

Transportation

A Global Supply Chain Perspective

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**Transportation: A Global Supply Chain
Perspective, 10th Edition
Novack/Gibson/Suzuki**

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A very special note of thanks and appreciation is due to our families.
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Yoshi Suzuki would like to thank his wife Kazuko and their children Takeshi and Mia.
Special mention should be made in reference to Dr. Edward J. Bardi and to Dr. John J. Coyle
to express our deep appreciation of their many contributions not only to
the continuing development of this text but also to the supply chain management text.

The authors would like to dedicate this edition to John Coyle. John was the first author on this text since the first edition in the 1970s. Dr. Coyle passed away on January 16th of this year. He will be remembered as being on the forefront of the supply chain discipline. He was a mentor and friend to all of us. He will be missed.

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Preface



This textbook is recommended by APICS® as a valuable study resource for the Certified in Logistics, Transportation, and Distribution professional certification program. For details, go to <http://www.apics.org/credentials-education/credentials/cltd>.

Transportation is the critical link in successful supply chains. It is a key facilitator of global economic development, quality of life improvement, and enterprise success. Effective transportation processes ensure the rapid flow of essential goods across complex global supply chains. Efficient transportation operations keep delivery costs in check to ensure that products are affordable in multiple markets.

Transportation professionals are tasked with balancing these effectiveness and efficiency goals. They must also manage complex transportation networks and minimize disruptions of cross-border product flows to meet the ever-increasing service demands of the 21st century customer. While these are not easy tasks, high-quality work by dedicated transportation professionals is essential for global trade to thrive.

In this book, *Transportation: A Global Supply Chain Perspective*, Tenth Edition, we continue to focus on the widespread impact of commercial transportation on worldwide commerce. We believe that the contents of this book will help future transportation professionals prepare for successful careers in this dynamic field. Our text follows the format of the previous edition with three sections and thirteen chapters. Substantive additions and revisions have been made to enhance the content and organization. In particular, the critical role of technology in global transportation receives special attention in this edition.

Part I provides the foundation for the overall text. Chapter 1 explores the nature, importance, and critical issues in the global economy, which are important to understand for the current and future transportation systems. Chapter 2 provides the economic foundation and rationale for the role of transportation as well as its political and social importance. Chapter 3 highlights the expanding role of technology in transportation, addressing both software and equipment innovations that drive greater service and lower costs. Chapter 4 offers a discussion of transportation costing and pricing in a market-based economy.

Part II provides an overview of the major transportation alternatives available to individual and organizational users. Chapters 5 through 8 discuss and examine the key features and issues of the five basic modes of transportation, namely, motor (5), rail (6), airline (7), water and pipeline (8). Each of the basic modes offers inherent advantages for shippers of particular commodities or locations that need to be appreciated and understood to gain the economic benefits they offer. The dynamic market environment that exists in many economies demands continuous improvement of modal capabilities if they are to remain relevant.

The chapters in Part III cover a variety of important issues related to the successful management of transportation flows. Each of the five chapters in this section have been updated and revised to further improve their value to the readers. Chapter 9 supplements the information provided in Part II with a detailed discussion of logistics service providers that support the transportation industry. These organizations improve the efficiency, effectiveness, and execution of global supply chain flows. Chapter 10 discusses the topic of risk management, a key concern for many organizations because of the increasing threat of supply chain disruptions in the global economy. Strategies, methods, and outcomes for risk management are explored as well as overall security enhancement. Chapter 11 provides an in-depth discussion of the planning and execution of global transportation with emphasis on trade facilitation, product flows, and information sharing. Chapter 12 covers the all-important role of government policy, regulation, and promotion in fostering a strong transportation network. Finally, Chapter 13 explores some of the major challenges for transportation in the 21st century, namely, infrastructure funding needs, talent management gaps, environmental sustainability, and fuel management. Each issue threatens to disrupt transportation flows, reduce competitiveness, and increase costs if not managed proactively.

Overall, we are convinced that transportation is a critical engine for business growth and societal advancement but is often taken for granted until a crisis arises. As stated previously, it may be the most important industry for all economies regardless of their stage of development. Such recognition needs to be accorded to transportation in the future.

Features

1. Learning Objectives in the beginning of each chapter provide students with an overall perspective of chapter material and serve to establish a baseline for a working knowledge of the topics that follow.
2. Transportation Profile boxes are the opening vignettes at the beginning of each chapter that introduce students to the chapter's topics through familiar, real-world examples.
3. On The Line features are applied, concrete examples that provide students with hands-on managerial experience of the chapter topics.
4. Transportation Technology boxes help students relate technological developments to transportation management concepts.
5. Global Perspectives boxes highlight the activities and importance of transportation outside of the United States.
6. End-of-chapter Summaries and Study Questions reinforce material presented in each chapter.
7. Cases at the end of each chapter build on what students have learned. Questions that follow the cases sharpen critical thinking skills.

Supplements

1. Additional instructor resources for this product are available online. Instructor assets include an Instructor's Manual, PowerPoint® slides, and a test bank powered by Cengage®. Sign up or sign in at www.cengage.com to search for and access this product and its online resources.

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About the Authors

Robert A. Novack is currently an Associate Professor of Supply Chain Management and Associate Director in the Center for Supply Chain Research at Penn State. Dr. Novack worked in operations management and planning for the Yellow Freight Corporation and in planning and operations for the Drackett Company. He received his bachelor's and MBA degrees from Penn State and a PhD from the University of Tennessee in Knoxville. Dr. Novack has numerous articles published in the *Journal of Business Logistics*, the *Transportation Journal*, and the *International Journal of Physical Distribution and Logistics Management*. He is also the coauthor of three textbooks: *Creating Logistics Value: Themes for the Future*, *Supply Chain Management: A Logistics Perspective* (11e), and *Transportation*. He is on the editorial review board for the *Journal of Business Logistics and Transportation Journal* and is an area editor for the *Journal of Supply Chain Management*. Dr. Novack is very active in the Council for Supply Chain Management Professionals, having served as overall program chair for the annual conference, as a track chair, and as a session speaker. In addition, he has served on numerous committees with this organization. Dr. Novack holds the CTL designation from the American Society of Transportation and Logistics. His current research interest is on the development and use of metrics in managing supply chains. In 2009, he received the Atherton Teaching Award from Penn State, the highest award given for teaching at that university.

Brian J. Gibson is the Wilson Family Professor of Supply Chain Management and Executive Director of the Center for Supply Chain Innovation at Auburn University. Previously, he served on the faculty of Georgia Southern University and as director of the Southern Center for Logistics and Intermodal Transportation. Dr. Gibson also served as a logistics manager for two major retailers. He is an accomplished faculty member who has received multiple awards for outstanding teaching, research, and outreach. Dr. Gibson has coauthored numerous articles in the *Journal of Business Logistics*, *CSCMP's Supply Chain Quarterly*, *Supply Chain Management Review*, *International Journal of Logistics Management*, and other leading industry publications. He is also the coauthor of three textbooks: *Supply Chain Management: A Logistics Perspective* (11e), *The Definitive Guide to Integrated Supply Chain Management*, and *Transportation*. He is actively engaged in executive education, seminar development, and consulting with leading organizations. Dr. Gibson recently served as Chairman of the Board for the Council for Supply Chain Management Professionals and is a Supply Chain Steering Committee Member for the Retail Industry Leaders Association. Dr. Gibson earned a BSBA from Central Michigan University, an MBA from Wayne State University, and a PhD in logistics and transportation from the University of Tennessee.

Yoshinori Suzuki is Land O'Lakes Endowed Professor of Supply Chain Management at the Debbie and Jerry Ivy College of Business, Iowa State University. He holds a BS degree in Business and Economics from Sophia University (Tokyo, Japan), an MBA degree in Marketing from New York University Leonard N. Stern School of Business, and a PhD degree in Business Logistics from The Pennsylvania State University Smeal College of Business. His research interest is in mathematical modeling of logistics and transportation problems. During his 24-year academic career, he has conducted numerous research projects with both private and public organizations, which include Ruan Transportation Management Systems, GROWMARK Inc., C.H. Robinson, Renewable Energy Group (REG), Des Moines International Airport, and National Aeronautics and Space Administration (NASA). His recent research work has appeared in journals such as *Computers & Industrial Engineering*, *Transportation Research* (various parts), *Journal of Transportation Engineering*, *Naval Research Logistics*, *Decision Sciences*, *Decision Support Systems*, *Journal of Business Logistics*, *International Journal of Production Economics*, *International Journal of Production Research*, *Transportation Journal*, and *International Journal of Physical Distribution and Logistics Management*. He has several years of industry experience. His work experience includes sales, logistics management, and transportation management. Dr. Suzuki has served as the Co-Editor-in-Chief of *Transportation Journal* for six years until 2021, has served as an Associate Editor of *Decision Sciences*, and is currently serving as a Senior Editor of *Journal of Business Logistics*.

Transportation is the most overlooked but yet most critical component of global supply chains. This has been brought to light by the Covid-19 “Black Swan” event over the last two years. When the virus first emerged in the United States during early 2020, consumers started hoarding certain necessities and demand far exceeded consumption. This caused suppliers to increase output which put transportation in a tight capacity situation. Then China and the United States went into lockdown so exports to the United States went down significantly but online shopping in the United States increased dramatically. This resulted in there being excess capacity in the ocean, air, less-than-truckload (LTL), and truckload (TL) sectors of the transportation industry. However, the small parcel network (UPS, FedEx, FedEx Ground, and the United States Postal Service) saw significant increases in volume.

When the pandemic eased and imports to the United States started to arrive from China in large volumes, the West Coast ports of Los Angeles and Long Beach were overwhelmed and dwell times for container ships were longer than 60 days. At one point there was over 80 ships waiting to be unloaded off the west coast. On some freight lanes between China and the United States, the cost of a 20-foot-equivalent (TEU) container went from \$2,200 to \$28,000.

Today, the congestion is easing on the West Coast but China is in lockdown again because of their “zero-tolerance” policy because of a resurgence of Covid cases in that country. So, imports to the United States have gone down again. The dramatic increases and decreases in global and domestic demand for products have played havoc on global transportation networks. These volume swings have had impacts on transportation capacity and rates that have fueled rising consumer prices in the United States and across the world.

Global transportation systems have also been seriously challenged in the twenty-first century by high fuel costs (\$3.22 per gallon of diesel nationally in May 2021 versus \$5.57 in May 2022), changing capacity, and government regulation. In addition, the transportation infrastructure, namely seaports, airports, highways, and so on, is not sufficient to accommodate the flow of global commerce in many countries, thus stymying the economic progress of these regions. Many parts of the infrastructure require government or public funding because of the different users. The public coffers are frequently financially strained because of the many alternative demands for these somewhat limited resources. Transportation infrastructure has to “compete” for an allocation of public funds, and the benefits, while real, are more in the long run in terms of outcome and value. Consequently, such needed resources might not be allocated in a timely manner. Transportation and the related logistics systems are a necessary requirement for all economies, developed and underdeveloped, but the public investment in social capital necessary to not only improve but also sustain the infrastructure has not been forthcoming in many countries. Hopefully, one of the outcomes of this text will be a better understanding and appreciation for the criticality of efficient and effective transportation systems for economic development and social welfare.

Part I will provide an overview and foundation for the role and importance of improved transportation from a micro and macro perspective in global supply chains.

The discussion will cover economic and managerial dimensions of transportation in the global economy. Part I is designed to provide the framework for the analysis and discussion for the following sections of the book.

Chapter 1 examines the nature, importance, and critical issues in the global economy, which are important to understand for the current and future transportation systems that will provide the needed service for the diverse requirements of the various regions and countries. This chapter will also discuss the special nature of transportation demand and how transportation adds value to products. There is also an overview of the concept of supply chain management and the important role of transportation in supply chains of various organizations.

Chapter 2 examines the role of transportation from a macro and micro perspective. The chapter adds to the discussion in Chapter 1 but explores more broadly the special significance of improved transportation systems. The analysis includes not only the economic impact but also the political and social impact of transportation. Current and historical perspectives are provided in the discussion to help the reader appreciate and better understand the contribution of improved transportation in an economy. The discussion also examines the impact of improved transportation upon land values and prices of products and services.

Chapter 3 provides an overview of the technology and systems currently in use and planned for execution in the transportation sector. Special attention is given to the technology used in the various modes, including On-Board Recorders (OBRs) and driverless vehicles in the motor carrier industry and Positive Train Control (PTC) in the railroad industry. The discussion also emphasizes the impact the various technologies have had on transportation efficiency.

Chapter 4 extends the discussion of costing and pricing introduced in Chapters 1 and 2. Given the importance of transportation on a micro and macro level to the cost and value of products and services, costing and pricing deserves a more detailed examination. There are unique dimensions to transportation services in general and between the basic modes that need to be understood by managers and public officials. Chapter 4 also provides an analysis of the differences and unique dimensions of transportation services.

Chapter

1

Global Supply Chains: The Role and Importance of Transportation

Learning Objectives

After reading this chapter, you should be able to do the following:

- Appreciate why efficient transportation systems are so critical to advance the growth and development of regions and countries, and how they contribute to social and political systems as well as national defense
- Discuss the importance of transportation to globalization and how it contributes to the effective flow of commerce among close and distant regions
- Understand how global supply chains can contribute to the competitive position of countries and allow them to penetrate global markets
- Appreciate the dynamic nature of the global economy, which can impact and change the competitive position of a region or country in a relatively short period of time
- Explain the underlying economic basis for international exchange of goods and services for the overall benefit of two or more countries or regions and gain some perspective on the volume and overall importance of the more advanced countries of the world
- Discuss the size and age distribution of the population and the growth rate of the major countries of the world and understand how the size of the population can impact a country positively or negatively
- Understand the challenges and opportunities associated with the world-wide growth in urbanization and why there has been such a major shift from rural to urban areas
- Appreciate the importance and impact of land and resources to the economic advancement and development of the various countries of the world and how they can be exploited to their advantage
- Explain why technology has become such an important ingredient for the economic progress of companies and countries in today's global economy and understand the need for and types of technology

- Discuss the overall characteristics and importance of globalization and supply chains in the highly competitive world economies of the twenty-first century

Transportation Profile

Time for Contingency Plans

The 2021 logistics nightmare has forced shippers to react to problems and to try to divert shipments to alternative ports of entry, alternative transport modes (air freight, cross-border rail) and alternative providers (“premium rate” NVOs). Such moves, however, have left them with no time to pause and contingency plan.

Consequently, it’s now more important than ever for shippers to work with the right logistics providers and strengthen carrier relationships and business continuity plans. “This will help shippers deal with ‘the next crisis’ as and when it happens,” advises Philip Damas, managing director and head of supply chain advisors at Drewry.

This means reviewing your supply chain and transportation networks to reduce exposure to the super-inflated container shipping costs that are expected to remain at least through the midterm.

“Many members of the Drewry Benchmarking Club are already looking at sourcing products from alternative locations to avoid spending 5-digit freight rates per container from Asia to the West,” Damas reveals. “Others are looking at warehouses closer to the port instead of using those located near congested rail hubs such as Chicago, for example.”

Based on recent and current consultancy work carried out for shipper customers, Drewry suggests that shippers optimize internal operations. This means improving minimum quantity commitments (MQC) management processes as well as volume forecasting and communication of forecasts to carriers, etc. In essence, control better what you can control.

Source: Karen E. Thuermer, *Logistics Management*, February 2022, p. 28. Reprinted with permission of Peerless Media, LLC.

Introduction

In previous editions of this text, transportation was referred to as the “glue” that holds the supply chain together and an enabler of the underlying tactics and strategies that have catapulted supply chain management to the level of acceptance, which it now enjoys in many organizations, both private and public. For example, transportation management systems technology along with complementary software is used by many organizations to improve logistics and supply chain efficiency, effectiveness, and execution. Transportation has moved from playing a reactive or supporting role to a role that is more proactive and enabling. In other words, transportation has become much more strategic for organizations in determining their ability to compete in the growing and complex global marketplace.

The global marketplace is also changing on a continuing basis, that is, it has become very dynamic, and is buffeted by economic, political, social, and natural forces, which can impact a country or region negatively or positively in the short or long run. For example, the high cost of fuel has impacted the rates charged by transportation service providers, which in turn impacts the distance that it is economically feasible to transport goods. The cost and availability of labor can change over time to the disadvantage of some geographic areas and to the benefit of others. For example, the labor cost advantage that China enjoyed, along with low rates for ocean carrier movement, had a positive impact on their ability to sell products on a global basis. These advantages have diminished somewhat allowing other countries to develop an improved competitive position because of market proximity, labor costs, or other factors. These changes in turn impact global supply chains and their associated flow of goods.

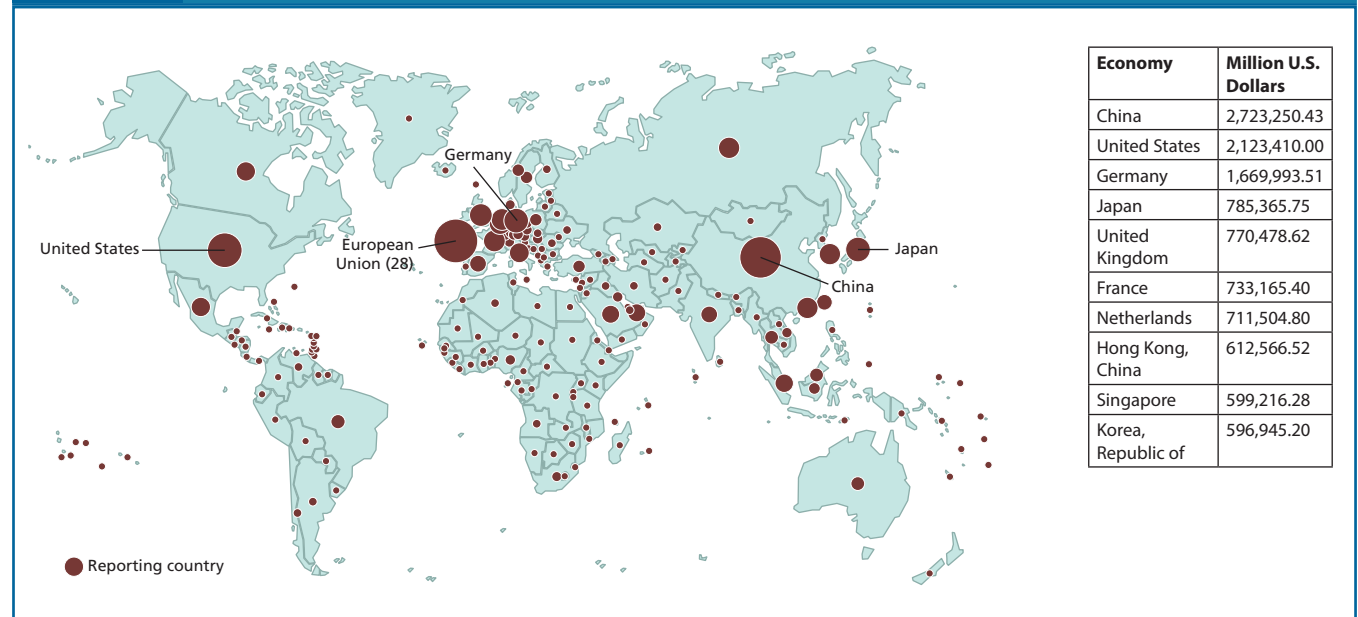
In this chapter, the initial focus will be upon developing an overview of the flow of global commerce and trade overtime on a worldwide basis not only to understand the importance and magnitude of global supply chain flows but also to gain some perspective on important changes that have occurred. A variety of economic data will be used to illustrate the impact of the overall changes that have occurred. The next section will examine the underlying rationale and economics of global flows of goods and services. In other words, the “why” of global flows will be discussed to understand the advantages of international trade to countries and consumers in contrast to the “what” of the first section of this chapter. The third section will provide additional insights into the factors that can contribute to the economic advancement and development of countries. The final section of the chapter will provide an overview of the supply chain concept including its development, key characteristics, and major activities.

Global Supply Chain Flows

Early in the twenty-first century, frequent reference was made to acronyms such as the BRIC (Brazil, Russia, India, and China) or VISTA (Vietnam, Indonesia, South Africa, Turkey, and Argentina) countries. The former were identified as the top emerging economies and the latter as those developing at a fast pace. The development of the BRIC and VISTA countries was seen an indication of opportunities for “sourcing” of materials, products, and services and the identification of potential markets for the more developed economies such as the United States, the European Union (EU), and Japan. Also, they were a sign of a more economic balance in the world and continued growth. Consequently, one noted author¹ declared that the world was really flat because of the developing economies. Interestingly, there have been some economic shifts already with respect to these countries, and the future importance of some of the VISTA countries is not clear. For example, South Africa has been added to the first group, BRICS, by some economic pundits. Nevertheless, all of this supports the observation made earlier about the dynamic and competitive nature of world markets. An important caveat is the potential for disruption caused by political instability, associated acts of terrorism, and military actions, which can cause a major disruption in global trade flows.

Figure 1-1 and Table 1-1 indicate export trade flows of merchandise from various country or region origins. In Figure 1-1, the size of the circle indicates the importance and volume of exports on a worldwide basis. It is interesting to note the large number of exporting countries and the big

Figure 1-1 Export–Trade Flows of Merchandise



differences in the volume. Table 1-1 shows the value of world exports in U.S. dollars. China is clearly number one for exports of merchandise and the United States is second, but what may be surprising is Germany being third. They are relatively close to the United States in terms of the value of their exports. If we added up the value of exports for all the EU countries, it would by far exceed the United States. The EU also compares favorably to the Asian bloc of countries in terms of exports.

Figure 1-2 and Table 1-2 show the import trade flows of merchandise into various countries and regions. Figure 1-2 is interesting because it is a visual representation of the magnitude of the value of imports and provides some perspective of the differences in the world markets. In terms of regions, Figure 1-2 indicates that Asia is the largest importing region and is followed by the EU. North America is third in terms of the value of imports. Among individual countries, the United States is the largest importer, followed by China and then Germany.

A comparison of relative shares of imports and exports provides some additional perspectives. China's share of global exports in terms of value is 14.7 percent and their share of imports is 11.5 percent making them a net exporter, whereas the United States by comparison is a net importer with 8.1 percent of merchandise exports and 13.5 percent of the global imports. Germany is also a net exporter with exports representing 7.8 percent of the global total with imports of 6.6 percent of the total. There are economic implications associated with these differences, but the merchandise flows do not provide a complete economic picture because the value of services imported and exported are also important for the balance of payments of individual countries. However, the focus of this text is obviously upon merchandise flows.

The importance of the so-called developed countries/economies is evident from the information presented earlier, but additional insight can be gained by summarizing the impact of the top countries in each category (see Tables 1-1 and 1-2). In 2020, the top 30 exporting countries accounted for 86.9 percent of the world's exports (\$17.070 trillion), but the top three (China, the United States, and Germany) accounted for about 31.7 percent of the total exports. The top 30 importing countries accounted for 85.3 percent of the total imports (\$17.376 trillion), but the top three (the United States, China, and Germany) accounted for 32.4 percent of the total imports. The data presented in Tables 1-1 and 1-2 substantiate the observation about the important role of developed economies made earlier.

Additional insight can be gained by examining the growth in the volume of global trade and gross domestic product (GDP) from 2014 to 2020 (see Table 1-3). From 2014 to 2018, both trade and

Figure 1-2 Import–Trade Flows of Merchandise

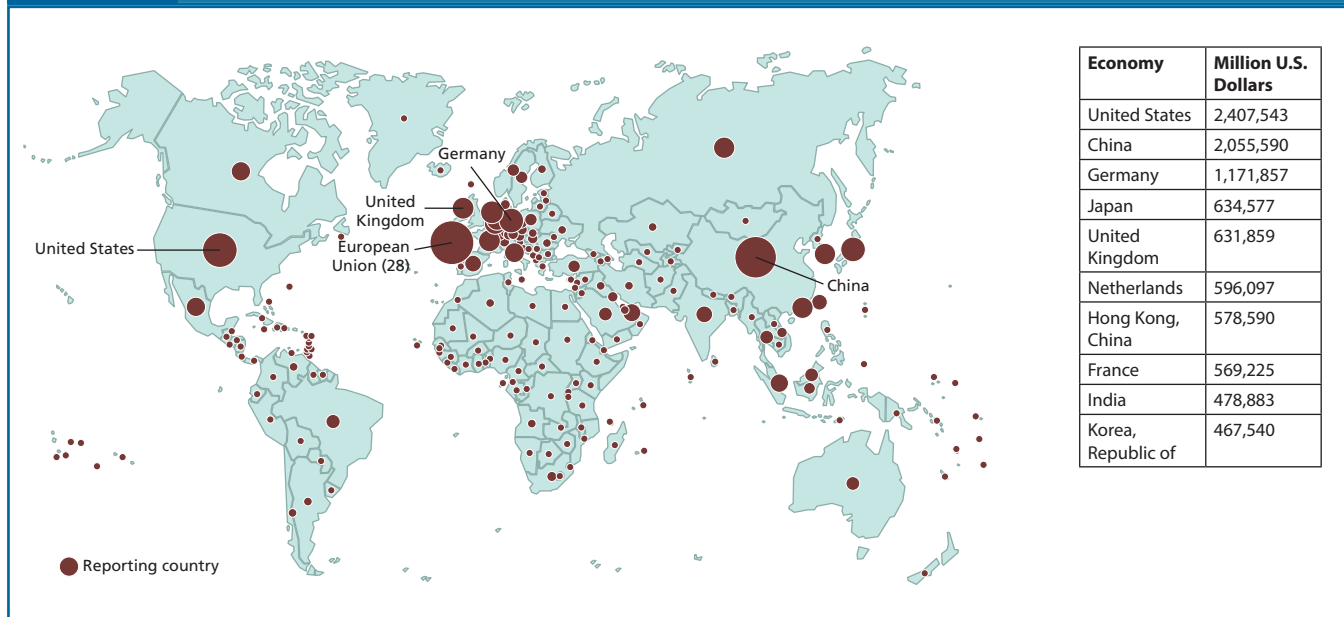


Table 1-1 Top 30 Exporters In World Merchandise Trade, 2020

Rank	Exporters	Value	Share	Annual % Change
1	China	2,591	14.7	4
2	United States	1,432	8.1	−13
3	Germany	1,380	7.8	−7
4	Netherlands	674	3.8	−5
5	Japan	641	3.6	−9
6	Hong Kong, China	549	3.1	3
7	Korea, Republic of	512	2.9	−5
8	Italy	496	2.8	−8
9	France	488	2.8	−14
10	Belgium	419	2.4	−6
11	Mexico	418	2.4	−9
12	United Kingdom	403	2.3	−14
13	Canada	391	2.2	−13
14	Singapore	363	2.1	−7
15	Chinese Taipei	347	2.0	5
16	Russian Federation	332	1.9	−21
17	Switzerland	319	1.8	2
18	Spain	307	1.7	−8
19	United Arab Emirates	306	1.7	−21
20	Vietnam	283	1.6	7
21	India	276	1.6	−15
22	Poland	271	1.5	2
23	Australia	250	1.4	−8
24	Malaysia	234	1.3	−2
25	Thailand	231	1.3	−6
26	Brazil	210	1.2	−7
27	Czech Republic	192	1.1	−4
28	Ireland	179	1.0	5
29	Saudi Arabia, Kingdom of	173	1.0	−34
30	Turkey	169	1.0	−6
	Top 30 Countries	14,836	100.0	—

Source: World Trade Organization.

GDP grew at a fairly constant rate. The impacts of the global pandemic can be seen by the decrease in both global trade and GDP in 2020. A number of factors came into play to explain the pre-pandemic increased growth rate including trade agreements among countries along with a reduction in tariffs, which promoted global trade and its associated benefits. There was also greater acceptance of importing finished products that were manufactured in foreign countries.

Traditionally, many countries imported raw materials that were scarce or not available in the importing country, and they then produced finished products mostly for domestic consumption. The raw materials were much lower in value than the finished products that contributed to the imbalance of trade among developing and developed economies. However, that situation has changed, countries that previously imported materials for domestic production and consumption are exporting more

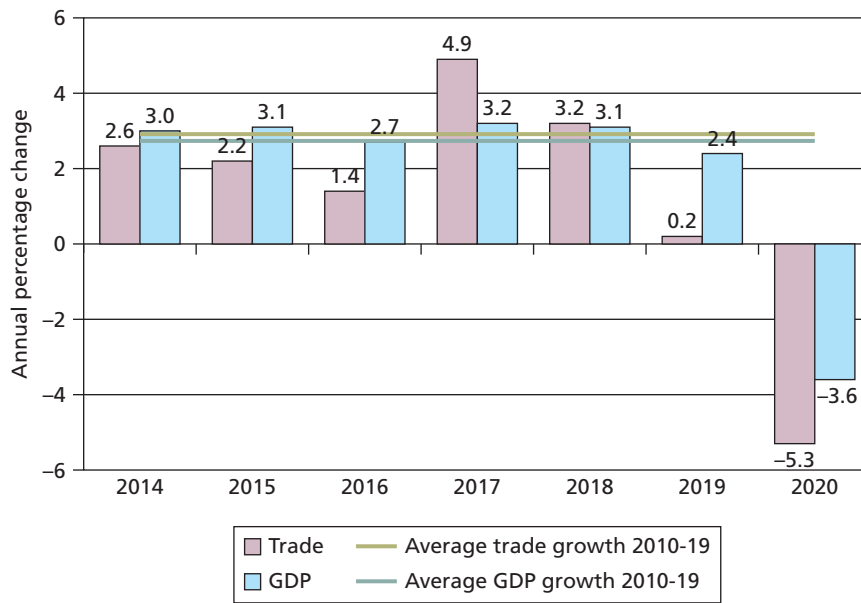
Table 1-2 Top 30 Importers In World Merchandise Trade, 2020

Rank	Importers	Value	Share	Annual % Change
1	United States	2,408	13.5	−6
2	China	2,056	11.5	−1
3	Germany	1,171	6.6	−5
4	United Kingdom	635	3.6	−9
5	Japan	635	3.6	−12
6	Netherlands	597	3.4	−6
7	France	582	3.3	−11
8	Hong Kong, China	570	3.2	−1
9	Korea, Republic of	468	2.6	−7
10	Italy	423	2.4	−11
11	Canada	414	2.3	−11
12	Belgium	395	2.2	−8
13	Mexico	393	2.2	−16
14	India	372	2.1	−23
15	Singapore	330	1.9	−8
16	Spain	325	1.8	−13
17	Switzerland	291	1.6	5
18	Chinese Taipei	288	1.6	0
19	Vietnam	263	1.5	4
20	Poland	257	1.4	−3
21	Russian Federation	240	1.3	−6
22	United Arab Emirates	226	1.3	−16
23	Turkey	219	1.2	4
24	Australia	208	1.2	−6
25	Thailand	207	1.2	−12
26	Malaysia	190	1.1	−7
27	Austria	172	1.0	−7
28	Czech Republic	170	1.0	−5
29	Brazil	166	0.9	−10
30	Sweden	149	0.8	−6
	Top 30 Countries	14,820	100.0	—

Source: World Trade Organization.

finished products while so-called underdeveloped countries are participating more in manufacturing, especially of parts of a finished product. A very good example is the automobile industry. The typical automobile of today has over 10,000 parts, which can be manufactured in many different countries. Furthermore, the individual parts may be exported and put together into subassemblies that are frequently shipped to an assembly plant in another location. So, a Ford assembled in Detroit may have less U.S.-made parts than a Toyota assembled in Mexico. The efficiency of global supply chains and especially the transportation systems afford these more complex operations as compared to an earlier era when the auto parts were produced in locations which were more contiguous to the assembly plants. This is also an excellent example of companies using logistics systems analysis to evaluate the trade-offs among production costs, transportation services, and inventory carrying costs to arrive at the overall best location for efficiency and effectiveness.

Table 1-3

Volume of World Merchandise Trade and Gross Domestic Product, 2014–2020
(Annual Percentage Change)

Source: World Trade Organization.

As indicated earlier, the global supply chains of today allow production of products with parts being produced in several countries before the final finished product is assembled. A major contributing factor to the global supply chains and the economics of production is the efficiency and effectiveness of global transportation and associated services. The improved global supply chains with faster transit times and lower rates help promote global trade. Consumers received not only lower prices but also in many instances better quality food and manufactured products. In the next section, we will examine the economic basis and complimentary logic for global trade.

The Economic Basis and Logic of Improved Global Trade

International trade is not a post–World War II phenomenon. During the Middle Ages, it was not uncommon for “traders” to cross regional and country borders by land or sea to buy, sell, or trade selected commodities. Even the Bible references traders from other regions. The exploits of European explorers studied in high school and college history books were often rationalized upon finding high value or exotic products to bring back to their home country in exchange for their domestic products or valued items. The discovery of foreign lands for future settlement was also a motive but with the recognition of the potential trade opportunities. Obviously, the trading was inefficient and slow because of the bartering required and the transportation.

Absolute and Comparative Advantage

As the European countries advanced economically in the eighteenth century, there was a growing recognition of the value and potential of international trade. Adam Smith in his 1776 book, *The Wealth of Nations*,² not only provided a rational basis for a market economy based upon open or free competition, but also advanced the so-called Theory of Absolute Advantage that provided an economic basis for “free trade” among countries. Essentially, he stated that if two regions or countries produced and consumed the same two products—for example, eggs and butter—but had

different costs of production, trade could be beneficial. For example, if Country A had an advantage with producing eggs (50 cents versus \$1 per dozen) and Country B had the advantage with butter (75 cents versus \$1.25 per pound), Smith concluded that A should produce eggs and buy butter from B, while B should produce butter and buy eggs from A. Both would benefit by being able to buy more of each product at lower prices than if they each continued to produce both products. This example is somewhat simplistic because it does not consider transportation costs for delivery or other costs that could be incurred. If the additional costs were added to the production costs, the subsequent “landed cost” would have to be lower than the importing country’s cost of production. In other words, in the example earlier, the eggs produced in A would have to have a landed cost in B (50 cents plus transportation costs) less than \$1.00.

This same logic was used by Smith to advance the rationale for specialization or division of labor that supported the concept of mass or assembly line production, which will be discussed in more detail in the next chapter. The important point is that global or regional trade could be based upon the lack of certain materials or products in an area, but also upon differences in the cost of producing two or more products in two or more different countries.

The Theory of Comparative Advantage was advanced about 40 years after the publication of Smith’s *Wealth of Nations* by several economists.³ They maintained that even if two countries produced and consumed the same two products and one country could produce both products at a lower cost (absolute advantage in both products) than the other country, it could possibly be beneficial for both countries to specialize and trade. It would require the country with the advantages to specialize in the product that it had the greatest comparative advantage over the other country. For example, if Country A could produce butter for 75 cents less than Country B and Country B could produce eggs for 25 cents more than Country A, A should produce butter while B should produce eggs. Again, transportation cost and other costs would have to be considered to develop a landed cost.

The concepts of absolute and comparative advantage are logical but relatively simple for the more complex economic environment of the twenty-first century. As one would expect, there have been economists who have enhanced or modified these earlier concepts. For example, one such enhancement is the so-called Factor Endowment Theory advanced by Heckscher and Ohlin that enhances Ricardo’s Theory of Comparative Advantage.⁴ Ricardo’s theory was based upon a difference in efficiency associated with better technology, whereas the Factor Endowment Theory postulates that when a country has more of one of the four factors of production (land, labor, capital, or entrepreneurship), they can have a comparative advantage in producing one or more products. Therefore, a country with an abundance of capital and an educated workforce can produce high-tech products and import agriculture products from other countries.

In today’s more complex, global economy, there are more variables than the traditional factors of production (land, labor, capital, and entrepreneurship) that can give advantages to countries and provide a basis for global trade flows. Some of these factors help to explain the development of the so-called BRIC and VISTA countries that were previously discussed. For example, two of the BRIC countries, India and China, have developed and prospered during the last 20 years because of factors such as improved global transportation, faster communication with lower costs, population growth, and technology advancement. China, for example, has taken advantage of their low labor costs, including skilled workers, ample raw materials, and capital to invest in production facilities. India’s expanding population and growth in technology expertise contributed to their economic advancement. In a later section of this chapter, China’s and India’s advancing economies and leadership positions in the world economy will be discussed in more detail.

Contributing Factors for Global Flows and Trade

Important factors that are frequently cited for greater economic development may include population growth and age distribution, urbanization, land and resources, economic integration, knowledge dissemination, labor mobility, financial flows, and investment in infrastructure by public and/or private agencies to promote improved transportation, faster communication systems, improved financial services, and increased flow of goods and services. These same factors also become the driving forces for overall globalization. At this juncture, it would be worthwhile to examine some of these factors in terms of the global economic growth and development of selected countries.⁵

Population Size and Distribution

Table 1-4 shows the population of the 10 largest countries and the total world population, which can be used as a basis for understanding current and future economic growth and development potential. The table includes totals for 2000, 2010, and 2022 and a projection for 2050. In 2022, the top 10 countries accounted for about 56 percent of the total world population and China plus India account for over 36 percent of the total. Additionally, China has over a billion more people than the United States. By 2050, it is projected that India will have over a billion more people than the United States, and India will have a larger population than China unless there is some change in their respective birth rates. The sheer size of their respective populations is an important advantage in terms of one of the previously noted factors of production, that is, labor. The size of their labor forces along with their education and skills will continue to be a strategic advantage, especially in light of the “aging” populations of other countries, which will be discussed later in this chapter.

Table 1-5 depicts the total world population and indicates a decrease in the percentage of people 24 years old and younger, from 1980 to 2100. Experts point out that the worldwide rate of population growth has already peaked and is now declining, which is important in terms of global resource base.⁶ Additionally, the population growth rate is greatest in some areas that can probably least afford it. Unless there is some change in their economic development, the population explosion in certain underdeveloped economies could lead to dire levels of poverty and other health-related problems and potential political unrest.

While the total population of a country is an indicator of economic growth potential in terms of workforce and consumers, it has some limits. We need additional information about the population to draw meaningful conclusions such as age distribution and education levels. If we examine population age distribution on a macro level, the young-age balance is shifting throughout the world. In the more developed regions in 2000, the proportion of older people (over age 60) is almost the same as children (under age 15), 19.5 percent versus 18.4 percent. But by 2100, the numbers are predicted to be 35.5 percent versus 14.7 percent, respectively. Europe will have the greatest disparity followed by North America. The longer life spans in developed countries are exacerbating the young-age disparity ratio and has important implications for the labor force in various countries and the needs of consumers for food, housing, and medical care. Figure 1-3 shows the number of persons aged 80 or older per 100 children under the age of 14 for 2020 and a projection for 2100. The difference between 2020

Table 1-4 Top 10 Countries with the Highest Population

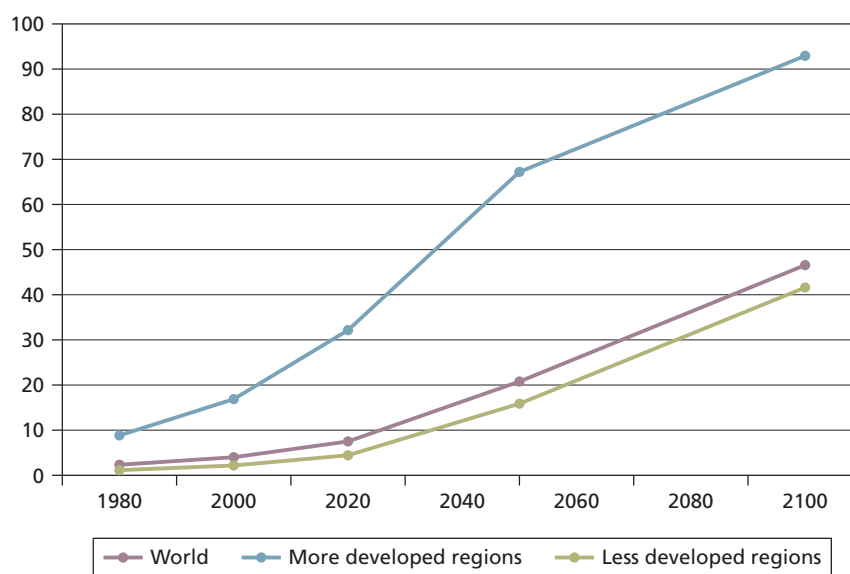
	Country	2000 Population	2010 Population	2022 Population	2050 Expected Population
1	China	1,268,301,605	1,330,141,295	1,410,539,758	1,364,000,000
2	India	1,006,300,297	1,173,108,018	1,389,637,446	1,659,000,000
3	United States	282,162,411	310,232,863	332,838,183	390,000,000
4	Indonesia	214,090,575	242,968,342	277,329,163	322,000,000
5	Pakistan	146,404,914	184,404,791	242,923,845	307,000,000
6	Nigeria	123,178,818	152,217,341	225,082,083	411,000,000
7	Brazil	123,945,463	152,217,341	217,240,060	233,000,000
8	Bangladesh	128,734,672	156,118,464	165,650,475	202,000,000
9	Russia	147,053,966	139,390,205	142,021,981	133,000,000
10	Mexico	99,775,434	118,600,000	129,150,971	164,000,000
	Top Ten	3,539,948,155	3,959,398,660	4,390,391,984	5,185,000,000
	Rest of the world	2,574,375,889	2,962,455,931	3,478,480,467	4,550,033,900
	Total	6,114,324,044	6,921,854,591	7,868,872,451	9,735,033,900

Source: World Bank, United States Census Bureau, United Nations, Department of Economic and Social Affairs

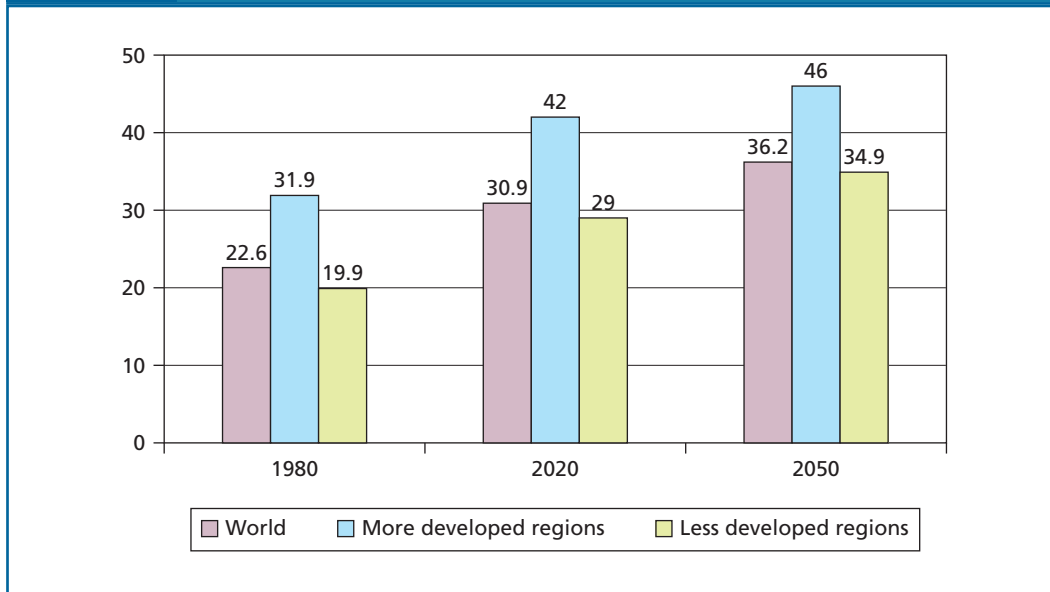
Table 1-5 Population by Major Age Group and Percentage Distribution by Age Group for the World and the Development Groups, 1980, 2000, 2020, 2050, and 2100

Age Group	Population (Thousands)					Percentage				
	1980	2000	2020	2050	2100	1980	2000	2020	2050	2100
World	4,458,002	6,143,497	7,794,799	9,735,036	10,875,394	100.0	100.0	100.0	100.0	100.0
0–14	1,574,981	1,851,319	1,983,648	2,055,659	1,897,705	35.3	30.1	25.4	21.1	17.4
15–24	844,818	1,085,432	1,209,584	1,338,497	1,305,862	19.0	17.7	15.5	13.7	12.0
25–59	1,655,930	2,595,860	3,551,819	4,261,239	4,602,207	37.1	42.3	45.6	43.8	42.3
60–79	346,546	539,171	904,245	1,653,273	2,188,513	7.8	8.8	11.6	17.0	20.1
80+	35,727	71,715	145,503	426,368	881,107	0.8	1.2	1.9	4.4	8.1
Total	4,458,002	6,143,497	7,794,799	9,735,036	10,875,394	100.0	100.0	100.0	100.0	100.0
More Developed Regions										
0–14	243,758	218,234	208,457	191,776	182,862	22.5	18.4	16.4	15.0	14.7
15–24	179,989	163,033	140,184	132,347	128,574	16.6	13.7	11.0	10.3	10.3
25–59	490,618	575,870	597,678	528,750	491,773	45.3	48.5	46.9	41.3	39.5
60–79	147,359	194,425	259,962	298,216	270,989	13.6	16.4	20.4	23.3	21.8
80+	21,404	36,798	67,024	128,824	170,099	2.0	3.1	5.3	10.1	13.7
Total	1,083,128	1,188,360	1,273,305	1,279,913	1,244,297	100.0	100.0	100.0	100.0	100.0
Less Developed Regions										
0–14	1,331,223	1,633,084	1,775,192	1,863,883	1,714,842	39.4	33.0	27.2	22.0	17.8
15–24	664,830	922,399	1,069,400	1,206,149	1,177,288	19.7	18.6	16.4	14.3	12.2
25–59	1,165,312	2,019,988	2,954,140	3,732,489	4,110,433	34.5	40.8	45.3	44.1	42.7
60–79	199,187	344,747	644,283	1,355,058	1,917,524	5.9	7.0	10.0	16.0	19.9
80+	14,324	34,918	78,480	297,542	711,010	0.4	0.7	1.2	3.5	7.4
Total	3,374,876	4,955,136	6,521,495	8,455,121	9,631,097	100.0	100.0	100.0	100.0	100.0

Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019.

Figure 1-3 Number of Persons 80+ Per Hundred Children 14 or Under: World and Development Regions

Source: United Nations, Department of Economic and Social Affairs, Population Division (2019), World Population Prospects 2019.

Figure 1-4 Median Age of the Population: World and Development Regions, 1980–2050

Source: United Nations, Department of Economic and Social Affairs, Population Division (2019), World Population Prospects 2019.

and 2100 is quite evident. Figure 1-4 shows the median ages for 1980 and 2020 and the projection for 2050—the total world, less developed, and more developed regions. The median age has and will change for all three regions, but the differences among the regions are important, especially between the more developed and the less developed.

The private sector and the public sector will be challenged by these changes in terms of the size of the workforce, medical care, and even retirement benefits, but some opportunities are likely for certain types of businesses including health care, housing, transportation, food products, and so on. Much depends upon immigration policies, technology, retirement ages, and educational opportunities. However, there could be benefits but challenges also will persist. An interesting opportunity could occur with more mobile migration among countries. The European countries with their “graying” populations could probably benefit with a migration of younger individuals from less developed countries not only to help care for the older citizens but also to provide a younger workforce for the developed economies. Even in the United States, this could be a possible benefit. Table 1-6 compares selected age groups in the United States for 2010 and 2020. The age groups of less than 18 years up to

Table 1-6 Breakdown of the United States by Age (In Thousands), 2010–2020

	2010		2020		Change	
	Number	Percent	Number	Percent	Number	Percent
Total population	308,756	100	332,601	100	23,885	7.7
Sex						
Male	151,781	49.2	164,773	49.5	12,992	8.6
Female	156,964	50.8	167,828	50.5	10,864	6.9
Selected Age Groups						
<18 Years	74,182	24	74,660	22.4	479	0.65
18 to 24 Years	30,672	9.9	30,053	9.0	−619	−2.0
25 to 44 Years	82,135	26.6	88,801	26.7	6,666	8.1
45 to 64 Years	81,489	26.4	84,615	25.4	3,126	3.8
> = 65 Years	40,268	13	54,303	16.3	14,035	34.9

“Notes: Estimates may not sum to totals shown because of rounding. Year of birth refers to events occurring between April 1 and March 31 of the indicated years.”

Sources: U.S. Census Bureau, Population Division, 2020 Demographic Analysis (December 2020 release), 2010 Census Summary File 1.

24 years saw a decline of 0.13 percent between 2010 and 2020 while the age groups of 25 to 64 years saw an increase of almost 6 percent. The ripple effect in future years may turn out to be important for population growth and workforce productivity.

Urbanization

There has been a noticeable demographic shift in a number of countries with the migration from rural to urban areas. In 2000, 47 percent of the world's population lived in urban areas. In 2020, increased to 56.1 percent, and the change will be most rapid in underdeveloped countries. This will cause additional challenges for those countries to provide the housing, infrastructure, health care, and security necessary for effective and prosperous expansion. The rural areas will also face challenges with smaller and likely older populations. There will be opportunities for business to help alleviate the burdens for the public sector and develop new business opportunities for domestic and global economic expansion. The challenges will be daunting in some cases. A relatively new term is the *megacity* (more than 10 million people). It has been estimated that Asia will have 18 megacities, the United States will have five, but there will be none in Europe.⁷ This will be an interesting demographic change with important implications for global trade. The megacities in some countries, especially Africa, will be faced with inadequate infrastructure, especially transportation and utilities, to support the population growth.

One of the interesting megacities or a so-called metropolis is Lagos in West Africa, which is being referred to as Africa's Big Apple by some economists and demographers. Lagos has new tech hubs, a new wealthy class, and an exploding population, but with many in poverty status. The estimated population is 15 million although local officials claim a population of 18 million. In the 1970s, the population was estimated to be about 2 million. Lagos has developed into a powerful economic engine based upon an oil boom and a growing economy. The average Nigerian woman gives birth to more than five children in her lifetime, and the population of Lagos expands by about 500,000 a year over the last three years. The growth has pluses and minuses and has many challenges with its limited infrastructure. However, there are those who maintain that Lagos is Africa's future, which you can interpret in different ways, good or bad. One of the critical ingredients needed for improvement is local and inter-regional transportation systems. As pointed out previously, the lack of adequate transportation will hinder and restrain economic development.

Land and Resources

The availability of land and critical resources such as energy, food, and water are of paramount importance for economic viability and future development. Technology will play a critical role in mitigating the scarcity of key resources from desalinization of ocean water, to fracking for increased oil and gas production, to biotechnology for improving crop yield and food production. Fracking for oil and gas has already changed the global dynamics for energy with the United States likely to become a net exporter and the changes in transportation requirements, which will be discussed in later chapters. All three are keys to stable economic growth and development, but the geographic disparity among areas of the world could be daunting and lead to political conflicts. The public and private sectors can both be instrumental in alleviating the challenges and potential crises. Our success in this area will be of immeasurable importance for peace and prosperity. Transportation can play an important role in resolving the disparity by moving these resources efficiently and effectively among regions and countries, but governments and businesses have to provide the stable economic bases for this to happen. The expansion of oil and gas pipelines in recent years and improvements in rail tank cars and water vessels are based upon such growth.

Technology and Information

Technology has two important dimensions. It can be viewed as an internal change agent that can enhance the efficiency and effectiveness of an organization and its ability to compete in the global marketplace. However, technology can also be viewed as an external driver of change similar to

globalization. In many organizations, the rapid development of new systems by technology companies whether it was hardware or software changed the “rules of engagement” and enabled new forms of competition or new business models. The new technology and new companies changed the nature of the competition, which meant that existing companies had to change or perish. There are many examples of established organizations that were blindsided by the technology. The Internet alone was the biggest “culprit” or agent of change because it made information available in real time to large segments of the population via their personal computers, telephones, or other devices.

The development and sharing of so much information is a major force for changing business models and for the obsolescence of some businesses. Travel agents, for example, became passé. Amazon without stores can compete with Walmart’s store network, as can Zappos with more traditional shoe sales organizations. Technology and transportation services have been major factors supporting these changes. For example, companies have been able to outsource selected internal functions like customer service centers or personnel services. One of the most significant impacts has probably been more efficient and effective supply chains and related services such as high-tech warehousing and overnight delivery via Federal Express or UPS. From the specially designed supply chains of Amazon and Zappos to the realigned supply chains of companies like Macy’s or Kimberly Clark, supply chains have become a critical ingredient for profitability and customer service. In other words, supply chains are a staple for the success of overall corporate strategy, and transportation is an integral part of these new supply chains.

While information technology has become an important dynamic for external and internal change, there is another important dimension of technology, especially for supply chains, and that is industrial robotics. They have been around for over 50 years and do not resemble R2D2, as depicted in the *Star Wars* film. The first generation of industrial robots was “one-armed” and installed in a permanent position to carry out simple and routine tasks usually on an assembly line. It has been reported by the International Federation of Robotics that since 2011 there have been approximately 3.4 million installations of working robots around the world. The largest users are in the automotive industry, and they operate about 37 percent of the total. There is a new wave of less expensive and more flexible robots becoming available for a wider array of manufacturing and distribution tasks. In distribution, these robots will store, retrieve, and pack goods for efficient and effective delivery.

As businesses and other logistics organizations invest in robotic development, the robots will have a positive impact on global trade flows. The newer robots will be used in an environment where humans will be working with them side by side combining the skills of humans with the precision and efficiency of robots. This may allow for smaller-scale operations not only for manufacturing but also for distribution, for example, warehouses and transportation terminals with logistics and supply chain networks being changed accordingly.⁸

Another technology with the potential of having a major impact upon supply chains, logistics, and transportation systems is digitization of manufacturing with facilities being run with smarter software using inputs from product development, historical production data, and advanced computational methods to model and change the entire manufacturing process for individual orders quickly and efficiently. This will also reduce the required scale of operations and allow faster responses to change in the short run as well as the long run.

A related technology is additive manufacturing or 3D printing, which has been creating a real buzz in business circles. Essentially, a 3D printer would allow organizations to make a physical 3D copy of a product or a part. Despite the buzz, 3D printing is a long way from producing a car or making assembly lines obsolete. Material costs are extremely high for a number of reasons including higher purity standards and the “middlemen” in the material supply chains. However, 3D printing is already being used to produce some customized, smaller products such as the covers for iPhones and some specialized parts for automobiles. The latter use will probably continue to be the leader for 3D printing in the short run, but the long-run development of more, smaller, and better machines will have a major impact on logistics and supply chains. For example, if repair technicians who travel about in vans with inventory can have a 3D printer in the van with one of each part, they could reduce inventory costs and never be out of stock. Many smaller-scale operations could also benefit with major implications as indicated earlier for supply chains including producers of products. It would probably be comparable to the impact that the improved printers for personal and business computers and related software have had upon commercial printing operations. Some organizations or parts of supply chains will become obsolete or redundant. Like globalization, to be discussed next,

technology will continue to be an agent for change up and down supply chains making them and the transportation system more efficient.⁹

Globalization

Globalization has become a very frequently used term or concept not only in business-related conversations but also in more casual settings. Individuals probably have many interpretations and use the word differently in different settings. However, in this particular context, globalization can be used synonymously with economic integration and development across country and regional borders. The integration will increase the flow of goods and services globally based upon the logic of comparative advantage discussed previously. Also, the efforts to eliminate and/or reduce tariff and nontariff barriers will promote greater interregional flows. However, military and terroristic interruption pose a real threat to increased global economic progress as demonstrated by the Russian invasion of the Ukraine in 2022.

The global interdependence can be good or bad news. On the good side, the lower prices, wider availability of goods and services, land and resource development, and new employment opportunities have benefited many countries and regions of the world, both developed and developing areas. However, the benefits and advantages have not been equal for all. In other words, some have benefited more than others, but on a macro level one could argue that the wins have outnumbered the losses. The BRIC and VISTA countries mentioned previously are an indication of some positive outcomes of globalization. On the negative side, the interdependence can lead to global recessions as was the case in 2009 with serious repercussions felt throughout the world. The economic recovery has been very painful and has required government intervention. There are still lingering economic problems from this recession in some areas of the world. However, there have been strong recoveries in other regions such as North America and some countries in Europe.

On a micro level, the global interdependence has increased the level of complexity and competition with shorter product life cycles, new forms of competition, and new business models. Outsourcing, offshoring, and insourcing have become part of the lexicon of businesses. The information technology previously discussed has allowed supply chains to be reexamined and redesigned for more efficiency and effectiveness and even better execution. The fast or even real-time information flows globally have allowed companies to connect in sharing information and to collaborate much more expeditiously than in the past. This has placed a premium on flexibility of planning and operations to respond and adjust to changes in the competitive environment. Also, visibility of inventory and other assets has become an important dimension for efficiency and effectiveness. Successful and well-established business enterprises have felt the impact of the new competitive environment and changing consumer tastes and needs. Again, it is important to recognize the importance and need for good transportation for the success of global supply chains—their efficiency and effectiveness depend on good transportation.

Supply Chain Concept

References to supply chain management can be traced to the 1980s, but it was not until the 1990s that supply chains captured the attention of senior level management in many organizations. They began to recognize the potential of effective supply chain management to improve global competitiveness and to increase market share with consequent improvement in shareholder value.

Development of the Concept

Supply chain management is not a new concept. Rather, supply chain management represents the third phase of an evolution that started in the 1960s with the development of the physical distribution concept, which focused on finished goods or the outbound side of a firm's logistics system—in other words, the distribution-related activities that occurred after a product was produced. In the 1980s, the concept of business logistics or integrated logistics was developed and added the inbound side to the outbound side. Logistics management was the second phase of development for the supply chain concept. As indicated previously, the supply chain management concept was developed primarily in the 1990s and represented the third phase of development.

Global Profile

Index Highlights Ongoing Strong Global Volume Growth

The new edition of the Pitney Bowes Parcel Shipping Index continues to show how e-commerce continues to influence parcel-shipping activity. The index, which measures parcel volume and spend for business-to-business, business-to-consumer, consumer-to-business and consumer consigned shipments with weight up to 31.5 kg (70 pounds), found that for calendar year 2020, global parcel volume came in at 131.2 billion. That translates into 4,160 parcels shipped per second, a 27% annual gain, with 34 parcels generated per person, in addition to parcel revenue—at \$429.5 billion—rising 22% since 2019. The top three markets by revenue were the United States at \$171.4 billion; China at \$127.5 billion; and Japan, at \$33.3 billion, accounting for 77% of 2020 global parcel revenue.

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The focus of **physical distribution management** was on system costs and analyzing trade-off scenarios to arrive at the best or lowest physical distribution system cost. The system relationships that exist among transportation, inventory levels, warehousing, protective packaging, materials handling, and customer service were analyzed and evaluated. For example, rail and motor carrier service impact inventory, warehousing, packaging, customer service, and materials handling costs, but motor carriers would have a different impact on the same cost centers than rail. Rail service would usually have the lower transportation rate, but there could be higher costs for inventory, warehousing, and packaging that would result in higher total costs than motor carrier service. The type of product, volume, distance, and other factors would influence which mode of transportation would have the lower total cost. Managers in certain industries, such as consumer package or grocery products, high-tech companies, and other consumer product companies, as well as some academicians, became very interested in physical distribution management. A national organization called the National Council of Physical Distribution Management (NCPDM) was organized to focus the leadership, education, research, and interest in the area of physical distribution management.

The 1980s were a decade of change with the deregulation of transportation, financial institutions, and the communication industry. The technology revolution was also underway. During the 1980s, the **business logistics** or **integrated logistics management** concept developed in a growing number of organizations (see Figures 1-5 and 1-6). The deregulation of transportation provided an opportunity to coordinate the inbound and outbound transportation movements of large shippers, which could impact a carrier's outbound costs by minimizing empty backhauls, and lead to lower

Figure 1-5 Typical Logistics Network—Physical Distribution

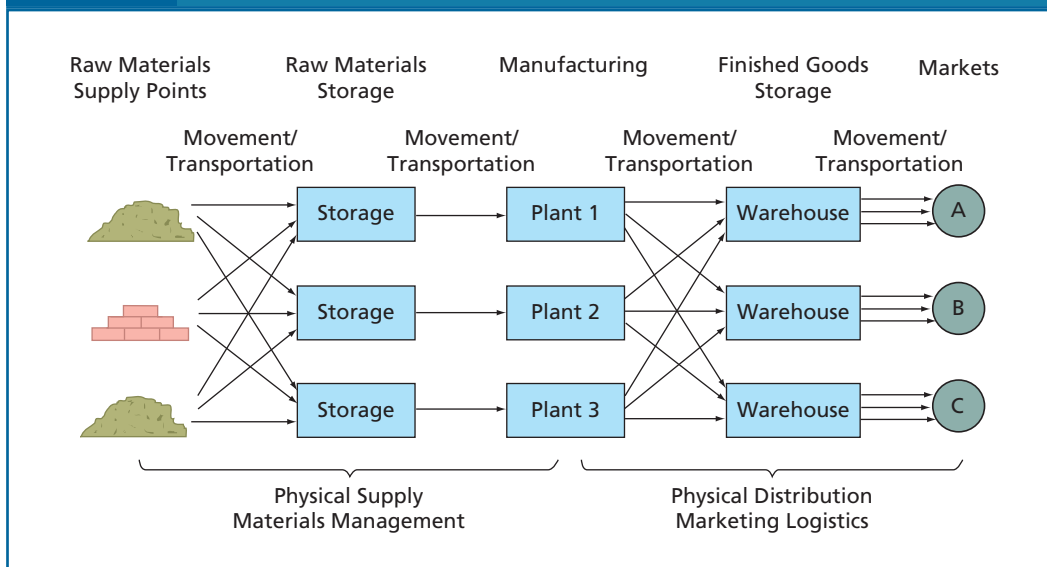
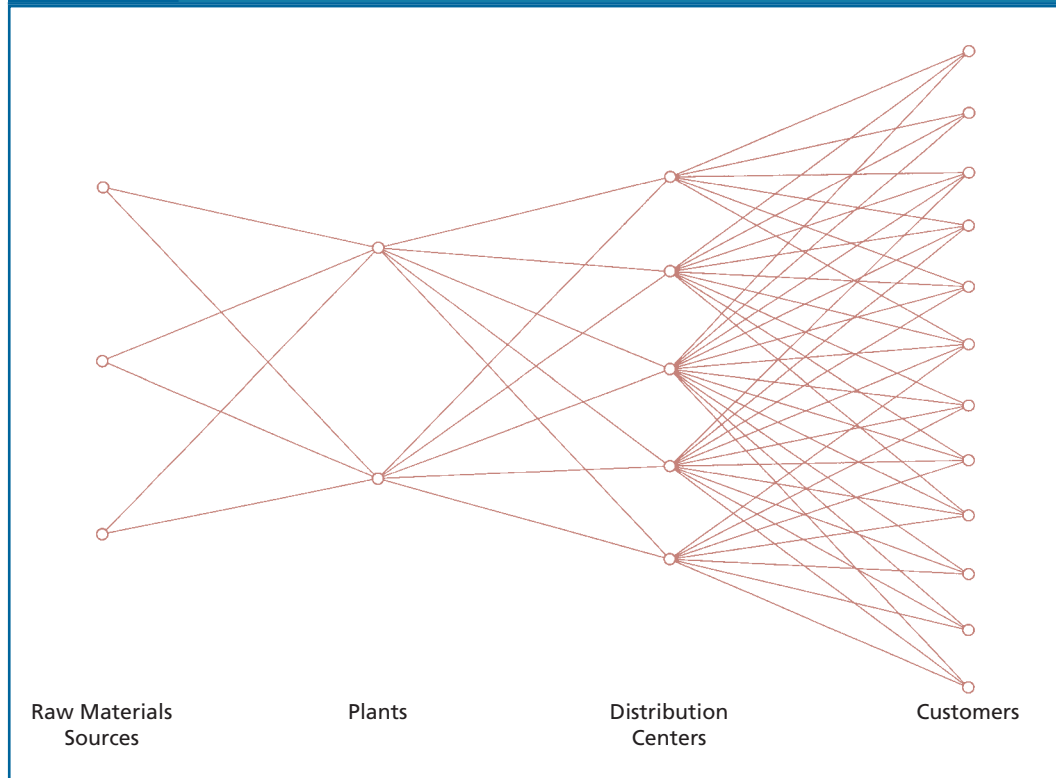


Figure 1-6 Typical Logistics Network—Materials Management



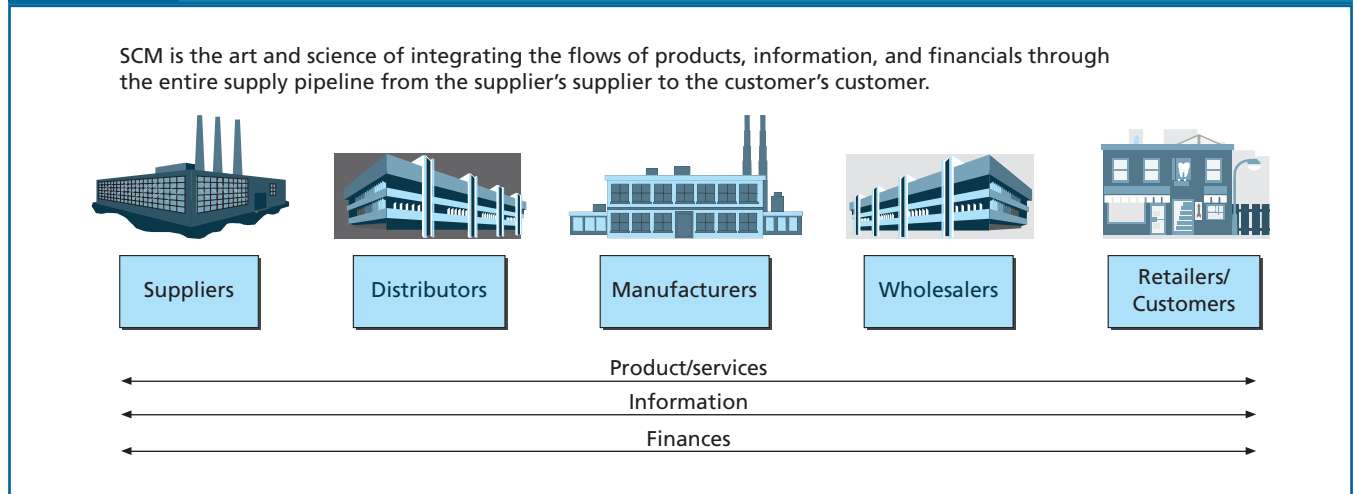
Source: Center for Supply Chain Research, Penn State University, 2004.

rates for the shipper. Also, international or global sourcing of materials and supplies was growing in importance. As will be discussed subsequently in more detail, global transportation presents some special challenges for production and scheduling. Therefore, it became increasingly apparent that coordination between the outbound and the inbound sides of logistics systems provided an opportunity for increased efficiency and also better levels of customer service.

The underlying logic of the systems concept was also the rationale for the development of the logistics management concept because in addition to analyzing trade-offs for total cost it could also include the value of demand aspects of customer service effectiveness. Also, procurement was usually included as an element in a logistics system because of the opportunity for a trade-off analysis between procurement quantity discounts, transportation discounts, inventory, and warehousing costs, and other related costs to obtain the lowest cost.

Supply chain management came into vogue during the 1990s and continues to be a focal point for making organizations more competitive in the global marketplace. Supply chain management can be viewed as a pipeline or a conduit for the efficient and effective flow of products and materials, services, information, and financials (usually cash) from the supplier's supplier through the various intermediate organizations out to the customer's customer (see Figure 1-7). In essence, it is a system of connected networks between the original vendor and the ultimate final consumer. The extended enterprise or boundary spanning perspective of supply chain management represents a logical extension of the logistics concept, providing an opportunity to view the total system of interrelated companies and their impact on the final product in the marketplace in terms of its price–value relationship.

At this point, a more detailed discussion of the supply chain is appropriate. Figure 1-7 presents a simplified, linear example of a hypothetical supply chain. A real-world supply chain would usually be more complex than this example because supply chains are often nonlinear and have more supply chain participants. Also, Figure 1-7 does not adequately portray the importance of transportation in the supply chain. As indicated previously, transportation can be viewed as the glue that holds the

Figure 1-7 Integrated Supply Chain

Source: Center for Supply Chain Research, Penn State University.

supply chain together to allow the member organizations to operate efficiently and effectively as a system. It should be noted that some companies may be a part of several supply chains. For example, chemical companies may provide ingredients for manufacturers of different products that will be distributed by many different retail and wholesale establishments.

Figure 1-7 does illustrate the basic characteristics of a supply chain that are important to this discussion. The definition, which is a part of the illustration, indicates several important points. A supply chain is an **extended enterprise** that crosses the boundaries of the individual firms to span their related activities involved in the supply chain. This extended enterprise should attempt to execute a coordinated or integrated two-way flow of goods, information, and financials (especially cash). The three flows illustrated in the figure are very important to the competitive success of the organizations. Integration across the boundaries of the several organizations, in essence, means that the supply chain needs to function like one organization in satisfying the ultimate customer by delivering an appropriate price–value relationship for products in the marketplace.

The top flow, products and related services, has traditionally been an important focus of logistics and transportation and is an important element in supply chain management. This particular flow is directly dependent upon effective transportation, which is the focus of this text. Customers expect their orders to be delivered in a timely, reliable, and damage-free manner, and transportation is critical to this outcome. Figure 1-7 also indicates that product flow is a two-way flow in the environment of the twenty-first century because a growing number of organizations are involved in **reverse logistics systems** for returning products that were unacceptable to the buyer for some reason—damage, maintenance, obsolescence, and so forth. Note also that networks for reverse systems usually have to be designed somewhat differently than for forward systems. The location, size, and layout of facilities are frequently different. The transportation carriers that need to be utilized may be different. Consequently, there are a growing number of logistics companies (including transportation companies) that specialize in managing reverse flow systems for retailers and manufacturers. They can provide a valuable service in appropriate situations.

The second flow indicated is the **information flow**, which has become a very important factor for success in supply chain management. Figuratively, information is the trigger or signal for the logistics or supply chain system to respond to a customer order. Traditionally, we have viewed information as flowing back from the marketplace as customers purchased products and wholesalers and retailers replenished their inventory. The information was primarily demand or sales data, which triggered replenishment and was also the basis for forecasting future sales or orders. Note that in addition to the retailer or final seller, the other members of the supply chain traditionally reacted to replenishment orders. If there were long time intervals between orders, the members of the supply chain were faced with uncertainty about the level and the potential pattern of demand, which usually resulted

in higher inventory (safety stock) or stock out costs. The uncertainty contributed to a phenomenon known as the **bull whip effect** in the supply chain. One of the objectives of supply chain management is to mitigate the bull whip effect by reducing the level of uncertainty. In traditional supply chains with independent organizations, the level or magnitude of uncertainty increased with the “distance” from the market or customer. Therefore, the level of safety stock increased to cover the degree of uncertainty as you moved back through the supply chain.

On The Line

POLA and POLB Set New Monthly Volume Records in May

Another month brought another set of records for the two largest ports in the United States—the port of Los Angeles (POLA) and the port of Long Beach (POLB)—according to data recently issued by the ports, POLA reported that total May volume saw a 74% increase, setting a new record in the port’s 114-year history, and topping the previous monthly high set in April. This also marks the 10th straight month of annual increases, as well as the first time a Western Hemisphere port has topped 1 million TEU in a month. POLB reported that May volumes also hit a new monthly record, coming in at 907,216 TEU, increasing 44.4% annually and topping the previous high set in March by 66,829 TEU. This also marks the first time that monthly volumes came in above the 900,000 TEU mark in POLB’s 110 years of operation.

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One of the realizable outcomes of supply chain management is the sharing of sales information on a more real-time basis to reduce uncertainty, which reduces the need for safety stock. In this sense, the supply chain is compressed through timely information flows from the marketplace. In other words, inventory can be reduced in the supply chain by timely, accurate information about demand. If point of sale (POS) data were available from the retail level on a real-time basis, it would help to mitigate the bull whip effect associated with supply chain inventories and would reduce costs. It should also be noted that transportation plays an important role in the level of supply chain inventory. One of the components of transportation service as discussed was reliability of delivery. It was noted that if service was unreliable, companies carried more inventory or safety stock, which would be true along the whole supply chain. It was also noted that transit time had an effect upon inventory, namely, longer transit times could contribute to higher inventory levels. Longer transit times combined with unreliable service exacerbate the need for safety stock in the supply chain. Consequently, transportation is an important cog in the whole supply chain in terms of efficiency and effectiveness.

Note the illustration also indicates a two-way flow of information. In a supply chain environment, information flowing forward in the supply chain has taken on increased significance and importance. Forward information can take many forms, such as **advanced shipment notices** (ASNs), order status information, and inventory availability information. The overall impact of good forward information has been to reduce uncertainty with respect to order replenishment. A related aspect of forward information flow has been the increased utilization of bar codes and radio frequency tags, which can increase inventory visibility and help reduce uncertainty and safety stock. The improved visibility of pipeline inventory, including transportation equipment, also makes possible many opportunities for improved efficiency, such as transportation consolidation and merging-in-transit strategies. These latter two have contributed to some shift in modal selection because of the opportunity for consolidation of smaller shipments and the opportunity to use merging in transit strategies to eliminate warehousing. The combined two-way flow of timely, accurate information lowers supply chain-related costs (including transportation), which also improves effectiveness or customer service.

The third and final flow indicated is financials, or usually and more specifically, cash. Traditionally, financial flows have been viewed as one-directional—backward in the supply chain. In other words, this flow is payment for goods, services, and orders received. A major impact of supply chain compression and faster cycle times has been faster cash flow. Customers receive orders faster, they

are billed sooner, and companies can collect sooner. The faster cash-to-cash or order-to-cash cycle has been very important for companies because it reduces the amount of working capital they need in their system. If cash flow is slow, a company needs more working capital to finance the processes until they collect from the customers. There are some companies that have negative working capital or what financial organizations refer to as “**free**” **cash flow**. They collect from their customers before they have to pay their vendors or suppliers. In such companies as Dell, the period between collection and payment may be as much as 30 or more days. This cash can be used for financial investment purposes or another source of funding for product development or other improvements. Cash flow measures have become an important metric of the financial community to gauge the viability of companies. Slower cash flows increase the need for working capital and may require loans from time to time to pay suppliers, service providers, or even employees. Frequently, one will see in the financial analysis of an organization references to their cash flow situation. Supply chain management provides organizations with an opportunity to improve customer service and cash flow, and transportation service is an important part of this equation.

As indicated previously, it is important to be aware of the significant role that transportation provides in the supply chain framework. At the “end of the day,” the customer expects to have the right product, delivered at the right place, at the right time, in the right quantity, in the right condition, and at the right cost. Transportation plays a critical role in these attributes for an efficient and effective logistics and supply chain system.

Summary

- Transportation is one of the most critical and important ingredients for the economic and social advancement of geographic regions. From the corner grocery stores to large complex factories, efficient and effective transportation is the lifeblood of their ability to operate and compete. Globalization has made transportation even more important with the increased distances and the importance of reliability for today’s organizations.
- Transportation was often viewed as the “glue” to hold complex global supply together to make good on the potential, competitive advantages that were frequently extolled for effective supply chain management. Globalization has elevated transportation to a more strategic role in many organizational supply chains.
- There have been some notable changes in the global economic landscape in the last 20 years or so. The emergence of the so-called BRIC and VISTA countries are examples of that change. The first group is the more advanced of the two groups, especially China and India who are challenging the more advanced economies. The second group are more appropriately labeled emerging economies, but some faster than others.
- The global flow between countries of imports and exports continues to expand, which is a clear indication of the theories of absolute and comparative advantage at work. While many countries participate in these flows, the more developed countries in Asia, the EU, and the United States dominate the volume. China, the United States, Germany, and Japan are the world leaders.
- An important contributing factor to the growth in trade flows among countries is the more sophisticated supply chains and transportation services, which permit the production and assembly of parts for finished products to be produced in several countries with appropriate sequencing. Overall growth of global trade has increased significantly between 2000 and the present with help from trade agreements and increased acceptance of foreign products.
- Population growth, age distribution, and urbanization will play important roles in fostering economic development and associated global trade flows. The populations of China and India exceed a billion in each country and represent an important advantage for these two countries in terms of labor and potential consumers as their economies have grown and developed in the last 25 years.
- Land and resources are also important elements for increased economic development, especially energy, food, and water. Energy has provided the basis for improved economies in a number of countries in the Middle East and Africa, but even developed countries in Europe, and the United States and Canada have added growth because of energy growth associated with new technology

for recovering oil and natural gas. Advancements in crop production have helped to alleviate food shortages, but there is much more that can and should be done in this area.

- Technology has played a major role on a macro and micro level to influence the growth of global trade flows. Information technology and knowledge dissemination have promoted economic growth and development by allowing more countries to participate in the production of goods and services while separated by distance but connected through information technology.
- Technology is broader than information and consideration has to be given to the “hard side” of technology. Industrial robots are making inroads into the production and distribution phases of global supply chains making them more efficient as well as more effective. In some cases, technology is replacing humans, while in other instances, complementing human effort. Industrial robotics can play an increased and important role in the future.
- Increased globalization by crossing country borders through economic integration has the potential to improve the economies of many countries of the world with consequent economic advantage of their respective citizenry, but the political tensions and actual combat will thwart these efforts and protectionism may rear its “ugly head” again to the detriment of all.

Study Questions

1. Transportation has sometimes been described as the glue that holds global supply chains together. What is the meaning of this statement, and do you agree? Why or why not?
2. During the last 20 to 30 years, there have been a number of countries whose economies have experienced important economic expansion and development. One group of countries has been labeled the BRIC and the other the VISTA. Identify each of the nine countries and provide some insights about their economies and economic importance.
3. The theories of absolute and comparative advantage have been offered as economic rationale for trade between and among regions and countries. Compare and contrast the two concepts. Which of the two do you think is more important for explaining the growth in global trade during the last 25 years? Why?
4. The overall growth of global trade has more than doubled since 2000. Why? What has been the most important factor prompting this growth. Is this rate of growth likely to continue in the future? Why or why not?
5. The size of a country’s population and the associated age distribution can be causal factors for economic growth. Why is the size of the population important to economic development? Can size be a disadvantage? Why is age distribution important?
6. Energy, food, and water are frequently cited resources that are critical for economic development. Explain the importance of each one to economic development. What disparities exist among countries with respect to these three resources? How can these challenges be resolved?
7. Technology can impact economic development on both a macro and a micro level. What types of technology do we need to have such impacts on a macro basis? On a micro basis?
8. Robotics have attracted more attention in recent years. Why? How are robots being used in supply chains?
9. The economic integration associated with globalization can provide an opportunity for more widely dispersed development. Why is this possible? What are the major stumbling blocks to such integration?
10. Supply chain management has enabled some companies to operate more efficiently and compete more effectively on a global basis. What inherent characteristics of supply chain management contribute to these outcomes?

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Case 1-1

Off-Shoring? Near-Shoring? On-Shoring?

As Chapter 1 discussed, global trade is at an all-time high with the United States being a net importer based on its business relationship with China and other Asian countries. This scenario was working very well for the United States until the “Black Swan” event of Covid-19 swept across the globe. Economies shut down and global transportation networks stopped functioning to avoid spreading the virus. The pandemic showed how reliant the United States is on its global trading partners.

Three U.S. industries that were significantly impacted and are of strategic importance to our economy were high tech, pharmaceuticals, and automotive (parts). All three industries rely very heavily on global sources for supply, so much so that U.S. firms in these industries have very little, if no, supply production capacity on U.S. soil. Because these industries have so much importance, President Biden authorized a committee to assess the impact and devise a plan to mitigate the impacts of any future potential disruptions.

Because these supply sources are off-shored, an obvious solution would be for U.S. companies to on-shore (bring production capacity back into our country so as to not rely on global sources. However, off-shoring can give U.S. companies a competitive cost advantage and technical expertise that might not exist with domestic production. Another option might be near-shoring, i.e., using suppliers closer to the United States (for example, Canada, Mexico, South America) to minimize long transportation times and concentrate trade into a smaller geographic area. Moving the sources of supply for these three industries “closer to home” would obviously lessen the risks of trade with Asian countries and would secure more stable production capacity. However, there are risks. What would happen to the cost advantage of these three industries? Does production capacity exist locally or geographically closer? What could the federal government do to incentivize U.S. firms to re-configure their global supply chains?

Case Questions

1. Discuss the advantages and disadvantages of off-shoring, near-shoring, and on-shoring for these three industries?
2. What could the federal government do to convince firms in these industries to change their global trade patterns?

Case 1-2

TEA Logistics Services, Inc.

Company Overview

TEA Logistics Services, Inc. (TEA) was started in 2005 by three siblings in a family that had a long history of involvement in logistics. TEA began operations primarily as a freight brokerage in the United States, matching shipper loads with carrier capacity. While this operation was profitable, it did not give TEA the opportunity to develop deeper partnerships with its clients. So, in 2010, TEA decided to become an asset-based third-party logistics (3PL) company that focused on three verticals: electronics, automotive, and pharmaceutical in the United States. Their assets included temperature-controlled and dry van trailers with over-the-road tractors, delivery vans, and leased distribution center capacity. TEA continued its brokerage operation until 2012 and then decided to cease that operation and focus on 3PL activities.

Current Situation

The success of the brokerage operation gave TEA numerous contacts in the shipper community. One of them, Systa Technologies, was a major U.S.-based assembler of high-end computer servers and storage units. Systa, based in Houston, Texas, had assembly facilities in California, Alabama, and Minnesota. Systa relied on 3PL transportation and warehousing companies to provide their logistics services. TEA proposed that it act as a 3PL and 4PL (non asset-based provider) to manage Systa's transportation and distribution needs. In 2014, the contract was signed and TEA became Systa's sole provider of logistics services in the United States.

Expansion Opportunity

While Systa was a world leader in the quality of its products, it was being pressured to increase margins because of global competition. One of its major costs of assembling servers and storage capacity in the United States was labor. Systa made a strategic decision to open a new assembly facility in South Africa. It chose South Africa for three reasons. First, South Africa has abundant and low cost labor. Second, the Chinese have been investing billions of dollars in building infrastructure in South Africa to accommodate the eventual relocation of assembly plants from China to South Africa. Third, China was not selected for the facility because its labor rates are on par with those in the United States. Systa has proposed to TEA that it expand into South Africa as well so it can handle all Systa's logistics needs in that country. TEA has never operated outside of the United States.

Case Questions

1. What opportunities do you see for TEA to expand globally, specifically to South Africa?
2. What challenges do you see facing TEA in making this operating expansion?
3. If TEA were to accept the offer, how would you suggest that TEA enter the South African market when establishing its operations?

Chapter

2

Transportation and the Economy

Learning Objectives

After reading this chapter, you should be able to do the following:

- › Understand the importance of transportation to the economic vitality of the United States and other countries and regions and why it is probably our most important industry
- › Appreciate the role and contributions of transportation systems to the economic development of countries or regions
- › Understand how transportation of goods and people impacts the social and political dimensions of an economy or region
- › Appreciate the historical role of transportation from an economic, social, and political perspective
- › Discuss the impact that improved transportation has upon land values and economic development
- › Understand how transportation affects the price of goods, services, and market areas
- › Appreciate the function and scope of transportation in advanced and developed economies

Introduction

Transportation is a pervasive and extremely vital function in all industrialized economies. Transportation systems provide the necessary critical links between producers and consumers both domestically and globally. The citizens of industrialized countries are dependent upon transportation systems to move products from distant locations where they are produced to markets where they are needed and where they can be sold and consumed. An efficient and effective transportation system is essential for businesses to produce and sell products and services. It has long been recognized that one of the critical ingredients for underdeveloped countries to improve economically is the need to invest in transportation infrastructure. This investment is frequently referred to as social capital, that is, society as a whole is the beneficiary of such investment because of the economic benefits associated

with new businesses, higher wages, more jobs, and social benefits associated with mobility, improved educational systems, and communication. Even developed countries like the United States need to continually evaluate the adequacy of their transportation infrastructure to insure that the system meets the needs of the economy.

Transportation is one of the requirements of a developed economy because it can bring order out of chaos. It reaches and touches every phase and facet of our well-being. Viewed in totality from historical, economic, social, and political perspectives, it is the most important industry in the world. Without transportation, you could not operate a retail store or win a war. The more complex society becomes and the more developed the economy, the more indispensable is the transportation system.

Unfortunately, the transportation system is frequently taken for granted, and the benefits that accrue to the economy from the transportation system are not fully appreciated. Therefore, it would be appropriate at this point to discuss the many benefits of improved transportation. This chapter will investigate the historical, economic, environmental, social, and political impact of a well-designed and improved transportation system.

Up and Down with the Big Muddy

The Mississippi River has been an important avenue of commerce for several centuries in the United States. It has been referred to as the “Big Muddy” by many individuals because of the color of the water and the amount of soil that washes down the river from northern states, especially during the spring, and is deposited in the so-called deltas near the Gulf of Mexico. That dimension of the river may be important for agricultural and other important reasons, but from the perspective of the economy, it indicates a challenge to utilizing the river as a major transportation artery because flooding and droughts change the channel depths. The Big Muddy is an important component of our transportation system and especially for the Inland River System since the volume of traffic (over 500 million short tons of import, export and domestic traffic in 2019) is very significant.

Like many parts of the transportation system, there is a tendency to take the Mississippi River for granted and not recognize its impact on the economy until there is an obstacle to navigation on the river. Some potential obstacles are probably obvious to many people such as flooding or freezing, but one that is not as obvious to many is a long-term drought, which lowers the depth of the river. The newer, larger vessels to be discussed in Chapter 8 require deeper channels. In normal times, these larger vessels are an important dimension of the efficiency of river transportation, but when the river is low, they are stymied. Also, the solution is basically in the “hands of Mother Nature.” Flooding is frequently a problem for a shorter duration, but a serious drought is usually more long term and requires seeking alternative means of transportation.

The recent major variation in weather patterns (flooding in 2019 and drought in 2012) have been a growing problem for shippers and the barge lines. Shippers of harvested agricultural products like corn and wheat do not want to be caught without service to bring their product to market. Low water levels will halt barge service and/or mandate reduction in the loads that the barges can carry. The higher costs by alternate types of carriers, rail or motor carrier, can reduce farm profits significantly. The lesson here is that efficient and reliable transportation service is a critical ingredient for all segments of our economy. Shippers that use the Mississippi River System regularly need to have alternative shipping plans in place to protect their businesses from the vagaries of the river.

Historical Significance

The importance of transportation becomes more apparent when one understands its historical role. The growth of civilizations is associated with the development of transportation systems. For example, the strengths of ancient Egypt demonstrated how one form of transportation, water, could become the foundation for a great society. The Nile River helped to integrate Egypt. It provided a means to transport Egyptian goods, a way to communicate, and a method for Egyptian soldiers to move to defend their country. The Nile River, like all transportation systems, also affected the society’s political and cultural development as people traveled and communicated.

A transportation system can help create a social structure because people traveling or living within the bounds of a particular transportation network will tend to share ideas and experiences. Eventually a society develops, with somewhat unified political opinions, cultural ideals, and educational methods. However, methods of transportation also can disrupt societies. People may become alienated from a distant central government system. For example, America's secession from Great Britain is partly attributable to localized transportation systems developing in the 13 colonies. Transportation to and from Britain was slow and inefficient, and American families could lead better lives trading among themselves without having to pay duties (taxes) to the government of King George III. As the colonies developed into a separate economic system, political and cultural attitudes that were unique to America prevailed, which led to alienation with Great Britain and eventually to the Revolutionary War.

The United States continued to grow in tandem with its transportation networks in the nineteenth century. Few families thought to move West without first knowing that explorers had blazed trails and found rivers suitable for travel. The **Erie Canal**, steamboats, early turnpikes, and the early rail system were developed to meet the economic and social needs of the growing nation. Table 2-1 provides an overview of transport developments in the United States.¹

Transportation also plays a major role in **national defense**, which has been recognized by governments. The Roman Empire built its great system of roads primarily for military purposes, but they had an overall positive economic impact. Sir Winston Churchill pointed out that transport was the underlying basis for all that could be accomplished in effectively fighting a war. In other words, transportation was a critical ingredient for success on the battlefield. U.S. requirements for national defense have been a major reason for a number of important transportation projects. As indicated previously, under the Eisenhower administration, enabling legislation was passed for a National System of Interstate and Defense Highways. This highway system was envisioned as being a system of superhighways

Table 2-1 U.S. Transport Developments

Year	Development	Year	Development
1774	Lancaster Turnpike: first toll road—Pennsylvania	1970	Amtrak established
1804	Fulton's steamboat—Hudson River, New York	1976	Conrail established
1825	Erie Canal: first canal—New York	1978	Act to deregulate airlines passed
1830	Baltimore and Ohio Railroad begins service	1980	Act to deregulate motor carriers and Staggers Rail Act
1838	Steamship service—Atlantic Ocean	1982	Double Stack Rail container service initiated
1865	First pipeline—Pennsylvania	1986	Conrail profitable and sold by government
1866	Completion of transcontinental rail link	1990	Amended National Transportation Policy Statement
1869	Bicycles introduced—United States	1995	ICC succeeded by Surface Transportation Board
1887	First daily rail service coast to coast	1998	Internet applications widely used in transportation
1887	Federal regulation of transportation begins	1999	Norfolk Southern and CSX acquire Conrail
1903	First successful airplane flight—Wright Brothers	2002	Protective action against terrorist attacks after 9/11
1904	Panama Canal opens	2002	Airline industry enters decade of restructuring
1919	Transcontinental airmail service by U.S. Post Office begins	2014	Political disputes of infrastructure funding
1925	Kelly Act: airmail contract to private companies	2020	Positive Train Control made mandatory for all U.S.-based railroads
1927	Lindbergh solo flight—New York to Paris	2020	Waymo offers driverless taxi rides
1940	National Transportation Policy Statement	2021	Canadian Pacific Railroad announces its intent to acquire the Kansas City Southern Railroad
1961	Manned space flights begin		

connecting the states and their major centers within the states, which could enhance our ability to defend against enemy attack. The economic and social benefits of the Interstate Highway System have far exceeded the defense contribution. Generally, the expenditures on air transport infrastructure are based primarily on military and political consideration as opposed to economic benefits, but the economic benefits usually outweigh the political and military benefits over the longer run.²

In the twenty-first century, transportation systems will face significant challenges and problems because of global competition, government budget constraints, increasing demand from special interest groups such as senior citizens, infrastructure challenges, sustainability issues, and energy costs. The pattern of trade that helps to drive transportation requirements is changing more quickly and becoming more complex because of the dynamic global environment and the changing economic base in the United States.

Economics of Transportation

Transportation touches the lives of all U.S. citizens and citizens in other areas of the world. It affects their economic well-being, their safety, their access to other people and places, and the quality of their environment. When the transportation system does not function well, it is a source of great personal frustration and perhaps economic loss. But when the transportation system performs well it provides opportunity and rewards for everyone. Understanding the basic fundamentals of transportation economics will provide important insights into the role of transportation in the economic viability of a country, and also the businesses and other organizations that provide the output, revenue, and income that really drives an economy.

Demand for Transportation

The economic growth of the U.S. economy, as well as the economies of most industrialized countries, is attributable, in part, to the benefits derived from mass production and the associated division or specialization of labor, which enables mass production to occur. Specialization of labor and production can result in an oversupply of goods at one location and unmet demand for these goods in another area. For example, a large food processing plant in Hanover, Pennsylvania, can produce far more product than can be consumed in the immediate market area and will need to sell its output in distant markets to take advantage of the scale of their plant operations. Transportation plays an important role in helping to bridge the supply and demand gap inherent in the mass-production-oriented approach.

The interrelationship between transportation and mass production points out the dependency of our global economy upon transportation. As geographical areas begin to specialize in the production of particular goods and/or services, they are relying more upon the other regions to produce the additional goods and services that they need or desire. We depend upon transportation to move these goods and provide these services in an efficient and effective manner. Like the citizens of most industrialized countries, U.S. citizens, as individuals, are not self-sufficient. On a global scale, countries recognize their international interdependencies. The United States supplies many countries with a variety of agricultural products, manufactured products, and other types of services. While other countries provide the United States with raw materials, other agricultural products and additional manufactured products. For example, the United States is dependent upon the Middle East, South America, and Canada for energy production, even though the United States produces enough energy to meet its demand. Other countries usually rely on the United States to provide a variety of manufactured goods such as aircraft, clothing, and computers to meet their needs. Again, transportation plays a key role in this international or global dependency by providing the ability to match supply and demand requirements on a global basis. The ability of countries to trade among themselves and to efficiently move goods is a key element in the success of global development.

Passenger Demand

Similarly, people move from areas where they are currently situated to areas where they desire to be on a daily, weekly, or permanent basis. Transportation also provides the bridging function between supply and demand for people to move from their current places of residence to new locations. As

with freight, people depend on transportation for mobility. The more developed a society, the more critical an efficient economical passenger system is to its citizens. With today's technology, an executive in Chicago can leave home early on a Monday morning and catch a flight to Los Angeles to attend an early afternoon meeting. At the end of the afternoon that same executive can board a flight to Australia with a continuation to London later in the week. This global workweek is possible because of the speed and effectiveness of air transportation, and such travel has become more commonplace in the global economy.

The automobile has been a form of transportation that affects most people's lifestyle, particularly in the United States. The convenience, flexibility, and relatively low cost of automobile travel allow individuals to live in locations distant from where they work. The growth of suburban areas is usually attributable largely to the automobile and the appropriate roadway infrastructure. Although in some areas, efficient mass transportation or passenger transportation is also important. It is not unusual in some areas of the United States for people to travel 20-plus miles one way to go to work. The automobile also enables people to seek medical, dental, and recreational services at various locations throughout their region or even their country.

Rising costs of automobile and air travel occurring as a result of escalating energy, labor, and equipment costs is beginning to cause some change in lifestyles. Instead of traveling longer distances for vacation, some people may stay closer to home or not travel at all. Areas of a country that are highly dependent on tourists have experienced some economic difficulties and a need for changing their economic base. This same set of factors is impacting the movement of freight and causing companies to source or purchase for their supply chains in more contiguous locations. The combination of low labor costs in some global locations and relatively low transportation costs made some distant sources of supply more attractive, but this has been changing with the rising costs of energy and labor mentioned above. Consequently, some companies are reevaluating their logistics and transportation networks to determine more optimum, usually closer, locations.

Transport Measurement Units

Transportation demand is essentially a request to move a given weight or amount of cargo a specific distance between two specific points. The demand for transportation is usually measured in weight-distance units for freight and passenger-distance units for people. For freight, the usual demand metric is the **ton-mile**, and for people, the unit is the **passenger-mile**. Both measurements are two dimensional, which can present some challenges for modal comparisons. The ton-mile, for example, is not homogeneous for comparison purposes. The demand for 200 ton-miles of freight transportation could be a movement of 200 tons for one mile, 100 tons for two miles, or 1 ton for 200 miles. In fact, any combination of weight and distance that equals 200 ton-miles would be regarded as the same or equal. In addition, the unique transportation requirements for transportation, equipment, and service may vary among customers for a 200 ton-mile movement. The same unit of demand could have different costs for producing it and different user requirements. However, measuring only the miles moved or the weight moved does not adequately reflect the components of freight transport demand for comparison purposes. The relative importance of transportation movements can best be measured using the ton-mile concept.

Similarly, the passenger-mile is a heterogeneous unit. Five hundred passenger-miles could be one passenger moving 500 miles or 500 passengers moving 1 mile. The demand for 500 passenger-miles could be automobile, railroad, or airplane. The demand attributes of the passenger-mile vary from passenger to passenger. However, the passenger-mile is still the single best measure of the relative importance of transportation alternatives. While neither the ton-mile nor the passenger-mile is perfect, they are still the best metric available as long as we recognize the challenges inherent in the units when comparisons are made both are useful.

The demand for transportation can be examined at different levels of aggregation. Aggregate demand for transportation is the sum of the individual demands for freight or for passengers. In addition, aggregate demand is the sum of the demand for transportation via different modes or the aggregate demand for a particular mode. Table 2-2 shows the allocation of aggregate passenger-miles for 2017, 2018, 2019, and 2020, whereas Table 2-3 shows the allocation of aggregate tons via different modes of transportation for 2019, 2020, 2022, and 2050. Table 2-3 shows that motor carriers move

Table 2-2	Passenger Miles: 2017–2020 (millions)			
	Air	Rail	Bus	Light Duty Vehicles
2017	685,472	32,618	364,357	4,816,223
2018	722,415	32,252	387,181	4,849,254
2019	754,450	32,766	380,337	4,894,385
2020	304,253	16,802	319,548	4,304,298

Source: U.S. Department of Transportation, Bureau of Transportation Statistics, 2021, Washington, D.C.

On The Line

ATA Report Points to Future Trucking Volume Growth

A new report recently issued by the American Trucking Associations (ATA) presented a positive future outlook for the trucking sector. The report, entitled “U.S. Freight Transportation Forecast 2021 to 2032,” featured some key takeaways, including total freight tonnage will grow from an estimated 15.1 billion tons in 2021 to 19.3 billion tons in 2032—a 28% increase; and while truck’s share of the freight tonnage will slowly decline from 72.2% in 2021 to 71% in 2032, overall volumes will grow across all segments of the industry: truckload, less-than-truckload and private carrier. Truck tonnage should grow from 10.23 billion tons this year to 13.7 billion tons in 2023; and the total revenue derived from primary freight shipments in the United States will increase from an estimated \$1.083 trillion in 2021 to \$1.627 trillion in 2032.

Source: *Logistics Management*, February 2022, page 1. Reprinted with permission of Peerless Media, LLC.

a majority of the freight tons in the United States. However, if current data were available, it would show that railroads move the most ton-miles in the United States. Rail and pipeline are very competitive when comparing the number of tons moved. This is not surprising since oil and oil-related products are moved by both modes. Overall, the tons and passenger-mile metrics are useful modal comparisons or modal splits.

Modal split is a useful analytical tool for the study of transportation because it divides the total transportation market for passenger and freight movements according to use or volume by the major modes of transportation. Highway transportation (public and private) dominates the movement of people in the United States and represents more than 92 percent of passenger-miles traveled in the United States in 2020. Deregulation of airline service in the late 1970s brought about an increase in travel options and services for the traveling public. During this period, the relative level of airfares did not keep pace with the overall inflation level. As a result, air travel became more convenient and relatively cheaper for long-distance travel. Table 2-3 also shows the negative impact on passenger travel demand in 2020 because of the pandemic.

The freight intercity modal split is dominated by motor carriers, with about 68 percent of the tons moved in 2020. Railroads declined in relative share after World War II but have increased in

Table 2-3	U.S. Tons of Freight (Millions), 2019–2050				
Year	Air	Truck	Rail	Water	Pipeline
2019	14	12,206	1,363	1,198	3,681
2020	12	11,902	1,241	989	3,377
2022	13	12,152	1,266	1,054	3,595
2050	25	17,987	1,583	1,328	4,976

Source: U.S. Department of Transportation, Bureau of Transportation Statistics and Federal Highway Administration, Freight Analysis Framework, version 5.3, 2022, <https://www.bts.gov/faf>.

share since 1990 because of fuel prices and other factors. Motor carriers have also increased their relative share of the total ton-mile market after 1980, but their share has remained relatively stable since 2000. Railroads typically move bulk, low-value commodities such as grain, coal, ore, and chemicals for longer distances, which impacts their ton-miles share. In recent years, rail traffic by container, which transports relatively higher value finished goods, has increased. The air mode, while more visible, still handles less than 1 percent of the total ton-miles in the United States. Each of these modes will be accorded more detailed analysis in subsequent chapters (Chapters 5 through 8).

In recent years, the economy has expanded at a faster rate than the demand for freight transportation. The increase in global trade is one of the reasons for this phenomenon. For example, in the past, a domestic steel firm usually purchased transportation service for inbound raw materials (ore, lime, coal) and the movement of the outbound finished goods to the customer domestically. At the very minimum, this involved four different movements. Today the steel may be imported, requiring one domestic movement between the port and the customer. Even if the steel is being used in the economy, fewer transportation moves are involved in making it available to the customer.

As stated previously, good transportation spurs economic development by giving mobility and lower **landed cost** to production factors, which permits scale economies and increased efficiency. Efficient and effective transportation enlarges the area that consumers and industries can draw on for resources and products. It also expands the area to which a given plant or warehouse can distribute its products economically, and the resulting specialization and scale economies provide a wider choice of products for consumers at a lower cost. The overall economic importance and significance of improved transportation systems need to be understood and appreciated.

Demand Elasticity

Demand elasticity refers to the sensitivity of customers to changes in price. If customers are sensitive to price, a price reduction should increase the demand for the item and the total revenue should also usually increase. An increase in price will have the opposite effect—less revenue and a reduction in sales. If customers are not sensitive to a change in price, we consider that demand to be inelastic because a price reduction will result in a small relative increase in the quantity demanded, and the total revenues will decrease. In mathematical terms, demand elasticity is the ratio of the percentage change in the quantity demanded to the percentage change in price or elasticity equals percentage change in quantity divided by percentage change in price. If demand is elastic, the quantity demanded changes more than the change in price, and the elasticity coefficient is greater than one. Conversely, a product or service said to be price inelastic or insensitive to price changes, if the quantity demanded changes less than the change in price or in other words, the coefficient is less than one.

$$\text{Elasticity} = \% \text{ change in quantity} / \% \text{ change in price}$$

In general, aggregate demand for transportation is **inelastic**. Freight rate reductions will not dramatically increase the demand for freight transportation because transportation costs generally represent, in the aggregate, less than 4 percent of a product's landed cost, and the demand is a derived demand (to be discussed subsequently). Substantial rate reductions would be required for a meaningful increase in the demand for the product and consequently, the demand for transportation of that product. On the other hand, if we consider specific modes of transportation or specific carriers, the demand is generally elastic or price sensitive. The modal share of the aggregate demand is, in part, determined by the rates charged. Reductions in rates charged by a particular mode will usually result in increases in the volume of freight by that mode, other things being equal. This assumes that the mode that reduced the rate is physically capable of transporting the freight.

For example, long-haul transportation of new automobiles was dominated by motor carriers in the 1960s and 1970s. The railroads developed a new railcar specifically designed to transport new automobiles. This new railcar enabled the railroads to improve efficiency and reduce the rates that they charged for hauling automobiles while also improving some of the service characteristics of the movements. The percentage of new automobiles hauled by railroads increased with the introduction

of the new railcar and the lower rates, and the share of intercity ton-miles of new automobiles transported by motor carriers decreased. Today, motor carriers are usually used primarily to transport new automobiles shorter distances from rail yards to dealerships. In addition, when plant locations are close to the points where new cars are needed or where dealers are located, motor transportation is frequently used.

For modal shipments or for a specific carrier within that mode, demand may also have service elasticity. Assuming no price changes, the mode or specific carrier demand is often sensitive to changes in service levels provided by competing carriers. For example, many air passengers monitor the on-time service levels of the various air carriers and, when possible, will select the air carrier that provides the best on time transportation service. Transit time and service reliability have become much more important to freight movement during the last several decades, as shippers have become increasingly aware of the impact of carrier service on inventory levels and customer service. Consequently, higher cost service providers such as UPS and Federal Express now move larger-sized shipments because of their superior direct service and some of the ancillary logistics services that they provide.

Freight Transportation Demand

The demand for freight transportation is usually dependent upon the demand for a product in another location. As indicated previously, specialization and mass production create a need for market expansion at more distant locations, which gives rise to increased demand for freight transportation. In this section, attention is given to the characteristics of freight transportation demand.

Derived Demand The demand to transport a product in a given location usually depends on the existence of demand to consume or use that product in the distant location. Freight is not usually transported to another location unless there is a need for the product. Thus, the demand for freight transportation is generally referred to as a **derived demand**. Sometimes it is also referred to as a secondary as opposed to a primary demand. Derived demand is not unique to transportation since the demand for many raw materials is dependent upon the demand for the finished products, which are produced from these raw materials. Figure 2-1 illustrates the derived demand nature of freight transportation. If a supply of widgets is available at the production site, City A, widgets will not be moved or transported to City C because there is no demand for widgets at City C. However, there is a demand for widgets at City B. Because of the demand for 100 widgets in City B, there is a demand for transportation of 100 widgets from City A to City B.

The derived demand characteristics implied that freight transportation would not be affected by transport carrier actions. As noted above, this assumption is true for the demand for transportation at the aggregate level. For example, if a freight carrier lowers the rate to zero for moving high-tech personal computers from the United States to a developing nation, this free transportation may not

Figure 2-1 Derived Demand for Freight Transportation

