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BESPOKE SUPPLY CHAIN RESILIENCE FACILITATED BY DEDICATED AND SHARED RESOURCES

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Abstract

In this paper, we offer a characterization of resilience-enhancing measures. We argue that resilience-enhancing measures are either based on using dedicated resources (referred to as “dedicated resilience levers”) or on using shared resources (referred to as “shared resilience levers”). By dedicated resources, we mean resources that are provided only for the purpose of building resilience. In contrast, shared resilience levers are based on using shared resources. By shared resources, we mean resources that are not only used for risk mitigation but also serve another purpose, such as helping to better meet customer demand without disruption. We argue that shared resilience levers are particularly helpful for supply chains that focus on cost-efficiency and produce basic/functional products. In contrast, dedicated resilience levers are particularly helpful for supply chains that are less exposed to cost pressure and that produce innovative products. Further, we discuss how the supply chain finance solution reverse factoring can be considered a shared resource that helps build resilience and efficiency simultaneously. We provide an overview of past and future research directions and a conclusion.

Keywords: supply chain resilience, supply chain efficiency, shared resources, flexibility

JEL Classification: M1

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1. INTRODUCTION

The production of chips needed for the assembly of automobiles ground to a halt in December 2020 due to COVID-19-related disruptions in the People's Republic of China (PRC). As a result of these supply shortages, chip manufacturers raised chip prices and also invested in expanding capacity. Automotive companies experienced production shortages, which resulted in declining sales. Supply chain disruptions such as these were reported continually across various industries in the years after the coronavirus was first identified at the end of 2019.

Practitioners and academics alike have looked into ways of building resilience in supply chains. A variety of levers have been identified to increase the resilience of supply chains, including keeping buffers (such as additional inventory) and building flexibility in supply chain networks. The total cost of operating a supply chain is often much higher when disruptions are included than when they are ignored. Anecdotal evidence, however, suggests that firms are often reluctant to implement resilience-enhancing measures. Many firms are not willing to make financial commitments (for example, in the form of sourcing from an expensive reliable supplier instead of sourcing from a cheaper unreliable) that pay off only in the unlikely event of a disruption. Firms' resistance to adopting these resilience levers is further exacerbated by the fact that firms are often unable to estimate the likelihood of a rare event, making it difficult for them to quantify the benefits of resilience investment. In addition, firms often focus on a short time horizon for creating shareholder value, whereas resilience investments often only pay off in the long term. Consequently, many firms are reluctant to make significant investments to build resilience in their supply chains.

One might expect that firms are not well prepared to deal with disruptions. However, this is not necessarily always true. The pandemic illustrated how some firms managed to flourish during the crisis, whereas others lost significant revenues and market share. True, some of these differences can be explained by the different markets firms serve (e.g., many grocery retailers had only a few demand or supply disruptions); however, some firms managed to create genuine resilience in their supply chain without sacrificing supply chain efficiency. Here are some examples:

- Zara and H&M. While Zara experienced only a small decline in sales and profit, H&M was badly hit by the lockdowns that prevented customers from shopping in its brick-and-mortar stores. Zara's success relative to H&M has been attributed to its omnichannel solution. An omnichannel solution refers to selling goods (in this case, clothes) through the online and brick-and-mortar stores. Essentially, both sales channels merge in an omnichannel solution. That way, for example, customers might decide to order online and pick up the good from a store. Having a sophisticated omnichannel solution in place has allowed Zara to generate and meet customer demand in spite of lockdowns (Orihuela and Hipwell 2020). Interestingly, Zara originally set up an omnichannel solution to increase supply chain efficiency. It came as a surprise that this omnichannel solution would also be helpful in dealing with the disruption caused by the pandemic.
- Walmart, Amazon, and Target. Many large retailers, such as Walmart, Amazon, and Target, capitalized on their internal flexibility to manage supply or demand disruptions during COVID-19. Besides being capable of switching sales from brick-and-mortar stores to online stores, they are also increasingly capable of dealing with supply disruptions. They have the flexible internal capacity to

transship goods between different stores and warehouses whenever product shortages occur at a single location.

These examples illustrate that some resilience levers – often related to some sort of flexibility – not only provide some resilience but also increase supply chain efficiency, i.e., they allow the supply chain to run at low cost even in normal times in the absence of any disruption.

In this paper, we offer a characterization of resilience-enhancing measures. We argue that resilience-enhancing measures are either based on using dedicated resources (referred to as "dedicated resilience levers") or on using shared resources (referred to as "shared resilience levers"). By a dedicated resource, we mean a resource that is provided only for the purpose of building resilience. An example would be to source components from an expensive reliable supplier rather than a cheaper unreliable one. In contrast, shared resilience levers are based on using shared resources. By shared resources, we mean resources that are not only used for risk mitigation but also serve another purpose, such as better meeting customer demand (through a higher service level, for example). Typically, shared resources not only help build resilience but also help meet customer demand in the absence of disruptions. An example would be increasing the safety inventory, which helps improve the service level and the supply chain's resilience. We argue that shared resilience levers are particularly helpful for supply chains that focus on cost-efficiency and produce basic functional products, such as consumer goods (where price competition exists). In contrast, dedicated resilience levers are particularly helpful for supply chains that are less exposed to cost pressure and that produce innovative products, such as patented medical drugs. The paper aims to highlight the importance of matching the right resilience lever with the right supply chain. That way, firms can achieve a suitable level of resilience while considering the associated costs. Another objective is to call for more research in the area of shared resilience levers.

In this paper, we explore the topic of shared resilience levers for building resilience and efficiency using a field research study approach. Field research is a particularly useful methodology when exploring a new topic (Eisenhardt 1989; Yin 2003). Voss, Tsikritsis, and Frohlich (2002) and Seuring (2005) argue that field research is helpful when new topics are explored that are not yet well understood or even defined. The observations developed in this paper are based on qualitative analysis where different sources of input are used. (i) Interviews were conducted with about 10 executives in different industries such as pharmaceutical, consumer goods, and finance. Open questions were asked with regard to how their firms build resilience while considering the pressure to operate a supply chain at low cost. The output of these interviews was used to form initial hypotheses about how firms manage risks while considering cost-efficiency. (ii) These initial hypotheses were then further validated through a detailed literature review. The literature review is based on searching articles in the Web of Science over the past 20 years using the keywords supply AND (chain OR chains) AND (disruption OR resilience). The literature review has helped in finding additional support for the initial findings. Such a methodology is common in the literature, where a two-step framework is often proposed (Voss et al. 2002). First, direct observations are conducted (in our case, the interviews). Second, the initial findings are further validated to make initial findings more concrete (in our case, the literature review). Applying this methodology has helped us develop a characterization of resilience levers and a description of how they match the supply chain characteristic.

Our paper is structured as follows. Section 2 introduces a categorization of resilience-enhancing levers and argues how they match with different supply chain topologies. Section 3 provides a detailed example of the reverse factoring of the supply chain finance solution. We explain how reverse factoring works and argue why it helps improve supply chain efficiency and resilience. As such, reverse factoring can be considered a shared resilience lever. Finally, in Section 4, we call for more research to enhance understanding of the trade-off between resilience and efficiency in supply chains. Although the traditional supply chain disruption risk management literature indicates that resilience is typically achieved by sacrificing efficiency (Yildiz et al. 2016; Lücker and Seifert 2017; Lücker et al. 2019), the discussion around shared resilience levers shows that supply chain resilience and efficiency can be achieved at the same time. Further, most previous research emphasizes how managing disruption risk is different from managing demand uncertainty. However, we believe that more research is needed to identify the joint benefits of resilience-enhancing levers for mitigating disruptions and serving customer demand in the absence of disruptions.

2. TAILORED RISK MANAGEMENT APPROACH

Identifying the right levers to build resilience in the supply chain is critical for succeeding in a versatile business environment. In this section, we aim to categorize resilience-enhancing levers (shared versus dedicated resilience levers) and argue how they match with different supply chain archetypes (just-in-time versus just-in-case supply chains).

In the following, we argue that resilience levers (i.e., a measure that enhances a supply chain's resilience) can be shared or dedicated. In order to explain the difference between the two levers, let us distinguish two situations: a) Normal times where no disruption occurs. During normal times, firms are primarily concerned with serving customer demand using the available supply while keeping costs low. b) Disruption times. During disruption times, firms are primarily concerned with recovering from the disruption and still serving customer demand using all available (not disrupted) resources.

The insights discussed in this section are primarily based on the interviews conducted. As only open questions were posed, the output of the interviews was further backed up with findings from the literature search.

2.1 Dedicated Resilience Levers

In this section, we give examples of dedicated resilience levers. Recall that these levers are defined as levers that use dedicated resources. By a dedicated resource, we mean a resource provided only for building resilience (and that is not of help in normal times when no disruptions occur). Here are some examples:

a) **Sourcing from a reliable supplier.** Firms often have a choice to source raw materials from more reliable or less reliable suppliers. Less reliable suppliers are often cheaper than more reliable ones. Thus, sourcing from a more reliable supplier typically comes at an additional cost, and thus requires resources or funds (Tomlin 2006). The key observation is that these additional resources are provided only for the purpose of building resilience. There is no other benefit of sourcing from a more reliable supplier than enhancing resilience (as long as all the other characteristics of the supplier remain unchanged). Thus, sourcing

from a reliable supplier is a dedicated resilience lever, as the resource provided is dedicated only to building resilience.

b) **Protecting manufacturing plants from external threats/hazards.** Some firms might be exposed to the risk of external threats/hazards such as floods or earthquakes. It is known that there is an increased likelihood of floods in some areas (for example, manufacturing plants close to a river). In such cases, firms might decide to invest in protecting manufacturing plants against flooding (by setting up barriers). This additional protection would only be helpful to ensure the continuation of production even if there is flooding (up to a certain degree). The payoff occurs only in the event of disruption, and not in normal times. Thus, protecting manufacturing plants from external threats/hazards is a dedicated resilience lever.

c) **Better estimating disruption probabilities.** Firms sometimes make an effort to better estimate the probability of disruption at specific production sites (Lim, Bassamboo, and Chopra 2013). Pharmaceutical company Roche, for example, purchases data from insurance companies to better estimate the likelihood of natural hazards at their production sites in California, US. Clearly, improving the estimation of disruption probabilities requires a dedicated resource of funds that help build resilience but do not offer any other benefit in the absence of disruptions.

d) **Incentivizing suppliers to increase reliability.** Firms may make an effort to increase the reliability of a supplier (Wang, Gilland, and Tomlin 2010). This helps to stabilize the supply chain. Increasing reliability can be achieved through closer collaboration, financial incentives, or penalty contracts that stipulate a penalty fee for not delivering goods (Tang, Gurnani, and Gupta 2014). Such measures typically help to make a supply chain more resilient but are less helpful for other purposes.

2.2 Shared Resilience Levers

Shared resilience levers are based on using shared resources. By shared resources, we mean resources that are not only used for risk mitigation but also serve another purpose, such as better meeting customer demand in normal times (through a higher service level, for example). Typically, shared resources not only help build resilience but also assist in meeting customer demand in the absence of disruptions. Here are some examples:

a) **Using safety inventory.** Firms hold a safety inventory to protect them from stockouts when demand is higher than anticipated. Holding a safety inventory allows a firm to achieve a high service level. Because carrying an inventory is costly, firms often hold only some safety inventory and accept the risk of some stockouts. The key observation is that a safety inventory not only helps to deal with jumps in demand, but it is also a stockout protection when supply disruptions occur (Liu, Song, and Tong 2016). Thus, we may argue that a safety inventory is a shared resource as it serves the purpose of building resilience and of increasing service levels.

b) **Using excess capacity.** Firms typically do not operate at 100% capacity utilization because of demand swings. If demand turns out to be higher, additional goods can be produced to serve customer demand. Having too much excess capacity, however, is expensive. As a result, companies have to carefully assess the amount of excess capacity they need, which is often in the range of 5%–20%, depending on the industry. It turns out that excess capacity not only helps in dealing with demand swings but also builds some resilience in the supply chain network (Lücker, Chopra, and Seifert 2021). If one manufacturing plant is disrupted, some production might be scheduled at a nondisrupted plant where there is some excess capacity. Obviously, this works only if the manufacturing plants are flexible and qualified to allow this capacity scheduling change. Here again, excess capacity is a shared resource that helps both build resilience and increase customer service levels without disruption.

c) **Reducing lead time.** Roughly speaking, lead time is the time it takes to produce a good. It is the time that elapses between starting and finishing the production. Lead time reduction provides significant operational benefits and is generally seen as a tool for better matching supply with demand (De Treville et al. 2014). It helps significantly in reducing inventory levels, thereby making supply chains more cost-efficient. At the same time, lead time reduction might make supply chains more resilient. A short lead time might allow a firm to recover more quickly (because the production lead time after recovery is shorter), but it also provides more flexibility in the supply chain.

d) **Using component commonality.** Using the same components for different products (referred to as “component commonality”) also increases supply chain efficiency (Thonemann and Brandeau 2000). Although there might be an initial increase in cost (due to having more expensive components even though a cheaper one would also work for some products), it provides the benefit that these components can be shared if some products experience more demand than others. Likewise, it provides resilience because these components can be shared across products if there is some supply issue for some products.

e) **Using pricing flexibility.** Dell uses pricing flexibility to manage demand. If there is more demand than anticipated for one product, a similar product might be offered at a lower price to shift demand from the popular product to the less popular one. The same argument can be made when there is a supply chain disruption (Tang and Yin 2007). Demand for a product with limited supply can simply be shifted to similar products through changing prices.

f) **Using multi-sourcing.** Multi-sourcing might reduce the impact of a disruption and increase the resilience of the supply chain (Babich, Burnetas, and Ritchken 2007). In some cases, it might also help the buyer to negotiate lower wholesale prices with the suppliers as the buyer can let the two suppliers compete against each other to lower the wholesale price.

g) **Emergency purchases.** Emergency purchases might be possible for some commodity products where there is a spot market for such products. Purchasing on the spot market is typically considered to be more expensive than regular purchases through long-term contracts (Gümüs, Ray, and Gurnani 2012). However, having access to such a spot market enables a company to serve demand when a disruption occurs or when demand is higher than anticipated. As such, access to a spot market might help both objectives, i.e., to build resilience and increase the efficiency of the supply chain.

h) **Flexible transportation.** Flexible transportation may mean that the speed of transportation can be accelerated (Fan, Schwartz, and Voss 2017). Goods may use a faster means of transportation that also comes at a high price. Being able to accelerate transportation helps with resilience and efficiency. Flexible transportation may also mean that there are more transportation paths. For example, transshipment may allow a firm to move goods from one warehouse (serving a specific market) to another (serving another market). This additional transportation link – transshipment – gives the firm more flexibility, which helps build resilience and efficiency.

i) **Reverse factoring.** The supply chain finance solution of reverse factoring might increase resilience and efficiency simultaneously (Banerjee, Lücker, and Ries 2021). We explain reverse factoring in a separate section, Section 3, and highlight how it helps build resilience and efficiency in the supply chain.

The list of dedicated and shared resilience levers is by no means exhaustive. The suitability of resilience levers always depends on the industry and product characteristics. Some levers are not suitable in some industries due to the characteristics of the supply chains or products.

We conclude this section with a key observation: Dedicated resources are always available for risk mitigation, whereas shared resources might not be available when needed.

Let us consider the dedicated resilience lever of sourcing from a reliable supplier. A reliable supplier will always provide some level of guaranteed resilience. In contrast, shared resources are used for two purposes and might not be available during a disruption. Thus, shared resources may fail to provide resilience. Consider the shared resource of a safety inventory. It might happen that just before a disruption occurs, there is increased customer demand, resulting in the depletion of the safety inventory. Thus, this safety inventory cannot be used for risk mitigation anymore. Also, the opposite could happen. Demand could be much lower than anticipated, and the entire safety inventory could be available during a disruption. Thus, shared resilience levers only provide some resilience in expectation and cannot guarantee a minimum level of resilience.

We may conclude that dedicated resilience levers provide the benefit of some guaranteed resilience. However, this comes at a higher cost than having shared resilience levers. Shared resilience levers, in contrast, might fail to provide resilience when needed.

2.3 Matching the Right Resilience Lever with the Right Supply Chain

In the previous two sections, we classified resilience levers as dedicated or shared. A summary is provided in Table1. In this section, we want to address which lever to use for which supply chain.

Table 1: Dedicated and Shared Resilience Levers

Dedicated Resilience Lever	Shared Resilience Lever
Sourcing from a reliable supplier	Using safety inventory
Protecting manufacturing plants from external threats/hazards	Using excess capacity
Better estimating disruption probabilities	Reducing leadtime
Incentivizing suppliers to increase the reliability	Using component commonality
	Using pricing flexibility
	Using multi-sourcing
	Emergency purchases
	Flexible transportation
	Reverse factoring

Source: Author.

We consider two supply chain archetypes that are often discussed in the literature: just-in-time supply chains (Sugimori et al. 1977) and just-in-case supply chains (see Table 2 and Jiang, Rigobon, and Rigobon 2022).

Just-in-time supply chains (sometimes also referred to as “cost-efficient supply chains”) focus on using lean principles to reduce costs where possible. These supply chains are useful for producing functional products with low product margins. Functional products tend to be exposed to stable market environments with predictable demand patterns. Cost reduction adds value because the products often compete on price, not quality.

Just-in case supply chains (sometimes also referred to as “responsive supply chains”) focus on reducing the likelihood of supply chain breakdown. These supply chains are useful for producing innovative products with high margins. Innovative products tend to be exposed to more volatile market environments where precise demand forecasts are often difficult. For such supply chains, flexibility is valuable as it helps to cope with a volatile market environment. Supply chain managers add value by ensuring a reliable supply of goods to customers using buffers such as inventory, capacity, or multi-sourcing.

Table 2: Just-in-Time and Just-in-Case Supply Chains

Just-in-time Supply Chain	Just-in-case Supply Chain
Focus on cost-reduction to create supply chain value	Focus on reducing the likelihood of supply chain breakdown
Used primarily for functional products such as consumer goods (where firms compete on price)	Used primarily for innovative products where there is less competition on price
Supply chain managers aim to increase the efficiency of supply chains	Supply chain managers aim to build resilience by using buffers such as inventory, capacity, multiple-sourcing, near-shoring

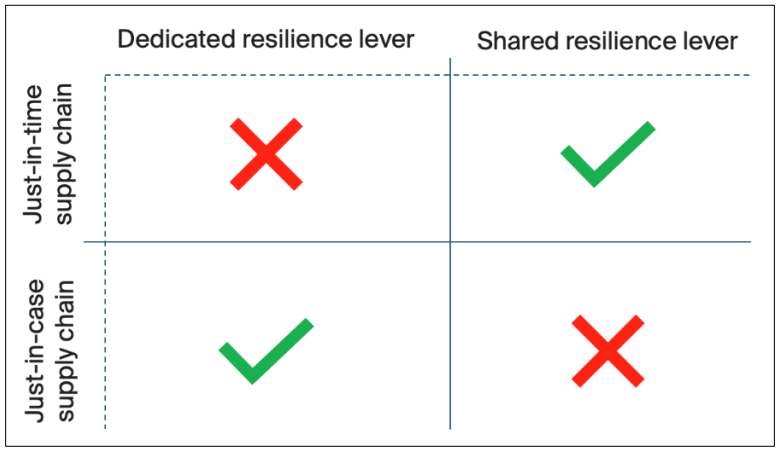
Source: Author.

We argue that it is often economical for just-in-time supply chains to use shared resources rather than dedicated resources when building resilience. The argument is that supply chains that need to operate cost-efficiently simply do not have the financial resources to use dedicated resources. While using shared resources has the drawback that a certain level of resilience cannot be guaranteed, it provides an expectation of some reasonable level of resilience while significantly reducing costs. Arguably, these supply chains can’t afford to provide a guaranteed level of resilience as dedicated resources are often considered to be too expensive.

We further argue that it is often economical for just-in-case supply chains to use dedicated resources rather than shared resources when building resilience. Dedicated resources are typically very expensive but provide a guaranteed level of resilience. Dedicated resources might be helpful for companies that are less exposed to cost pressure and where some guaranteed level of resilience is needed. As an example, consider the pharmaceutical industry, which produces patented life-saving drugs. Given the patents, the operating margins are often very high. Thus, increasing operating costs a little might not be a game-changer for pharmaceutical companies such as Roche. Having guaranteed resilience in the supply chain is strategically important to pharmaceutical companies for three reasons: 1) Patient safety. As the drugs are frequently life-saving and patented, often only one pharma company can produce these drugs. Patients often can't find alternative drugs to get treatment. 2) Regulatory requirements. Pharmaceutical companies are under pressure to be on good terms with regulators such as the FDA. Regulators want to ensure that pharmaceutical companies can reliably supply drugs to patients, even when major disruptions such as COVID-19 occur. 3) Given that the margin is so high, financial leeway exists to provide resources for building resilience.

We can say, in summary, that firms producing basic products using just-in-time supply chains find more value in using shared resilience levers than dedicated resilience levers. Firms producing innovative products using just-in-case supply chains might find more value in using dedicated resources for building resilience in the supply chain. We illustrate this observation in Figure 1.

Figure 1: Just-in-Case Supply Chains Match with Dedicated Resilience Levers Whereas Just-in-Time Supply Chains Match with Shared Resilience Levers



Source: Author.

3. EXAMPLE OF SUPPLY CHAIN FINANCE

This section aims to provide an example of how the use of supply chain finance solutions, such as reverse factoring or dynamic discounting (Gelsomino et al. 2016), can be seen as a shared resource that helps increase supply chain resilience and efficiency. Supply chain finance solutions aim to help optimize the flow of money or funds in the supply chain. This section considers a supply chain consisting of a buyer and a supplier. We are interested in learning what factors affect the time when the buyer pays the supplier and the amount of money the buyer pays the supplier.

Besides the flow of goods in the supply chain, the flow of money or funds is critical when managing risks in the supply chain. It is not unusual for suppliers to default because of a lack of liquidity (i.e., no access to cash). For example, a buyer might pay a supplier very late, even after the agreed payment date, and as a result, the supplier might struggle to have enough cash on hand to pay back some loans or pay the salaries of the employees. A supplier default can result in a significant supply chain disruption, particularly when the supplier provides a critical component needed for the production of a finished good. Thus, when building resilient supply chains, it is important to ensure that critical suppliers have access to sufficient liquidity (money) in order to ensure a reliable supply.

Managing liquidity can be a challenge for a supplier, particularly when the supplier is a small company. Small companies may struggle with accessing capital as they might not have a sufficient trading history that convinces a banker about the viability of their business model. Thus, smaller suppliers are particularly exposed to the risk of default due to a lack of liquidity. The common practice of delayed payments exacerbates this problem. Delayed payments refer to the practice that buyers buy goods now but pay suppliers later, often 30, 60, or 90 days after the delivery of the good. Thus, a small supplier has to find a source of money to cover the 30, 60, or 90 days of late payment. Late payment is often considered a reason for supplier default.

One could argue that a buyer might be interested in paying a supplier more quickly. However, there is a drawback of paying the supplier early. The buyer would rather keep the money for themselves in order to invest in internal growth projects such as the development of a new product or the exploration of a new market. The buyer might also decide to invest the money better in new production technology, such as 3D printing, which might help the buyer to reduce production costs in the long run. Thus, paying the supplier early might enhance supply chain resilience, but it comes at the cost of sacrificing supply chain efficiency (as long as the purchase price remains unchanged).

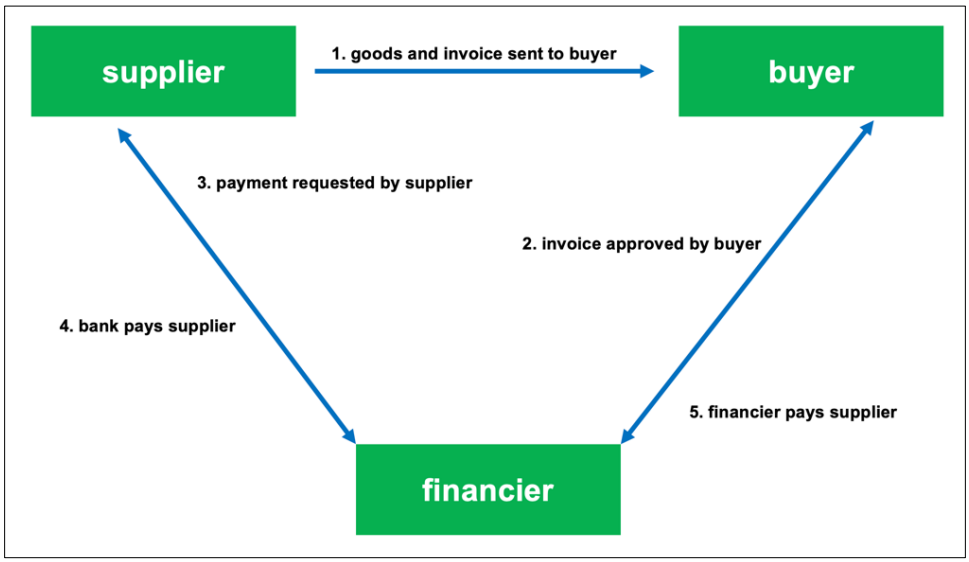
To overcome these problems, the financial service industry has developed so-called “supply chain finance solutions” aimed at helping the supplier access capital (while providing benefits to the buyer). While many supply chain finance solutions are available, such as reverse factoring, dynamic discounting, in-transit financing, purchase order financing, and deep tier financing, we focus in this paper only on the two most popular ones: reverse factoring and dynamic discounting (PwC 2017). However, the insights developed from analyzing reverse factoring and dynamic discounting continue to hold for many other financing solutions as well.

3.1 Reverse Factoring

One solution that helps suppliers access capital is called “reverse factoring.” The goal of this section is to convince the reader that the use of reverse factoring may enhance the supply chain’s resilience while also increasing the cost-efficiency of the supply chain. We will argue that reverse factoring can be considered a shared resilience lever as it serves two objectives: building resilience and improving the flow of funds in the supply chain, resulting in enhanced efficiency.

The aim of reverse factoring is to provide money to the supplier immediately after shipping goods to the buyer while allowing the buyer to stretch payment terms even further (see Figure 2). The buyer borrows from a financier – a fintech or a bank – who pays the supplier early (minus the financing costs) and receives the money from the buyer later. Reverse factoring reduces the supplier's working capital needs and allows the buyer to pay at an even later point in time than they would have done under trade credit to the suppliers (Banerjee, Lücker, and Ries 2021; Kouvelis and Xu 2021). Essentially, the process is as follows (see Figure 1): (1) The supplier sends goods and an invoice to the buyer. (2) The buyer sends an approved invoice to the financier. (3) The supplier sends a payment request to the financier. (4) The financier pays the supplier the invoiced amount less the total discount based on the payment period for the buyer, the financier's cut. (5) The buyer pays the full amount to the financier upon maturity. There are variants to this process: The discount could be deducted later if only 75%–90% of the invoiced amount is paid upfront in Step 2 and the remainder upon maturity. If the buyer cannot pay, the supplier may be liable or not, depending on the recourse arrangements.

Figure 2: The Process of Reverse Factoring



Source: Author.

While initially, the implementation of reverse factoring turned out to be cumbersome given the huge number of suppliers that large buyers have, nowadays, reverse factoring is being applied across entire supplier bases for large buyers. This is possible due to innovative technology solutions offered by providers such as Taulia and C2FO. A recent celebrated example is Airbus, which offers reverse factoring across their entire supplier base, resulting in improved supply chain resilience and better access to working capital for the suppliers and buyers. Deploying reverse factoring enhances supply chain efficiency as the supplier has improved access to financing, resulting in lower costs for the supplier. Likewise, the use of reverse factoring enhances supply chain resilience as the supplier is arguably less likely to default due to the improved access to capital through reverse factoring. Empirical evidence suggests that using reverse factoring enhances supply chain resilience. Thus, deploying reverse factoring allows a firm to increase resilience and efficiency at the same time.

Reverse factoring is a financing solution that is offered by international and domestic banks. An increasing number of fintechs (financial technology companies) offer reverse factoring through a digital platform. Suppliers and buyers can join such platforms and access the reverse factoring scheme there. The benefit of using a digital platform is that the process of participating in a reverse factoring scheme becomes simpler and more cost-efficient, especially for suppliers. The availability of these platforms has resulted in a significant increase in the use of reverse factoring for suppliers and buyers in recent years.

3.2 Dynamic Discounting

Dynamic discounting is another supply chain finance solution that helps to stabilize the supply chain by improving access to cash for suppliers (while also increasing the efficiency by optimizing the allocation of cash between supplier and buyer). The basic idea behind dynamic discounting is that a supplier and buyer agree on a discount on the wholesale price in exchange for an early payment. For example, instead of paying the supplier 30 days after shipping the goods, the buyer might receive a discount for paying the supplier immediately after the buyer has received the goods. There are different variations of dynamic discounting on the market. They are differentiated by how the discount rate and payment time are determined. Let us discuss the two most common variations: (i) the sliding scale approach and (ii) the market-based approach.

The sliding scale approach is based on the buyer offering a discount rate to the supplier that depends on the time when payment is executed. Generally, the earlier the buyer pays the supplier, the higher the discount for the buyer. That way, the buyer is incentivized to pay early. The early payment is helpful for the supplier because it helps to reduce the cash conversion cycle (or working capital need) of the supplier.

The market-based approach is based on creating a market/digital platform where suppliers can upload discount offers for their invoices. The buyer can then choose to pay those invoices early that offer a sufficiently large discount rate. That way, the buyer benefits from receiving a high discount on the wholesale price. Also, suppliers might benefit because those suppliers that are most in need of cash would offer the highest discounts, which in turn results in providing the available cash from the buyer to those suppliers that most need it. This illustrates that dynamic discounting is often a cash management tool as well. Any excess cash that a buyer has can be used to pay the supplier early in return for a profit (rather than depositing the money in a current account where the interest rate is typically low).

From a supplier perspective, it is not evident which dynamic discounting variation is more beneficial. The buyer may ask for a smaller discount in the sliding scale approach than in the market-based approach. In contrast, the market-based approach might be helpful for those suppliers that are most desperate for cash. However, under the market-based approach, the discount rate might be higher because the buyer might reject the discount offered by the supplier if the discount offered is too low. In either case, dynamic discounting is always offered as a voluntary source of financing, meaning that suppliers are not forced to participate in dynamic discounting programs. Dynamic discounting is simply an offer from the buyer to the supplier and provides an alternative way to access the supplier’s capital. Arguably, this additional source of financing may help smaller suppliers overcome times when suppliers struggle with liquidity, and as such, it may help stabilize the supply chain.

Fundamentally, the gain in efficiency arises from overcoming trade credit inefficiencies. A trade credit agreement might be inefficient if the supplier has to pay a high interest rate to raise funds and provide them to the buyer in the form of trade credit. Under dynamic discounting, this inefficiency is reduced or even completely eliminated. Thus, dynamic discounting releases supply chain surplus and makes the supply chain more efficient.

Other supply chain finance solutions, such as purchase order financing and deep tier financing, also aim to smoothen the flow of funds in the supply chain and increase supply chain efficiency and resilience.

4. PAST RESEARCH AND FUTURE RESEARCH DIRECTIONS

In this section, we continue our review of the academic literature. Specifically, (i) we identify similarities between the literature on shared resources and flexibility in the supply chain, (ii) we identify further examples of how sharing resources helps build resilience in the supply chain, and (iii) we identify gaps in the existing literature and provide avenues for future research.

The concept of using shared resources for building resilience is closely related to the more general concept of flexibility in supply chains. While flexibility does not specifically refer to supply chain resilience, it often refers to resources that can be shared for different purposes in supply chains. As such, it is not surprising that there is some overlap with the flexibility literature. Indeed, flexibility has been acknowledged in the disruption risk literature as a valuable risk mitigation strategy. The literature review by Snyder et al. (2016) specifically looks at the risk mitigation strategies of *sourcing flexibility* and *demand flexibility*. The use of both types of flexibility results in increased resilience, but not necessarily increased supply chain efficiency (in the absence of disruptions). At the same time, the supply chain literature that ignores disruption risk highlights the value of flexibility in dealing with demand uncertainty (Sethi and Sethi 1990). Further, Jordan and Graves (1995) introduce the concept of *chaining*, whereby capacity at each production node is flexible enough to serve a couple of markets, creating a chain. A chain requires a small amount of manufacturing flexibility while maximizing the benefit of this flexibility. Although chaining is designed primarily to deal with normal variations efficiently, it naturally provides some resilience against disruption without requiring any additional investments. As such, chaining can be seen as a shared resilience lever.

Avci (2019) studies the value of (i) transshipment (i.e., having an additional transportation path between different markets) and (ii) expedited shipping in a distribution network subject to disruptions. A feature of the paper is that the author considers the effect of these two levers on building resilience (measured in terms of conditional value at risk) and improving supply chain performance in the absence of disruptions (measured in terms of service level). The author finds that particularly expedited shipping helps to build resilience and to achieve a high service level in the absence of disruptions (despite the higher costs). In contrast, transshipment helps build resilience but is less effective in maintaining a high service level without disruptions. Similarly, Fan, Schwartz, and Voss (2017) study the value of flexible transportation modes (with different speeds) in a multi-product supply chain subject to the risk of disruptions. Disruptions can be mitigated by changing the transportation mode of some products; that is, the delivery of some products can be accelerated to reduce potential stockouts due to disruptions, thus increasing resilience. Interestingly, providing

flexibility in the transportation mode also helps to deal with day-to-day glitches such as transportation delays, thereby increasing supply chain efficiency.

Similarly to this discussion, Chopra, Sodhi, and Lücker (2021) propose that supply chain resilience and efficiency can be achieved by creating multiple channels for the flows of information, product, and funds in a supply chain. These multiple channels are often facilitated by means of supply chain commons – a set of pooled resources for the flows of information, product, and funds. The authors argue that firms often create multiple channels for the three flows to improve efficiency. Yet, it turns out that these multiple channels also create some resilience *for free*. Further, the authors argue that the availability of supply chain commons further reduces the costs of established risk mitigation strategies, such as using flexibility in the supply chain.

Chopra, Glinsky, and Lücker (2023) study a sourcing problem where a buyer sources from an unreliable supplier, and the demand for the good the buyer sells follows a finite life cycle curve where future customer demand depends on present sales. The authors show that in such a setting, moving part of the order quantity from a later period to an earlier period – referred to as "placing anticipatory orders" – is optimal. Anticipatory orders are placed at optimality only when future demand depends on present sales (e.g., a supply disruption would result in fewer sales and thus dampen demand in the future). While placing anticipatory orders is optimal even when ignoring demand uncertainty, it turns out that anticipatory orders are placed at even lower disruption probabilities when there is demand uncertainty relative to the case where there is no demand uncertainty. The reason is that ordering a large order quantity in an earlier period of the product life cycle not only helps to protect against disruption risk, but it may also help to serve higher demand than anticipated and thus increase the service level. In other words, because there is a dual benefit (building resilience and increasing supply chain efficiency), anticipatory orders are placed at even lower disruption probabilities (relative to settings with constant demand).

We believe that more research is needed that analyzes strategies that are helpful for creating resilience and improving supply chain efficiency (or do not reduce efficiency significantly).

While our literature review highlights that there may be synergies in sharing resources for risk mitigation and for normal times, we acknowledge that some resources cannot be shared for such dual/multiple purposes. Here, firms have to make a trade-off and decide what is best. Consider the well-known pooling effect (Eppen 1979). Firms often pool production at a single location and serve demand in various countries from this single location. The supply chain efficiency gains of achieving economies of scale and reducing demand uncertainty (through aggregating demand) have been widely studied in the literature. Nevertheless, such pooling at a single location also increases the vulnerability of the supply chain and may make it less resilient. During the COVID-19 pandemic, many companies, including Apple, faced supply disruptions because they relied heavily on one location to produce the bulk of their products (which is the PRC in the case of Apple). Here, a firm faces a trade-off between gaining efficiency and gaining resilience. We call for more research to better understand this trade-off. The gains of pooling have diminishing returns for each unit added. Recall that the benefit of reducing demand uncertainty due to pooling increases with the square root of the number of markets served. Thus, when a firm already produces a significant amount at one location, the additional benefits of further pooling resources at that one location might be small, and instead it might be economical to source from other locations. While sourcing from several different locations might result in a loss of some supply chain efficiency, significantly more resilience can be achieved. Sourcing from just a few different locations might be sufficient to build significant resilience. Saghafian and Van

Oyen (2016) show that even a little bit of flexibility here can significantly help a firm deal with disruptions: A little backup flexibility can go a long way (p. 403).

5. ANECDOTAL EVIDENCE FROM INDUSTRY AND IMPACT ON ASIA AND THE PACIFIC

The struggle of companies to build resilient and cost-efficient supply chains is illustrated in a recent survey by Gartner (Wilson 2021). The survey reveals that "almost half of the respondents see lean methodologies, just-in-time systems, and low-cost country sourcing" as relevant to future strategies. Further, 30% of Gartner's survey respondents report that they are shifting from a "global to a more regional supply chain model" even though expensive local suppliers stay beyond consideration for many companies. Further, in the Allianz survey (see Azouz 2020), the respondents comprise 1,181 executives in risk-averse sectors such as IT, machinery and equipment, chemicals, energy and utilities, automotive, and agrifood, and it appears that less than 15% of companies consider reshoring. This highlights the fact that many firms are unable to take the costly decision of sourcing from more reliable suppliers even though they aim to build resilience.

This discussion has some implications for developing Asia and the Pacific. While many global companies are considering moving production closer to the main markets (which for some companies are in North America and Europe), our analysis indicates that there might be value in companies continuing to use less reliable but cheaper suppliers in developing Asia and the Pacific. The cost of using expensive local suppliers might be excessive for many companies. Instead, they might find value in implementing shared resilience levers such as increased flexibility or the placement of anticipatory orders. These measures might be more cost-efficient while providing a higher level of resilience.

6. CONCLUSION AND FUTURE RESEARCH

In this paper, we offer a characterization of resilience-enhancing measures. We argue that resilience-enhancing measures are either based on using dedicated resources (referred to as "dedicated resilience levers") or on using shared resources (referred to as "shared resilience levers"). By dedicated resources, we mean resources that are provided only for the purpose of building resilience. In contrast, shared resilience levers are based on using shared resources. By shared resources, we mean resources that are not only used for risk mitigation but also serve another purpose, such as better meeting customer demand without disruption. Typically, shared resources not only help build resilience, but they also help meet customer demand in the absence of disruptions. We argue that shared resilience levers are particularly helpful for supply chains that focus on cost-efficiency and that produce basic/functional products. In contrast, dedicated resilience levers are particularly helpful for supply chains that are less exposed to cost pressure and produce innovative products. Further, we discuss how the supply chain finance solution reverse factoring can be considered a shared resource that helps build resilience and efficiency simultaneously.

This discussion requires more rigorous research to support the observations presented. Specifically, we call for more research that helps in better understanding the value of shared resilience levers for organizations. More rigorous research might be carried out through in-depth case study research and/or expert interviews, as well as modeling work that may help quantify the benefits of shared resilience levers for building resilience in the supply chain.

In the academic literature, supply chain resilience and supply chain efficiency have mostly been discussed as separate topics (with some exceptions, such as Chopra, Sodhi, and Lücker (2021)). For many companies, dedicated resilience levers are simply too expensive, and we need to better understand what value shared resilience levers offer to companies.

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