HOW ACCURATE IS YOUR DATA? AUTOMOTIVE INDUSTRY SUPPLY CHAINS COLLIDING WITH LOGISTICS IN WESTERN ROMANIA

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Abstract

The purpose of this paper was to emphasize the importance of data accuracy within internal logistics systems and their extended influence on supply chains in automotive industry through a 6 month case study conducted on 3 first tier original equipment manufacturers (OEM) based in Western Romania.

Data collection and analysis revealed that main issues arise due to ordering quantities mismatching actual customer demand, a wide range of order lot sizes, lead times and delivery reliability concerns and the reluctance to shift away from mainstream cost-effectiveness and towards strategic added value thinking. These issues sourced significant other related operational challenges such as excessive inventory, short-term stockouts and subsequent express shipping services or product-related inconveniences (quality and capacity levels, contracted volumes and dedicated lines).

The paper sources different logistics and supply chain approaches used by the 3 OEMs, their features and operational performance, as well as their overall effectiveness which can be applied by other automotive industry suppliers to improve own results. Introducing more reliable real-time data collection tools and performance metrics has started hauling more focus towards solving these prevalent issues with some ongoing improvement projects showing up to 25% better results. For one of the 3 OEMs introducing a new warehouse management system has already sourced an overall quality increase (5 percentage points) due to a 60% higher utilization of its production equipment.

Keywords: data accuracy, operational performance, logistics, supply chain management

1. INTRODUCTION

The automotive industry is one of the most important industries worldwide, driving investments, employment and innovations throughout its highly competitive supply chains, both vertically and horizontally. According to ACEA at EU level only the automotive industry sources, directly and indirectly, 13.8 million jobs (11.5% of EU manufacturing jobs and 6.1% of overall EU employment) in its 322 vehicle assembly, engine and battery production plants and is the leading investor in R&D with almost 60 billion euros (31% of total spending, 2022). Dacia and Ford are the pillars in Romania (12% of GDP, 17.5% of the manufacturing industry and 30% of exports, 2022), enabling around 230,000 specialized jobs within more than 500 suppliers across the country.

Most of the automotive supplier network is concentrated in Western Romania, where important multinational brands have set up and extended capacity in recent years and experience business growth. Reduced product life cycles, engine downsizing, head-up displays (HUD) and the shift towards electric vehicles (EVs) all mean that carmakers have to balance out integrating innovative technologies [1] fast whilst also being able to plan out an operational and competitive business unit [2,3]. A reliable and supporting supplier network is vital in such a challenging setting and its appropriate design (location, alternates and preferred selection) will determine the extent of a dependable and relevant data interchange system [4-7]. Adapted and appropriate logistic system choices (own/external warehouses, in-house logistics department/third-party logistics (3PL) externalizing and distribution center (DC)/logistic service providers (LSP), etc.) will have a major effect on cost structures, delivery times and quality of data [8-11].

The overall performance of the company's internal organization, logistics (inbound, production scheduling, outbound) and supply chain management can be measured against its level of inventory [12]. This is because an actual JIT production strategy with properly balanced flows will not face inventory fluctuations that may cause excess amounts or, worse, stockouts and thus show the degree of its leanness [13,14]. This paper was motivated by research projects carried out within the logistics departments of 3 such multinational first tier original equipment manufacturers (OEM) during a period of 26 weeks to assess accuracy of specific data (inventory, forecasting and production) and quantify its influence on internal logistics KPIs and short loop supply chain (supplier-manufacturer-customer) performance.

2. METHODOLOGY

Forecasting, planning & scheduling and performance management data from the last 5 years (2018-2022) was studied with relevant professionals of the 3 OEM's logistics departments. The reports submitted upon completion of the carried out research are subject to non-disclosure agreements (NDA), but the OEM's have consented for publishing some data and conclusions (only partially) therefore limitations are to be expected.

Production planning is based on relevant data (historical, projected volumes and actual customer orders) in order to compile a more reliable forecast, each of the 3 OEM's having different techniques. Projected volumes are increasing on a year-to-year basis in all 3 cases (7-12% on average for OEM 1, 3-8% for OEM 2 and 2-6% for OEM 3) thus the Holt-Winters exponential smoothing method was the most appropriate choice to process forecasting data accuracy. Forecasted levels for each of the 26 weeks were based on projected volumes and smoothed exponentially with trend and seasonality (α=0.2-0.3; β=0.25-0.35; γ=0.4-0.6) by each of the 3 OEM's production planners.

The mixed team was tasked to provide a range of applicable solutions and improvement proposals by the end of the research contract. Our proposed approach was to target a smoother average throughout a complete business cycle (52 weeks) while also using 3-6 month shorter cycles to dynamically adjust outputs and increase accuracy. A slight added weight (α) was given to more recent data, but longer-term trend (β) was preferred with only marginal adjusting for the seasonal smoothing coefficient (γ) being necessary. The (partial and ongoing) results of our individually submitted proposals combine practical solutions from each OEM's logistics professionals and theoretical methods from academic literature to attain optimum outcomes.

3. RESULTS

Table 1 Overview of each OEM's characteristics

Outline		OEM 1	OEM 2	OEM 3
Production	*type*	standard	standard	standard
	technology	superior	above average	average
	volume	very high	high	high
Warehouse	*own*	yes	yes	yes
	external	yes	DC	yes
	management	in-house	in-house	outsourced
Data	*ERP*	new*	standard	standard*
	KPIs	real-time*	real-time	real-time
	employees	mix*	mix	mix

Table 1 presents an outline of the 3 automotive industry OEMs' main characteristics. In terms of production, all manufacture standard products involving industry innovations, fitted on any car brand or model. There are technology differences, OEM 3 having rather average technology-encompassed products, while the others have above average (OEM 2) and superior such outputs (OEM 1). Volumes are high for 2 of the 3 OEMs, as they each source important amounts for their customers, whereas OEM 1's volumes are very high due to a larger product range delivered. Raw materials and components, as well as finished goods, are stored in both own and external warehouses, only OEM 2 not having an own external facility and using a distribution center (DC) instead. Warehouse management is done in-house (OEM 1 and 2), except for OEM 3 who has outsourced this activity to a third-party logistics (3PL) provider. Data management is rather different, as only OEM 2 uses an industry standard enterprise resource planning (ERP) software tool. OEM 3 has added significant extra features to enhance its data analysis to its existing ERP, whilst OEM 1 is currently transitioning the switch to a new ERP system and thus replacing the one it has previously been using for over a decade. All OEMs use systems that collect, show and monitor real-time data, only OEM 1 still having some processes where some data, decisions and reports have to be approved manually before being subsequently computed. There is a good balance of young and experienced employees in all 3 OEMs', with OEM 1 having more novice employees that need to be inducted and properly trained after termination of their internships in order to start handling some of the company's projects. OEM 1 has the highest volumes and is therefore more active in the hiring process than the other 2 analyzed business units.

Table 2 Overview of OEM 1's excess inventory per semester

Materials and components	**Semester usage (units)**	**Monthly average (units)**	**Excess quantity (units)**	**Excess/semster usage (ratio)**	**Excess/monthly usage (ratio)**
Supplier 1	151	25.16	518	3.43	20.58
Supplier 2	160	26.66	480	3	18
Supplier 3	191	31.83	512	2.68	16.08
Supplier 4	68	11.33	172	2.52	15.17
Supplier 5	150	25	300	2	12
Supplier 6	942	157	1404	1.49	8.94
Supplier 7	830	138.33	1109	1.33	8.01
Supplier 8	5320	886.66	6469	1.21	7.29
Supplier 9	640	106.66	765	1.19	7.17
Supplier 10	2190	365	-872	-0.39	-2.38
Overall average*	**1762**	**293.66**	**4921**	**2.79**	**16.75**

Table 2 outlines the forecasting, ordering and storage issues of OEM 1 in regards to some of its main raw materials and needed components for the manufacturing process. The logistics department is based on a functional unit system where an employee fulfills a specific role regardless of the number of customers, product range, models and associated specific requirements, creating an unbalanced workload. The planning department has access to the company's forecast, but each planner (3 levels) decides what amount to order, being able to adjust the quantity ordered. More experienced planners will tend to add a small margin (up to 15%), whereas the younger and less experienced ones will tend to add up to 50% or even double the ordered amount in view of rising volumes and long-terms contracted quantities. This choice will however increase the delivery lead time from the supplier and also bottleneck the warehouse, both own and external, its reception and storage capacity (recurring issue). Sometimes the ERP system shows a shortage of materials, but the truck is actually at the plant waiting to be unloaded (physically) with no available storage capacity within the own warehouse, causing further delays in production. These issues can be found within the data shown in

Table 2, as for the selection of 10 materials and components there is an average excess of inventory that would last for almost 2.79 semesters (18 months). Other material excesses, not shown in the table, range from 4-6 semesters using up unnecessary storage capacity, whilst others may be subject to stockouts (supplier 10). These issues are then transferred to the shop floor, where it is very difficult to make up for the time lost with the reception, unloading and storage procedures and urgent and quick shipments are sometimes needed to compensate, as shown in **Table 3.**

Table 3 Overview of express shipment deliveries of OEM 1 towards main customers per semester

Express shipments	Deliveries (units)	Main reason	Price variation range (%)	Maximum amount (units)	Total amount (units)	Average price (units)
Customer 1	17	constant	15-20%	23,806	106,346	1,500-2,000
Customer 2	6	spread	10-15%	11,200	59,727	9,000-10,000
Customer 3	14	peak	25-30%	11,200	38,346	2,000-2,500
Customer 4	6	spread	10-15%	2,570	12,032	1,500-2,000
Customer 5	11	shortage	25-40%	9,850	31,097	2,000-2,500
Overall average	**10**	**constant**	**20-30%**	**10,000-15,000**	**247,548**	**2,500-3,000**

Table 3 presents express shipments to some of OEM 1's customers within a semester (54 such deliveries in 6 months). While some of the urgent shipments are also due to external factors (peaks, shortages and unforeseen issues), most come about on a rather more regular basis due to similar reasons (customer 2 and 4) or are even constant occurrences (customer 1) tying up important amounts of working capital (almost 250,000 monetary units). This frequency of quick shipments is also due to a range of new projects coming in and despite an extension of the manufacturing which is currently under way, it will not be completed until 2025, therefore production capacity is at full tilt, but also bottlenecked by unbalanced ordering levels. Overrating storage capacity (which has lost space due to shop floor being increased), also means backlogging production and not fully using manufacturing capabilities which in addition to the longer supplier lead times generate unproductive waiting times (longer production lead times, delayed loading of orders) and the risk of not delivering on time. Most customers have dedicated production lines, whereas the rest have their products manufactured in a flexible system (FMS), both ranging from front-end to back-end processes.

Table 4 Overview of OEM 2's yearly production planning figures for a range of suppliers

Materials and components	Yearly usage (units)	Monthly average (units)	Minimum variation (%)	Maximum variation (%)	Average variation (%)
Supplier 1	2000	166.66	10	70	29.17
Supplier 2	960	80	10	100	32.50
Supplier 3	522	43.50	17	100	27.59
Supplier 4	504	42	71	100	83.33
Supplier 5	336	28	14	100	47.62
Supplier 6	91	7.58	18	124	69.23
Supplier 7	1000	83.33	20	100	63.33
Supplier 8	3200	266.66	12	100	45.83
Supplier 9	432	36	0	150	58.33
Supplier 10	324	27	33	167	61.11
Overall average	**936.9**	**78.07**	**21**	**111**	**51.80**

Table 4 highlights OEM 2's production variation for a range of materials and components. Despite the OEM's high volumes, the average yearly variation was just above 50% for all material and component orders passed to the selected suppliers. Orders to suppliers 1-3 even had an average variation of around 30% throughout the year, a very decent accuracy level. With 2 exceptions (suppliers 4 and 10) minimum variation is under 20%, whereas except the cases where no orders are placed (100% variation), maximum variations range between 60-90%, most cases however usually average between 30-50%. Two thirds of supplier orders match a batch-size ordering pattern, therefore our aggregated variation calculations show higher fluctuations and unpredictability than is actually the case in practice. Supplier 3 has the best forecasting, as their actual orders variations range between 17-24% throughout the entire year, whilst supplier 9 has 2 months with a perfect match between its forecasted orders and its actual passed order levels. Having a rather stable ordering pattern in the short loop supply chain (supplier-manufacturer-customer) with smaller fluctuations will improve the flow of goods and delivery reliability as well as reduce the risk of generating an upstream bullwhip effect (BE). Suppliers 9 and 10 also experience both a zero order situation, as well as a doubling of the order level throughout the year. To accommodate rising volumes OEM 2 decided to increase shop floor space on its premises instead of contracting an external warehouse and use a distribution center (DC) closer to its customer locations. With no external warehouse to rely on in case of excess storage needs, OEM 2 relies on its forecasting and production planning to be accurate in order to deliver finished goods to its customers. The logistics department is divided into teams and each team focuses on specific customers and product ranges, as their orders will be divided among members based on the characteristics and complexity of the entire process (supplier orders, production lead time and delivery requirements). All in all, OEM 2's forecasting and planning in fairly reliable (forecasting accuracy has increased by 22% on a year-to-year basis, while production planning sourced a 17% improvement) with peaks and troughs being properly handled due to standard production leveling techniques. In addition, within the analyzed business year, only 3 express shipments were required due to a more balanced ordering-manufacturing cycle. The business unit's excellent logistics performance has been noticed by upper management and the facility will start managing the same range of services for one of the group's additional plants starting 2024.

Table 5 Overview of OEM 2's delivery characteristics from the distribution center towards end customers

Distribution center	Driving time (hours)	Pick-up day	Outsourced to	Expected service level (%)	Delivery type
Customer 1	1h52min	Thursday	LSP1	95	JIT
Customer 2	3h46min	Wednesday	LSP2	85	JIT
Customer 3	4h03min	Friday	LSP3	98	JIS
Customer 4	7h40min	Wednesday and Friday	LSP1	95	JIT
Customer 5	21h19min	Monday	LSP 3 or LSP4	85	JIT
Overall average	**7h44min**	**N/A**	**N/A**	**91.6**	**JIT**

Table 5 presents the delivery characteristics for some of OEM 2's most important customers. OEM 2's DC is located at 15h52min driving time from Western Romania (border crossing times are not included). Customer 1 has 3 possible locations for delivery from the distribution center: DL1 (58 min driving time), DL2 (1h10min driving time) and DL3 (3h28min driving time), so an average of these was used in the table. Customer 4 and customer 1's 3 delivery locations are managed by the same logistic service provider (LSP1), only one other LSP (LSP3) having more than 1 customer to manage (customers 3 and 5). Customer 3 has the highest required service level (98%) and is the only one to expect a Just-in-Sequence delivery, all others using the typical automotive industry standards, the Just-in-Time (JIT) delivery.

Table 6 Overview of OEM 3' manufacturing process KPIs

Distribution center	Availability increase (%)	Performance target (%)	Performance level (%)	Quality level (%)	OEE (%)
Process 1	62	95	96	NDA	NDA
Process 2	66	95	94	NDA	NDA
Process 3	71	95	97	NDA	NDA
Process 4	46	95	87	NDA	NDA
Overall average	**61.2**	**95**	**93.5**	**NDA**	**NDA**

Table 6 presents the OEM 3's most important manufacturing processes and their overall performance after implementing an extended warehouse management (EWM) system within the past semester, as an extra add-on to its current ERP system. Actual quality levels and overall equipment effectiveness (OEE) measured values were subject to agreed NDA terms, only broad comments being consented. Despite an investment required to attach the EWM to the company's current ERP system, the return on investment (ROI) was attained sooner than expected. OEM 3 has both an own and external warehouse, but decided to focus on its core competence (manufacturing) and contract an LSP for its warehouse management. Only the company's outbound logistics is outsourced (3PL), therefore an internal logistics department is required to support the production process (including planning, scheduling and leveling). Implementing the EWM has enabled better inventory accuracy, improved real-time process flow tracking and automatically-triggered replenishment (e-Kanban system). The increase in time availability (average of 61.2%) has also triggered a performance level increase of around 10% for all processes, most notably for Process 1 (96%) and Process 3 (97%), both above the set target, whereas Process 2 was just 1 percentage point below. Process 4 experienced some unexpected technical issues and a temporary minor backlog which affected its rating (87%) within the current analysis. Nevertheless, after the issue was solved, the process had a similar output, matching the other processes' performance (within the same monitored timespan), therefore results should be more balanced towards the end of the business year. The performance of each process is the average of the performance of the 3 shifts in the company per process, the morning and day shifts having slightly higher productivity figures (up to 3 percentage points higher) than the night shift (around 5 percentage points lower than the average of the first 2 shifts). Moreover a 5 percentage point quality level increase has been observed, as well as an OEE increase of 12 percentage points, key takeaways after only 6 months of implementation.

4. CONCLUSION

The overall results confirm the existence of internal logistics performance issues within the 3 first tier OEMs from Western Romania. OEM 1's main logistics issues are inventory-related, as overestimating actual demand creates excessive inventory (up to 18 months for the analyzed materials), as well as increased supplier lead times and insufficient storage capacity, causing production delays. Furthermore, in addition to excess inventory (tied up working capital), several express shipments (worth almost 250,000 units) had to be contracted to prevent stopping customer production lines (carmakers) and bear huge penalties. OEM 2's main challenge lies within accurate forecasting and balanced production planning schedule. With no external warehouse and a distribution center almost 16 hours away from the plant, on time deliveries are mandatory to uphold car manufacturer service levels. Forecasting accuracy has improved by 22%, also enabling a more balanced production planning schedule. Only 1 carmaker requires a 98% service level rate and JIS delivery, whilst the others mainly expect a 95% level and JIT delivery, the furthest away customer (22 hours from the DC) only imposing 85% rate on the service level. OEM 3's outsources its outbound logistics therefore proper inbound logistics and production performance are needed to avoid shipping delays to its 3PL and end customers. Implementation of the EMS has boosted the company's performance on all levels, as availability has increased by more than 60%, performance by around 10% (actual levels are within the set targets) and quality has risen by 5 percentage points. The OEE rating is thus 12 percentage points higher after implementing the new additional data management system, validating the relevance of an improved process flow performance monitoring system with real-time, reliable and accurate data.

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