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HEDGING CURRENCY RISKS? AN EVALUATION OF SMES IN NORTHERN GERMANY

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ABSTRACT

One of the important issues for companies is liquidity from domestic and foreign trade. The market is classically defined by the number of available markets. Globalization and free trade zones set up the foreign market, which becomes increasingly important – even for SMEs. This paper analyzed approx. 60,000 bank transactions with foreign reference of Northern German SMEs by using Chi-square test and correlation analysis. The analysis proofs that an increasing number of foreign transfers increases the number of foreign currency accounts per company. The results also show that despite the existence of currency hedging tools, a significant proportion of SMEs continues to expose themselves to currency risk. The willingness to manage currency risks increases with the increase in value per transaction. Transactions with a value of less than EUR 10,000 are often transferred abroad in EUR instead of in foreign currency.

KEY WORDS

active currency management, hedging instruments, exporters, importers, currency volatility, foreign currency account, forwards, swaps

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A10, G30, G40

1 INTRODUCTION

Managing foreign exchange risk remains a controversial issue, as far as it comes to hedging. With Shakespeare's Hamlet, we can say: "To hedge or not to hedge that is the question." A primary focus of hedging is the reduction of the volatility of earnings and to increase companies' value. FX-exposure is a financial risk that all firms with foreign reference face as part of their ongoing operations. Firms face this risk regardless of whether trading in foreign currencies or not (McCarthy, 2014), as far as foreign goods are purchased, or goods sold

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abroad – regardless of the invoiced currency. Whenever international trading is relevant for a company, an important factor is the volatility of currencies, influencing the profit. Managing exchange rate risks is an integral component in every company's decision whilst exposure to foreign currencies. According to Deltuvaitė et al. (2019), foreign currency positions are mainly influenced by exchange rate fluctuations and economic shocks, while the effects of interest rate shocks or inflation are limited. Following the argumentation of Papaioannou (2006), the importance of the exchange rate risk management arises with the disintegration of the Bretton Woods system as well as the end of the peg of U.S. dollars to gold in 1973.

While many empirical studies focus on the hedging activity of larger companies, only a few publications provide evidence on the use of hedging within small and medium sized enterprises (SMEs).[1] Within the scope of Malindretos and Tsanacas (1995) the smaller-sized companies are mostly forgotten or overlooked in studies within the FX-market, due to the dominance of MNEs in foreign business (Kula, 2012). Besides, only a few studies in the existing literature are reflecting the use of hedging in SMEs, while the research mostly concerns multinational firms. Every firm is subject to financial distress if it has frequent cash shortages and only a few revenue streams. This implies the problem of SMEs: the likelihood to experience financial distress is much higher compared to MNEs, due to the limited availability of assets in most cases. If a firm faces insolvency problems, it usually liquidates assets to settle debts. Ordinarily SMEs are having less assets to sell and are more likely to default (Quintiliani, 2018). Another study of FX-risks within the range of SMEs already argues that the probability of financial distress for SMEs is characterized as high, due to their typical capital structure (Keasey and Watson, 1993; Andrade and Kaplan, 1998; Frank and Goyal, 2009; Bhaird and Lucey, 2010). They examined the qualitative and quantitative elements of financial distress costs of SMEs by using a company's sample of two EU countries. On the one hand they found out, that German SMEs are subsidized by governmental programs and mainly financed by one local bank or "Mezzanine Kapital". On the other hand, they found out, that hedging is rarely used in SMEs, as they have a low ex ante perception of foreign exchange risk or, in the best case, only hedge individual transactions. That is why it makes no sense to hedge selectively, as any open currency position poses an open risk. Brown et al. (2006) investigated in their study of gold producing firms with focus on the managerial views on corporate policies, that there is no evidence that shareholders benefit from selective hedging. The results of the study furthermore implicate: Selective hedging is a common practice within the sector of nonfinancial companies, but where firms are unlikely to have informational advantages, selective hedging is uncommon in a broader context.

This article deals with the use of hedging instruments (explicit reference to: forwards, swaps, options and futures) with a focus on Northern German SMEs with a account at Sparkasse Holstein.

2 METHODOLOGY AND DATA

The paper analyzes whether currency risk management is a common practice in Northern German SMEs with a bank account to Sparkasse Holstein. For this purpose, more than 58,000 foreign transactions were valued, analyzed and classified over a period of more than 1.5 years (March 2017 to September 2018). The study group with a bank account to Sparkasse Holstein consists of 821 companies with an annual turnover from approx. EUR 1 million up to

[1] The main reason of limited availability of empirical studies is data limitation. The German "Mittelstand" – or so-called SMEs – faces strong competition in their market. It seems obvious, that they are not willing to give information on pricings and hedging activities. Only bank employees can research the real use of hedging in SMEs.

approx. 48 million. In addition, each company employs fewer than 500, but at least 8 people. These companies are clearly categorized as SMEs. To characterize the sample, a total of 236 companies have at least one foreign currency account, while an active currency management is explicitly used by 121 companies.

The USD, as the dominant foreign currency, represents most of the FX-accounts (211). The currencies GBP (102) and CHF (70) can be explained by their proximity to the European Monetary Union. Due to the regional reference of the bank to the Scandinavian countries, the examined SMEs also use for a great part DKK FX-accounts (30).

All in all, 236 companies with a foreign currency account have on average 1.3 foreign currency accounts at Sparkasse Holstein. The standard deviation is 0.81. Hereby, the average distance to the mean is nearly one more foreign currency account per company. While the 121 companies with active currency management have an average annual turnover of approx. EUR 22 million, the study group had an average annual turnover of approx. EUR 9 million. The arithmetic mean of the transactions is approx. EUR 35,000, where the median is more precise due to many statistical outliers of EUR 19,000. The investigated companies were either too small to engage in foreign currency transactions with other banks or were asked before the investigation whether there was another bank account for FX-hedging activities. The exception were larger companies with another bank account, which share their FX-business in equal parts to both accounts. In principle the Sparkasse Holstein is the sole supplier in terms of foreign currency transactions or has at least half of FX-transactions (these are only companies that count among the 121 companies with an active currency management anyway).

The period from March 2017 to September 2018 was chosen to test the behavior of companies nearly ten years after the financial crisis back in 2009. Based on an analysis by Koh (2010) of the 32 most relevant foreign currencies in terms of volatility between 2005 and 2010, it became clear that in the years leading up to the global financial crisis in 2009, market volatility was much higher, than in the post-crisis period. It can be presumed that approx. ten years after the last crisis, nearly every company should be sufficiently informed and, following the increased volatility during and after the crises, almost every foreign currency position should be hedged – at least within the scope of SMEs, due to the higher risk of default. In this case the research question is, at what level they continue to hedge themselves. By nature, foreign transactions are only a small part of the total transactions that are not an integral part of the study.

To start with a standard approach, used by Jorion (1990), namely in Bali et al. (2007) and Jorge and Augusto (2016), the company's exposure to exchange rate movements can be measured by the volume of the number of transactions. With increasing volatility, foreign currency transactions with a long maturity must be hedged or covered directly at the time of closing. Only 121 companies use FX-hedging to reduce the risk arising from volatility. Tab. 1 shows the relation of volatility to volume and transactions, where transactions mainly arise from 700 companies involved in foreign business without an active currency management (Jorge and Augusto, 2016). The volatility of the top six currencies (within the scope of Sparkasse Holstein) is being illustrated, while the volume of every currency defines the rank within Tab. 1.

There is no doubt that hedging with the right strategy[2] will reduce the level of risk exposed to a company. Jorge and Augusto (2016) found in their study, that derivatives only increase risk, when they are used to take on advantage of given market imperfections.

Davies et al. (2006) focus on exporting companies that were exposed to currency risk. They found out that the use of currency management essentially avoids financial distress and is dependent on the size and liquidity of the company. Their results provide evidence, that

[2]The right hedging strategy depends on the risk preference of a market participant. Hedging the calculation price on the basis of which a foreign transaction is still profitable is risk averse, i.e. calculated break-even exchange rate 1.05 USD/EUR and a current exchange rate 1.10 USD/EUR. Hedging the whole transaction at 1.10 USD/EUR secures the profit, but excludes a further participation.

70% of Norwegian exporters hedge the FX-risks. It is necessary to examine, if this also applies to Northern German SMEs. Hypothesis H_1: 70% of Northern German SMEs hedge against FX-risks.

In addition, it must be clarified hypothesis H_2, whether the hedging activity depends on the knowledge of the company. McCarthy (2014) explores the motives behind hedging activities. He found out in his research that firms do not know hedging as an instrument to reduce the risk of foreign transactions. Companies might not understand the risk of currencies and the impact on the firm's performance. He found out, that companies think their foreign amount of money is too small to be concerned about.

Furthermore, the following hypotheses should be checked to identify further characteristics of the recent status of hedging within Northern German SMEs:

1. Hypothesis H_3: With increasing foreign currency turnover as well as increasing number of transactions, the number of foreign currency accounts increases.
2. Hypothesis H_4: As the amount of each transaction increases, the currency risk is hedged more often.
3. Hypothesis H_5: The majority of SMEs use an active currency management to hedge against the FX-risk.

An analysis of foreign payment transactions of a Northern German medium-sized bank within the period from March 2017 to September 2018, led to dominant currencies being identified. In this case, only significant transactions ($\geq$ EUR 10) in terms of FX-hedging instruments like forwards, swaps, options and futures were counted. Following this restriction, marginal account settlements are not part of the study. The focus is on the total volume in EUR equivalent and the number of trades with the corresponding foreign currency. In the second step, only those transactions were considered that had a cumulative total volume of over 1.5 million EUR equivalent. Likewise, statistical outliers were excluded from the survey. These include one-off transactions in exotic currencies, such as South African Rand. As a result, only the six largest currencies, counted by transaction volume and number of transactions, were included in the valuation within the observed period. In the third step, the cumulated transactions per currency unit were examined regarding the historical price trend. The exchange rate fluctuations of the individual currencies were calculated by using the exchange rate history of the foreign exchange (finanzen.net, 2019) for the investigation period, using the average of daily differences for each currency between March 2017 and September 2018.[3]

3 RESULTS

Over the investigation period from March 2017 to September 2018 a total of only 1269 FX-hedging activities were observed. The above-mentioned method has resulted in a total of six currencies being identified as shown in Tab. 1. The highest volatility in relation to the EUR was calculated for the USD, volume and number of transactions are also dominant here. Overall, more than 2,100 transactions with a weighted, by the number of transactions, average volatility of $w_i = 10.35\%$ were observed with a cumulative value of more than EUR 243 million. Other transactions in other currencies were not paid attention to due to the methodological restrictions made above.

The correlation between the volatility of a currency, the converted volume and the number of transactions shows an overall positive correlation. This is a stylized fact.

However, the positive correlation between general hedging activities only allows conclusions to be drawn about those companies with active currency management but does not explain the entire corporate client base

[3]Presumption: Every company could have benefited from the lowest daily low or the highest daily high via a limit order: stop loss or take profit at a certain exchange rate.

with foreign operations. This leads to the assumption (hypothesis) that all those companies without foreign exchange trading either have no knowledge of currency volatility (the perception of FX-risk is not given) or no hedging occurs due to uncertainties regarding a currency management. Under the premise that the traded foreign currency of the 121 companies with active FX-hedging is subject to foreign contracts: During the investigation period approx. 126 million EUR secured volume can be observed. On the other hand, there are 700 companies without active currency management. An observed volume of approx. EUR 964 million (EUR 741 million in foreign currency and around EUR 224 million in EUR currency). Thus, the statement can be made that 12% of the foreign contracts of the 121 companies are hedged with foreign exchange trading and 88% of the 700 companies are unsecured or not hedged.

Tab. 1: Currency volatility-matrix using historical data of finanzen.net (2019), added by volume and transactions

No.	Currency	Volatility [%]	Volume [mil. EUR]	Number of transactions
1	USD	11.11	182.44	1,816
2	GBP	4.77	32.82	154
3	CHF	6.80	17.77	39
4	JPY	10.34	4.40	45
5	DKK	2.05	3.98	38
6	NZD	6.17	1.67	14
Total			243.08	2,106

Tab. 2: Correlation of volatility, volume and transactions, using historical data of finanzen.net (2019)

	Volatility	Volume	Transactions
Volatility	1		
Volume	0.58	1	
Transactions	0.59	0.99	1

The observed correlation between volatility and transactions can also be verified by the number of foreign currency accounts of those 821 companies with recurring transactions in foreign currencies. Within the scope of the study group 236 companies with at least one foreign currency account were identified, as shown in Tab. 3. It can be assumed that the number of foreign currency accounts should at least tend to rise as the number of transactions increases.[4] The average volume of a foreign currency transaction makes it clear that those companies that have a foreign currency account mostly use it for larger transaction volumes. The weighted average of all foreign currency transactions (weighted by the number of transactions) shows that payments over EUR 40,000 and above are made through foreign currency accounts.

In general, the hypothesis that the number of foreign currency accounts tends to increase as the number of transactions increases can be confirmed by the regression, as shown in Fig. 1. The regression diagram shows a correlation between the two variables, but correlation is not equal to causality.

Tab. 3: Structure of companies with foreign currency accounts

FX-accounts per company	Number of companies	Number of transactions	Average volume of transactions	Sum [mil. EUR]
1	196	17,530	34,467	416.49
2	22	4,224	63,441	169.81
3	12	4,651	30,946	220.74
4	1	117	41,571	2.14
5	4	1,008	114,046	30.72
6	0	0	0	0
7	1	549	4,150	6.41
Total	236	28,079	40,536	846.31

[4]This relationship is tested only on foreign-active companies within the study group, that already have at least one foreign-currency account.

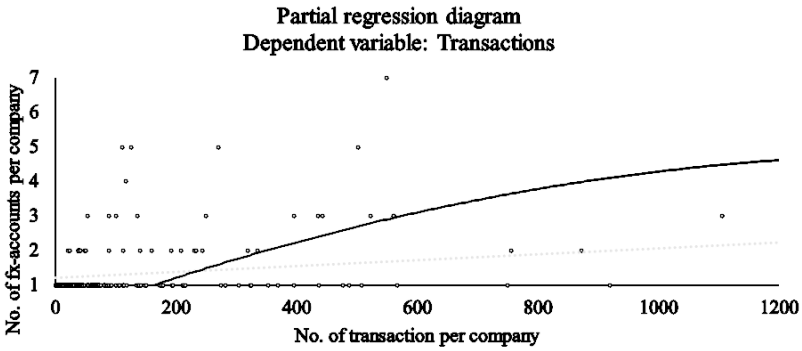

Fig. 1: Regression diagram of number of transactions and the number of FX-accounts.

The regression analysis in Tab. 4–6 shows that the coefficient of determination decreases with the inclusion of another variable (volume of transactions). This leads to the assumption that the transaction volume has only a small influence on the number of foreign currency accounts. Using the ANOVA matrix in Tab. 5, the explanatory contribution can be determined. Since the value of Significance F is significantly below the value of F statistic, an overall high contribution to explanation can be determined. The P-value of both x-variables is well below 0.05. This indicates a positive impact of the x-variables on the y-variable. The transaction volume, measured by the coefficient, has only a very small positive influence on the number of foreign currency accounts. The coefficient of the number of transactions has a more positive impact. As transactions increase, the use of another foreign currency account increases by 0.000605, with an intercept starting at 1.176426.

Tab. 4: Regression statistics matrix of volume and number of transactions

Correlation Coefficient	0.312420
R Square	0.097606
Adjusted R Square	0.089860
Standard Error	0.781363
Observations	236

The variables transaction volume, number of foreign currency accounts and number of transactions of those identified 236 companies with at least one foreign currency account were used in the correlation analysis shown in Tab. 7.

The transaction volume correlates with the number of transactions, as increasing sales tend not to be handled by a single transaction. The correlation between the number of FX-accounts and the transaction volume is $r = 0.338$. This positive correlation coefficient indicates that there is a correlation of both variables in the same direction. According to Cohen (1992), this correlation corresponds to a medium effect. This means that higher transaction volumes also increase the number of foreign currency accounts. Furthermore, the number of FX-accounts correlates significantly with an increasing transaction volume per company ($r = 0.338$; $n = 236$). The correlation can be explained by an omnipresent currency risk, because the exchange rate risk is not completely circumvented by a foreign currency account, but the conversion becomes an influenceable hedging instrument. While currencies that are converted by the bank at the current exchange rate as the payment arrives (STP – Straight Trough Processing) cannot be influenced (acceptance of the respective daily rate; no holding of the currency or early currency hedging at a fairly good rate). Much stronger, however, is the correlation between the number of FX-accounts and the number of transactions ($r = 0.432$; $n = 236$), as shown in Tab. 7. According to Cohen (1992), the correlation has a medium to strong severity. The number of FX-accounts correlates significantly with the number of transactions. The

Tab. 5: ANOVA matrix of volume and number of transactions

	df	Sum of squares	Mean square	F statistics	Significance F
Regression	2	15.386645	7.693322	12.601082	0.000006
Residue	233	142.253186	0.610529		
Total	235	157.64			

Tab. 6: Intercept, Coefficients, T-Statistics and Standard Error matrix of volume and number of transactions

	Coefficients	Standard Error	T-Stat.	P-value
Intercept	1.176426	0.056898	20.676169	0.000000
Volume of transactions	0.000000	0.000000	2.685797	0.007756
Number of transactions	0.000605	0.000224	2.696348	0.007522

Tab. 7: Spearman-Rho Correlation between FX-Accounts, Transaction volume and number of Transactions ($n = 236$). The correlation is significant at the 0.01 level (two-sided)

		Number of FX-accounts	Transaction volume	Number of transactions
Number of FX-accounts	Correlation coefficient	1.000	0.338	0.432
	Sig.		0.000	0.000
Transaction volume	Correlation coefficient	0.338	1.000	0.780
	Sig.	0.000		0.000
Number of transactions	Correlation coefficient	0.432	0.780	1.000
	Sig.	0.000	0.000	

more FX-accounts a company has, the more transactions will be reflected on these accounts. This indicates that as the number of FX-accounts increases, the awareness of currency risks within the scope of the companies also increases.

However, while foreign exchange trading and existing currency accounts of corporate customers are related to transactions and the number of foreign currency accounts, this dependency may not be common to all companies surveyed. A total of 821 companies with foreign currency activities were identified during the investigation period. The proportion of clients with foreign currency accounts is only 28.75% (236 companies), but only 14.74% (121 companies) of clients were identified, using hedging activities, such as forwards, swaps, options and futures. While not every company with a foreign currency account hedges, 85.26% (700 companies) have no active currency management. Considering the individual transactions of SMEs, whether they were transferred from the EUR-account or from the foreign currency account, the transactions can be categorized and split as shown in Tab. 8.

The majority of foreign currency transactions were transferred from the EUR-account. In other words, about 66% of all foreign currency transactions are paid by the EUR-account. In contrast, only approx. 34% of all transactions settled at the expense to the foreign currency account.

This classified data set can be examined using the Chi-square test. From the observed record shown in Tab. 8, the question arises as to whether the choice of account type (EUR-account or FX-account) depends on the transaction volume. The H_0 hypothesis is: The choice of the account type is independent of the transaction volume. Whereas the H_1 hypothesis is: The choice of account type is not independent of the transaction volume.

Using the Chi-square in Tab. 9 and the degrees of freedom as conventional criteria, this entitles a difference as extremely statistically significant, due to a two-tailed p-value less than 0.0001. That means, from a statistical point of

Tab. 8: Comparison of transactions in terms of the EUR-account or FX-account classified by transfer amount (observed)

Observed data	EUR-account		FX-account	
in EUR (categorized)	Number	(%)	Number	(%)
Less than 1,000	8,760	(64)	1,122	(16)
Between 1,000 and 4,999	2,323	(17)	1,804	(25)
Between 5,000 and 9,999	815	(6)	1,116	(15)
Between 10,000 and 49,999	1,407	(10)	2,042	(28)
Between 50,000 and 99,999	266	(2)	610	(8)
Between 100,000 and 149,999	96	(1)	204	(3)
Over 150,000	71	(1)	313	(4)
Total of 20,949 transactions	13,738	(100)	7,211	(100)

Tab. 9: Comparison of transactions in terms of the EUR-account or FX-account classified by transfer amount (expected)

Observed data	EUR-account		FX-account	
in EUR (categorized)	Number	(%)	Number	(%)
Less than 1,000	6,480	(31)	3,402	(16)
Between 1,000 and 4,999	2,706	(13)	1,421	(7)
Between 5,000 and 9,999	1,266	(6)	665	(3)
Between 10,000 and 49,999	2,262	(11)	1,187	(6)
Between 50,000 and 99,999	574	(3)	302	(1)
Between 100,000 and 149,999	197	(1)	103	(1)
Over 150,000	252	(1)	132	(1)
Total of 20,949 transactions	13,738	(100)	7,211	(100)

view, the H_0 hypothesis is rejected. As a result, the choice of account is not independent of the transaction volume. This is particularly evident in the higher transaction volumes. With perfect accordance, the example of the "over 150,000" would be that significantly more transactions would run via the EUR-account (252 instead of 71 observed). Whereas most transactions (compare percentages behind the observed values and the expected ones) continue to be settled via the EUR-account. The hypothesis that most of the examined companies do not operate an active currency management cannot be rejected. If all companies carry out an active currency management, all transactions greater than 4,999 EUR should be settled via the FX-account, to avoid an imminent currency risk.

In total, 700 companies that did not hedge the foreign exchange risk during the investigation period, were identified. It becomes clear that most companies transfer money to other European countries with just one currency (around 68.1%). Including companies transferring abroad with two currencies (i.e. EUR and USD), cumulated 89% of the investigation or cumulated 624 companies can already be explained, as shown in Tab. 10. If we now subtract all EUR-payments from the data set in Tab. 10, the parameters are quite different, as shown in Tab. 11.

After subtracting all EUR-payments into foreign countries in Tab. 11, it becomes clear that out of the originally 700 identified companies, only 367 use a foreign currency and thus explicitly wish to convert the EUR within their own bank to partly influence the conversion (no arbitrariness) – that equates to 52.4 percent of the SMEs using a (light) hedging strategy.[5] On the other hand, there are 333 companies ($700 - 367$) that only transfer to foreign countries in EUR. Nevertheless, it is more than questionable why a total of 700 companies do not use an

[5]This is not an active currency management. This type of currency hedging uses the company's known conversion margins to avoid foreign margins from other foreign banks.

Tab. 10: Comparison of payments – number of currencies and countries

	1		2		3		4		5		Sum	
1	375	(53.6%)	65	(9.3%)	14	(2.0%)	9	(1.3%)	14	(2.0%)	477	(68.1%)
2	13	(1.9%)	60	(8.6%)	29	(4.1%)	17	(2.4%)	28	(4.0%)	147	(21.0%)
3	0	(0.0%)	3	(0.4%)	15	(2.1%)	11	(1.6%)	19	(2.7%)	48	(6.9%)
4	0	(0.0%)	0	(0.0%)	3	(0.4%)	2	(0.3%)	11	(1.6%)	16	(2.3%)
5	1	(0.1%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	11	(1.6%)	12	(1.7%)
Total	389	(55.6%)	128	(18.3%)	61	(8.7%)	39	(5.6%)	83	(11.9%)	700	(100.0%)

Tab. 11: Comparison of payments – number of currencies and countries, excl. EUR-currency-payments

	1		2		3		4		5		Sum	
1	142	(38.7%)	53	(14.4%)	30	(8.2%)	14	(3.8%)	28	(7.6%)	267	(72.8%)
2	2	(0.5%)	17	(4.6%)	13	(3.5%)	14	(3.8%)	20	(5.4%)	66	(18.0%)
3	0	(0.0%)	1	(0.3%)	8	(2.2%)	2	(0.5%)	11	(3.0%)	22	(6.0%)
4	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	11	(3.0%)	11	(3.0%)
5	1	(0.3%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	1	(0.3%)
Total	145	(39.5%)	71	(19.3%)	51	(13.9%)	30	(8.2%)	70	(19.1%)	367	(100.0%)

active currency management, although foreign transactions are made. It is also interesting to note that 367 companies also transfer in one or more foreign currencies, even though they do not use hedging instruments like forwards, swaps, options and futures.

4 DISCUSSION AND CONCLUSIONS

Based on the positive correlation of the general hedging activities, it can be assumed that those companies with hedging activities have understood currency hedging as a relevant factor or have at least been adequately sensitized based on the expertise of an adviser[6].

To draw a clear picture of German SMEs regarding their hedging behavior, ongoing research must pursue according to an empirical study of those who did not hedge in the past and congruently to this study did not hedge their currency risks within the scope of this research. In other words, an ongoing research on those who did not hedge must follow to completely understand the decision against hedging within SMEs.

In general, the hypothesis that as the number of transactions increases, the number of foreign currency accounts also tends to increase, was already tested back in 1997. According to Fok et al. (1997) diversified companies and smaller companies might already have low income and a lower volatility in terms of open foreign currency positions. The consequence is a lower need of hedging. On the other side MNEs tend to have higher foreign exchange risks and reveal a higher need of hedging. In this case the hypothesis has not been rejected, due to the regression analysis and correlation: A coefficient of determination of 18.66% indicates that both variables are determined by common sources of variance. Due to the medium to strong correlation, a connection can be assumed. The more FX-accounts a company has, the higher the overall number of transactions on these accounts., indicating: with increasing number of FX-accounts, predominates the awareness of currency risks. Although, based on the regression model, only a few of the observed values can be explained with a coefficient of deter-

[6] An "adviser" is a currency expert in a bank that advises the company on currency risks.

mination ($R^2 = 0.0006$), it also becomes clear that a significant increase in foreign currency accounts per company can only be expected, if a company has more than 200 transactions. This is partly due to the dominance of the USD, but also to the study group of the evaluated SMEs, as their focus is not solely on foreign countries.

On the other hand, a positive correlation between the number of FX-accounts and the transaction volume indicates that higher transaction volumes also increase the number of foreign currency accounts. However, it is common practice that as the volume of transactions increases, awareness of currency risks and demand for currency accounts also increases. This correlation is explained by an omnipresent currency risk. A company without a currency account needs to accept a given exchange rate, when for example transferring foreign currency from the EUR-account, while a company with a foreign currency account can hedge their needed amount of foreign currency or hold the foreign currency on the account until a better exchange rate is achieved.

The third hypothesis can only be partially substantiated by the regression. Due to incomplete information of the purpose for each transaction, it can only be shown that, as the number of foreign currency transactions per company increases, the number of foreign currency accounts per company is going to increase. While few companies have more than two FX-accounts, it can at least be observed that some companies have at least one other foreign currency account in addition to the dominant USD, which is also briefly demonstrated by the Tab. 8 and 9.

The analysis of approx. 60,000 transactions during the investigation period shows that a significant proportion of the transactions continue to take place with the acceptance of the exchange rate risk. The data from Tab. 8 shows that far more transactions from EUR-accounts[7] go abroad, compared to transfers from foreign currency accounts (13,738 transactions from EUR-account vs. 7,211 transactions from FX-account). The Chi-square test has shown that the choice of the account (EUR-account or FX-account) is not independent of the transaction volume. Nonetheless, comparing the observed and expected levels in Tab. 8 and 9, many companies continue to operate without an active currency management in the overall average transaction volume. This proves the second hypothesis that most of companies do not currently have an active currency management. If we also take the results of transfer volumes, classified according to hedging or non-hedging, into consideration, it becomes clear that the hypothesis according to Davies et al. (2006) applies in part also to Northern German SMEs and can be confirmed. Thus, the hedging activity increases with the size of the transaction volume. Davies et al. (2006) found out that FX-hedgers (firms) in Norway are statistically different due to significance level of 1% in tax, the underinvestment at 10% level, the risk aversion at 5% level, the size sales and asset values at less than 10% levels, the internationalization at 1% level and the liquidity at less than 10%. This leads to the argue that Norwegian export companies have more opportunities in growing, a lesser diversified shareholder base, are significantly larger, operating under more financial constraints (lower level of liquidity) and are more international, compared to Northern German SMEs. Those results confirm the traditional theories and determinants of FX-hedging for Norwegian firms. Based on the Norwegian study, although underlying significantly more parameters, a first tendency can be derived. On the other hand, we can observe in Tab. 8 that cumulated 433 transactions ($\geq$ 50,000 EUR) went abroad in EUR. In contrast, there are cumulated 1,127 transactions ($\geq$ 50,000 EUR) that went from a foreign currency account abroad. While it cannot be assumed that EUR will be needed abroad, the relation shows a clear ignorance or even speculative component in those companies that have transferred from the EUR account. However, this contradicts the fifth hypothesis that most SMEs run active currency management because of their foreign currency risks. The customer structure of the

[7] In this case the transaction of the foreign currency is made at the expense to the EUR-account instead of the FX-account.

examined bank has no MNEs and allows conclusions on Northern German SMEs and their usage of an active currency management. While in Tab. 2 a correlation between the volatility and the number of transactions was found, which is a stylized fact, conclusions can be drawn on the fifth hypothesis. However, these are negated due to the observed structure of payments from Tab. 7. The fifth hypotheses can be rejected. Although the volatility of foreign currencies, as shown in Tab. 1, could be clearly demonstrated in the individual currency pairs, a not inconsiderable proportion of companies has no foreign currency account and thus no active currency management, although a foreign currency activity could be proven. On the other hand, Crespo Cuaresma et al. (2014) have found that volatility may not affect the demand for hedging as the potential losses of foreign exchange depreciation are more often underestimated by companies than during the financial crisis. Larger transactions are hedged more frequently (transactions > 150,000 EUR) as shown in Tab. 8. 313 were executed by the FX-account, while only 71 were executed from the EUR-account. It is noticeable that smaller payments are often made at the expense of the EUR-account. Thus, payments below EUR 10,000 were made to approx. 75% by the EUR-account. Only 25% of these payments were handled by the foreign currency account. Basically, the larger the payment, the greater the likelihood of being transferred in foreign currency.

It is noteworthy that the share of transactions below the value of 1,000 EUR, which go abroad as a foreign currency at the expense of the EUR-account, is dominant with 64%. Here it can be concluded that small bills in foreign currency usually run at the expense of the EUR-account. With increasing value, the number of overseas sales at the expense of the EUR-account decreases, but values between EUR 10,000 and EUR 50,000 with 10% share are quite high, suggesting that those companies without currency trading will bill their accounts against the EUR-account.[8] While larger transactions exceeding EUR 100,000 are rare to SMEs, it can be said that companies with foreign currency accounts have significantly more transactions exceeding EUR 100,000 (cumulated 167 transactions at the expense of the EUR-account and cumulated 517 at the expense of the foreign currency account), as shown in Tab. 8. This suggests that the willingness to manage currencies increases with the increase in value per transaction, which confirms the fourth hypothesis that as the amount of each transaction increases, the currency risk is also better perceived. This trend is also confirmed by the inclusion of transactions over EUR 50,000, as given in Tab. 8. A total of cumulated 1,127 transactions of companies were made at the expense of the foreign currency account. In contrast, cumulated 433 transactions are made at the expense of the EUR-account. This is congruent with McCarthy's observation: McCarthy's study shows that SMEs have limited understanding of hedging and sometimes no understanding of FX-risk, exposure or hedging. Some companies equated hedging as speculation – which is a major issue, because not hedging is speculation (McCarthy, 2014). More evidence for the fourth hypothesis is given by increasing volumes per transaction, because the share of payments charged to the EUR-account decreases in comparison to the foreign currency account. Given the example of Tab. 8, 313 transactions of the equivalent of EUR 150,000 are made at the expense to the foreign currency account. The EUR-account points out only 71 transactions. The same can be seen in the clusters between EUR 100,000 and EUR 149,999 and between EUR 50,000 and EUR 99,999.

However, if we consider those companies without foreign exchange trading but with foreign transfers in EUR or a foreign currency, as shown in Tab. 10, it becomes clear that out of 700 identified companies approx. 89% (cumulated) transfer money in one or two currencies abroad. If we assume that only 20% of these companies have a regular foreign currency requirement, approx. 125 companies of the investigation group should conduct currency management.

[8] Congruent with the high number of companies without foreign exchange trading and transactions abroad.

If we narrow down the scope of the investigation (Tab. 11), only those companies are evaluated, that transfer money abroad only in foreign currency (excl. EUR transfers). If we sum up the companies in terms of their use of currencies again, it becomes clear that with the use of two currencies approx. 90.8% (cumulated) of the sample can be declared (underlying a total of 367 companies). Consistently, we follow the argument that 20% of these companies have regular foreign currency requirements. Thus, about 73 companies of the investigation group should operate a currency management. However, a comparison of Tab. 10 and 11 also shows that out of 700 companies with a foreign currency reference, only 367 (SMEs hedged ratio: 52.4%) operate an active currency management. This confirms the examination results from 1997, where also approx. half of the SMEs were not hedged: According to the study of Fok, Carroll and Chiou (1997) 80% (201 firms) of the hedged firms were MNEs, *while 52% (70 firms) MNEs were not hedged*, with a significant level at 1%.

Thus, the statement, based on the clients of Sparkasse Holstein, can be made that SMEs in Northern Germany hedge only to approx. 52%. The results differ from those of the Norwegian study by Davies et al. (2006). They observed that approx. 70% of export-oriented companies hedge. The first hypothesis must be rejected, as the North German SMEs (client base of Sparkasse Holstein) are significantly different in terms of currency hedging from the Norwegian SMEs. On the other hand, a general statement can be made by using the data of Fok et al. (1997), Hentschel and Kothari (2001), Davies et al. (2006) as well as the data in this research: Hedging takes place in 50–70% of all medium-sized companies, but only 40 percent of non-financial firms do not hold any FX-positions in their portfolio. Remembering the financial crisis back in 2008/2009, where the market crashed and the exchange rates where highly volatile, a statement is given under the comparison of lower risk before the financial crisis and after the crisis: The higher the volatility in the market, the higher the share of hedging companies. It remains to ask in further research, why at least 30% of medium-sized companies even in times of high volatility expose themselves to the currency risk. For this purpose, the 700 companies, shown in Tab. 10, are possible subjects to a survey to find out the reasons for the conscious/unconscious acceptance of the currency risk.

As already stated in the discussion, the following statement applies in principle: the larger the payment, the greater the likelihood of transferring in foreign currency. In addition, it has also been observed that payments smaller than EUR 10,000 are paid more frequently (75%) from the EUR-account. It can be deduced that those companies without an FX-account with at least two foreign currency transactions in the previous year are potential users of a foreign currency account.

To give an example: With an open bill of USD 14,000 and an assumed todays exchange rate of 1.14 USD/EUR, the equivalent is EUR 10,000. Over the course of time (term of payment, 6 months), the observed volatility of 11%, as shown in Tab. 1, may result in an exchange rate change to 1.0146 USD/EUR. Consequently, the same invoice can be paid after 6 months to an equivalent of approx. EUR 13,800. In fact, it is also possible that the exchange rate is developing positively (i.e. 1.2 USD/EUR). Participating on this development, companies should also use active currency management and/or use options where the buyer has the right, but not the obligation, to converge at a certain strike price (Lacina and Toman, 2011). The cost driver "exchange rate changes" is not negligible. For SMEs, active currency management should be indispensable. That was also the conclusion of Ciner (2006). He concluded within the scope of his research, that hedging is more important than speculation as the main motive of trading. This statement also applies after the financial crisis in 2009. Whenever it comes to foreign exchange rates, one currency appreciates and the other depreciates. Riederová (2011) argues, two years after the financial crisis, in her study of the EUR/CZK currency pair, that a suitable hedging strategy for importers and exporters should be mandatory to minimize or even eliminate currency risks.

To sensitize SMEs, a bank should offer a foreign currency account at attractive terms,

so that the currency risk can be minimized. If the exchange rate is hedged early and the issuer collects exchange gains, while waiving monthly fees until the company hedges frequently, this corresponds to a win-win situation. Billing in foreign currency is particularly attractive for companies with an import or export share because the foreign business partner is not exposed to any exchange rate risks. As a result, the company generates a competitive advantage. Once the company hedges exchange rates through hedging, billing in foreign currency seems particularly attractive due to the fixed exchange rate per underlying transaction, as Fidrmuc et al. (2013) had already determined for Central and Eastern Europe.

An alternative is the introduction to the topic of active currency management. The identification of companies with recurring foreign transactions is essential. One starting point here is the average equivalent value of foreign transactions per company. Including the values from Tab. 1, each company can thus be shown which specific risks arise from their transactions.

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SMART INFORMATION SYSTEM CAPABILITIES OF DIGITAL SUPPLY CHAIN BUSINESS MODELS

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ABSTRACT

This study explores how supply chain management (SCM) information system (IS) capabilities can lead to superior business performance, and what are the detailed capabilities and methods to master volatility and uncertainties in business environments. Key concepts in SC modelling have been identified for decreasing SC complexity and increasing SC agility and key methods for supply network planning and synchronisation for optimising business performance and objectives that are often contradicting at the same time. The study developed a best practice recommendation for profit-optimised SCM for companies with capital intensive and capacity constrained resources such as in the steel companies and others of the industry, and for managing their integration between SC domains and between technological and organisations' needs simultaneously. Finally, the study shows how Industry 4.0 innovations such as Smart Services and blockchain technology can provide new value potentials such as cross-organisational network effects and increased autonomy in SC ecosystems, and concludes with suggestions for further research in needed rules and semantics for SC ecosystem collaboration.

KEY WORDS

supply chain management, capabilities, artefacts, alignment, Industry 4.0

JEL CODES

M110, M150, O310, O320

1 INTRODUCTION

The research motivation: A holistic methodology and framework for developing dynamic capabilities for SCM IS in an ambidexterity way for fast alignment to business competitive strategy and context has been developed by previous research of the author (Nürk, 2019). However, the author asks which are the actual and detailed IS capabilities of the SC domains

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that provide companies with optimal and continuous business performance, and, how do they need ideally work together for continuous strategic fit? Hence, the present study focuses on these capabilities and their interaction for providing companies in the steel sector – as presenter of the process industry – with SCM IS best practice.

The research objectives: Based on increasing global competition and industry consolidation, businesses such as steel companies need to respond to environmental changes effectively and fast with their SCM IS processes. Hence, this study explored new knowledge and methods of SCM IS capabilities for dealing with such changing business conditions to be aligned with business strategy and between the domains of SCM. For this reason, a capability-based assessment model – that was developed by author's 2019 research – has been used at two steel companies for analysing the impact of IS capabilities of different SC domains on strategic fit in-depth. The present study summarises the qualitative findings of these industrial case studies and of a case study conducted at SAP SE (the author's employer), and synthesises these with possibilities of innovative digitalisation technology – such as proposed by the Industry 4.0 initiative – to a holistic best practice for dealing with SC dynamics and volatility in the most profitable manner. Finally, key concepts have been explored for reducing SC complexity and providing the required responsiveness to business dynamics with the available resources.

The research question and objective: For addressing the stated research aims, the following research question and main objective have been implemented:

- **RQ:** What are the IS capabilities of SC domains, and how do they work together for keeping strategically aligned and leading to superior business performance?
- **RO:** Explore IS capabilities of SC business models and how they interact to align SC domains to strategy provide superior business performance.

Contribution to current research trends in SCM: According to Patterson et al. (2003) and Monczka et al. (2015), most firms face challenging marketplace and are confronted with numerous contenders that are providing products and services fast, cheap and in high quality. For mastering the requirements from the market, they need robust supply chains and have to manage demand or production fluctuations efficiently and simultaneously. Hence, SC complexity from technological approaches needs to be controlled and synchronised with their management process. The present study explores key capabilities of the SC domains with a focus on their integration on different levels that help organisations to arrive at a simplified SC model and processes configuration, but, with high organisational integration. Finally, the study shows how Industry 4.0 innovations can be useful utilised in ecosystems of the sample industry.

The steel industry review: The modern steel industry originated in the 1850s in Britain and had grown with the world's industrial economy since then (Birch, 1969, pp. 412–413). Global steel production rose from merely 28 million tonnes (Mt) the beginning of the 20th century to 781 million tonnes (Mt) at the end (Mangum et al., 1996, p. 39). During this period, the consumption of steel increased at an average annual rate of 3.3%. Steel consumption increases as economies are growing and investments in infrastructure being placed. Hence, attention has shifted to the developing regions such as China, Brazil, India, and South Korea towards the end of last century (Egenhofer et al., 2013, p. 29). The global steel production peaked in 2007 with 1,343.5 Mt, with the following shares in Mt (IISI[1], 2008): (1) 489.0 in China; (2) 120.0 in Japan; (3) 97.2 in the USA; (4) 364.8 in Europe. The automotive and construction sectors are the largest steel customers, with significant impact on the demand for steel (Egenhofer et al., 2013, p. 28). According to Egenhofer et al. (2013, pp. 10–13), the steel business is characterised by the following:

1. *high capital needs and fixed cost* – producing steel requires expensive facilities that lead to

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high fixed costs, which needs a high capacity utilisation to reach the break-even point;
2. *scale economies and minimum efficient scale* – production cost per unit falls as the capacity of steel making resources increases, which leads to economies of scale;
3. *product substitutability* – steel is a commodity with common standards, except in highly specialised steel products for the automotive sector instance;
4. *barriers to entry and barriers to exit on the industry* – high capital requirements for new facilities and the resulting strong financial effort constituted a structural barrier to entry. The capital intensity is also the main barrier to exit as the investment in steel-making facilities cannot be converted into different usable, and the scaling back of the output volume is not always economical.;
5. *intra-sectoral competitive dynamics* – steel firms' demand curve is usually very elastic due to high substitutability of steel products of the equal category, which result in out-compelling competitors by price rather than by scaling back production.

The fact that variable costs are low and fixed costs are very high due to huge capital outlays leads to industry consolidations as producers with weaker financial positions in spite of the exit barriers are increasingly expelled from the industry as demand declines.

Structural changes in steel production: The steel industry has faced structural changes over the last decades due to increasing production in Asia together with the economic crises. Hence, production of crude steel moves from historical locations, such as the EU and the US, to Asia and has reached 1 billion tonnes in 2012 globally (Egenhofer et al., 2013, p. 29). This upward trend in Asia caused by increased internal consumption and by cheaper steel production, mostly in China, leads to a search for economies of scale by the members of the EU – as the second biggest player – and the North American steel industry. Many M&A of steel companies have taken place within the last decade, and the industry consolidation trend remains.

2 THEORETICAL BACKGROUND

For responding to environmental changes effectively, companies need to change their competitive strategy often to comply with new rules (Johnson et al., 2008, p. 3; McLaren et al., 2011, p. 909), whereas strategic alignment leads to greater business profitability (Avison et al., 2004, p. 224; Luftman et al., 1999, p. 9; Naylor et al., 1999, pp. 3–4; Porter, 1987, p. 7). Dynamic capabilities are potentials for innovative capacity enabling firms to respond to fast-changing business conditions by building, integrating and reconfiguring their internal and external competencies to sustain competitive advantage (Teece et al., 1997, pp. 511–516). Ideal levels needed from IS capabilities to support steel companies' competitive strategies at different levels have been identified by applying a strategic fit measurement model developed by a 2019 study of the author. To get a holistic and detailed view of IS capabilities' impact on strategic fit and business performance, different approaches of key researchers have been combined such as a profile deviation approach and a cross-domain approach to assess second-order effects across SC domains (Tallon, 2012; McLaren et al., 2011; Henderson et al., 1996). This study explores the IS capabilities of the SC domains in the steel industry and focus on how they need to interact together for reaching appropriate levels of fitness and deal with uncertainties and volatility most profitably.

SCM challenges in the steel industry: The literature suggests that there are several major SCM-related obstacles challenging the steel industry in reaching its business objectives: (1) increasing volatility and uncertainty in demand, which might lead to uncertainty in the supply of raw materials; (2) steadily increasing prices of raw materials, which lowers profits; and (3) the lack of visibility across the entire steel supply

chain (Xiong and Helo, 2008, p. 161). Therefore, a demand-driven solution design with extended visibility seems promising to provide enhanced business agility and predictability of demand for managing steel industry supply chains (Xiong and Helo, 2008, pp. 161, 167). Furthermore, raw material supply could be sustained through extensive relationship management with raw material vendors (Wang, 2011, pp. 3, 102; Lee et al., 2007, pp. 444–446). Moreover, firms in the steel industry need to deal with lean and agile manufacturing paradigms (Naylor et al., 1999, pp. 107–117) and coping with high market pressures, and to better integrate and synchronise their upstream and downstream processes at the same time. Increased visibility of changing business conditions such as Demand and Supply volatility helps steel companies to extend the visibility of the impact on supply chain activities as well (Xiong and Helo, 2008, pp. 160, 166). Hence, Analytics and Supply Chain Performance Management (SCPM) capabilities have been explored on their role for steel companies in truly understanding what has happened in the past, and for predictive planning (Sowar and Gromley, 2011, p. 2).

Supply Chain domains and their strategic significance: Empirical studies show evidence of the significance of SCM processes for business success in the steel industry such as the following: (i) new product development (Sadler, 2008, pp. 120–133); (ii) sales and operation planning (Zoryk, 2012, pp. 4–5); (iii) downstream SC optimization (Lichtenstein, 2012, p. 7; Sadler, 2008, p. 20); (iv) customer and supplier relationship management (Lichtenstein, 2012, p. 4; Elliott et al., 2013; Sadler, 2008, pp. 27, 56, 59, 76); (v) SC upstream efficiency (Lichtenstein, 2012, p. 6; Sadler, 2008, pp. 119, 127–133); and (vi) SCPM (Zoryk, 2012, pp. 7–8; Sowar and Gromley, 2011, pp. 2, 11). These findings lead to the question of how IS capabilities for SCM improve the strategic fit of firms in the steel industry. And, to what extent and in which aspects do they contribute to the strategic alignment? To investigate these questions and the contribution of the identified SCM processes to the strategic fit of firms in the steel industry, the related IS capabilities, and their level of support needs to be identified and analysed in detail. Hence, the present research explores the impact on the degree of strategic alignment – on different levels – of IS capabilities for (1) new product development (NPD), (2) SC planning, (3) SC operations and execution, (4) relationship management capabilities, and (5) supply chain performance management (SCPM).

The degree of strategic fit of SCM IS is expressed by the levels of support that IS capabilities for SCM offer for strategic fit, and the levels of functional integration of SCM processes. Moreover, IS capabilities for SCM have to investigate about their ideal levels and their actual implemented levels of support to strategic fit. According to Wu et al. (2006), SCM capabilities embody a firm's qualifications for effectively combining resources for creating and sustaining competitive advantages through knowledge integration from multiple sources and multiple partners across the supply chain (Wu et al., 2006, p. 502; Amit and Schoemaker, 1993; Grant, 1996, pp. 115–116). Because of its significance of SC integration to SC performance SC capabilities identified by leading SCM researchers (e.g. Simatupang et al., 2002, pp. 291–306; Wu et al., 2006, pp. 494–495), such as (1) *information sharing*, (2) *coordination*, (3) *activity integration*, and (4) *resource sharing* have been explored on their support for strategic fit.

IS capabilities' effects on the business process level and second-order effects along the supply chain: According to Tallon (2012), strategic alignment shows performance effects on the processes where alignment measurements have been allocated, but can also show second-order effects on the process level from spill-over effects upstream in the value chain (Tallon, 2012; pp. 9–11). Further insights into the performance yield of second-order effects on the process level are very valuable for executives for the reason to determine purposeful investments in the supply chain in a more focused way (Tallon, 2012, p. 12). Moreover, because of the complex interconnection of supply chains, misalignment at some stages could affect business performance at many other stages along the supply chain (Tallon, 2012, p. 9). Hence, increased strategic

alignment at the process level can create more meaningful information within each process and across domains, which could be shared across the supply chain. Hence, the impact of capabilities by second-order effects on business processes of other SCM domains have been explored.

Concepts of IS artefact: IS artefacts are viewed as a data repository, as functionality to support or as instruments for transferring information and supporting decision making (Strong and Volkoff, 2010, p. 749). Strong and Volkoff (2010, pp. 749–751) extend the theory of IS artefacts by the concepts of latent structures to consider three types of structures (1) *deep structure phenomena* – is described as scripts that represent the real-world systems: the "things," their "properties" and "states," and the "transformations" that alter those states; (2) *surface* – the IS facilities for user interaction; and (3) *physical structures* – the mapping of deep and surface structures onto the underlying physical technology (Strong and Volkoff, 2010, pp. 732–751). They conceptualising IS fit via misfits by the empirically visible events that help to reveal the underlying structure of the IS fit construct. They defined the two types *'coverage fit'* and *'enablement fit,'* which are both complex constructs, addressing the fit between the elements of a business software application and the addressed aspects of an organisation's operations. The differentiation of these two types is seen by the present study as very useful because the *SC design* as a key enabler of fit and needs to be provided by *enablement* through appropriate SC modelling, and cannot be purchased from vendors. The observed causes of misfit will be collected and grouped into six domains of misfit that correspond to concepts of ES artefact as follows: (1) functionality, (2) data, (3) usability, (4) role, (5) control and (6) organizational culture (Strong and Volkoff, 2010, pp. 737–745).

3 RESEARCH METHODOLOGY AND CASE STUDIES

The Qualitative research methodology: As this research was to explore new knowledge in-depth in SCM, a qualitative research methodology has been selected, which is open to considering facts and findings that were not expected at starting the research (Eisenhardt, 1989, pp. 533, 546; Bryman and Bell, 2003, pp. 424–516; Silva and Hirschheim, 2007, pp. 333–334; Kaplan and Duchon, 1988, pp. 574–583; Yin, 2009, pp. 25–46, 130–134). While case studies make it hard to generalise findings in SC integration, specifically if there is no clear theoretical framework supporting these, surveys incorporated only limited aspects of integration and fail to consider what actually happens in SC relationships and to address the context or business conditions (van Donk and van der Vaart, 2005, p. 32). Van Donk and van der Vaart (2005, p. 33) suggest the use of a multi-case study for research in integrative practice to bridge the gap between single case studies and surveys for developing knowledge in the field in its prevailing stage. Hence, three case studies were used as primary sources *'to use multiple sources of data'* for developing the final research theory.

Basic theory development based on secondary data: An exhaustive literature review has been conducted for identifying key concepts of the various SC domains for dealing with challenges the sample industry is facing. In referring to Yin's (2009, pp. 130–162) *logic models* for increasing case study evidence, the main building blocks of the research methodology are the literature review and synthesis – in order *'to rely on proven theoretical propositions'* that form the basis for the development of the research question and objective and the development of the research theory and methodological framework – in order *'to develop logic models.'* The plan with used methods and processes for the research phases is highlighted in Fig. 1. Moreover, the Fig. 1 shows the field studies in two stages with a first case study at SAP and two subsequent case studies at two steel companies A an B).

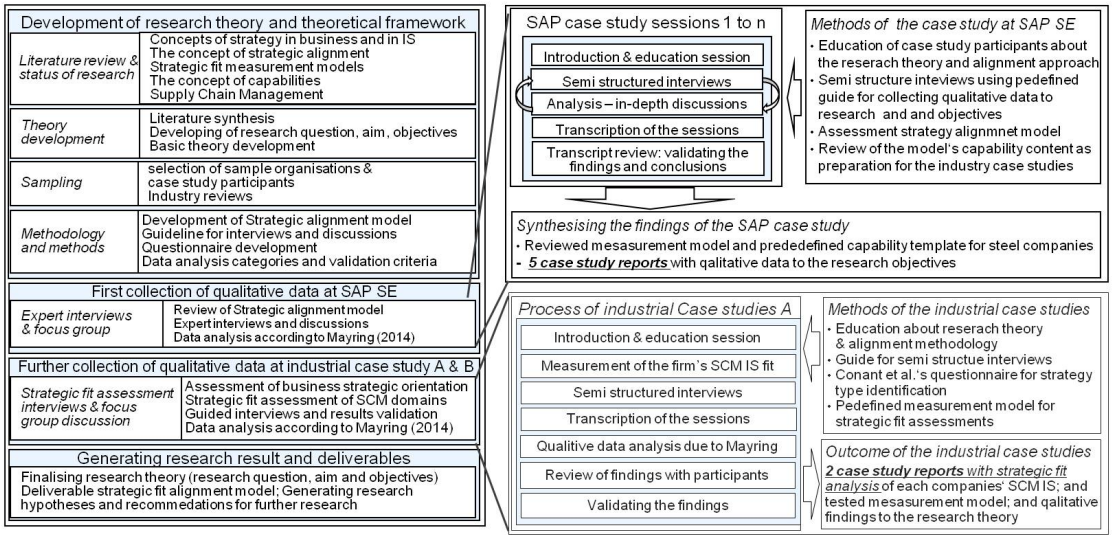

Fig. 1: The research design and plan; and the processes and outcomes of the case studies

Exploratory field study at SAP: An exhaustive case study at the author's employer SAP SE has been conducted as SAP is a leading vendor for SCM solutions and takes care of the steel sectors' challenges and needs. The approach provided rich information rather than using a single sample of a pilot case study that is typically used (Yin, 2009, p. 92). Session of sequences with each of 12 experts and semi-structured interviews have been used to identify IS capabilities required to point out the industry and organisation specific vital differentiators that are relevant for a strategic fit. Leading experts who developed SCM solutions for all manufacturing industries were involved, and, therefore, were able to assess the research theory regarding its generality and adaptability to other industries. For obtain a holistic picture of the factors influencing the research topic, these experts include: (1) Enterprise Architects whose work out IS architecture roadmaps; (2) Business Transformation Consulting and Business Process Consulting; (3) SAP Solution Management for the steel industry and the chemical industry; (4) SAP Product Management for SCM; and (4) SAP Industry Principals of the areas EMEA, North America, and Asia/India. All of them are very experienced, and have many years of experience in dealing with SCM processes (some of them more than 20 years) and have acted as manager for the development of SAP's SCM applications. In this role, the participants developed SCM solutions based on investigation and collaboration with steel firms and worked as trusted advisors for SCM implementations at these companies worldwide. Five reports (each between 8,000 and 18,000 words in length) have created as the outcome by transcribing each of 3 to 6 recorded interview sessions per participant and let them finally signed by the experts. These reports have served as raw data for the findings arrived. Additional experts from SAP have been consulted for spot interviews to digital innovations as follow up investigations.

The industrial case studies and the rationale for the sample selection: The case study organisations used from the steel industry are both global players based in Austria and Germany, with subsidiaries and international involvement around the globe. Moreover, both steel companies are engaged in both high-end product segments and low-end ones. The Austrian steel company is well known for highly innovative involvement in both collaborative product development concerning high-end products, and in driving IS innovations. In referring to Kuolikoff-Souviron and Harrison (2005, pp. 270–271), the present study goes for polar types in

Tab. 1: S&OP IS capabilities' support to fit at company A; deductive application of qualitative collected case study data for triangulation with strategic fit measurements of ideal level (to-be) and actual level (as-is), from Nürk (2019, p. 52)

IS capability	Ideal level	Actual level	Fit	Quotation or paraphrased quotation	Paraphrase	Paraphrase category B	Related KPIs
Demand planning	2.3	2.0	1.7	*"One of the most significant spill-over effects of demand prediction is the indirect, but the clear impact on resources balancing for productions of different segments. High levels of visibility in activity integration are the result contributing to smooth operations, SC synchronisation and coordination."* (PA1)	Demand prediction has an impact on well-utilised resources and indirectly on how well the activities are integrated for fulfilling the expected demand.	Enablement: The reached accuracy is a result of high SC modelling and configuration efforts in DP and S&OP.	1. Forecast accuracy 2. Profitability 3. OEE and plant utilisation 4. Delivery adherence 5. Material & resource availability 6. Transportations adherence
Demand review	2.2	1.9	1.7				
Demand alignment with operations	1.9	1.7	2.0				
Real-time visibility of demand changes across SC	2.6	2.1	2.2	*"Increased visibility of demand changes' impact on material flow has improved customer-order due-date adherence, reliability, and improved operational excellence as well."* (PA1)	Increased SC visibility improves operational excellence and delivery adherence.		
SC modelling	2.4	1.7	2.6	*"Simulation capabilities support strategic decisions, pro-activeness, risk mgmt. also, increase SC agility by better decisions."* (PA1)	Capabilities for modelling and simulating different business situations and contradicting objectives are vital drivers.		
Plan simulation	2.4	2.2	1.4				

sampling the highly innovative Austrian steel company (A), that offers high-end products to the automotive industry on the one hand, and in sampling the traditional German steel company (B) with a stable product portfolio for the packaging industry on the other hand. Hence, the polar type rationale is seen in the products the companies offer and the resulting different characteristics in their SCM processes. Both organisations are large steel producers and have to plan and synchronise their supply chains on a global scale. The industrial case studies have been conducted by streams of six sessions for each company using a guide for semi-structured interviews, the questionnaire (Conant et al., 1990) and the developed measurement model for assessing the competitive strategy types and the degree of strategic fit (Nürk, 2019, pp. 50–55). All sessions have been recorded by Skype capabilities so as there are available in mp4 video format for careful analysis. The team at both companies include the CIOs and IS strategists, the leads for manufacturing and sales and marketing. The questionnaire for determining the competitive strategy type was filled out by the companies' senior management. Reports have been created with 20,781 words in length for company A and 15,488 words for company B as the outcome by transcribing each of the interview session that have been recorded carefully and accurately and let these signed by the head of the group.

Strategic fit measurement between IS capabilities and high-order SC capabilities: The strategic fit measurement was to assess directly how the capabilities at different levels are aligned for transforming and executing the business processes following the business strategy. Therefore, strategic fit of SCM processes occurs through aligning assessed actual levels of capabilities to estimated ideal levels. Through this approach, IS capabilities identified have been grouped due to the structures of the SCM processes and subsequently to the organisations' SC domains (Nürk, 2019, pp. 46–55). In referring to previous research by McLaren et al. (2011), the overall measures as listed in Tab. 1 has been calculated using the Euclidean distance method and a Likert scale with the levels '3' for a high-level, '2' for a medium-level, and '1' for a low-level of support to the strategic fit of each capability.

Qualitative data analysis using content analysis: The rationale for the proposed *content analysis* is based on the complexity of SCM data and its interrelationships (Hsieh and Shannon, 2005, pp. 1281–1283) and the different interpretation of SCM terms in different contexts. The *deductive category application* was used by manually *fitting* interview data meaningful to predefined categories of IS capabilities for SCM and proving the plausibility by triangulating these against the quantitative measurements of strategic fit, as described in detail

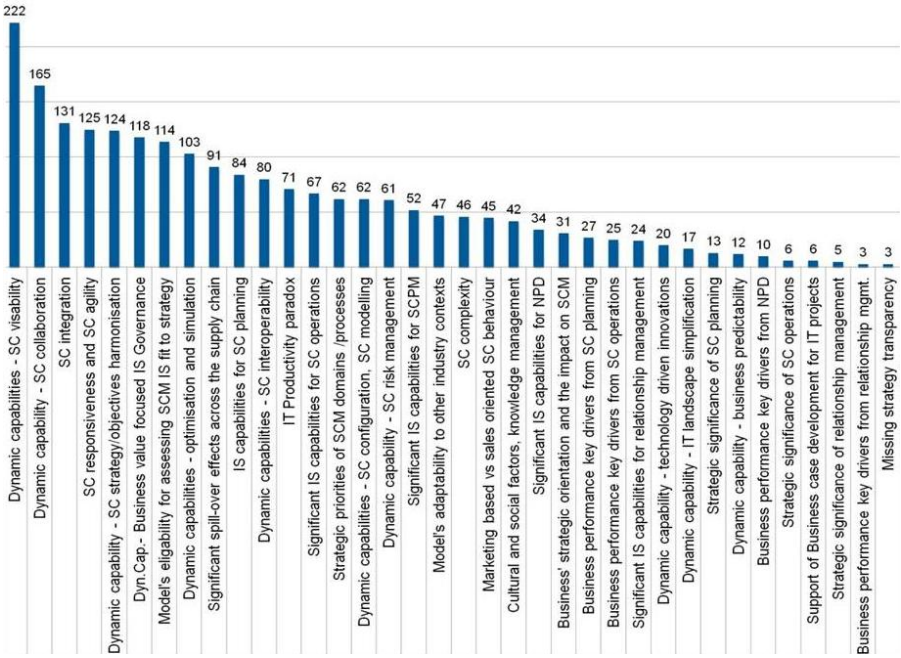

Fig. 2: Inductive format categories and their absolute frequency identified in the case study reports

in Nürk (2019, pp. 48–55) and highlighted in Tab. 1. The *inductive category formation* due to Mayring (2014) has been used for identifying further categories from the text content for developing in-depth findings to research objectives. For this reason, the online tool QCAmp for systematic text analysis based on the techniques of qualitative content, according to Mayring (2014) has been for used. For this reason, each transcribed case study report has been carefully reviewed to identify text passages that have a high relation to the research sub-objectives and assigned these to new categories. After new categories have been formulated, the selection criteria and rules have been established, and the reports have been repetitive review for identifying new relationships to these categories. Fig. 2 shows the categories that have been format as significant to research objectives and their absolute frequency within the reports collected at the SAP case study and the reports collected at the industrial case studies at steel companies A and B.

4 RESULTS AND DISCUSSION

Key capabilities for mastering SC dynamics and strategic alignment of SCM IS: For orchestrating IS capabilities of steel companies' SCM processes so as to moderate SC performance and antecedent capabilities of SC integration to deal with SC dynamics appropriately, the following key capabilities have been identified, (1) SC planning and optimisation capabilities, (2) SC simulation and visualisation capabilities and (3) SC design and SC modelling capabilities. The modelling of capability-patterns as yielded from strategic fit assessments have been identified as very useful for expressing needed levels for SC differentiation that can be used for IS configuration per companies' product segments. Moreover, such architectural artefacts with predefined organisational and technical configurations can increase SC agility in dynamic business environments significantly. Fig. 3 highlights a scenario where environ-

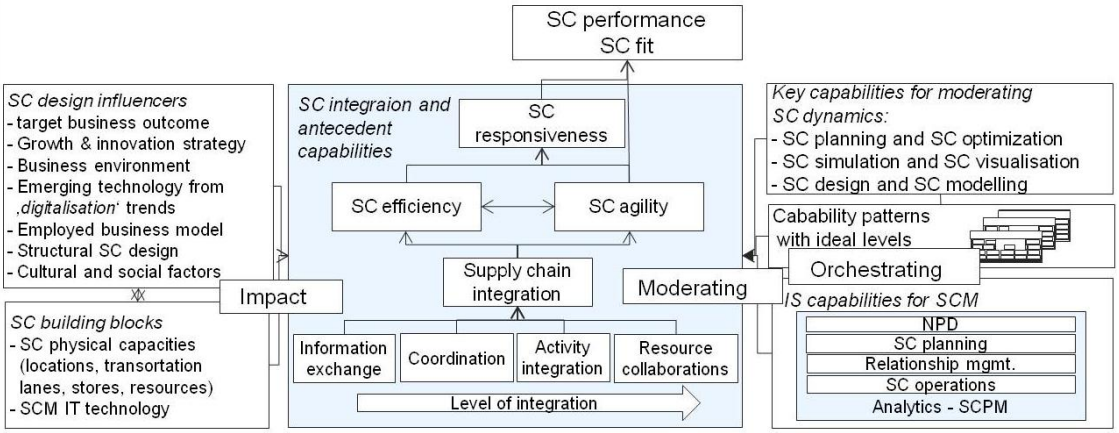

Fig. 3: The impact of SC moderating capabilities in SC performance (an author's view)

mental changes (left side) are affecting the levels of high-order SC capabilities needed for strategic fit (middle of the Fig. 3), and, how IS capabilities for SCM can be orchestrated by capability pattern (right side) dynamically for ideal levels of SCM IS fit.

Ambidexterity – balancing exploration and exploitation vs innovation and growth: Ambidexterity refers to a company's ability to balance exploration activities for variability creation with exploitation activities for variability reduction (Bledow et al., 2009) in a way to optimally acquire and assimilate new knowledge that can be exploited in innovations and will result ultimately in business performance. For this reason, the Portfolio Analysis provides a method for monitoring the proportion of products with a high market share but a low growth rate those come to the end of their life-cycle and need to be replaced by innovations. By this approach, companies can focus on reasonable effort for innovations to replace mature products in time. As a consequence, it provides valuable information for focused dynamic capability development for innovations that promises high-value potentials, and, therefore provides also initial information for the subsequent processes of segmentation, SC modelling and SC differentiation.

SC differentiation using customer and product segmentation: Following the above findings, a company's customer/product segment description can be enriched by information and characteristics useful for SC strategy and SC differentiation, which can be information about the value proposition, relationships, forecasting models and planning strategies and more. For this reason, the capability approach and the strategic fit measurement model that was developed by the author's previous research provide useful tools for bridging the business requirements to the IS capabilities as enablers and modelling theses as IS artefacts and dynamic capabilities. Finally, this information helps to differentiate the SC operating models such as for (1) Make-to-Stock (MTS) – producing stock-keeping units; (2) Make-to-Order (MTO) – where the same products are showing specific characteristic to customers; (3) Engineering-to-Order (ETO) – where the production or implementation procedure shows specific to customers and Assembly to order (ATO) – where the final production stage is configured to customer. By this approach, information that if interpreted together, can be combined by segments, which lead to coherence between portfolio strategy, marketing strategy and SC strategy.

4.1 The Impact of IS Capabilities for SC Planning to Strategic Fit

For safeguard SC profitability and SC performance, the levels of integration between demand management and supply management have been identified as the most strategically

relevant of steel companies in most cases. Sales & Operation Planning (S&OP) solutions help to determine business by predicting demand patterns that increase revenue and profit and provide plans to fulfil the demand in time and in a highly effective and reliable way; so as to satisfy the overall objectives such as service levels and profitability. Vice versa, the upstream and downstream processes have the highest impact on the S&OP domain by providing the entire SC capacity to fulfil the predicted demand with production and transportation resources. Their capacity is always constrained in nature, which limits production and presents a bottleneck. Such limitations by asset capacities have been identified as a key characteristic of the process industry and marketing-oriented businesses in general. This bottleneck also has a constraining impact on the sales figures and forecast to be realised. One of the main challenges that steel companies are facing is the complexity caused by the many constraints and dependencies need to be considered between processes and participants in planning supply chains.

Fig. 4 shows the high impact of the identified IS capabilities for SC planning onto all SC capabilities, including *second-order effects* on operational processes such as transportation. The high levels onto *coordination* and *activity-integration* show the significant impact of SC planning on operations by spill-over effects. Moreover, the figure shows the significance of IS capabilities for plan-modelling, optimisation and simulation for supporting business predictability and end-to-end visibility of supply chains. Furthermore, it shows the pattern of levels of support of the antecedent capabilities (ideal-levels) that would lead to ideal SC integration and ideal strategic fit. Finally, the right levels of support for the specific context can provide by IS capabilities for the antecedent capabilities of SC agility and SC responsiveness.

Value-based SCM has been evolved from cost and profit controlling to value-based management concepts to make the return on investment capital more transparent to the company and its shareholders (Kannegiesser, 2008, pp. 21–22). Indicators for measuring profitability were ratios between capital employed and the achieved business output such as Return on Assets (ROA) and Return on Capital Employed (ROCE), which have to provide meaningful analysis of profitability. According to Kaplan and Norton (1992, 2001), financial measures report the outcomes of past actions, but focusing on financial key indicators can promote behaviour towards short-term performance. Hence, they introduced the balanced scorecard and applied it with key measures driving financial performance.

Fig. 5 shows SCM value management concepts as part of a concise profit optimisation. There is a common view of the case study participants that effective financial management and financial performance measures are important prerequisites of operational performance management. Moreover, benchmarks in financial performance against competitors provide information to the firm's economic health in comparison to the industry average. SCM profitability depends on decisions in supply network planning and the levels of integration of the related processes. Moreover, as *'SC profitability'* is determined to a great extent by supply network planning decisions, high integration of cost control systems into S&OP processes has been identified as significant to support transparency in the planning of volumes and values. Concepts identified for managing value within the scope of SCM in the present study's target industry were examined in the subsequent sections in more depth.

Profit-focused supply chain planning: Asset utilisation in the most profitable way is highly important for steel companies as their production is very capital intensive. For this reason, transparency as to which products and which customers will bring the most profit will be highly important to secure margins. Subsequently, capabilities for reserving and allocating resources for highly-profitable orders were significant for steel companies. The conditions for profitable order placement were set in the S&OP processes, while sales order management will use these predefined conditions. Hence, forecast determination based on profit and service levels for product and customers presents a core objective of steel

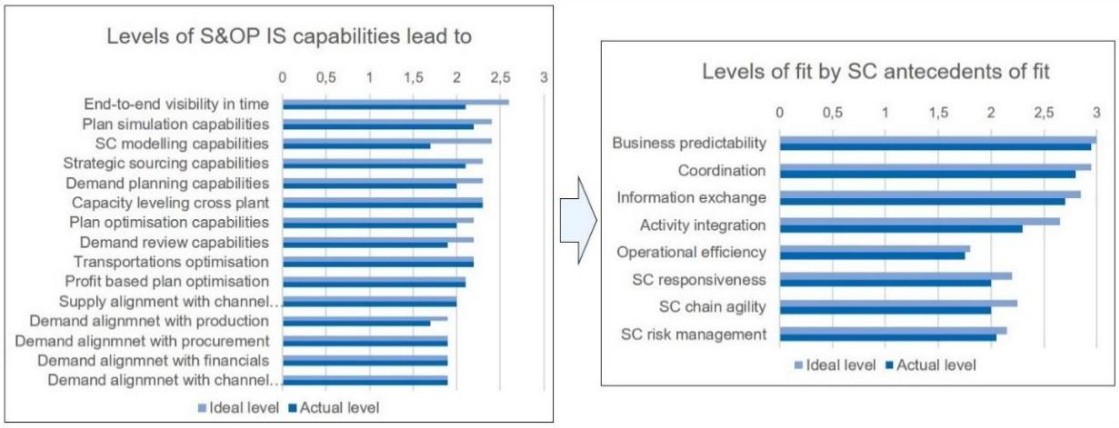

Fig. 4: Support of S&OP IS capabilities to the strategic fit of company A (figures from Nürk, 2019, p. 54)

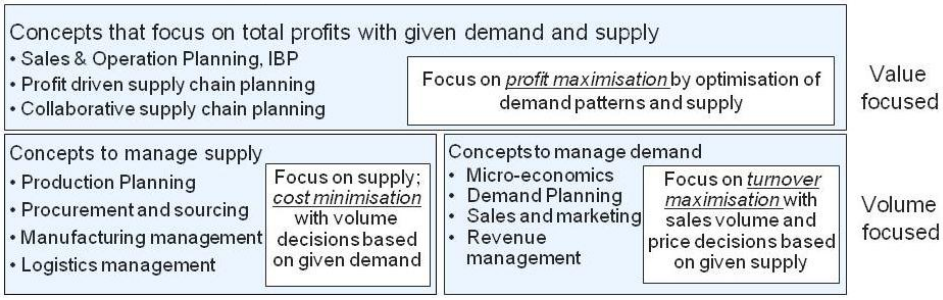

Fig. 5: Concepts in SCM for managing volumes & values (adapted from Kannegiesser, 2008)

companies' S&OP capabilities. At the highly innovative steel sample company, the most important objective of S&OP processes is to predict the most profitable plan that can be achieved with available and restricted resources. Moreover, long-term demand information for the expected product mix can be used for narrowing downtimes of important resources such as a blast furnace. Finally, sales-profit and resource-utilisation can be maximised at the same time using approaches such as the following:

1. forecast determination based on service levels and expected profit contribution;
2. forecast consensus based on business conditions and technical constraints;
3. sales allocation management based on consensus forecast and quotes of expected profit;
4. sales order acceptance management based on allocations and available supply.

The following S&OP capabilities were identified as key drivers for SC performance:

1. characteristic dependent demand planning; consider business rules in plan optimisation;
2. consider constraints and objectives in plan optimisation in a generic way;
3. increase plan profitability by demand prioritisation and finite capacity planning;
4. increase responsiveness to changing demand by alternative planning strategies such as plans with different product and demand mixes and capacity offers;
5. consider contradictory business objectives in plan optimisation;
6. ability to adapt plans to high demand as well as to low demand situations, which has been reported as important for steel companies for surviving.

The identified significance of supply alternative sourcing and consideration of transportation capacities show the necessity of highly

integrated S&OP processes to downstream processes such as sales order management and upstream processes such as production management. Finally, S&OP processes have to respond to fast-changing business conditions by quickly presenting new demand and supply situations in the most profitable way. High visibility of End-to-End processes and integrated collaboration capabilities are playing a major role in being responsive to changing market conditions. Hence, steel companies need extensive S&OP and Integrated Business Planning (IBP) capabilities for sustaining profit, such as the following:

1. extensive and highly integrated optimisation and simulation capabilities;
2. analytics capabilities for predicting demand and supply as reliably as possible;
3. collaboration capabilities for arriving at a consensus plan among stakeholders.

Profit optimisation versus delivery optimisation: S&OP processes have to deal with demand prediction and determination of raw material supply and resource capacity, and finally, the adjustment of all resources so far as possible with the ultimate market demand. For achieving the highest profit possible from the market demand, but, constrained by existing resource capacity and raw material supply, high integration of S&OP processes into operations processes of the downstream and upstream domain and finance, is needed for providing budgets based on the plan. Moreover, S&OP processes have to respond to rapidly changing business conditions by enabling planners to understand new demand situations as quickly as possible and integrating these into the supply plan in the most profitable way. Therefore, steel companies need extensive simulation capabilities for S&OP processes to be highly responsive to changing market conditions for sustainable business profit. As a result of these S&OP processes, a master plan as a reference is provided, which is aligned among the stakeholders involved and reflects the service levels and the planned profitability. Different levels of profitability for products and customers can be reflected in a master plan by this approach and can be selected most economically by subsequent sales processes. Using optimisation methods, the levels of profitability of demand positions are a criterion for selecting those in the master plan in case of restricted capacity. Hence, S&OP capabilities support steel companies in their long-term demand planning and supply planning by optimising the sales profit and the asset utilisation at the same time. The described approach helps to increase the profitability of the plan on the one hand and to decrease the complexity of the subsequent operational processes such as sales order management and production management on the other hand. The following core objectives of S&OP processes have been identified as significant in the case studies:

1. *Harmonise downstream and upstream processes* regarding the strategic objectives. For example, in many cases, the company uses the constrained S&OP plan to govern the acceptance process of sales orders concerning their profitability.
2. *From volume-based to profit-based decisions:* steel companies aim to shift from the pure volume-based demand and supply matching to a determination of the most profitable demand response. For this reason, they need to identify the best response opportunities and the required supply chain capabilities. For example, to get support on decisions such as *make or better buy* of subcontractor services – and for evaluating investments in new mills.
3. *One common plan for global synchronisation:* the increase in product proliferation and globalisation strategies of steel companies results in requirements of aggregation and scalability in S&OP processes. A key requirement identified from the case studies is that all information supporting business decisions shall be stored in *'one version of the truth'* to keep the global teams synchronised.

SC visibility versus SC complexity: Demand visibility is related to both of the defined IS fit types *'coverage'* by the implemented IS capabilities for Demand Planning and to a considerable extent to *'enablement'* through appropriate

modelling of hierarchical planning-data structures. Besides, *enablement* refers to modelling appropriate planning horizons and aggregation granularity and reflect the company's sales and distribution structure as well as the workflow design for the demand consensus process between the involved stakeholders. Moreover, demanding S&OP scenarios such as in the steel industry required planned customer-product combinations described by characteristics of being able to prefer combinations with high service levels or high-profit contribution by an optimiser. Such requirements in demand planning data show the dimensions and details that need to be modelled, but, also determine the extent of complexity that needs to be implied. Case study A shows that S&OP capabilities can significantly reduce the complexity of the SC operations processes through increased plan visibility, enabled by optimised master plans (Tab. 1, case study participant PA1).

The following characteristics of the steel companies' SC operation process show the requirement for extensive SC visibility and the complexity in SC modelling to provide these capabilities for a detailed End-to-End process perspective:

1. the manufacturing process is a continuous process rather than a discrete one;
2. the operations process is handled in most cases as a Make-to-Order process, and configured with quality and grade characteristics to customers' needs;
3. assets are capital intensive, and production capacities are restricted, and hence need to be utilised most effectively and profitably;
4. steel producers offer a wide variety of products and characteristics and face distinct fluctuations in profitability and demand.

The master plan acts as a mediator between demand management and supply management and supports sourcing decisions to meet customer's service level agreements and helps to fulfil companies' profitability objectives. It is based on aggregated production flow quantities, production capacities, and balances the cost of capacity and inventories against the master plan's profitability. Sales allocations for profitable product and customer combinations can be created based on the master plan, to reflect profitability and support reliable order processing. As a result, the master plan determines the supply options those constraint the demand. According to the case studies findings, demand-prediction and demand-alignment provide the foundation for balancing resource plans of the companies' plants, and therefore, has a significant impact in reducing the efforts for *'coordination'* and *'activity integration'* of operations' activities. Situations, where sales representatives cannot deliver promised products to customers because of capacity bottlenecks, are regularly recurring. Hence, demand prediction is seen as a capability with significant impact on delivery performance by spill-over effects from S&OP processes to operations and sales order fulfilment. Fig. 6 presents the levels of SCM and the positioning of Master planning, which needs to reflect the predicted incoming orders as accurate as possible as steel companies cannot change their technological processes in the short term.

The impact of SC planning capabilities on SC performance: Demand Planning capabilities enables segmenting customer and product combinations according to their profit contribution. S&OP-optimisation capabilities enable creating forecast plans by preferring demand of customer product combinations categorised as highly profitable, rather than combinations with lower profit. Hence, optimisation capabilities can support SCM processes so as to influence a steel firm's profit contribution positively, and decisions for the most profitable product mix and the most effective supply sourcing can be supported by S&OP planning capabilities. Moreover, strategic decisions on long-term sourcing of raw material and production capacities can be based on these processes. These decisions have a high impact on further product mix effectiveness and supply sourcing efficiency, and, therefore, on long-term profit. Based on that information, contracts for raw material can be negotiated with suppliers as early as possible. Particularly important supply sourcing decisions are those for high-end products for the automotive industry, which has to be produced onshore because

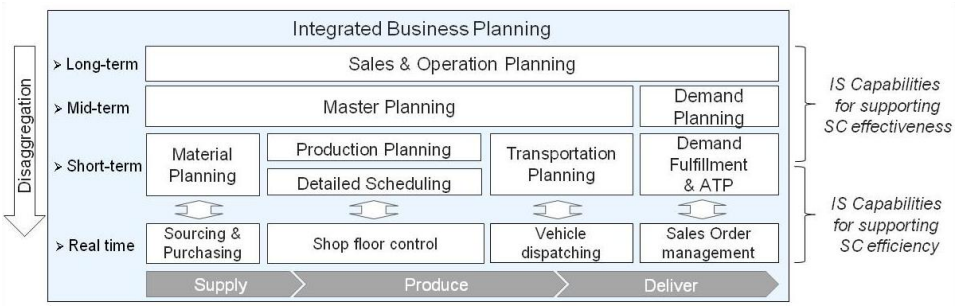

Fig. 6: The master plan for balancing demand & supply (adapted from Stadtler, 2005, p. 579; Meyr et al., 2002, p. 99)

of shorter distances to customers. Moreover, S&OP processes can deliver information about low-end products that are no longer profitable because of declining margins. Finally, production efficiency can be supported by S&OP processes by predetermined, effective patterns of orders schedules. Hence, optimisation and simulation methods are core capabilities for creating master plans.

Methods for plan optimisation in dynamic business: Master plan creation and *decision making* are supported in profit-oriented supply chain planning scenarios by different complementing methods, such as visualisation and analysis, *plan optimisation*, *simulations* and *plan references*.

The plan reference method: Reference models or in industry terms so-called *'best practice'* were used to support decisions by comparing with accepted good outcomes. The cases study has identified the following KPIs as the most important for steel companies: *'resource utilisation'* (in tones as a typical measure for steel companies; ROI), *'delivery reliability'*, *'inventory levels'*, and *'planning accuracy'* in volumes and demand patterns (Tab. 1). However, *demand patterns* represent an important instrument for steel companies for creating plans with different levels of profitability. Hence, modelling of demand patterns by comparing with good states in levels of profitability represents a key capability for profit-oriented supply chain planning.

The plan simulation method: Plans that reflect situations expected in the future can be created using simulation methods for supporting decisions. Simulations are prescriptive methods for supporting decisions in the planning of production and logistics. In the sample industry, simulation refers to creating variants of master plans using optimiser capabilities of SCM applications, to search for solutions in supply and demand that optimise profitability at a given resource capacity. However, uncertainty in profit-oriented SCM is a key motivation in other industries such as the automotive industry as well. It allows the comparison of different scenarios about demand volume and value to simulate capacity planning. SCM experts from SAP and participants of the industrial case studies rated *simulation capabilities* as significant for plans selections from different possible scenarios, based on expectations. Such *simulations* can support decisions concerning the overall SC strategy as well as decisions in SC planning and SC operations. The supported decisions relate mostly to demand and supply to reduce uncertainties and to provide alternated master plan variants for different situations in advance. Such simulated plan alternatives can reduce SC risk through increased awareness of the impact of possible environmental conditions on the plan results. The simulation method plays a key role in creating capability patterns, as architectural artefacts to increase SC responsiveness.

The plan optimisation method: Mathematical methods such as the *SIMPLEX* and *Branch & Bound* algorithms are used to solve optimisation problems in industrial operations for searching optimal results. Optimisation problems are characterised by a structure consisting of an objective function $H(X)$ to be maximised or to be minimised by varying the decision

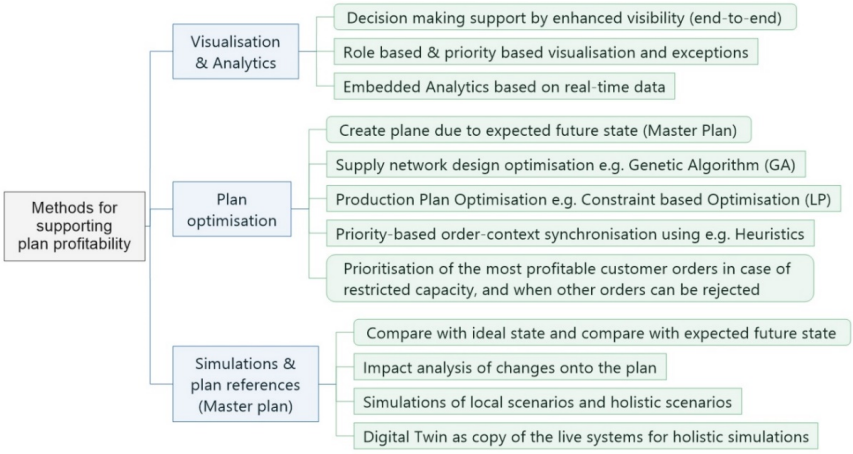

Fig. 7: Methods for supporting supply chain plan profitability

variable vector X, with X subject to a set of defined constraints θ leading to max (min) $H(X)$, $X \in \theta$ (Tekin and Sabuncuoğlu, 2004, p. 1067).[2] In contrast to local optimisation, global optimisation methods focus on finding global optima (minima or maxima) of an objective function f subject to the constraints S (Floudas et al., 2005, pp. 1185–1186). There is a consensus between the findings of the present case studies and the literature that a global value optimum should be reached in SCM scenarios instead of a local optimum (Floudas et al., 2005, pp. 1185–1186). Moreover, multiple-objective, instead of single-objective optimisation focuses on balancing multiple and competing objectives such as overall profit maximisation and further objectives of different stakeholders in the supply chain. Multi-objective optimisation requires evaluation and balancing of contradictory objectives such as customer's satisfaction versus one's profit. Modern SCM solutions use algorithms such as *Constraint Programming (CP)* for considering constraints in optimisation problems such as production scheduling (Kannegiesser, 2008, p. 57) and *Genetic Algorithms (GA)*[3] for large combinatorial problems such as in supply chain network design.

The plan analysis and visualisation methods: Analysis and visualisation methods provide capabilities for action-orientation, decision making by focused extraction, analysis and visualisation of data. These methods target increased the transparency of supply chain processes and an easy understanding of planning results. The methods introduced can be combined to support decision making. *Simulation-based optimisation* provides a prescriptive method for decision support (Kannegiesser, 2008, p. 58). SCM solutions provide comprehensive optimisation capabilities for creating consistent master plans. Such solutions are providing simulation capabilities for analysing effects of plan changes to End-to-End processes across SC networks, which covers transportation, manufacturing, and distribution processes, as well as stock, supply sourcing and procurement processes. Many steel companies are using such optimiser technology for their S&OP processes. Fig. 15 (in Annex) highlights examples of optimisation methods that were used in SC planning and SC operations on different levels.

[2]Since the simplex algorithm invention for LP problems by Dantzig in 1947, methods such as the branch & bound (Land and Doig, 1960) have been proposed for different mathematical programming models (Liu, 2011, pp. 22–33).

[3]GAs as meta-heuristics are commonly used to generate solutions in relying on bio-inspired operators such as mutation, crossover and selection. The GA is used by SCM applications for creating profit focused master plans.

4.2 The Impact of IS Capabilities for SC Operations to Strategic Fit

Key performance drivers of upstream and downstream processes: According to the experts' observation, there is a trend for steel fusion to be moved closer to the mines and the supply of ore, while the manufacturing of end products such as plate, tubes, and coils, and the associated differentiation stage relates to the customers' locations. As examples of such supply network setups, the steel plants of ThyssenKrupp in Brazil and ArcelorMittal in Mexico can be mentioned, where steel slabs are produced close to raw material supply in Latin America and transported to Europe and China for hot and cold rolling processes. A further example is the ThyssenKrupp cold rolling plant for stainless steel in Shanghai, where slabs were exported to Europe as semi-finished products. The primary objectives of this approach in placing the stages of product differentiation as close as possible to the market side are seen in enhanced responsiveness in case of demand changes and increased standardisation capabilities for raw material supply and semi-finished products. Managing such supply networks requires capabilities for planning and coordinating the transportation of semi-products from the steel fusion plants to the locations of finishing facilities synchronised to the local production, and finally, to external service centres for surface coating. For this reason, the following capabilities have been identified as significant key drivers of SC performance of steel companies' upstream and downstream processes:

1. *capabilities for plan optimisation* that can deal with technological constraints and with cost objectives for utilising capacities most effectively;
2. *capabilities for aligning plans with the actual sales demand product mix* to provide the right supply of material and resource capacity;
3. *capabilities for aligning supply,* such as material and capacity of production, transportation, and distribution resources with sales demand on a flexible basis;
4. *simulation capabilities* for reviewing plan reliability and profitability.

SC traceability by configurable production and batch valuation: High variability in steel grades wanted by customers is provided using product configuration capabilities. This variability needs to be propagated in most cases throughout the entire supply chain, from sales orders in batches of raw material. Hence, capabilities for handling batches with evaluating characteristics were prerequisites for tracing customer order positions onto raw material batches. Traceability capabilities were seen as highly relevant for return and complaint management as well as for tracking batches from suppliers throughout the supply chain until delivery to customers.

Fulfilment reliability and profitable order selection at the same time: Fast and reliable promising of sales demand and effective mapping of actual sales positions to supply as well as to allocations have been identified as significant. These are also core capabilities of the backlog management process of sample company B. Moreover, reliable demand fulfilment about delivery adherence is strongly impacted by sales order processing capabilities such as ATP[4] and CTP[5]. Steel companies use these capabilities in sales order processing to improve on-time delivery and reduce the opportunity losses by generating reliable quotes and finding the more feasible supply options. Finally, they help to increase profit by accepting orders with higher profit. Maintenance prediction for key resources has been regarded as significant for safeguarding the revenue sustainability by planning and scheduling with reliably available capacity.

Dynamic planning capabilities through innovative MRP concepts: In using production planning and scheduling capabilities, steel companies create detailed production plans for the short-term. The core objective is to create

[4] Available-To-Promise (ATP) is a business function that provide response to customer order requirements based on material availability to the requested quantity and due date.

[5] Capable-To-Promise (CTP) is a technique amending ATP taking existing inventory and the output of future period into consideration based on available production capacity and lead times of components.

highly effective production plans for the following criteria:

1. meet customer-demand reliably;
2. create order cycle times that are as short as possible;
3. consider available resource capacities and secure their effective utilisation;
4. reduce efforts for resource set-up and maintenance;
5. secure material availability and minimise inventory and work in progress.[6]

Dynamic MRP capabilities of a new generation of Enterprise Management Systems: As a result of the criteria above, a good plan shows contradictory objectives where involved parties need to compromise on a feasible approach. On the one hand, manufacturing lead times and inventory will be reduced; on the other hand, delivery performance to customers will be improved. MRP concepts of new Enterprise Management systems uses in-memory database technology, which enables companies to perform their overall planning run in very short time as the underlying database technology presents the company's full supply chain data model in the SCM IS working storage. Moreover, this approach provides real-time processing capabilities for planning and scheduling activities as well as enhanced end-to-end visibility of the supply chain. Moreover, in-memory database technology enables SC exception management and alert handling as well as supply chain analytics and reporting activities based on real-time supply chain data. The front-end applications of these Enterprise Management systems emphasises on user-centricity. The combination of the real-time data processing and user-role-centred front-end applications provides MRP planner with very high SC agility, SC responsiveness and SC visibility for priority and exceptions based MRP analysis.

Dynamic SC synchronisation – order scheduling and optimisation: A production schedule specifies the sequence of orders on given resources. For bottleneck resources, scheduling of orders needs to consider constraints such as finite capacity and fixed predefined sequences. The given master plan sets the frame for these planning and scheduling activities. By this approach, the plan is scheduled with a finite capacity to determine feasible dates for orders and activities in material availability can be considered at the same time. The production plan can be scheduled using optimisation capabilities or heuristics. The approach used depends on the objectives of the schedule: (1) when emphasising on scheduling single-order-contexts such as for Engineering-to-Order production (EtO) with focus on order priorities, a heuristic approach is preferred; (2) when contradictory scheduling objectives need to be considered in seeking an overall solution of a plan, an optimisation approach is preferred. The objective of an optimisation process is to find the best solution according to given objective functions and constraints. Moreover, the objective is to create a plan that satisfies the interests of stakeholders involved in the planning process by influencing the optimiser by setting the variables of the objective function such as virtual costs. Mathematical algorithms are selected based on the complexity of the scenario. An example for optimising the schedule of a production plan in minimising the control costs can show as follow:

$$\text{Objective function} =$$
$$= \text{minimise } (w_1 + w_2 + w_3 + w_4 + w_5),$$

where w_1 is total lead time, w_2 is setup time, setup cost, w_3 is max delay, w_4 is sum of delay and w_5 is production cost.

Constraints that determine the decision area for searching the optimal solution can be:

- C_1 availability of raw material and predecessor orders;
- C_2 capacity restrictions (finite capacity, shift models, downtimes);
- C_3 fixed patterns of order sequences, and more …

SC agility by preconfigured plan alternatives: The optimiser searches an initial solution and aims to optimise it by iterative approximation

[6]Work in progress (WIP): WIP is material on the shop floor or on the plant, in the process of transformation and therefore currently being worked on.

within an as geometrically defined convex polyhedron that describes the decision area defined by the planning constraints. Depending on the planning complexity – quantity and relationships of production-activities, cross-plant-dependencies, raw material and sales order relationships needed to be synchronised – such an optimiser run can take between minutes and hours, and the plan improvement time increases exponentially. As mentioned, the optimisation objective is not to reach an exact mathematical solution, but, rather plan the compromise the contradicting objectives of the stakeholder. The interviewed experts at SAP stated a needed timeframe of 1 to 3 months as an average in an implementation project for fine-tuning the optimisers weighting factors to reach such a compromised plan. Such a timeframe is not feasible in an ongoing business when business conditions were changing on short-term. For this reason, identifying needed plans and conditions in advance using simulation capabilities will help to identify configurations and predefine patterns as architectural artefacts to increase SC responsiveness.

Dynamic replenishment concepts: Besides the traditional MRP planning approaches of forecast-based planning (deterministic) and consumption-based planning (stochastic), there are innovative planning approaches for dealing with demand uncertainties and volatility of supply in a dynamic and agile way to safeguard supply chain resilience and demand fulfilment.

1. *Dynamic stock buffers and SC flow synchronisation:* High stock levels are needed when the lead time is higher as the delivery time accepted by customers, and for creating economies of scale. On the other side, a raw material stock is capital intensive and can run out of shelf-life in some cases and need huge space such as in the steel industry. Concepts such as Demand Driven replenishment offer dynamic ways to create stock buffers at strategic points within the supply chain for compensating volatility in demand and supply and enable a smooth production and resilient material flow at minimal stock levels. The concept of Demand Driven MRP is originated from the lean management concept Actively Synchronized Replenishment (ASR) and related to the Theory of Constraints (TOC). Such an approach safeguards work-in-process stock levelling for steel making process flow.

2. *Multi-Echelon inventory optimisation (MEIO):* While DDMPR focus on smooth production flow with minimal stock in assembly systems, MEIO aims to balance stock levels against promised customer service levels within multi-tier supply chains.

Both concepts aim to avoid bullwhip effects where depend demand rises within the supply chain by upward fluctuations due to planning procedures such as lot sizing and forecast errors.

SC synchronising and scheduling concepts of the process industry: Different industries with different manufacturing and material flow concepts are also using different order scheduling methods for synchronising their supply chains. Companies of the process industry such as chemical and pharmacy companies often use optimiser capabilities to create holistic plans for their make-to-stock production, synchronised as campaigns of orders for each product to minimise expensive and time-consuming resource setup efforts. Moreover, to create a continuous flow across product stages and resource networks. There are variations of this concept such as the sector-specific *'Block Planning'* and *'Coffin shape'* scheduling approach in the steel industry where the shape and sequence of orders for different products are clear predefined based on constraints of the process technology.

SC synchronising and scheduling concepts of the discrete manufacturing industry: Companies of the discrete industry with Make-to-Stock operating model uses holistic optimiser scheduling for order synchronisation as well. Companies with focus on Engineering-to-Order (ETO) approach prefer to use heuristics to schedule the customer-specific order contexts based on priorities and availability of raw material and resource capacity. Companies of the automotive industry focus on lean concepts to safeguard a continuous flow of the product mix at the assembly line that reflects exactly

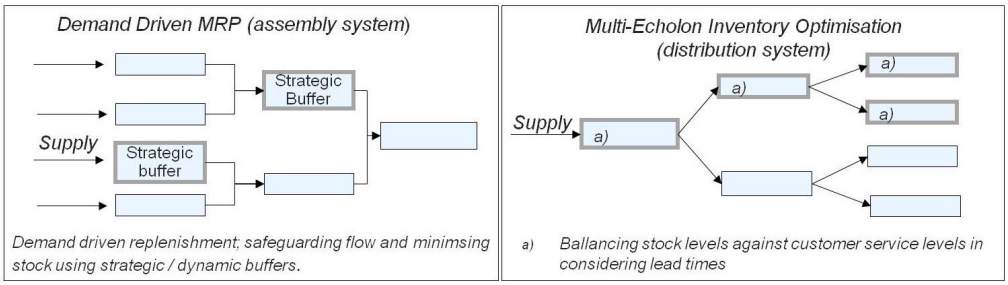

Fig. 8: Dynamic stock levelling in assembly and distribution scenarios (an author's view)

the rate of the demand. All dependent components, delivered from both internal and external suppliers, need to be provided Just-in-Time to the order flow at the assembly line.

Lean management versus continuous flow in the process industry: Companies in the discrete manufacturing industry primarily adopt lean management principles. The *production rate* in lean scenarios is determined by the *overall sale rate* of the product mix that is produced by the particular production lane. The production line is designed using lean principles such as *'Value stream mapping'* methodology and is equipped with lean methods such as *'Kanban cycles'* for material replenishment and methods such as *'rapid hunting cycles'* for labour force optimisation. Such scenarios require a reliable forecast of the model mix produced with a production line. Lean management principles play a minor role for steel companies and companies in the process industry. Instead of this, reliable schedules of continuous material flow with overlapping send-ahead quantities are important for these to safeguard the continuity of the technical processes.

Collaborative processes for safeguarding fulfilment: The following collaborative processes have been identified as significant for sharing information and resources in connected manufacturing ecosystems: (1) engineering change management such as phase-in processes for new products and phase-out processes collaboratively with engineering, manufacturing, suppliers and other related stakeholders; and (2) approval processes with suppliers for ensuring that they can deliver components that meet quality requirements and (3) quality data exchange between engineering, manufacturing, warehouse management and others. Finally, (4) collaborative equipment sharing and plant maintenance for ensuring services on-time and predict maintenance schedule reliable for factory capacity planning.

Overall Equipment Effectiveness for measuring productivity: The main KPI in the process industry called Operational Equipment Effectiveness (OEE) reflects the effectiveness of processes; covering qualitative measurements of the products in figuring out the process outcome. This KPI is particularly important in light of the high capital-intensive resource input in the sector. The OEE does not consider the profitability of the different products. As examined in previous sections, S&OP processes provide plans optimised on the profitability of the planned customer/product combinations. Hence, combinations with high contribution to profit can be preferred to realise in the case of restricted production capacity. Therefore, profitability can be managed on a master plan level using advanced S&OP planning capabilities. OEE management helps to transform the planed profitability most effectively by operational excellence.

EDI processes for synchronising multiple-tier supply chains: Automotive companies are managing their extended supply chains usually fully automated. OEMs (original equipment manufacturers) and their suppliers are communicating messages between their IT systems by electronic data interchange (EDI). Fig. 10 provides an overview of a *Just-in-Sequence* EDI process and the message-exchange between an OEM and its tier suppliers. Multiple tier suppliers can enhance the process chain in practice. An OEM communicates the demand

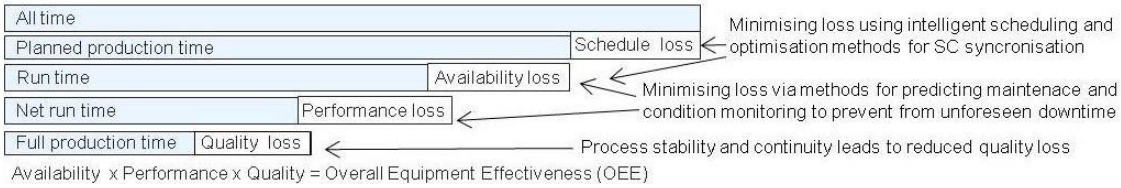

Fig. 9: The OEE as KPI for measuring effectiveness of processes and SCM methods (adapted from oee.com)

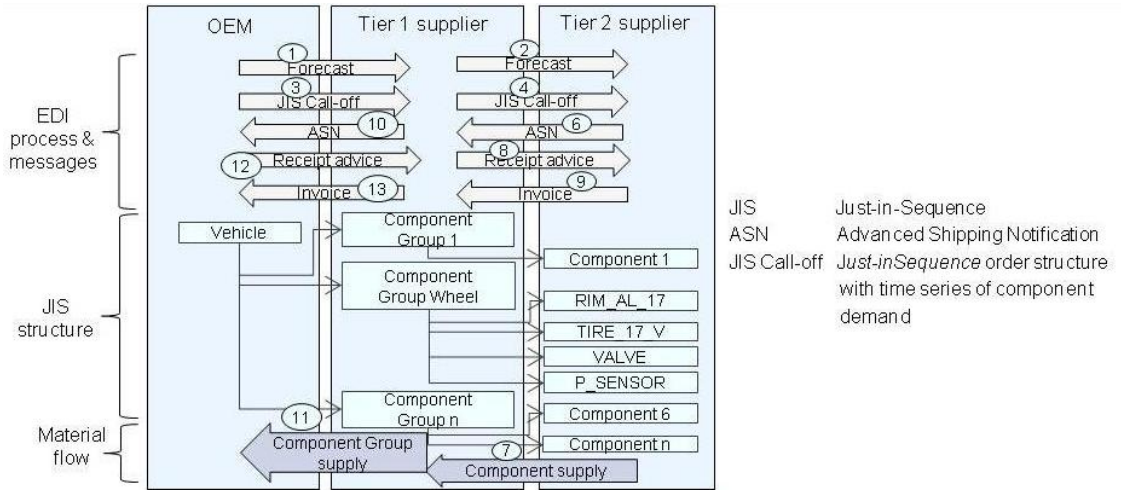

Fig. 10: Example of a multi-tier SC synchronisation process via EDI (an author's view)

for a specific part by a *forecast message* which provides the supplier a decision basis for calculating the own demands. *Just-in-sequence (JIS)* messages were used to communicate the component demand of complete BOM structures that are required for final assembly of cars configured by customers. The JIS-messages contain the sequences in which the parts must be delivered to the OEM's assembly line. With an Advanced Shipping Notification (ASN) that contains information such as used pallets, boxes, serial numbers, the supplier pre-informs the OEM about an upcoming delivery. The OEM confirms the receipt of the ASNs to the supplier by a functional acknowledgement, and as soon as the OEM proceeds the shipped goods, the supplier gets a receipt advice, which provides the basis for the credit note or an invoice message.

4.2.1 Value Potentials of SC Business Models from Industry 4.0 Innovations

SCM possibilities driven by the Internet of Things (IoT): The increasingly internet-based networking represents a major driver of change in the economy and society. The Internet of Things refers to a world in which uniquely identifiable objects and devices communicate and interact with each other. Previously non-interacting objects will get interoperable and digitally connected in global neural networks and virtually presented in the *'cloud'*. New possibilities emerge in all SC domains enabled by IoT solutions such as demand-signal-sensing from social networks to enhance planning and marketing capabilities. IoT devices such as for sensors have to connect with other IoT devices and in most cases cloud-based applications using the internet and IoT Platforms that provide the connectivity to manage the data that can come from hundreds of sensors. There are many IoT Platforms available that provide

deployment options with focus on services such as the following:

1. integrated machine learning for automating complex big data analytics;
2. predictive analytics and failure for increases uptime;
3. rules engine for message evaluation and alert monitoring;
4. automated sales orders creation and capturing potential opportunities;
5. marketing-notifies customers through texts directly on their devices.

Big data management refers to the IS trend of processing huge amounts of data to get appropriate data for faster decision making to increase business performance. The major proportion of new data is expected to be produced by machines talking to each other in automated scenarios. Hence, only a fraction amount of this data will be of real value in the marketplace. And even today, only a small proportion of the produced data have been explored for its value by analytics. Scalable data management and analytics systems allow fast and effective processing of *'big data'* to create *'smart data,'* from which new products and services can be created. Big data solutions accelerate decision-making to optimise business processes by generating meaningful information considering non-visible factors. Within the Industry 4.0 and Smart Service environments, big data analysis refers to the following components (adapted from Khan et al., 2017; Lee et al., 2014):

1. connection and sensing (networks, sensors, platform, cloud), Software as a Service (SaaS);
2. cyber-physical systems and self-learning Smart Services for SCM;
3. context and content (pattern, cross-context, correlation and sensemaking);
4. collaboration and sharing in supply chain ecosystems;
5. orchestration and customisation (alignment, personalisation, configuration and rules).

Autonomous systems are intelligent machines or group of machines those execute high-level tasks without being specifically programmed and without human control (Bekey, 2005). In comparison to automated systems that process predefined, engineered sequences of operations, autonomous systems can deal with unforeseen events (Tenorth and Beetz, 2013; Zühlke, 2008). These systems can deal with unforeseen events on an ad-hoc basis by flexible orchestrating their capabilities, which is also known as *sensomotoric skills*. This autonomy enables a system to respond quickly to unexpected events and varying environmental conditions intelligently and effectively without must to be reconfigured. The capability of autonomy enables the system to modify the course of actions and to react fast to variations in a production scenario based on local autonomous decisions without central replanning. Hence, autonomous systems are key enablers of flexibility industrial automation applications, and, are the basis of Cyber-Physical Systems. Moreover, simulations are an essential part of an autonomous system for looking forward to consequences of actions in particular situations enabling decisions between alternatives. CPSs enable intelligent technical objects those interact with each other in networks and via IoT. Embedded systems and online services can work together in the form of cyber-physical systems. Moreover, Smart Services are enabled by CPS and IoT. Hence, CPSs are an important contribution to the paradigm change to digital business models. Value chains of sectors, such as the automotive industry, energy-economy, and health-care, were expected to transform fundamentally based on these digital capabilities (SAP SE).

Basic components of CPS and challenges: Sensors were used to collect data from the physical system and from the environment, which is used for processing due to determine the further course of action in an autonomous process. Actors are receiving the information about the further course of action and are initiating activities required to govern the physical processes in a way to reach the business goals. *Modularity* is a major topic in industry 4.0 scenarios based on the various requirements for sensing and acting in different contexts and physical environments as well as *autonomy* as the key capability to deal with unexpected

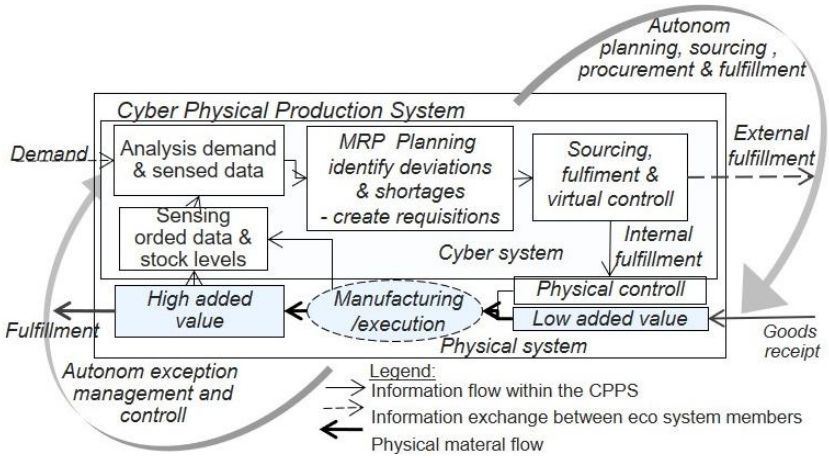

Fig. 11: Basic Cyber-Physical Production System (an author's view, encasing Trinh, 2016, p. 16)

exceptions in a reliable way. Among the present challenges and objectives of the research for CPS are *complexity reduction*, *development of controlling architectures*, *distributed sensor networks* and *compatibility standardisation of components for interaction and integration* among others (Geisberger and Broy, 2012). The concept of the CPS has been pushed forward by Acatec (Kagermann et al., 2013) using it for new digital production concepts such as Industry 4.0 scenarios with high levels of flexibility and autonomy along products and systems life-cycles. These concepts can lead to significantly increased competitiveness by new business models based on it.

A CPS for Production Management: In industry 4.0 scenarios, production systems and production units have to respond autonomously to new orders or unforeseen events by modifying order priorities and order sequence during operation on an ad-hoc basis, to name an example response. For mastering such situations, comprehensive and reliable knowledge about the current state of the production system, the further alternative possibilities and the system's capabilities is required. Moreover, high degrees of interoperability at the business process level and on technical levels are required for acting both partly and fully autonomously. Fig. 11 shows a basic CPS for production management. It demonstrates how the system can identify demand and sensed exceptions in manufacturing in an autonomous way and how it addresses these to planning and subsequently to internal and external fulfilment. A CPS can be a part of a CPS as well. Comprehensive, SC status information about processes and condition data of orders and resources can be gathered in a CPS by sensors. The processed data can be addressed via actors to initiate the physical actions as reasons to the initial status change. Each status change of supply chain data can be updated for members of the ecosystem in a reliable and trusted way using *blockchain* technology. Based on predefined rules, CPSs can interact in an autonomous way to identify unexpected demand and source potential suppliers within the ecosystem on an ad-hoc basis. The 'blockchain' concept, similar to a distributed ledger technology, shows promising for supporting SC processes based on CPSs. Moreover, the concept of Smart Contracts can support the autonomous application of predefined rules within an SC ecosystem.

Trusted SC collaboration through blockchain technology: International SC business partners require both improved document workflow and tracking visibility of goods transported across the globe. The blockchain approach supports a secure and transparent shared network and provides end-to-end visibility of status change to each participant on a real-time basis. A blockchain is a distributed database that maintains a continuously-growing list of records

secured from manipulation and modification. In referring to Morris (2016), Nakamoto (2008) and Popper (2016), Kim and Laskowski (2018) describe a blockchain as a distributed database that maintains a continuously-growing list of records secured from manipulation and modification, which consists of blocks with batches of individual transactions containing timestamps and a link to a previous block. Moreover, the used cryptographic technology *"offers a way for people who do not know or trust each other to create a record of who owns what that will compel the assent of everyone concerned… It is a way of making and preserving truths"* (Kim and Laskowski, 2018, pp. 18–22; The Economist Staff, 2015, p. 1). The approach provides improved business network's efficiency by increased visibility to all members of an ecosystem. Further benefits are significantly reduced settlement time and SC overhead costs and reduced risks of collusion and tampering based on full transparency to all actors and increased trust through shared processes and record keeping. Hence, the system inherent fraud prevention and reduced integration complexity result in reduced intermediation and increasing efficiency. Hence, the Blockchain technologies promise highly secure and immutable access to SC data and support digital SC scenarios in providing capabilities for trusted collaboration.

Value Drivers for the Blockchain technology in SCM are trust between ecosystem participants without central authority. Moreover, the data proceed and exchanged in the network consists of high quality and are up-to-date, consistent, accurate and in compliance with regulations and transparent to all peers with full history. The value created is transferred in real-time by this approach, which is expressed by the term *'exchange of digital assets.' Smart Contracts* assist process autonomy by providing system-enforced inter-company business rules. IoT devices are writing to smart contracts, which can provide real-time visibility of status information at each step of an enterprise entire supply chain. Such enhanced SC visibility provides tracking of goods across plants, distribution centres and retailers and real-time monitoring of stand-up and tear-down processes. These capabilities allow simplifying complex multi-party delivery systems and granular inventory tracking. Moreover, they potentially improve SC financing and insurance through enhanced tracing and verification capabilities. Neutral collaboration platforms for shared business data and business logic enable new consortium business models with trusted-multiple party scenarios with easy extension when new stakeholders will participate. The following characteristics having been identified in the SAP case study as indicators for potentials by a blockchain approach:

1. a multi-party scenario with three or more participants, preferably across companies and industries, e.g. consortia, and missing trust between members;
2. participants should be on eye level and multiple writers in the scenario;
3. a shared repository with a joint data model, semantics and standardisation;
4. need for transparency to reduce risks, avoid fraud, and to be compliant with regulations;
5. transfer of digital assets, which can be anything that comes in a binary format with the right to use such as digital documents, data, metadata, services, permissions and more.

Characteristics of Smart Services: Smart services are the core components of digital business models for generating value to businesses and customers and further ecosystem members. They are managed via platforms and are provided by internal and external service providers for orchestrating and operating the modular processes of ecosystems. They are interacting between sensors, systems and actors and are based on algorithms, and can adapt to changing contexts over time to sustain autonomous value creation in ecosystems by manufacturing systems and logistics. Cost of Smart Services is very limited as the marginal costs of digital value creation are nearly zero and can be distributed across the ecosystem that uses the service (Rifkin, 2015). The paradigm change from physical assets to digital assets reduces marginal costs significantly. Finally, Smart Services shift the focus from product ownership to their value-oriented usage.

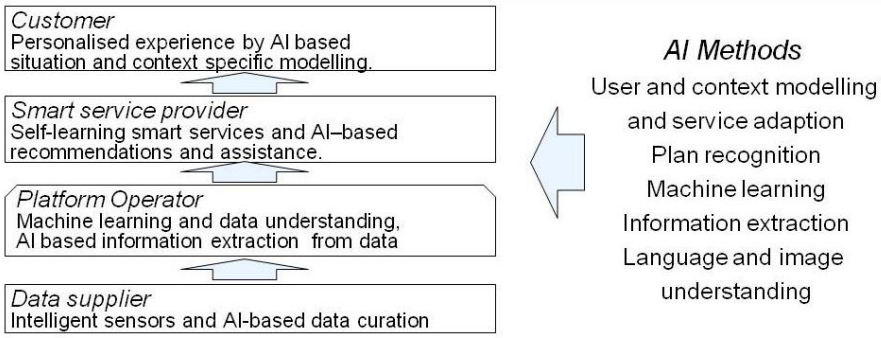

Fig. 12: Self-learning Smart Service architecture (Kagermann et al., 2013)

Potentials of Smart Services are such as the detection of deviations in processes and deriving measures as responses and autonomous processes by orchestrating predefined rules and flexibly combining with other services to adapt to environmental needs. Hence, they can increase process effectiveness and help avoiding waste and optimise resource usage, and solve unforeseen problems at an early stage. Their potential for external processes covers the digital interaction with customers, and to gather and analyse customer data on a large scale and individual perceptions to adapt the Smart Services to users needs. Such Artificial Intelligence (AI)-based approaches lead to self-learning services for selecting and meaningful interpreting collected data, which enable the extraction of context information that can be used for situational service adaption. Moreover, the reflection of acquired knowledge to different situations and contexts can lead to meta-knowledge meaningful for the business and customers. In sum, the potentials can lead to increasing innovative strength, turnover and profitability as well as increase customer loyalty and can provide a significant competitive differentiator. Fig. 19 (in Annex) highlights the building blocks for Smart Services modelling.

Digital-transformation of SC business models and opportunities: The following major areas were seen by SAP SE with significant value potentials from innovations and increased business process autonomy: (1) *Connected products* – with innovations in field service management and data-driven services based on real-time information from products. Moreover, sharing live insights on product usage, improving design and quality; (2) *Connected fleet* – tracking and managing fleets of cars, vans, buses, trucks, cranes, containers, land machines (with the integration of precision farming capabilities); (3) *Connected assets* – usage of statistical and machine learning capabilities, and physics-based models for operations and predictive maintenance and services. Moreover, leverage digital twins for simulating and analysing asset-performance and reducing risks; collaborating with ecosystem partners to share assets high efficiently; (4) *Digital Manufacturing* aims to increase the Overall Equipment Effectiveness (OEE) by vertical and horizontal integration of connected machines, robots and plant logistics, and, to reduce energy consumption and manage and predict quality.

Platform driven steel business – sensing and condition monitoring: More than 50,000 sensors can be implemented for monitoring SC end-to-end processes at a steel plant (Sagermann, 2019). They collect data such as quality characteristics and machine and environmental conditions of the factory. These data are continuously communicated to the SCM live system and can be communicated to a Digital Twin as well for doing trend analysis, simulations and predictions of an unacceptable trend by extrapolating deviations. Such insight can trigger an investigation and changes in the physical manufacturing process. Steel plants such as the sample companies produce 1.5 million tonnes of steel to fulfil 10,000 customer orders per year, delivering 70,000 coils. Considering the figures of downtime based on a hot strip spindle

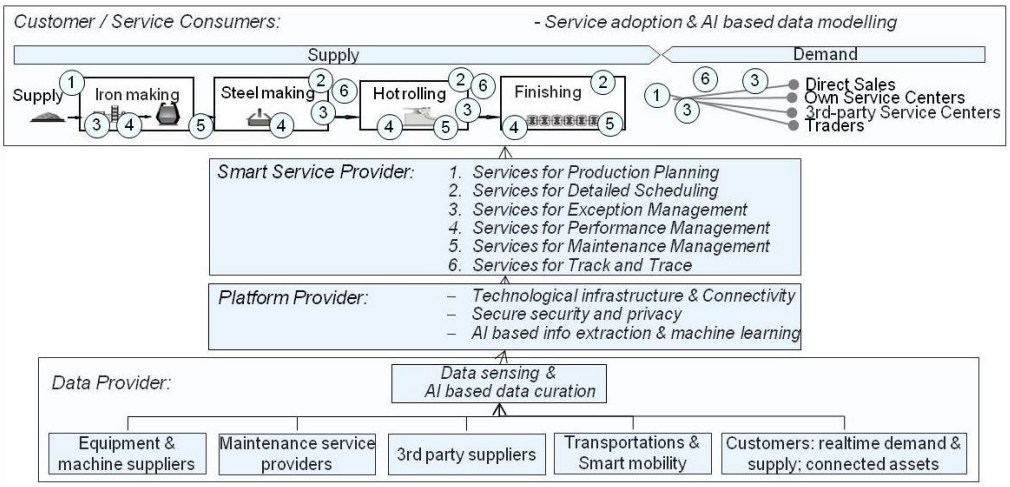

Fig. 13: Layers of a Smart SC business model (an author's view, adapted from Kagermann et al., 2013)

failure will result in EUR 3.7 Million for three days of repair work. This example demonstrates the high value that condition monitoring can provide to steel companies for preventing from such cases.

4.3 The Impact of Relationship Management IS Capabilities onto Fit

Objectives and capabilities of relationship management: Steel companies have a few large customers, such as automotive suppliers and construction companies, and few vendors for raw material such as mining companies. Therefore, the maintenance and care of these relationships have been identified by the case studies as essential for steel companies' survival and for securing sustainable long-term success. Hence, a much tighter relationship with strategic customers is required for firms in the steel industry in comparison with other sectors, such as the consumer industry. There are two categories of strategically relevant suppliers identified for steel companies: (1) suppliers of direct materials such as scrap and ore for iron production; and (2) suppliers of indirect material, such as technical equipment. Moreover, customers sometimes sell back scrap as input for further steel production.

Collaboration is embedded in SC processes: As seen in the assessment result of all SC domains, collaboration presents an integrated part of these SC processes. Moreover, SC integration antecedent such as *coordination* and *information exchange* plays a significant role in relationship management and SC processes of all domains. On the one hand, SCM IS independent qualities such as *partnership*, *trust* and *commitment* play a significant role in relationship management and in balance score cart system to control relationships. On the other hand, there is a common view by the participants that customer satisfaction and trust as a basis for good partnership relates to a high extent to qualities resulting from good SCM practices such as reliable order delivery to promised dates, which has finally, a significant impact on the market share from the long-term perspective. Collaboration is seen a company's ultimate core capability, providing benefits such as revenue enhancement, flexibility and cost reduction, but, levels of collaboration have not reached as aimed so far (Fawcett and Magnan, 2001; Wognum and Faber, 2002). Based on the impact from qualities of good SCM practice, the experts identified the S&OP domain with the highest impact on relationship management. Long-term plans, as the basis of relationship management, are determined using S&OP processes. Hence, customer and supplier

relationships need to be stabilised for securing sales volume and raw material supply.

SC performance effects of relationship management: The case study participants were of the view that there is no dedicated customer service process, but rather a focus on (1) delivery-quality, (2) support and provisioning of equipment, spare parts and services, and (3) finally, in product support. The assessment at company B shows that relationship capital with customers can be released in exceptional situations to safeguard the short-term performance by enabling agile collaboration with customers and supplier, and long-term performance through customer retention. As identified at company 'A,' steel producers of high-end products often were involved in the NPD process of their customers. Through such pre-investments in collaborative R&D processes, customer satisfaction and retention could be significantly increased by fast delivery of high quality as technical constraints were aligned before the order. Finally, nearly all efforts in relationships are seen by the experts as having an impact on business performance at other places in the supply chain. For example, capabilities placed in supply relationship growth will help positive effecting downstream and upstream by increasing availability of raw material for production, which will result in better delivery adherence. Supplier relationship management will result in improved inventory levels. These improved inventory levels will have a positive effect for just-in-time (JIT) production and adherence to delivery dates and will finally result, finally, in better customer relationships.

4.4 The Impact of IS Capabilities for NPD to Strategic Fit

Ambidexterity – balancing exploration and exploitation for NPD: In NPD, exploration refers to the new knowledge acquisition useful for developing breakthrough technologies and for innovative diversification. Moreover, it covers all skills, methods and tools used to organise and support this learning process. This learning process follows the organisational assimilation of the acquired knowledge and the merge with the exploitation process (Ahuja and Katija, 2001) where the deposited knowledge will be exhausted to provide the company value from new products and services. Ambidexterity refers to a company's ability to balance exploration and exploitation in this process considering a company's structure, context, domains and organisational dimensions in a congruent way. Bernal et al. (2016, p. 9) cite Lewin et al. (1999, pp. 536–539) in stating that exploration and exploitation are moderated by environmental dynamism and competitiveness. Jansen et al. (2006) reported that exploration activities show more effective in dynamic environments, and exploitative innovations are more beneficial in competitive environments.

Simultaneous exploration and exploitation for constraint NPD: As innovation drivers of NPD processes have been identified the provision of pioneering products to the steel companies themselves – upstream innovation – and to their customers, such as automotive suppliers-downstream innovation. Moreover, NPD in the steel industry emphasises two main processes: (1) the development of new steel products, which focuses on the development of new steel grades with improved characteristics and qualities; and (2) subsequently in the development of new production technologies to create these new steel grades in an effective and efficient way. Finally, the production of the newly developed products will be established by implementing the equipment needed and aligning the processes. Steel companies need to balance knowledge exploration for new products and the exploitation by producing these appropriate with existing process technology in a closed and simultaneous way because the constraining factors for new products are implemented in the organisation and their asses. Hence, they need to consider in NPD a company's structure and resource capabilities, the domain capacities and contextual constraints in a congruent way of developing new products.

Innovation focus of steel companies: Although steel business is a mature one, it needs to be continuously innovative to survive by designing new products but also by driving innovations for production processes.

Moreover, steel companies are also impacted by governmental considerations such as requirements regarding CO_2 certificates and for reducing energy consumption, which leads to enhanced efforts in NPD. Because of their positioning in the high-end product segment, sample organisation A's NPD strengths have an important impact on their business success. R&D objectives, such as weight reduction of products by innovative design, represent a very high value for automotive producers. Weight reduction goes hand in hand with reduced security, which needs to be compensated by the increased quality of the steel used, through improving its grades and characteristics. As a result, high-grade steel is needed, which leads to more complex production processes.

Business potentials enabled by collaborative product development: For obtaining first-hand information about their customer's needs, sample company A has placed engineers in their customers' organisations. Collaborative product development with customers, vendors and external laboratories enables first-hand information to increase responsiveness to new requirements from the market and can help in proactive resource alignment and external activity integration. By this approach, the exploration process, including information collection and assimilation has been moved as close as possible to the customer where the demand and technical requirements were created. Besides, many cases where an innovative recommendation has been provided to the customer in the design phase that result in winning activities of the overall supply chain stages. As an example, was reported to provide the customer surfaced finished sheet that must not sub-contracted after mechanical transformation for this reason. Moreover, information exchange with Government agencies regarding compliance criteria has become a hot topic for steel companies. Collaborative management of new development projects, technical document management and phase-in and phase-out management are the focus of the discrete manufacturing industry. Collaborative development of new substances using a common *'specification database'* in compliance with regulations of customers' countries Governances plays a major role in the process industry.

IS capabilities for collaborative Product Development have to cover requirements for integrated governance of the development project of different business domains such as mechanical engineering, electronic engineering and more and more software engineering. According to SAP SCM Product Management, in developing Smart Business models, companies' focus in R&D moves from products to services. NPD IS capabilities have to manage their overall life-cycle collaboratively, from idea development, design, production, service and maintenance until the rejection and replacement. Hence, capabilities for workflow management for status and document management for developers, partners and stakeholders as well as buy-off and release management, and finally, life-cycle management covering phase-in and phase-out activities become more important for innovative NPD. Case study findings show that first-order effects of IS capabilities for NPD occurring faster in developing new products and speed up innovation as a result. A key implication is improving speed to market by supporting the development and faster testing of new products and new types of steel. Moreover, NPD capabilities enable steel companies to react adequately to the innovation requirements from the market. For this reason, collaboration and information exchange by a common database to all related parties in the NPD process can result in speed up innovations, improved quality of the developments and reduced sources of errors and misconceptions as important spill-over effects of R&D and NPD processes.

4.5 The Impact of IS Capabilities for SCPM & Analytics to Strategic Fit

IS capabilities for Supply Chain Performance Measurement: According to the SCM experts from SAP, the most common SCPM-objectives are the definition, modelling, and application of KPIs for real-time monitoring of SC processes to increase plan-efficiency and accuracy, and, finally, to increase the visibility of the actual

value flow. Also, Supply Chain Analytics is observed as a hot topic to understand SC key drivers and KPIs more clearly about the companies' overall objectives. SCPM helps companies to reach transparency on the supply chain situation and helps to sharpen the focus on critical SC processes to be responsive to unforeseen situations coming from the market. Moreover, SCPM helps companies in mastering their SC processes by identifying weaknesses within and initiating appropriate measurements as a response to these. SCPM IS solutions provide capabilities to align SC planning and SC operational processes with financial objectives. Moreover, exceptions in the supply chain can be identified in time, followed up with root cause analysis and linked to SC risk management activities. KPI management for SC performance and SC risk prediction have been identified as highly important for steel companies as well as the definition of KPIs for SC objects on a generic basis.

Business value by improving the business predictability: Based on their support of the prediction of new business more quickly and more accurately, the interviewed business transformation principals observed a significant impact of Analytics and SCPM on the business value regarding shareholder value and market capitalisation. They see accuracy in prediction of business performance by determining the future quantity and value flow on business forecasting as an important driver of trust from company's shareholders and therefore can impact the overall market capitalisation by positively. Such predictions require the ability to consider internal and external aspects in planning and budgeting and to link to reporting capabilities for material and value flow. As a result, such capabilities can increase a company's value significantly.

SCPM at different levels: Business-wide unified SCPM engagements have been identified as core activities of leading international steel companies such as ArcelorMittal and Gerdau. The following activities were identified with high priority for SC performance optimisation:

1. provide business-wide harmonised reporting structures;
2. monitor SC performance and SC risk regularly;
3. manage exceptions to respond in real-time to critical SC events.

Critical SC KPIs and real-time exception management: The following KPIs have been identified as a core for safeguarding steel companies' SC performance: (1) cost and profitability on certain levels, such as plant, product, and planner; (2) on-time delivery performance; (3) asset utilisation and *'overall equipment effectiveness'* (OEE); (4) inventory turnover and days in inventory; (5) reduction of revenue loss due to stock-outs. Exception management capabilities for identifying deviations of these KPIs and causes and roots of critical SC events in real-time have been identified as particularly important. The practice of SCPM on different levels and the global harmonisation of the related reporting structures and processes have been identified as key activities of strategic alignment at global steel companies such as ArcelorMittal and Gerdau for supporting overall business performance (Beeby, 2014; Legrand, 2014).

Adoptions and global harmonisation of Performance Management: Performance improvements through aligning SC processes with strategy goes hand in hand at global steel companies with the alignment of business structures and reporting structures. Optimisation of global SC performance rather than the local SC performance needs to be addressed using common KPIs and aligned shared incentives for the parties involved in a global supply network. According to ArcelorMittal's CIO Legrand (2014), the following activities are used for harmonising business and reporting structures: (1) develop *'components for reuse'* for all SC processes to increase speed in scaling up SC models and in alignment activities; (2) *'integrate'* SC processes with resource maintenance (RM) and human resource management (HRM) when setting up new global plants; and finally (3) *'standardise'* and *'automate'* SC processes (Legrand, 2014, pp. 8–19). The following key points have been identified as significant for SCPM effectiveness: (1) align SC objectives, KPIs, and incentives of involved parties on

a global scale; (2) align reporting structures across subsidiaries (vertical and horizontal); (3) establish a central, single source of truth of data for the global enterprise; (4) provide global access to that data by technologies such as CLOUD computing (Legrand, 2014, pp. 8–19).

Identified performance potentials from SCPM harmonisation: Harmonised reporting structures contribute to increasing end-to-end visibility and are supporting global business process alignment. Hence, it supports adoption and scaling out of technical and organisational developed capabilities that improve effectiveness and efficiency. Finally, harmonisation of reporting structures provides enhanced benchmarking capabilities and accuracy and can result in better alignment of local and global SC strategy and their improvement by sensemaking effects.

Embedded Analytics for real-time operations insight: Embedded analytics provides capabilities for modelling and performing analysis based on the real-time operational data of business applications databases. By this approach, analytical views, and reports can be modelled as needed by business users' roles. Moreover, analytical Queries and KPIs can be performed with high precision and speed based on operational data not limited on predefined aggregates, which were replicated (pulled) from business application databases to a Business Intelligence (BI) or Business Warehouse (BW) system. Enhanced reporting capabilities and machine learning capabilities can be realised based on the embedded analytics solutions. Cloud applications allow access global of real-time data for analysing and benchmarking different plants and work centres performance and provide global monitoring by digital boardrooms for the following reasons: (1) *SCPM* using analysis of manufacturing KPIs, comparing with target figures and alerting in case of exceptions; (2) *Benchmarking* and comparison of plants and nodes using OEE key figures; (3) *Order status information* such as actual cycle time, start on time; (4) *Conformance and non-conformance information monitoring* for identifying scrap and yield and related Root Cause Analysis; (5) *Condition monitoring:* defining machine models with sensor sub-subscriptions for monitoring e.g. Indicating resource down situations, and (6) *Predictive Quality from manufacturing insights:* selective investigation of machine data to build and operate predictive quality models, e.g. data stratification analysing contribution such as of machine and process parameters and material characteristics based on segmentation.

4.6 Interoperability and EAM Principles as Catalysts of SC Dynamics

SC interoperability has been identified with significant impact on SC integration and SC dynamics. There are various definitions of SC interoperability in the literature such as the *"ability of interaction between enterprises"* (IDEAS, 2003) and the *"ability of a system or a product to work with other systems or products without special effort on the part of the customer"* (IEEE, 2016). Technical, organisational and operations has been identified as the most common types of interoperability by Ford et al. (2009), but, the meanings of SC interoperability need to be defined according to the context (Palfrey and Gasser, 2012), and its multidimensional nature in regard of used technology for communications and the involved organisations and individuals should be considered (Chalyvidis et al., 2013). The 2007 ATHENA Interoperability Framework defines the following useful categories (Berre et al., 2007, pp. 14–15):

1. *data interoperability* – for information sharing by business applications in heterogeneous IS landscapes, considering different data models, conceptual schemas and data structures;
2. *services interoperability* – concerns about identifying and composing functions of various applications by solving syntactic and semantic differences;
3. *processes interoperability* – aims to link various processes for smooth work;
4. *business interoperability* – refers to harmonised work within and between companies, despite different modes of decision-making, culture, commercial methods and legislation.

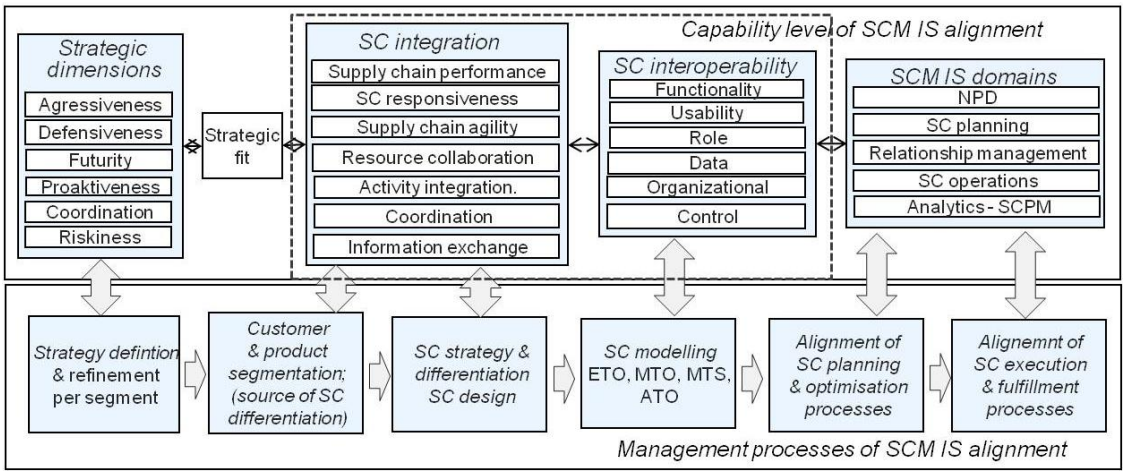

Fig. 14: SC integration levels needed to fit enabled by apposite SC interoperability (an author's view)

5. *conceptual compatibility* of methods, rules, syntactic and semantic;
6. *organisational compatibility* of companies and their structures, persons and authorities;
7. *technological compatibility* of communication between business partners.

SC interoperability as an enabler of SC integration: There are different interpretations of the concepts of SC integration and SC interoperability in the literature. The present research draws on the view that *interoperability* at various levels between involved systems provides the prerequisite of good SC integration. Integration is broadly used recognised in SCM (e.g. Bagchi et al., 2005; Childerhouse and Towill, 2011, pp. 7458–7460; van de Ven and Drazin, 1985; Rai et al., 2006, p. 237) and in strategic alignment and business-IT alignment (e.g. Avison et al., 2004, pp. 224–225; Henderson and Venkatraman, 1990, p. 11; Ward, 2011, pp. 30–31; Broadbent and Weill, 1997, pp. 79–81, 89). Both integration and interoperability are seen as systemic concepts, while interoperability has been recognised as autonomous, and, a provider of compatibility between systems and therefore integration capabilities such as coordination and collaboration (Chen et al., 2009). Chalyvidis et al. (2013) provide a useful view for designing supply chains with architecting a *'System to System'* (StS), with a focus on orchestrating and subsequently managing the identified interfaces between the business partners. Encasing this view and enhancing it with the identified interoperability categories, Fig. 14 highlights the present study's concept of *systems-to-systems* interoperability as an enabler of SC integration.

The following EAM Principles have a positive impact in interoperability on several levels when adopted by IS Governance to an organisations specific needs and priorities (Source: SAP):

1. *Enterprise Commonality* and controlled technological diversity to minimise the cost of maintenance and connectivity and promotes reuse of existing investments.
2. *Enterprise Alignment* by prioritised investments as opposed to the business view. Keep visibility of initiatives and change activities to balance conflicting strategic priorities.
3. *Manage data across organisation* accurately and timely based on a single source of data shared across the enterprise for effective and consistent decision making.
4. *Solutions should be scalable* for dealing with volatility in business volumetric.
5. *The flexibility of business processes, applications and technology* should be aligned with the organisation's requirement. However, it comes at a price and should be focus on processes that differentiate an organisation from its competition.

6. *Buy solutions in preference to build them* benefits companies by reducing the time-to-implementation of new assets and technical risk and increase system stability.

7. *Manage and control the implementation of new IS solutions* using a defined life-cycle for careful system selection, proof-of-concept and pilot stages to reduce implementation risks and do not randomly increase complexity or inconsistency of the technology footprints.

8. *Outsource stable and non-differentiating services* with an agreed set of SLAs to third-party vendors that may handle the operation more efficiently. Enterprises may then focus resources on extending differentiating architectures providing added value to strategy.

5 CONCLUSION

For maximize companies' performance, it is not enough simply to coordinate the activities of different functional areas across a supply chain (Danese et al., 2013), but, rather the intra- and inter-organisational activities need to be integrated (Fazli and Amin Afshar, 2014, p. 349), which is also underpinned by a study of Sukati et al. (2012) about the positive impact of SC integration on competitive advantage. The present study explores SCM IS capabilities as key performance enablers and how they need to be integrated ideally between technological and organisational domains and between external and internal parties. While the author's 2019 study provides a comprehensive framework for dynamic SCM IS alignment using high-order SC capabilities for mediating integration of antecedent capabilities (as shown by Fig. 3), the present study contributes a coherent methodology for managing key SC objectives and SCM IS capabilities with a focus on integration between SC domains and between technological and organisations' management. In referring to Battisti et al. (2014) and Monczka et al. (2015), the study's concept contributes to complementary management of technological and organisational innovations and simultaneous adoption. Besides, the present study contributes to detailed methods for designing, modelling, planning and synchronising SCM IS in the most simplified and profitable way. Moreover, the study provides organisations with a guide for utilising SCM IS capabilities following businesses strategy and organisational needs in a prioritised way. Finally, the study shows how Industry 4.0 innovations such as Smart Services (Kagermann et al., 2013) and blockchain technology (Kim and Laskowski, 2018) can provide new value potentials such as cross-organisational network effects (Rifkin, 2015) and increased autonomy.

The study demonstrates a holistic approach for SC integration and profit optimisation considering spillover effects and antecedent capabilities across all SC domains. It focuses on integration and not on functional features in detail, such as the various forecast-based planning methods and consumption-based planning procedures as they are well known. However, innovative approaches such as dynamic replenishment methods have considered by the study. In practice, many companies expect stock reduction and availability from highly sophisticated planning methods and syncronised orders from complex algorithms of scheduling heuristics. But, many SCM projects fail as the needed integration levels between the domains are not given, and the right priorities are not reflected by the processes and capabilities. In referring to the theory of constraints (TOC), the present study focus on integration for balancing levels of fit and capabilities across domains.

The impact of SC dynamics on the complexity on steel companies' SCM: Complexity implied in SCM IS has been identified as the major concern of steel companies against the implementation of these solutions. Hidden interdependencies and functional changes can lead to unpredictable side-effects within the

supply network. Moreover, SCM processes are often automated and balanced against the known business situation but failed in cases of changes. Therefore, configurations of SCM IS are often not robust against a massive change in business conditions and process targets are partly conflicting, but highly related to each other. For that reason, the SC design and SC modelling have been identified as the most significant practices for managing SC dynamic and SC complexity that steel companies are facing, and for dealing with contradicting objectives and balance long-term business objectives against short-term targets.

Key capabilities for managing SC dynamics and SC complexity: The overall SC profitability and the transparency to identify the impact of environmental changes have been identified as key business objectives. Hence, key capabilities for managing SC performance in dynamic business environments and concepts to respond fast and agile have been identified as the following:

1. *SC design and SC modelling:* manage ambidexterity between innovation innovations and segmentation with SC differentiation and SC strategy using capability patterns as artefacts;
2. *SC planning and profit optimised Master plans* for the supply network;
3. *SC simulation* and *visualisation* for predicting bottlenecks and priority management;
4. *DC from IS Governance by EAM:* preconfigure architectural artefacts for projected business situations to increase SC agility;
5. *DC accelerators:* promote (1) a collective view on objectives and a common direction of actions by organisational learning; and (2) principles of EAM and interoperability.

Trends that lead to increasing complexity in SCM and IS capabilities for dealing with these: The individual characteristics customers want from steel companies' products have a direct impact into the complexity of the SC planning processes by characteristic dependent demand differentiation, while the quality from the upstream process flow is difficult to predict precisely. As a result, there is a high interdependency between characteristics-driven profit-based planning processes and the characteristic-based matching sales orders, manufactured orders and forecast consumption. Moreover, as steel companies are facing restrictions of their production resources' overall capacity and capacity shortages caused by periodic maintenance activities, fast capacity increase often cannot be provided. With infinite capacity, demand could be fulfilled by never exceeding capacity, and order acceptance can be based on comparing marginal profit with marginal costs (Hintsches et al., 2010, p. 177). But, based on described implications, steel companies were confronted with the challenge of optimising their sales order acceptance when demand exceeds the production capacities and need to select orders that contribute the most profit. For supporting these sales order acceptance processes, sophisticated S&OP solutions are necessary, which provide managers with *Master plans* that prioritise the most profitable products and customers in case of finite resource capacity. *Master plans* represent ideal states regarding profit contribution, resource utilisation and customer service level fulfilment. SC planning solutions such as S&OP and IBP can consider profit contributions in plan creation and provide collaboration capabilities for reaching plan consensus between stakeholders. For dealing with the high variety of SC objectives, planning on different levels of aggregation and granularity is often managed by different IS applications as grown in the past that are connected by interfaces. As a consequence, the IS applications does cover the company's business limited from a local point of view and information originated in different areas cannot be leveraged throughout because of missing transparency. Hence, *end-to-end visibility* and the clear definition and harmonisation of *SC overall objectives* and alignment of the local objectives to the overall ones have been identified with high priority as prerequisites for managing supply chains performance-oriented. Optimisation and scheduling methods can synchronise companies' extended supply network in considering process technological sequencing

characteristics and availability of raw material flow and transportations. *SC design complexity* can be reduced by combining lean supply chain with agile supply chains that can be flexible and priority-based management. Besides, innovative, dynamic replenishment methods such as DDMRP can be used in assembly and distribution systems for adapting to volatility from raw material supply, service levels and lead time. Key concepts for SCPM and Analytics has been identified for monitoring the overall SC objectives on the corporate level and aligning local SC objectives; local managers can be highly effective supported by *Embedded Analytics capabilities* focusing on business role-specific data insight. Finally, capabilities and methods for collaborative NPD and relationship management processes have been identified for supporting cross-organisational ambidexterity. Fig. 20 (in Annex) provides an overview of the key capabilities for mastering SC dynamics.

Profits increase by improved transparency and methods for dealing with volatility: A 2013 review on SC complexity drivers by Serdarasan underpins the positive impact of improved SC integration, SC visibility and data synchronisation onto reduction of complexity from dynamics (Serdarasan, 2013, pp. 533–540). According to the present study's findings, unnecessary complexity implied by missing transparency and contradicting SC objectives can be reduced by harmonised SC objectives and SC business applications that focus on priority and exception management. Moreover, end-to-end visibility and appropriate levels of differentiation and the right levels of aggregation for the SC processes have a significant impact on SC integration. On the one hand, too less visibility in SC processes can lead to un-appropriate fulfilment result from missing details in planning and in missing SC agility in SC operations. On the other hand, too much detail in SC modelling can lead to unnecessary SC complexity with bad business process performance as a result of a difficult appliance and suffering IT performance. SCM concepts for dealing with volatility are summarised in Tab. 2 (in Annex).

SC interoperability as an enabler of SC integration and SC dynamics: The right level of SC integration for providing appropriate SC dynamics, as a response to environmental changes, can be managed continuously by EAM. Fig. 18 (in Annex) provides a best practice for dynamic SCM IS alignment, and Fig. 17 (in Annex) shows examples of interoperability of SCM IS on different layers. Types of IS misfit according to Strong and Volkoff (2010, pp. 732–751) – (1) *functionality*, (2) *data*, (3) *usability*, (4) *role*, (5) *control* and (6) *organizational culture with the dimensions coverage and enablement* – have been identified as very useful for defining SCM IS artefacts by expressing SC interoperability to reach the right context-specific SC integration.

Key performance drivers of SC operations: Profitability can be predicted by SC planning, but, operations have to transform the plan to yield the profits. Therefore, supply chain end-to-end visibility needs to be provided to the extent needed for tracking and tracing priority and exception-based SCM. The following methods have been identified as performance drivers of upstream and downstream processes: Business-role-centred MRP analysis based on real-time data, exceptions and priorities and decision support by simulation capabilities help to arrive on well-founded planning solutions by estimating the impact of alternative decisions more reliable. Combining lean and agile supply chains using customer order decoupling points (CODP) separates supply chains in highly efficient parts that can provide operational excellence and parts that focus on flexibility, differentiation and responsiveness to customers' needs. SCPM solutions provide managers with analysis for monitoring operational excellence by KPIs such as the OEE. Business-application specific Embedded Analytics capabilities offer in-depth investigation on process efficiency and output quality and reliable prediction of resource maintenance for safeguarding the OEE.

New value from smart technology for SC ecosystems such as platform capabilities and self-learning Smart Services are increasing the autonomy of SCM and improve synchronisation of supply chains and can deal ad-hoc with unforeseen events and exceptions. Data

replication technologies such as the blockchain approach foster trust in autonomous collaboration between SC ecosystems members through increasing transparency and reliability of SC statuses by nearly real-time SC synchronisation. Transforming principles of interoperability and EAM serve compatibility, scalability, and reusability and are core drivers of demand-side network effects to provide increased business value at declining marginal costs at the same time. The artificial intelligence (AI) methods and use cases introduced by the study are providing key components for designing collaborative, digital SC business models. New value potentials arise from a cross-context 'big view' in business modelling as values potentials are expected to come from scaling effects and spill-over effects and network effects across SC ecosystems. Following the *'zero marginal cost'* paradigm uncovered by Rifkin (2015), development efforts for such IoT connected Smart Services, and digital products will converge nearly zero at significantly increasing opportunities for creating business value at the same time.

Recommendation for a further research avenue: Recommendation for a further research avenue: Aligning business rules and configuration schemas for collaboration with partners have been identified as a present gap in steel companies' extended supply network. Norms such as ICLASS exist, but, need to be developed and aligned further to industry-specific taxonomies and semantics. Such developments can enhance standardised EDI processes for multiple-tier supply chain synchronisation by customer-specific configurations. Moreover, these can lead to enhanced autonomy and increase trust in collaborative SC processes such as demand identification, supply sourcing and order fulfilment. Finally, these developments will provide companies with further opportunities for machine learning use cases across different contexts.

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7 ANNEX

Concepts in SCM for dealing with dynamics and volatility: Tab. 2 summarises the SC concepts for dealing with business dynamics and volatility on different levels of aggregation.

Tab. 2: Concepts in SCM for dealing with volatility in demand and supply (an author's view)

Level & horizon	**SCM Processes**	**Business objectives**	**Sources of volatility**	**Concepts for dealing with volatility**
Sales & Operation Planning Long-term ~ 12–24 month	Predict the optimal plan for demand and supply at known sources of change and volatility	Prediction of business, supply, margin and profit; Longterm alignment of resource base and supply; financial planning	Market demand; customer behaviour and perceptions; supply availability, macro-economic impact.	Optimisation methods such as the Genetic Algorithm for optimal matching demand & supply; recognition of predefined master plans
Production Planning mid-term days to months	MRP planning & analysis; Finite capacity planning; Optimisation & synchronisation	Provide a plan for optimal fulfilment of customer orders, stock reduction; order lead time minimisation and resource utilisation.	Unsteady Sales order demand; Volatility of supply, transportation and resource capacity	MRP planning concept, heuristics and optimisation (e.g. Simplex and Line Programming) concepts for optimal, iterative order synchronisation
Production Execution actual & near-term	Manufacturing and Continuous Processes: MTE, MTO and MTS	Continuous flow order sequence and optimal supply and fulfilment, OEE optimisation	Unsteady supply of components (delivery time and delivery quantity)	Dynamic Replenishment: DDMRP (assembly); Multi-echelon (distribution) Balancing service levels against stock levels
Shop-floor management near-time and ad-hoc	Order management on production resource on time and in sequence.	Continuous production flow; just-in-time supply and delivery; OEE optimisation	Unforeseen tool breakdown and other exceptions; unforeseen demand and supply situation.	Autonomous systems for dealing with unforeseen exceptions and addressing these to useful actions (e.g. CPS, I.4.0, blockchain)

Methods and examples of SC optimisation

Processes	Examlpes of SC optimisation methods	Coverage / enablement
Integrated Business Planning	1. Shape a common demand signal from different internal & external sources using Big Data methods 2. Create a Master plan for the extended supply chain based on consensus demand, supply restrictions and optimized profit contribution by technology such as Line Programming (LP) and Genetic algorithm	1. High levels of coverage by available optimiser technology 2. Very high levels of enablement requird for SC modeling of planning data structures and process configuration
MRP	Create a detailed production & supply plan for given demand and mostly at finat capacity (to-be plan)	High levels of coverage through provide functional IT capabilities
Detailed Scheduling & optimisation	1. Create a holistic plan using *optimiser (LP) technology* and synchronise the most effective order sequence for fulfillment, considering finite capacity and weighted constraints such as setup optimisation and due date adherence and more. 2. Optimal order sequencing using *heuristics for* single order contexts, considering different algorythm for different synchronisation goals such as priorities for backorder processing.	Very high levels of enablement. required from SC modeling for: 1. high acuracy needed for order data and resource data; 2. (2) clear knowledge about plan objectives and their reflection in weighting data like in setup matrix 3. Clear consensus between stakeholders about plan objectives
Shop floor optimisation ME systems	1. Create detail order sequence for each resource using heuristics technology 2. Block-planning methodology in the steel industry: create order sequence by a predefined sequence pattern that fits the process technology.	1. Very high levels of enablement needed for concise plan integration between ME system and core Enterprise Systems.

Fig. 15: Methods of SC optimisation and examples per layer (an author's view)

Examples for SC visibility and dimensions on different levels

Processes	Examlpes of significant visbility requirements	Data, characterisrics
Demand Signal Management	1. Understand the market using Big Data and IoT technology for analysing consumer data and social data 2. transforming unstructurd data into structured information using qualitative content analysis (e.g. summative coading)	Unstructured data to Meaningful inform. • Brand / Product • Location/Region • Time…
Integrated Business Planning	1. Create a consensus forecast and a common view for alignment with stakeholders 2. Understand demand impact onto the extended supply chain 3. Create and understand the most profitable Master plan from it	Aggregated time series 1. Customer/region 2. Location, resources 3. Profit contribution …
MRP	• Create and understand the optimal order plan for fullfilment	Detailed order data
Detailed Scheduling & optimisation	1. Optimise and synchronise the most effective order sequence for fulfillment by finite and constrained based scheduling 2. Understand the impact of demand and supply changes and define actions based on priorities and exceptions	1. Detailed order sequence 2. Resource based data 3. Priority based data
NPD & Project Management	1. Understand the needs for innovation from the market 2. Provide a common database with customer and suppliers for collaborative development 3. Understand the impact of innovations into planning, execution 4. In Engineering-to-Order: Understand the impact of changes from customer in into project management and SC execution	1. Master data management 2. Engineering change Management 3. Engineering data base
Production execution	1. Role based order execution and monitoring of order backlog 2. Understand priority and changes and decide for actions.	1. Order backlog 2. Resources mgmt.
SRM, sourcing & procurement	1. Understand long-term and short –term requirements for procurement in balancing promised customer service levels against effective stock levels	1. Stock data 2. History data 3. Demand insight
CRM, sales & distribution	1. Understand the order backlog and have knowledge about opportunities in the market 2. Understand customers' value propositions from the own offer	1. Opportunity data 2. Demand & history 3. sales & supply data
Shop floor control	1. Operations transaction control, and operations analytics 2. Insights in distributed manufacturing ; predicted quality 3. Predictive maintenance; IoT technology for asset inside	1. Operational Analytics based on transactional data

Fig. 16: SC visibility at different levels of SCM and examples (an author's view)

Layers and examples of SC interoperability

Layer	Examlpes of interoperability requirements and methods	Concepts / standards
Strategic	1. Align business strategy and corporate strategy with vision 2. Harmonise strategy by adoption and scaling out 3. Align business model and capabilities to strategy	1. Business model canvas 2. Strategic alignment

Operational	1. Business application and process interoperability:
	  1. OData for application integration on UI level
	  2. API standard for application integration on programme level
	2. Business data interoperability for collaborative SC processes:
	  1. Interoperability of product structures and configurations
	  2. Electronically data sharing for forecasts, scheduling agreements, supply and delivery notifications (ASN) , JIT, JIS
	  3. Tracking and tracing using (1) RFID technology and sensors data on the status of the material and (2) batch configuration
	  4. Data interoperability for collaborative NPD processes
	3. Methods and data interoperability for SCPM:
	  1. SCOR model for SCPM and benchmarkling
	4. Blockchain & distributed ledgers or cyber planning cycles
		1. OData as layer for common SC object definitions on UI level
		2. ODET, VDA Norms for JIT, ASN, JIS (automotive)
		3. EBOM, VDAFS, Eclass, IDoc
		4. BAPI, BADI
		5. KPI structures and business metrics
		6. Hyperledger

Infrastructure technology	1. Bridging system boundaries using processes interfaces and Data Base interfaces 2. Open source operating systems and SW development 3. H ANA Cloud Intergration (HCI) for integrting local business application with cloud solutions	1. HCI interface 2. Open Source Cloud Computing 3. Governance service standards such as ITIL

Fig. 17: Layers of SC interoperability and examples (an author's view)

Best practice for dynamic SCM IS alignment by EAM

EAM domain	Best Practice activities
SCM IS fit assessment	1.Continuously assess strategic fit of SCM IS accross the supply chain for all SC doamins 2.Continuoulsly assessed needed and expected levels to fit the competitive strategy
Architecture development (absorptive capacity)	1.Artefacts for business architecture were designed for all SC domains based on identified SC capabilities and needed levels to strategic fit (as-is and to-be). 2.Artefacts for application and IT architecture were designed for all SC domains based on identified IS capabilities for SCM and needed levels to strategic fit (as-is and to-be). 3.Context specific artefacts were designed for different expected business situations, and organised by useful strategic differentiators such as product secments. 4.Clearly capability description by objectives and required organisational and technical setup. 5.Different *'views'* of the artefacts were linked to stakeholders needs 6.The Artefacts cover all domains – business, application, data, technology and governance.
EA process (exploitation)	1.Continuously measure and review as-is levels of implemented capabilities and compare with ideal levels (to-be) needed to fit competitive strategy 2.In case of deviations, review catalog of available artefact on capability to fit startegy. 3.Initiate implementation of selected artefact (technical and organisational transformation) 4.Initiate capability definitition e.g by prototyping if approriate capabilies is not available----
Stakeholder involvement	1.Executive management and LoB participate in promoting and optimizing EA processes 2.Stakeholders actively support the architecture review process and promote the approach
Architecture communication	1.SC objectives are understood by stakeholders and are up to date 2.There is a process for collecting feedback and is used for continuous improvements. 3.Architecture models where maintained in one central repository. 4.Senior management use EA views to decide and demonstrate key decisions
Architecture governance	1.EA standards and guidelines are linked to IT and business strategy and vision 2.IT strategy has been clearly defined and linked to business and SC strategy 3.EA models and capability patterns are linked to business drivers and SC objectives 4.EA Governance team has senior executive sponsorship and key stakeholders participate 5.Ideally, all planned IT acquisition and purchases where guided and governed by EA 6.EA compliance KPIs where defined and tracked and regularly communicated. 7.Common definitions, standards, applications and systems exists and were govern 8.Architecture models and artefacts were developed based on common taxonomy

Fig. 18: Best practice for SCM IS EAM (an author's view, adopting SAP best practise for EAM)

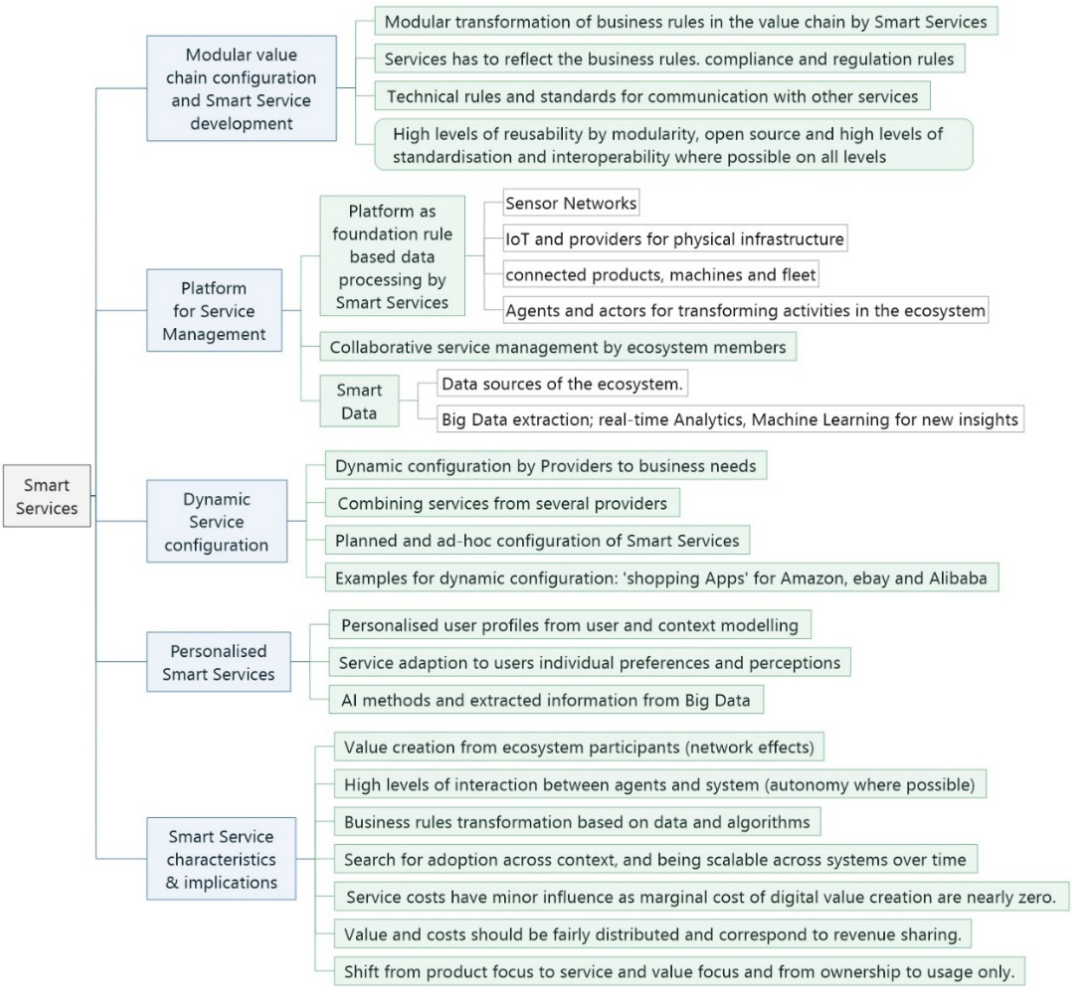

Fig. 19: Building blocks of Smart Services modelling (an author's view, source adopted from Smart Service Welt, Kagermann et al., 2013)

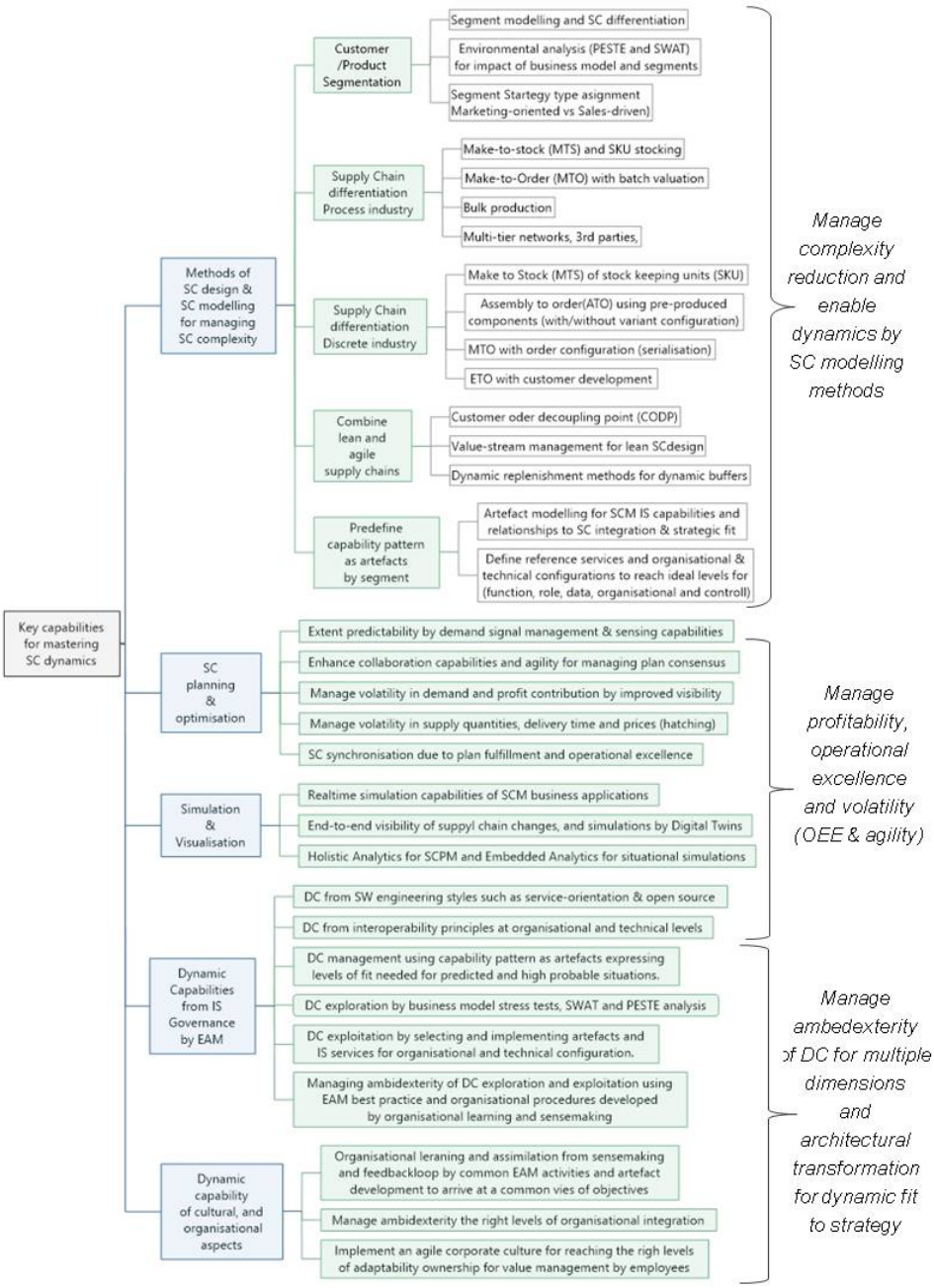

Fig. 20: Key capabilities for mastering SC dynamics and SC complexity (an author's view)

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CORPORATE VENTURING EVALUATION: HOW START-UP PERFORMANCE IS MEASURED IN CORPORATE VENTURING DURING THE COLLABORATION PHASE

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ABSTRACT

In the context of business performance assessment, current research often focuses on evaluating effects of innovation projects with start-ups. Subsumed as corporate venturing (CV), investigating the impact of these projects is becoming increasingly important. Thus, the number of studies on the ex-post value of corporate venturing projects (CVP) has steadily increased over the last years. In contrast, this research attempts to cover the evaluation of CVP in the period between from the contract conclusion to termination. By conducting interviews, this research primarily aims at identifying indicators applied for evaluating CVP performance during the cooperation of subjects in the automotive industry. The results obtained show that evaluation is mostly based on subjective criteria and that no formal indicators are implemented to manage CVP during the collaboration phase. This research contributes to literature by revealing practically applied CVP performance indicators during the collaboration phase and by discussing their weaknesses.

KEY WORDS

corporate venturing, performance measurement

JEL CODES

M10, M13, O32

1 INTRODUCTION AND OBJECTIVE

Corporate venturing (CV) is the umbrella term for entrepreneurial activities regarding collaborations of established organizations with new and innovative businesses (Reimsbach and Hauschild, 2012). Even though the relevance of CV has been acknowledged in literature and in practice, the theoretical understanding is still in its beginnings (Maula et al., 2009). CV has been discussed in literature every now and then. Three major peaks of attention can be identified so far. In 1960 there was the first peak, when over 25% of the Fortune 500 businesses

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engaged into CV (Baldi et al., 2015). In 1980, the second attention peak was reached, when corporates strived for diversification. The third peak emerged in the 1990s. New technological trends, market opportunities and an improved legal environment with less regulation and tax incentives fuelled the engagement in CV (Dauderstädt, 2013). Today, the attention on CV is increasing again. This is based on the fact, that corporates more and more collaborate with other organizations in order to keep up with a disruptive and fast developing world (Pekkola and Ukko, 2016; Ferreira et al., 2012). CV is a mean for corporates to achieve their goals in order to fulfil stakeholders' needs. To achieve these goals, the management of CV becomes crucial. Thus, an encompassing understanding of how to manage CV, including the underlying mechanisms and indicators is needed.

Yet, to the knowledge of the authors, research on CV management during the collaboration phase is rare. Existing literature investigates the ex-ante and ex-post phases of CV, e.g. start-up selection criteria or measurement of ex-post CV success. Even performance measurement literature does not offer a framework to evaluate CV during the collaboration phase (Pekkola and Ukko, 2016; Westphal et al., 2010). Yet, as stated by Busi and Bititci, a deeper understanding of CV and its evaluation measures is needed (Busi and Bititci, 2006).

Also, from an empirical perspective CV proved its importance. An Accenture study reveals that 50 out of the top 100 companies from the Fortune 500 ranking engage in CV (Berthon et al., 2015). Simultaneously, the investment sum increased (Brigl et al., 2016). A Boston Consulting Group study states that German corporates invested 1,3 Billion US Dollar in CV over a five-year period from 2011 until 2016 (Boston Consulting Group, 2016).

Considering, that at least 50% of corporate venturing projects (CVP) fail, indicators to evaluate when to end CVPs would increase the economic performance of corporates {Carneiro 2012 #72D: 995}. Consequently, such indicators could not only be used to manage the relationship, but also to influence the accomplishment of CV goals.

Following the need for such research (Pekkola and Ukko, 2016; Bititci et al., 2012; Benson and Ziedonis, 2009), the present study aims to answer the following research question: which indicators are practically applied within the automotive industry to evaluate CVP during the collaboration of subjects? Consequently, the research goal is to identify indicators for the evaluation of CVP during the cooperation of subjects. Special emphasis will be held on indicators which signal CVP problems and let assume, that the termination of the cooperation is more economically advantageous for the corporate. Research will be carried out only in organizations working within the automotive industry. By answering the research question this research contributes to literature by offering first empirical insights into CVP performance evaluation during the cooperation phase and by revealing practically applied indicators in the automotive industry.

In the following, basic theoretical information and applied methods are made transparent. Then empirical results and most important insights are shared. Afterwards the results will be discussed, before a conclusion regarding the indicators used for CVP evaluation during the collaboration phase is drawn.

2 THEORETICAL FRAMEWORK

After having shown the theoretical and practical importance of CV, a common understanding of CV and its goals is created. According to literature, CV is the umbrella term for entrepreneurial activities regarding collaborations of established companies with new and innovative businesses (Chesbrough, 2002; Keil et al., 2008; Dushnitsky and Lenox, 2006; Freese, 2006). Alongside others collaboration forms, like alliances and joint ventures, CV focuses on establishing mutual beneficial relationships (Pekkola and Ukko, 2016; Lee and Kang, 2015).

CV collaborations represents the closest form of relationships (Parung and Bititci, 2006). CV can be structured in intern and external CV. Internal CV refers to internal entrepreneurial activities. These are anchored by establishing a start-up inside the corporate's boarder. In contrast, external CV focuses on entrepreneurial activities outside the corporate's border (Dauderstädt, 2013). In more detail, external CV describes the idea that a large, well-established organization (the corporate) engages into a collaboration with a small autonomous business (the start-up) with high potential for growth and innovation (Reimsbach and Hauschild, 2012).

CV represents a financial investment. Driven by the desire for control and mitigation of risk, organizations either invest directly or indirectly into start-ups. When organizations focus on controlling a start-up, they normally take equity. When corporates strive for few liability and management complexity rather than control, they tend to take no equity (Neumann et al., 2019).

Corporates engage in CV based on the economical decision to jointly solve problems which cannot be solved by the corporate alone (Camarinha-Matos et al., 2009). Especially in the case of innovation start-ups are great CVP partners, since start-ups are more innovative than corporates and therefore offer access to innovation and new technologies (Chemmanur et al., 2014; Engel, 2011; Bititci et al., 2012). However, also start-ups benefit from CV. Mostly, resources and managerial support is provided by corporates. Financing also plays an important role. Based on this support, CV backed start-ups reach a higher output in innovation (Chemmanur et al., 2014). Consequently, CV serves to leverage the benefits for both organizations (Maula, 2001; Faisst, 2005; Dushnitsky and Lenox, 2006).

When engaging in CV, corporates pursue an individual set of strategic and financial goals (Reimsbach and Hauschild, 2012). Yet, corporates do not focus mainly on financial benefits, but rather on strategic ones (Covin and Miles, 2007; Dushnitsky and Lenox, 2006; Chesbrough, 2002). This can be seen in Tab. 1, reviewing CV goal definitions.

Even though CV goals are formulated differently, they can be categorized into 6 categories. The first category represents the goal to create innovation and gain insight into new technologies. The goal to enter and develop markets embodies the second category. Thirdly, the goal to create spill-over effects and cross-selling opportunities builds a category. A fourth category includes the goal to positively influence the brand and an organization's reputation. The fifth category represents a more qualitative goal, namely the enhancement of (entrepreneurial) culture. Finally, the sixth category encompasses the goal to generate additional financial returns.

Literature argues, that although an organization might target different goals, the "window on technology" or the creation of innovation is the most important one (Baldi et al., 2015; Chemmanur et al., 2014; Reimsbach and Hauschild, 2012; Faisst, 2005; Dushnitsky and Lenox, 2006).

Obviously, a mechanism to manage the organization towards achieving its objectives and to evaluate the degree of objective realisation is needed (Pekkola and Ukko, 2016). This is known as performance measurement (PM). PM represents a systematic approach to plan, measure, monitor, assess, reward, and control the performance of organizations whilst using suitable methods and tools (Pekkola and Ukko, 2016; Kaack, 2012). In general, PM represents a learning system, which is constantly optimized and refined to enhance its information and steering function. More specifically, PM is a method to plan and conduct data collection regarding goal achievement. According to Westphal et al. PM comprises two main elements. The first element encompasses the definition of performance measurement systems (PMS) to describe how performance measurement is set-up and conducted. The second element represents the definition of dimensions and key performance indicators (KPI) to evaluate the business performance (Westphal et al., 2010).

Tab. 1: CV goals (Kann, 2000; Keil, 2000; Maula, 2001; Ernst et al., 2005; Covin and Miles, 2007; Dauderstädt, 2013; Berthon et al., 2015)

Year	Author(s)	CV goals
2000	Kann	External innovation
		Fast market entry/new market entry
		Expansion of demand
2000	Keil	Establish entrepreneurship
		Generate innovation
		Enter/develop new markets
		Gain knowledge
		Diversification/strategic renewal
		Growth
2001	Maula	Financial gain: return/profit
		Learn: insights in markets/new technology
		Option building: fast market entry/discovery/development of markets/companies
		Leverage: demand for own products/resources
2005	Ernst	Identification of new/competing technologies
		Access to complementary capabilities/resources/knowledge
		Access to growth opportunities
2007	Covin, Miles	Organizational development
		Cultural change
		Strategic benefits
		Real option development
		Financial returns
2013	Dauderstädt	Generate of financial return
		Develop ecosystem
		Talent scouting
		Access new products/technologies
		Increase networking/option building
		Improve image/positioning
		Leverage internal resources
		Outsource research & development
		Increase intrapreneurship
		Access specific skills/knowledge
2015	Berthon et al.	Access specific skills/knowledge
		New market entry
		Improve internal R&D return
		Accelerate inhouse innovation
		Develop new products/services
		Enhance company image/brand
		Enhance entrepreneurial culture

A PMS is a system to measure and steer the multi-dimensional strategic and operational performance in balance with its alternating interdependences and thus represents A bundle of different but linked performance measures (Ferreira et al., 2012; Collier, 2005).

The PMS's focus changed over time. Originally, formal and financially measurable information was collected to support management decision making. Today also external information concerning customers, markets, competitors and especially non-financial information plays an important role (Collier, 2005). Solely using financial measures is discussed critically, because strategic goals and effects get lost (Pekkola and Ukko, 2016). These effects and

the status of goal realization can be transferred into indicators (Ferreira et al., 2012). These indicators refer to different dimensions, e.g. efficiency and effective-ness, internal and external or financial and non-financial measures (Pekkola and Ukko, 2016; Ferreira et al., 2012). Literature discusses the value of both, financial and non-financial KPIs.

The impact on business performance through PMS and KPIs is widely acknowledged (Pekkola and Ukko, 2016; Dauderstädt, 2013). Even though the establishment of a PMS for CVP evaluation during the collaboration phase seems to be worthwhile, research regarding this topic is extremely limited (Basu et al., 2011; Banik, 2011; Westphal et al., 2010; Weber, 2009). Systematically structured operational indicators, which evaluate the strategic outcome and CVP success do not exist (Dauderstädt, 2013; Kollmann and Kuckertz, 2010; Faisst, 2005). Consequently, empirical research reading applied indicators for CVP evaluation during the collaboration phase plays an important role in gaining in-depth understanding of CV.

3 SEMI-STRUCTURED INTERVIEW

To deepen the understanding of CVP performance evaluation during the collaboration of subjects, this research strives to give empirical insights on applied performance indicators. Since only very limited research on this topic exists, the authors chose a qualitative approach to explore the research topic. They conducted multiple interviews in different organizations as a starting point to gain insights into CVP performance evaluation. Already the first interviews showed that organizations are not aware of the indicators they apply. Thus, the main purpose of the interviews is to reveal indicators used by organizations in the automotive industry to evaluate CVPs.

18 in-depth interviews were conducted in 4 automotive or automotive supplier organizations over a 16-month period from April 2018 until July 2019. All companies are located in Germany. The investigated corporates are well-established organizations which regularly collaborate with start-ups in order to access innovation and gain technological insights. Together engaging in about 75 CVP a year, the organizations are chosen due to the proven CV maturity.

The interviews were conducted with 7 experts and focus on the CV process, goals and performance indicators. As interview strategy both, the strategic and operational level of the CVP were investigated. Therefore, the interviewees were chosen according to different levels of closeness to the CVP. This cross-level interviewee selection sharpened the understanding. Furthermore, this approach reduced the ex-post rationalization bias. All interviews are based on a semi-structured interview guideline with predefined interview questions. This safeguards a common approach and the discussion of the same topics in the different interviews, thus paving the way for comparison between the interviews and organizations.

The interview had two main goals. Firstly, they served to investigate whether CVP performance indicators are established in organizations. Secondly, they served to reveal implicitly used CVP performance indicators, even if there was no official CV performance measurement system implemented. All interviews lasted between 45 and 120 minutes. In accordance with the interviewee, the interviews were transcribed and then analysed with MAXQDA software. In some cases, the researchers were only allowed to take notes. Afterwards, the collected notes were confirmed with the interviewee.

Each interview started gathering background information about the interviewee and her/his responsibility. After gathering information about the organization's CV history, dependent on the interviewee either strategic information or information about applied CV performance indicators were discussed.

The authors analysed the data collected from the interviews by using a coding system. In a first step the authors deduced relevant codes, based on a literature review and assigned

these to the transcribed interviews. Afterwards, further codes were added based on the interview analysis. Codes with similar content got merged into a bigger code and in further iterations into categories. These categories are codes, which built overall indicator perspectives clustering implicitly applied indicators according to their evaluation focus.

Since there is no awareness and no transparency of the indicators for CVP performance evaluation within the interviewed organizations, the semi-structured interview represents the only way, to reveal the indicators in order to reach the article's goal.

4 RESULTS

Following the described approach, the interviews revealed not only applied CVP performance indicators, but also lead to some basic and foundational results and insights. Before presenting the revealed CVP performance indicators, these basic insights are shared.

As a first result, none of the interviewed organizations applied an objective, clearly defined indicator system for the CVP evaluation. Instead of using an indicator system, the evaluation of CVP is solely based on the gut feeling created out of CVP manager's experience and subjective judgement. However, all interviewed organizations announced that they want and need an indicator system for the evaluation of CVP during the collaboration phase. As revealed by the interviews the major challenge for the organizations is to define what to measure and how to measure.

Nevertheless, based on the in-depth investigation the authors were able to reveal CVP performance indicators which have been implicitly applied. Even though none of these indicators is documented or officially announced, the CVP managers implicitly used these indicators to generate their gut feeling. Consequently, this research contributes to a deeper understanding of CVP evaluation by revealing these implicitly applied indicators. The research findings and thus the revelation of the implicit performance indicators applied by the CVP managers are presented in Tab. 2.

The indicators listed in Tab. 2 are implicitly and unknowingly used by CVP managers to evaluate whether a CVP is beneficial for an organization or not. In total 16 performance indicators were revealed. Yet, CVP managers only based their judgement about a CVP on seven to 14 out of the total indicator list. As an insight from the interview it can be concluded, that CVP managers apply different indicators to draw conclusions on CVP performance. Thus, there is no consistent standard for CVP evaluation during the collaboration of subjects within an organization. Simultaneously, this means that a CVP manager might draw his conclusion about CVP performance on different indicators each time he evaluates the same CVP project, but also when evaluating another CVP project. Consequently, it is likely that a CVP manager's performance evaluation is influenced and biased by his environment.

Looking at the indicators themselves, they can be clustered into 4 categories. These categories are the same for all interviewed organizations. The category "financial indicators" includes two measures. The first indicator was used by four out of four interviewed organizations and describes the ratio between invested capital and planned investment. It measures the investment status and offers insight into the start-up's capital consumption. For this indicator milestones with dedicated budgets are defined. In case the capital consumption exceeds the budget, it is assumed that the start-up is inefficient and might not reach the target objective.

The second indicator of the financial category is the corporate's share of venture's revenue. The interviewed organization use this indicator to determine the drive and commitment towards the CVP and the contracting corporate. When the corporate's share of the venture's revenue decreases, it is assumed that the start-

ups loyalty decreases as well. This might lead to negatively affect indicators from another category. In conclusion for the financial category, CVP performance evaluation is done by implicitly considering progress indicator, like capital consumption, rather than output indicators, like profit.

The second category encompasses indicators regarding collaboration. In total five indicators regarding collaboration were identified: team stability respectively team fluctuation, management support, response time, number of conflicts and number of social interactions. Considering team stability, the CVP managers evaluate how often changes regarding the team constellation happen. Changes regarding the team are used as an indicator for two aspects: (1) reduction of team performance because of the norming process and (2) withdrawal of resources and/or knowledge. Both affect the CVP performance negatively. All interviewed companies rely on the team stability indicator. Remarkably, team fluctuation is seen negatively by all CVP managers. None of them considered that a change in the team constellation might bring in additional knowledge or specific experience.

A CVP performance indicator which is used by three out of four interviewed organizations is management support. Interpreted slightly different by each organization, this indicator reaches from management's benevolence to management's commitment and prioritization. Mostly the commitment is determined by management's attendance at meetings or postponement of meetings and decisions. The assumption behind is, that with less attendance a CVP becomes deprioritized and loses grip, which will lead to the failure of the CVP. As a result, it can be deduced that in CVP performance evaluation not only the outcome of the CVP team is crucial, but also management involvement. The consideration of management involvement represents a difference to traditional PMS.

Also used by three out of four companies, the response time is seen as an CV performance indicator. Response time means the time a start-up takes to respond to a request. Yet, the start-up is not required to deliver the solution right away. A notification that the request was received, and that the start-up works on a solution is enough. A short response time conveys commitment to the CVP, reliability and thus helps building trust. Trust reduces monitoring activities, leaves freedom for creativity as well as for trial and error. As a result, response time represents an approximator for trust. Even though it does not measure any output or outcome, organizations rely on this indicator. With "number of conflicts" another CVP performance indicator for the collaboration category was revealed. Number of conflicts has two layers, which are evaluated by CVP managers. The first layer represents social conflicts between the start-up's and corporate's teams. The second layer refers to number of problems, which cannot be solved between the teams and therefore are escalated to a higher decision level. A high number of conflicts slows down the CVP collaboration and affects performance negatively. Using this indicator complements the evaluation of CVP performance by adding an approximator to evaluate the CVP atmosphere and thus the chemistry between organizations.

Moreover, one out of the four interviewed organizations applied an indicator measuring the number of social interactions. Social interaction simply refers to the number of "off the job" socializing. It is seen as a performance indicator directly affecting the CVP collaboration. If the CVP team has a strong personal bond, they share information and support each other as quickly as possible. This personal bond beyond the job is tried to grab by measuring the number of social interaction and events after working hours. In summary of the collaboration category, the focus of the applied indicators again lies on progress indicators. Mostly, approximators are used which try to make trust quantifiable. Interestingly, not only the pure CVP output performance is considered, but also the involvement of management as a key element for CVP success.

The next category refers to innovation. As described above, CVP focus on innovation and the window on technology in the case of

Tab. 2: Revealed set of indicators for CVP performance evaluation in automotive interviewed organizations

Indicator	Org. A	Org. B	Org C.	Org. D	Sum
Finance					
Invested capital/planned capital	×	×	×	×	4
Corporate share of venture's revenue	×		×		2
Collaboration					
Team stability/change	×	×	×	×	4
Management support	×	×		×	3
Response time	×	×	×		3
Conflicts	×	×	×		3
Social interactions			×	×	2
Innovation					
Impulses	×	×	×		3
Features tested/updates	×	×	×		3
Off-the-job time	×				1
Process					
On-time-delivery	×	×	×	×	4
Implemented best practices	×	×		×	3
Slow decisions/not available incidents	×		×	×	3
Information e×change sessions	×	×	×		3
E×change session attendance rate	×		×		2
Celebrated successes			×		1
	14	10	13	7	

the investigated organizations. Still, only three performance indicators were revealed: number of impulses, number of features tested/ updates and off the job time. Three out of four interviewed companies use "number of impulses" as indicator for CVP performance. With this indicator the organizations try to monitor the CVP innovativeness. It is assumed that a high number of impulses increases the likelihood of innovation and success. Referring to this interpretation an idea represents an impulse as much as a proposal of a joint workshop or an innovative solution. The only restriction is, that impulses must refer to the product or service the CVP team is working on. In contrast, it embodies a loss of commitment and effort, if the number of impulses decreases. For CVP managers this indicates that the CVP might not be able to achieve the CVP innovation goal.

The number of features tested/qualified updates represents another CVP performance indicator. Three out of four interviewed organizations use this indicator to evaluate the quality of the start-up's deliverables. The corporates compare successfully tested features with the total features tested. The closer the ratio is to 1, the better the quality. Apart from that, the number of qualified updates is considered. Having current project management data and proper documentation available (called qualified updates) is as important as the features tested. In case the quality decreases, it is assumed that either the start-up is not capable of delivering the innovation or that the commitment decreasing. Both aspects reduce CVP performance. Interestingly, all interviewed companies which use this indicator also used the indicator "number of impulses". Another innovation indicator, which is applied by one corporate, measures off-the-job time. Off-the-job time sums up the time, the CVP team is not working on the innovation, but is caught in meetings or in administrative tasks.

The probability of innovation and a successful CVP decreases with a high off-the-job time.

In conclusion, it can be deduced that the innovation category tends to rather focus on output than on progress. This is a difference towards the other CVP performance evaluation categories. Nevertheless, no traditional lagging indicators like number of patents are used. The applied indicators rather try to anticipate the likelihood of innovation by referring to impulses and elements of the desired innovation. Simultaneously, it can be deduced that the assumption behind is, that innovation is plannable and therefore dedicated features can be determined ex-ante.

The last category uses a process perspective. It encompasses six performance indicators to evaluate CVPs at an early point of time. Firstly, the number of on-time deliveries is measured. Therefore, milestones and assigned deliverables are predefined. If the results are delivered at the pre-defined milestone, the CVP is evaluated as successful. The indicator simply builds the ratio between promised deliverables and actual deliverables based on the milestone plan. The closer the ratio is approaching 1, the better the performance. Four out of four interviewed organizations deployed this performance indicator. Asking the interview question, which revealed indicator is the most important one, all interviewees answered that on-time delivery is most crucial. This indicator implies that a CVP is plannable and has a clearly defined outcome. also implies, that Even though on-time delivery implies plannability and a clearly defined structure of innovation

Another process indicator is the number of implemented best practices. Three out of four investigated companies apply this indicator to implement improvements. It is assumed that the relationship and way of working improves by a high number of best practices. Simultaneously, implemented best practices increases the likelihood of innovation and therefore CVP performance. As a result, this indicator aims to improve one of the main issues in CV, namely the disconnection between corporate and start-up regarding processes.

Time-to-market is essential for innovations. Consequently, three out of four interviewed organizations use the number of slow decisions or not available incidents of the start- up's management as a CV performance indicator. Both, slow decisions and unavailability of the start-up's management implicitly mirror, that the priority of the CVP is not very high. In case the CVP has highest priority, the start-up's management will find the time to cope with decision or requests from the corporate. This indicator is strongly interlinked to the collaboration category and the indicator management support.

A quite popular indicator represents the number of information exchange sessions. Three interviewed organizations use this measure to evaluate the CVP. The assumption is, that meetings with the purpose to exchange information help to provide relevant information and thus augment the likelihood of innovation. Moreover, information exchange sessions are associated with joint problem-solving. Thus, the interviewed organizations argue that frequent meetings increase performance. As a result, the basic requirement of collaborations is targeted with this indicator. Only if the information flow between entities is enabled, innovation leading to CVP success is possible.

Two out of three interviewed organizations complement this indicator with the exchange session attendance rate. Since measuring only the number of information exchange sessions is not representing the entire picture, these two organizations also measure whether the relevant experts participate (assuming that the meeting participants are relevant for the session). A high attendance rate safeguards information exchange between relevant experts and thus fosters innovation. Consequently, good information exchange is likely to increase the CV performance.

The last process indicator which was revealed is only used by one interviewed organization. It is the number of celebrated successes. This indicator refers to two topics. On the one hand, the number of celebrated successes only increases if the innovative outcome for the milestones has been achieved. Thus, representing

the overarching success of the CVP. On the other hand, this indicator implicitly supports building the relationship between the teams, since a joint celebration fosters the personal bond and increases motivation. Implicitly the number of celebrated successes sums up the overall performance and thus represents a CVP performance indicator.

Summarizing the process category, this category encompasses the most indicators in comparison to the other three categories. The implicitly applied indicators represent a mixture of traditional indicators like on-time delivery and more dynamic indicators like number of not available incidents. The indicators are rather used to monitor the development instead of leading to a digital decision stating whether the goal is achieved or missed.

In conclusion, all interviewed organizations implicitly apply indicators to evaluate CVP during the collaboration of subjects. None of the organizations uses a defined, standardized set of indicators, nor are thresholds for the implicitly applied indicators defined. Only due to the interview the authors were able to reveal the applied CVP performance indicators. The revealed indicators can be categorized in 4 categories which are the same for all interviewed organizations: finance, collaboration, innovation and process. Apart from that, the interviewed organizations use quite similar indicators with only little variance. All investigated companies implicitly evaluate the start-ups and CVP based on 16 financial and strategic aspects. The finance category is the least important category for all interviewed organizations. Even though, innovation represents the main goal of the CV collaboration, only three indicators directly refer to this category. Interestingly, most applied indicators embody progress indicators, which rather approximate the outcome. Most of the indicators try to capture qualitative performance elements and transfer them in an approximated quantitative measure. In comparison to traditional performance measurement, the CVP indicators not only focus on the team's performance, but also considers management performance by measuring for example availability. As an insight, all implicitly applied CVP performance indicators contribute to build trust between the corporate and the start-up. These results help to understand the mechanisms how corporates evaluate CVP performance during the collaboration of subjects. Moreover, the revealed indicators contribute to a deepened understanding of CVP evaluation during the collaboration phase.

5 DISCUSSION

After having presented the empirical results, a discussion of the results, especially the 16 performance indicators applied for CVP evaluation during the collaboration phase gives the opportunity for further insights regarding the research topic.

In the present study the author coped with the lack of missing empirical research and empirically examined the applied indicators to evaluate CVP. It became obvious that none of the interviewed companies established a formal CVP evaluation framework for the collaboration phase with defined performance indicators. Still, all interviewed organizations long for such a framework and desire a guideline with defined indicators. As the empirical research results show, the investigated organizations implicitly apply 16 different CVP performance indicators during the collaboration phase. These indicators are discussed in the light of existing indicators from various research areas.

Existing literature focuses on traditional performance measurement methodologies and indicators. Yet, the usage of established measures – not developed for CV – has its limitations (Banik, 2011; Keil, 2000). Existing frameworks focus on measuring performance of single businesses (Pekkola and Ukko, 2016; Westphal et al., 2010). Frameworks which focus on CVP evaluation during the collaboration phase and thus cross-company management are hardly existing (Westphal et al., 2010).

Available CV performance measurement research almost exclusively evaluates CV success determinants or CV strategies. Systematically structured operational indicators, which evaluate CVP during the collaboration itself are lacking (Dauderstädt, 2013; Faisst, 2005; Kollmann and Kuckertz, 2010). Literature acknowledges, that a CV performance evaluation framework is crucial to increase transparency and effectiveness regarding CVP (Faisst, 2005). Therefore, CV specific requirements need to be met (Westphal et al., 2010; Faisst, 2005). To develop a CV specific and practically usable performance indicator set, empirical insights help to understand CVP performance evaluation.

Even though, implicit performance indicators have been identified, three of the four indicator categories are quite vague – with exception of the financial category. In general, a huge point for critique is that all interviewed organizations only refer to managers' gut feelings when evaluating CVP performance. There are no clearly defined indicators, thresholds or guidelines for orientation in order to define good CVP performance. This holds true for all indicators. This overarching result will not be mentioned further in the discussion. Only selected indicators with need for discussion are presented in the following.

Looking at the collaboration indicator category, team stability for example is used by four out of four interviewed organizations. Changes in the CV team are assumed to have negative impact. Having a solid team aligns with existing venture capital literature. However, venture capital looks at the team constellation ex ante in order to determine whether a team is capable of being successful. In this context literature states that a stable team positively impacts performance (De Clercq et al., 2006). Yet, during a CVP this holds only partially true. Sometimes, changes in the team bring new expert knowledge into the CVP. Thus, in case of high-quality staffing the change of team constellation might even increase CVP performance. Since experts oftentimes add value only to specific topics or phases, a change of the team constellation might even be necessary. Consequently, counting the number of team changes is not enough. In order to be reliable, only random team changes should be considered negatively. From the authors point of view, this indicator should not be adopted from venture capital literature and not be considered in CVP performance evaluation during the collaboration phase.

Top management support is stated to be one of the most important indicators for CVP performance, not only by the interviewed organizations, but also in literature (Schween, 1996; Banik, 2011). Still, the indicator top management support should be discussed critically. Top management support is very important for successful CVP. However, it must not be confused with approval of all CVP requests. Moreover, there is no clearly defined way of measuring top management support. From the authors point of view, top management support could rather be measured by the indicator "not available incidents". Since top management support is a vague term, the author recommends to clearly define measurable events in order to consider this indicator for CVP performance evaluation.

Two out of four interviewed organizations use the indicator "number of social interactions". This indicator is also discussed controversially in literature (Maula, 2001). From the authors point of view, this indicator could lead to wrong evaluations. Implicitly, the number of social interactions might increase performance. Yet, setting this indicator in stone would also lead to a more negative evaluation of CVP, which simply does not offer the possibility to visit joint events – for example because of geographical distance. Moreover, social interaction could also lead to negative effects, when people recognize at social events that they do not trust one another. Based on the geographical influence and the missing focus of a clear goal when considering this indicator, the authors recommend further investigation whether this indicator is suitable for CVP evaluation.

Even though all CVP focus on innovation, basic definition and thresholds are missing to have conclusive innovation indicators. Based on the vagueness of the implicitly applied indicators, it is almost impossible to deduce reliable

conclusions about CVP performance. From the authors perspective at least a clear process of how to define thresholds for each CVP and a up front acceptance of the thresholds between the CV parties needs to be given. Defining a standard threshold without considering specific CVP does not make sense, since each CVP has different requirements.

Looking at the process category, the before mentioned challenge of missing thresholds and clearly defined indicator hamper objective measurement. Especially when focussing on the number of slow decision/not available incidents two topics need to be critically discussed. Firstly, it is not defined what a slow decision is and how it is measured. On the one hand, "slow decision" is decision specific and depends on the individual perception of everyone. On the other hand, even if a slow decision could be defined, there would still be the question how to measure it referring to starting point. This discussion also emerges in entrepreneurship literature (Sadowski, 2001; Toschi, 2009). In entrepreneurship literature this indicator is seen as the basis for fast innovation – the key goal of CV. From the authors perspective, measuring not available incidents would be easier to measure in comparison to slow decisions. Still, it needs to be defined when non-availability can be counted as not available incident. Is it a not available incident when the decider is on vacation? Does a not available incident refer to all events or only for important decision with time pressure? How much time needs to pass until missing availability can be counted as not available incident? So far, this indicator plays only a minor role, however it offers quite some insights into CVP performance. Consequently, the authors recommend analysing the practical applicability of the indicator number of not available incidents.

Another process indicator represents the number of exchange sessions. Not only for the interviewed companies, but also for various literature streams this indicator is relevant for performance evaluation (De Clercq et al., 2006; Dauderstädt, 2013; Camarinha-Matos et al., 2009). Yet, from the authors point of view, solely looking at the number of exchange sessions might distort the picture. Firstly, the amount of necessary exchange sessions depends on the project. Too many exchange sessions for example even might decrease performance, since the CV team spends much time in non-value-adding meetings. Thus, a suitable number of sessions needs to be defined. Secondly, exchange sessions themselves are not enough to transfer relevant information. Also, the relevant experts need to be present. Consequently, the number of exchange session is only relevant in combination with the attendance rate of relevant experts and managers (Camarinha-Matos et al., 2009; Westphal et al., 2010). Only with the right people, quality of the information exchange sessions can be guaranteed. From the authors perspective, these indicators only give insights into CVP performance when considered together.

Even though the authors revealed the indicator "number of celebrated successes", this indicator seems to be a practical appearance, not discussed in in literature so far. At first sight, the indicator seems to correlate with the number of social interactions. However, the number of celebrated success has a broader perspective and from the authors perspective is more relevant for CVP performance evaluation. Celebrated successes include various components. Firstly, it means that endeavours have been successfully finished. Secondly, it means that the milestone plan including the deliverables have been successfully achieved. Thirdly, the number of features tested/updates was great enough to achieve the targeted outcome, which also implicates that the number of impulses and off-the-job-time was in balance. Fourthly, it strengthens the personal bonding between the organizations, which would also partly cover the indicator number of social interactions. Fifthly, it increases motivation of the CV team which inherently influences performance positively. To the knowledge of the author, this indicator is its infancy and further investigation is needed.

All in all, this empirical research reveals practically applied indicators. In the discussion part of the paper, the authors shed light on the weaknesses and insufficiencies of the

implicitly applied CVP performance indicators for the collaboration phase. By revealing the indicators and discussing their weaknesses, this research contributes to CV literature and a deeper understanding of CVP performance evaluation.

6 CONCLUSION

Even though the importance and value-add of CVP has been widely acknowledged in literature, the understanding of CVP performance evaluation during the collaboration phase is in its beginning (Dauderstädt, 2013; Husted and Vintergaard, 2004; De Clercq et al., 2006). Empirical studies coping with CVP performance evaluation during the collaboration phase are lacking. Therefore, this study addressed the need for empirical data on practically applied CVP performance indicators. To reveal these indicators, the authors conducted 18 in-depth interviews at four automotive companies.

The results show that even though the interviewed organizations longed for an objective and clearly defined set of indicators, the actual evaluation was based on subjective gut feeling. The authors made visible, which factors lead to the CV managers' gut feelings and summarized implicit indicators. In total 16 CVP performance indicators, used for the evaluation of CVP during the collaboration phase have been revealed. They all align with one of the four categories: finance, collaboration, innovation and process.

The study contributes to existing literature by expanding theoretical knowledge of CVP performance measurement during the collaboration phase. As one of the first in-depth studies of the CVP collaboration phase, it revealed implicitly applied performance indicators. Also, this empirical research explains why the revealed indicators are applied. Finally, this research contributes to literature not only by revealing applied indicators, but also by comparing these indicators with indicators extracted from various literature streams and shedding light on the weaknesses and insufficiencies in the context of CVP.

From a managerial perspective this research contributes by proposing four CVP performance perspectives and the revelation of 16 CVP performance indicators applied by various organizations in order to set the basis for defining a CVP performance measurement framework. By explaining applied indicators and critically examining them, the authors give an orientation for managing CVPs during the collaboration of subjects.

Nevertheless, interviews can only be a starting point of the research. One of the research's limitation is the restricted generalizability. In order to establish a proven set of CVP performance indicators for the collaboration phase, quantitative research is needed to validate and generalize the research's results. Moreover, further research is needed to investigate the transferability of the revealed CVP performance indicators to different industries.

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COMPARING FINANCIAL PERFORMANCE OF STATE OWNED COMMERCIAL BANK WITH PRIVATELY OWNED COMMERCIAL BANKS IN ETHIOPIA

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ABSTRACT

The main objective of this study is to examine the effect of ownership structure on financial performance of Ethiopian commercial banks. Hence, the financial performance of state owned commercial bank was compared with privately owned commercial banks in Ethiopia based on key financial performance measures. In order to achieve the stated objective, the study adopts a quantitative research approach by using financial ratio analysis and test for means equality analysis techniques. Samples of fifteen commercial banks were selected based on the year of establishment. Audited financial statement data covering from 2011 to 2017 analyzed. The result reveal that ROEs of public sector bank was higher than those of private banks but the overall performance of state owned bank was not observed sound because other financial ratios including ROA, LDR, CDR, CAR and NIM, of most of the private banks were found superior. Other findings of the study show that there is a significance difference between the financial performance measures like ROE, CDR, LDR, CAR, EIR and NIM between states owned CBE and the privately owned banks in Ethiopia. In terms of ROA, not statically significant difference between state owned and private commercial banks in Ethiopia over the studied period.

KEY WORDS

financial ratio analysis, banks, *t*-test, correlation, descriptive analysis

JEL CODES

G21, M41, N27, N20

1 INTRODUCTION

Financial system is serving as back bone in a country and acts as good facilitator for financial institutions. Financial institutions play vital role for the development and progress of country's economy. Strong financial system promotes investment by financing productive

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business, mobilizing savings, efficiently allocating resources and facilitating trade activities. McKinnon (1973) and Levine (1997) mentioned that an efficient financial systems are critical to reduce information and transaction cost. Consequently, financial institutions are keys for growth and efficient capital allocation (Levine, 2005). From the financial institutions, banks are one of the principal units in financial ecosystem which determine its prosperity and consequently that of countries economy as well. Accordingly, Schumpeter (1934) noted that banking sector is the main source of fund for long term investment and the sector is the foundation of economic growth.

A commercial bank's performance is examined for various reasons. Bank regulators identify banks that are experiencing severe problems so that they can be remedied. Shareholders need to determine whether they should buy or sell the stock of various banks. Investment analysts must be able to advise prospective investors on which banks to select for investment. Commercial banks also evaluate their own performance over time to determine the outcomes of previous management decisions so that changes can be made where appropriate. Without persistent monitoring of performance, existing problems can remain unnoticed and lead to financial failure in the future.

1.1 Commercial Banks in Ethiopia

The major financial institutions operating in Ethiopia are banks, insurance companies and microfinance institutions. Financial system in Ethiopia is determined by banks where the banking systems account for around 88.33 percent of total capitals of the financial sector in 2018. The total capital of the banking industry reached about Birr 85.5 billion (about USD 2.98 billion) by the end of June 2018 National Bank of Ethiopia (NBE, 2018). Ethiopia has mixed banking system comprising state- and private-owned banks. The number of banks still remained 18, of which two state-owned banks including Commercial Bank of Ethiopia (CBE) and Development Bank of Ethiopia (DBE) and sixteen private commercial banks. Regarding to the share of capital, private banks jointly accounted for 39.9 percent of the total capital, with the remainder 51.1 percent by CBE and 9 percent being held by DBE. The share of private banks in total branch network was 68.8 percent in 2017/18 (NBE, 2018). Total number of branch banks operating across the country is 4757. Out of these branches, 35.3 percent of the total bank branches were located in Addis Ababa. As it is bank branch to population ratio stood at 1 : 20286 people in 2017/18 (NBE, 2018). This shows the fact that Ethiopia indeed, is under-banked country with limited outreach.

During the time period, the banking system collected Birr 111.6 billion in loans. Of the total loan collection, the share of private banks was Birr 65.6 billion (58.8 percent) the remaining is collected by public banks. However, total outstanding credit of the banking system (excluding credit to the central government about 452 billion or 57% of total credit) increased to Birr 394.554 billion at the end of June 2018. The total deposit in all commercial banks reached 816.2 Billion on Feb. 2019 (Ethiopian reporter, April 21, 2019), out of it Commercial bank of Ethiopia accounted 60.8%.

Currently operating commercial banks in Ethiopia are listed as: Abay Bank (AB), Addis International Bank (AdIB), Awash International Bank (AIB), Bank of Abyssinia (BOA), Birhan International Bank (BrIB), Bunna International Bank (BuIB), Commercial Bank of Ethiopia (CBE), Cooperative Bank of Oromia (CBO), Dashen Bank (DB), Debub Global Bank (DGB), Development Bank of Ethiopia (DBE), Lion International Bank (LIB), Enat Bank (EB), Nib International Bank (NIB), Oromia International Bank (OIB), United Bank (UB), Wegagen Bank (WB), Zemen Bank (ZB), and PBA (Private Bank Average) is used as an abbreviation.

1.2 Statement of the Problem

Bank financial performance gets a great deal of attention in the finance literature by considering that banks serve as a key role in the economy. The financial performance of banks is expressed in different ways like via profitability,

concentration, efficiency, productivity and so on. Firms with better performance are better able to resist negative shocks and contribute to the stability of the financial system. Athanasoglou et al. (2008) as a result the financial performance of the banking sector has been one of the hot issues in financial environment. Since the banking industry plays a major role in the financial system of the countries and supports the competitiveness of the financial institution. It is reasonable to expect that the performance of a bank is affected by its ownership structure or origin of capital.

There is no foreign bank involved in Ethiopia so the financial markets leave to only domestic private and state-owned banks. As a result, currently the banking sector in Ethiopia is characterized by little and insufficient competition and perhaps can be distinguished by its market concentration towards the big government commercial banks and having undiversified ownership structure (Lelissa, 2007). Ethiopian law prohibits non-Ethiopian citizens from investing in Ethiopian Financial Institutions (NBE, 2016).

In Ethiopian banking sector, regardless of the series of changes and liberalization measures undertaken, which are expected to change the ownership structure, concentration, and profitability and in general its performance of the sector as compared to the situations prevalent before the reform period, currently the country's banking sector is characterized by the existence of high concentration (low competition) and operational inefficiencies; which is a clear sign of unimpressive performance of the sector (Lelissa, 2007). Related to this, Kefela (2008) also noted that non-competitive market structure exists in the Ethiopian banking industry, due to the nature of the country's financial sector in which there are no foreign banks. Furthermore, even if the financial sector reform aims at improving profitability, efficiency and productivity, by adopting a strategy of gradualism, Ethiopian banks' performance has still remained poor with substantial gaps in service delivery to private agents, particularly to the rural and lower-income population (Lelissa, 2007).

In particular, Kapur and Gualu (2012) revealed that private sector banks had better profitability, asset quality and capital adequacy performance measurements, while state-owned banks were better in cost management indicator. In terms of liquidity, no difference was observed between the private and government banks. On the contrary, Yaregal (2011) found the performance of state owned-banks is superior to private banks in Ethiopia in terms of profitability, liquidity and solvency. He concluded that privatization is not the only solution to improve poor performance of state ownership rather introduction of competition can substantially get better performance of both state and private ownership.

In general, there are no universally accepted findings about the effects of ownership structure on financial performance of banking sector, because countries different each other by their economic systems, financial systems, political systems and operating environments. Thus, in this study the researchers examined financial performance differences between the ownership structure of Ethiopian commercial banks by using variety of variables (profitability, liquidity, asset management, efficiency and capital adequacy) and comparing the financial performance of selected banks. Even though, several of earlier studies have made to add their own contribution to the literature and stated their own findings, they were inclined towards to the transition and developed economy, and less developing countries including Ethiopia received little attention in this arena. Consequently the conclusion and finding of the study in one country may not serve to another.

1.3 General Objective

The general objective of the study is to compare the financial performance of private commercial banks and state owned commercial banks in Ethiopia over the period July 2011 to June 2017.

Specific Objectives

Specific objectives that are derived from the general objective and needed to be addressed in the studies are:

- To examine the financial performance of commercial banks in Ethiopia by using key financial ratios.
- To compare the profitability of private banks with state owned bank in Ethiopia.
- To compare the liquidity of private banks with state owned bank in Ethiopia.
- To compare the capital adequacy of private banks with state owned bank in Ethiopia.
- To compare the efficiency of private banks with state owned bank in Ethiopia.

2 EMPIRICAL LITERATURE

A number of studies have been examined the influence of ownership structure on financial performance on various sectors including banking industry around the world. Most of the studies conducted on either a particular country or a number of countries case. Thus, the following section reviews the empirical literature related to the effect of ownership structure on financial performance with a particular focus on those that have been conducted more recently, as far as they are the best indicators of the current situation.

In 2007, Unal et al. (2007) studied a comparative profitability and operating efficiency analysis of state and private banks in turkey and suggests that state owned banks are as efficient as Private Banks and even more efficient at some aspects. Thus, it raises the question of "Whether to privatize banks or not?" in the studied period 1997–2006. Iannotta et al. (2007) compared the performance and risk of a sample of 181 large banks from 154 European countries over the 1999–2004 periods and evaluated the impact of alternative ownership models, together with the degree of ownership concentration, on their profitability, cost efficiency and risk.

Chen et al. (2005) found that state banks outperformed other types of banks. According to authors some previous researchers like La Porta et al. (2002) and Barth et al. (2004) believe that government banks do more harm than good to the economy because the hidden political agendas prevent them from fulfilling their expected role of economic prosperity. In the developing countries where the legal tier is weak the possibility of corruption in government banks cannot be ruled out. On the other hand, researchers such as Yeyati et al. (2004) believe that government banks should not be judged solely on profitability but also on the way they so the economic conditions of any country. But a research by Altunbas et al. (2001) studied bank ownership and efficiency in German Banking market. They found that little evidence to suggest that privately owned banks are more efficient than their mutual and public-sector counterparts

Another research by Omran (2007) analyzes both private and state banks' relative performances and also evaluates bank privatization process in Egypt by comparing the pre- and post privatization performances of privatized banks. He addressed the financial and operating performance of a sample of 12 Egyptian banks from 1996 to 1999, during which time control was transferred from the state to the private sector. Following privatization, the results indicate that some profitability and liquidity ratios for private-owned banks decline significantly, but other performance measures were virtually unchanged. Antithetically, the results indicate that the relative performance changes of private-owned banks were better than those of mixed banks with majority state ownership but worse than those of banks with other ownership forms (state-owned and mixed private ownership). Yet, the study finds a strong evidence to support the theory and previous empirical findings that banks with greater private ownership perform better. Therefore, the author reports that private banks outperform government banks.

Similarly, García-Herrero et al. (2009) found that less concentrated banking system as well as

lower government intervention increases bank profitability. They concluded that companies under control of government as shareholder are valued lower than the comparable companies under control of non-government shareholder. In this regard, many authors present evidence justifying the view that state-owned enterprises are less efficient than private firms.

Ben Naceur and Goaied (2008) investigates the impact of banks' characteristics, financial structure and macroeconomic indicators on banks' net interest margins and profitability in the Tunisian banking industry for the 1980–2000 period. The empirical findings suggested that private banks were relatively more profitable than their state-owned counterparts. Moreover, banks which hold a relatively high amount of capital and higher overhead expenses tend to exhibit higher net-interest rate margin and profitability levels, while size was negatively related to bank profitability. During the period under study, they found that stock market development had a positive impact on bank profitability. The result indicated that macroeconomic conditions had no significant impact on Tunisian banks' profitability.

The research conducted by Hsiao et al. (2010) emphasized and analyzed the operating efficiency changes in the pre- and post-reform period. For the purpose of their study the researchers used a samples of 40 Taiwanese banks over the period of five years from 2000–2005 and Data Envelopment Analysis (DEA) tool used. The results of DEA showed that banks faced lower operating efficiency during First Financial Restructuring reform era (2002–2003) in comparing to pre-reform period (2000–2001), yet in the post-reform period (2004–2005) faced higher operating efficiency. The results also shown that banks with a higher non-performing loan ratio have lower operating efficiency mean while banks with a high capital adequacy ratio have higher operating efficiency. In the same year Cornett et al. (2010) uncovered the pattern of changing performance difference between state owned and private banks around the Asian financial crisis.

On the same country, Lin and Sum (2012), using a panel of Taiwanese bank data over the period from 1997–2010, the paper conducts a joint analysis to examine the static, selection, and dynamic effects of ownership on bank performance. Simultaneously, the researchers attempt to determine whether politics had a significant effect on the performance of public banks, by incorporating dummy explanatory variable that represents a pan-public bank in a major election year was also included. The results indicate that both the pure-public banks and the private banks experiencing mergers and acquisition significantly outperform the pure-private banks in most performance measures (static and selection effects). Private Banks experiencing mergers and acquisition had consistently ascending non-performing loan ratios in both the short and long term, yet four other performance measures display a short-term improvement but a long-term deterioration after the mergers and acquisition (dynamic effects). They found that public banks undergone privatization had particularly poor loan growth rates which improve significantly following the privatization, in addition all other performance measures presented short-term deterioration but long-term improvement after the privatization (selection and dynamic effects). Banks participated or acquired by foreign banks perform significantly outperform than the pure-private banks in all five performance measures, yet had all measures show short-term deterioration but long-term improvements following the ownership change (selection and dynamic effects) indicating that foreign participation and acquisitions had a positive effect on bank performance. Finally, the pan-public banks have ascending NPL ratios in the major election years indicated that politics do matter.

A research done by Jiang and Yao (2010) pays special attention to the ownership, selection effect and dynamic effect of governance changes on bank performance. For the purpose of their study the researchers used a samples of Chinese banks over the period of thirteen years from 1995–2008 and one-step stochastic frontier analysis (SFA) approach was employed. The results of SFA approach showed that Joint Stock Commercial Banks and City Commercial Banks (the two private-owned banks) out-

perform State-owned Commercial Banks. The results also showed that bank efficiency has improved over the data period 1995–2008, since the estimated average cost and profit efficiencies were 74% and 63% respectively. Moreover, the researchers found that foreign ownership participation has a negative effect on profit efficiency in the long-term while initial public offerings (IPOs) improve bank profitability in the short-term. The researchers recommended that bank reforms in China should be done to tackle the current financial crisis.

Another research done by Qasim et al. (2012) found mixed results. They was made an attempt in order to compare the financial performance of public and private banks of Pakistan for a samples of twenty-five private and two public-owned commercial banks during the period of 2006–2011. From the sampled period, the researchers found that public and private banks have different ranking based on different financial ratio. For instance, on the basis of ROE, ROA, breakup value per share, cash and cash equivalent deposit to total assets, non performing loans (NPLs) to gross advances and NPLs to equity ratios, the performance of public banks were at first while private banks are at second. On the other hand, on the basis of investment to total assets, total liabilities to total assets, advances to total assets, net interest margin, interest expenses to total income, spreads and capital ratios, the private banks are at first while public banks were second.

On the same country, the primary research question of the study conducted by Haider et al. (2013), was to find out, whether the privately owned banks perform better than state owned banks? To answer their research question performance of both types of banks i.e. private and state owned banks was examined. These findings are very much consistent with some of the other researches which showed no performance difference between state-owned and private-owned banks, like Micco et al. (2007), Unal et al. (2007) etc.

Aswini et al. (2013) studied the soundness and efficiency of twelve public and private sector banks based on market cap. CAMEL approach has been used over a period of twelve years from 2000–2011, and they found that private sector banks were at the top of the list, with their performances in terms of soundness being the best. Public sector banks like Union Bank and SBI have taken a backseat and display low economic soundness in comparison. On the other hand, they measure the efficiency change of selected banks operating in India during 2010–2012. By using frontier based non-parametric technique, Data Envelopment Analysis (DEA), provides significant insights on efficiency of different banks and places private sector ones at an advantage situation and thereby hints out the possibility of further improvisation of most of the public sector banks.

Rahman and Rejab (2015) suggested that the bank performance varies with different types of ownership structure. Ozili and Uadiale (2017) investigated whether ownership concentration influence banking profitability in a developing country context. They found that banks with high ownership concentration have higher ROA, higher NIM and higher recurring earning power while banks with dispersed ownership have lower ROAs but have higher ROE.

Gupta and Sundram (2015) worked to compare the financial performance of selected public and private sector banks in India from 2009–10 to 2013–14. The study found that overall performances of private sector banks are better than public sector bank. A number of other significant contributions to the study of comparing bank performance with respect to ownership structure listed as (Sathye, 2005; Shankar and Sanyal, 2007; Chaudhary and Sharma, 2011; Waleed et al., 2015).

2.1 Review of Previous Related Studies in Ethiopia

Geda (2006) examines liberalization program by analyzing the performance of the sector before and after the reform. His study notes that given the recent nascent development the financial sector in the country, the relatively good shape in which the existing financial institutions find themselves, and given that supervision and

regulation capacity of the regulating agency is weak, the government's strategy of gradualism and its overall reform direction is encouraging. However, he argue for charting out clearly defined time frame for liberalization and exploring the possibility of engaging with foreign banks to acquire new technology that enhance the efficiency of the financial sector in general and the banking sector in particular.

Similarly, Kiyota et al. (2007) focus on issues of financial sector liberalization in Ethiopia, with reference in particular to the Ethiopian banking sector. They identified two factors that may constrain Ethiopia's financial development. One was the closed nature of the Ethiopian financial sector in which there are no foreign banks, a non-competitive market structure, and strong capital controls in place. The other was the dominant role of state-owned banks. Their observations suggested that the Ethiopian economy would benefit from financial sector liberalization, especially from the entry of foreign banks and the associated privatization of state-owned banks.

Likewise, Lelissa (2007) aimed to assess the impact of financial liberalization on the ownership structure, market concentration and profitability performance of the Ethiopian banking industry. He found out that the reform has brought a lot of remarkable changes on the structure and performance of the banking sector as compared with the situations prevalent before the reform period. However, the reform has restricted the advantages that could be obtained from diversified ownership structure via prohibiting operation of foreign banks and participation of the private sector to the ownership of government banks. Moreover, the researcher found that the profitability of the industry has also shown a tremendous improvement after the reform measure has been taken. However, the existing government banks are enjoying having the higher share of profit from the industry and still the pattern of the industry profit is following the profitability structure of the giant bank, CBE, as mentioned by him. Finally, he identified and recommended areas that need further liberalization measures so as to enhance the performance of the industry.

More specifically, Rao and Lakew (2012) examine the relationship between cost efficiency and ownership structure of commercial banks in Ethiopia using data envelopment analysis (DEA). They found that the average cost efficiency of state-owned commercial banks over the period 2000–2009 was 0.69, while that of the private commercial banks is 0.74. The aggregate cost efficiency of Ethiopian commercial banks was found 0.73. The Kruskal-Wallis (K-W) nonparametric test indicates that the difference between cost efficiency of the state-owned and private commercial banks was statistically insignificant. They also found little statistical evidence to conclude that the state-owned commercial banks were less cost efficient than the private commercial banks. Thus, ownership structure has no significance influence on the cost efficiency of commercial banks in Ethiopia. In addition, the study has identified bank size, loan loss reserve to total assets, market share, market concentration, capital adequacy, and return on average assets as the key factors that influence the cost efficiency of the commercial banks.

Another study done by Kapur and Gualu (2012) was examined the impact of ownership structure on performance of commercial banks in Ethiopian. They used eight Ethiopian commercial banks over the period from 2001–2008. They have employed both parametric and nonparametric tests of differences among public and private sector banks. Their results revealed that private sector banks had better profitability, asset quality and capital adequacy performance and public sector banks were better in cost management measures. In terms of liquidity, there was no difference observed between the private and public sector bank.

On the contrary, Yaregal (2011) examined the performance of banks by classifying in terms of their ownership type to explore the effects of ownership on performance over the period from 2005–2010. The researcher begin by documenting the extent of, theoretical rationale and measured performance of state and private owned banks around the world, and then assessed the performance of banks in Ethiopia. His empirical evidence clearly shows that state owned banks

are superior in performance than privately owned banks, and from eleven ratios used to measure performance seven supports for state ownership and the remaining supports private ownership. In case of growth pattern of deposit, loan and asset, the researcher founded better trends in private banks than state owned banks.

Eshete et al. (2013) assessed the trend, nature, and extent of competition in the Ethiopian banking industry using qualitative, descriptive and econometric techniques. They mentioned that the financial system in Ethiopian is dominated by banking industry, and yet, it is amongst the major under-banked country in the globe. Moreover, they mentioned that Ethiopian banking industry can be characterized as highly profitable, concentrated and moderately competitive. In addition they mentioned that CBE seizes quasi-monopoly power. In terms of contestability, they indicated that the Ethiopian banking industry could be characterized as incontestable as entry in the industry was difficult; due to legal, technological and economic factors. Competition in terms of price was relatively weak in the Ethiopian banking industry.

Worku (2015) found that even if private-owned banks have shown some superiority, the difference is not that much greater in Ethiopia. This is because ownership structure may have very limited impact on performance of banks in Ethiopia which are operating in environments that are weakly competitive and highly regulated.

Rao and Desta (2016) disclosed ownership type have no significance impact on the financial performance of Ethiopian commercial banks. Moreover, Dinberu and Wang (2017) showed there is a significance outperformance of state owned commercial banks than privately owned competitors in Ethiopia over the year 2005–2014. And hence, examining the impact of ownership on the financial performance of banking sector in Ethiopia, where the financial system is at its infant stage and closed for foreign investors have significant importance in policy directions and also to the addition of the existing literature in the area.

3 METHODOLOGY

This research study adopts two methods in order to describe the entire financial performance of commercial banks in Ethiopia such as analytical as well as descriptive study. In order to reach a complete analysis, the financial statements of the bank such as income statement, balance sheet and statement of cash flow was analyzed. The financial ratios computed as an indicator to compare the financial position of the banks. Financial ratios have long been considered as good predictors of business failure and are proved to accurately discriminate between failed and non-failed companies several years prior to failure (Moscalu and Vintila, 2012; Dang, 2011). For this reason, essential variables which are highly correlated with the financial performance for the studied banks, have given a complete picture of how the bank carries on its operations which influence the financial position and contribute enhancing the overall performance.

Main source data for the paper are the annual audited financial reports of each concerned bank included in the studies. Four main financial statements are used for ratio analysis of selected commercial banks, such as balance sheets, income statement, cash flow statement, statement of shareholder's equity.

The sample size consists of fifteen Ethiopian commercial Banks listed on National Bank of Ethiopia. The researcher used purposive sampling techniques based on date of establishment. Only commercial banks who have seven year audited annual report included in the research. The two private banks excluded from the study were Debub Global bank and Enat Bank these banks have only 1.7% in branch network share and 1.5% in capital of the banking system (NBE, 2018). Annual Time Series data for both independent and dependent variables were extracted from the data. To accomplish the aforementioned research objectives, the data for

this study was gathered from the bank's financial statements as published on their respective banks annual audited financial report from the period July 2011 to June 2017.

In this work by using the data from financial report such as balance sheet, income statement and cash flow statement of the respected commercial banks and by using financial ratio analysis method the financial performance of private commercial banks and state owned commercial banks in Ethiopia analyzed. The profitability ratios (ROA and ROE) are assumed as dependent variables while capital adequacy ratio (CAR), interest expenses to total loan (IETTL), net interest margin ratio (NIM), loan to deposit ratio (LDR), cash to deposit ratio (CDR), expenses to income ratio (EIR), operating efficiency ratio (OER) and size of the bank were used as independent variables. Also, Independent sample t-tests were used to identify the statistical differences in performance between state owned commercial bank and privately owned commercial banks in Ethiopia.

4 RESULTS AND DISCUSSIONS

4.1 Financial Ratios of Commercial Banks in Ethiopia

Financial ratio analysis has been extensively employed to assess the financial performance of operations for a long time by investors, creditors, and managers. It permits them to obtain more valuable information from financial statements than they can receive simply from reviewing the absolute numbers reported in the documents (Andrew et al., 1993).

4.1.1 Profitability

Profitability is the company's ability to generate optimal profit. In this study, the position of profitability has been measured with the help of return on assets, return on equity, expense to income ratio and net interest margin. Return on assets is a comprehensive measure of overall bank performance from an accounting perspective (Sinkey, 2002).

Tab. 1 (column 1) depicts average ROA of major commercial banks in Ethiopia for the period 2011 to 2017. The average ROAs of all the studied banks have been estimated positive shows that in the recent years, the performance of the banking system in Ethiopia was reasonable in terms of net profit. The average ROA of private sector banks (2.66%) was found lower than that of state owned (2.79%). The earning performances of commercial banks were satisfactory and no banks suffered from net operating loss. The net profit to total assets ratio of Zemen bank to gain profit seemed most attractive due to proper mobilization of available resources than other commercial banks. The second position was for Wegagen bank with average ROA equal to 3.07%. The last position was belonged to Abay bank with average ROA equalled to 1.74% but ROA values computed during the study period were found positive. CBE was maintained eight places with ROA equalled to 2.79% among studied commercial banks. As ROAs of ZB, WB, AIB, DB, AdIB, NIB, and LIB were estimated greater than CBE, it can be concluded that these banks were successful in mobilizing their available resources more effectively than the state owned bank CBE. The two sample t-test with 95% confidence interval includes the null value, as shown in Tab. 3; there is no statistically significant difference between the two subsectors with respect to ROA.

The second profitability measure is ROE; this ratio shows the ability of management to manage equity to generate profits for the company. The ROE measure is probably the most commonly encountered, and is usually integrated into bank strategy, with a target ROE level stated explicitly in management objectives. Note that there is a difference between the accounting ROE and the market return on equity; the latter is calculated as a price return, rather like a standard profit and loss calculation, which is taken as the difference between market prices between two dates. The

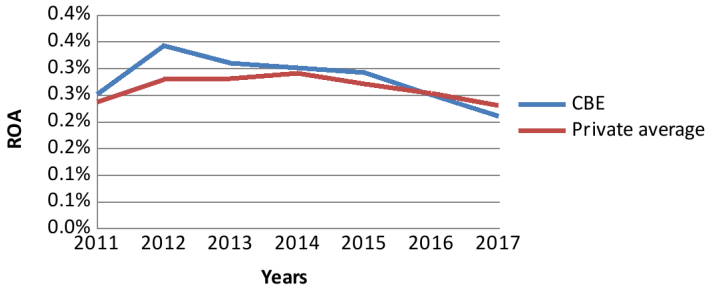

Fig. 1: Average ROA of state owned and private commercial banks in Ethiopia

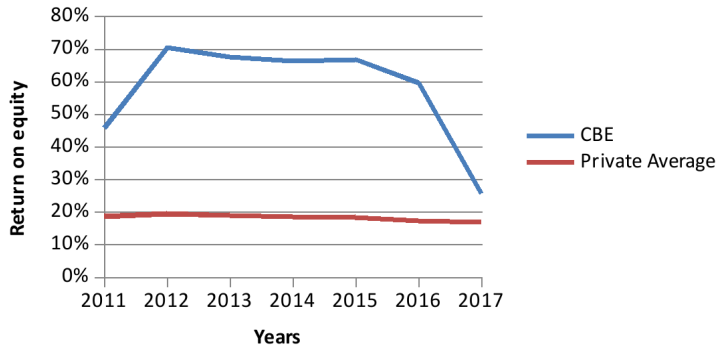

Fig. 2: ROE of state owned and private banks in Ethiopia

ROE target needs to reflect the relative risk of different business activity.

Fig. 1 reveal that in the study period state owned CBE had a better ROA from 2011–2016 in 2017 private banks average was above CBE.

The ROE of the major commercial banks in Ethiopia are presented for the average of the seven years in Tab. 1, column 3. The average ROE ratio was 18.37% for privately owned banks and 62.69% for CBE over the period 2011 to 2017. This implies that the shareholders receive low returns in terms of dividend relative to state owned bank. In order to rank the commercial banks based on this ratio, CBE was the first one; it has an average ROE of 62.69%. The second position was for DB with ROE equalled to 27.22%, the third position was for ZB with ROE 24.78% and the last position was belonged to AB with ROE equalled to 11.13%. It shows that higher ROE had satisfactory earning profit and the shareholders earn better return on their investment than lower ROE. The average ROEs of all studied commercial banks in Ethiopia were positive and enjoy with satisfactory earning. As indicated in Tab. 3, the 95% confidence interval does not include the null value then we conclude that there is statistically significantly difference between the subsectors with respect to ROE.

NIM has been treated as an extremely important measure to the bank and its minimum value for a healthy bank is considered about 4.5% (Dang, 2011). A small change in the interest margin has a huge impact on profitability. Higher NIM is associated with profitable banks by maintaining good asset quality.

Tab. 1, column 10 indicates that the average of privately owned banks had higher average NIM (3.47%) than that of state owned bank (3.45%). It means private banks were able to maintain good asset quality than state owned bank in average. While comparing the individual banks, AIB was occupied first position with the highest NIM of 5.33%. The interest margin of NIB was 4.00% is in second position; CBO was 3.86% and ranked in third position. The

Tab. 1: Average financial ratio of the fifteen commercial banks in Ethiopia

Bank	ROA	CAR	ROE	LDR	CDR	IETTL	EIR	NIM
CBE	2.79%	5.54%	62.69%	45.89%	20.07%	3.68%	27.49%	3.45%
DB	2.97%	11.72%	27.22%	55.97%	35.13%	5.52%	43.56%	2.72%
AIB	2.98%	13.71%	23.20%	60.55%	28.88%	4.93%	43.24%	5.33%
BOA	2.39%	12.52%	20.87%	56.84%	29.09%	5.42%	50.44%	3.51%
WB	3.07%	18.40%	17.42%	60.58%	35.80%	4.25%	47.59%	3.80%
UB	2.27%	12.81%	18.76%	58.76%	32.45%	5.30%	52.28%	3.65%
LIB	2.88%	16.69%	18.10%	59.93%	42.12%	4.16%	47.79%	3.75%
CBO	2.39%	12.41%	20.51%	61.10%	39.75%	3.53%	58.25%	3.86%
NIB	2.89%	17.37%	17.15%	63.47%	33.10%	4.34%	44.81%	4.00%
ZB	3.58%	15.55%	24.78%	53.27%	42.07%	6.89%	41.23%	1.87%
OIB	2.10%	13.47%	16.84%	52.20%	33.98%	4.38%	60.76%	3.33%
BuIB	2.45%	18.75%	14.30%	67.74%	39.28%	4.10%	54.89%	3.85%
BrIB	2.62%	17.94%	15.38%	59.84%	47.24%	3.99%	49.83%	3.19%
AB	1.74%	19.41%	11.13%	60.55%	40.98%	3.75%	71.18%	3.03%
AdIB	2.96%	27.31%	11.57%	66.43%	52.74%	4.88%	55.19%	2.74%
PBA	2.66%	16.29%	18.37%	59.80%	38.04%	4.67%	51.50%	3.47%

state owned CBE was in ninth positions with 3.45% NIM. It seems the profitability of the banks in Ethiopia was not so satisfactory.

4.1.2 Capital Adequacy

As stated in the foregoing analysis, banks under study are well capitalized and they are complying with the directive of NBE on CAR. According to the Licensing and Supervision of Banking Business Minimum Capital Requirement for Banks Directives No. SBB/50/2011, all licensed banks total capital should be greater than 8% of the total risk weighted assets of commercial banks in order to be a strong capital base. As indicated by CAR, on the average, capital adequacy of privately owned banks was fair during the study period. Total capital adequacy ratio of private banks lies between 11.72% and 27.31% indicates that capital adequacy is fair and on the average, this ratio falls within this range.

It is clear from Tab. 1 column 2 that the average CAR of state owned bank is below NBE requirement. AdIB ranked first in CAR with 27.31%, AB was second position with 19.41%, BuIB ranked third spot with average CAR of 18.75. In addition, average capital fund ratios of privately owned banks during the study period hang around 16.9%. This was higher than the minimum ratio specified by NBE. This clearly implies that private banks are complying with the directive of NBE on the requirement of the capital base of commercial banks. The two sample independent t-test (Tab. 3) result showed that there is no significance difference between the two sectors with respect to CAR at 95% confidence interval.

4.1.3 Liquidity Ratio

The LDR is a major tool to examine the liquidity of a bank and measures the ratio of fund that a bank has utilized in credit out of the total deposit collected. Higher the LDR entail the effectiveness of the bank to utilize the fund it collected. As per the Tab. 1, column 4, the LDR of the state bank shows that their liquidity position was lower than that of the private banks average. There is no standard for LDR in commercial banks in Ethiopia.

The LDR of the bank was quite consistent over the past 7 years beginning from 2011–2017. Among the fifteen commercial banks BuIB was ranked first and state owned CBE was in the last position. In an average, the bank has been able to utilize half portion of the depositors fund in the form of credit. The average LDR of private banks was 59.80% higher than the state owned CBE which had 45.89% in the studied

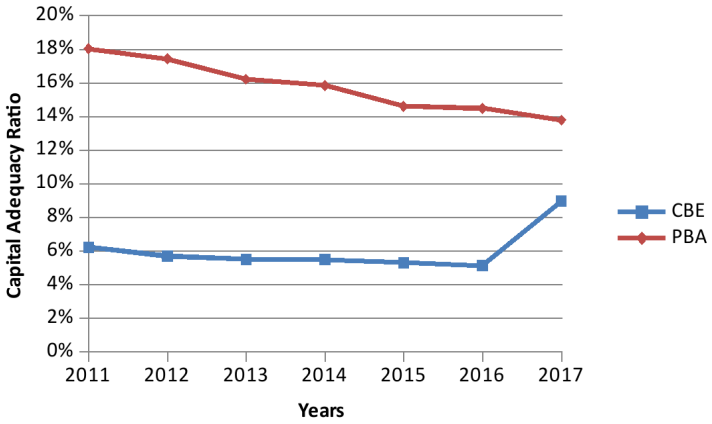

Fig. 3: CAR of state owned and private commercial Banks in Ethiopia

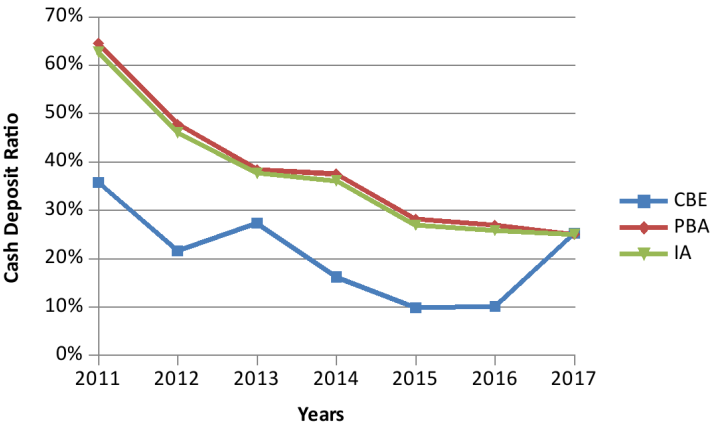

Fig. 4: CDR of commercial banks In Ethiopia

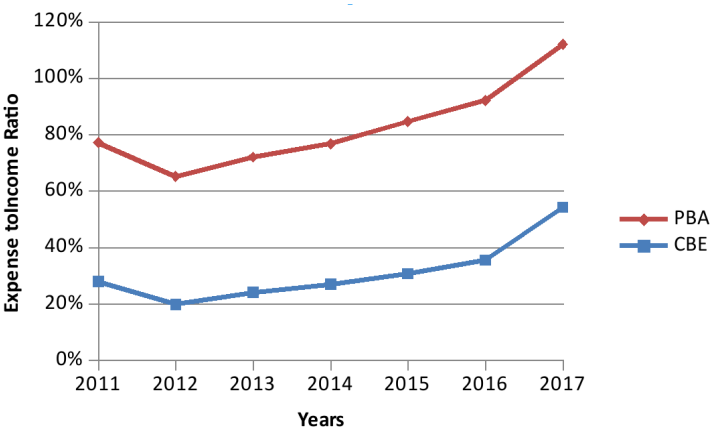

Fig. 5: EIR of state owned and private commercial Banks in Ethiopia

period average. In order to rank the banks, BuIB was the first one; it has an average LDR of 59.80%. The second position was for AdIB bank with LDR equalled to 66.43%, and the last position was belonged to CBE bank with 45.89%. It seems new private banks are efficient to utilize the funds collected as deposit. The independent two sample *t*-test of LDR reveal in Tab. 3, there is a significance difference between the groups in 95% level of confidence. The proper LDR is a delicate balance for banks. If banks lend too much of their deposits, they might overextend themselves, particularly in an economic downturn. However, if banks lend too few of their deposits, they might have opportunity cost since their deposits would be sitting on their balance sheets earning no revenue. Banks with low LTD ratios might have lower interest income resulting in lower earnings.

Other liquidity measure was CDR. Cash to deposit ratio is the ratio of how much a bank lends out of the deposits it has mobilized. It indicates how much of a bank's core funds are being used for lending, the main banking activity. It can also be defined as Total of Cash in hand and Balances with NBE divided by Total deposits. CDR is the amounts of cash balance branches maintain to meet their liabilities. As cash holding is very expensive, banks try to maintain minimum holding.

Tab. 1, column 5, shows that CDR of commercial banks in Ethiopia lie 20.07%–52.74%. From Tab. 2 and Fig. 4 shows in the study period 2011–2017 CDR of commercial banks in Ethiopia declined sharply. Among the fifteen commercial banks AdIB was highest CDR and state owned CBE was lowest CDR in average throughout the studied period. Further Fig. 4 implies that PBA was above CBE in the studied time intervals.

4.1.4 Efficiency Ratio

In this study the efficiency of the Bank's performance is measured by EIR and IETTL. Tab. 1, column 6, exhibits average IETTL of major commercial banks in Ethiopia for the period 2011–2017. The average IETTL of privately owned banks (4.67%) was found higher than that of state owned CBE (3.68%) the result imply that management of the private sector banks was the more efficient than state owned commercial banks in Ethiopia. Among the individual banks CBO (3.53%) management was the least efficient, whereas ZB (6.89%) management was the most efficient among the studied banks for the studied period.

For a bank, an efficiency ratio is an easy way to measure the ability to turn assets into revenue. The efficiency ratio for banks is calculated as expenses (not including interest) divided by revenues. Since a bank's operating expenses are in the numerator and its revenue is in the denominator, a lower efficiency ratio means that a bank is operating better. An efficiency ratio of 50% or under is considered optimal. If the efficiency ratio increases, it means a bank's expenses are increasing or its revenues are decreasing.

In the year 2011 to 2017 the major commercial banks in Ethiopia had an average EIR lies between 27.14% and 71.18%. Tab. 1, column 7 confer state owned CBE was the lowest EIR and AB had the highest average EIR in the studied period. The result reveal that CBE operating better than other commercial banks in Ethiopia. Fig. 5 unveil that operating EIR from the start 2012 sharply increasing this divulge noninterest expense grow faster than the total income.

4.2 Ranking of the Commercial Banks

Different commercial banks had different ranking based on each financial ratio related to ROA, ROE, CAR, EIR, IETTL, NIM, CDR and LDR (Tab. 1). Based on the bank return on assets, the higher rank was for ZB, which is a private bank, WB Bank, was the second and the last position belonged to AB, private bank. The state owned CBE was in the 8th position. Based on return on equity CBE belonged to first position, DB was second position and the lowest one was AB. Based on capital adequacy ratio AdIB was first position, AB was second position and last position belonged to CBE.

Based on the NIM, AIB was first position while NIB was second position and last position

Tab. 2: CDR of fifteen commercial banks in Ethiopia for the year 2011–2017

Bank	2011	2012	2013	2014	2015	2016	2017
CBE	35.69%	21.53%	27.28%	16.11%	9.79%	10.05%	25.18%
DB	52.58%	41.05%	38.24%	37.00%	27.91%	30.19%	18.91%
AIB	52.28%	31.89%	27.27%	33.65%	20.96%	19.27%	16.83%
BOA	47.67%	37.26%	23.20%	30.19%	25.95%	22.76%	16.61%
WB	69.51%	45.18%	33.98%	21.34%	24.79%	27.96%	27.85%
UB	58.68%	42.36%	25.57%	38.00%	23.07%	21.46%	18.02%
LIB	70.35%	59.83%	42.43%	42.05%	34.45%	22.07%	23.65%
CBO	61.46%	38.83%	69.95%	32.25%	31.53%	25.14%	19.07%
NIB	66.79%	46.77%	31.63%	24.18%	18.39%	23.97%	19.99%
ZB	60.82%	46.03%	36.67%	49.28%	30.19%	35.24%	36.28%
OIB	55.68%	41.69%	32.52%	37.26%	22.97%	22.98%	24.74%
BuIB	76.97%	44.67%	37.54%	41.53%	23.41%	23.27%	27.58%
BrIB	76.19%	57.76%	46.44%	48.79%	40.52%	29.39%	31.61%
AB	79.13%	59.96%	38.65%	34.17%	24.61%	23.34%	26.97%
AdIB	75.11%	75.11%	53.06%	54.43%	44.12%	49.11%	40.65%
Industry average (IA)	62.59%	46.00%	37.63%	36.02%	26.84%	25.75%	24.93%

Tab. 3: Independent t-test result of CBE (Group 1) and PBA (Group 2)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ROA	EVA	3.538	0.084	0.865	12	0.404	0.0016463	0.0019042	−0.0025025	0.0057952
	EVNA			0.865	9.068	0.410	0.0016463	0.0019042	−0.0026563	0.0059490
ROE	EVA	11.342	0.006	6.349	12	0.000	0.3912758	0.0616295	0.2569966	0.5255549
	EVNA			6.349	6.037	0.001	0.3912758	0.0616295	0.2406955	0.5418560
CDR	EVA	0.499	0.493	−2.719	12	0.019	−0.1746892	0.0642501	−0.3146782	−0.0347002
	EVNA			−2.719	10.521	0.021	−0.1746892	0.0642501	−0.3168917	−0.0324868
LDR	EVA	1.141	0.306	−6.565	12	0.000	−0.1458059	0.0222081	−0.1941932	−0.0974185
	EVNA			−6.565	11.560	0.000	−0.1458059	0.0222081	−0.1943984	−0.0972134
CAR	EVA	0.689	0.423	−12.465	12	0.000	−0.0972917	0.0078053	−0.1142981	−0.0802854
	EVNA			−12.465	11.668	0.000	−0.0972917	0.0078053	−0.1143519	−0.0802316
EIR	EVA	1.678	0.220	−4.388	12	0.001	−0.2019160	0.0460156	−0.3021754	−0.1016566
	EVNA			−4.388	8.024	0.002	−0.2019160	0.0460156	−0.3079725	−0.0958596
NIM	EVA	0.588	0.458	0.323	12	0.752	0.0011429	0.0035374	−0.0065646	0.0088503
	EVNA			0.323	11.176	0.753	0.0011429	0.0035374	−0.0066280	0.0089138
IETTL	EVA	8.528	0.013	−1.608	12	0.134	−0.0066571	0.0041407	−0.0156791	0.0023648
	EVNA			−1.608	6.544	0.155	−0.0066571	0.0041407	−0.0165885	0.0032742

Source: SPSS Result (EVA: Equal Variance Assumed, EVNA: Equal Variance Not Assumed)

belonged to ZB. Based on interest expenses to total loan, ZB was in the first position; DB was occupied second position while the last position was for CBO.

Based on cash to deposit ratio, the first position was for AdIB while BrIB was occupied the second position and CBE was in the last position. Based on loan to deposit ratio, BuIB was first position, AdIB was second position and last position belonged to CBE.

4.3 Independent Samples Test

The two-sample (independent groups) t-test is used to determine whether the unknown means of two populations are different from each other based on independent samples from each population. If the two-sample means are sufficiently different from each other, then the population means are declared to be different.

Tab. 3 reveal that from the studied performance measure ROA, NIM, IETTL ratios didn't show significance difference between state owned commercial bank and the private commercial banks average in the studied periods. In other variables like ROE, CDR, CAR, LDR and EIR there were a significance difference between the subsectors with 95% confidence intervals. Under column 9 and 10 of Tab. 3 the negative sign implied that the PBA performances were better than state owned commercial bank in Ethiopia in the studied period.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main objective of the study is to compare the financial performance of state owned commercial banks with privately owned commercial banks in Ethiopia. The study period covered the year 2011–2017 on which fifteen banks are considered. The study used secondary data which was gathered from the Banks annual financial reports.

Though financial ratios analysis compares the financial performance among commercial banks, the same bank had different ranks under the different financial ratios. Two profitability ratios (ROE, EIR) out of four profitability ratios (ROA, ROE, EIR, NIM) demonstrated statistically significant differences between CBE and PBA. However, in terms of practical aspects, the results showed that PBA was in the better situation in terms of two out of four profitability ratios which are (NIM and EIR). CBE was in the better situation in terms of two out of four profitability ratios which are ROA and ROE. This is because ROEs of state owned bank was higher than those of private banks due to having utmost low share holder equity. EIR and IETTL are the two efficiency measure in the study. The state owned CBE was lower EIR means the banks performed well. High overhead costs created high EIR for private sector banks. Interest expense to total loan (IETTL) of CBE is smaller compared with other privately owned banks. A higher ratio indicates that a company has a better capacity to cover its interest expense.

The values determined for CAR reveal that state owned CBE not so strong in Ethiopia to manage the possible large-scale shocks to their balance sheet. The CAR of CBE in the studied period doesn't satisfy the NBE requirement 8%.

From the studied eight performance indicators three (ROA, NIM, IETTL) of them have not significance difference between the two subsectors. For the remaining five we conclude that there are statistically significant differences between the groups as shown in Tab. 3.

5.2 Recommendation

This study compares the financial performance of commercial banks in Ethiopia over the period of 2011 to 2017. On the basis of the findings and conclusions reached, the following recommendations were forwarded.

Management of state owned banks should strive to improve returns on their asset investments as compared with private owned banks. Since return on asset is main parameter to measure financial performance of banks. On the other hand, private commercial banks managements should improve returns on their equity/capital investment as compared with state owned banks. In particular the newly established banks AB, BuIB and AdIB are below the standard 15%.

Managements of state-owned banks should strive to improve its capital adequacy ratio, interest expense to total loan ratio, net interest margin and loan to deposit ratio as compared with private banks.

Managements of private commercial banks should try to reduce its expense to income ratio as compared with state-owned banks. This can be done through decreasing general and administrative expenses or by improving revenue.

The problem of excess liquid asset of the banks should be handled with due attention. All studied Banks satisfy liquidity requirement directives No. SBB/57/2014. In order to utilize the excess liquidity, efficient fund management should be exercised by both private- and state-owned banks.

Generally, private banks performed by far better than state owned bank in Ethiopia. The two sample independent t-test result showed that there is a significance difference between the two sub-sectors on the studied financial performance measures except ROA, NIM, and IETTL. Finally, the study provides bank managers with understanding of activities that would enhance their banks financial performances. The results of this study imply that it might be necessary for a bank management to take all the required decisions to enhance the financial positions of the bank.

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THE EFFECTS OF SHORT SELLING ON FINANCIAL MARKETS VOLATILITIES

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ABSTRACT

The paper investigates the relationship between short selling activities of stocks on the volatility of the US market and its sectors. We apply the multivariate DCC GARCH Model on the NYSE US 100 Index between November 2017 and October 2018. We find evidence that investments in some specific firms on the market reduce the market volatility and higher short selling activities reduce risk in the market. The study also finds that firms in the financial sector dominate the market and short selling activities in this sector has a greater impact on the market volatility. We also find portfolio managers to be better off investing in the market than creating portfolio within sectors.

KEY WORDS

short selling, market volatility, dynamic conditional correlation

JEL CODES

C58, G12, G15

1 INTRODUCTION

The activities of short sellers in financial markets were largely criticized and argued to be one of the factors which caused the financial crises of 2007/2008 as the practice aggravated market volatility and in extreme cases destabilised the market (Jain et al., 2013). Short sellers were also argued to be manipulators of stock prices during the crises (McGavin, 2010). This led to a ban on short selling that was later lifted in some markets and strict regulations were introduced in attempts to reduce volatility and strengthen the weakening market. This paper follows these literatures and investigates the effect of short selling on the financial markets after the crisis (Bohl et al., 2016; Deng and Gao, 2018; Sobacı et al., 2014).

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Short selling still remains a very risky and aggressive investment strategy used by traders in the financial markets. In cases when large number of traders and investors decide to short a particular stock, their actions impact on the stock prices. Several companies have blamed the activities of short selling for the price decline in their stock and also criticized as short seller profit only when companies are performing poorly (Desai et al., 2002). Angel and McCabe (2009) argues short selling creates incentives for illegal activities in the financial markets such as the spread of false information. Short selling remains controversial and regulators have enacted several bans on different occasions to regularize the practice to avert crises. However, the practice still continues to be a major contributing factor in any financial crises.

We follow Baklacı et al. (2016) by focusing on the effect of short selling on the various sector of the market (10 sectors of the US economy). Especially, we show that the financial sector dominates the market with more companies that affect the volatility. The results of the DCC-GARCH estimates indicates just about 15.97% of firms directly affects the volatility of the market. We find that investment in specific companies listed in the NYSE US 100 Index decrease the volatility of the market. Our results also show only two sectors; industry and consumer staples have some specific companies that increase the volatility of the market. On the contrarily, the financial, the financial, materials, health care, energy and consumer discretionary sectors consists of companies that reduce the market volatility.

The remainder of the paper is structured as follows. Section 2 gives analysis of existing literature on short selling activities. Section 3 provides the data and methodology. Section 4 provides the empirical results of the study and the section 5 concludes.

2 LITERATURE REVIEW

Short sellers borrow and sell shares in an anticipation of falling share prices. Short interest is derived from the short selling trading activity. It is expressed as a percentage of the short sale of shares to the shares outstanding. Short sellers were identified as one of the key triggers of the recent financial crises commencing in 2008 (McGavin, 2010).

The collapse of Lehmann Brothers in September, 2008 led to the emergency ban on short selling by the regulator; Securities and Exchange Commission (SEC) which caused a wider impact of falling stocks. Other countries such as Australia, Britain, Canada, Germany, Ireland, Portugal and Taiwan also imposed restrictions on short selling. These restrictions have been extensively studied in existing literature (Alves et al., 2016; Boehmer et al., 2013; Boehmer and Wu, 2013; Beber and Pagano, 2013). Imposing constraints on short selling activities can lead to overvaluation which makes it hard for securities prices to reflect on negative market information (Miller, 1977; Hong and Stein, 2003; Chen et al., 2002). The removal of these constraints can reduce stock crashes as argued by Hong and Stein (2003). Bris et al. (2007) conclude market returns are significantly negatively skewed when constraints are put on short selling while Beber and Pagano (2013) argues liquidity decreases and slows the price discovery process.

There are several literatures that focus on short interest and the activities short selling with opposing arguments. While some do find good and positives in this trading strategy by complicated investors, others have criticized their activities. Miller (1977) who was the originator of short selling argued on price discovery impairment as a result of negative information of the markets due to short sale constraints. Bianchi and Drew (2012) argue positively for short selling as it can be employed as a hedging tool.

Woolridge and Dickinson (1994) show short sellers enhance market liquidity by buying back the shares when prices fell. Warren Buffet a well know Wall Street tycoon also believes short

selling help in identifying fraudulent corporate activities and is very key in forensic accounting (Bianchi and Drew, 2012).

The aftermath of the financial crises resulted in several literature criticizing the short selling strategy with tighten laws by the Securities and Exchange Commission to check the activities of short selling. Their argument was that short selling could artificially depress prices and weaken market efficiency. Several researchers have considered short selling as a market manipulative activity. Short sellers negatively affect the financial market by increasing volatility and instability while beneficial by increasing efficiency and price discovery (Henry et al., 2015; Feng and Chan, 2016). Henry and McKenzie (2006) find market display greater volatility after a period of short selling while Cáceres et al. (2015) conclude volatility can be reduced by imposing constraints on short selling activities.

Literature on short selling suggests short sales contributes to efficiency in the stock markets (Boehmer et al., 2008; Chang et al., 2014; Boehmer and Wu, 2013; Cohen, 2010; Saffi and Sigurdsson, 2011; Chen and Rhee, 2010; Zhao et al., 2014) as it corrects the mis-pricing in stock. However, the constraints placed on short selling activities have been concluded by several researchers to decrease market liquidity resulting and in higher volatility and poor market quality (Boehmer et al., 2013; Sobacı et al., 2014; Wang et al., 2013; Lee and Piqueira, 2017).

This paper contributes to the existing literature on short selling and focus on the impact of short selling activities on the various sector of the US economy and the individual listed stocks on the market volatility. To our best of knowledge, no literature has focus on the sector impact of short selling activities on the market volatility.

3 METHODOLOGY AND DATA

We build a daily frequency time series data comprising of short selling volumes, listed stock prices and prices for the market represented by the stock index. The short selling data are mainly retrieved from the Financial Industry Regulatory Authority (FINRA) website. The study uses 95 listed firms in the NYSE US 100 Index. The firms are categorized into 10 sectors of the US economy; Communication, Consumer Discretionary, Consumer Staples, Energy, Financials, Health Care, Industries, Materials, Technology and Utilities. The data of the NYSE US 100 Index and prices of all the companies are retrieved from the NYSE website which are published daily. The dataset consists daily log returns in the period November, 2017 – October, 2018 (23,562 obsevations)

The daily log returns for the firm i on dat t is given as

$$r_{it} = \ln \frac{p_{it}}{p_{it-1}}, \tag{1}$$

where p_{it} and p_{it-1} are the closing prices of the firms and index for days t and $t-1$, respectively.

To identify the impact of short selling on the volatility of the market, we employ the multivariate Dynamic Conditional Correlation (DCC) Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model that identifies stock markets volatility spillovers across different markets proposed by Engle (2002). The model has the flexibility of the univariate GARCH models coupled with parsimonious parametric models for the correlations (Engle, 2002).

The conditional correlation matrix of the DCC GARCH as proposed by Engle (2002) expressed as

$$H_t = D_t R_t D_t, \tag{2}$$

where D_t is the diagonal matrix of conditional variances defined, R_t is the $n \times n$ correlation matrix defined as

$$R_t = \text{diag}\,(Q_t)^{-\frac{1}{2}}\, Q_t\, \text{diag}\,(Q_t)^{-\frac{1}{2}}, \tag{3}$$

where diag (A) denotes a matrix with diagonal equal to the diagonal of A.

$$Q_t = \hat{Q}(1-\alpha-\beta) + \alpha\varepsilon_{t-1}\varepsilon'_{t-1} + \beta Q_{t-1}, \tag{4}$$

where ε_t is the vector of standardized returns, $\varepsilon_{it} = \frac{r_{it}}{\sigma_{it}}$, α and β are scaler, $\hat{Q} = \frac{1}{T}\sum_{t=1}^{T} \varepsilon_t \varepsilon_t'$ with $\alpha, \beta > 0$ and $\alpha + \beta < 1$. $\hat{Q}$ represent the $n \times n$ unconditional matrix for the short selling volumes of the firms i and Q_t represent the conditional volatility of the NYSE US 100 Index.

The logarithm of the likelihood function of the DCC GARCH model is

$$\ln L = -\frac{1}{2}\sum \left(T \ln(2\pi) + 2|D_t| + \right.$$
$$\left. + \ln |R_t| + \varepsilon' t R_t^{-1} \varepsilon_t \right). \quad (5)$$

Thus, positive conditional volatility provides empirical evidence of volatility persistence in the market.

4 RESULTS

In order to investigate the relationship between the Volatility of the NYSE US 100 Index and short selling volumes of the equities, we evaluate the estimates of DCC GARCH for all 95 companies. Out of the 95, only 19 companies showed significant impact on the volatility of the index as shown in the Annex. These 19 companies are re-evaluated to show the actual impact of short selling trades on the conditional volatility. The estimates in Tab. 2 indicate 15 companies have impact at 5% and 10% levels of significance on the volatility of the index.

The estimates also indicate just about 15.97% of the firms significantly affects the conditional volatility of the index. We proceed to perform the sector analysis of the effect of short selling on the market. The initial results reveal short selling activities of companies in the technology and communication sectors on the NYSE US 100 has no impact of market volatility and the respective sectors. The utilities sector in the index consist of three companies. The Southern Company (SO) with coefficient of (0.0002) has little or no significant impact at of the market volatility. Hence, we conclude short selling activities has no effect on the market volatility.

The material sectors consist of 7 companies. Two companies Alcoa Corporation (AA) and Freeport-McMoRan Inc (FCX) with coefficients -0.0006 and -0.0007 are both significantly at 5% and 10% respectively. These companies have negative relation to the market volatility; thus, they reduce the market volatility. Alcoa Corporation in additional also reduce the volatility of the sector. We conclude the materials sector on the NYSE US 100 index reduce the market volatility.

The health sector consists of 12 companies representing 12.60% of the market. Danaher Corporation (DHR) is the only significant companies in the health sector with coefficient 0.0002. This indicates a positive relationship between the sector and the market implying the sector increase the volatility of the market. No company however significantly affects the volatility of the sector.

The market is dominated by the financial sector which represent 22.10% consisting of 21 companies. Berkshire Hathaway Inc. (BRK-B), Mastercard Incorporated (MA), Prudential Financial Inc. (PRU), Simon Property Group Inc. (SPG) and U.S. Bancorp (USB) are all companies that affect the volatility of the market. The coefficients -0.0015, 0.0008, -0.0005, -0.0002 and -0.0005 respectively are all significant at 5% and 10% levels. Mastercard Incorporated (MA) increase the volatility of the market while the remaining companies significantly reduce market volatility.

The energy sector consisting of 13 companies has just Devon Energy Corporation (DVN) with coefficient -0.0004 significant affecting the volatility of the market. It reduces the market volatility while increasing that of the energy sector. The consumer discretionary sector also consists of 8 companies with Ford Motor Company (F) and Las Vegas Sands Corporation (LVS) with coefficients -0.0016 and 0.0010 at 5% and 10% significant levels respectively affect the volatility of the market. Ford Motor

Tab. 1: DCC-GARCH Estimates

Comp.	NYSE US 100 Index	Utilities	Materials	Industries	Health Care	Financials	Energy	Consumer Discretionary	Consumer Staples
SO	0.0002	0.0002							
	(0.0003)	(0.0004)							
AA	−0.0006*		−0.0008*						
	(0.0002)		(0.0003)						
FCX	−0.0007**		−0.0008						
	(0.0003)		(0.0004)						
UNP	0.0003**			0.0001					
	(0.0001)			(0.0010)					
DHR	0.0002**				−0.0004				
	(0.0001)				(0.0002)				
MDT	−0.0003				−0.0001				
	(0.0002)				(0.0002)				
ALL	0.0001					0.0001			
	(0.0001)					(0.0001)			
BRK-B	−0.0015**					−0.0016*			
	(0.0007)					(0.0008)			
MA	0.0008**					0.0008**			
	(0.0005)					(0.0005)			
PNC	−0.0006					−0.0004*			
	(0.0002)					(0.0002)			
PRU	−0.0005*					0.0003**			
	(0.0002)					(0.0002)			
SPG	−0.0002*					−0.0002*			
	(0.0001)					(0.0001)			
USB	−0.0005**					−0.0003			
	(0.0002)					(0.0003)			
V	0.0015*					0.0008			
	(0.0006)					(0.0007)			
DVN	−0.0004**						0.0004**		
	(0.0002)						(0.0002)		
MRO	0.0005						0.0001		
	(0.0003)						−0.0004		
F	−0.0016*							−0.0019*	
	(0.0006)							(0.0006)	
LVS	0.0010**							0.0007**	
	(0.0003)							(0.0004)	
WBA	0.0003**								0.0000
	(0.0001)								(0.0001)
α	0.0013*	0.0001	0.0008	0.0006	0.0007	0.0002*	0.0002	0.0010	0.0005
	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
β	0.0000*	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*	0.0001*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	228	228	228	228	228	228	228	228	228
Number of Companies in Sector	95	3	7	13	12	21	13	8	11

Note: * and ** denotes statistical significance at 5% and 10% levels, respectively.

Company has a reducing impact while LVS increase the volatility. Both companies have similar effect within the volatility of the sector.

The results of the estimates show significance evidence that the market volatility is impacted by some specific companies. Most of these companies significantly reduce the volatility. We interpret these results as higher short selling activities reduce the uncertainties in the market.

Tab. 2: DCC GARCH Estimates for the Holiday Effect on the Market Volatility

Companies	**NYSE US 100 Index**	**from 01.11.2017 to 23.12.2007**	**from 02.01.2018 to 25.05.2018**	**from 29.05.2018 to 03.07.2018**	**from 05.07.2018 to 28.09.2018**
SO	0.0002	0.0009*	0.0012	−0.0022	0.0001
	(0.0003)	(0.0004)	(0.0011)	(0.0024)	(0.0003)
AA	−0.0006*	−0.0003	−0.0005**	0.0024*	−0.0005*
	(0.0002)	(0.0004)	(0.0005)	(0.0011)	(0.0002)
FCX	−0.0007**	0.0004	−0.0007*	−0.0049*	−0.0006**
	(0.0003)	(0.0006)	(0.0005)	(0.0019)	(0.0005)
UNP	0.0003**	0.0002*	−0.0003	0.0017	0.0002
	(0.0001)	(0.0001)	(0.0003)	(0.0013)	(0.0003)
DHR	0.0002**	−0.0001	0.0002*	0.0012**	0.0000
	(0.0001)	(0.0002)	(0.0001)	(0.0008)	(0.0005)
MDT	−0.0003	−0.0002	−0.0006	−0.0013	0.0002
	(0.0002)	(0.0002)	(0.0003)	(0.0010)	(0.0003)
ALL	0.0001	0.0002**	−0.0010	0.0006*	0.0004*
	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0001)
BRK−B	−0.0015**	0.0021*	−0.0030*	0.0010	0.0010**
	(0.0007)	(0.0008)	(0.0016)	(0.0020)	(0.0006)
MA	0.0008**	−0.0008	0.0035*	0.0005	0.0014**
	(0.0005)	(0.0005)	(0.0012)	(0.0011)	(0.0006)
PNC	−0.0006	−0.0015*	−0.0002*	0.0011	−0.0002*
	(0.0002)	(0.0003)	(0.0006)	(0.0012)	(0.0003)
PRU	−0.0005*	0.0003*	−0.0003*	0.0003	0.0000
	(0.0002)	(0.0001)	(0.0003)	(0.0007)	(0.0004)
SPG	−0.0002*	−0.0001	−0.0001*	−0.0001*	−0.0011*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0006)
USB	−0.0005**	−0.0002	−0.0009**	0.0004	0.0005
	(0.0002)	(0.0002)	(0.0006)	(0.0004)	(0.0007)
V	0.0015*	−0.0004	0.0008	0.0023	−0.0002
	(0.0006)	(0.0007)	(0.0010)	(0.0019)	(0.0008)
DVN	−0.0004**	−0.0021*	−0.0004**	0.0004	0.0000
	(0.0002)	(0.0005)	(0.0003)	(0.0011)	(0.0004)
MRO	0.0005	−0.0001	0.0005	0.0019	0.0009
	(0.0003)	(0.0003)	(0.0005)	(0.0020)	(0.0006)
F	−0.0016*	0.0003	−0.0014*	−0.0128*	−0.0010*
	(0.0006)	(0.0009)	(0.0009)	(0.0039)	(0.0006)
LVS	0.0010**	0.0007**	0.0020*	−0.0015	0.0000
	(0.0003)	(0.0004)	(0.0006)	(0.0015)	(0.0003)
WBA	0.0003**	0.0007**	0.0000	0.0005**	0.0011**
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.00003)
α	0.0013*	0.0011*	0.0019**	−0.0015	0.0003
	(0.0006)	(0.0005)	(0.0012)	(0.0015)	(0.0006)
β	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	228	40	91	26	60

Note: * and ** denotes statistical signifincance at 5% and 10% respectively.

4.1 Robustness Analysis

We run a robustness analysis to confirm the effect of short selling activities of the various sectors of the market. We divide our data in 4 distinct time periods (Period 1: 01/11/2017–23/12/2017; Period 2: 02/01/2018–25/05/2018; Period 3: 29/05/2018–03/07/2018; Period 4:

05/07/2018–28/09/2018). These periods are selected based on 3 important market holidays where the NYSE is closed for activities. The dates; 01/01/2018, 28/05/2018 and 04/07/2018 represent the New Year's Day, Memorial Day and Independence Day. The holiday effect has widely studied in literature with many researchers concluding of investors achieve significant abnormal returns on day prior to the holiday and around the holiday (Gama and Vieira, 2013; Casado et al., 2013).

The estimates for the various periods are consistent with our results that some specific firms affect the volatility of the market. While the firms in Period 1 indicate the increase in market volatility, firms in periods 2, 3 and 4 show a significant effect of short selling activities decreasing volatility. We interpret these results as short selling reducing the risk of investors during holiday periods which can results in abnormal returns on investments.

5 DISCUSSION AND CONCLUSIONS

This paper investigates the impact of short selling activities of stocks on a single index (NYSE US 100 Index) in the US market using DCC GARCH model proposed by Engle (2002) and focuses on the impact of the various sectors. The results of the DCC-GARCH estimates indicates just about 15.97% of firms directly affect the volatility of the market which is dominated by the financial sector. We find evidence that investments in specific companies listed on the NYSE US 100 Index decrease the volatility of the market. The sector analysis shows the technology and communication sector have no effects on the market, while the utility sector has an insignificant impact.

The industry and consumer staples sectors estimate show weak positive impact on the market by increasing the volatility. The financial, materials, health care, energy and consumer discretionary sectors estimates show a strong significant negative impact of the market. Short selling activities of these sectors reduce the market volatility. These results are consistent with literature (Sobacı et al., 2014; Cáceres et al., 2015) who conclude short selling activities is associated with decreased market volatility These results show short selling reduces the risk on investments which can lead to higher returns.

The sector analysis also indicates portfolio managers may achieve higher returns by investing in the market rather than creating portfolio within sectors. The implication of our results is that investors can use short selling as a hedging tool to reduce their risk exposure (Bianchi and Drew, 2012). Portfolio managers can also increase their short positions in the identified specific firms that reduce market volatility in their portfolios. In so doing, the investors are expected to achieve higher returns with minimal risk.

The findings of this paper include implications for the regulatory bodies. The results show the need for closer monitoring of short selling activities on sector to sector basis. This will give the regulators informed knowledge of how the activities of short selling in the sectors affect the market volatility. This may lead to specific regulations on short selling on the sectors.

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8 ANNEX

Tab. 3: Descriptive Statistics

Company	Ticker	Observ.	Mean	Standard Deviation	Skweness	Kurtosis
NYSE US 100 Index	NYSE US 100	228	0.0004	0.0080	−1.5701	7.0167
Alcoa Corporation	AA	228	0.5369	1.9180	4.6398	30.6408
Abbott Laboratories	ABT	228	0.3889	1.4158	4.1058	26.7986
Allergen Plc	AGN	228	0.8846	7.0292	14.1107	209.6982
American Int. Group Inc	AIG	228	0.9734	3.7736	8.0074	87.0814
The Allsate Corporation	ALL	228	1.3515	4.5443	5.3011	37.3938
Apache Corporation	APA	228	0.6245	2.2598	4.4820	27.0461
American Express Company	AXP	228	0.6846	2.7965	6.5989	58.2335
The Boeing Company	BA	228	0.2325	0.8862	2.2958	8.2884
Bank of America Corporation	BAC	228	0.1391	0.7173	4.6903	35.9234
Baxter Int. Inc.	BAX	228	1.1379	4.0505	5.3619	36.3035
Franklin Resources Inc.	BEN	228	1.4121	4.4205	5.1403	34.7487
Baker Hughes, a GE Comp.	BHGE	228	2.1770	6.8890	4.8149	29.2364
Bank of New York Mellon Corp.	BK	228	1.1482	4.4860	8.8064	103.0218
Bristol-Myers Squibb Comp.	BMY	228	0.9431	3.5654	6.7857	63.7279
Berkshire Hathaway Inc.	BRK-B	228	0.1775	0.7284	1.7689	4.1321
Citigroup Inc.	C	228	0.1774	0.7135	1.8681	6.4646
Caterpillar Inc.	CAT	228	0.2926	1.2894	5.2704	41.1698
Carnival Corp. and Plc	CCL	228	1.5068	5.1807	5.4310	37.5457
Colgate-Palmolive Comp.	CL	228	0.6071	2.6332	8.4144	94.4828
ConocoPhillips Comp.	COP	228	0.4247	1.4258	3.7604	24.2763
CVS Health Corporation	CVS	228	0.4750	1.9699	4.9242	31.6639
Chevron Corporation	CVX	228	0.2587	0.9566	2.5798	11.4795
Dominion Energy Inc	D	228	0.6042	2.5280	5.2735	35.0977
Deere & Company	DE	228	0.5817	2.0292	4.8663	33.6324
Danaher Corporation	DHR	228	1.2928	7.0014	12.2490	171.0975
The Walt Disney Company	DIS	228	0.4764	1.6033	2.9833	10.7316
Devon Energy Corporation	DVN	228	0.5446	2.2615	7.4144	78.9532
DowDuPont Inc	DWDP	228	0.3272	1.4622	5.5482	40.4393

(to be continued on the next page)

Company	Ticker	Observ.	Mean	Standard Deviation	Skweness	Kurtosis
Emerson Electric Co.	EMR	228	0.4803	1.4509	2.5175	9.0955
Exelon Corporation	EXC	228	0.6346	2.3332	6.6071	65.1775
Ford Motor Company	F	228	0.2027	0.8076	2.2358	7.9205
Freeport-McMoRan Inc.	FCX	228	0.3370	1.3267	4.6997	35.6298
FedEx Corporation	FDX	228	0.3590	1.1608	2.1338	5.7998
General Dynamics Corp.	GD	228	0.7499	2.5196	3.8844	18.8370
General Electric Company	GE	228	0.2056	0.9147	3.4481	17.6822
General Mills Inc.	GIS	228	1.0489	6.5228	10.7920	133.7067
Corning Incoporated	GLW	228	0.7764	2.5720	4.1948	23.2962
The Goldman Sachs Gp. Inc.	GS	228	0.2942	1.1780	3.1931	13.1642
Halliburton Company	HAL	228	0.5320	1.8499	3.6611	17.0124
The Home Depot Inc	HD	228	0.2546	0.9474	2.3399	8.2559
The Hartford Financial Serv. Gp. Inc	HIG	228	4.9213	30.0093	12.7951	181.1323
Honeywell Int. Inc.	HON	228	0.4577	1.6132	3.5479	16.1143
HP Inc.	HPQ	228	0.6467	2.7417	7.6981	81.1854
International Business Machines Inc.	IBM	228	0.4355	1.9897	6.1912	47.4994
Illinois Tool Works Inc.	ITW	228	0.7481	2.3411	3.2708	13.5643
Johnson & Johnson	JNJ	228	0.3163	1.6948	8.2404	87.0857
JPMorgan Chase & Co.	JPM	228	0.1793	0.8054	4.1604	33.5679
Kimberly-Clark Corp.	KMB	228	1.0067	4.4536	10.1645	128.6628
The Coca-Cola Comp.	KO	228	0.3528	2.0394	11.0653	148.5944
Eli Lilly & Company	LLY	228	1.4756	7.9620	10.4659	128.3707
Lockhead Martin Corp.	LMT	228	0.5486	2.1227	6.4006	61.0188
Lowe's Companies Inc.	LOW	228	1.0057	5.5972	11.8312	162.2424
Las Vegas Sands Corp.	LVS	228	0.4280	1.4578	3.2543	14.6972
Mastercard Incorporated	MA	228	0.2637	1.0827	3.2435	14.0641
McDonald's Corporation	MCD	228	0.3733	1.3201	3.2586	16.5784
Medtronic Plc	MDT	228	0.6816	2.3666	4.1833	23.3725
Metlife Inc.	MET	228	0.6079	2.3375	5.1764	34.1693
3M Company	MMM	228	0.5496	2.4588	6.7302	55.7211
Altria Group Inc.	MO	228	0.4795	1.6395	3.4215	15.0424
Merck & Co. Inc.	MRK	228	0.4262	1.5699	3.7837	19.2646
Marathon Oil Corporation	MRO	228	0.4664	1.5105	3.1944	14.0376
Newmont Goldcorp Corp.	NEM	228	0.3833	1.3325	3.2491	15.3863
Morgan Stanley	MS	228	0.6023	2.5606	6.8809	61.9066
NIKE Inc.	NKE	228	0.4904	1.9572	6.7376	68.7425
National Oilwell Varco Inc.	NOV	228	1.7107	5.6369	4.9545	31.4586
Occidental Petroleum Corp.	OXY	228	0.6639	2.0228	3.1094	12.3648
PepsiCo Inc	PEP	228	0.4746	1.7568	5.7040	51.8705
Pfizer Inc.	PFE	228	0.2658	0.9673	2.2473	7.0353
The Procter & Gamble Comp.	PG	228	0.2107	0.9664	4.0460	25.9584
Phillip Morris Int. Inc	PM	228	0.8479	4.2294	9.7834	118.6667
The PNC Financial Serv. Gp. Inc.	PNC	228	0.8002	2.6910	6.1058	55.5829

(to be continued on the next page)

Company	Ticker	Observ.	Mean	Standard Deviation	Skweness	Kurtosis
Prudential Financial Inc.	PRU	228	0.8393	3.3744	7.0599	64.8173
Parxair Inc	PX	228	1.5967	7.7090	10.6377	135.3735
Transocean Ltd	RIG	228	0.4539	1.6658	3.8882	19.6857
Southern Copper Corp.	SCCO	228	7.7544	89.4463	14.8863	225.6449
Schlumberger Limited	SLB	228	0.3963	2.3047	11.0576	147.2325
The Southern Company	SO	228	0.3508	1.4947	6.6216	67.4193
Simon Property Gp. Inc.	SPG	228	1.5911	6.5436	6.3743	47.6210
AT&T Inc.	T	228	0.2440	1.1947	5.1862	38.6297
Target Corporation	TGT	228	1.1136	7.4573	13.4661	196.1881
The Travelers Companies Inc.	TRV	228	14.5316	206.4652	14.9941	227.8767
Texas Instruments Incorporated	TXN	228	0.5456	2.0935	4.8437	31.9162
UnitedHealth Group Incorporated	UNH	228	0.3475	1.4912	5.0394	34.1646
Union Pacific Corporation	UNP	228	0.9456	3.6617	6.8243	59.2131
United Parcel Services Inc.	UPS	228	0.4944	1.9285	5.2898	40.7156
U. S. Bancorp	USB	228	0.5314	2.0446	5.2454	38.8063
United Technologies Corp.	UTX	228	0.6025	2.1980	4.0998	21.7327
Visa Inc.	V	228	0.2111	0.8914	3.0551	15.1551
Valero Energy Corp.	VLO	228	0.3965	1.4635	3.4111	16.8235
Verizon Communications Inc.	VZ	228	0.2101	1.0384	5.6211	48.6167
Walgreens Boots Alliance Inc.	WBA	228	0.9621	3.6803	5.3788	34.6242
Well Fargo & Company	WFC	228	0.5124	1.9614	4.1591	20.4456
Walmart Inc.	WMT	228	0.4184	1.9514	5.8811	44.7787
Exxon Mobil Corporation	XOM	228	0.2159	0.9073	3.2684	15.6107
YUM Brands Inc.	YUM	228	1.8752	7.8740	7.0996	61.6398

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