Developing quantitatively-driven, technologically empowered supply chains to revitalize the Sri Lankan economy

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Introduction

Sri Lanka gained independence as the second most developed nation in Asia in 1948. Numerous opportunities have presented itself over those years (Seneviratne, 2022). While Sri Lanka has seized on to some of them as a nation, we have failed to grasp most of those opportunities to drive the nation's economy forward. At this point of crisis, various discussions have emerged on how to revitalize the economy. While all efforts must be taken to preserve any industry and exploit the opportunities they present, it is imperative that we focus on new paradigms to find innovative market opportunities to compete with the rest of the world and bolster our economy. Building resilient and cost-effective supply chains is a must to ensure that Sri Lanka prospers. For instance, one of the cornerstones of Germany's success in navigating through the Global Financial Crisis about a decade ago was its heavy investments on research and innovation to develop resilient supply chains that are sustainable and capable of being lean or agile to serve the product need. This concept later gained worldwide acclaim as Industry 4.0 (fourth industrial revolution). The need of the hour is to amass a quantum leap that the likes of South Korea, Japan and Germany recorded after the world war. Even the much talked about Singapore has achieved tremendous heights since its independence through quantum leaps that have powered their economy. This paper aims to synthesize emerging perspectives across the global supply chain to catalyze economic revitalization in Sri Lanka through technology driven solutions that are backed by a quantitative backbone. Focusing on a knowledge driven economy that empowers our population while supporting the numerous interconnected supply chains provides a big piece of the puzzle in making Sri Lanka a vibrant economy. This fact is further enshrined by the World Economic Forum which predicts supply chain to be one of the fastest growing professional domains for the years ahead (World Economic Forum, 2020).

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Supply chain thinking

The term "supply chain" is relatively new in the vernacular. The origin of the term "supply chain" traces back to 1982 when an American consultant named Keith Oliver coined the term to explain the intricate interconnection between various stakeholders working together to fulfill customer demand (Perera & Sugathadasa, 2014). The domain has evolved to concentrate on optimizing the flows of information, materials, and money to add value to all stakeholders connected with the supply chain (refer Figure 1). While the term supply chain has been widely accepted over the past 40 years, it essentially takes the form of a supply network (refer Figure 2) which works cohesively to deliver products/services to satisfy the consumer while also increasing profits/utility of each stakeholder (Perera & Perera, 2022). Stakeholders towards the consumer end of the supply chain are labelled as downstream partners while those that are more inclined towards the supply side are termed as upstream partners.

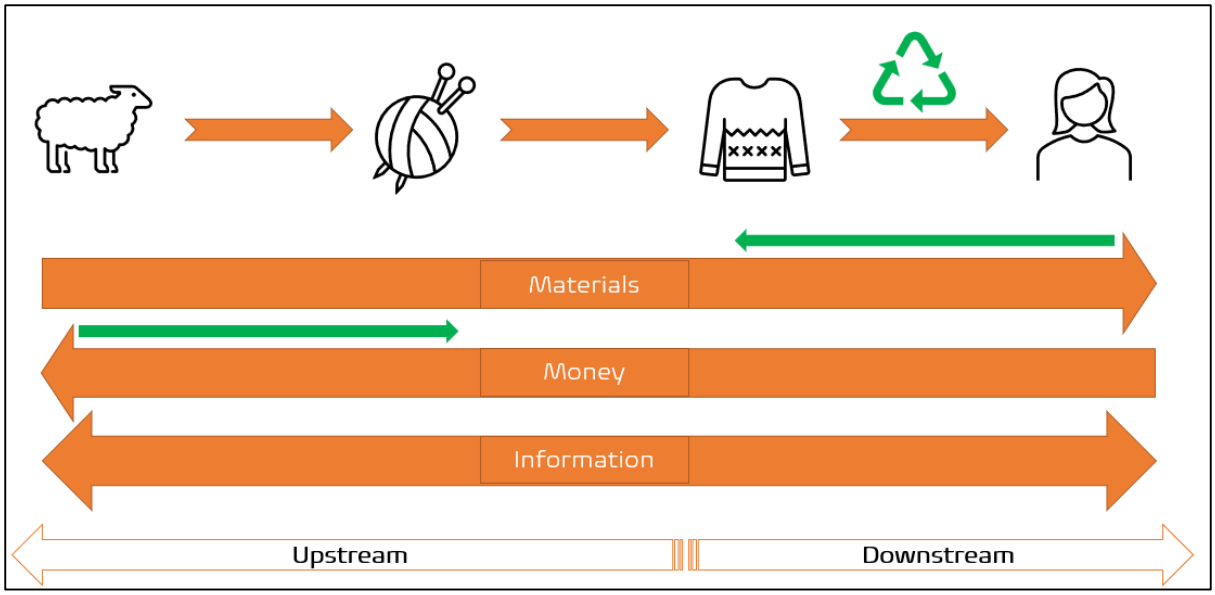

Figure 1: The three flows of the supply chain

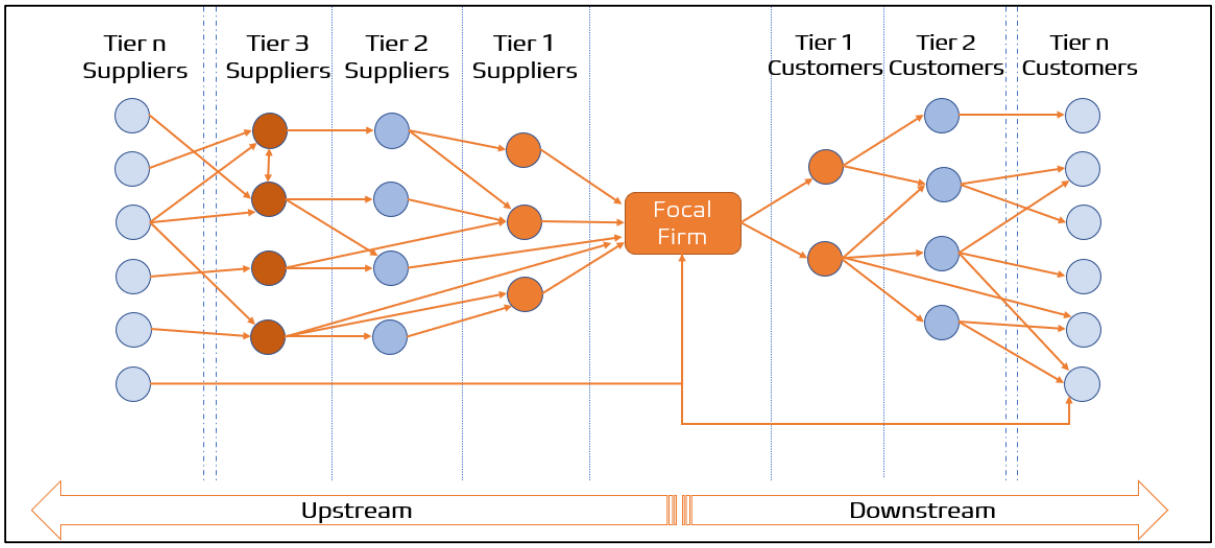

Figure 2: The supply network

A simple example could be an agricultural supply chain. The entire value chain would have numerous stakeholders that are distributed across various tiers/echelons; farmers, collectors, intermediaries, transporters, wholesalers and retailers, etc. The fact that each of these stakeholders have their own set of suppliers complicates matters. For instance, the farmers need fertilizer and if the fertilizer supply is thwarted, that has adverse effects on the harvest of the farmer that trickles down the supply chain. Transporters require fuel to move produce from production centers to consumption centers. When fuel runs dry, trucks cannot operate which leads to making the harvest obsolete. Therefore, it is evident that optimizing supply chains are pertinent to ensure the resilience and growth of any industry.

There is a school of thought that perceives supply chain management to be a qualitative field. This is mostly dominant in the Sri Lankan context. However, most developed countries perceive supply chains to be a multidisciplinary field that is mostly quantitative in nature. It integrates fundamentals of Industrial & Systems Engineering, Operations Research (a

subdomain of mathematics) as well as management concepts (Perera & Perera, 2022). Sri Lanka must embrace supply chains as such and focus on optimized supply chains that aim (a) to reduce associated costs and (b) increase profits/utility. This must be done without disincentivizing any of the stakeholders. End-to-end integration and holistic thinking are paramount towards building resilient and optimized supply chains.

Lack of awareness of supply chain fundamentals confounds problems of the country further. One of the main theoretical constructs of supply chain management is the bullwhip effect (BWE). BWE relates to the amplification of order quantities across the supply chain from downstream to upstream due to (a) erroneous demand forecasting, (b) rationing and shortage gaming, (c) order batching and (d) price fluctuations (Lee *et al*., 1997). However, the incompetence of the authorities to maintain proper stocks and prices as well as imposing rations violates the theoretical foundations of supply chain management thereby exacerbating demand. This has led to an artificial uptick in demand as consumers are wary of stockouts and are enticed to purchase frequently due to vulnerability of supply.

Logistics is the subdomain of supply chain that deals with the material flow in a supply chain. Improper route planning, ad-hoc distribution, delays in terminal operations, problems with capacity utilization, etc. have also contributed to the problems we face today. Properly applying latest technologies and operations research techniques can ease these issues to provide a high level of service. Expanding the usage of rail to convey goods should be high on the agenda of any reforms aiming to revitalize the goods transport sector (Kumarage, 2022).

Recent examples of the chaos created around fuel, liquified petroleum gas (LPG) and commodity supply underscores why we need supply chain and logistics professionals who have a sound understanding of the underlying theories as well as the quantitative knowhow to understand how certain decisions would trigger ripple effects across the supply chain which take weeks and months to resolve.

Understandings our strengths and weaknesses

Sri Lanka has long touted numerous advantages that provide a pivot point to build our economy. Our plantation industry which produces world class crops, our geographical location at the center of the Indian Ocean, various minerals and resources bestowed upon us, the capacity to provide services to the greater region are among a myriad of solutions brought forward. Optimized supply chains are paramount if we are to unlock our true potential in any of these fields.

Evidence suggests that the human capital Sri Lanka possesses cannot be discounted. The nation has succeeded in producing experts in a variety of fields including science, technology, engineering, and mathematics (STEM) as well as humanities. There are many with a Sri Lanka background holding high ranking positions across the globe which further validates this point.

Our free education and healthcare systems have empowered our population to provide a meritocratic ladder to achieve their potential regardless of what their background is. Unfortunately, the country has failed to setup proper mechanisms to harness all of its products to build the nation. This is not so different in the field of supply chain and logistics. Thus, emphasis needs to be given at streamlining education programs to develop professionals capable to tackling the future work world.

Sri Lanka has challenges in competing with other developing economies when concerned with costs. However, we bear an advantage at delivering quality through high-end customer service. This has been the cornerstone of success for the large-scale Sri Lankan apparel manufacturers as well as some conglomerates in which we have acquired sustained local and international success. Therefore, the country must ensure that it taps on to the local talent in building resilient, technology-driven supply

chains with a quantitative backbone. This requires a multidisciplinary approach integrating supply chain professionals with experts in respective industries. Local universities with sufficient support from foreign experts, industry and political leaders must intensify efforts to produce professionals to spearhead the industry in the medium run, while those who possess technical awareness must shoulder key responsibilities in navigating the short-term challenges of bringing the economy to an even keel.

Optimizing our supply chains

Highly qualified professionals alone would be inadequate to build resilient supply chains that can achieve our national aspirations. We must endear ourselves to look at supply chains from a quantitative standpoint focused on cost minimization and profit maximization while safeguarding expected quality standards and ensuring the welfare of all stakeholders involved across the supply chain. Application of state-of-the-art technologies and optimization techniques must be at the forefront of revamping our supply chains to meet future challenges.

Forecasts are considered the lifeblood of supply chains as they trigger most activities in the supply chain (Perera et al., 2019). Supply chains must invest heavily on improving the accuracy of forecasts. This should come in the form of trusting data-driven professionals to develop novel forecasting solutions to accurately predict future demand as opposed to investing in expensive solutions as research indicates that well-trained forecasters can continuously improve forecast accuracy (Hewage, 2021). In fact, we have the capability of developing homegrown solutions driven by explainable artificial intelligence (XAI) and machine learning (ML) to deliver optimized outputs (Hewage & Perera, 2022). Accurate forecasts play a significant role in mitigating the accumulation of inventory that leads to excessive cost generation as well as wastage along the supply chain (Perera *et al*., 2020). This is most profound for sectors which contain highly perishable products with a short shelf life as Sri Lanka is not able to afford wastages any further.

Optimizing routing and space allocation are serious concerns that require immediate attention. Underutilizing vehicle capacity and improper route planning gives rise to wastage of fuel. Operations research techniques such as vehicle routing problem, linear programming, mixed integer linear programming, multi criteria decision making, knapsack problem, etc. helps to optimize these problems (Thibbotuwawa *et al*., 2020, Agustina *et al*., 2014, Validi *et al*., 2014). These techniques can derive optimal solutions through various computational packages that are off the shelf or open source. Therefore, the sector needs to pay more attention to increase the usage of analytical computational software that aid optimizing supply chains.

While forecasting, inventory decision-making and operations research are low-cost but highly effective tools, one must recognize the importance of deploying technological innovations across the supply chain. Industry 4.0, which was introduced earlier, encompasses a variety of technologies such as big data analytics, artificial intelligence/machine learning, cloud computing, internet of things (IoT), blockchain technology, augmented reality, additive layer manufacturing, simulations, etc. (Zhang *et al*., 2021). While some of those technologies are expensive, some are not. Through proper needs identification, these technologies can benefit local industries as well (Lee & Lee, 2015). Especially, technologies such as IoT are quite cost-effective and have the potency to make significant impacts in a local context (Lee & Lee, 2015, Ben-Daya *et al*., 2019, Abdel-Basset *et al*., 2018). For instance, IoT has many application possibilities in agricultural supply chains to reduce wastages that amount to nearly 40% of the harvest (Daily FT, 2022).

Other thrust areas requiring attention include forward buying and risk pooling by identifying major cost variations that are likely to impact the supply chain while ensuring expected levels of service. In addition to this, emphasis ought to be given to smoothen the decoupling points in

the supply chain to facilitate seamless integration. Trying to reintegrate the railway system as a core of our goods transportation system too is a timely challenge to mitigate some of the inefficiencies present in the transportation system. This could be further supported through algorithmically developed first-mile and last-mile delivery plans that help towards accumulating and distributing out of predefined collection/distribution centers.

Research and innovation in supply chains

The country must resist the urge to go towards expensive plug and play solutions and try to focus on homegrown innovations that are both cost-effective and efficient. Our aim should be to develop commercializable technologies that generate revenue for local organizations as well as having the potency to be exported, at least to the developing world. As an enclosed system, it is natural that only a fraction of the countries in the world can maintain a positive balance of payment while the others would inadvertently have to survive with a negative balance of payment that leads to budget deficits and economic strife. Sri Lanka must exploit any opportunity that presents towards consolidating our export capabilities and developing technological innovations that can be exported to the developing world is one such fertile area.

A natural question that may arise is how to find funding to support innovation at a time where the country is sinking financially. The simple answer is through international research grants and funding. There are ample opportunities available to attract funding to support novel and practical research and capacity building, especially in developing countries. Unfortunately, the government procedures in place to approve of such international research grants are discouraging and shortsighted. Delays faced due to the numerous hurdles posed by circular PS/SP/SB/Circular/06/2019 issued by the Presidential Secretariat on 19th December 2022 and associated rules and regulations make the lives of a grant recipient miserable, thereby discouraging them from applying for more international funding. Responsible authorities must take immediate measures to repeal these regulations that only stand against progress and empower universities to bring in foreign currency to invest on homegrown research and innovation. Moreover, these grants aid the country in another way by contributing towards local capacity building without any financial obligations other than transparent spending of the grant money. The wisdom that the country gains from top professors across the globe through joint research carried out through such research grants would be priceless.

Additionally, mechanisms must be put in place to ensure binding policies are made scientifically with the greater good of the country in mind. Moreover, universities should be vested the power of being centers of excellence that are at the forefront of carrying out state-of-the-art research for the benefit of the public. The model which the Frauenhofer Institute implements in Germany is of special importance. As Europe's largest application-oriented research organization, it links industry and academia to cohabitate towards mutual gain. Professors and universities are endowed on competitive basis to expertise on a particular field. Once selected, the relevant professor and the institute has to work tirelessly to solve application-oriented problems in the country while the industry has a gateway to solve their problems at a reasonable cost. The process often hires postgraduate students who also improve their skills and add value to the economy (Fraunhofer-Gesellschaft, 2022). Collaboration between industry, academia and the government is a must to ensure that resilient supply chains are developed in the country.

While Sri Lanka is at the embryonic stages of adopting Industry 4.0, the developed world is already embarking on Industry 5.0. The fifth industrial revolution enables cyber-physical systems to work seamlessly alongside humans and is enabled by the emergence of 5th generation (5G) telecommunication technologies that eliminate lag of information flow (Demir, 2019). We must aim towards shifting gears to ensure a rapid rise in research and innovation to support Industry 5.0 driven supply chains in Sri Lanka. While implementing 5G technology across the country may not be the need of the hour, providing such facilities

around research laboratories may provide them the ability to become incubators of developing cutting-edge technology that has a commercial value. The ecosystem to support such innovations must be established no sooner, so that the country can take a quantum leap in our quest towards development. Needless to say, besides the countries which are rich in minerals/oil and into gambling, all the other developed countries have achieved development through a strong foundation that focuses heavily on science, technology, engineering and management (STEM). Therefore, Sri Lanka should also put trust in our sciences while also retaining the cultural, humane and artistic elements that make us so unique.

Conclusion

Sri Lanka is at crossroads with years of mismanagement and lack of vision bringing us to the brink. Yet, there lies hope in the eleventh hour thanks to the competencies of our younger generations as well as the experience of intellectuals who have contributed to the country over the years despite many hardships. Building resilient supply chains by harnessing those competencies and new technologies provides us a pathway towards economic prosperity. A truly multidisciplinary approach which integrates all stakeholders to maximize the benefits of the supply chain towards mutual success is much needed. The government and the industry should cease being penny wise and pound foolish. Investing in science, technology, engineering, and mathematics (STEM) is pivotal for both the public and private sectors to ensure that Sri Lanka recovers from this fall by becoming a nation that boasts of highly efficient supply chains that are supplemented by cutting-edge technology.

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