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SUSTAINABLE INDUSTRY AND SUPPLY CHAIN - WHAT TO TEACH

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Abstract

How to teach students about development and sustainable operation of companies and supply chain are a complex task with several partly conflicting issues. Entrepreneurship business models are more different than sustainable business models for operation and maintenance, but they can be seen as complementary or two stages of industrial development: explore and exploit. Both are part of what can be described as Entrepreneurial Mindset. Teaching in collaboration with companies tells us something of how this may be done as experienced in course cases. Supply Chains are becoming more and more global even for SMEs. With increasing use of global Supply Chains together with increased volume and frequency, the activities and logistics in between main operations have become more important to ensure reliability and sustainable operations. And these are based on collaboration and communication between involved companies and agencies. Core issues in this are charges that determine cost involved together with custom clearance issues, delays, miscommunications, and unforeseen circumstances. The sustainable Supply Chain of tomorrow needs to be data-driven to achieve improvement. We need to go from customer data to customer benefit. It may be achieved by utilizing AI to improve decisions and reduce latency. A 3-stage roadmap for utilizing Entrepreneurial Mindset in teaching digitalization of sustainable Supply Chain is suggested.

Keywords: Teaching, Supply Chain, Logistics, Entrepreneurship, Operations, Sustainable

1. Introduction

To educate for industry and business is a complicated activity. Most of students will be employed within 1-5 year after university education, and many of them will need years after that to have an impact of how their employers conduct their activities. Most of the businesses win or lose depending to how they develop their business model and conduct their operations. Therefore, it is vital to provide students with a holistic understanding on methods and tools that prepare them to contribute to their future employer. An entrepreneurial mindset is needed both to develop a new company and to ensure operations in an existing to be sustainable. A sustainable company keeps employees, environment, processes, and products safe, and does this profitable both on short and long term. Their operations make them reliable now and the next years. Operation connects the activities from vendors to customer, determines capacities and flow of goods and service. Core knowledge in this is asset management where buildings, equipment, employees,

systems etc. shall be prepared for what happens both tomorrow and next year (Acur *et al.* 2003; Seuring and Müller, 2008).

Supply chains are essential for all kinds of companies, and they are becoming more and more global, even for SMEs. A chain element in a supply chain consists of a vendor that offers a product (or service), logistics that moves the product to the buyer, and a buyer who uses the product. Linking these elements together creates a chain, and in some industries, such a chain can be extended with several chain elements following each other. In other industries, we see a considerable number of parallel elements to a buyer but then short sequences.

A supply chain is thus a link of activities where traditional focus has been on operations like manufacturer, assembly, distributor, and final customer. And with a long sequence of supply chain elements, these basic operations can be to first make raw material available, then several levels of making components and subassemblies, then final assembly and distribution. Such sequence is rarely delivered as planned for an ideal world since all events that may occur will result in delay and waste (Ali, 2022; Caiado *et al.* 2022; Malhéné and Pourcel, 2014).

Much of such delays and therefore waste, are related to cost in logistics that occur in change of transport method or border crossing. This is due to many different companies or organizations involved, and that they all try to optimize their own involvement in the supply chain (Bechtsis *et al.* 2022).

This paper is based on four decades lecturing experience in collaboration with industry mainly on entrepreneurship and operation topics related to industrial development. Much of these issues have been related to ICT use in various context and included on bachelor, master, and PhD levels. And the question is then what have been done and improved over the years, and what to learn from it. The paper relates some to what, where, when, who, but the emphasis is on why and how and this is included in the suggested roadmap.

To deal with this, we provide a holistic view in the bachelor operation management course where student groups design a simplified factory. It is utilized in University of Stavanger bachelor entrepreneurship course where students are told to design a business plan according to a paying customer. The courses teach students to take care of equipment and systems in maintenance teaching, focus on lean methods, and provide them with modeling and simulation tools that encourage optimization.

2. Methodology

This paper collects experiences from courses taught mainly in Norway but also in other locations. International projects have dealt with how to handle complexity utilizing Problem-Based Learning. (Kuran *et al.* 2017; Pedersen *et al.* 2019). A challenge is that most students have limited experiences and much of our traditional courses simplify and does not prepare the students for how businesses operate (Pedersen *et al.* 2019).

Operations in a company are complex since it combines much of what happens on a short-term daily basis. It connects the overall supply chain from vendors via logistics and internal work to customers. It organizes internal workflow and inventories. It manages work orders and conditions for employees. It adapts to changes from product development, marketing, sales, vendors, customers, and not at least changes in technologies. All these must happen within requirements on quality, delivery time, and economy (Caiado *et al.* 2022).

Companies are in different phases as well. A new company struggles with first to develop and then to use a business plan in an entrepreneurial process. Later, a similar process occurs in established companies, but then we name it strategy and budget. And focus has changed from exploring and establishing to growth and sustainability. Therefore, the following course-cases have utilized Problem Based Learning in different ways depending on the purpose and level of the course.

The University of Stavanger had several relevant courses in 2020/2021. These courses aim to teach the students first how companies operate and how different functions fit together to perform business in a company: Explore and make a business model. Then second, the issue is how management can optimize the operations to ensure that the business is profitable and sustainable: Exploit. Courses in 2020/2021 are restricted due to pandemic compared to former

years. Digital lectures and hybrid digital and physical lectures limit collaborative work, discussions, and methods such as games in classroom.

"Entrepreneurship and Business Plan" (10 ECTS) is an introduction for bachelor students to the process of starting a new business. It is based on the "Disciplined Entrepreneurship" by Bill Aulet at MIT (Aulet, 2017). and the student groups present each week 2 of the 24 steps about their own idea or project. In this way, it is a "flipped classroom" where the main part of the lecture are groups presenting. The lecturer introduces the topics for the following week and organize (and complement) the peer feedback to presenting groups. The method is just as fitting for new companies as for initiating growth at smaller companies or a department.

The 24 steps start with identifying who is the customer and then what do we do for the customer. That becomes a market pull process in developing a business plan. Before this approach, we always got plans based on developing ideas and students as last activity checked if there was a market for their idea. We believe this approach increases probability for a new company to survive. The sequence of the 24 steps is different from a usual business plan structure, but when reshuffled the presentations contain more than 90% of what should be in a business plan. This is to explore how a new company or business should develop it business model.

"Introduction to companies" (10 ECTS) is a new course 2020 for first semester bachelor students. The idea is to make students familiar with what a company consists of- and how it works since most of the new students have no experience with producing companies. It is also a training in finding public information, and to work with students they did not know in advance. The students are introduced to company functions for 5 weeks by 10 lecture topics, and then groups of students are given a task to analyze one company without visiting that company or interviewing anyone at the company. During former years, we have realized that a lot of information about almost all companies are publicly available and can answer questions on what, where, when, who, why, and how. Not all details on how will be available, but enough that bachelor students can find the big picture on how a company operates. By combining public information (Palffy, 2022), the groups write good reports. We sent the reports to some of the companies, and they were surprised on how much and how accurate the students could describe them based on public sources. This is to explore how business models of existing businesses work.

"Operation Management" (10 ECTS) is an introduction for bachelor students to general Operation Management topics. It includes assignments where students in groups are challenged to design a factory with product, process, layout, volume, inventory, employees, and profitability. This is done on a product and sales numbers provided by lecturer. In 2021, the product is a small hovercraft where some parts are to be made and assembled with purchased parts. The groups get feedback during semester and deliver a revised version that counts for 50% of evaluation. Remaining 50% is individual oral exam. This course introduces the exploitation in how to optimize a business model for growth and sustainability.

"Supply chain and Lean Management" (10 ECTS) is a Master course that includes Operation Management topics but focuses on topics related to optimizing in supply chain and lean management. It includes student groups writing 3 essays on given cases. The idea is to challenge students to analyze possibilities and problems for specific companies or trades by utilizing methods from lectures. The groups get feedback during semester and the deliver a revised version that counts for 50% of evaluation. Remaining 50% is individual oral exam. This course focuses on the exploitation in how to optimize a business model for growth and sustainability.

3. Important topics to make supply chain sustainable

3.1. Waste

A common definition by Ohno (1988) is the 7 types of waste: Overproduction, Over-processing, Defects, Waiting, Transport, Motion, and Inventory. Different types of delays are typically a waste of their own, but also have a waste of resources in later stages of the Supply Chain as items do not arrive as intended. The main waste, however, is the overproduction that occurs when companies try to make sure that enough will arrive at the final customer. This is also called the

bullwhip effect (Metters, 1997). An important part of this is the logistics and related activities such as documentation and customs that occur between the main buyers and sellers in the supply chain. These between activities will often contribute to the delays.

3.2. Reliable and sustainable

With the increasing use of global Supply Chains together with increased volume and frequency, the activities and logistics in between main operations have become more important to ensure reliability and sustainable operations. These are based on collaboration and communication between involved companies and agencies. What are reliable and sustainable operations in a supply chain context? A short answer is that a supply chain is reliable when delivering as expected regarding time, cost, volume, and quality. In an ideal world, this should occur without delays and waste. However, with sub-optimization and unforeseen events this happens when planners include enough slack in their estimates (Ferdows, 2016).

Regarding sustainability, this is more complex since sustainability implies that the supply chain can perform reliability repeatedly over a long time and with a minimum of waste anywhere in the supply chain. Sustainability as topic is often referred to the 17 UN goals that state how the world should function on a very high level. However, digging into this relates that several of the goals have a role as goal regarding supply chain issues, and Industry 4.0 technologies and management methods will get an impact (Kvæstad and Hebnes, 2021).

3.3. Variation in port arrivals

A local example is ships arriving in port. They announce their arrival several days in advance and then quay space, unloading and loading resources are reserved. The reality is that many ships arrive ± 2 days before or after what is announced. Then, there are much waste in either getting space or resources earlier than planned or having allocated resources to wait. This sloppy communication creates not only direct waste in the port but also has an impact on the later part of the supply chain (Rygh, 2018).

Such variation occurs anywhere in a supply chain and makes it less sustainable. Variation or deviation from the schedule is thus a major issue to keep operations within the companies lean and sustainable and perhaps even more of all operations between productions companies and the final customer.

3.4. Amazon case

The most well-known of such operation in between production and customers is Amazon, which collects items from producers, stores as little as possible, gets orders from final customers, and delivers the item within a short time. The focus is effective distribution and involves both the logistics in and out of the distribution centers and the storage and fulfilling customer orders inside each distribution center. Amazon is an extreme case of high volume and high frequency on operations and is seen as an example for the future operation of most companies. Due to efficiency in many types of goods and operating globally, they increase their market share. However, most local SMEs cannot compete this way since they depend on local often-limited markets and need to have goods in inventory to enable short delivery time. Without goods in inventory, SMEs buy and make to orders and this makes them dependent on a supply chain that often is global, and where they as a small company do not get priority without high cost.

4. Core cost issues

Important issues that contribute to unwanted variations in time are demurrage and detention tariffs that have two main purposes: (i) Compensating the shipping line for the use of its container, and (ii) Encouraging the merchant to return the container as soon as possible for the shipping line to reuse it and have a fast turnaround. Every small-added cost that occurs makes involved actors try to optimize their part. Even if many of these costs may seem small on their own, they are

significant when accumulated for the supply chain (Mulder and Dekker, 2017; Kraft and Zheng, 2021).

Demurrage is the charge that you pay for the use of the container within the terminal beyond the free time. It is the period from container discharge from the vessel until gate-out of the full container from the terminal and similar from arrival to vessel (Roeloffs, 2021). This is an important issue as it adds cost but tends to be invisible in supply chain planning.

Demurrage is inside the terminal and the detention is the charge that you pay for the use of the container outside of the terminal or depot, beyond the free time (Roeloffs, 2021). This is often also invisible in planning but can be important when delays occur in loading and unloading, or when customer is located far away from the terminal.

Port Storage Charges add to this and are related costs charged by terminal operators for containers staying on the ground (Roeloffs, 2021). Any wholesaler has such storage charges, but it adds to the demurrage and detention. Together they add cost to the supply chain due to what may be regarded as minor delays or buffer in schedule.

Dealing with this, we need to look for the causes since increased demurrage and detention charges can be seen as effects. Increased cost for the supply chain due to delays and variation is an effect, but increased cost can also be a cause since operators tend to optimize their share of activities and do this by adjusting cost of their services. Adjusting cost is done both to ensure income of the operators, but also the means to regulate versus available capacity. Everyone involved want to utilize available capacity but avoid lack of capacity since more demand than available capacity creates waste.

Consignee did not receive documents in time for customs clearance, the documentation received is incorrect or insufficient or cargo received was not as per the sales order. This is often a neglected issue, but dialogue with logistic companies indicate that delays in customs clearance for document handling and incorrect documents are often occurring when SMEs or smaller logistic companies are involved (Steger-Jensen, 2022). A related issue might also be that customs do not have local representation in all small ports or border crossings. Any problems in the information flow will create an effect on the supply chain.

Shipping lines announce closing dates for the actual delivery of the loaded export container to the terminal. It has been documented that arrival of ships often have a ± 2 days variation compared to early announcement (Rygh, 2018). Variation in local arrivals of ships have the waste of loading and unloading resources and lack of available quay location but also consequences of waiting truck transport or extra storage due to lack of available trucks. This creates waiting lines in many container ports and therefore extra cost.

Terminal congestion, bad weather conditions or labor strikes as well as a shortage of truck drivers and chassis cab block containers. Such unforeseen circumstances are due to unexpected variation but relates much to the available capacities of the port including both space and handling.

5. Data driven supply chain

Then what are the possibilities to achieve this? Obviously, much can be done by information exchange and better communication (Banda, 2017; OECD/ ITF, 2021). Such improvement needs to include all involved parties from the raw material producer to the final customer. It includes all activities both within and between the main companies in the supply chain. (Stich *et al.* 2012) This is possible as we can deduct from the Amazon case. However, it is not enough to only exchange information. The sustainable supply chain of tomorrow needs to be data-driven to achieve this.

To become data-driven means that the main flow in the supply chain becomes the data flow with the material flow as consequence (Ali, 2022). Exchange of correct information that all involved can access is the core. (Stich *et al.* 2012). Today most supply chains focus on the movement of material with cost as a major issue, and the data flow comes consequently. Then, demurrage and detention are frequent causes for variation.

A data-driven supply chain needs to be accessible for all that needs access, but it also needs to be secure to provide access for not- involved actors. The sourcing and understanding of customer data are crucial since a data-driven supply chain will have its origin at the final

customer who is the one that pays. All parties going upstream in the supply chain add their information to ensure a smooth operation when the goods are going downstream (Eriksen *et al.* 2010).

A holistic approach to the information flow is needed. We need to go from customer data through customer analysis, customer insight, customer-centric decisions to customer benefit (Stich, 2021). This must be coordinated among all parts of the supply chain with business to business (B2B) relations and the between logistics until the final customer (B2C) (Bechtsis *et al.* 2022).

6. Suggested roadmap

After working with companies for decades and participated in international academic networks, we see that companies and therefore students being employed in them, need to understand context (Frick, 2014). Far too many students learn about mathematics, statistics, innovation, or digitalization technologies without understanding how such can be applied profitable and sustainable in a company.

There are major game-changing trends that local and international businesses need to relate to. One is sustainability where issues like less waste, green energy, and circular economy are important. This is often referred to as people, planet, and profit as core issues to care for. Another is digitalization where everyone expects all parts of material and information handling in a business supply chain to be digital recognized, optimized, and constant improved by machine learning. This is often referred to as the 4th industrial revolution which contains sensors, analytics, digitalization, communication, mobility, and how people utilize these technologies.

Context for such issues is rapidly changing. 20-30 years ago, most local companies were local operators. Now, most local companies operate on global marked both regarding supplies and customers, and their own backyard is similar invaded by external competitors.

The main product from a university is educated students. We need to make them understand context and challenges, and to know methods and tools to utilize when employed in companies. We want to educate and train our students to be able to make a difference and impact both in new companies and in improving existing companies (Sheffi, 2021).

An important aspect is to increase what students remember and can make use of after university. Several research results indicate that we should activate students as much as possible since they understand and can make better use of what they have done than what they only have heard or read. In this context, that includes challenging them do presentations and do analysis/ write reports with no clear correct answer. However, that needs proper tutoring and that students are present in a process. We need students to be part of dialogues with lecturer and with other students. In other words, we cannot have students that only read a book or watch videos on their own. Getting knowledge from books, videos and lectures are important, but to gain the intended outcome, it is vital to be activated as part of a learning process. The learning outcome should enable them to take part in developing their future company or organization, not to remember details for a written 4-hour exam, details that they forget next day. The process is important, and our experiences show that to activate students as much as possible during the class increases learning. One way of doing that is to utilize variations of Problem Based Learning (Kuran *et al*. 2017).

An important learning for this comes from MIT Sloan school about Disciplined Entrepreneurship (Aulet, 2017). It says you need the Spirit of a Pirate and the skills of a Navy Seal. In other words: we need to create a culture where the topics are both interesting and fun, and at the same time train them to develop needed skills. For many years, we have given students the task of writing bachelor thesis and expected them to perform exemplary. However, we have not trained them in advance for that goal. How can we expect state of the art world level results without proper training of relevant skills? Too much university activities focus on reading a book or listen to a lecture without any practice in how to utilize the knowledge pushed to the students. An important part of the Sustainable Business and Operation Management learning must include new tools. Digitalization provides many possibilities for companies and public services, and our

education is behind in the proper implementation and utilization of such tools. The proposal in this paper is to follow the 3- stage process as outlined in a roadmap here:

Stage 1: We should start by adopting the thinking from Disciplined Entrepreneurship (Aulet, 2017) where we utilize the following sequence 1-5:

i. Understand who is the “customer”
ii. What do we do for the “customer”
iii. How do the “customer” acquire our product or service
iv. How do we make money from the “customer”
v. How do we develop, maintain, or scale needed products, service, and processes

Stage 2: And then from LEAN processes and management (Ohno, 1988; Vlachos, 2015):

vi. What is needed sequence (flowchart) with activity capacities versus demand
vii. Where is added value or waste (MUDA)
viii. Do we have overburden (MURA) or unbalanced load (MURI)
ix. Is variation in processes or activities too high
x. Do we have proper plans for improvement and sustainability (A-3)

Stage 3: And at last, we can do useful digitalization (OECD/ ITF, 2021; Frick, 2014)

xi. Where do we collect facts by sensors and Internet of Things (IoT)
xii. How do we communicate and store information
xiii. How do we do analysis or machine learning to utilize the facts from LEAN stage
xiv. What kind of reports and key performance indicators tells us how to adapt or improve

This roadmap is made to generate sustainable and profitable operations. It is tested in the COM-3 project (atene KOM GmbH, 2022) The roadmap utilizes knowledge from marketing, economy, and technology, but the main part is proper management. One of our problems is that to understand the stages and their implications, one needs understanding of processes and organization in companies. This is a background that most of our students do not have. To compensate, we try to collaborate with as many companies as possible to have a dialogue that provides updated knowledge to the students, and then provide the companies with better new employees.

The main issue to remember from this paper is that the future to improve supply chains and to make them sustainable is to make them data driven. To achieve this, the proposal is the 3- stage roadmap where stage 1 explores what to do, stage 2 exploits it with LEAN, and stage 3 is the digitalization of the processes.

7. Conclusion

Experiences show that to keep track of changes in industry and enable our students to make a future impact when employed, we need to activate and train students. That implies that active participation in a learning process is needed even if it is via digital tools as of 2020& 2021. It is not acceptable to have students that nobody has seen before a written exam. An exam is a certificate to document a finish line, but the important part is the participation in a learning and training process before (Kuran *et al.* 2017; Pedersen *et al.* 2019).

A sustainable supply chain for the future may be achieved by utilizing AI to improve decisions and reduce latency. Much of the information flow and documents in a supply chain are standard forms and standard handling. Thus, AI and machine learning should be feasible (Cheushvili, 2021; Sharma *et al.* 2022).

Better customer analysis, customer insight, and customer-centric decisions are main competitive issues in sustainable supply chains. To integrate better the analysis, insight, and decisions, we need to involve digital infrastructure, digital architecture, and business development

in combination (Sethi, 2016). Amazon does this as a distributor between producers and the final customer, but such issues must be developed for the full length of the supply chain. (Page, 2022). Most actors in global or local Supply Chains does not have the volume or resources as Amazon. SMEs need solutions that are affordable and manageable within their resources and other limitations. The operations between the B2B companies are perhaps a core issue to this in terms of digital infrastructure, digital architecture, and business development. However, these are complex as they include both private companies, global consortiums, and governmental organizations as customs (De Menezes, 2017; Bechtsis *et al.* 2022)

This may be seen as the implementation of Industry 4.0 methods and tools and may also meet the UN sustainability goals (Kvæstad and Hebnes, 2021). To proceed then data driven supply chains needs to be developed in pilots and later scale-ups. This has started with the physical internet approach (Monttreuill, 2011), but needs to be extended and includes more of the people and organizations involved in the total supply chain (Rosich *et al.* 2013; Stich *et al.* 2008). However, the basis for developing the sustainable data driven supply chain is that the students must learn to explore the processes, then to exploit them, and to move the best optimized processes into the digital tools.

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