

SUPPLY CHAIN ECONOMICS

1.INTRODUCTION

Course Notes



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INTRODUCTION

Let us start from the definitions of supply chain and economics.

1. SUPPLY CHAIN

The Council of Supply Chain Management Professionals (CSCMP) defines supply chain¹ as:

Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements.

Let's see how this definition applies to the supply chain of a calculator.

1.1 Supply of a calculator

The manufacturer of a calculator such as Texas Instruments, produces calculators based on its demand forecasts. The casing, as well as many other parts, are made of plastics, which are made from oil or recycled plastics. Crude oil is explored, excavated, stored, and transported to where they are synthesized into various types of pellets. The pellets can be extruded, molded, or formed to make the final parts with different geometries and mechanical properties, for calculator cases, buttons, etc. The pellets can also be made by processing recycled plastics. However, the quality of recycled pellets is not as good as virgin pellets, and hence cannot be used for more demanding products unless they are mixed with sufficient virgin pellets. A calculator also has integrated circuits (ICs) as processor or memory chips. Sand is processed into single crystals in a foundry to make silicon and that is then cut into wafers. Many processes are applied to the wafer to create transistors, connectors, and connections based on the design. The wafer is then tested, cut and finally packaged for protection and for connections to other devices. These chips are stored, transported to the assembler for final product assembly. There are many other components in a

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https://cscmp.org/CSCMP/Academia/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921, July 12, 2019

calculator. Each will go through its own complex process. Texas Instrument, as an original equipment manufacturer (OEM), will produce some parts while procure other components or subassemblies from its suppliers and assemble all the components into a calculator. Each component starts from some natural resources such as minerals, sand, water, air or plants and go through different manufacturers before reaching to the OEM. Therefore, any product must go through many processes in different firms that convert, store and transport the material a into the final product.

1.2 Distribution of a calculator

The product will go to distribution channels. The OEM can sell the product directly to end user via their own distribution centers (DCs) and fleet. More commonly, the OEM distribute their products via distributors, wholesalers, retailers, etc. The e-commerce has already changed the distributions a lot and will continue to do so for the years to come. An OEM will have more and more ways to select to source and distribute their products. Figure 1 shows the supply chain of a consumer electronic product. Each block represent a player along the chain with ID such as “A” for assembly, “S” for supplier, “DC” for distribution center, “S” for store and “C” for customer. The arrows represent the transportation. The values are the average leadtimes and variability in each block or arrow.

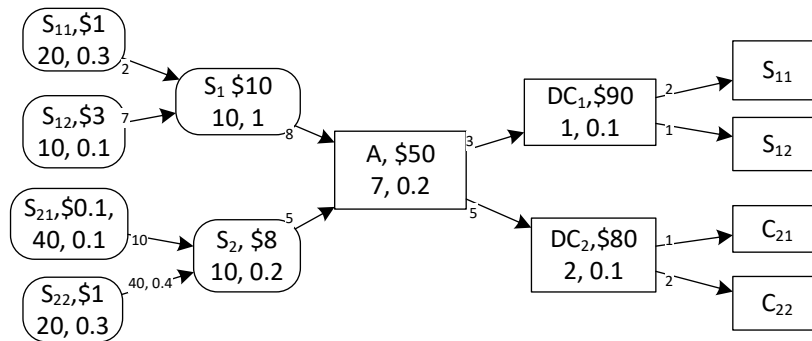


Figure 1 The Illustration of a single product supply chain. More details are in the following sections.

1.3 The supply of a calculator

No single firm performs all of the functions in this simple calculator supply chain. This is true for most consumer goods as well. There are firms that specialize in exploration, excavation, transportation, material processing, parts fabrication, components assembly, final assembly,

distributors, wholesalers, retailers, financiers, insurers, IT, software, etc. The simple calculator links these firms through its material, liability, risk and information exchanges.

The CSCMP's definition emphasize coordination and collaboration among partners along the chain. We will also discuss the effective ways in use incentives to get the best from and for the channel partners. The focus will be on the information and logistics such as storage, ownership and the flow of goods.

1.4 Information and financial flow in supply chain

Along the way, the information flows within and across firms. Some information is private not to be shared, some is shared, still others partially shared. Delays, distortions occurs in the sharing process, and are impacted by the technologies. The timing, the amount, the methods of sharing has significant impact on each firm.

The money change hands among partners. The terms or timing of financial flow, along with information and actions performed has significant impact on the performance of firms. For example, people may not reveal all relevant information before the contract is signed. Another example is that if paid in full before the completion of the delivery, moral hazard can hinder the performance.

The term "supply chain management" emerged in the 1980s and 1990s. It stems from the fact that solutions with minimum cost in silos may not be economical or sustainable overall throughout the entire chain.

2. MICRO-ECONOMICS IN SUPPLY CHAIN

Let's start with the definition of microeconomics directly related to the supply chain. We then look at general economics at the entire supply chain at a macro-level later.

Microeconomics (Intermediate Microeconomics, Walter Nicholson and Christopher Snyder, 2015) is

Microeconomics is the study of the economic choices individuals and firms make and how these choices create markets.

This definition captures the demand, supply and market and is useful for a firm as a player in the supply chain. From supply chain perspective, the demands come from self interest of the end users or clients. The self interest also directs the use of resources, energy and intelligence to produce the supply. The supply and demand meet in market. A player may also have expanded self interests that lead to collaboration between the supplier and client to benefit the both. At the market, the prices are set and completion drives for higher supply chain efficiency. Let's consider the calculator example from the micro-economics definition.

2.1 The demand, the supply and the market for calculator

In order to take various tests such as SAT, students need calculators, even in the age of smart devices. The student's self-interest generates the demand.

The calculator supplier such as Texas Instruments, explained in the last section, invests in technologies and facilities to forecast, plan, produce and market the calculators to satisfy the demand.

The demand and supply of the calculators meet in the markets such as in stores or in e-retailers where many suppliers compete on features, quality, prices, deliveries to earn profit and gain market share. The competition encourage higher quality, better service and lower prices, as well as the advancement of the technologies.

2.2 The cost as a driver in the supply chain efficiency

If you open a book on supply chain, you will notice that the "cost" is used most frequently as objective. Cost reduction is very important because it contributes to profit if the revenue stay the same. In the competition, the supply chain professionals must work continuously to reduce the cost.

2.2.1 Economies of scale

Probably the biggest factor impacting supply chain cost is the economies of scale – lower unit cost at higher production quantity. If you do not believe, try to compete with Ford, Apple, Amazon, UPS on the same product or service. Scale is one of the motivations for mergers and acquisitions. Look at the producers, logistics providers, bankers, hospitals, etc.

2.2.2 Economies of uniformity

The second biggest factor is what I call the economies of uniformity. The reduction of variations, deterministic or probabilistic, reduces the cost. The deterministic variation can be the number of product, equipment, personnel, or customer. The more the variety, the more complex to manage, and the smaller of scale for each type, and more the cost. For example, The limited variety of iPhone make it easier to manage, and enjoy bigger scale effect for each product type. Aldi is much smaller than Walmart. However, it carries much less number of SKUs, and therefore, much easier to manage. The volume of a particular SKU is higher than that in Walmart, and enjoys scale effect from quantity discount, handling, and others. JetBlue only have Boeing 737s. It is much easier to manage and enjoys deeper discount in purchasing. The negative impact of the variety can be mitigated by economies of scope. The economies of scope refers to the fact when more variety is added, the different variety enjoy synergy to reduce unit cost. For example if different product can be produced on the same machine as if they are the same, the different

products can enjoy economies of scale. The cross-trained personnel can handle multiple job types.

The probabilistic variations are uncertain. There is always cost associated with uncertainty, unless your business model is based on hedging the risk, in which basically you can handle risk better than your competitions. In addition to cope with the uncertainty in supply chain, you should also proactively work to reduce the uncertainty itself through information, partnership, and analytics.

2.2.3 Economies of speed

A third major factor is economies of speed. In the age of anything-anywhere-now consumer mentality, speed is just as important. The faster (and reliable) suppliers enjoy better customer satisfaction, better market share, and possibly at higher prices. We will see later that faster can also reduce the window of uncertainty, with many side benefits.

The economies of scale, uniformity and speed are closely related to the cost. Therefore, the objectives of traditional supply chain is to lower the cost. Since lower cost is internally controllable and can translate directly to the profit, the objective to minimize the cost has been proven extremely effective. Cost reduction is the object of most courses in industrial engineering. We will relate the cost reduction to the economies of scale, uniformity and speed specifically in supply chain.

2.3 Other financial objectives in supply chain

In the calculator example, we have seen that no firm would perform all tasks to make calculators. To be successful, it is important for the firm to collaborate with its suppliers and its clients. Collaboration involve communications which involve revealing of information, even private information, to benefits all parties. One of the ways to encourage better collaboration is through incentives. Firms can select what to reveal, called adverse selection, or select to take the easy route when it does not hurt its themselves. People and firms respond to incentives. The right use of incentives can increase the efficiency among all partners in the supply chain. In the same example, we have seen that Texas Instruments must compete with other suppliers. They can compete on prices but also on supply quantity, quality or features.

2.3.1 Collaboration and incentives

One of the contributing factors of Dell computer initially was its no-inventory strategy. The initial sales channel for Dell was e-retailing. Dell uses its market position to require the supplies to ensure supply at the Dell site. Upon reception of the customer on-line order, Dell pick the parts from the supplies at the Dell site to “kit” for the specific order. The inventory change hands after the parts are picked. The “kit” is assembled in a custom made computer in a few hours. It

will go through testing for a day, then shipped to customer in about 2 days. Dell received customer payment at the time of ordering, and pays its supplier days later, based on the contract terms. Dell incurs zero inventory cost, took zero risk. In fact, many say that Dell held “negative inventory”. Therefore, Dell took no risk, made a little money from inventory, the best of all worlds, right? Dell no longer does that. We will see later why some shared interests among partners is actually better than forcing one side taking all the risks.

In Georgia Tech, many senior design clients asked the design teams to figure out the reduction of overtime costs. Sometimes, the issue has to do with the capacity issue, scheduling issue, efficiency issues, demand fluctuations, etc. However, sometimes, it is incentive issue when the associates prefer to work in some overtimes. In such situations, it is important to find out if the incentive is at the core of the issue. The solutions can be very different.

A senior design project worked with a large call center overseas. The problem was the low productivity. An operator helped a lot less customers per day than the call centers in other countries. The initial instinct was to identify the efficiency issues in the process. However, it was not successful. They later found that the operators are incentivized to work with a client longer times! They redesigned the incentive structure. The client tested the recommended change for 2 weeks before the end of the semester. The results are excellent! People perform to measures and incentives.

The key factor with incentives is information, and information asymmetry.

2.3.2 The use of production quantity in competition

Another example not related to the cost is oil prices. Started from the summer of 2014, oil prices decreased rapidly from the approximately \$90 per barrel to \$36 in January 2016, thanks to the increased production from US and reduction in consumption. The OPEC decided to sustain its supply quantity. The move has nothing to do with the cost minimization but has a lot to do with long term economic impact. The production quantity control continues to play out even today. Within financial terms, industrial engineers often focus on cost. However, many supply chains issues are beyond cost.

2.3.3 Pricing for revenue management

You may all experienced the airline and hotel pricing for revenue management. The quantity and group discounts are all part of revenue management. Below is a specific example. Unilever, P&G tweaked their products for higher prices in the developing world in hope the increase their revenue and profit (Peter Evans, WSJ, WSJ, Jan 1, 2015).

New, Improved!

Unilever is refocusing its strategy in the developing world to sell products with added features—and often higher prices.

	PRODUCT DEVELOPMENT	CURRENT PRICE
Omo (BRAZIL) 	Multiaction powder (2 Kg) Introduced in 1988	16.00 reais (0.88 real per use)
	Multiaction liquid (5 L) 2000s	49.90 reais (0.75 real) ▼-15% per use
	Super concentrated liquid (1 L) 2010s	20.99 reais (0.73 real) ▼-3% per use
Fair & Lovely (INDIA) 	Skin fairness cream (50 g) 1978	89 rupees
	Skin cream with SPF 15 (50 g) 1990s	99 rupees ▲+11%
	Anti-marks cream (50 g) 2009-10	110 rupees ▲+11%
Lifebuoy* (INDIA) 	Basic soap bar (59 g) 1890s	10 rupees
	Clini-care 10, soap bar (75 g) Early 2000s	29 rupees ▲+190%
	Color changing handwash pump (200 ml) Late 2012	80 rupees ▲+176%

*Smallest product size available in each category
 Notes: Prices as of November 2014;
 10 Brazilian reais = \$3.76; 10 rupees = \$0.16

Source: the company
 The Wall Street Journal

Figure 2 Increasing prices by differentiation.

There are many other examples such as in-house vehicle maintenance facility, restaurant equipment service, and many others in which the revenue, market share, the incentives built into the reward system is at the core of the economic efficiency.

2.4 Game theory

In incentives and competition, the outcomes of your strategies depends on the partners or the competition, similar to playing games. Game theory apply. We will discuss a few relevant game theory models that can be used to make decisions in such situations. We will discuss agent models, Prisoner's dilemma, Cournot competition, Bertrand competition, the tragedy of commons, etc.

2.5 Summary of the micro-economics in supply chain

The financial objectives have worked extremely well to increase efficiency in supply chain. Today, we enjoy wide supply of many products and services in the developed economies.

3. ECONOMICS AND BROADER PERSPECTIVES OF SUPPLY CHAIN

Economics (W Nicholson and C. Snyder, 2015),

“Economics is the study of the allocation of scarce resources among alternative uses.”

This definition offers a different perspective from the microeconomics definition. The important concepts are allocation, scarce resources and alternatives.

3.1 The allocation criteria

To allocate resources from the alternatives, we need to establish the criteria to measure different alternatives. Economists use “utility” as a measure. Human utility is broad, it is something bring about satisfaction in some dimension. The utility in supply chain is most commonly interpreted in financial terms, such as cost, revenue or profit. However, the concept of utility is more than just financial. For a firm, it can include public relations, reputation, and “feeling good”. More later.

3.2 The scarce resources at the micro-level

The second important part of this definition of economics is the scarce resources. The resources a supply chain professional must deal with typically involve budget, materials, equipment, personnel, space or time. You may have heard that you never have enough money, enough time, or enough people to accomplish something. From micro or local perspectives, these are truly scarce resources. At macro-level however, more and more people have realized that what we produce, food, T-shirts, shoes, flash drives, information storage capacity, are no longer scarce because there is much more supply than demand at the market. In fact, there is a lot of waste, although there is scarcity for specific individuals in certain circumstances. The current market does not address those issues because they are often addressed by philanthropy and charity organizations.

3.3 The scarce resources at the macro-level

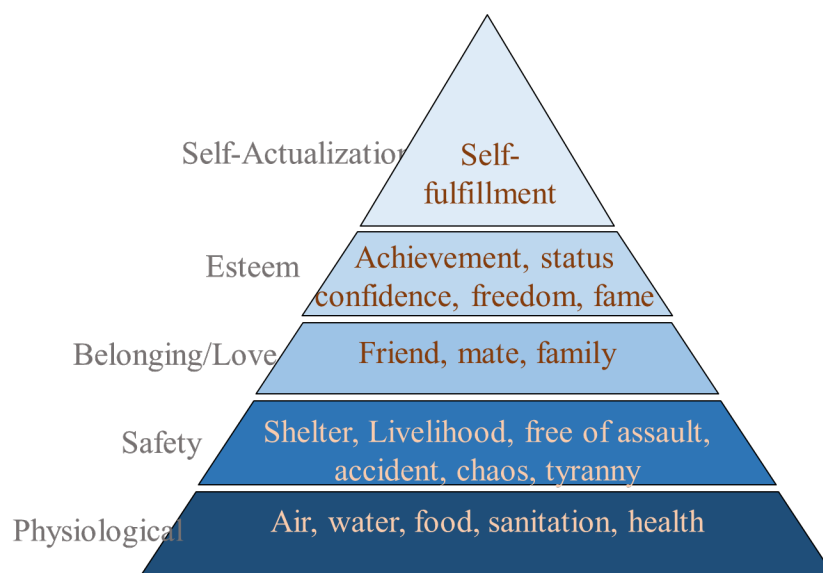
Then, what is scarce at the macro level? At the macro-level, we can consider that the supply chain starts from the natural resources such as air, water, trees, sand and oil. It go through a complex network of firms to supply the consumer goods and the services that satisfy human needs, as explained in the calculator example. In the developed countries, most commodities are

in abundance, thanks to the leaps and bounds of industrial development and efficient supply chain. However, fresh air, fresh water, oil, trees, or other natural resources have become scarce. However, these resources are not accounted in the financial system commensurate to their importance to our lives.

3.3.1 Supply chain and human needs

A player in the supply chain, such as a chip maker or a distributor, focuses on the efficiency in making chips or distribute the calculator, instead of what human needs the chip or distribution provide. There is no commonly accepted definition for human needs. Human utilities is normally more than just financial. For example, graduates may not always take the job with the highest pay or the best financial packages. The firms may not always take the alternative with the largest financial outcomes considering the public relations or environment.

Most people may have heard Maslow's hierarchy of human needs. A simple representation is in the figure below.



For the physiological needs, such as food, freshwater, sanitation, the financial measures of cost, revenue and profit have helped the society to come a long way to reach what human beings enjoy greatly today in the developed economies. The pricing signals of Nobel laureate Fredrick Hayek and the invisible hand of Adam Smith incentivize the suppliers to satisfy these human needs very well.

The health in the United States, a very important physiological human needs, have been more challenging. By the measure of life expectancy, the United States is the only developed economy

with reduced life expectancy 3 years running. This is especially alarming considering the great medical advances we have made. Without these medical advances, the life expectancy will be much shorter! Many may not survive with heart attack, stroke, accidents, etc. US has more free market element in the health systems than the other developed countries. It is a sign that the financial measures may not be sufficient to capture the supply of health.

For the needs of safety, the supply chain also supplies sufficient shelter and livelihood to most. The safety measured by free of assault, chaos, accident, tyranny have been for most. However, in the United States, health, livelihood, and free of assault have been fluctuating in recent years. It is not clear that the financial measures alone would help to improve the supply of these important human needs.

For the belonging and love, the social media, changes in the families, friends are changing the social structure. It is unclear how these changes improve the supply of human needs.

For the esteem, the increasing quality of life, the liberty and democracy in the developed economies have increased the human esteem for most tremendously. However, there is increasing signs of stress, especially for the generation Z, or iGeneration. In colleges, the number of reported depression and mental stress are increasing at alarming rate. Is this related to the supply chain? This again, cannot be measured financially.

To summarize, market, measured by the financial terms, has provided for the human needs very well at all levels. However, as the capacity to supply for the basic human needs have exceeded the demand in many dimensions, such as food and commodities. In these sectors, the advanced economies have reached the economies of abundance. However, the well lubricated supply chain will continue to “invent” product or services that are no longer important for human needs, such as another sweetener. In the meantime, the abundant supply have led to other problems such as health problems. Therefore, the financial measures from individual players alone may not be sufficient to improve the supply for human needs.

3.3.3 The scarcity in the advanced economies at the macro-level and supply cycle

The abundant supply capacity have moved the scarcity from supply of goods and services to the raw materials that feed the supply chain.

Based on the conservation of mass, the materials are not destroyed. When someone is no longer pleased with a product, it can be reused by others. For example, a lot of used cell phones, clothing are consolidated, shipped to some developing countries. They can also be refurbished, upgraded and resold, a common practice in appliances in Europe. They can be recycled to become raw materials such as paper, aluminum cans and plastic bottles. Or become solid waste for the landfill. Most materials, such as fibers in the paper, pellets made from recycled plastics can only be used to make products of lower quality than the products from the original raw materials. Therefore, they can only be recycled finite number of times, each time are only useful

less types of product types. Ultimately, they all become waste and become landfill and let nature to break them down the material for future use. This will form a supply circle, humans withdraw products from the cycle to satisfy their needs. The amount of materials discarded after satisfying human needs have been increasing rapidly, the earth's ability to restore the materials back to useful raw material for the supply loop is limited and very slow.

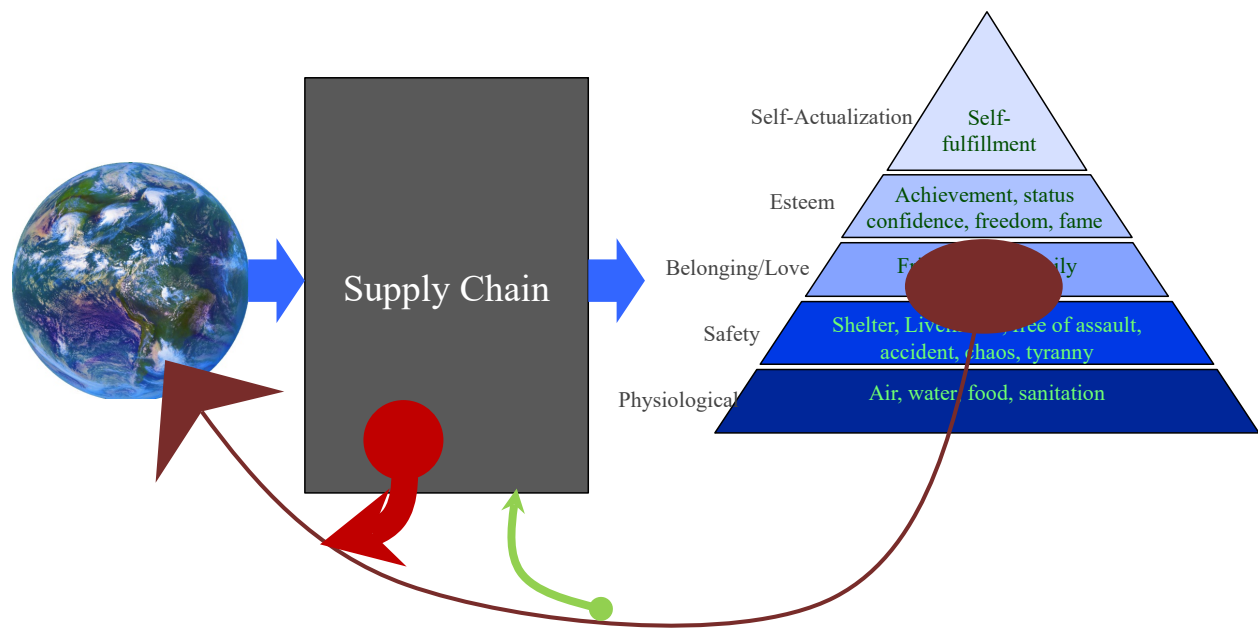


Figure 1.1 Illustration of supply loop

What happens to the landfill and industrial wastes? In 2015, Georgia Tech launched project One: the reading of book Garbology by Edward Humes. It exposed many serious problems with the landfill. The nature's ability to absorb the materials in landfill takes much longer time and with worse results than previously anticipated. When can the earth return the landfill into useful materials as input to supply chain? Probably thousands times longer than the time it took from the raw material to final products. We can make ethanol from corn. In fact, in US, most gasoline contains some ethanol. The average is about 10%. Ethanol contains 33% less energy contents than gasoline (US Energy Information Administration, 2015). In addition, ethanol only provide one part of what oil provide. In addition to gasoline, jet fuel, diesel, lubricant, plastics, paints, pharmaceuticals, etc. We are consuming finite amount of natural materials at a more and more rapid speed. However, the earth cannot recycle these materials back to useful form quickly enough.

3.3.3 The measures at macro-level in the economies of abundance

From the middle ages to the middle part of twenty century, the economic measures provided excellent surrogate measure for human's well beings because there is true scarcity in the supply for human physiological and safety needs. However, as the productivity increases, the capacity of production exceeds that of human needs in many ways, evidenced by the fact that most production systems do not run full capacity. However, there are still poverty, violence, myriad of health problems, etc. The abundance of supply with unsatisfied needs implies that the financial measures alone is no longer sufficient to measure our well beings. For example, there is tremendous waste in food while there is hunger, the violent crime is still around us, and the life expectancy in US has decreases for 3 consecutive years even with the great advances in medicine. Would healthy people with low medical needs generate more profit for the health systems? Would building more prisons increase the GDP?

4. EXAMPLES OF PROBLEMS WITH SIMPLISTIC FINANCIAL MEASURES

In this section, we will look at the limitations or opportunities associated with micro-level financial measures in the food and health system supply chains. The food production in US is very efficient with low costs for the consumers and healthy profit for the suppliers, thanks to the effective use of financial measures in the supply chain. In terms of cost, the consumer expenditure on food in US is the lowest among all developed countries. The companies that supply food perform well financially. Therefore, the food supply in US is outstanding financially both for consumers and for suppliers.

However, one of the major objective for human well beings is health. The health performance in US is among the lowest among the developed countries, measured by the life expectancy, diabetes, obesity and others, in spite of the great medical advances in medicine. Abundant supply of strong flavored, highly refined and processed food is correlated to the obesity and diabetics. The financial optimization by the complex network of pharmaceutical, insurance, doctors and hospitals individually at micro-level leads to high cost in medical services and poor availability. The financial incentivize the focus on the cure for the sick instead of health. For example, there is limited incentive to find the cure than for the treatment for diabetics.

4.1 The characteristics of food supply chain

There many reasons for low cost on food. Here are a few.

1. The use of fertilizers, pesticides, herbicide increased the yields, reduced the costs.
2. The development of genetically engineered organisms (GMO) or seeds increased yields, increased the crops' tolerance to drought, pests, and can beats out weeds in absorbing nutrients.

3. The concentrated animal feeding operations (CAFOs) of livestock increased the yield, consistency in products, speed up the production, and reduced the land use.
4. The use of antibiotics and hormones in CAFOs to avoid disease, to speed up growth, to get tenderer and juicy meat.
5. The consolidation of farms, factories enjoys the economies of scale, economies of uniformity and economies of speed.
6. Long distance transportation of food to enjoy lower cost.
7. The large scale and efficient machines to grind the grains, to remove fibers and germs, to make the products more attractive or more convenient for the consumers. The use of additives such as vitamins to fortify the product and compensate for the nutrients removed in the process.
8. The packaging of the product for convenience in transportation, storage and handling, and to protect the product from contamination and to trace the product for possible problems in the supply chain.
9. The packaging of the product for convenience and attractiveness for the consumers.
10. Fast food chains using the economies of scale, uniformity and speed to cater to the crave of human appetite that supply to the crave of human wants: energy, convenience, speed with strong flavors.
11. The food supply chain can produce flavors beyond what the immediate nature can produce. For example, sweets.

All these great improvement are driven by the self interests in financial measures. Therefore, these financial measures are extremely important, and must be used continuously to incentivize the suppliers for more innovation to improve many aspects of the food supply chain.

However, many of these great improvement have side effects. For example, the excess fertilizers pesticides, herbicides degrade the land and pollute the water. There is great debate and confusion on the genetically modified organisms (GMO) to the level that there is a great market for non-GMO products. Michael Pollan put it interestingly: the GMO can make crops that we eat but pests do not. It is unclear if the consolidation and industrialization of farms has improved the social life of farmers. Many are concerned with animal life and its impact in environment in CAFOs. The meat from CAFOs are linked to health problems. There is strong move to reduce or remove the use of antibiotics for animal feeds. The super refined and processed food with additives are now linked to diabetes and slew of other diseases. The packaging for conveniences promote the consumption of food that human often do not need. The fast growth and less variety of food types can lead to nutrition deficiency that are not known yet. The strong flavoring of the additives hide the lack of taste of the original food.

The market economy, with pricing signals and invisible hands, works wonders. The lack of nutrition of industrial farming products spawns a multi-billion dollar industry for supplements. However, there is no scientific evidence that they actually provides long term benefits. The

whole wheat, the stone ground whole wheat, steel cut oats, non-GMO products, cage free chicken and eggs, grass fed beef, community gardens, the popularity of slow food, restaurant marketing.

However, non-GMO crops requires better irrigation, more pesticides, herbicides, more labor for weeding, it costs more. The whole wheat, stone ground wheat, cage free (real) needs more land and can cost more. Grass fed beef, local food cost more. However, the strong flavors can feed to the positive feedback loops to the short term human “wants” that is beyond the long term human needs. The healthier food supply cannot compete with the main stream food supply chain due to lack of scale, uniformity, speed and flavor. Ironically, the health problems in US are more prevalent for low income population (Doreen M Rabi and et al, 2006). The people need the healthier food cannot afford. Therefore, financial measures alone cannot resolve the problems.

4.2 Characteristics of health system supply chain

One of the Georgia Tech students call the healthcare system is a “sick care” system. Ironically, this is mostly true because sick care comes with the financial reward. The long term health and wellbeing often do not have financial reward. The obesity and diabetics are indication of bad health or poor well-being. However, they spawn a huge healthy food industry, medicine research and delivery, and services for caring those with needs, and generate huge financial gains for many firms and individuals.

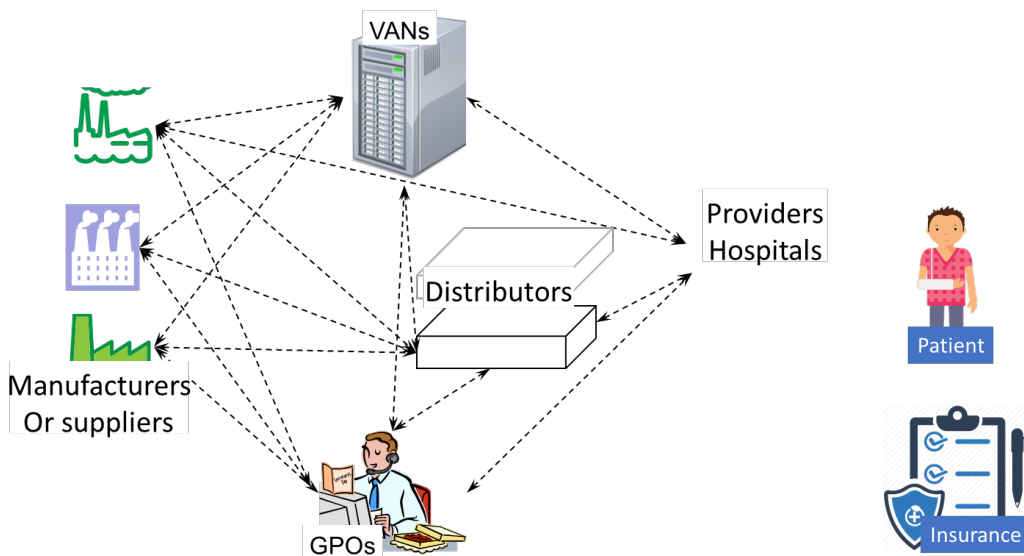
Health care system has many other interesting characteristics.

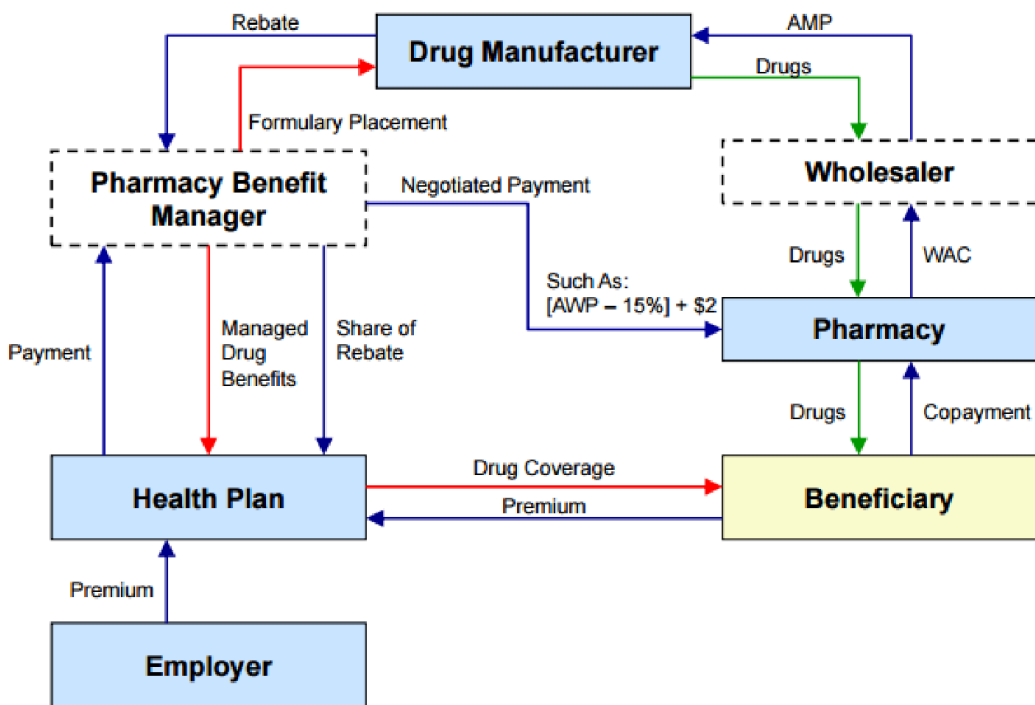
1. Health is highly uncertain, and is contagious. Some form of insurance is necessary to hedge against the risks.
2. Government is always part of the system due to many reasons: in US, half of the payment is by government.
3. Complex financial transactions among multi-payers: manufacturer ,insurance, government, patient, value added networks (VANs), group purchasing organizations (GPOs), hospitals. Please see the illustration at the end of this list for information link and drug supply chain.
4. Information asymmetry: medical knowledge, pricing, adverse selection by both the provider and patient.
5. Demand is insensitive to the price or inelastic
6. Government involvement: necessary to avoid high cost of epidemics, but it leads to patient’s moral hazard that incur cost to others or to the tax papers.
7. Moral hazard by doctors: doctor induced demand, hospitals overcharge insurance, patient wasting of resources.
8. Patient irrationality in the selection of treatment.
9. Lack of transparency in pricing, service, etc.
10. Complex medical procedure coding system.

The table below shows some of the health performance data from certain countries.

Country	GDP Capita PPP	GDP Capita	Healthcare % GDP	Life Expectancy	Infant Mortality	Overwt (WHO)	Diabetes (2015)
India	5,733	1,593	4.7	68	38	19	9.3
China	13,572	8,069	5.5	76	9	35	9.8
Brazil	15,553	8,678	8.3	75	15	54	10.4
Mexico	16,490	9,005	6.3	77	11	64	15.8
Korea, Rep.	34,387	27,222	7.4	82	3	33	7.2
France	37,775	36,353	11.5	83	4	58	5.3
Japan	37,872	34,524	10.2	84	2	24	5.7
United Kingdom	38,509	43,930	9.1	82	4	62	4.7
Germany	43,778	41,179	11.3	81	3	56	7.4
United States	52,704	56,115	17.1	79	6	67	10.8
Singapore	80,192	52,889	4.9	83	2	33	10.5

It is clear that simplistic market economy cannot function properly. Therefore, the financial measures from individual players will not be sufficient for the





5. IMPORTANT EDUCATIONAL OBJECTIVES

The university mission statements, accreditation requirements and business world now have broader objectives. We will look at a few of these here.

5.1 Georgia Tech Mission Statement and Serve-Learn-Sustain program

The mission statement of Georgia Tech made it clear that humans are most important.

We will be leaders in improving the human condition in Georgia, the United States, and around the globe

In 2016, Georgia Tech started the 10-year Quality Enhancement Program Serve-Learn-Sustain initiative. You can find similar mission statements and programs in other universities also. It emphasize on learning to serve and sustain.

5.2 Accreditation required student outcomes

BSIE in Georgia Tech is a ABET accredited engineering program. Your degree would not have much value if not accredited. The ABET criteria includes 7 student outcomes. The student outcomes 2, 4, and 5 are related broader (others on

(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

(4) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

(5) An ability to function effectively on a team whose members together provide leadership, create a collaborative & inclusive environment, establish goals, plan tasks, and meet objectives.

5.3 What are important other than financial measures?

You can see that ethical, social and environmental are very important in your studies, in addition to financial. Many firms now use triple bottom line to assess their projects. It includes social, environmental and economic. The “economic” is often interpreted as “financial”, although from the definition above, the economic can include much broader perspectives than financial.

5.3.1 Ethics in supply chain

What does ethical mean in supply chain? One way to look at it is if your decision is fair to the end customers. Should an IE or a consultant in a hospital consider the patient’s welfare in terms of health and in terms of financial burden be considered when make changes to improve financial or other performance?

5.3.2 Social and supply chain

What does social apply to supply chain. The United Nation lists 5 categories of social indicators.

1. Population: size, composition, growth and distribution.
2. Health: Life expectancy, Maternal mortality and infant mortality, Child bearing, Contraceptive prevalence, and HIV/AIDS
3. Housing: Persons per room (0.5 in US, 1997, 3.3 in Serbia and Montenegro, 1991), Human settlements (urban/rural), Water supply and sanitation
4. Education: Literacy, Primary education (ratio by gender, girl’s share), Secondary education, Tertiary education, School life expectancy (years of education by gender)
5. Work: Income and economic activity, Part-time employment, Distribution of labor force by status in employment, Adult unemployment (by gender)

I underlined some that are closely related to supply chains. For example, a hospital should not only look at cost and revenue, they should also consider patient health, mortality. When a factory improve efficiency with lower employment or less full time workers should also consider the

employment rate and part-time employment by finding other productive activities for the people targeted for layoff.

There are other important measures such as social mobility which is highly related to the educational system. OECD published a study shown intergenerational persistence of individual earnings. It is a percentage of extra earning of two off springs from two fathers with the first father makes twice of the second. For example, the black bar of OECD is at 38%. It meant that if an offspring of a father earned twice the earnings of the second father, then he/she will on average earn 38% more than the offspring of the second father, on average (Figure 1.*). This figure ranges from 12% in Denmark, 40% in US to 76% in Colombia. US has made some improvement. However, more can be done.

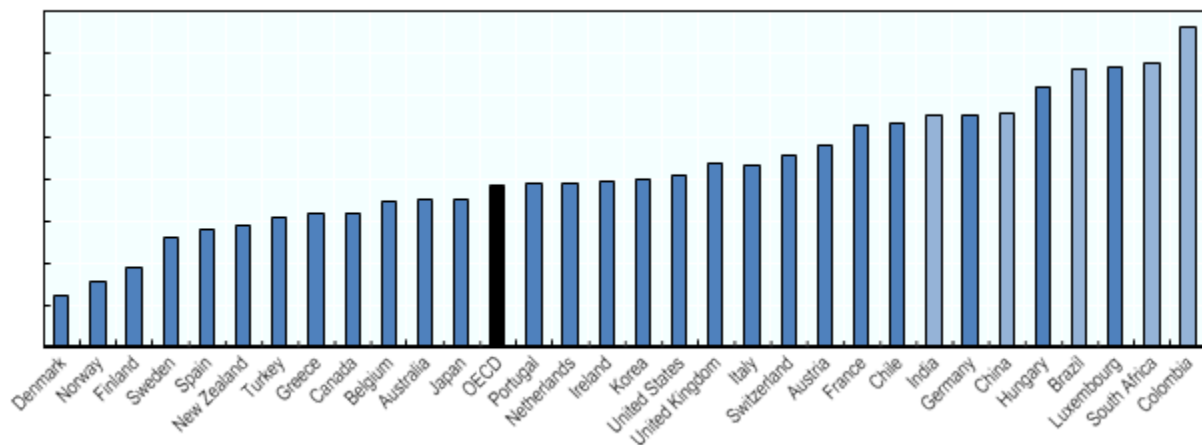


Figure 1.6 The inter-generational earnings elasticity. The lower represent more social mobility.

<https://www.oecd.org/inclusive-growth/inequality-and-opportunity/The-Issues-Note-Social-Mobility-and-Equal-Opportunities-May-4-2017.pdf>

5.3.3 Environment and sustainability

We say environment, we often mean air, water, plants, and animals. Some often link the color “green” with environment. However, we protect the environment for what? Is it for the sake of air, water, plants, and animals? Human beings are the only live thing that consciously change the environment at extremely high speed, much faster than the evolvement of the things on earth on their own, and allow the things to adopt the change.

We say sustainability, we often mean ecosystems, water supply, etc. Again, we sustain the ecosystems and water supply for what? Would earth rotate with or without human beings on it?

Human sustainability has internal and external aspects. The internal aspect is our own ability to adapt to the environment. Newborns are extremely vulnerable. However, they adapt themselves to fit the environment with varying temperature, humidity, pressure, food and biosphere. They develop immunity and learn to handle stress and adversaries. Each person has his/her own

limitations on the speed of development. Over exposure can cause problems or death. However, not given chance to develop can lead to undeveloped ability to sustain. That is why many pediatricians would tell the parents do not worry too much about kids getting cold, dirty, picking up things from floor and put in mouth. It is part of the development for more sustainable life (or pushing the envelope). Such advises counter to the advice to wash your hand with soap for at least 20 seconds.

The external dimension of sustainability is our environment we live in. Our body have been developed to the current structure on earth for at least thousands of years. Our maximum range of living space will not change a lot in one or a few generation. No one can live with extreme thin air or sea water. Although there is already hope to live on Mars, it will not happen for most people soon. We need the similar environment to sustain: air, water, biosphere, food, temperature range, absence of disasters, etc. We need to protect these to ensure our own sustainability.

5.4 It is for Human being to determine

Human beings is also rationale. It can decide not to do certain things even if we are able to. For example, the self driving cars is probably already safer than human driven cars. However, we have not allowed the self driving cars roam in large scale through regulations. Another example is that cloning of human beings. Another example is the academic advisors. Technically, the advising can be done via computers, if we decided to do so. I have made a point to ask many students. I have yet to find a student who does not find human advisor is needed.

6. SUMMARY AND OVERVIEW OF THE COVERAGE

Supply chain economics applies economic principles to the supply chain applications. Traditionally, supply chain management and supply chain engineering focus on cost reduction. It had worked fantastically. However, there are more opportunities, illustrated with several examples. Some of these are closely related to the other courses in industrial engineering while the others are related to incentives, collaborations, competition, and revenue management.

In each section, we will first discuss the supply chain issues at the micro-level using the financial measures.

We will then discuss these issues at macro-level and look at broader perspectives for the supply chain to serve human needs.

Doreen M Rabi, Alun L Edwards,¹ Danielle A Southern, Lawrence W Svenson, Peter M Sargious, Peter Norton, Eric T Larsen, and William A Ghalicorresponding, "Association of socio-economic status with diabetes prevalence and utilization of diabetes care services," BMC Health Services Research, 2006; 6: 124.

Exercises

1. Please describe a supply chain of something you use frequently.
2. Why do supply chains often involve partners?
3. What is the objective most supply chain engineers and managers try to optimize?
4. What other financial objectives should we consider?
5. Why the financial objective alone can lead to problems?
6. What are the externalities in the supply chain you described in 1?
7. What is the root cause of these externalities?
8. Does the term “supply chain” reflect the product supply process properly? Why?
9. What does triple bottom line objective include?
10. What are the reasons that the objectives of cost or profit do not necessarily reflect the objectives of human needs?
11. Please give an example of natural resource scarcity in US today.
12. Please give examples of abundance in human made products (not food because it is already mentioned above).
13. Please give an example in which minimizing cost or maximizing profit may conflict with each of the other bottom lines.
14. Please search the web to find the time it takes to form some of the natural resource, and how much time it will take to deplete most of them. This can be oil, coal, natural gas, or anything else you want.
15. How would you define sustainability?
16. Many students interested in health care. Can you describe health system supply chain similar to the food supply chain?
17. Many students interested in financial systems. Can you describe the financial systems similar to the food supply chain?
18. What are Porter’s five forces important in forming supply chain strategy?