after the merger. Hendricks and Singhal (2005) analyzed the effect of supply chain glitches on operating performance in the two years following supply chain glitches that are publicly announced. The more time passes after a merger, the more likely are operational metrics affected by factors other than the acquisition. The factors

include operational improvement, new customer needs and new technologies. The practice of evaluating two years after an acquisition is supported by the typical post-merger integration process. Srai, Bertonecclj, Fleet and Gregory (2010) described the three stages of post-merger integration. The 100 days right after the merger often entail the biggest decisions, as the uncertainty in the merging organizations creates a window of opportunity for change. In the first year after the merger, activities focus on value delivery. Thereafter, operations return to business as usual. Therefore, I focus on the first and second year after the merger to evaluate whether the inventory build-up persists or is reverted.

The second research question concerns the timing of the change in inventory levels. Previous studies such as Zhu, Boyaci and Ray (2011) compared average inventory levels before and after mergers. However, a detailed understanding for when the increase in inventory occurs is missing. I calculate quarter over quarter inventory growth rates from quarter q-4 to Q8. An individual company may experience quarterly variations as part of their operations in any quarter. However, on average growth rates are close to the long-term average. The quarters following a merger are exceptional as the growth rate peaks to above normal levels. To account for the long-term average growth trend, I deduct the average growth rate from each quarter's average. The average growth rate is calculated as the mean over all firm quarter observations. The resulting variable is called inventory growth rate above average. It reflects the extraordinary share of the growth rate which exceeds usual levels. For each quarterly average, I test the difference to zero with the student's t-test for means and the Wilcoxon sign rank for medians.

The third research questions investigates potential reasons for the inventory build-up, including expected and realized revenue growth and fundamental changes in the production and supply chain setup. First, I compare inventory and revenue growth rates to understand in how far inventory growth is driven by the companies growth ambition. I utilize a measure called inventory responsiveness, which is calculated as the quarterly inventory growth less revenue growth. Inventory responsiveness measures whether inventory and sales grow at the same rate. Positive (negative) values indicate that inventory grow faster (more slowly) than sales. Rumyantsev and Netessine (2007) showed that companies should aim to align the growth of inventory to the growth in sales. An alternative interpretation connects to lean manufacturing in which companies drastically reduce their inventory levels. In these situations the fundamental relationship that connects growth in sales and inventory is dissolved and companies would aim for negative values of inventory responsiveness. The quarterly values for inventory responsiveness are driven by a long-term growth trend, similarly as the quarterly inventory growth rate. I calculate the long-term average inventory responsiveness across all firm quarter observations. I deduct the long-term average from each quarter's average. The resulting measure is called in-

ventory responsiveness above average and reflects the extraordinary share of inventory responsiveness. I test each quarters mean inventory responsiveness above average for its difference from zero using the student's t-test. Median averages are not reported in this study. The findings are in line with the ones from analyzing mean averages.

Second, I decompose the inventory position into raw material, work in progress and finished good inventory. According to hypothesis 5, each type of inventory is dedicated to a distinct purpose. The development of each type of inventory is expected to give clues to the causes behind the inventory build-up. As illustrated in table 5, the sample size for this part of the analysis is substantially smaller. Only for 60 out of 926 deals in the full sample, acquiring and target company both report the decomposition of inventory. For each type of inventory, I calculate quarterly median averages across firm observations from quarter q-4 to Q8. As for the inventory growth rate, I deduct the average growth rate from each quarter's average to account for the long-term growth trend. The average growth rate is calculated as the mean over all firm quarter observations. The resulting variable is called inventory growth rate above average. It reflects the extraordinary share of the growth rate which exceeds usual levels. For each quarterly average, I test the difference to zero with the student's t-test.

The fourth research question looks at company characteristics and their relationship to the inventory build-up phenomenon. First, a measure for the inventory build-up is needed. I calculate the compound average growth rate (CAGR) of inventory between Q1 and Q4 for each firm in the sample. As I am interested in the exceptional part of the inventory growth, I again deduct the average growth rate for all firm quarter observations. The inventory build-up is partially caused by revenue growth. Therefore, I create a second measure that aims to eliminate the inventory growth caused by revenue growth. I calculate the compound average growth rate (CAGR) for inventory responsiveness between Q1 and Q4. The inventory growth rate is replaced by the difference of inventory growth rate and revenue growth rate.

Second, I develop a regression model to assess the relationship of explanatory variables to the measure of inventory build-up. As mentioned in section 4.2 Descriptive statistics, the explanatory variables comprise gross margin, inventory turnover, capital intensity, size of the target company and of the acquiring company. I follow standard econometric practices as shown in Verbeek (2008) and Dougherty (2011). In an ordinary least squares (OLS) regression model, the coefficient estimates of explanatory variables are calculated by minimizing the sum of the squared residuals. The coefficient estimate shows how the explanatory variable affects the dependent variable (e.g. inventory turnover) when controlling for other explanatory variables.

Important considerations in developing regression models are heterogeneity, heteroscedasticity and multicollinearity. Heterogeneity bias is caused by unobserved effects that are

correlated with the explanatory variables. Unobserved effects can relate to the industry or time. As the model is not able to control for the unobserved effect, the coefficient estimate of the explanatory variable will be biased. Even if the unobserved effects are not correlated with the explanatory variables, the OLS model generates biased standard errors and inefficient estimates. In a fixed effects model, dummy variables for industry and year are added to gauge the unobserved effects. When adding a dummy variable one category of the variable needs to be excluded to avoid the dummy variable trap. Without the reference category the sum of categories would equal to 1 for all observations resulting in perfect multicollinearity. One drawback of fixed effects models is that it does not calculate the coefficient estimates of explanatory variables that are constant for a category. Also, adding dummy variables results in the loss of degrees of freedoms.

Heteroscedasticity arises when error terms do not have a constant variance and leads to biased standard errors and thus biased test statistics. Therefore I use White (1980) standard errors, which are heteroscedasticity-consistent.

For high correlations between explanatory variables and for linearly related explanatory variables, multicollinearity issues arise resulting in flawed coefficient estimates. Multicollinearity arises when two variables measure the same phenomenon. The Pearson correlation matrix in table 10 shows that there is little correlation between explanatory variables which indicates that multicollinearity is not an issue. As expected, relative target size shows high correlation with acquirer size and with target size. Therefore these variables should not be used in the same regression model. Despite the low correlation values, potential multicollinearity issues could arise: Several variables are derived from the same accounting metrics including revenue, inventory and costs of goods sold. Therefore, variables that are based on same accounting metrics are not used in the same regression model.

Gross margin and inventory turnover both depend on the factor costs of goods sold (abbreviated as COGS) and should therefore not appear in the same regression model. The same holds for capital intensity and gross margin in respect to revenue. And capital intensity and company size both depend on assets. For acquirer and target size, I use the natural logarithm \ln of mean assets to linearize their relationship.

Under consideration of the constraints for using variables in the same regression model, I formulate the following six regression models. Note that the equations represent least square dummy variable (LSDV) regressions. The dummy variables for industry and year effects are not listed here to improve readability.

$$\begin{aligned} \text{Inventory CAGR Q1 - Q4} &= \beta_1 \times \text{Gross margin} \\ &+ \beta_2 \times \text{Target size} + \beta_3 \times \text{*Acquirer size} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{CAGR of inv. responsiveness Q1 - Q4} &= \beta_1 \times \text{Gross margin} \\ &+ \beta_2 \times \text{Target size} + \beta_3 \times \text{*Acquirer size} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{Inventory CAGR Q1 - Q4} &= \beta_1 \times \text{Inventory turnover} \\ &+ \beta_2 \times \text{Target size} + \beta_3 \times \text{*Acquirer size} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{CAGR of inv. responsiveness Q1 - Q4} &= \beta_1 \times \text{Inventory turnover} \\ &+ \beta_2 \times \text{Target size} + \beta_3 \times \text{*Acquirer size} \end{aligned} \quad (4)$$

$$\begin{aligned} \text{Inventory CAGR Q1 - Q4} &= \beta_1 \times \text{Inventory turnover} \\ &+ \beta_2 \times \text{Capital intensity} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{CAGR of inv. responsiveness Q1 - Q4} &= \beta_1 \times \text{Inventory turnover} \\ &+ \beta_2 \times \text{Capital intensity} \end{aligned} \quad (6)$$

Note that the model does not include a constant. It regresses the deviation from normal growth levels on company and deal characteristics. That means measures the differential impact of deal characteristics on the above average inventory growth. The model follows Ghosh (2001) who argued that change models without a constant are superior to intercept models as proposed by Healy, Palepu and Ruback (1992). Intercept models are named according to their feature that captures the change in performance in the intercept. The benefit is that persistence of performance is accounted for as temporary deviations of performance are captured in the random error. However, Ghosh (2001) showed that intercept models are likely to generate biased estimates. The bias originated from econometric problems and depended on measurement errors, the degree to which merging firms outperform industry-median firms, and whether the reasons were temporary or permanent. Powell and Stark (2005) compared both methodologies and found the intercept model generally resulted in higher estimates supporting the notion of Ghosh (2001).

5 Results

The following section presents the results from the analysis and develops the key findings. The structure follows the four research questions.

The first research question seeks to confirm that the phenomenon of inventory build-ups after a merger exists. Average inventory levels of the pro-forma combined entity before and after the merger are compared and tested to be different at statistical significance. The comparison shows that inventory levels increase significantly after the merger. Table 6 demonstrates that mean inventory levels increase from \$837.9 million in the four quarters before the merger in the quarter denoted as Q0 to \$937.3 million in the four quarters following the merger. The increase of \$99.4 million corresponds to a 21.6% increase of mean pre-acquisition inventory. Median inventory levels show a similar pattern although the increase is smaller. Inventory grows from \$287.0 million to \$306.9 million (12.9% of median inventory levels before the deal).

The increase in inventory levels persists in the second year (Q5 - Q8 after the merger date) as inventory continue to grow. Mean inventory levels climb to \$993.3 million and are \$155.5 million or 35.3% higher than before the merger. Median inventory are at \$325.1 million (\$34.9 million or 21.2% above pre-merger levels).

The results are in line with previous literature. Zhu, Boyaci and Ray (2011) found that mean inventory grows by 12% in the first year following the merger and 20% in the second year. Table 6 showed that mean inventory grows by 21.6% in the first year and 35.3% in the second year. While the authors observed the same effect, its magnitude was smaller. A potential reasons is that the their research is limited to a shorter time period 1997-2006 which includes the dot-com merger wave and may be characterized by special effects. Table 6 demonstrates that the additional inventory levels are significantly different from zero at the 1% level. The significance levels hold in case of mean as well as median averages. Hypothesis 1 is accepted because the results establish that the phenomenon of inventory build-up in the quarters following a merger exists. Hypothesis 2 is also accepted because the inventory build-up is not reverted in the following quarters as mean and median inventory levels continue to grow in the second year after the merger.

The second research question analyses the timing of the inventory build-up. Inventory development often follows seasonal cycles and should be analyzed on quarterly basis. I calculate quarter-over-quarter inventory growth rates to show when the inventory build-up occurs and whether it is reverted in the following quarters. Table 7 shows that quarterly inventory growth rates range between 3.65% and 4.76% before the merger. The growth rate then soars up to 7.89% in Q1 and 6.93% in Q2. In the following quarters it normalizes at a slightly lower level than before, ranging between 1.49% and 3.97% in Q3 to Q8.

Table 6: Average inventory levels before and after merger, \$ million

	Means of all firms			Medians of all firms		
	Average inventory level	Inventory above pre-deal average	% of pre-deal mean	Average inventory level	Inventory above pre-deal average	% of pre-deal median
Average q-4 - q-1	837.9	0.0	0.0	287.0	0.0	0.0
Average Q1 - Q4	937.3	99.4*** (7.1)	21.6	306.9	22.9*** (12.1)	12.9
Average Q5 - Q8	993.3	155.5*** (7.9)	35.3	325.1	34.9*** (12.9)	21.2

The table shows mean and median inventory levels before and after the merger date. The average q-4 - q-1 is calculated as the average of means of the pro-forma combined acquiring and target firm. Similarly, averages Q1- Q4 and Q5 - Q8 denote the averages of the firm's mean inventory. To test for difference from zero, Student's t-test for means and Wilcoxon sign-rank test are employed. The values in brackets denote test statistics. The stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

Inventory growth follows a long-term trend. To test whether the inventory growth rate in a quarter is significantly different, quarterly growth rates are adjusted for the long-term average growth rate. The average growth rate across all firm quarter observations of 4.11% is deducted from all observations. The difference represents the extraordinary part of the inventory growth. The extraordinary, above average inventory growth lies at 3.77% and 2.81% in the first and second quarter after the merger. Employing Student's t-test shows that both mean averages are statistically different from zero at the 5% significance level.

The results are confirmed when using median averages rather than means although the magnitude is smaller. Inventory growth peaks at 3.55% in Q1. The above average inventory growth rate lies at 1.09%. Testing for differences in medians with Wilcoxon sign-rank test shows that the above average growth rate is significantly different from zero at the 5% level. The inventory build-up effect can not be observed in the second quarter. Median inventory growth rates are lower than the corresponding mean averages for all quarters. Large outliers for individual firms can explain the difference between means and medians. Companies can experience extreme inventory growth within a short time frame. For instance, inventory requirements increase drastically when new products are introduced, production facilities and distribution centers are opened. Table 7 illustrates that the inventory growth peaks in the two quarters following the change of control. Srjai, Bertonecelj, Fleet and Gregory (2010) and Herd, Saksena and Steger (2005) described that post-merger integration activities are most intensive in the 100 days following the change of control. The uncertainty in the merging organizations creates an opportunity to initiate change. This analysis suggests that the change results in a need

Table 7: Inventory growth rate, quarter over quarter

Quarter relative to merger	Means of all firms		Medians of all firms	
	Inventory growth rate	Inventory growth rate above average	Inventory growth rate	Inventory growth rate above average
q-4	4.76	0.64 (1.26)	2.28	-0.37 (-0.07)
q-3	4.47	0.36 (0.56)	2.15	-0.55 (-1.40)
q-2	4.20	0.09 (0.14)	1.80	-0.91* (-1.91)
q-1	3.65	-0.47 (-0.68)	1.96	-0.81*** (-3.18)
Q0	4.11	-0.01 (-0.01)	2.19	-0.71* (-1.88)
Q1	7.89	3.77** (2.92)	3.55	1.09** (2.09)
Q2	6.93	2.81** (2.44)	2.15	-0.74 (-0.84)
Q3	3.97	-0.15 (-0.15)	1.46	-1.36*** (-4.21)
Q4	3.58	-0.54 (-0.80)	2.00	-1.46*** (-3.82)
Q5	2.24	-1.88*** (-3.38)	1.09	-1.53*** (-5.55)
Q6	3.39	-0.73 (-0.98)	1.27	-1.62*** (-5.14)
Q7	1.49	-2.63*** (-5.11)	0.93	-2.01*** (-7.07)
Q8	2.86	-1.26** (-2.12)	1.34	-1.31*** (-4.70)

The table shows mean and median inventory growth rates by quarter relative to the merger date which is denoted as Q0. To account for long-term growth trend, the average inventory growth rate is deducted from quarterly growth rates. The average inventory growth rate is calculated across all firm quarter observations. Positive (negative) values for inventory growth rate above average denote buildup (reduction) of excess inventory. To test for difference from zero, Student's t-test for means and Wilcoxon sign-rank test are employed. The values in brackets denote test statistics. The stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

for higher inventory levels. Although other factors including new technologies or higher customer expectations may cause a similar need, they would be expected to appear at a specific time rather than after a merger. The change in inventory development occurring abruptly and right after the change of control is a strong indication that it is linked to the post-merger integration.

These findings bring novel insights into the timing of the inventory build-up. Existing research has not investigated when the inventory build-up occurs. Langabeer (2003) used data from annual reports to get a larger sample size. Zhu, Boyaci and Ray (2011) used quarterly data but look at the averages of four quarters before and after the deal. The recognition that inventory build-up is very closely related to the post-merger integration raises the questions what happens to inventory in that time period. The third research question investigates reasons for the inventory build-up.

The third research question investigates potential reasons for the change in inventory development after acquisitions. The analysis for hypothesis 2 based on table 6 shows that the inventory build-up is not reverted in the second year after the merger. Therefore, temporary reasons to create additional inventory are unlikely. Merging companies seem to have better tools to prepare for and to respond to operational disruptions that may occur during the post-merger integration. Waters and Waters (2003) and Tang (2006) described risk monitoring, pro-active inventory management and planning of mitigation actions as useful tools. Hypothesis 3 analyses revenue growth as a potential driver for inventory growth. For hypothesis 4, inventory is decomposed to raw material, work in progress and finished goods to explore operational changes of suppliers, production setup and product portfolio.

Devos, Kadapakkam and Krishnamurthy (2009) cited revenue synergies as a frequent motive for mergers. And a survey conducted by Häkkinen et al. (2004) showed that the respondents see product/ market extension and geographic roll up as the two most important merger motives. Revenue synergies are likely to create a need for higher inventory to make the new product available or to start selling in a new market or geography. Table 8 shows inventory responsiveness quarter of quarter. Inventory responsiveness is a metric used by Rumyantsev and Netessine (2007) to measure how well a company is able to adapt inventory levels to changes in revenue development. It is calculated as quarterly inventory growth less quarterly revenue growth. Positive values show that inventory grows faster than revenue, meaning that the firm is building up an inventory position above its historical levels.

Before the merger, mean inventory responsiveness ranges between -0.90% and +0.92%. Average revenue growth and inventory growth are very close which suggests that revenue is an important driver for inventory development. As the companies in the sample grow, they increase their inventory proportionally to the growth rate. This changes after the merger.

Table 8: Inventory responsiveness, quarter over quarter

Quarter relative to merger	Means of all firms			
	Inventory growth rate	Revenue growth rate	Inventory responsiveness	Inventory responsiveness above average
q-4	4.82	5.71	-0.90	-1.89* (-2.4)
q-3	4.47	5.23	-0.75	-1.74* (-1.66)
q-2	4.20	4.60	-0.40	-1.38 (-1.60)
q-1	3.65	2.73	0.92	-0.07 (-0.08)
Q0	4.11	0.13	3.98	3.00*** (2.68)
Q1	7.89	-0.82	8.72	7.73*** (6.00)
Q2	6.93	5.15	1.78	0.79 (0.61)
Q3	3.97	3.45	0.52	-0.47 (-0.42)
Q4	3.58	2.85	0.73	-0.26 (-0.28)
Q5	2.24	4.05	-1.81	-2.79*** (-2.85)
Q6	3.39	3.10	0.29	-0.69 (-0.74)
Q7	1.49	2.02	-0.54	-1.52* (-1.76)
Q8	2.86	2.56	0.30	-0.68 (-0.82)

Inventory responsiveness is calculated as inventory growth rate less revenue growth rate. The average inventory growth rate is calculated across all firm quarter observations. Positive values for inventory responsiveness mean that inventory grows faster than revenue. To account for long-term growth trend, the average inventory responsiveness is deducted from quarterly values. The average inventory growth rate is calculated across all firm quarter observations. Positive (negative) values for inventory responsiveness above average denote buildup (reduction) of excess inventory. To test for difference from zero, Student's t-test for means are employed. The values in brackets denote test statistics. The stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

In the first quarter, inventory growth soars up to 7.89% while revenue drops by -0.82%. Inventory responsiveness increases to 8.72%. In the first quarter, inventory growth is not driven by revenue growth. However, in the second quarter revenue growth can account for higher inventory growth rates. Inventory grows at 6.93% while revenue increases by 5.15%. The resulting mean inventory responsiveness lies at 1.78%, which is merely out of the usual range. In the following quarters Q3 to Q8, inventory responsiveness stabilizes in a range between -0.54% and 0.73%. The fifth quarter after the merger is an exception as inventory grows at 2.24% which is clearly below revenue growth 4.05%. Inventory responsiveness lies at -1.81% which suggests that in this specific quarter the merged companies are able to grow revenue faster than inventory. In the other quarters, inventory and revenue development are well aligned. The inventory build-up is not reverted and the merged companies stabilize on a higher inventory level.

This finding is in line with previous results from Zhu, Boyaci and Ray (2011). Their analysis shows that average inventory responsiveness in the first year after the merger is on average 1% above the pre-merger level. For the second year, it is 2% above the pre-merger level. This analysis shows that hypothesis 3 can only partially be supported. Revenue growth can explain increased inventory for the second quarter. However, it can not explain why inventory grows at 7.89% as revenue growth lags behind at -0.82%. This effect is not reverted in the following quarters. Therefore, it is unlikely that the inventory increase is caused by overly optimistic management that builds up inventory in anticipation of revenue growth. However, gaining new sales in the quarters after the merger may involve actions that require an over-proportional increase in inventory. For instance, reaching new, remotely located customers may entail the opening of new warehouses or longer delivery times. And ensuring steady customer deliveries in the new environment may require higher safety buffers.

Revenue growth can only partially explain why companies build-up inventory. Decomposing inventory into raw material, work in progress and finished goods may lead relevant insights into the type of inventory that drives the inventory build-up. Raw material inventory is primarily held to secure availability of input for production. As denoted in hypothesis 4a, merging companies may have an incentive to build up raw material inventory when they are concerned that raw material supply may be disrupted after the merger. The primary purpose of work in progress is to maintain and facilitate a smooth and efficient production. Hypothesis 4b states that work in progress inventory could increase after a merger when production reliability decreases due to a new operating system or a restructured production network. Bottlenecks in production can occur when companies are able to grow their business to the capacity limits or when the merger is driven by the motive to decrease production capacity. The purpose of finished good inventory is to ensure customer deliveries throughout the distribution network. Hypothesis 4c sug-

gests that merging companies increase finished good inventory if they anticipate demand growth. Persuading new customers often involves offering additional services, such as on-demand deliveries or promising no stock-outs.

Table 9 shows median quarterly growth rates for raw material, work in progress and finished goods inventory. The table is structured similarly as table 7 which shows quarterly inventory growth rate for the full sample of 926 companies. Comparing the inventory development in both tables shows that there are some notable differences between the sub-sample in table 9 and the full sample in table 7. The long-term average inventory growth rate is 1.9% in the sub-sample which is clearly below the full sample of 4.1%. In the first quarter, average inventory in the sub-sample grows by 8.1% at similar rates as in the full sample 7.9%. However, in the second quarter, inventory growth drops to -2.6% while the full sample still maintains a high growth rate of 6.9%. In the following quarters, inventory growth in the sub-sample ranges between -0.4% and 1.5%. This shows a fundamental difference as the inventory build-up after their merger is reverted in the following quarters. The inventory development in the sub-sample is not fully comparable with the full sample. This may be because inventory management is more important for companies that report detailed inventory decomposition. The reason to report in details is likely that these metrics are relevant to the specific type of company. And shareholders are likely to pay more attention to inventory development when it is reported in detail. Therefore, the companies in the sub-sample may have superior capabilities and a stronger interest to revert the inventory build-up effect after the merger.

The number of companies that reports the decomposition of inventory to raw material (63 companies), work in progress (58) and finished goods inventory (74) is substantially smaller than in the full sample (926). Table 5 in section 4.2 Descriptive statistics shows that companies that do report detailed numbers tend to be larger, with a mean total inventory of \$1126.4 million compared to \$919.1 million for companies in the entire sample. Due to the small sample size, the analysis of decomposed inventory in table 9 should be treated with care.

The growth rates for raw material inventory range between 1.8% and 15.2% before the merger. The large variation in averages is likely due to the number of observations as only 63 companies report raw material inventory for the required time period. It is not unusual for individual companies to exhibit large variations in individual quarters, for instance when new production sites or warehouses are opened and new products are launched. There is a peak in inventory growth at 13.8% in the first quarter after the merger. However, the effect is not significant. In the following quarters, the growth rate ranges between -3.0% and 7.1%. The analysis gives some support to hypothesis 4a. There is a peak in inventory growth after the merger. However, it is not statistically significant. The magni-

Table 9: Decomposition of inventory growth rate to components, quarter over quarter

Quarter relative to merger	Total inventory		Raw material inv.		Work in progress inv.		Finished goods inv.	
	Mean growth rate	Growth rate above average	Mean growth rate	Growth rate above average	Mean growth rate	Growth rate above average	Mean growth rate	Growth rate above average
Number of deals	58	58	63	63	58	58	74	74
q-4	3.3	1.4 (1.3)	8.5	3.7 (0.7)	4.0	1.6 (0.6)	6.1	3.1* (1.8)
q-3	2.1	0.2 (0.6)	1.8	-2.9 (-1.0)	0.4	-2.1 (-0.9)	2.1	-0.9 (-0.5)
q-2	3.6	1.7 (0.1)	15.2	10.5 (1.1)	2.8	0.3 (0.1)	12.3	9.4 (1.6)
q-1	2.8	0.9 (-0.7)	5.7	1.0 (0.3)	1.4	-1.0 (-0.5)	4.2	1.3 (0.6)
Q0	3.9	2.0 (-0.0)	3.8	-0.9 (-0.3)	4.4	2.0 (0.7)	3.8	0.9 (0.4)
Q1	8.1	6.2*** (2.9)	13.8	9.1 (1.1)	9.9	7.5* (1.6)	8.2	5.2 (1.2)
Q2	-2.6	-4.5** (2.4)	2.7	-2.0 (-0.5)	0.2	-2.2 (-0.6)	-3.0	-5.9** (-2.3)
Q3	3.4	1.5 (-0.2)	-0.2	-4.9* (-1.8)	6.8	4.3 (1.4)	1.8	-1.2 (-0.5)
Q4	-0.2	-2.1 (-0.8)	3.1	-1.7 (-0.6)	-0.3	-2.8 (-1.2)	0.7	-2.2 (-0.8)
Q5	1.5	-0.4*** (-3.4)	-3.0	-7.8*** (-2.7)	3.5	1.1 (0.4)	3.5	0.6 (0.2)
Q6	-0.2	-2.1 (-1.0)	0.8	-3.9 (-1.5)	0.6	-1.8 (-0.6)	1.4	-1.6 (-0.9)
Q7	-0.4	-2.3*** (-5.1)	7.1	2.3 (0.5)	-1.9	-4.3** (-2.0)	-1.3	-4.3* (-1.9)
Q8	-0.3	-2.2* (-2.1)	2.4	-2.3 (-1.0)	-0.1	-2.5 (-0.9)	-1.4	-4.3* (-2.9)

The table shows median quarterly growth rates for raw material, work in progress, and finished goods inventory. To account for long-term growth trend, the average inventory growth rate is deducted from quarterly growth rates. The average inventory growth rate is calculated across all firm quarter observations. Positive (negative) values for inventory growth rate above average denote buildup (reduction) of excess inventory. Student's t-test is employed to test for difference from zero. The values in brackets denote test statistics. The stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

tude of inventory growth in the first quarter of 13.8% suggests that merging companies do face challenges on the supplier side during the post-merger integration. This may include disruptions from changing suppliers or conflicts of interests that lead to a discontinuity of relationships with key suppliers.

Work in progress inventory growth rates range between 0.4% and 4.0% before the merger. The growth rate peaks in Q1 at 9.9%. Testing the inventory growth rate above long-term average for difference to zero, the effect is found to be significant at the 10% level. A similar, but smaller effect is observed in Q3, when the growth rate goes up to 6.8%. In the following quarters the growth rate ranges between -1.9% and 3.5%. The inventory build-up in work in progress inventory supports hypothesis 4b. The merger seems to create a fundamental change in the operations of many merging companies that necessitates higher inventory. Such changes may include decreases of production reliability due to a new operating system or a restructured production network. Bottlenecks in production can occur when companies are able to grow their business to the capacity limits or when the merger is driven by the motive to decrease production capacity. An extension of the product portfolio may require to hold on stock a larger variety of intermediate products. In the quarters before the merger and in the second year after the merger, the average inventory growth rate stays at relevant constant levels and mostly ranges between 0.4% and 4.0%. In the year after the merger, the growth rate varies peaking at 9.9% in the first quarter, dropping to 0.2%, soaring up to 6.8% and dropping again to -0.3%. The variation may be caused by the integration activities. The integration often includes reorganization of the workforce, restructuring of the production footprint, and reallocation of warehouses and distribution centers which are likely to cause disruptions. Inventory management could be used to temporarily buffer the disruptions and mitigate any adverse effects.

Table 9 shows that finished goods grow at rates between 2.1% and 12.3% before the merger. There is a peak in the first quarter, when the growth rates shoots up to 8.2%. The inventory build-up is reverted in the following quarters. In the second quarter, the growth rate is -3.0%. In all following quarters except for Q5, the inventory growth rate is below the long-term average of 3.0%. Hypothesis 4c is rejected as the inventory build-up is reverted in the following quarters.

This analysis may contradict the findings from table 8 which shows quarterly inventory responsiveness. The table and the respective analysis in hypothesis 3 show that revenue growth is a key contributor to inventory growth. In the second quarter after the merger, inventory growth of 6.9% can be explained by similarly high revenue growth of 5.2%. When companies anticipate revenue growth, the first place to increase inventory should be finished goods as they are closest to the customers. This is not the case in 9. To

validate the findings from hypothesis 3, I replicate the table with quarterly inventory responsiveness for the sub-sample of 58 companies that report decomposed inventory. The result in table 16 shows that revenue growth does not explain inventory build-up for the companies in the sub-sample. The inventory growth rate peaks in the first quarter at 8.1%. Revenue growth is negative at -2.2% can not account for the inventory growth. In the following quarters, inventory and revenue growth are closely aligned as should be expected. However, there is no further notable peak in inventory growth. The growth rate ranges between -2.6% and 3.4% in the following quarters. This confirms the contradiction to the analysis in table 8. This may be because inventory management is more important for companies that report detailed inventory decomposition. It is likely to be more relevant for their business and shareholders are likely to follow its development more closely. Therefore, the companies in the sub-sample may have superior capabilities and a stronger interest to revert the inventory build-up effect after the merger.

The decomposition of inventory shows that operational changes are likely to be a reason for companies to build up inventory after an acquisition. The build-up in work in progress inventory suggests that these changes could include restructuring of production network, increase of capacity utilization or an increase in the number of intermediate products. The build-up of raw material inventory may also be part of the explanation. Although the effect is not significant, the increase of raw material by 13.8% in the first quarter suggests that some companies face challenges with changing to new suppliers or with maintaining key supplier relationships. For the companies in this sub-sample, revenue growth can not account for inventory growth. This may be due to small sample size and to the important role that inventory management plays for companies in the sub-sample.

Summarizing the findings for the third research question, revenue growth and operational changes are likely to be key drivers for the inventory build-up. Table 8 shows that in some quarters, inventory growth is driven by higher revenue growth. And table 16 exhibits that for the sub-sample of companies that report inventory types, operational changes drive the build-up in work in progress inventory. Table 6 demonstrates that the inventory build-up is persistent over time and disruptions during the post-merger integration are unlikely to be the reason for the inventory build-up.

The fourth research question addresses which company characteristics explain changes in inventory. Understanding company characteristics associated with inventory build-up is relevant for merging companies to assess to what extent they may have to create additional inventory. The analyzed company characteristics include gross margin, inventory turnover, capital intensity, size of the acquiring and size of the target company. The relation of the company characteristics to inventory build-up is assessed through a regression

Table 10: Pearson correlation matrix

	Gross margin	Inventory turnover	Capital intensity	ln acquirer size	ln target size
Gross margin	1.000				
Inventory turnover	-0.233	1.000			
Capital intensity	-0.451	0.101	1.000		
ln acquirer size	0.125	-0.082	-0.087	1.000	
ln target size	-0.010	0.053	-0.090	0.161	1.000

The table shows a Pearson correlation matrix for explanatory variables employed in the regression analysis. ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

analysis. Table 10 shows the Pearson correlation matrix for explanatory variables. None of the variables are correlated with each other at significant levels.

Gross margin is negatively correlated with inventory turnover with a correlation coefficient of -0.233. Comparing to the formulation of hypothesis 5a and 5b, a negative relationship between the two variables was to be expected: Companies face a strategic choice whether to focus on generating a high profit margin through a premium offering or to maximize sales through high volumes and thus high inventory turnover. Gross margin is negatively correlated with capital intensity at -0.451. This relationship may be surprising. Companies that have invested into their asset base should be able to earn higher margins to account for their investment.

The relationship between the natural logarithm of acquirer size and the natural logarithm of target size is noteworthy with a correlation coefficient of 0.161. The positive correlation coefficient implies that bigger acquiring firms tend to aim for dis-proportionally larger targets. This could be explained by the special set of capabilities required to integrate a major acquisition. Smaller companies may therefore prefer proportionally smaller targets, such as in bolt-on acquisitions.

Table 11 shows a regression analysis with the dependent variables cumulative average growth rate for inventory and for inventory responsiveness. The Hypothesis column indicates the expected relationship for each explanatory variable based on the hypotheses defined in section 3. Despite the low correlation values in table 10, potential multicollinearity issues could arise. Several variables are derived from the same accounting metrics including revenue, inventory and costs of goods sold. Therefore, variables that are based on same accounting metrics are not used in the same regression model.

Hypothesis 5a states that the expected relationship for gross margin and inventory growth is negative. The argument is that companies earning higher gross margins often have developed more resilient supply chain and inventory management practices. I argue that they are able to utilize superior production planning tools and develop better foresight into customer needs, instead of increasing inventory to deliver on the value proposition. Regression model 1 shows that gross margin is negatively correlated with inventory build-up with a regression coefficient of -2.898. Although the relationship is not significant, the analysis supports hypothesis 5a. Higher gross margins are negatively correlated with inventory build-up. This result also holds true for regression model 2. The metric for inventory build-up has been replaced by the cumulative average growth rate of inventory responsiveness (IR CAGR). The dependent variable reflects only the increase in inventory in the four quarters after the merger that can not be explained by higher revenue. The regression coefficient is -0.837. The effect of gross margin on inventory build-up in this case is negative, but smaller than in regression model 1.

Companies with high inventory turnover often pursue a strategy to maximize profits through high volumes in a low margin business. Hypothesis 5b argues that the effect of adverse changes like disruptions or less efficient inventory practices is magnified by high volumes, thus increasing the impact to the inventory position. Such adverse changes are likely to occur during the post-merger integration period. For instance, the analysis of decomposed inventory based on table 9 suggests that changes in the production and supply chain setup are likely to contribute to the inventory build-up. Regression model 3 analyses the relationship of inventory turnover, target size and acquirer size to the measure of inventory build-up in the four quarters after a merger. The regression coefficient for inventory turnover is 0.313 with a significance level of 10%. In regression model 5, acquirer and target size are replaced by capital intensity. It generates similar results. The regression coefficient for inventory turnover is 0.298 with a significance level of 10%. Hypothesis 5b is accepted. Acquiring companies need to expect higher inventory build-up when they intend to increase inventory turnover as a result of the merger. 4 shows that the mean company has an inventory turnover of 2.3. For an increase of the inventory turnover to 2.5, we expect additional inventory build-up of 0.2%. Assuming mean inventory of \$ 837.9 million yields a negative financial impact of \$ 1.9 million. The effect of inventory turnover on inventory build-up vanishes in regression models 4 and 6. In these regression models, the dependent variable expresses the inventory growth in the four quarters after the merger that exceeds revenue growth. The regression coefficients are -0.030 and 0.008 respectively. This may be because the phenomenon is smaller as revenue growth accounts for a substantial share of inventory growth.

Table 11: Regression on cumulative average inventory growth rate in Q1 - Q4

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)	Hypothesis
	Inv. CAGR	IR CAGR	Inv. CAGR	IR CAGR	Inv. CAGR	IR CAGR	
Gross margin (Revenue-COGS)/Revenue	-2.898 (2.411)	-0.837 (1.665)					5a (-)
Inventory turnover COGS over Inventory			0.313* (0.186)	-0.030 (0.129)	0.298* (0.181)	0.008 (0.121)	5b (+)
Capital intensity Assets over Revenue					-0.158 (0.156)	-0.257 (0.156)	5c (-)
Acquirer size ln of mean Assets	-0.120 (0.304)	-0.449** (0.222)	-0.097 (0.299)	-0.459** (0.219)			5d (-)
Target size ln of mean Assets	-0.758*** (0.223)	0.187 (0.167)	-0.774*** (0.220)	0.195 (0.166)			5e (-)
Time dummy variables	Yes	Yes	Yes	Yes	Yes	Yes	
Industry dummy variables	Yes	Yes	Yes	Yes	Yes	Yes	
Observations	926	926	926	926	926	926	
R^2	0.085	0.059	0.089	0.059	0.076	0.055	

The table shows least square dummy variable regressions. The dependent variable in regression models 1, 3 and 5 is the cumulative average growth rate of inventory in the four quarters after the merger (Inv. CAGR). For regression models 2, 4 and 6 the dependent variable is based on the same logic but inventory growth is adjusted for revenue growth (IR CAGR). The last column shows for each variable the number and expected direction of the corresponding hypothesis. The values in brackets denote t-statistics and stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

Hypothesis 5c assesses the relationship of capital intensity to post-merger inventory development. Capital intensity is measured as assets over revenue to reflect the amount of investments required from a company to generate its revenues. The hypothesis argues that high investments are likely to result in superior infrastructure that provide the tools to avoid the need for significant inventory build-ups. Regression model 5 shows that the relationship of capital intensity and inventory build-up is negative. The regression coefficient is -0.158. While the result is not significant, it lends support to hypothesis 5c. Companies with a high ratio of assets to revenue create less new inventory after a merger. The result holds for regression model 6, in which the dependent variable is replaced by a measure that accounts for revenue growth.

Hypothesis 5d puts forward that larger acquiring companies are associated with lower inventory build-up. My rationale is that larger companies have better capabilities. Such

capabilities may include advanced analytics, superior tools for inventory management and more manpower to staff the post-merger integration. Larger companies are also more likely to be serial acquirers. Hayward (2002) shows that serial acquirers are able to learn from their mistakes and on average can achieve better M&A performance. Regression models 1, 2, 3 and 4 show that larger acquiring companies on average create lower inventory. In regression models 1 and 3 the dependent variable is inventory growth. Acquirer size has a negative but small correlation with inventory build-ups. In regression models 2 and 4 the dependent variable is the cumulative average growth rate for inventory responsiveness (IR CAGR). Now the regression coefficient is at -0.449 and -0.459 respectively. The effect is bigger and significant at the 5% level. These findings give support to hypothesis 5d. However, the relationship of acquirer size to inventory growth in regression models 1 and 3 is not significant.

Hypothesis 5e states that smaller target companies are associated with higher inventory build-ups. Larsson and Finkelstein (1999) find that smaller targets are likely to receive less management attention. After the deal is closed, top management attention may divert and the integration is carried out with less rigor and control. I argue that this may affect negatively on inventory development. Regression models 1 and 3 analyze the relationship of target size and inventory growth. The regression coefficients are -0.758 and -0.774 respectively. The relationship is negative and significant at the 1% level. Hypothesis 5e is accepted. Smaller targets on average require higher inventory build-up. When choosing a 50% larger target the acquiring company can expect a 0.3%-points smaller cumulative average growth rate of inventory in the first year after the merger. For the median company holding \$ 837.9 million in inventory before the merger, this implies \$ 2.5 million lower inventory build-up. The magnitude of this effect may cause managers to reconsider how they set priorities. This finding does not hold when adjusting the dependent variable for revenue growth. In regression models 2 and 4, the relationship for target size is positive with a regression coefficient of 0.187 and 0.195 respectively.

Table 12 shows the inventory development for a sub-sample of 71 wholesales and 99 retail companies. Trade companies are interesting subjects because efficient inventory management is often a competitive factor for many companies in the industry. Trade companies often hold inventory to fulfill their function of relocating and distributing goods into smaller cargo sizes, bringing the product into closer proximity of the customer and improving accessibility. The important role of inventory for trade companies is reflected in higher average inventory levels. Table 12 shows that wholesale companies hold average inventory of \$ 340.6 million before the merger. For retail the average is even at \$ 403.4 million. In contrast, companies in the full sample of 926 companies hold \$ 287.0 million in inventory. Table 3 shows that in particular general merchandise stores that engage in

Table 12: Average inventory levels before and after merger in segments of trade industry, \$ million

	Wholesale (SIC codes 5000-5199)				Retail (SIC code 5200-5999)			
	No. of obs.	Median inventory level	Inventory above pre-deal median	% of pre-deal median	No. of obs.	Median inventory level	Inventory above pre-deal median	% of pre-deal median
Average q-4 - q-1	71	340.6	0.0	0.0	99	403.4	0.0	0.0
Average Q1 - Q4	71	386.9	61.8*** (4.4)	28.6	99	428.2	46.5*** (5.3)	19.9
Average Q5 - Q8	71	389.4	79.4*** (5.8)	30.6	99	470.0	66.6*** (5.8)	29.9

The table shows the development of inventory levels for the two segments in the trade industry: wholesale and retail. Either acquiring or target firm belong to the industries according to their two-digit SIC code. The average q-4 - q-1 is calculated as the average of medians of the pro-forma combined acquiring and target firm. Similarly, averages Q1- Q4 and Q5 - Q8 denote the averages of the firm's median inventory. To test for difference from zero, Wilcoxon sign-rank test is employed. The values in brackets denote test statistic and the stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

acquisitions hold high inventory levels with a median average of \$ 2755.6 million. The inventory build-up phenomenon is especially distinct for trade companies. Table 6 shows that the median average inventory build-up in the full sample is 12.9% in the first year and 21.2% in the second year after the acquisition. For retailers, the effect is stronger as they reach 19.9% already in the first year and even 29.9% in the second year. For wholesale companies, the size of the inventory build-up is similar. However, it occurs a lot faster as merging companies build-up 28.6% more inventory already in the first year and stay relatively stable in the second year at 30.6%. At the first look, this finding may be surprising as high inventory levels and strategic importance of inventory management in trade companies should offer higher optimization potential. Waller, Johnson and Davis (1999) gave vendor managed inventory (VMI) as an example of inventory improvements in retail supply chains. And Chen, Frank and Wu (2007) showed that inventory in the wholesale and retail industries became leaner in the period 1987-2000. However, trade companies may have stronger incentives to build-up inventory when they fear negative consequences from operational disturbances. Finley and Bonno (2012) gave poor quality and stock-outs as examples for negative consequences. Trading companies often sell to end customer which may be concerned that a focus on savings in the merger integration may come at the cost of service quality. The customer relationship may be more transactional which lowers barriers for switching to competitors. To ensure deliveries and customer satisfaction, trading companies may decide to build-up above average inventory levels. Table 13 summarizes the results and implications for each hypothesis.

Table 13: Summary of results

No	Hypothesis	Result	Implication
1	Post-acquisition inventory is significantly higher than pre-acquisition inventory.	Accepted	The phenomenon of inventory build-up after mergers exists.
2	The average inventory levels of merging companies are significantly higher in the second year after the merger compared to the year before the merger.	Accepted	The inventory build-up is not a temporary phenomenon, but is driven by fundamental and long-term changes in the business.
3	Merging companies grow revenue at similar rates as inventory in the quarters following an acquisition.	Accepted	The inventory build-up is partially driven by revenue growth.
4a	The inventory build-up occurs in raw material inventory.	Supported	The increase in raw material inventory is statistically not significant.
4b	The inventory build-up occurs in work in progress inventory.	Accepted	The build-up in work in progress inventory indicates a fundamental change in production and supply chain setup.
4c	The inventory build-up occurs in finished goods inventory.	Rejected	For the sub-sample, inventory build-up is not driven by revenue growth.
5a	Gross margin is negatively correlated with the build-up of above average inventory.	Supported	Companies operating in a high margin segment build-up less inventory.
5b	Inventory turnover is positively correlated with the build-up of above average inventory.	Accepted	Adverse changes in inventory management have a stronger impact to companies with high inventory turnover.
5c	Capital intensity is negatively correlated with build-up of above average inventory.	Supported	High rate of investments may create tools that reduce the need for inventory build-ups
5d	The size of acquiring company is negatively correlated with the build-up of above average inventory.	Supported	Larger companies may have superior capabilities in deal making and integration.
5e	The size of target company is negatively correlated with the build-up of above average inventory.	Accepted	Small targets are likely to receive less management attention leading to higher inventory build-up.

The result column indicates whether the hypothesis is accepted, rejected or not supported. Not supported is used when the evidence indicates that the hypothesis may be right, however, it is not sufficient to accept the hypothesis and further research should be conducted. The implication columns repeats in short the conclusion from the analysis in the results section.

6 Conclusion

This study establishes a novel phenomenon as merging companies experience a inventory build-up during the post-merger integration period. Average inventory levels in the year after the merger are \$99.4 million or 21.6% above pre-merger averages. This phenomenon is surprising, as decision makers frequently expect to reduce inventory. The inventory build-up persists throughout the second year after the merger. I conclude that the inventory build-up is driven by fundamental changes rather than a temporary need to buffer disturbances during post-merger integration.

The inventory build-up happens in the first and second quarter after the merger. Inventory growth of merging companies peaks at 7.9% in the first and at 6.9% in the second quarter after the merger. These growth rates are above the long-term average of 4.1% at statistical significant levels. The timing of the build-up suggests a strong link to post-merger integration as the cause for the phenomenon.

The inventory build-up is partially caused by revenue growth. In the first quarter after the merger, revenue growth is at -0.8% and can not explain inventory growth at 7.9%. However, in the second quarter after the merger, 5.2% revenue growth is the main driver for inventory growth of 6.9%. This observation appear intuitive as merging companies often intend to create revenue synergies by moving into new geographies, market segments or product offerings.

I find that work in progress and raw material inventory are strongly affected by M&A activity. For the sub-sample of 58 companies that report decomposed inventory, work in progress inventory grows by 9.9% and raw material grows 13.8% in the first quarter. This suggests that many merging companies experience fundamental changes in the production and supplier setup that create additional inventory needs. Such changes may include the creation of bottlenecks in production through higher volumes or through close downs. An extension of the product portfolio may require to store a larger variety of intermediate products. Although the effect on raw material inventory is not statistically significant, companies seem to face challenges when changing suppliers to gain synergies or when maintaining relationship with key suppliers.

Deals that involve smaller target companies tend to result in higher inventory build-ups. Management attention may divert easily from smaller targets as they have less significance for the company. Less support and pressure from management may lead to lower performance in the post-merger integration including higher inventory levels. Companies with higher inventory turnover are likely to build up more inventory. Companies with higher inventory turnover typically operate in high volume businesses. High volumes can magnify adverse effects to inventory management resulting in higher inventory build-ups. Acquirer size exhibits a negative and significant relation to inventory build-up when adjusting inventory growth for revenue growth. Larger acquiring companies appear to have

superior capabilities and resources to manage and integrate their acquisitions. In addition, I find that companies in retail and trade industries experience above average inventory build-ups.

The main contribution of this study is to establish that merging companies build-up inventory and to respond to the key questions when, how and why the inventory build-up occurs. The results have important implications for deal decision making and post-merger integration. Synergy estimates are frequently based on the assumption that inventory levels can be reduced after the merger. Too high synergy estimates will be factored into the premium leading the acquiring company to pay a too high premium. The magnitude of the inventory build-up can easily account for 6.1% of the deal value as illustrated in table 14. I compare a conservative scenario for expected inventory development to the actual inventory growth rates based on table 7. Taking the difference and discounting it to the merger date yields an implicit deal premium of \$ 86.8 million or 6.1% of the average deal value.

Unrealistic expectations in the inventory development can affect post-merger integration when companies focus on the wrong actions. Integration planning may reckon with reductions of inventory and initiate actions accordingly. However, actions in the opposite direction might be what is really needed. When inventory piles up in the first and second quarter after the merger, supply chain management needs to ensure that the warehouses and infrastructure scale up accordingly. If planning does not account for higher inventory needs, the company risks stock outs of critical stock keeping units which may affect customer deliveries.

A final implication of this study is that supply chains matter for merger success. Although supply chain considerations are rarely the reason to commence a merger, they are essential to make the deal work. Unfortunately the topic is often left out of the CEO level agenda because it is considered too operational and detailed. This study gives a hands-on example that illustrates that detailed understanding of the value creation mechanism is needed. The inventory build-up is partially driven by revenue growth which implies that the ability to reduce inventory is limited by revenue growth. Without the understanding how much additional inventory is needed to support revenue growth, estimates for future inventory needs can go awfully wrong. Therefore, early involvement of supply chain experts in the merger process is important. A strong role of supply chain management has also been promoted by Herd, Saksena and Steger (2005), Finley and Bonno (2012) and Tompkins (2012).

My study has important limitations. The research design is based financial reporting data which limits the depth and understanding of interconnections. Future research should consider alternative data sources. For instance, management accounting shows inventory

Table 14: Inventory build-up as an implicit premium paid on top of deal value

Unit of measurement	Before merger	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
<i>Panel A: Expected inventory development of merging firms</i>									
\$ million	837.9	863.0	888.9	915.6	943.1	971.4	1000.5	1030.5	1061.4
%-growth		3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
<i>Panel B: Actual inventory development of merging firms</i>									
\$ million	837.9	904.0	966.7	1005.0	1041.0	1064.3	1100.4	1116.8	1148.8
%-growth		7.9%	6.9%	4.0%	3.6%	2.2%	3.4%	1.5%	2.9%
<i>Panel C: Difference of actual and expected inventory development</i>									
\$ million	0.0	41.0	36.8	11.7	8.5	-5.0	6.9	-13.6	1.0
discounted to Q0	0.0	40.8	36.4	11.6	8.4	-4.9	6.8	-13.2	1.0
Cost of inventory build-up	\$ 86.8 million								
in percentage of deal value	6.1%								
Mean average deal value	\$ 1428.9 million								

This table estimates the cash flow impact of expected and actual inventory development for an average firm in the sample. Panel A shows a scenario for expected inventory development assuming 3.0% growth per quarter. This is a conservative assumption as the long-term average inventory growth in the sample lies at 4.1%. The starting inventory level \$ 837.9 million is based on the average inventory levels before mergers, as denoted in table 6. Panel B shows the actual inventory development with growth rates based on table 7. Panel C estimates the net present value of the difference in expected and actual inventory. The discount rate is based on average cost of capital 6.9%, following Damodaran (2014).

development by stock keeping units across geographies and business units. More detailed data enables the analysis of interesting questions. For instance, the inventory build-up could primarily occur for products of the target company when those are made available in the larger distribution network of the acquiring company. Post-merger revenue growth may necessitate over-proportional creation of inventory when new customers are located remotely or have extraordinary expectations into service levels.

Interviews and surveys targeted at key decision makers and stakeholders can improve the understanding for the interconnections in inventory management after mergers. The effect of a restructuring in the production and distribution networks on inventory development is rarely considered thoroughly but may be an important obstacles when the operations are not able to scale to the new setup. The decision to stock up inventory may be caused

by the management's risk aversion or by its inability to maintain tight control of inventory levels of the new organization.

This study is limited to the inventory build-up as one specific area of supply chain management. Future research should also investigate the role of supply chain management in M&A on a broader scale. Herd, Saksena and Steger (2005) and Finley and Bonno (2012) proposed a supply chain centric approach that involves early involvement of supply chain leaders in developing the deal rationale, verifying its potential and preparing post-merger integration. Sagner (2012) argued that inventory and receivables could serve as an early indicator for merger success that should be thoroughly analyzed in the due diligence. Reese (2007) highlighted data challenges in supply chain that may lead to poor decision making when being ignored. Singh (2009) saw a fundamental problem in the extensive focus on short-term cost savings in the supply chain integration. Typical actions like shut-downs and labor reductions result in supply chain disruptions that are detrimental to achieving the merger targets. Instead, post-merger integration should focus on delivering sustainable benefits from combining product offerings and joint production of intermediary components. The cited practitioner articles convey two important messages. First, there are many great ideas in the supply chain area that can make mergers more successful. Academic research should take a pro-active role in verifying and promoting these ideas. Second, there are so many and innovative ideas that companies are not able to tell which ones apply to their situation other than through trial and error. Academic research can make an important contribution by developing new methodologies that structure the ideas and identify clear use cases for different approaches.

7 Appendix

Table 15: Data availability and sample size by industry of the target firm

	Retrieved from SDC database	Acquirer data available	Target data available	Data available for both	Deals included in sample	% of total in sample
Mining and Construction	274	115	159	71	59	6.4
Process manufacturing	471	342	334	244	224	24.2
High tech manufacturing	1082	806	718	534	499	53.9
Transport and Utilities	416	181	263	119	0	0.0
Trade	350	236	233	159	144	15.6
Services	996	358	585	217	0	0.0
Public Administration	1	1	1	1	0	0.0
Total	3590	2039	2293	1345	926	100.0

The table shows the number of deals by industry of the target firm, based on one-digit SIC codes. Deals were excluded from the original sample due to missing data for the acquiring or target firm. In addition, deals with firms in the service, and transport and utilities industries were excluded because inventory does not play a significant role for them.

Table 16: Inventory responsiveness, quarter over quarter for companies in sub-sample that report inventory decomposition

Quarter relative to merger	Means of all firms			
	Inventory growth rate	Revenue growth rate	Inventory responsiveness	Inventory responsiveness above average
Number of deals	58	58	58	58
q_4	3.32	4.67	-1.35	-1.93 (-1.48)
q_3	2.13	0.90	1.23	0.65 (0.44)
q_2	3.62	2.32	1.30	0.72 (0.28)
q_1	2.84	-1.40	4.24	3.66 (1.51)
Q0	3.92	1.87	2.05	1.47 (0.65)
Q1	8.09	-2.20	10.29	9.71** (2.28)
Q2	-2.61	-1.34	-1.26	-1.84 (-0.62)
Q3	3.42	3.12	0.30	-0.28 (-0.10)
Q4	-0.21	3.86	-4.07	-4.65** (-2.02)
Q5	1.54	0.49	1.05	0.47 (0.25)
Q6	-0.20	1.00	-1.20	-1.78 (-0.69)
Q7	-0.36	2.85	-3.21	-3.79 (-0.76)
Q8	-0.28	1.55	-1.82	-2.40 (-1.12)

Inventory responsiveness is calculated as inventory growth rate less revenue growth rate. The average inventory growth rate is calculated across all firm quarter observations. Positive values for inventory responsiveness mean that inventory grows faster than revenue. To account for long-term growth trend, the average inventory responsiveness is deducted from quarterly values. The average inventory growth rate is calculated across all firm quarter observations. Positive (negative) values for inventory responsiveness above average denote buildup (reduction) of excess inventory. To test for difference from zero, Student's t-test for means are employed. The values in brackets denote test statistics. The stars ***, **, * indicate a significant difference at the 1%, 5%, and 10% levels, respectively.

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