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Comparing and Improving the Performance of Multinational Subcontractors in Metalworking – A Comparative Case Study

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Abstract
Companies aim to stay competitive while ensuring that subcontracting networks play a key role. This study examines multinational subcontractors to identify factors affecting competitiveness, comparing countries with different income levels. Salary costs are generally expected to directly impact product prices. The study's goal is to find measures that highlight development targets and methods to improve productivity for both customers and subcontractors. In addition to component price, the research examines service delivery and quality indicators that influence the customer's competitiveness. Profitability depends on identifying development areas that impact overall competitiveness. However, deficiencies in the production engineering development activities of the subcontractors were found, which could have improved their competitiveness. Results also showed that the primary factor influencing the customer's purchasing decision was component price, often leading to orders being placed outside Finland, due to lower costs. This underscores the need for subcontractors to focus on total overall productivity to maintain a competitive advantage in global markets.

Keywords
Competitiveness, Production engineering, Productivity, Quality, Delivery accuracy.

Introduction

Non-value-adding work in subcontracting consists of costs which are discussed in this paper in terms of component quality and delivery reliability, leading to repairs, waiting for late deliveries, and storage costs due to premature deliveries, all of which have a negative impact on competitiveness. The phenomenon is commonly seen around the world.

This study focuses on comparing manufacturing competetiveness between three Finnish companies and their European competitors. Labor cost is one of the assumed factors that may weaken the competitiveness of Finnish industry with companies from countries with the lowest labor costs. There are, however, factors that can be used to maintain a competitive advantage against countries with the cheapest labor costs, such as work automation, new technologies, such as Industry 4.0, as databased business architecture with robotics, automation and IoT. However, there are still craft-dominated companies in the Finnish metal industry as well as in competitor countries, where the production is project-type one-piece industrial production or small batch production. According to studies, there are challenges in the development of work productivity in the metal industry (e.g. Suomen virallinen tilasto, 2024).

The companies have not focused enough on the reduction of non-value-adding activities that weaken competitiveness because they have obviously not been identified (Carreira, 2005). In addition, the availability of professional labor in the metal industry brings additional challenges (Media Potentia Oy, 2021; Teollisuusliitto, 2021). The customer's and subcontractor's understanding of the benefit and need for development activities seems unclear. Possibly joint development is perceived as too difficult and challenging, which requires persistence and new learning and understanding of development methods.

This article studies a pairwise comparison of three metal manufacturing processes. These are weldable structures, weldable plate structures, and weldable sheet metal structures. For each manufacturing process, two companies are compared in terms of productivity-related key performance indicators.

The objective of this study has been to compare performance of multinational subcontractors and identify development areas which have an essential impact on the competetiveness of the supplier network partners.

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The research question of the article is as follows: In what ways can the competitiveness of subcontractors be improved in the supply network?

The data for this comparative study has been collected from supplier network partner systems. Collected data has been analyse statistically in this research. This has been more thoroughly introdused in section Materials & Methods.

Based on the results it has been pointed out an idea of development targets and methods that may affect the better productivity of both the customer and the subcontractors.

The concept of productivity in this article is labor productivity at the national level as a ratio of GDP to hours worked (OECD, 2024). The research also seeks an answer to how information from the main contractor's information systems can be utilized when evaluating subcontractors' performance.

Literature review

In global competition, as the level of requirements increases, companies are looking for value in their subcontracting networks for the components they purchase by reducing costs and increasing value (Morris & Pinto, 2007).

According to da Silveira's research results, manufacturers who consider costs more important continue to invest in offshore deliveries (da Silveira, 2014). In countries with cheap labor used by multinational companies, there is an increase in labor costs, but also at the same time a development in manufacturing and an increase in the ability to innovate (Moavenzadeh et al., 2012).

On the other hand, back shoring is a growing industry trend; as was observed in the United States in 2022, a historic number of jobs and subcontracting networks returned (Brown et al., 2022). The threat to the European Union's competitive position is the low productivity level, the cause of which is by no means labor costs, the importance of which, however, cannot be completely excluded because it is a useful indicator for monitoring the country's competitiveness (Ark et al., 2005). Despite everything, labor costs are a guiding factor in choosing a subcontractor, such as in Johansson & Olhager (2018), where a study on Swedish industrial manufacturing shows that labor costs are the dominant factor behind offshoring decisions. There are different views on Finland's competitiveness. According to Haaparanta (2013, pp. 2–11), cost-based salary increases would not have eaten away at Finland's competitiveness, but the reason for the weakening of competitiveness would be weak management skills. On the other hand, Maliranta and Vihriälä (2013) do not agree with the weak level of competitiveness of business management, but rather see the costs brought by unit labor costs as the reason. High labor costs are often considered to limit productivity (Borg & Vartiainen, 2015). According to Chew (1988) the matter can be looked at from another point of view, where productivity is not limited by high salary costs, but by the inordinately low productivity of employees in relation to salary. However, the most significant motivational factors for the outsourcing of Finnish companies abroad in 2018–2020 were the reduction of labor costs (Tilastokeskus, 2022).

Part 1 Development work related to competitiveness

Subcontracting productivity development activities should be reflected in price competition, quality and service ability, which includes timely deliveries. In addition, factors affecting quality and performance in the subcontracting network include, for example, the ability of production processes, management and delivery time (ee, e.g., sBen Mabrouk et al., 2020; George & Pillai, 2019). The purpose of the quality assurance program is to ensure that the production process achieves the agreed quality goals (Sihombing & Sumurung, 2023).

Basically, challenges arise in the application of various quality management techniques, and the root cause of the problem remains unidentified. Challenges include gaps in understanding the benefits of the methods, a lack of employee training in the application of said methods, a lack of understanding of when, where and why these methods should be applied and how, in addition to poor data collection methods without planning and lack of management commitment and support (Antony et al., 2021).

However, Chew (1988) states that not all the people who make daily decisions can define what it means to improve the productivity of production facilities. In his article, Ketchum (1986) shows how productivity can be improved by focusing on the content of doing work by utilizing the unused potential of human resources. In this case, with the help of properly measured and available data analysis, it can be found, for example, that the most productive employee is not necessarily the employee with the most working hours (PR Newswire Association LLC, 2021). In addition, active management helps employees perform their tasks faster by monitoring whether they follow best practices or do unnecessary tasks and encounter obstacles that have not previously been considered. Supervisors should guide their subordinates to work smarter and not harder.

However, changing the work culture from manager to coach has been found to be difficult (Stahl, 2013, pp. 74–91). Productivity growth is not sought by working harder or longer working hours (Harris, 1999, pp. 32–43). Andresen & Kleiner (2005, pp. 32–43) state that smarter working methods leading to better job satisfaction have a direct connection to more efficient productivity. If, in addition to joint development, the subcontractor does not develop its operations and the main contractor does not develop the component and its manufacturability, the effect is seen as a weakening of competitiveness (Häkkinen, 2004).

The coordination costs of subcontracting also come into play with their challenges, which increase depending on the distance and how dispersed the subcontractors are (Ali-Yrkkö, 2013). Close cooperation of the entire subcontracting network achieves cost advantages, better competitiveness and innovation in component development, production and logistics as well (Cavinato, 1992).

Part 2 Different operating models of subcontracting network management

Subcontracting networks have different operating models that are either push-, pull-, or a combination of these push-pull controls. In the 1950s, Taiichi Ohno's waste-eliminating and profit-generating idea of just-in-time delivery by reducing warehouses and employees, a proportional share of value-adding time could be added to component handling time (Pande, 2019).

In the push-driven model, the principle is to produce large production batches in accordance with demand forecasts to reduce unit costs, which led to large inventory quantities to achieve better service levels (Rossin, 2012). Although the model achieves savings in transportation costs, the weakness of such large warehouses is the slow delivery time caused by large delivery batches for components that are not in stock at the time of the order (Simchi-Levi & Simchi-Levi, 2002). The most suitable model of the subcontracting network depends on the long-term forecasts of component demand, in which case the make-to-stock model based on material-requirements-planning is suitable for the operation (Rossin, 2012). In the suction-driven model, the company has the opportunity for a better level of service when demand drives production and distribution, and to minimize inventory and costs. The weakness of the model is the longer lead times compared to components delivered from stock with push control. With pure intake control, it is difficult to take advantage of economies of scale because the operation of the production chain is scheduled as needed. The need for a push-pull hybrid model arises when delivery costs are low, which indicates suction control, and when demand is low, which indicates a push control-type subcontracting network. In addition, another hybrid model is formed when it is uncertain to ask and delivery costs are high (Rossin, 2012; Simchi-Levi & Simchi-Levi, 2002).

Part 3 From outsourcing to backshoring

Low labor costs attract customers to low-cost countries (Slack et al., 2016). Business outsourcing involves misleading price comparisons when comparing standard costs that include fixed costs with the cheaper price of a subcontractor company. If some fixed costs are not eliminated, the total costs and the costs of other components will increase because of outsourcing, because the fixed costs are distributed over a smaller number of units. A prerequisite for the growth of the company's total productivity is that the effect of fixed capital productivity must be greater than the effect caused by the decline in labor productivity (Broedner et al., 2009).

In a simple comparison of the purchase prices, almost any component yields a profitable transfer from a local subcontractor to an offshore supplier. However, cost savings do not always improve profitability, which is weakened by the growth of inventories, because orders from further afield are likely to be delivered in large batches. If quality problems occur in the components, it takes time to deliver a new batch, causing delays in production and delivery to the end customer (Dolcemascolo, 2006).

Edmund and Whitehead (2013) emphasize long-term partnerships in supplier selection based on the principle of a culture of continuous improvement, where problems are solved together. In a comparative study of the logistics performance of developed country and low-cost country supply sources, the biggest differences were in suppliers' information system capabilities, communication infrastructure, corporate culture and practice, as well as delivery accuracy. In this low-cost country, the supply sources were weaker, even though the component prices were the most favorable (Ruamsook et al., 2009).

Choosing the cheapest supplier solely based on financial savings is not always justified because the savings are wasted on component repair, long delivery times, transport costs, delays, warranty costs, travel costs, safety stocks, extra quality control work, among other things. Total costs with all hidden costs are not recognized and the importance of collaboration is not considered (Piatanes & Arauzo-Carod, 2019; PR Newswire, 2004).

In companies, backshoring is a phenomenon where production is returned to the original country due to the increase in the production costs of offshore companies, due to the improvement of competitiveness in the home country, or the reduction of distances that bring flexibility between manufacturing and the customer (Barbieri et al., 2018).

On-time deliveries within the organization as well as in operations between companies bring confidence to customers (Lampón & González-Benito, 2020; Stentoft et al., 2016).

Summary of Parts 1–3

Subcontracting productivity should reflect competitive pricing, quality, and timely service, with effective management and smarter work methods being key to improvements. Challenges in quality management, like poor training, can hinder productivity. Taiichi Ohno's just-in-time delivery model emphasizes waste reduction, but different subcontracting network models (push, pull, hybrid) offer varying benefits and challenges related to inventory, costs, and delivery times. While outsourcing to low-cost countries may seem profitable, hidden costs can erode benefits, making long-term supplier partnerships and potential backshoring more effective for maintaining competitiveness and ensuring reliable, on-time deliveries.

Materials & Methods

The study employs a multiple case study approach, where manufacturing-related key performance indicator data was collected from the database of the main contractor. The focus area of the case study are Finnish subcontractors in the metal industry, who in the 2010s were joined by a foreign competitor as a result of the selection of the main subcontractor, according to which the main subcontractor splits its orders. The customer was a main contractor belonging to a Finnish multinational group, and the research object was its six subcontractors, from which comparison pairs were formed. There were three subcontractors from Finland, two from the Czech Republic and one from Estonia, who were named as follows with their initial information.

In the first comparative study, the Finnish (FIA) subcontractor with less than 50 employees was compared with a Czech (CZA) subcontractor, which had more than 10 times the number of personnel and more than six times the turnover compared to the Finnish one. The studied period was 2014–2023. In the second comparative study, the sizes of the subcontractor companies leveled off compared to the previous one. The Finnish (FIB) medium-sized subcontractor with more than 50 employees was compared to another Czech subcontractor (CZB), which had more than five times the number of personnel and more than twice the turnover compared to the Finnish one. The studied period was 2015–2023. In the third comparative study, the Finnish (FIC) and Estonian (EEA) subcontractors were medium-sized companies of more than 50 employees of the same size, both in terms of turnover and number of employees and which were studied in the period 2017–2023.

The effect of the size of subcontractor companies on competitiveness can be seen, both in terms of number of employees and turnover. In the comparison of the size differences of the subcontracting companies, the averages of the number of personnel and turnovers for the years 2017–2018 were used.

The selection of comparison pairs of Finnish subcontractors was influenced by the availability of comparable data from the same period. The subcontracting network under study operates in a pull-controlled and partially hybrid model, whereby Czech subcontractors mainly manufactured finished or semi-finished components, which were modified according to the orders of the customer.

The customer centralized the subcontracted components as follows:

1. In the first comparison pair, the Finnish company had 12 times more component variants than the Czech subcontractor. In financial terms, two-thirds of the Czech subcontractor's deliveries were mass-produced.
2. In the second comparison pair, the Finnish subcontractor had 20 times more different titles than the Czech subcontractor. In practice, all the components delivered by the Czech Republic can be treated as mass-produced, even though their length and width dimensions varied, but the manufacturing process was the same in all of them.
3. In the third comparison, the Estonian subcontractor had twice as many different items as the Finnish one, and neither subcontractor had a clear serial component type of activity.

Results

Factors influencing the performance of pairs of subcontractors were searched statistically.

First, to obtain a development, the subcontractors' component quality and delivery accuracy abilities, as well as the relative monetary and quantitative shares related to ordering activities, were calculated for the entire analysis period.

Orders deviating from the agreed delivery times were also considered, as were the relative shares of different components between pairs of subcontractors. After this, the mutual effects of the variables are searched for, after which the variation in the quality level and delivery accuracy is described on an annual basis, alongside which the annual coefficients of variation were calculated.

The results during the entire research period are described in Table 1, where the first is a comparison of the subcontractors' ability to produce quality. FIA and CZA stand out from other subcontractors with their weakest quality return capabilities. A mutual comparison between the two shows that CZA has 10% more unit errors than FIA, which has a higher relative share of different components and rush orders than CZA.

CZA and CZB seem to have the ability for good component quality, because the number of component variations they have is small, in which case they had better conditions than others to develop their operations through routine repetitions of similar components. Their economic delivery volume was also higher than their competitors' and their delivery volumes were correspondingly smaller than their competitors', which means that they were able to focus on the production of certain components more easily than others.

Delivery reliability was evaluated with a four-day time window, where the delivery date (confirmed by the subcontractor and three days ahead of schedule) was counted as an accepted delivery. In terms of delivery accuracy, EEA seems to get the best result, but the difference with Finnish subcontractors does not seem to be large, while the delivery accuracy of CZA and CZB is clearly weaker than the others.

Financially, CZB and FIB were equal. In other comparison pairs, CZA and EEA clearly took a larger share of monetary orders compared to their Finnish competitor. EEA's total number of orders was greater than its reference subcontractor FIC, and unlike in monetary orders, CZA's and CZB's number of orders were smaller than FIA's and FIB's. The difference in the relative shares of deliveries made as express orders with an accelerated schedule did not arise except between CZB and FIB. The number of express orders talks more about the challenges of the customer's order than the ability of the subcontractor's ability to deliver on time, because the express order usually falls within the already full planned production schedule.

The increase in the number of different components manifested itself as better delivery accuracy, due to an unknown reason.

Second, we look for factors that affect the variation in component quality and delivery accuracy. A Box–

Table 1
Comparison of subcontractor

	Weldable structures 2014–2023		**Weldable plate structures 2015–2023**		**Weldable, sheet metal structures 2017–2023**	
Comparable feature	**CZA**	**FIA**	**CZB**	**FIB**	**EEA**	**FIC**
Sigma quality level (σ)	2.77	3.69	4.29	4.27	4.06	4.10
Delivery accuracy (%)[1)]	70	80	70	77	83	80
Financial share of delivery of the combined total (%)[2)]	66	34	51	49	77	23
Share of total orders of the number (%)[2)]	30	70	18	82	64	36
Numerical share of rush orders out of the total number of orders (%)[3)]	6	9	1	8	3	4.1
The share of express order delays in the total number of delays (%)[3)]	16	4	1	7	11	7
Urgent orders sped up on average from the original delivery time (%)[3)]	11	55	30	52	49	77
Share of the total number of different component types (%)[2)]	4	22	6	26	22	48

[1)] When the delivery is on the requested day or a maximum of three days ahead of time, the delivery certainty is 1, otherwise it is 0.
[2)] The share of the total amount of both companies
[3)] About the subcontractor company's own delivery quantities

Cox transformation was used to normalize the data so that data with positive values and large ranges could be used for parametric Pearson correlation. The Box–Cox transformation is calculated as follows:

$$y' = \begin{cases} \frac{y^{\lambda}-1}{\lambda}, & \lambda \neq 0 \\ \ln y, & \lambda = 0 \end{cases} \tag{1}$$

where y is the original variable and λ is the transformation parameter that determines which exponential transformation best fits the data.

Pearson's correlation coefficient is calculated as follows:

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \overline{y})^2}} \tag{2}$$

where x and y are variables and n is the number of pairs of numbers x and y.

A test of the significance of the Pearson correlation coefficient is given by:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \tag{3}$$

Dependence between variables was tested with Pearson's correlation, while factors were being searched for that affect late deliveries and reduce component quality. The influencing factors are summarized in Table 2.

The increase in late deliveries seems to be mainly influenced by the increase in the quantities related to orders and the increase in monetary terms, which can be seen in the activities of the Subcontractors CZA, FIA, CZB, FIB and FIC.

However, the variables did not have statistical significance for the lateness of Subcontractor EEA. According to the previous Table 1, subcontractors CZA and CZB had a significantly more concise item portfolio than other subcontractors, which should be reflected in better delivery accuracy. Subcontractors FIA and FIB also produced similar components to CZA and CZB, but also many other different components (Table 1). CZA's deliveries were of standard different sizes, which also manifests itself in correlations of the same order of magnitude as the effect of orders and component quantities $r = 0.439$ and the effect of piece quantities and order quantities on component quality $r = -0.113$. The increase in the number of components seems to weaken the component quality of FIC and EEA. Manufacturing seems to be a routine activity because manufacturing included many similar components, of course there were also many different components. The increase in the number of orders weakened the quality of FIA and correspondingly improved the quality of FIB.

Thirdly, the annual variation in the quality and delivery accuracy of the subcontractor pairs' components was studied (Figures 2–13), from which the direction of development can also be observed. In statistical calculation, original data without normalization from operational systems has been used.

In Figures 2–13, the annual change in the development of component quality and delivery accuracy is compared to the base year, and the trend is described linearly. A boxplot, as shown in Figure 1, indicates the distribution of the data by showing the median, interquartile range, the range, and the deviations with a *-mark for each group. An abnormal value is counted as a value that is more than 1.5 times the length of the box from the edge of the box. The first quartile,

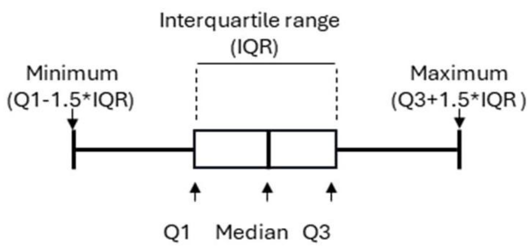

Fig. 1. Different parts of a boxplot (according to Galarnyk, 2024)

Table 2
Interdependence between variables

	CZ A	FI A	CZ B	FI B	EE A	FI C
Effect of the financial growth of deliveries on lateness	0.359*	0.399*	0.544*	0.447*	–0.221	0.425*
Effect of order quantity of deliveries on lateness	0.439*	0.310*	0.563*	0.653*	–0.022	0.506*
The effect of the quantity of components on lateness	0.439*	0.140	0.237**	0.237**	–0.168	0.150
Effect of the quantity of components on component quality	–0.113	–0.211**	–0.071	–0.135	–0.553*	–0.384*
Effect of the number of orders on the quality of the component	–0.113	–0.281*	–0.063	0.341*	0.016	–0.140

*$p < 0.01$, **$p < 0.05$

Q1, is in the 25th percentile and the third quartile, Q3, is in the 75th percentile (Galarnyk, 2024).

In the first comparison pair, there was no development in the subcontractors' ability to produce better quality during the analysis period. Compared to the situation at the starting point, both subcontractors are experiencing a downward trend according to Figure 2.

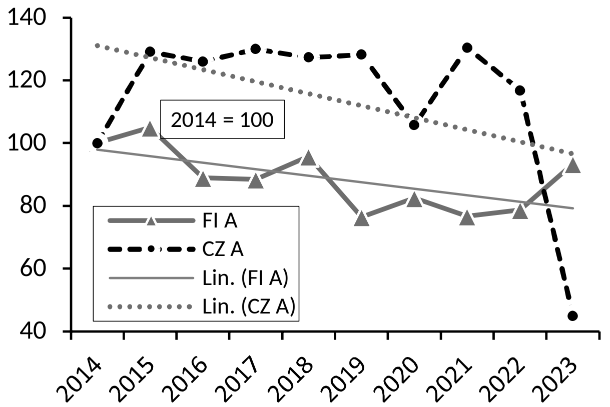

Fig. 2. CZA and FIA quality level

In Figure 3, it is not possible to see a decrease in the variability of the quality yield, but on the contrary, the variability of FIA even increased, however, remaining significantly smaller than that of CZA.

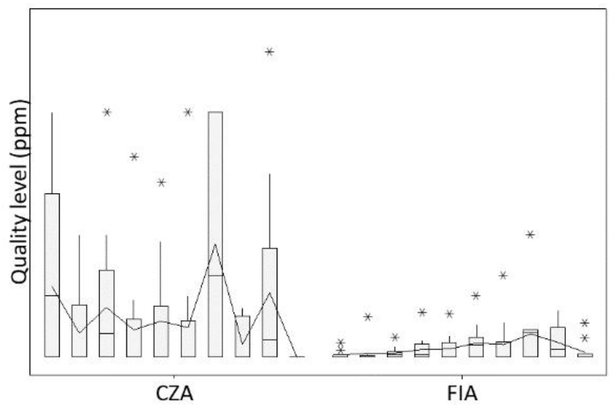

Fig. 3. CZA and FIA Variation in the quality level of weldable structures, years 2014–2023

Note that in Figure 3, the lower value on the Y-axis represents a lower ppm reading, as in the other figures that depict the variation in quality within each year of the study. Correspondingly, in Figure 5, the largest value on the y-axis represents 100% delivery reliability, as in the other images that describe the variation in delivery reliability within each research year.

The coefficient of variation is the ratio of the standard deviation to the average, which in this study is the overall result of the research period in question, both in terms of component quality and delivery accuracy. The coefficient of variation of quality yield was 54% for CZA and 22% for FIA.

For both subcontractors, the trend of delivery punctuality was decreasing during the research period (Fig. 4).

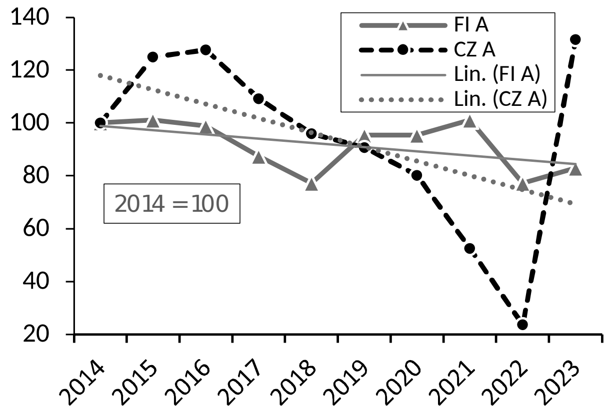

Fig. 4. CZA and FIA Delivery accuracy

Statistically, the monetary and order growth of the CZA subcontractor's deliveries and the growth in the number of ordered components had a significant effect on delays, with a p-value below 0.01. Statistically examining the operations of the FIA subcontractor, the increase in the number of orders for deliveries affected delays and component quality, with a p-value below 0.01.

In Figure 5, there was no development in the variation of delivery punctuality at either subcontractor. The coefficient of variation for delivery accuracy was 162% for CZA and a slightly larger 186% for FIA.

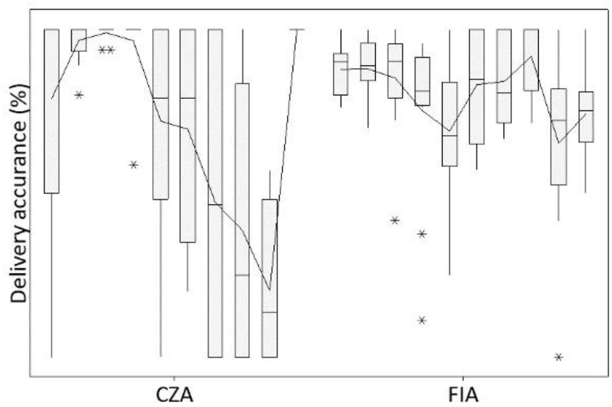

Fig. 5. Variation in delivery accuracy of weldable structures in the years 2014–2023

In the second comparison pair, both subcontractors have an overall upward trend in quality development during the research period (Fig. 6).

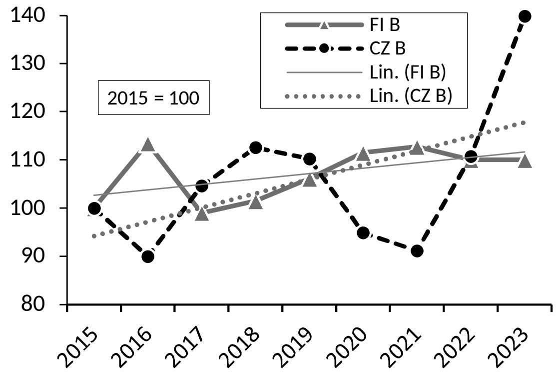

Fig. 6. CZB and FIB Quality level

In the annual quality yield capacity, the CZB subcontractor has periods where quality problems are minor and there are years where there are correspondingly more quality problems, strongly increasing the variation as shown in Figure 7, causing the CZB coefficient of variation to increase by 241%. In the operation of the FIB subcontractor, the variation is more even, with a coefficient of variation of 130%, and there are no similar strong variation spikes as in CZB. However, any variation in component quality or operational quality causes uncertainty for the customer.

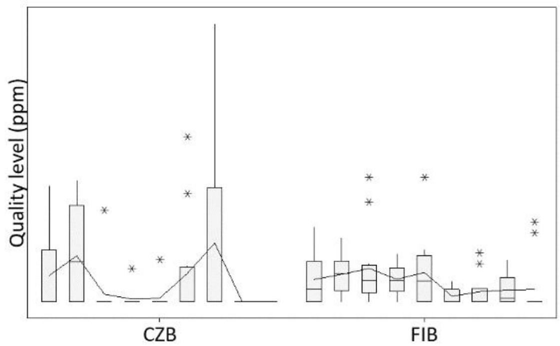

Fig. 7. Variation in the quality level of weldable plate structures in the years 2015–2023

Structures in the years 2015–2023

In terms of delivery accuracy, CZB's coefficient of variation was 40% and FIB's was 19%. The supply reliability trend of both subcontractors was decreasing, which can be seen more strongly in the operation of the FIB subcontractor in Figure 8.

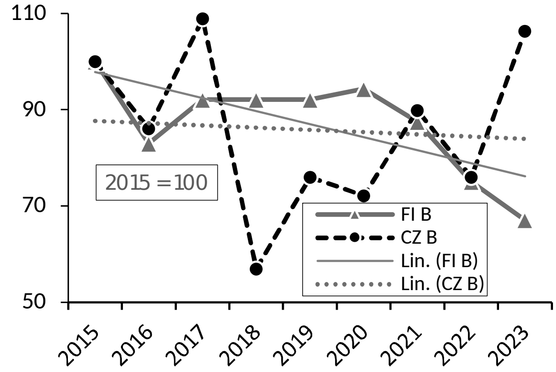

Fig. 8. CZB and FIB Delivery accuracy

The annual variation is shown in Figure 9, where CZB's delivery punctuality has a larger variation than FIB's.

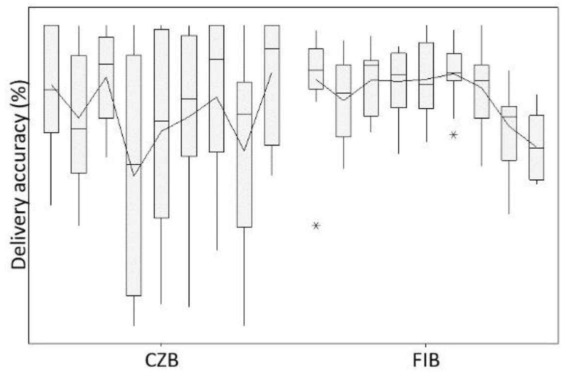

Fig. 9. Variation in delivery accuracy of weldable plate structures, years 2017–2023

Statistically, with a p-value < 0.01, FIB's quality errors increased with the number of orders, and according to a similar correlation level, the delivery accuracy of both subcontractors was affected by the monetary number of deliveries and an increase in the number of orders.

In the third comparison pair, both subcontractors had a developing trend in quality yield during the research period (Fig. 10).

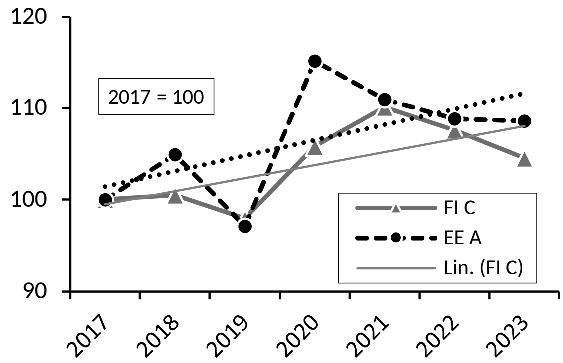

Fig. 10. EEA and FIC quality levels

For the last years of the study period, the variation appears to level off (Fig. 11). Statistically, with a p-value < 0.01, the effect of the increase in the number of components weakens the quality production ability of EEA and FIC.

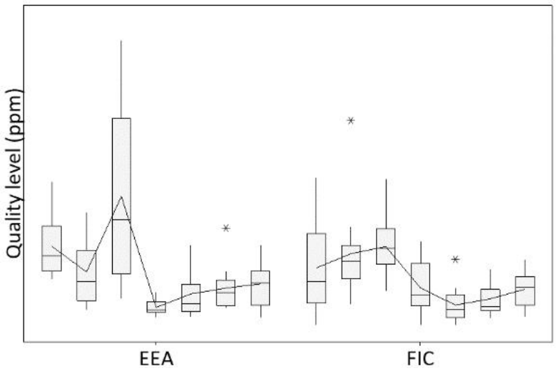

Fig. 11. Variation in the quality level of weldable sheet metal structures, years 2017–2023

The coefficient of variation of the quality productivity during the entire period is 92% for EEA and 78% for FIC.

The negative development of delivery accuracy can be seen in Figure 12.

Figure 13 shows a strong variation in the delivery accuracy of both subcontractors. The increase in the monetary number of deliveries and the number of orders weakens FIC's delivery accuracy with the coefficient of variation being 14% and EEA's 17%. No statistical explanation was found for EEA's delivery problems.

The variation can be seen in the previous pictures and their coefficients of variation can be found in Table 3, where the coefficient of variation is the ratio of the standard deviation to the mean.

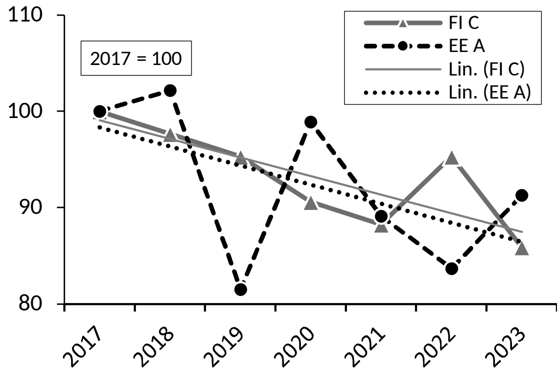

Fig. 12. EEA and FIC Delivery accuracy

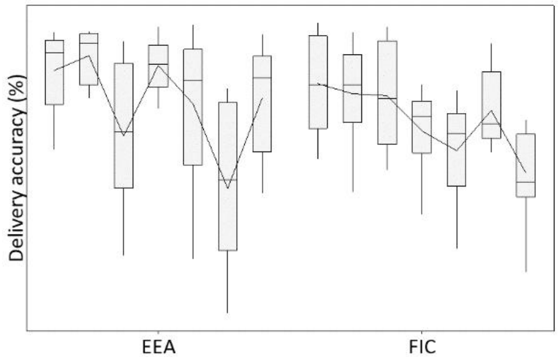

Fig. 13. Variation in delivery accuracy of weldable, thin metal sheet structures in the years 2017–2023

There is no noticeable improvement in component quality in the activities of the subcontractors. There is also no noticeable development in the ability to deliver, where all subcontractors seem to have a downward trend throughout the study period.

Table 3
Indicators of subcontractor variations

		Quality level		Delivery accurance	
Subcontractor	N^x	**Mean (ppm)**	**Cofficient of variation (%)**	**Mean (%)**	**Cofficient of variation (%)**
CZA	106	185 638	162	70	54
FIA	120	38 910	186	80	22
CZB	107	2 992	241	70	40
FIB	108	2 994	130	77	19
EEA	84	6 827	92	83	17
FIC	84	5 939	78	79	14

*In this case, due to business secrecy, N is the number of delivery months, which includes delivery quantities and delivery pieces.

In the fourth, the coefficients of variation (CV) were calculated for the subcontractors' quality level and delivery reliability expressed as a percentage (Table 2), i.e., the higher the percentage reading, the more variation there is in relation to the average, which is obtained as follows:

$$\mathrm{CV} = (\mathrm{SD}/\bar{\mathbf{x}}) \cdot 100 \tag{4}$$

The coefficients of variation of subcontractors' quality and delivery accuracy are summarized in Table 3.

Discussion

According to Ark et al. (2005), a low level of productivity has been identified as a threat in monitoring the European Union's competitive position. Labor costs are the main target for savings when looking for lower costs in countries with lower-cost labor (see, e.g., Maliranta & Vihriälä, 2013), because high labor costs are said to limit productivity (Borg & Vartiainen, 2015).

Identifying and admitting problems is the basis for the joint continuous development efforts of the main contractor and subcontractors towards better productivity at all levels.

The statistical data available from the main supplier's information systems can be used to identify a development target in a subcontracting network, but improving competitiveness requires deeper individual insights and joint development with the subcontractor, as well as using qualitative research methods. Also, development work must be long-term so that the whole subcontracting network can benefit from the results of the development work.

The collected long-term data can indicate the most significant development potential in subcontractors' operations and in the whole subcontracting network. The variety of components or serial production types doesn't impact the development of their operations. This necessitates changes in attitudes and methods between customers and subcontractors, as well as within their own operations.

In this study, the most significant development targets are identified based on the statistical data from the main supplier's database.

Understanding Customer Requirements

Subcontractors need better comprehension of customer requirements and quality assurance. Guidance on manufacturing methods is provided by the customer.

Delivery Reliability

Delays are noted despite longer order times. Subcontractors may not recognize their production capabilities or may accept excessive orders to avoid losing them to competitors. Time management and understanding process downtime versus production time are crucial. The customer lacks detailed knowledge of subcontractors' processes, which affects cost structure and value assessment.

Expedited Orders

Customer's expedited orders likely disrupt subcontractors' schedules, though the exact impact is unclear. Better coordination and agreement on order models between customers and their own clients can prevent such issues. These rush orders, if compensated extra, affect customer productivity.

Uneven Component Distribution

Equalizing component load among subcontractors and standardizing methods can enhance productivity and quality, ensuring correct delivery times and shortening subcontracting network lead times.

Globalization has been a growing trend in the manufacturing sector, mainly in the 2000s. Manufacturing companies have sought profitability for their own operations in lower-wage countries. This has led to the emergence of global supplier networks for the supply of components and products. This outsourcing has not necessarily been based on any hard facts and data but has been driven mainly by comparing the wage levels of different supplier countries in search of cost efficiency. The assumption has been that the pricing of labor has had the greatest impact on the price of the products procured. This approach may not always have been the best, as not all risk factors have always been identified. A good example is the Ever Given container ship getting stuck in the Suez Canal in 2021, which caused several months of delays in the logistics chain. In addition, rising energy costs and geopolitical tensions and risks have also posed their own challenges in assessing the profitability of subcontracting networks. To manage risks and get a complete picture, it is therefore important to collect comparable data to support decision-making and thus assess the position of global suppliers in the subcontracting network. The review and benchmarking model presented in this study supports this work and guides customers to focus on issues that improve their own profitability.

Conclusions

The research sought an answer to how information from the main contractor's information systems can be utilized when evaluating subcontractors' performance and point out development targets.

In this study, the challenges to competitiveness brought about by component quality variation and delivery accuracy, which have an impact on productivity, were targeted.

According to Figures 2–13 and Tables 1–3 of the study, the performance of the subcontractors is clearly visible. Quality defects and poor delivery punctuality, as well as their sometimes very strong fluctuations, have an impact on productivity. Based on the results, all subcontractors need development activities together with the main contractor.

More practical investigation and qualitative analysis in the whole subcontracting network is needed to point out the most significant development targets in different subcontracting network levels.

However, four main areas for development targets were identified from the tables and figures:

1. Subcontractor's component quality
2. On-time delivery performance
3. Rush orders
4. Uneven distribution between the customers' component models and those of the subcontractors.

The subcontractor's operations should identify and verify the root causes of the problem using different methods. The starting point in this case would be to do a value st ream analysis, which would help to identify the activity that causes waste. To identify the root causes of problem points in the value stream analysis, you can use, for example, the cause-and-effect method, which can be refined with the 5 Whys method, or if the root cause of the problem is clear, then one of the two methods.

Value stream analysis should be done which will also help to see the activities that cause waste. After this, countermeasures can be taken to achieve better productivity. The value stream analysis measured and carried out jointly by the customer and the subcontractor forces the subcontractor to take development actions, because the customer does not want to pay for non-value-adding work. The subcontractor's productivity increases, which is reflected in improved competitiveness.

In development operations, the transition to Industry 4.0 enables cost calculation and management in a subcontracting network that can be accessed with real-time information. Its main goals are to maximize efficiency and effectiveness. The commitment of the main contractor and the subcontractor to joint continuous development can be seen in the competitive prices of the components, better component quality and better quality of services, however, in all of these cases, without reducing profitability.

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