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13. ABSTRACT *(Maximum 200 words)*

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An overview of the macroscopic causes of rail congestion and its effects on railroads and the national economy is provided to demonstrate the significance of this study. Additionally, Union-Pacific Railroad's chronic congestion problems associated with their 1997 merger with Southern-Pacific Railroad is summarized.

Two quantititative models are used to test power's relation to congestion. Friedman's Rank Test, a nonparametric statistical model, tests the significance of power against eight other factors in their relation to train delays. The second model tests the correlation between train time delays and number of "36-hour cars."

This study concludes that lack of power is the most significant contributor of rail congestion in the Knoche Yard based on the results of the quantitative models. The results of the first model clearly show power to be the most significant contributor of train delays. The results of the second model show a correlation, albeit weak, between delayed trains and number of "36-hour cars."

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A STUDY OF RAIL CONGESTION IN THE KANSAS CITY SOUTHERN RAILWAY SYSTEM

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

By

ROBERT A. GANTT, LCDR, SC, USN
M.B.A., National University, San Diego, California, 1994
B.A., Virginia Tech, Blacksburg, Virginia, 1986

Fort Leavenworth, Kansas
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ABSTRACT

A STUDY OF RAIL CONGESTION IN THE KANSAS CITY SOUTHERN RAILWAY SYSTEM. By Lieutenant Commander Robert A.Gantt, SC, USN, 84 pages.

This study investigates the contributing factors of rail congestion at Kansas City Southern Railway's (KCSR) switching yard--Knoche Yard--located in Kansas City, Missouri. This thesis asserts that lack of locomotives, known as power, is the most significant contributor to congestion in the Knoche Yard.

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ACKNOWLEDGEMENTS

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It is important to acknowledge the source of my inspiration and energy--the Holy Father, my dad, and my wife and kids. Thank you Lynne, Bryn, and Collin for keeping me focused on the important things in life.

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CHAPTER 1

INTRODUCTION

Overview

As the membership of Class I Railroads shrink and as the demand for rail services increase, the rail industry is confronted with the problem of moving an increasing amount of freight over a rail network limited by its size, equipment and personnel. The rail industry must meet its customers' growing needs effectively while optimizing its operations to remain competitive and prevent loss of market share to other modes of transportation. In today's economy, characterized by a steady growth rate and expanding international trade opportunities presented by the North American Free Trade Act (NAFTA), the rail industry is dedicating millions of dollars to improving its infrastructure and facilities to ensure it can meet future demands.[1]

The future growth of the rail industry depends on how well it manages a potentially serious problem inherent to railroads--rail congestion. As stated by Landon Rowland, Chief Executive Officer of Kansas City Southern Industries, parent company of Kansas City Southern Railways (KCSR), "Rail congestion is ... a topic of vital concern to railroads."[2] Congestion is a disconcerting problem for the rail industry. It leads to inefficient use of resources and equipment, freight delays, increased operating costs, and loss of business--all of which adversely affect profits.

Congestion as defined by The American Heritage Dictionary means overfilling or overcrowding.[3] Pertaining to the transportation industry, congestion is a condition where the transporting elements or units containing cargo are constricted, slowed or delayed due to an inability to move them efficiently. Rail congestion is a condition in which an excess buildup of freight cars occurs at a particular place and time and leads to delays and difficulties in moving freight cars throughout the rail network. Some other descriptors of rail congestion as described by railroad professionals include:

1. Too many freight cars for the amount of track space.[4]

2. Inability to handle volume expeditiously as governed by the customer's demand or expectations exceeding the dwell time.[5]

3. A condition where inbound traffic overruns capacity to efficiently switch, classify, and push outbound traffic.[6]

Significance of Study

Although congestion has existed in varying degrees since the beginning of the rail industry, it reached record levels in 1997 as a result of the Union-Pacific and Southern-Pacific merger.[7] Rail congestion was considered a chronic problem for most of the Class I Railroads as Union-Pacific's (UP) problems spread throughout the industry. Terminals were backed up with excess freight cars and intermodal containers, sidings were jammed with diverted trains, millions of bushels of grain rotted on the ground outside grain elevators awaiting hopper cars, interchange trains lacked proper blocking integrity, and the incidence of serious rail accidents increased.[8] These were the characteristics of the chronic congestion experienced by the Union-Pacific. At the height of their problems, Union-Pacific had an excess of 40,000 intermodal cars jamming their terminals, 500 trains held for locomotive power, 131 of 591 sidings blocked with diverted freight cars, and 100 million bushels of uncovered crops rotting outside licensed warehouses while awaiting pickup.[9]

These examples demonstrate a few of the reasons why congestion is a serious concern to the rail industry as well as to commerce and the economy. At the individual railroad, congestion captures the attention of its stockholders, management and operators. Congestion is important to all employees of a railroad, especially the operations personnel since they are responsible for managing the traffic on a daily basis. Mr. William J. Slinkard, the General Superintendent of

Kansas City Southern Railway's (KCSR) Kansas City Rail Yard, best describes the sentiment of management on congestion when he stated during a tour of the facility: "Everything I do as a manager is to combat congestion. I've spent my entire career fighting congestion." [10]

Rail congestion is a real problem as shown by the chronic congestion experienced at the Union-Pacific in 1997. Customers complained, business migrated to trucking, operating expenses rose, and profits shrank.[11] Additionally, opportunities for expanded market share were lost. No railroad wants to experience the severe problems suffered by Union-Pacific, so it is logical that railroads are taking an especially careful look at congestion on their lines.

Problem Statement

There are many factors--both internal and external--that cause rail congestion. Potential causes include factors such as locomotive shortfalls, manpower constraints, lack of capacity, infrastructure limitations, and procedural deficiencies. All these contribute to congested rail systems. Efforts to reduce congestion can be very expensive due to the high cost associated with laying new track, expanding rail yards, or purchasing new locomotives. Therefore, efficient use of limited resources such as track and locomotives is a fiscal requisite for railroads.[12]

Railroads focus on maximizing throughput at their rail yards to help keep their systems running smoother.[13] Union-Pacific recently acknowledged in its rail recovery plan to the Surface Transportation Board that its failure to clear congestion at its yards was the source of its service problems.[14] Union-Pacific stated in the report, "The core of the problems lies in major switching yards that are too full of cars to operate efficiently and are backing up other trains on line."[15] The point is that rail yards are primary locations of congestion since they are the hubs and intersections of railways and are the place where most rail activity occurs.

Research Question

The research question for this thesis is: Is insufficient availability of locomotive power the leading cause of rail congestion in KCSR's Knoche Yard? This thesis investigates the causes of rail congestion by concentrating on the premise that lack of locomotives (referred to as "power") is the leading cause of congestion. Lack of power refers to a train that is ready for departure from a rail yard but is held up or delayed because it lacks a locomotive to pull it to its next destination. The result is that lack of power means a train is stationary, idle and delayed because there is no locomotive to pull it. This study demonstrates that lack of power is the most significant cause of rail congestion in Kansas City Southern Railway's (KCSR) Kansas City Yard. It is not the intent to specify why lack of power occurs, but only that it is the main cause.

Supporting Questions

Five supporting questions will be addressed in this thesis which will assist in the analysis. They are:

1. What is congestion and how is it measured? A thorough understanding of the meaning of congestion and how it affects rail operations is necessary to conduct meaningful research.

2. What are the causes of congestion? Causal factors that contribute to rail congestion will be discussed and grouped as internal or external causes. Internal causes are those factors that can be influenced by rail management. External causes pertain to factors normally beyond the control of rail management.

3. Is congestion caused by a single factor or is it the result of a complex interrelationship of forces?

4. What implications or effects does congestion have on a railroad? Although this research focuses on the causes of congestion at a single rail yard, it is important to discuss some of the adverse effects generated by congestion.

5. How does identifying the primary causes of congestion benefit a railroad? The study's intent is to provide KCSR statistical evidence that the leading cause of congestion in one of their largest rail yards is lack of power.

Background

Although this study's intent is not to consider the causes of rail congestion from a macroscopic point of view, it is relevant to this thesis to demonstrate some of the complex forces that lead to congestion. This allows for a better understanding of the significance rail congestion plays in the rail industry.

The Staggers Rail Act of 1980 lifted the financial protection of the nation's railroads by de-regulating the industry.[16] Railroads can no longer rely on protected markets and regulated price structures, but now have to concern themselves with improving efficiencies and achieving profitability in a de-regulated market. Since 1980, the number of Class I railroads has decreased from 90 to a level of 9 today.[17] Railroads are leaner today as a result of cost cutting measures and improved resource utilization, and operate with reduced infrastructure in terms of track and equipment as compared with the days of regulation.[18] Amid a growing economy and increasing freight business, Class I railroads are faced with moving more freight with fewer resources.

Congestion problems have recently consumed more of the headlines in business news and show a steadily increasing trend of adverse effects among America's intermodal ports and railways. Congestion not only affects rail carriers and their customers, but also has greater ramifications. It creates the obvious problems of freight delays and associated service complaints, and affects the operations and balance sheets of businesses throughout the country.[19] On the macroscopic scale, it has effects on the nation's trade balance, inflation and the nation's consumer price index. Chemical manufacturers in 1997 experienced many delays in freight shipments costing companies millions of dollars in lost production time. At the height of Union-Pacific's congestion, the chemical industry lost $33 million each month.[20] The president of the Chemical Manufacturer's Association, Frederick L. Webber, stated, "The current crisis (at Union-Pacific) is causing increased costs for every industry in America. It will have a considerable ripple effect throughout the economy, pushing up prices and hurting our global competitiveness."[21]

External Causes of Congestion

Figure 1 provides an overview of some of the external causes of congestion. These are not comprehensive, but illustrate that many factors contribute to an environment of congestion. Although these are external to and beyond the immediate control of railroad management, they can be anticipated and expected. Some are products of the business environment and come in the form of added demand for rail services. These external forces are not always predictable and encompass events such as large harvests, peaks in the business cycle, and increased container traffic. Examples include: colder than expected winters resulting in increased coal and oil shipments to power plants; bumper harvests requiring many additional hopper cars; and added demand experienced during the holiday season as companies tend to build up their inventories.[22]

The growth in intermodal traffic (i.e.: "piggybacks") refers to containers on flatcar (COTF) and trailers on flatcar (TOFC), and is an external cause of congestion. Intermodal traffic has grown an average of 7 percent annually since 1990.[23] Expanded ocean terminal capacity compounded by the employment of super-sized container ships is overwhelming many rail lines because intermodal facilities are not expanding fast enough to accommodate the increased freight volumes.[24] Congestion in the intermodal network occurs primarily at the rail terminals, and has rippling effects throughout the rail lines.[25]

Finally, an intangible contributor to congestion is the rail industry's efforts at reducing operating costs. Since deregulation, railroads have trimmed costs to remain competitive. Some of the cost cutting measures compounding the effects of congestion include: removing or abandoning track; reducing the fleet of locomotives; and enticing customers to purchase their own freight cars.[26] These cost cutting measures, prevalent since deregulation, have resulted in reduced rail capacity and have aggravated congestion.[27]

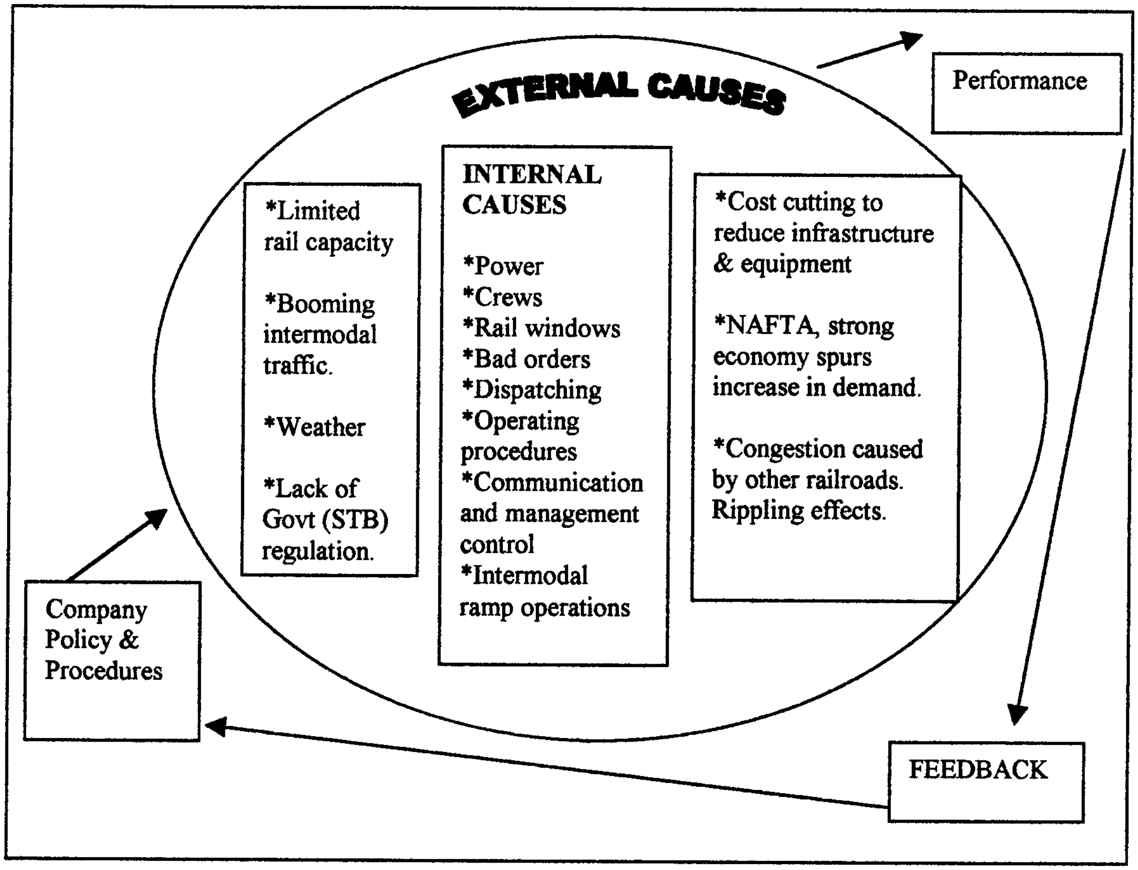

Figure 1. Causes of Congestion Diagram

Scope and Limitations

The location of most rail activity--receiving, staging, classifying, switching, interchanging and departing--occurs in rail yards. Since these are the hubs and interchanges of main line track, this is where most congestion occurs. This study will focus on and be limited to KCSR's rail yard located in Kansas City, Missouri, known as the Knoche Yard.

For causes of congestion to be analyzed statistically, rail congestion must be quantifiable. For the purpose of this study, it is measured by the number of "36-hour cars." This represents rail cars exceeding 36 hours dwell time in a rail yard. KCSR management established 36 hours as the maximum time it should take for a railcar to be received, classified, built/folded (into a train) and dispatched. The 36 hours standard is not uniform in the industry, but differs among railroads and yards. The time of measurement generally ranges from 24 hours to 48 hours. An example of the standard dwell time used by a different rail yard is that of the Belt Railway of Chicago, which is the nation's busiest rail hub. This standard is about 26 hours.[28]

The first supporting question regards the definition and measure of congestion. Although congestion is defined as a condition where inbound traffic overruns capacity to efficiently switch, classify, and push outbound traffic, a quantifiable measure is also needed. Knoche Yard is considered congested when the level of "36-hour cars" exceeds 120.[29] This quantity represents a subjective approximation by management and provides a useful tool for managing yard operations. This figure is used with a high volume of freight traffic. As a general rule of thumb, 120 "36-hour cars" would be associated with a corresponding large numbers of railcars (approximately ten times as many or 1,200) still under the 36 hour window.[30]

This study excludes certain factors that may affect congestion within the Knoche Yard, but are considered beyond the control of yard management. These are part of the operating environment of the yard and are considered an unchangeable part of operations with which management must work. The extent to which these factors contribute to congestion is unknown and will not be addressed. These factors include limitations of the existing automated traffic management system including its hardware and software, physical constraints of the existing yard layout, particularly its limited amount of track, inefficient spatial design, and limited geographic room for expansion.

Definitions

Numerous esoteric terms and acronyms apply to the railroad industry which are pertinent to the development of this study. An alphabetical list of commonly used terms is provided in the glossary. The knowledge gained through six months of interviews, literature review and observing operations at the Knoche Yard provided the means to define these terms. Unless otherwise noted, all terms are defined as clearly as possible in the author's own words.

Summary

Chapter 1 addresses the primary and supporting questions relevant to this study, and gives an overview of the macroscopic causes of rail congestion to provide the reader with insight into its complexities. Although the goal of this study is to show that lack of locomotive power is the most significant cause of rail congestion in KCSR's Knoche Yard, it is important to note that external causes exist which contribute to congestion and are beyond the immediate control of management. The supporting questions concerning measures and definitions of congestion are answered in this chapter, as well as is the supporting question regarding possible causes of congestion.

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[1]Mark J. Greenfield, "Squeezing the Most Out of Yard Capacity," *Progressive Railroading,* November 1997, 37-41.

[2]Landon Rowland, Chief Executive Officer of KSCI, interview with author, written notes, Kansas City, Missouri, 15 October 1997.

[3]*American Heritage Dictionary.* 1982 Second College Edition, s.v. "congestion."

[4]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, and staff members, interview by author, written notes, Joint Agency, Kansas City, Missouri, 13 January 1998.

[5]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, and staff members, interview by author, written notes, Joint Agency, Kansas City, Missouri, 13 January 1998.

[6]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, and staff members, interview by author, written notes, Joint Agency, Kansas City, Missouri, 13 January 1998.

[7]Daniel Machalaba, "Union Pacific Told to Open Up Business," *Wall Street Journal,* 03 November 1997, 1(A).

[8]See Jack Burke, "A Difference of Opinion," *Traffic World,* 08 December 1997, 22 - 24; Associated Press, "UP Says Service is Improving," *Kansas City Star,* 21 October 1997, 4(D); Associated Press, "Railroad Says Corn on Ground Can Wait," *Kansas City Star,* 19 November 1997, 3(B); Jack Burke, "Breathing Room for UP," *Traffic World,* 03 November 1997, 6-8; John H. Winner, "Service, Safety Woes Put Spotlight on Mergers," *Progressive Railroading,* November 1997, 49.

[9]See Associated Press, "UP Says Service is Improving," *Kansas City Star*, 21 October 1997, 4(D); Jack Burke, "A Difference of Opinion," *Traffic World*, 08 December 1997, 22 - 24; Jack Burke, "Breathing Room for UP," *Traffic World*, 03 November 1997, 6-8; Associated Press, "Railroad Says Corn on Ground Can Wait," *Kansas City Star*, 19 November 1997, 3(B).

[10]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, interview by author, written notes, Joint Agency, Kansas City, Missouri, 16 January 1998.

[11]See Associated Press, "UP Target of Complaint," *Kansas City Star*, 12 November 1997, 2(B); Beth Belton, David Fedd and Chris Woodyard, "Transportation Delays Might Drive Prices Up," *USA Today*, 09 October 1997, 1(B); Randolph Heaster, "Unclogging the Lines," *Kansas City Star*, 23 October 1997, 1(B) and 5(B); Pat Foran, "Tale of Two Recoveries," *Progressive Railroading*, November 1997, 24-25.

[12]Mark J. Greenfield, "Squeezing the Most Out of Yard Capacity," *Progressive Railroading*, November 1997, 37 - 41.

[13]Ibid., 37.

[14]Ibid., 41.

[15]Ibid., 41.

[16]Microsoft Encarta Encyclopedia on CD ROM, 1997 ed., "Government Regulation of Railroads."

[17]Gerald Vaninetti. "Coal Train Blues," *Electric Perspectives*, July/August 1997, 14.

[18]See David Field, "East Faces Rail Traffic Jams, Too," *USA Today*, 09 October 1997, 2(B); William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency. interview by author, written notes, Joint Agency, Kansas City, Missouri, 28 October 1997.

[19]Beth Belton, David Field and Chris Woodyard, "Transportation Delays Might Drive Prices Up," *USA Today*, 09 October 1997, 1(B).

[20]Jack Burke, "Breathing Room for UP," *Traffic World*, 03 November 1997, 6-8.

[21]Ibid., 6.

[22]See Beth Belton, David Field and Chris Woodyard, "Transportation Delays Might Drive Prices Up," *USA Today*, 09 October 1997, 1(B); Associated Press, "Unclogging the Lines," *Kansas City Star*, 23 October 1997, 5(B).

[23]See Helen L.Richardson. "Act Now, Keep Intermodal Moving," *Transportation and Distribution*, April 1994, 28; John Davies, "Riding the Wave," *International Business*, March 1996, 30.

[24]John Davies, "Riding the Wave," *International Business*, March 1996, 30.

[25]Helen L. Richardson, "Act Now, Keep Intermodal Moving," *Transportation and Distribution,* April 1994, 28.

[26]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency. interview by author, written notes, Joint Agency, Kansas City, Missouri, 28 October 1997.

[27]David Field, "East Faces Rail Traffic Jams, Too," *USA Today*, 09 October 1997, 2(B).

[28]Mark J. Greenfield, "Squeezing the Most Out of Yard Capacity," *Progressive Railroading*, November 1997, 40.

[29]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency. interview by author, written notes, Joint Agency, Kansas City, Missouri, 16 January 1998.

[30] William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, and staff members, interview by author, written notes, Joint Agency, Kansas City, Missouri, 23 February 1998.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews the available literature, articles and reports concerning rail congestion. Abundant information is available through periodicals, trade journals and newspapers, but the data generally cover only its broad aspects. No prior research or studies are known to exist which analyze the specific causes of congestion, with exception of unpublished management reports. This chapter discusses prior research, trends, and causes and effects of congestion associated with the Union-Pacific and Southern-Pacific merger.

Research Projects

Major John L. Kelly's thesis, *The U.S. Railroads - A Mobilization Asset?*, identifies rail mergers as a contributor to congestion when they result in "...changing mainline routings with the commensurate reduction in alternate service paths."[1] It also identifies rail interchange points as likely sources of congestion during increased traffic flows such as mobilization.[2] *The Role of Army Railroading at the Operational Level of War*, a monograph by Major Bradley E. Smith, offers insights into the inherent strengths--economy and capacity--railroads offer.[3]

A study by Stephen S. Roop and Richard W. Dickinson titled *International Rail Freight Transportation in South Texas: Decreasing Fuel Consumption, Roadway Damage, and Hazardous Materials Movement on Texas Roadways*, discusses the environmental and economic advantages of rail over motor transport. It makes reference to the negative effects rail mergers have on reducing branch line track through abandonments, which eventually lead to shrinking capacity.[4] It also provides information regarding the increase in intermodal traffic on rail lines and its expected future growth.[5]

Two minor studies that mention the problems of rail congestion at the U.S. and Mexico border identify inadequate equipment and infrastructure as the main causes of congestion. A study by D. M. Guzman titled, *Railroad Transport and its Relationship to Congestion in the Ports*, proposes that lack of rail equipment is the primary cause of intermodal congestion in Mexican ocean terminals.[6] Likewise, a speech by R. Blackburn of the Union-Pacific Railroad at the 1994 Transportation Research Forum Annual Meeting blamed border congestion between the U.S. and Mexico on inadequate infrastructure and inefficient rail policies.[7]

At least two previous cases exist where locomotive power is reported as the significant cause of congestion at former Southern-Pacific rail yards. William J. Slinkard, previously employed by Southern-Pacific Lines as a yard superintendent, provided personal notes derived from earlier analyses conducted on specific congested rail yards. A 1993-94 yard operations management analysis at Southern-Pacific's Englewood Yard in Houston, Texas revealed lack of power to be the leading cause of congestion.[8] Additionally, a management analysis of Southern-Pacific's West Colton Yard in Los Angeles found lack of power to be included among a list of significant factors causing congestion as seen in figure 2.[9]

RAIL CONGESTION ANALYSIS AT SOUTHERN-PACIFIC LINE'S WEST COLTON YARD 1993.

- Delays due to lack of power.
- Locomotive turn time inconsistent.
- Key tracks not utilized effectively.
- Lack of proactive planning to reduce congestion in Departure Yard.
- Restricted cars not switched timely.
- Congested with storage/hold cars.
- Local industry cars not moved daily.
- Congested with bad order cars.

Figure 2. Causes of Congestion at Southern-Pacific's West Colton Yard (1993-94).

Trends and Indicators

Many articles on rail congestion found in journals, magazines and newspapers point to certain "indicators" or causes of congestion that are becoming more prevalent since deregulation. As mentioned in chapter 1, several external factors are considered primary causes of congestion--rail mergers, rise in intermodalism, shrinking capacity and increasing trade resulting from NAFTA.[10] Interestingly, a trend is apparent in the rail industry's reaction to congestion in that most railroads subscribe to a standard industry response when fighting congestion: expand infrastructure, invest in automation, and buy more locomotives.

Many railroads respond to congestion by leasing or purchasing new locomotives. This implies that lack of power is perceived as a significant cause of congestion. In 1995, the president of the former Southern-Pacific Lines, Edward L. Moyers, stated that his company is countering congestion with more locomotive purchases and the building of new track.[11] More recently, in 1997, Union-Pacific included in its rail recovery plan to the Surface Transportation Board its intent to purchase and lease scores of locomotives in its efforts to ease congestion.[12]

Citing capital investments in infrastructure improvement and information technology upgrades, *Progressive Railroading's* November 1997 article, "Squeezing the Most Out of Yard Capacity," revealed that the Belt Railway Company of Chicago, which operates the country's busiest hub, invests at least 20 percent of annual gross revenues on capital improvements.[13] As a result, since 1994, congestion has eased as average dwell time has been reduced from 38 hours to 23 hours.[14] A July 1996 *Trains Magazine* article revealed that Norfolk Southern Corporation invested $65 million to upgrade and expand its Chicago terminals to accommodate growing intermodal business, which has increased 67 percent over the past five years.[15]

Causes and Effects of Rail Congestion Resulting From Union-Pacific Merger

Most of the information published since mid 1997 on rail congestion refers in some way to the problems associated with the mega merger between Union-Pacific and Southern-Pacific

Railroads. Once expected to be a seamless merger as boasted by Union-Pacific's president, Richard K. Davidson, the merger is now viewed as an example of the worst rail congestion in history.[16] As commented by Mr. Davidson upon official announcement of the merger, " This will be the best-planned and best-executed merger that has ever taken place in the history of North American railroads."[17] The merger demonstrates the problems rail congestion creates and provides examples of how Union-Pacific reacted to congestion. The following section provides a synopsis of the congestion problems, why they occurred, and what Union-Pacific has done to solve them.

Severe congestion throughout Texas and the West during 1997 and 1998 has resulted in horrific delays, lost freight and billions of dollars worth of lost revenue to customers due to production interruptions, lost contracts, and spoiled freight.[18] The center of Union-Pacific's troubles is Southern-Pacific's Englewood Yard in Houston.[19] As the primary switching yard in Houston, Englewood Yard serves as the hub for several north-south and east-west routes. When this yard backs up, its effects are far reaching. It has experienced such severe congestion that no trains could enter or depart Houston.[20]

As illustrated in figure 3, Union-Pacific's perceptions of the causes of congestion have varied. At one time, Union-Pacific even denied that its congestion was a result of the merger, but was attributed to natural disasters, labor agreement problems, unexpected retirements, and maintenance work.[21] But the severity of Union-Pacific's problems are perhaps best summed up in Fortune Magazine's March 1998 article titled, "The Wreck of the Union-Pacific," which implies the problems relate to management arrogance, outdated labor agreements, lack of integration of automated management systems, power shortages, and crew shortages.[22]

Union-Pacific's course of action in solving the congestion problem and returning traffic flow to normal consists of a variety of efforts. In September 1997, Union-Pacific considered using ocean carriers to help move 40,000 excess containers from ports in California.[23]

Temporary measures included reducing locomotives per train, rerouting, transferring traffic to other lines, and allocating business to other rail carriers.[24] Additional temporary measures included leasing more locomotives and suspending intermodal traffic between Chicago and Texas to free up badly needed equipment and clear up rail lines.[25] Long term measures included major equipment purchases and the hiring of managers and railmen.[26] Planned outlays for the purchase of new locomotives approached $500 million dollars.[27]

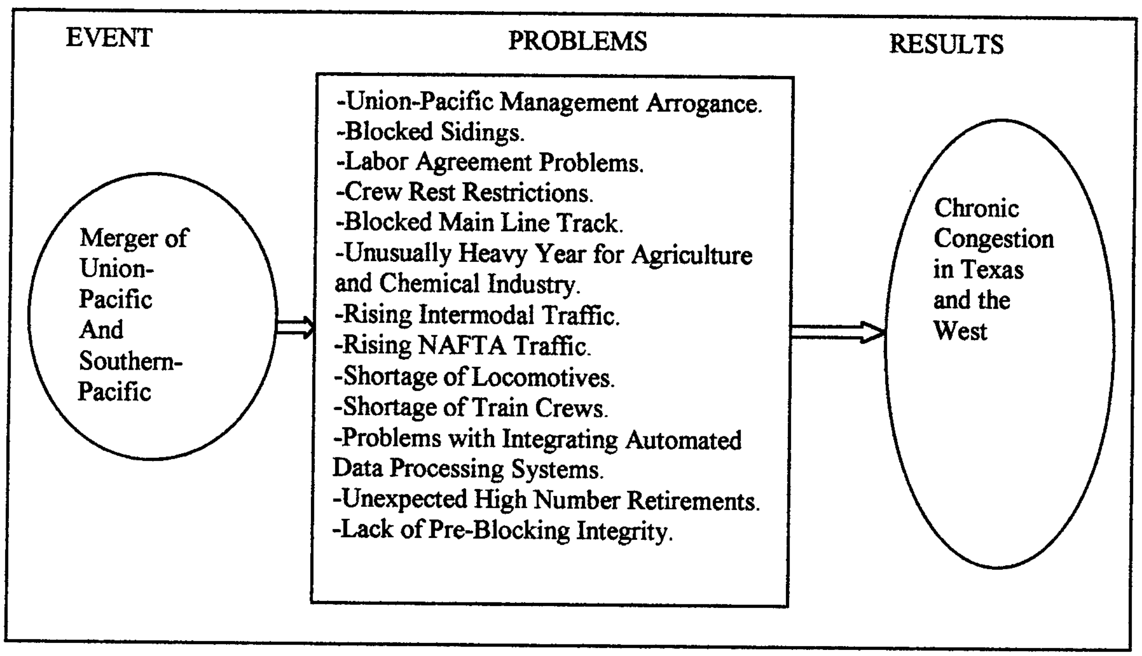

Figure 3. Union-Pacific Problems Resulting From Merger

Summary

This chapter addressed the supporting questions regarding possible causes of congestion, implications of congestion, and its relevance to rail management. Previous studies, periodicals, and newspapers provided valuable information on the most prevalent causes of congestion and revealed that it is the result of a combination of factors. Recent articles on the Union-Pacific merger showed some of its adverse effects. Additionally, the Union-Pacific scenario demonstrated the value of identifying the primary causes of congestion, because rail congestion cannot be fixed until the causes are identified accurately.

It is evident that rail congestion is a serious concern for the industry and that there are many factors that contribute to it. It is also apparent that lack of locomotive power is considered a significant causal factor. A common denominator seen among different railroads is that they often respond to congestion by leasing or buying additional locomotives, or by laying new track. The remainder of this study attempts to demonstrate that lack of power is the leading cause of congestion for KCSR's Knoche Yard, through use of logical inference and statistical analysis.

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[2]Ibid., 68.

[3]Bradley E. Smith, Major, U.S. Army, "The Role of Army Railroading at the Operational Level of War," Monograph, School of Advanced Military Studies, USA Command and General Staff College, Fort Leavenworth, Kansas, 1989, 1-35.

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[8]William J. Slinkard, Southern-Pacific Railway personal notes on Inglewood Yard congestion, 1994, Houston, Texas.

[9]William J. Slinkard, Southern-Pacific Railway personal notes on West Colton Yard congestion, 1992, Los Angeles, California.

[10]See Rip Watson, "KCS Gets Nod to Buy Gateway," *Journal of Commerce*, 05 May 97, 1(B); John Davies, "Riding the Wave," *International Business*, March 1996, 30-35; Edward L. Moyers, Dick Davidson, et al, "Rail Must Gear Up For More Business," Executive Summary of

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[12]See Rip Watson, "Kansas City Offers Another Plan for UP," *Journal of Commerce*, 23 September 1997, 13(A); Daniel Machalaba, "Union-Pacific Told to Open Up Business," *Wall Street Journal*, 03 November 1997, 1(A).

[13]Mark J. Greenfield, "Squeezing the Most Out of Yard Capacity," *Progressive Railroading*, November 1997, 40.

[14]Ibid., 40.

[15]Bill Stephens, "NS Revises Chicago Sites," *Trains Magazine*, July 1996, 22.

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[17]Ibid., 18.

[18]Brian O'Reilly, "The Wreck of the Union-Pacific," *Fortune*, 30 March 1998, 96.

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[20]Ibid., 96.

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[24]See Associated Press, "History is Not on Their Side," *Kansas City Star*, 08 October 1997, 1(B); Associated Press,"UP Files its Proposal to Clear Congested Railroad Lines," *Kansas City Star*, 02 October 1997, (B).

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[26]Rip Watson, "Kansas City Offers Another Plan for UP," *Journal of Commerce*, 23 September 1997, 13(A).

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CHAPTER 3

METHODOLOGY AND RESEARCH DESIGN

This chapter explains the methodology and research approach for this study. The methodology is structured in two parts. First, we gain an understanding of the causal factors of rail congestion while at the same time studying the current issues in the rail industry. Second, we obtain a base level of knowledge of KCSR's yard operations. The methodology demonstrates how a basic level of railroading knowledge was acquired so that meaningful research could take place. This approach applies the scientific method to answering the thesis statement: Is insufficient availability of locomotive power the leading cause of rail congestion?

Methodology

Since the rail industry, like the military, is a culture of its own that is characterized by a unique vocabulary, well-established customs, century-old traditions and continuous operations, it requires an immersion in daily operations to gain familiarity and understanding. All knowledge gained in the pursuit of this thesis is based on the following sources: previous professional knowledge and experience gained by the author as a Naval Supply Corps Officer having a subspecialty in transportation logistics; a literary review of trade journals, periodicals, newspapers, research projects, and books obtained through Fort Leavenworth's Combined Arms Research Library; telephone and personal interviews with railroad professionals; advice from thesis research committee members; and observations of rail switching operations at KCSR's Kansas City yard.

Research Design

This study's design is based on a fundamental scientific approach of problem identification, hypothesis formulation, analysis, and conclusion. It establishes a criterion for measuring congestion and then testing various factors' significance through a nonparametric statistical model application. Additionally, linear regression is used to test the correlation between train delays and number of "36 hour cars."

Problem Identification

The problem originates from KCSR management's need to determine the leading cause of congestion on their railroad. Identifying the most significant cause of congestion in the Knoche Yard will provide management relevant information needed to better control congestion, and may facilitate the application of lessons learned to other rail yards.

Hypothesis Formulation

Initial information used in developing the hypothesis included literature review, interviews, and surveys. A questionnaire was developed (appendix A) and was administered to rail professionals from various levels of management. This provided a starting point from which to focus research. From this, an initial hypothesis was formulated concerning what is perceived by management as the most significant cause of congestion--lack of locomotives. The hypothesis asserts that lack of locomotive power is the leading cause of rail congestion in KCSR's Knoche Yard.

Hypothesis Testing / Analysis

Analysis requires the establishment of certain limitations, assumptions, and criteria. The study is limited to KCSR's Kansas City yard, referred to as "Knoche yard," and includes data collected over a 50-day period. The phrase, "leading cause," as used in the main thesis question means having the highest frequency of occurrence. Congestion, as measured in the Knoche Yard, equates to the number of "36-hour cars" on a given day.

Chapter 4 (Analysis) demonstrates the linkage between lack of power and the number of "36-hour cars." It accomplishes this through the application of statistical methods. The first uses a nonparametric statistical model that tests locomotive power against eight other causal factors that contribute to train delays. The nine causal factors of congestion are derived from this study's questionnaire and from quantifiable factors used by Knoche Yard management. These include ramp release, late sets, dispatcher held, power, crew rest, bad orders, extra cars, rail windows, and other. A definition of each is provided in the glossary. These factors are not necessarily inclusive of the many possible sources of congestion, but are quantifiable and considered to be the most prevalent in Knoche Yard operations according to the yard superintendent.[1] Some of the causal factors may be broad in meaning and result from other indirect factors contributing to delay. It is up to the general superintendent's expert judgement to assess each situation and to ascertain the specific reason for delay. It is important to note that inadvertent bias may occur during this assessment. Other causes of train delays not explicitly covered by the eight causal factors used in this study are grouped under the "other" category. An example of the "other" category is delays caused to a train as a result of Federal Regulators conducting safety inspections in the yard. Since more than one factor may contribute to congestion, this analysis determines and compares each factor's level of significance or importance.

The first statistical study seeks to show that lack of power is the most significant cause of train delays within the Knoche yard. It does this by comparing power with eight other factors in its relation to train delays and determining the relative statistical significance of each. All tests are conducted using 95 percent confidence intervals, which indicate that there is a 95 percent chance that the true population mean is contained within the interval.

The second model tests the relationship between train delays and the number of "36-hour cars" for each day in the sample. This model analyzes one independent variable (cumulative train delay time over a 24-hour period) and one dependent variable (number of "36-hour cars" on-hand at 0600 for the respective 24-hour period). Linear regression is used to test the strength of correlation between train delays and the number of "36-hour cars." An indicator used to measure the effect of train delays in reducing the variation in number of "36-hour cars" is the coefficient of determination (R-squared). The strength of association between train delays and changes in

"36-hour cars" is obtained by taking the square root of R-squared which is known as the coefficient of correlation (R).

The data required in the first statistical study come from daily management reports used by the general superintendent. The first is a Knoche Yardmaster report provided from each shift. This indicates whether certain trains were set according to schedule and whether additional switching jobs were performed. The report also provides data regarding the causes of delay. The second report used is a daily train report, which summarizes not only the daily but also the monthly cumulative train departure results. This compares the results of each train departure to the schedule and provides reasons for delays.

The data required for the second statistical study, a regression analysis, come from several sources. The data for "36-hour cars" are obtained from a manual daily operations report, which includes a tally of "36-hour cars" as of 0600 for that day. The data for the number of trains and cumulative time of delays are obtained from a daily trains report as discussed in the preceding paragraph. The general superintendent further elaborated on all data extracted from these reports.

A logic diagram, which shows the reasoning used in this research, is depicted in figure 4. It demonstrates what the regression study shows--how the lack of power affects congestion in a rail yard. By linking yard congestion with train delays and measuring congestion by the number of "36-hour cars" present in the yard, this study supports the hypothesis of the thesis--that lack of power is the leading cause of rail congestion. The logic diagram shows the following logic flow:

1. This study's reasoning is predicated on the assumption that train delays contribute to yard congestion. (Delays ➔ Congestion).

2. Lack of power is the main factor contributing to train delays. (Power ➔ Train Delays).

3. Therefore, lack of power is the main contributor to congestion. (Power → Congestion).

Summary

The thesis methodology and research design's purpose is to determine the significance that lack of power plays in rail congestion. The research design relies on two different statistical studies to determine this significance of data collected from KCSR's Knoche Yard. Chapters 4 and 5 provide the analysis and conclusions/recommendations.

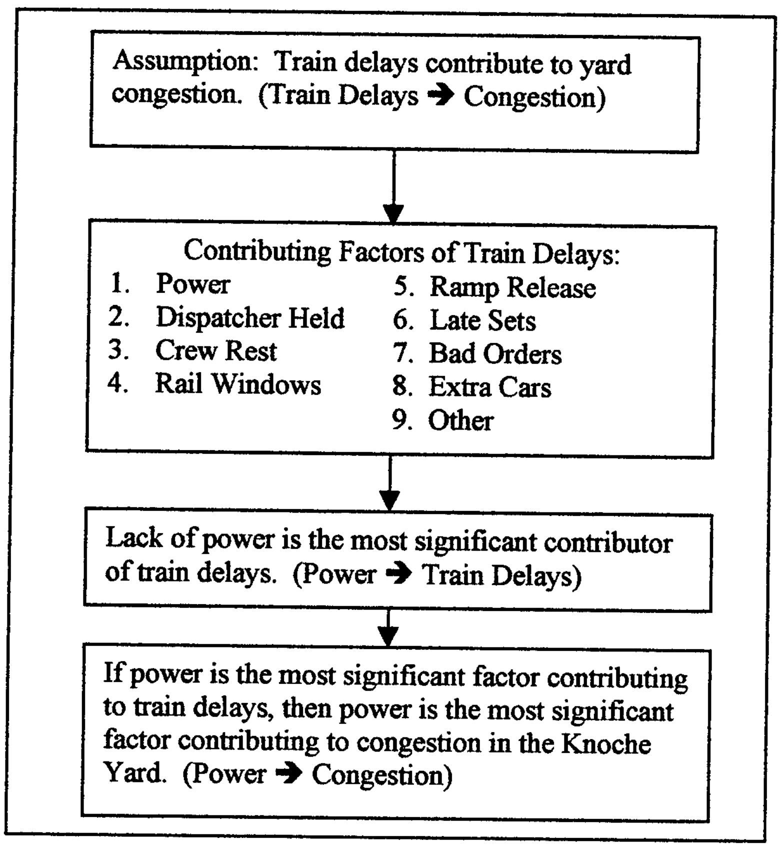

Figure 4. Logic Diagram

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[1]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, interview by author, written notes, Joint Agency, Kansas City, Missouri, 16 January 1998.

CHAPTER 4

ANALYSIS

This chapter provides detailed analysis of the causal factors of congestion as they pertain to train delays and number of "36-hour cars" in the Knoche yard. It begins with preliminary research analysis on rail congestion by reviewing rail professionals' perceptions. These subjective assessments as to the causes of congestion provide the building blocks of this thesis--lack of locomotive power is the most significant cause of congestion. To assist the readers in visualizing Knoche Yard operations, a description of the following will be provided: daily traffic flow, yard layout, and railcar movement processes. This chapter provides analysis of the statistical studies used to validate or invalidate the hypothesis.

Survey Results

A questionnaire (appendix A) was used to assess KCSR management's perception regarding rail congestion causes. The intent was to gain insight into the many congestion factors while determining which factor was considered most significant. The target sample was mainly rail operations managers from Knoche Yard and KCSR's Shreveport, Louisiana yard; however, midlevel managers in KCSR's marketing and industrial engineering departments from the headquarters office also contributed. Of 15 questionnaires distributed, 13 were returned. A tabulation of the questionnaires is provided in figure 6 (appendix B). Most of the nine factors used in this study's analysis of delayed trains were extracted from the survey as mentioned in chapter 3.

The survey results, as depicted in figure 5, clearly show that rail professionals believe power to be the most significant rail congestion cause. Although subjective, these results are important because they reflect opinions of experienced rail professionals who have many years of experience in railroading. Also significant are the next three leading congestion causes--crews, dispatching, and effects from other railroads--as perceived by the sample of respondents.

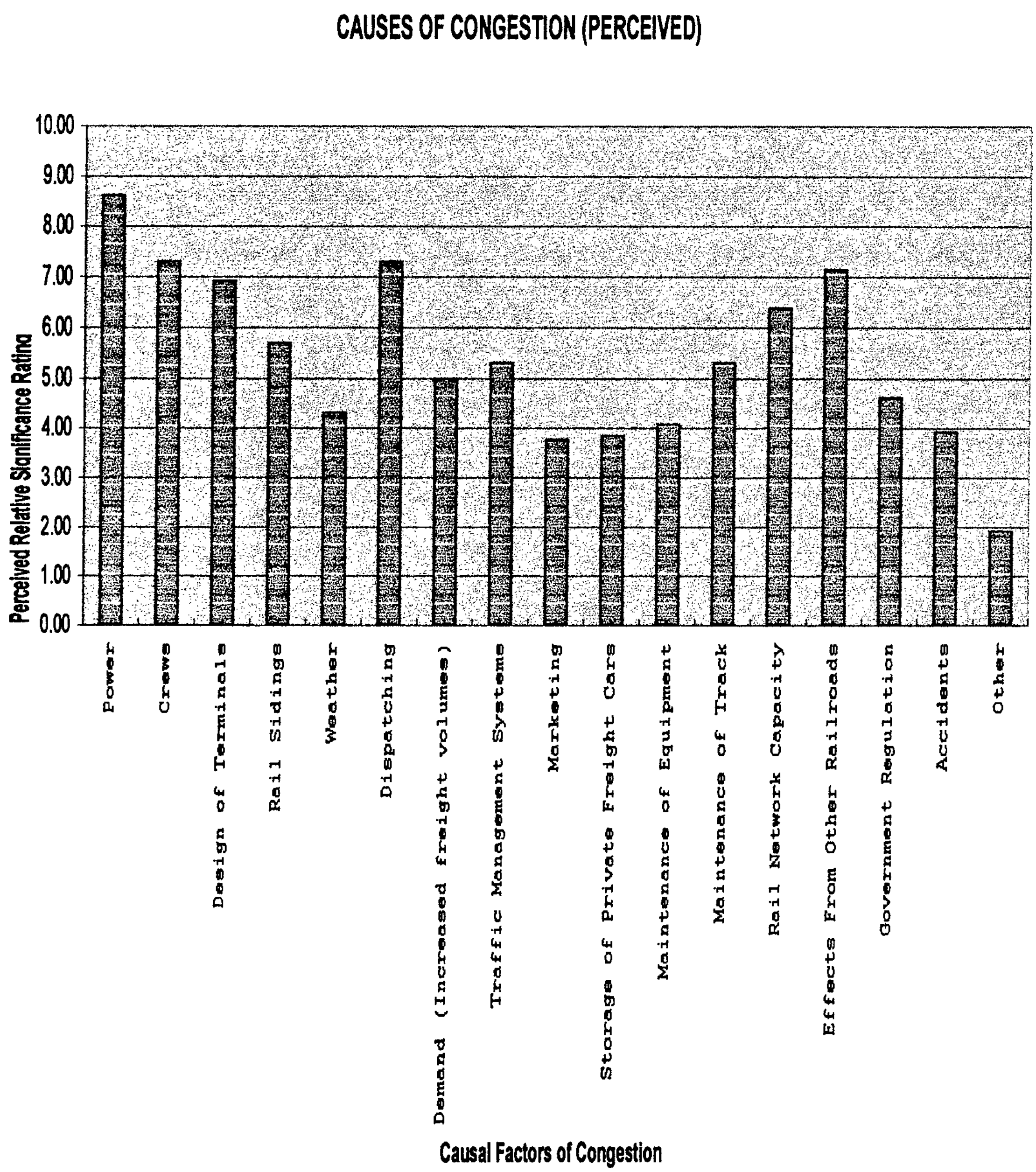

Figure 5. Perceived Causes of Congestion

"Crews" refers to lack of crews or manpower resulting from crew rest requirements or actual manpower shortfalls necessary to man main line locomotives or switch engines. Dispatching refers to the centralized assigning and coordinating of locomotives and crew to outbound trains. "Effects from other railroads" pertains to congestion caused by problems or delays in other rail carrier's lines.

The survey results further demonstrate a commonality in perceptions held between managers from Knoche, Shreveport, and headquarters. Table 7 (appendix B) provides a summary of results for each of these locations, and compares their top three selections. Power is considered the most significant cause of congestion by Knoche Yard and Shreveport managers, but seen as the second most important cause by headquarters. It is interesting that Knoche and headquarters view dispatching as a more significant problem than does Shreveport. This may reflect a bias on Shreveport's part since the dispatchers are co-located in Shreveport. Again, this survey is not intended to provide objective and statistically valid results, but is meant to reflect the current perceptions of congestion as held by experts in the field. This is important not only because it provides this thesis' foundation, but also because it provides a yardstick against which to compare the test results.

Knoche Yard Operations

Providing a general description of the yard layout, daily traffic flow and switching processes is important to the concept of this thesis. Learning about rail yard operations came from observations and from much assistance by the General Superintendent and his officers over a six-month period of time. As a starting point, learning the processes of the Knoche Yard operations would have been easier if written operating procedures had been available. No written operating procedures were known to exist with the exception of several memoranda delineating daily procedures for each shift. A standard shift for a yardmaster and crew is eight hours, but can increase to twelve hours with overtime. The local memoranda's intent, some of which are provided in appendix C, are to provide general guidance and direction to yard supervisors in ensuring trains depart on time.

Yard Layout

The yard, located in Kansas City, Missouri, is comprised of several distinct areas called East Yard, South Yard, Knoche Yard, and New Yard. The East Yard is the principal receiving area. It contains a large portion of tracks used to stage blocks from inbound manifest trains. The South Yard is the location of the intermodal facility where container-on-flatcars and trailer-on-flatcars are assembled. The Knoche Yard contains both the classification tracks (referred to as "the bowl") and the departure tracks. The New Yard is the location of the maintenance facility as well as the primary interchange staging area. Interchange cars coming and going to other rail carriers are staged in this area.

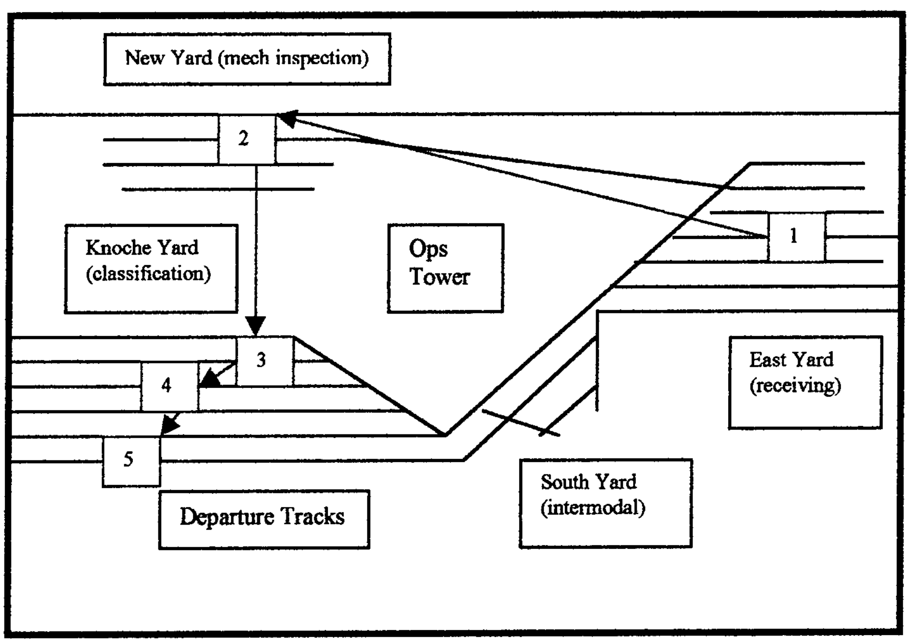

Figure 6. Layout of Knoche Yard

Traffic Flow

Each day Knoche Yard processes a combination of unit and manifest trains not exceeding 20 trains. Most of the trains, approximately 14 per day, are unit coal or grain trains. These normally require little work, other than occasional maintenance, switching selected cars, and/or repositioning misaligned coal or grain cars. The Knoche Yard stop for most unit trains is simply a temporary staging area used to regulate traffic flow along the entire rail line.

In addition to the unit trains, six originating manifest trains are built each day. Train processing and building is Knoche Yard's main focus. Although additional trains are built every few days to maintain an efficiently run system and to prevent undue railcar build-up, this study focuses on the regularly scheduled originating trains listed below in table 1.

Table 1. Schedule of Train Departures

TRAIN I.D.	**SCHEDULED DEPART TIME** (Military Time)
#112	0600
KCSH1	0700
KCBM	1400
#264	1600
KCSL #373	2000
KCND #11	0005

Car Switching Process for Building Trains

The procedure for building a train, although conceptually simple, increases in difficulty when incorporated into the many dynamic operations ongoing in a rail yard. A yardmaster is responsible for directing traffic in the yard. He or she supervises the crews (from the tower) by directing switching, cross hauls, and car classifications. The yardmaster also coordinates with the central dispatcher (located in Shreveport, Louisiana) for all inbound and outbound trains. The yardmaster's primary goal is to build and move trains out in accordance with the train schedule while coordinating all activities within the yard. Preventing train delays pre-empts the accumulation of railcars in the yard. The more cars there are in the yard, the more the maneuvering space is restricted.

A goal for yard management is to minimize the number of times it takes to switch a railcar. The fewer the switches, the less time, equipment and manpower will be needed and the more efficient and timely the process will be. The yard's physical layout imposes certain limitations as to how a railcar can be moved between receiving and departure tracks. For Knoche Yard, approximately five switches are required to move a railcar from receiving tracks into an outbound train on the departure tracks.[1] This applies to railcars originating on inbound trains, but doesn't necessarily apply to railcars originating from cross hauls or from the intermodal facility (South Yard). For an illustration of this process, refer back to figure 6. The average length of inbound and outbound manifest trains, system wide, is 75 cars with the length of cars varying according to type.[2] Car lengths vary from 60 feet for boxcars, 75 feet for covered hoppers, 90 feet for conventional intermodal cars, to approximately 250 feet for 5-pack intermodal cars.[3]

After the railcars of an inbound train are staged among various tracks in the receiving yard (East Yard), a cut identified for a specific outbound train will be switched to the New Yard for mechanical inspection. After passing inspection, the railcar will move to the classification yard where it will be placed on a particular track designated for a specific destination. In the classification yard, railcars are assembled into "blocks" where they eventually can be folded into the outbound train on the departure tracks. While in the classification yard, multiple switching may be required because not only do the number of destination classifications exceed the number of available track, but also the length of some of the classification tracks is short. See table 2 for track lengths in the classification and departure tracks.

Table 2. Track Length Table For Knoche Yard

TRACK LENGTHS (ft) FOR CLASSIFICATION AND DEPARTURE YARDS			
DEPARTURE TRACKS	LENGTH (ft)	CLASSIFICATION TRACKS	LENGTH (ft)
1	5371	7	2694
2	2631	8	2492
3	2773	9	2361
4	2927	10	2174
5	3094	11	2051
6	2810	12	1847
		13	1647
		14	1487
		15	1325
		16	1175
		17	1001
		18	838
		19	638
		20	300

Statistical Analysis

The assertion that power is the leading cause of congestion is tested through the application of two quantitative models. The first model tests the significance of power, compared with eight other causal factors, in causing train delays. The second model tests whether a correlation exists between train delays and the number of "36 hour cars." The statistical methods used to analyze the data were recommended and computed by Major Lloyd A. Stephenson, United States Army, who holds a M.S. in operations research from Kansas State University and a U.S. Army sub-specialty in operational research and statistics. David L. Bitters, Ph.D., the Army Command and General Staff College staff statistician, also provided guidance and verified the logic and accuracy of the methodologies used.

Model No. 1
(Tests Significance of Nine Causal Factors of Congestion)

The first model is used to determine the most significant cause of train delays. Several tests can be used to determine if one variable is more significant than the others--assuming certain conditions are met. Examples of tests are Analysis of Variance (ANOVA) and Friedman's Rank Test. The use of ANOVA, the most powerful test, requires the following assumptions be met--the data must be normally distributed and the variances for all populations must be equal.[4] Table 3 displays the variances for each independent variable and provides a comparison. After testing the assumptions, it was determined that ANOVA could not be used since the data did not pass the test of equal variances.[5]

Table 3. Descriptive Statistics Table. Derived from rail yard observations provided in table 9 (appendix D).

Variables	**Count**	**Sum**	**Average**	**Variance**
Power	41	28	0.683	0.572
Crew Rest	41	04	0.098	0.090
Dispatch Held	41	09	0.220	0.326
Rail Window	41	01	0.024	0.024
Ramp Release	41	10	0.244	0.289
Late Set	41	18	0.439	0.552
Extra Car	41	02	0.049	0.048
Bad Order	41	08	0.195	0.161
Other	41	07	0.171	0.245

Since the variances of the observations are not equal, a nonparametric test known as Friedman's Rank Test was used to determine if the causal factors vary in significance in their influence on train delays.[6] This test relies on the ranks of data and hypothesizes that all data ranks are to be equally likely.[7] Friedman's Rank Test was used to determine if at least one causal factor was more or less significant in causing train delays compared to the others. It cannot be used, however, to indicate the relative significance between variables. Another statistical method using multiple comparisons is needed to ascertain relative significance between variables.

The sample observations to be analyzed, which contain data on causes of train delays from 02 January through 20 February 1998, are located in table 8 (appendix D). Observations from days with no train delays are deleted from the sample (table 9, appendix D). They are not relevant in determining significance between causal factors and train delays. Days with zero delays have no effect on train delays.

Friedman's Rank Test assigns ranks to observations for each day of the sample and computes the sum of the ranks for each independent variable (table 10, appendix D). Since there are nine causal factors, rankings range from 1 - 9 with higher rankings assigned to observations with higher numbers of occurrence. Then in table 11 (appendix D), the squares are taken for each rank. This is necessary to determine two sub-component equations, A_2 and B_2, so that the test statistic, T_2, can be computed.

$$T_2 = \frac{(b-1)\left[B_2 - bk(k+1)^2 / 4\right]}{A_2 - B_2} = 7.39$$

$$A_2 = \sum_{i=1}^{b} \sum_{j=1}^{k} \left[R(X_{ij})\right]^2 = 10308.5$$

$$B_2 = \frac{1}{b} \sum_{j=1}^{k} R_j^2 = 9393.88$$

Using Friedman's Rank Test, the null hypothesis is that all nine independent variables (causal factors of congestion) equally contribute to train delays and the alternative hypothesis is that at least one independent variable is more significant than the others. If this thesis is to be validated, then it requires that the null hypothesis be rejected. The test statistic, T_2, is compared to the F statistic listed below to determine if the null hypothesis is accepted or rejected.

$$F_{(\alpha;\, k-1,\, (b-1)(k-1))} = F_{(.05;8,320)} = 1.94$$

α=level of significance, (95%)
b=# of samples per causal factor (days) = 41
k=# of independent variables (causal factors) = 9

The decision rule is as follows: if T_2 is less than the F statistic, then no causal factors can be shown to be more or less significant than any others in causing train delays; but if T_2 is greater than the F statistic, then the null hypothesis is rejected in the alternative hypothesis' favor which concludes that at least one causal factor is more significant in causing train delays. Since T_2 (7.39) is greater than the F statistic (1.94), the null hypothesis is rejected; therefore, at least one causal factor is more or less significant than the others in contributing to train delays.

Friedman's Rank Test has determined that at least one variable is more or less significant in causing train delays, so it is necessary to analyze which causal factor(s) is the most significant. This is performed by applying a multiple comparison model using the comparative analysis formula below.

$$\left|R_j - R_i\right| > t_{1-\alpha/2}\left[\frac{2b\left(A_2 - B_2\right)}{(b-1)(k-1)}\right]^{\frac{1}{2}}$$

This formula computes the differences between the summed ranks as provided in table 10 and compares them to the test statistic on the equation's right side. Any number derived from subtracting the summed ranks between two independent variables that exceeds the test statistic indicates a significant difference. The test statistic's first term is computed by the following t-test.

$$t_{(1-\alpha/2;(b-1)(k-1))} = t_{(.975;320)} = 1.96$$

Computing the test statistic's remainder, using the comparative analysis formula, results in a value of 30.01. (Refer to figure 9 (appendix D) for computations). Any causal factor having a calculated value exceeding 30.01 is considered to be significantly different. Applying the multiple comparison model to all causal factors clearly establishes power as the most significant train delay cause since it is the only cause that exceeds 30.01 when compared with all other causes. Relative significance between variables can be determined by comparing the values found in table 4 with the test statistic of 30.01

One independent variable, power, tests statistically more significant than all other independent variables. Comparing power to all other independent variables indicate values ranging from the closest in significance, late set (36.5), to farthest in significance, rail window (94.0). All values, from 36.5 to 94.0, are greater than the test statistic of 30.01; therefore, a statistical difference exists between power and all other variables. Comparing all independent variables to late set, the next most significant causal factor, all values exceed the test statistic, except for ramp release (26.5) and bad order (27.5).

Table 4. Comparative Statistics Table

Table 4	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other
Power		80.5	72.0	94.0	63.0	36.5	90.5	64.0	75.5
Crew Rest	80.5		8.5	13.5	17.5	44.0	10.0	16.5	5.0
Dispatch	72.0	8.5		22.0	9.0	35.5	18.5	8.0	3.5
Rail Window	94.0	13.5	22.0		31.0	57.5	3.5	30.0	18.5
Ramp Release	63.0	17.5	9.0	31.0		26.5	27.5	1.0	12.5
Late Set	36.5	44.0	35.5	57.5	26.5		54.0	27.5	39.0
Extra Car	90.5	10.0	18.5	3.5	27.5	54.0		26.5	15.0
Bad Order	64.0	16.5	8.0	30.0	1.0	27.5	26.5		11.5
Other	75.5	5.0	3.5	18.5	12.5	39.0	15.0	11.5	

Comparing the remaining values of each causal factor further substantiates power as the most significant factor in causing train delays. A picture summarizing the relative significance of each causal factor is provided in table 5.

Table 5. Relational Significance Of Independent Variables

Power	A			
Late Set		B		
Ramp Release		B	C	
Bad Order		B	C	
Dispatch Held			C	D
Other			C	D
Crew Rest			C	D
Extra Car			C	D
Rail Window				D

A caution area when using this comparative model is that a global confidence level is not assured, which means that each variable's relative significance is not statistically validated. However, this model does suffice to show statistically that power is the most significant cause of train delays since the differences between power and all other variables are so large.

Model No. 2
(Tests Significance Between Train Delays and Numbers of "36-Hour Cars")

The second model's intent is to determine whether a correlation exists between train delays and the number of "36-hour cars." This is important because a correlation between train delays and number of "36-hour cars" is needed to show that a link exists between power and rail congestion. Since power is statistically shown to be the most significant train delay cause, a causal link between power and congestion can be established if a link is shown to exist between train delays and numbers of "36-hour cars."

Linear regression is applied to determine the strength of correlation between train delays (independent variable) and numbers of "36-hour cars" (dependent variable). The sample data used are from the same time frame as in the first model--02 January through 20 February 1998. As depicted in appendix E, a decision rule is established which tests the slope of the line to determine if a relationship exists. The decision rule tests the slope by comparing the t-statistic, computed through the regression, against a critical value derived from t-distribution tables. The slope is equal to zero if the t-statistic is less than the critical value. If the slope is other than zero, then a relationship exists between train delays and changes in the number of "36-hour cars." As described in figure 7, the slope is determined to differ from zero, implying that a positive relationship exists between train delays and numbers of "36-hour cars."

Test for slope of line	**DECISION RULE**: If t Statistic < test statistic, then "beta not" is failed to be rejected. (NO RELATIONSHIP)
$B_0 = 0$ $B_1 \neq 0$	If t Stat > critical value, then "beta not" is rejected. (POSITIVE RELATIONSHIP)
$tDistribution = t(\alpha/2, n-2)$ $t = (.05/2, 49-2) = t(.025, 47)$ $t = 2.013$	t Statistic (from figure 10) = 3.01 Critical value (from t-Distribution tables) = 2.013 Since 3.01>2.013, "beta not" is rejected, the slope does not equal zero, and A POSITIVE RELATIONSHIP EXISTS.

Figure 7. Regression Decision Rule Table

Analyzing the regression output in figure 10 (appendix E), the coefficient of determination (R-square), 0.16, measures the effect of train delays in reducing the variation in numbers of "36-hour cars." R-square represents "the proportionate reduction of total variation."[8] Another valuable regression indicator is the correlation coefficient (R), 0.40, which is obtained by taking the square root of R-square. The correlation coefficient represents the strength of association between train delays and number of "36-hour cars."

These regression indicators explain a great deal about the relationship between the variables. The R-square value indicates that 16 percent of the variation around the regression line can be explained (refer to figure 11 (appendix E) for graph of data). The R value (.402) represents the strength of relationship between train delays and the number of "36-hour cars." In crude terms, number of "36-hour cars" as caused by train delays can be explained 40 percent of the time. The 0.16 R-square value is a very weak indicator of the strength of association between the variables. The closer R-square values approach 1.0, the stronger the relationships are between the variables. Higher R-squares can provide predictive value, but since the R-square is so low in this case, the regression does not lend itself to useful predictive applications. It does, however, statistically substantiate with 95 percent confidence that a relationship exists between train delays and number of "36-hour cars."

An important note regarding this linear regression model is that an outlier was discovered during an exploratory analysis of the data observations (appendix F). Removing the outlier improves the strength of relationship between train delays and number of "36-hour cars" (appendix G).

An outlier corresponds to any data point that is at least three standard deviations away from its expected value. Testing for outliers, as depicted in figure 12 (appendix F), discovers one outlier representing 15 January 1998. This data point represents 190 minutes of train delays and 155 "36-hour cars." The observation from 15 January is verified to be skewed as a result of a labor union dispute which resulted in four switch jobs being vacant for the day. This lack of manpower directly contributed to an inordinate rise in "36-hour cars" since the yard was four crews short for the day.[9] Since the outlier can be reasonably justified as to its cause, the 15 January data point can be excluded from the sample data and the regression recomputed.

Summary

Not only do the perceptions of management reflect the belief that lack of power causes rail congestion, but statistical inference also supports this premise. The first statistical analysis substantiates the assertion that the congestion causal factors weigh differently in their influence on train delays, and that power is the most significant cause. Applying Friedman's Rank Test demonstrates that differences exist between the variables, and through a multiple comparison of the differences in summed ranks, power is determined to be the most significant variable. The second statistical analysis, although very weak in its results, verifies that a positive relationship does exist between train delays and number of "36-hour cars."

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[1]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, interview by author, written notes, Joint Agency, Kansas City, Missouri, 13 January 1998.

[2]Mark Davidson, KCSR Director of Industrial Engineering, phone interview by author, written notes, 20 April 1998.

[3]Mark Davidson, KCSR Director of Industrial Engineering, phone interview by author, written notes, 20 April 1998.

[4]Levine, David M., Berenson, Mark L., and Stephan, David. Statistics for Managers Using Microsoft Excel. (New Jersey: Prentice Hall, 1997), 426.

[5]Testing for equal variances is done by using Hartley's F-max Test (Neter, John, Wasserman, William, and Kutmer, Michael H., *Applied Linear Statistical Models (Regression Analysis of Variance and Experimental Designs.* (Boston: Richard D. Irwin, 1990), 619-620.). This test compares variances of the independent variables as provided in table 3 by computing the ratio between the largest and smallest sample variance, and comparing this ratio to a test statistic. The null hypothesis for this test is that the variances are equal for the nine independent variables (i.e., the causal factors of congestion) and the alternative hypothesis is that at least one variance is different. The ratio computed by comparing the largest and smallest variances--power (.572) and rail window (.024)--is 23.83. [Fmax = variance (power)/variance (rail window) = .572/.024 = 23.83]. Comparing this difference, 23.83, to a standardized F_{max} test statistic, 2.90, the hypothesis

of equal variances is rejected. The critical value is derived from the formula: [F (a;k, b-1)=F (.05; 9, 40) = 2.90, where a equals level of significance, b equals number of sample days, and k equals the number of independent variables]. Since the calculated value of 23.83 exceeds the critical value of 2.90, the alternative hypothesis is accepted which concludes that the variances are not equal. Therefore, since the variances are not equal, ANOVA, the most powerful statistical test can not be used.

[6]Neter, John, Wasserman, William, and Kutmer, Michael H., *Applied Linear Statistical Models (Regression Analysis of Variance and Experimental Designs.* (Boston: Richard D. Irwin, 1990), 948-950.

[7]Ibid.

[8]Ibid., 101.

[9]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, interview by author, written notes, Joint Agency, Kansas City, Missouri, 19 March 1998.

CHAPTER 5

CONCLUSIONS

Introduction

Chapter 5's purpose is to address this study's assertions by tying together all aspects of the analysis. In so doing, this study's hypothesis--lack of locomotive power is the most significant cause of rail congestion--is verified. This chapter also summarizes the pertinent points applicable to the supporting questions, and concludes with recommendations for further study.

Conclusions

Supporting Questions

A review of the supporting questions presented in chapter 1 helps show their importance in constructing the foundation of this study's primary assertion that power is the leading cause of rail congestion in KCSR's Knoche Yard. As addressed earlier, rail congestion is an excess buildup of freight cars at a particular place in time resulting in inefficient flow of rail traffic. Management at the Knoche Yard defines yard congestion as the number of "36-hour cars" exceeding 120. Rail congestion, for the purpose of this study, is measured by the number of "36-hour cars" during each day of a specific period of time.

Congestion is clearly the result of a combination of factors--both internal and external to the yard. Some factors are within the influence of yard management while some are the product of the global economy and natural market forces. Figure 1, located in chapter 1, lists some of the possible causes of rail congestion: capacity, automated traffic management systems, weather, intermodal activity, cost cutting, government regulation, power, labor, and others. Congestion's implications are widespread. Not only affecting the operations and profits of rail carriers, congestion affects its customers and potentially the entire national economy.

Primary Question

Experienced rail managers' perceptions indicate that most believe lack of locomotive power to be the leading cause of rail congestion. This perception is statistically validated for KCSR's Knoche Yard as shown by the results of two statistical models.

The first model uses a nonparametric test (Friedman's Rank Test) to show that at least one of the nine causal factors of congestion--power, crew rest, dispatch held, rail window, ramp release, late set, extra car, bad order and other--is statistically more significant than the others in causing train delays. The null hypothesis states that all causal factors are equal in causing train delays; and conversely, the alternative hypothesis states that the causal factors are not equal in causing train delays. Although the test rejects the null hypothesis in favor of the alternate, the relative significance of each causal factor is still undetermined. In order to ascertain the relative significance of the causal factors, a multiple comparison test is used. By comparing each variable's relative mean rank, power is distinguished as the most significant train delay cause with the other causal factors arrayed in three distinct groupings. Of importance here is that the relative ranking of the other eight factors can not be statistically validated with a credible confidence level. Next in significance, yet statistically inconclusive in their relative significance, are late set, ramp release and bad order. A table of relative significance is provided in table 5 (chapter 4). The first model substantiated power as the most significant train delay cause.

The second model used a regression study to test the strength of relationship between train delays and number of "36-hour cars." After removing an anomalous data point (15 January) that is attributed to a labor dispute, the regression proves with 95 percent confidence that a weak correlation exists. The results conclude that a relationship exists between train delays and number of "36-hour cars."

Because power is shown to be the most statistically significant cause of train delays, because a correlation is shown to exist between train delays and number of "36-hour cars," and because congestion is measured by number of "36-hour cars," it is concluded that lack of power is the most significant cause of rail congestion.

Subjective Assessment

Through observation of yard operations, from the perspective of a professional military officer, two areas of concern merit mention. These concerns, although not directly linked to the topic of this study, pertain to yard operations. Since similarities exist between the military and the rail industry with regard to operations, reliance on equipment, and unique cultures, I believe these observations have relevance.

The first concern regards the lack of written operating procedures and standards pertaining to the Knoche Yard, which breeds potential inefficiencies and lack of continuity. Aside from the Code of Federal Regulations CFR 49, KCSR "pocket guide," and superintendent originated memoranda, no standardized company operating procedures exist. The absence of written operating procedures and standards likely has a degrading effect on training and operations. Absence of written procedures makes it difficult to maintain consistency and continuity of operations, especially during turnover of managers and personnel. Written operating procedures aid managers and leaders in formulating objectives and goals and providing minimum guideposts on which to base performance as well as the ability to judge or measure results.

The second concern pertains to the existing automated traffic management system, which appears to be outdated and limited in its capability. Its ability to monitor, sort and classify rail cars appears to be inefficient. The current system leaves too much of the decision making process to human intervention and interpretation (i.e.: the yardmaster). Greater efficiencies and more timely movement of railcars most likely would be experienced if the automated traffic management system removed a part of the subjectiveness of assigning track to railcars and eliminated the need to use handwritten track assignments via pneumatic tube.

Recommendations

The intent of this thesis is to raise the awareness of the primary cause of congestion--power. Although lack of locomotives or power is established statistically as the most significant cause of rail congestion, this study did not address whether lack of power was a scheduling problem or a capital equipment problem. Through the demonstration of subjective as well as quantitative evidence that power is the most significant cause of rail congestion, management is provided with an important decision making tool for determining if more emphasis should be placed on locomotive power as a means of achieving improved traffic flow.

Recommendations for controlling the causes of congestion pertain to information management and personnel training. The first recommendation is to establish written operating procedures for yard operations. This should include a mission statement and goals and objectives for the respective yard. It should also contain standard operating procedures for switching operations, maintenance issues, safety issues, refueling, weather issues, and emergency response measures. Written operating procedures are essential to sustaining quality performance, and help ensure continuity when personnel turn over.

The second recommendation includes upgrading system software to provide real-time capability for managers to measure factors causing train delays and levels of "36-hour cars." Providing real time information regarding factors and indicators of congestion can significantly enhance a manager's situational awareness and ability to effectively manage yard operations.

The last recommendation regards incorporating refresher training into the company's training plan. Refresher training should provide periodic educational training to all operations managers and supervisors on fundamental causes of congestion, specifically recent congestion trends along local lines. For supervisors and managers to be maximally effective in daily operations and controlling congestion, it is useful to provide a medium to enhance awareness of problems and to review recent problems.

Recommended Areas for Further Research

Further research that may prove valuable to rail management includes several areas. The first refers to the reason why lack of locomotive availability occurs. Is it the result of an equipment problem or is it a resource allocation problem? In other words, is the existing quantity of locomotives insufficient to meet the needs of the railroad or is the locomotive dispatching and scheduling system at fault? A second area of research could be to further develop and substantiate this study's results, and apply it to other KCSR terminals--specifically Shreveport, Louisiana. The methodology could be similar to the one used in this study but include additional samples. A third area could encompass analyzing Knoche's automated traffic management system and comparing it to current systems in use by industry. This study could focus on the potential effect technology has on optimizing traffic flow within a rail yard. Could enhanced software or hardware improve efficiencies for building trains, minimizing required switches, controlling congestion, and reducing administrative manpower requirements?

A fourth area of recommended further study could be to develop an improved regression model that identifies better predictors than number of "36-hour cars." Improve the model used in this study which correlates train delays to number of "36-hour cars." Expand the model to a multi-regression study encompassing additional independent variables such as daily traffic volume, number of jobs worked per day, weather conditions, number of unit trains entering yard, etc. By including additional factors such as these, the R-square (goodness of fit) may be improved.

A final area of further study could be to identify a statistical method that can rank order the causes of congestion. Instead of identifying only the most significant cause of congestion, determine the relative significance of all causes of congestion. Developing a model with a 95 percent global confidence level may prove valuable to management since it would delineate the relative importance of all factors of congestion.

Summary

This chapter addressed conclusions, recommendations and areas for further study. The hypothesis asserting that lack of locomotive power is the leading cause of rail congestion in KCSR's Knoche Yard was established statistically by applying Friedman's Rank Test, comparative statistics, and linear regression to a 50 day sample pool. These results match the perceptions held by many KCSR managers as derived through the survey at appendix A.

GLOSSARY

Bad Order. A freight car identified as in need of repair and placed out of service until repairs are made.

Block. An arrangement of railcars connected by destination.

Class I Railroad. A classification of regulated railroad companies having annual operating revenues of at least $50 million.

Congestion. An excess buildup of freight cars at a particular place and time leading to friction and difficulties in moving freight cars throughout the rail network in a timely manner; too many freight cars for the amount of track space; inability to handle volume expeditiously as governed by the customer's demand or expectations exceeding the dwell time; a condition when inbound traffic overruns capacity to efficiently switch, classify, and push outbound traffic.[1] Congestion is measured by the changes in "36-hour cars," and is quantified, as it relates to the Knoche Yard, as the point at which "36-hour cars" exceed 120.

Consist. A composition or inventory of the freight cars of a train; a manifest of a train's freight cars.

Crews. Established groups of rail and locomotive personnel comprising teams to perform specific functions such as: switching cars, hauling interchange cars, making runs. Different types include: train crews, engineering crews and yard crews.

Crew Rest. Federally mandated minimum rest requirements for crews. A minimum of 10 hours rest is required after working a 12-hour shift. A minimum of 8 hours rest is required after working less than a 12-hour shift.

Cross Haul. Freight car(s) belonging to another rail company that are transported from one switchyard to a competitor's yard.

Cut. A group of rail cars. Refers to an assembly of cars to be moved during classification or interchange of rail cars.

Dispatcher. The person who synchronizes movement of trains throughout KCSR's network. KCSR's centralized dispatcher is located in Shreveport, LA and is responsible for assigning and coordinating power and crew for every outbound train in any of KCSR's rail yards.

Dispatcher Held. An outbound train that is manned and ready to depart, but held in a yard by a centralized train dispatcher, until the schedule allows for the train's departure.

Dwell Time. The length of time a freight car remains in a rail yard. This is measured from the time a car arrives in a yard until the time it departs the yard as part of a train or an interchange cut.

Extra Car. A non-documented railcar located in an inbound or outbound train. A railcar that was not included on a consist or inventory.

Folding. Placing a block of railcars into a train. Assembling a train in preparation for departure.

Haulage Rights. An agreement between rail carriers allowing a carrier (Carrier A) to operate its train on another carrier's tracks (Carrier B) with the requirement that the other carrier's crews (from Carrier B) operate its train (Carrier A).

Hold. A railcar lacking documentation of its destination. Also, "frustrated cargo."

Inbound Train. An arriving manifest train that will be received and whose cars will be broken down and reclassified according to destination.

Interchange. The transfer of equipment and freight between carriers in a joint freight move.

Interchange Trains or Cars. Train or railcars designated to be delivered or received to/from another rail company.

Intermodal Transport. The movement of freight over different modes of transportation. For example, containers and trailers which are transported between ocean shipping, rail and or motor carrier.

Job. The scheduling of one crew to work one eight-hour shift.

Late Set. A train assembled or "set" behind the scheduled time that most likely will not meet its scheduled departure time.

Manifest Train. A train carrying different types of freight onboard consigned for various ultimate destinations.

Piggy-Backs. Intermodal railcars carrying containers and/or trailers. Each intermodal car can be of differing lengths carrying multiple containers and/or trailers.

Power. A railroad locomotive. Used interchangeably with locomotive throughout the thesis.

Rail Siding. A parallel section of track connected to a single main rail line, which accommodates a train during the passage of an opposing train. Sidings are strategically located along the length of a track.

Rail Window. A pre-assigned time that a specific section of track will be down due to repairs (maintenance of way).

Rail Yard. Synonymous with switchyard, terminal, and yard. Fundamentally comprised of receiving tracks, classification tracks and departure tracks. Normally contains an intermodal area.

Ramp Release. The release of intermodal cars from an intermodal ramp as it applies in the process of building a train.

Restricted Cars. A railcar with strict limitations on where it can be located in a train due to its cargo or mechanical design.

Rework. Redundant switching of a railcar.

Remain in Place (RIP). Repair of a railcar on the track rather than a maintenance facility.

Round House. A locomotive inspection and maintenance facility characterized by its rotating "turntable" track.

Run. The movement of a train, an interchange cut or pick-up / delivery of specific cars between two locations.

Throughput. A measure of output in terms of railcars moving through a specific rail yard in a specified time period.

Trackage Rights. An agreement between rail carriers allowing a carrier to operate its train and crew on another carrier's tracks.

Track Space. The relative length of track available for movement or positioning of locomotives or freight cars.

Unit Train. An entire train moving uninterrupted between origin and destination. Usually applies to trains of a single commodity such as coal or grain.

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[1]William J. Slinkard, General Superintendent of KCSR Kansas City Yard Joint Agency, and staff members, interview by author, written notes, Joint Agency, Kansas City, Missouri, 13 January 1998.

Appendix A

Questionnaire

Topic: Rail Congestion
Researcher: LCDR Robert A Gantt, SC, United States Navy
Purpose: To provide data in support of Thesis (Masters in Military Arts and Science, Army Command and General Staff College)

1. Rank the relative importance of the following factors you believe lead to congestion on railroads. (Circle the number)

		Not important Very important
(a)	Power (lack of it)	[1-2-3-4-5-6-7-8-9-10]
(b)	Crews	[1-2-3-4-5-6-7-8-9-10]
(c)	Design of terminals	[1-2-3-4-5-6-7-8-9-10]
(d)	Rail sidings	[1-2-3-4-5-6-7-8-9-10]
(e)	Weather	[1-2-3-4-5-6-7-8-9-10]
(f)	Dispatching	[1-2-3-4-5-6-7-8-9-10]
(g)	Demand (Fluctuations in customer demand for rail)	[1-2-3-4-5-6-7-8-9-10]
(h)	Automated traffic management systems	[1-2-3-4-5-6-7-8-9-10]
(i)	Marketing (makes promises operators can't keep)	[1-2-3-4-5-6-7-8-9-10]
(j)	Storage of private freight cars	[1-2-3-4-5-6-7-8-9-10]
(k)	Maintenance of equipment	[1-2-3-4-5-6-7-8-9-10]
(l)	Maintenance of track	[1-2-3-4-5-6-7-8-9-10]
(m)	Rail network capacity	[1-2-3-4-5-6-7-8-9-10]
(n)	Effects from operations at other railroads	[1-2-3-4-5-6-7-8-9-10]
(o)	Government regulation	[1-2-3-4-5-6-7-8-9-10]
(p)	Accidents	[1-2-3-4-5-6-7-8-9-10]
(q)	Other	[1-2-3-4-5-6-7-8-9-10]

2. For each factor you assigned a rating of 8 - 10, please explain. (On back if needed)

Appendix B

Table 6. Survey Results

	RESPONDENTS														
	Knoche Yard					Shreveport Yard			KCSR Headquarters						
Factors	A	B	C	D	E	F	G	H	I	J	K	L	M	Totals	Avg
Power	8	10	9	10	10	7	10	9	10	6	5	10	8	112	8.62
Crews	8	4	7	7	9	6	10	6	10	6	5	10	7	95	7.31
Design of Terminals	6	7	10	5	7	6	5	8	5	8	10	7	6	90	6.92
Rail Sidings	6	7	1	7	5	4	7	5	5	8	8	6	5	74	5.69
Weather	5	10	1	3	1	7	4	5	7	6	5	2	0	56	4.31
Dispatching	6	10	5	7	5	6	7	5	8	8	9	10	9	95	7.31
Demand (Increased freight volumes)	9	10	1	6	3	5	5	5	5	4	5	7	0	65	5.00
Traffic Management Systems	8	10	1	5	3	5	6	7	5	5	7	5	2	69	5.31
Marketing	7	8	1	3	4	2	6	6	3	4	4	1	0	49	3.77
Storage of Private Freight Cars	6	10	1	4	6	2	5	5	2	4	4	1	0	50	3.85
Maintenance of Equipment	6	10	4	3	5	2	5	4	2	6	4	1	1	53	4.08
Maintenance of Track	6	10	1	6	8	3	6	5	2	6	5	7	4	69	5.31
Rail Network Capacity	8	9	1	8	9	6	5	8	7	8	2	2	10	83	6.38
Effects From Other Railroads	7	8	8	9	8	6	9	7	8	7	8	5	3	93	7.15
Government Regulation	6	7	3	8	5	2	4	6	6	4	1	8	0	60	4.62
Accidents	5	7	1	2	5	4	5	7	8	4	1	2	0	51	3.92
Other	5	0	1	1	5	0	4	6	2	0	0	1	0	25	1.92

Table 7. Survey Results By Origin Of Respondents

	Knoche Yard						Shreveport Yard			
	A	B	C	D	E	Avg	F	G	H	Avg
Power	8	10	9	10	10	9.4	7	10	9	5.7
Crews	8	4	7	7	9	7	6	10	6	5.3
Design of Terminals	6	7	10	5	7	7	6	5	8	3.7
Rail Sidings	6	7	1	7	5	5.2	4	7	5	3.7
Weather	5	10	1	3	1	4	7	4	5	3.7
Dispatching	6	10	5	7	5	6.6	6	7	5	4.3
Demand (increased freight volumes)	9	10	1	6	3	5.8	5	5	5	3.3
Traffic Management Systems	8	10	1	5	3	5.4	5	6	7	3.7
Marketing	7	8	1	3	4	4.6	2	6	6	2.7
Storage of Private Freight Cars	6	10	1	4	6	5.4	2	5	5	2.3
Maintenance of Equipment	6	10	4	3	5	5.6	2	5	4	2.3
Maintenance of Track	6	10	1	6	8	6.2	3	6	5	3.0
Rail Network Capacity	8	9	1	8	9	7	6	5	8	3.7
Effects From Other Railroads	7	8	8	9	8	8	6	9	7	5.0
Government Regulation	6	7	3	8	5	5.8	2	4	6	2.0
Accidents	5	7	1	2	5	4	4	5	7	3.0
Other	5	0	1	1	5	2.4	0	4	6	1.3

	KCSR Headquarters					
	I	J	K	L	M	Avg
Power	10	6	5	10	8	7.8
Crews	10	6	5	10	7	7.6
Design of Terminals	5	8	10	7	6	7.2
Rail Sidings	5	8	8	6	5	6.4
Weather	7	6	5	2	0	4
Dispatching	8	8	9	10	9	8.8
Demand (increased freight volumes)	5	4	5	7	0	4.2
Traffic Management Systems	5	5	7	5	2	4.8
Marketing	3	4	4	1	0	2.4
Storage of Private Freight Cars	2	4	4	1	0	2.2
Maintenance of Equipment	2	6	4	1	1	2.8
Maintenance of Track	2	6	5	7	4	4.8
Rail Network Capacity	7	8	2	2	10	5.8
Effects From Other Railroads	8	7	8	5	3	6.2
Government Regulation	6	4	1	8	0	3.8
Accidents	8	4	1	2	0	3
Other	2	0	0	1	0	0.6

Rankings	Knoche Yard	Shreveport Yard	Headquarters
1	Power	Power	Dispatching
2	Dispatching	Crew	Power
3	Track Mainten.	Effects from other yards	Crews

Appendix C

NEW OPERATING YARD PLAN FOR JOINT AGENCY

- *1ST SHIFT*
- *A) RESWITCH TRACK__ AND TRACK__ TO BUILD # 81 SET BY 10AM CALL FOR 12 NOON SET WITH EAST LEAD JOB*
- *B) RESWITCH TRACK__ AND TRACK__ TO BUILD # 264 SET BY 11 AM CALL FOR 2PM SET WITH WEST KNOCHE LEAD JOB*
- *C) RESWITCH TRACK__ AND TRACK__ TO BUILD # 98 SET BY 1PM CALL FOR 3PM SET WITH WEST KNOCHE LEAD JOB*
- *D) WEST KNOCHE LEAD JOB SWITCH 1 TRACK OUT OF NEW YARD*
  EAST KNOCHE LEAD JOB SWITCH 2 TRACKS OUT OF NEW YARD
- *E) TRAMP JOB TO CROSS HAUL EAST KANSAS CITY CAR*
  BY 2PM
- *F) TRAMP JOB TO HAUL UP CUT TO KNOCHE BY 3PM AN*
- *G) TRAMP JOB TO COUPLE AND LINE UP "INDUSTRIAL L*

YARD PLAN CONTINUED

- **2ND SHIFT**
- A) WEST KNOCHE LEAD JOB SWITCH 2 TRACKS OUT OF NEW YARD (ONE OF WHICH ARE XHAULS) EAST KNOCHE LEAD JOB SWITCH 2 TRACKS OUT OF NEW YARD 9ONE OF WHICH ARE XHAULS)
- B) TRAMP JOB BUILD GWWR TRAIN # 373 IN SOUTH YARD OFF RAMP TRACK # 148 DOUBLE TRAIN OUT AND PULL TO KNOCHE WITH THE GERBELS SPOT TO AIR BY 7:30PM
- C) SPREAD PIGS FOR # 11 WITH BATON ROUGE CARS SET BY 9PM CALL FOR 10PM
-
- D) TRAMP JOB CROSS HAUL BOTH WAYS BY 10PM
- E) WEST KNOCHE LEAD JOB COUPLE AND LINE UP ELMDALE AND TEAM TRACK CARS BY 10PM
- F) EAST KANSAS CITY LEAD JOB COUPLE AND LINE UP COBURG CUT BY 10:30PM

YARD PLAN CONTINUED

- *ALL CARGILL CARS WILL BE KEPT ON SOUTH MAIN AT ELMDALE AND WILL BE TAKEN THERE EACH DAY WITH RUN 50, AS WELL AS CARS FOR BULK TERMINAL WILL BE TAKE TO DONAVAN SPUR EACH DAY. IN ADDITION BATLINER CARS WILL BE TAKE TO 902 POCKET.*
- *RUN 29 WILL CONTINUE TO SWITCH WOLCOTT ELEVATOR*
- *SOUTH YARD WILL BE KEPT CLEAR FOR THE GATEWAY PIG TRAIN AND MAY ONLY BE USED FOR IMO EQUIPMENT THAT WILL NOT INTERFERE WITH TRAIN # 373.*

YARD PLAN CONTINUED

- ***3RD SHIFT***
- ***A) EAST KNOCHE LEAD JOB SWITCH 1 TRACK OUT OF NEW YARD AND WEIGH WEST KNOCHE LEAD JOB SWITCH HOLDS AND SWITCH RIP TRACK***
- ***B) SWITCH TRACK #__ AND TRACK #__ FOR # 5 AND SET BY 3AM. CALL FOR 5AM***
- ***C) TRAMP JOB PULL BN TRANSFER TO KNOCHE BY 5AM AND SPOT TO AIR.***
- ***D) TRAMP JOB CROSS HAUL BOTH WAYS BY 6AM***
- ***E) EAST KANSASA CITY LEAD JOB SWITCH 2 TRACKS OUT OF NEW YARD***

ALL YARDMASTERS

We have put fourth some standards for you to follow as we felt it necessary to try to put some focus into our jobs and make a routine that the railroad needs to operate. The duties assigned to each yardmasters job was not authored by me, but rather by the customers that we serve. All the information was compiled from sources like the TSP and commitments make by our company to our customers. The standard sheets are to be used as a tool for us to measure what we are going and if we meet the customers expectations, and you know what will happen if we do not give them what they want.

We need for you to fill out the sheets and let me know what keeps you from doing your job. We know this will not bring more engines or people to the property, however it will allow us to fix the thing we can fix, in house.

The yardmaster is just what his name implies, "Master of the Yard," you now have the responsibility to run the yard and make thing work like you are paid to do. We think each of you want to take charge and run the terminal and we are here to give you the tools,I to the best of our ability, so you can do just that. There are a couple of things that need to happen ;to make this work. One, you need to support the officers and two, the authority to do the things you need to do. We can assure you, you have those two ingredients to perform your job. The other side is you must be held accountable for the things you do. We are not going to "Monday Morning Quarterback, " all you have to do is make good intelligent decisions and answer for why you made the decision you did and use good thought process. We know hindsight is 20/20, just do what is best for the mission of the yard and company.

We want if perfectly understood that you will be held accountable for your performance and only you can control your own actions. If you do not want to be held accountable and responsible for your job and duties you are on the wrong job. The jobs are very demanding and require a lot of leadership skill and job knowledge, your job performance will be judged, as we are, on your performance and results you achieve.

The standards sheets are made available and are to be filled out and sent to my office for review. I cannot monitor your progress or lack there of without these sheets. We considered these duties as outlined on these sheets a starting point to getting ourselves on schedule and doing what the customers want and stopping the "Free lance" that we have been doing through the years. If we are to survive in the industry we must get a schedule and be focused together and do things right the first time.

We know that all you do cannot be put on a sheet of things to do. You are all good railroad men and women and know what to do for the most part. The check sheet is a sheet for things that must be on schedule as there may other tasks that must be done such as second schedules and excess cars to be moved at certain times and these thing must still be done. The priority tasks are listed and must take preference as is outlined by the officer on duty.

If you have questions about any of the above or questions about anything please feel free to call and talk.

Thanks for your time for reading this note and hope I have helped clarify any doubt as to what is expected of you.

Bill Slinkard

TSP BLOCKING INSTRUCTIONS

- ***KCS TRAIN # 5 HAS 7 BLOCKS***
- ***KCS TRAIN # 81 HAS 7 BLOCK***
- ***KCS TRAIN # 11 HAS 6 B LOCKS (5 OF WHICH ARE IMO)***
- ***IMRL TRAIN # 112 HAS 3 BLOCK (2 OF WHICH ARE IMO)***
- ***IMRL TRAIN # 98 HAS 5 BLOCKS (1 OF WHICH ARE IMO)***
- ***IMRL TRAIN # 264 HAS 5 BLOCKS***
- ***GWWR TRAIN # 373 HAS 3 BLOCKS (2 OF WHICH ARE IMO)***

- ***TOTAL OF 37 BLOCKS OF WHICH 20 HAVE TO OVER FLOW INTO OTHER TRACKS THAT EQUALS 57 TRACKS NOT TO MENTION TRACKS FOR HOLDS, BAD ORDERS, CP CARS, WEIGHERS, AND LOCAL INDUSTRY CARS EQUALING 62 TOTAL***
- ***WE HAVE A TOTAL OF 17 TRACK TO USE AS CLASSIFICATION TRACK AT KNOCHE YARD CAUSING THE ROOT OF OUR PROBLEM AT KANSAS CITY***
- ***WE HAVE TO RESWITCH IN EXCESS OF 300 CARS PER DAY TO MAKE THE SPREADS NEEDED. IMRL CARS ARE SWITCHED 5 TIMES BEFORE DEPARTING BECAUSE OF OUR TRACK UTILIZATION PROBLEM.***

TO: ALL JOINT AGENCY EMPLOYEES

FROM: JOINT AGENCY OFFICERS

SUBJECT: SCHEDULED TRAIN DEPARTURES

DATE: DECEMBER 10, 1997

OUR GOAL ON THE JOINT AGENCY IS TO RUN A SUCCESSFUL TRAIN OPERATION TO MEET THE CUSTOMERS NEEDS AND HAVE A GOOD QUALITY OF LIFE FOR OURSELVES IN ORDER TO DO THIS, WE MUST ALL COMMIT AND WORK AS A TEAM TO MAKE THIS POSSILE.

THE GOAL: ON - TIME TRAINS DEPRTURES FROM THE JOINT AGENCY

THE TRAIN DEPARTURE STANDARD THAT WAS WRITTEN BY OUR CUSTOMERS, HAS BEEN ESTABLISHED FOR EACH OF THE TRAINS WE OPERATE ON THEIR BEHALF. PLEASE FIND ATTACHED " JOINT AGENCY TRAIN DEPARTURE STANDARDS" SHEET. THE STANDARD OR PERFORMANCE GOAL FROM "CREW ON DUTY" TO "TRAIN DEPART" IS SHOWN FOR EACH TRAIN AND IS A CONSTANT REMINDER TO ALL OF US AS TO WHAT IS EXPECTED AND WHAT IS REQUIRED IN OUR EVERY DAY ROUTINE.

WE ARE GOING TO MEASURE OUR PROGRESS IN VARIOUS WAYS, AND WE CAN SEE OUR PERFORMANCE TO WHAT IS REQUIRED. THIS DATA WILL BE TRACKED, CHARTED AND DISPLAYED WEEKLY, AND THIS WILL ALSO HELP US TO INDENTIFY OPPORTUNITIES FOR IMPROVEMENT.

IT IS CRITICAL THAT WE MAKE MAJOR IMPROVEMENT AT THE JOINT AGENCY, TO DO THIS WE MUST FOCUS ON DOING OUR PART TO GET THE TRAINS OUT ON TIME, ACCORDING TO WHAT THE CUSTOMER DEMANDS.

THE JOINT AGENCY DEPARTURE STANDARDS WILL BE UPDATED FROM TIME TO TIME AND INFORMATION WILL BE POSTED FOR YOUR REVIEW.

IF YOU HAVE QUESTIONS OR IDEAS ON HOW WE CAN DEPART ON TIME PLEASE CONTACT AN OFFICER.

THANK YOU FOR YOUR COOPERATION IN MAKING THE JOINT AGENCY, KCS, AND THE IMRL A SUCCESSFUL PLACE FOR OUR CUSTOMERS TO DO BUSINESS AND AN OPERATION WE CAN BE PROUD OF.

W. J. SLINKARD

Appendix D

Table 8. Data Observations For Friedman's Rank Test

Date	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other
2-Jan	0	0	2	0	2	0	0	0	0
3-Jan	2	0	2	0	2	0	0	0	0
4-Jan	0	0	0	0	0	1	0	0	0
5-Jan	0	0	1	0	0	3	0	0	0
6-Jan	0	0	0	0	0	0	0	1	2
7-Jan	0	0	0	0	0	0	0	0	2
8-Jan	1	0	0	0	0	0	0	1	1
9-Jan	2	0	0	0	1	1	0	1	0
10-Jan	0	0	0	0	0	3	0	0	0
11-Jan	1	0	0	0	0	1	0	0	0
12-Jan	0	0	0	0	0	0	0	0	1
13-Jan	1	0	0	0	0	0	0	1	0
14-Jan	0	0	0	0	0	1	0	0	0
15-Jan	1	0	0	0	1	0	0	1	0
16-Jan	1	0	2	0	0	0	0	0	0
17-Jan	1	0	0	0	0	0	0	0	0
18-Jan	1	0	0	0	0	0	0	0	0
19-Jan	0	0	1	0	0	0	0	0	0
20-Jan	2	0	0	0	0	0	1	0	0
21-Jan	1	0	0	0	0	0	0	0	0
22-Jan	1	0	0	0	1	1	0	0	0
23-Jan	0	0	0	0	0	1	0	0	0
24-Jan	2	0	0	0	0	0	1	0	0
25-Jan	0	0	0	0	0	0	0	0	0
26-Jan	1	0	0	0	0	0	0	0	0
27-Jan	1	1	0	0	0	1	0	0	0
28-Jan	0	0	0	0	0	1	0	0	0
29-Jan	0	0	0	0	0	1	0	0	0
30-Jan	0	0	0	0	1	1	0	0	0
31-Jan	2	0	0	0	0	1	0	0	0
1-Feb	1	0	0	0	0	0	0	0	0
2-Feb	0	0	0	0	0	0	0	0	0
3-Feb	2	0	1	0	0	0	0	1	0
4-Feb	0	1	0	0	0	0	0	0	0
5-Feb	0	0	0	0	0	0	0	0	0
6-Feb	0	0	0	0	0	0	0	0	0
7-Feb	0	1	0	0	0	0	0	1	0
8-Feb	0	0	0	0	0	0	0	0	0
9-Feb	0	0	0	0	0	0	0	0	0
10-Feb	1	0	0	0	0	0	0	0	0
11-Feb	0	0	0	0	0	0	0	1	0
12-Feb	0	0	0	1	0	0	0	0	1
13-Feb	2	0	0	0	0	1	0	0	0
14-Feb	0	1	0	0	0	0	0	0	0
15-Feb	0	0	0	0	0	0	0	0	0
16-Feb	1	0	0	0	0	0	0	0	0
17-Feb	0	0	0	0	0	0	0	0	0
18-Feb	0	0	0	0	0	0	0	0	0
19-Feb	0	0	0	0	1	0	0	0	0
20-Feb	0	0	0	0	1	0	0	0	0
	28	4	9	1	10	18	2	8	7

Table 9. Revised Data Observations (Minus Days With No Delays)

Date	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other
2-Jan	0	0	2	0	2	0	0	0	0
3-Jan	2	0	2	0	2	0	0	0	0
4-Jan	0	0	0	0	0	1	0	0	0
5-Jan	0	0	1	0	0	3	0	0	0
6-Jan	0	0	0	0	0	0	0	1	2
7-Jan	0	0	0	0	0	0	0	0	2
8-Jan	1	0	0	0	0	0	0	1	1
9-Jan	2	0	0	0	1	1	0	1	0
10-Jan	0	0	0	0	0	3	0	0	0
11-Jan	1	0	0	0	0	1	0	0	0
12-Jan	0	0	0	0	0	0	0	0	1
13-Jan	1	0	0	0	0	0	0	1	0
14-Jan	0	0	0	0	0	1	0	0	0
15-Jan	1	0	0	0	1	0	0	1	0
16-Jan	1	0	2	0	0	0	0	0	0
17-Jan	1	0	0	0	0	0	0	0	0
18-Jan	1	0	0	0	0	0	0	0	0
19-Jan	0	0	1	0	0	0	0	0	0
20-Jan	2	0	0	0	0	0	1	0	0
21-Jan	1	0	0	0	0	0	0	0	0
22-Jan	1	0	0	0	1	1	0	0	0
23-Jan	0	0	0	0	0	1	0	0	0
24-Jan	2	0	0	0	0	0	1	0	0
26-Jan	1	0	0	0	0	0	0	0	0
27-Jan	1	1	0	0	0	1	0	0	0
28-Jan	0	0	0	0	0	1	0	0	0
29-Jan	0	0	0	0	0	1	0	0	0
30-Jan	0	0	0	0	1	1	0	0	0
31-Jan	2	0	0	0	0	1	0	0	0
1-Feb	1	0	0	0	0	0	0	0	0
3-Feb	2	0	1	0	0	0	0	1	0
4-Feb	0	1	0	0	0	0	0	0	0
7-Feb	0	1	0	0	0	0	0	1	0
10-Feb	1	0	0	0	0	0	0	0	0
11-Feb	0	0	0	0	0	0	0	1	0
12-Feb	0	0	0	1	0	0	0	0	1
13-Feb	2	0	0	0	0	1	0	0	0
14-Feb	0	1	0	0	0	0	0	0	0
16-Feb	1	0	0	0	0	0	0	0	0
19-Feb	0	0	0	0	1	0	0	0	0
20-Feb	0	0	0	0	1	0	0	0	0
	28	4	9	1	10	18	2	8	7

Table 10. Ranked Observations

Date	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other
2-Jan	4.0	4.0	8.5	4.0	8.5	4.0	4.0	4.0	4.0
3-Jan	8.0	3.5	8.0	3.5	8.0	3.5	3.5	3.5	3.5
4-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
5-Jan	4.0	4.0	8.0	4.0	4.0	9.0	4.0	4.0	4.0
6-Jan	4.0	4.0	4.0	4.0	4.0	4.0	4.0	8.0	9.0
7-Jan	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	9.0
8-Jan	8.0	3.5	3.5	3.5	3.5	3.5	3.5	8.0	8.0
9-Jan	9.0	3.0	3.0	3.0	7.0	7.0	3.0	7.0	3.0
10-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
11-Jan	8.5	4.0	4.0	4.0	4.0	8.5	4.0	4.0	4.0
12-Jan	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	9.0
13-Jan	8.5	4.0	4.0	4.0	4.0	4.0	4.0	8.5	4.0
14-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
15-Jan	8.0	3.5	3.5	3.5	8.0	3.5	3.5	8.0	3.5
16-Jan	8.0	4.0	9.0	4.0	4.0	4.0	4.0	4.0	4.0
17-Jan	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
18-Jan	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
19-Jan	4.5	4.5	9.0	4.5	4.5	4.5	4.5	4.5	4.5
20-Jan	9.0	4.0	4.0	4.0	4.0	4.0	8.0	4.0	4.0
21-Jan	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
22-Jan	8.0	3.5	3.5	3.5	8.0	8.0	3.5	3.5	3.5
23-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
24-Jan	9.0	4.0	4.0	4.0	4.0	4.0	8.0	4.0	4.0
26-Jan	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
27-Jan	8.0	8.0	3.5	3.5	3.5	8.0	3.5	3.5	3.5
28-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
29-Jan	4.5	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5
30-Jan	4.0	4.0	4.0	4.0	8.5	8.5	4.0	4.0	4.0
31-Jan	9.0	4.0	4.0	4.0	4.0	8.0	4.0	4.0	4.0
1-Feb	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
3-Feb	9.0	3.5	7.5	3.5	3.5	3.5	3.5	7.5	3.5
4-Feb	4.5	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5
7-Feb	4.0	8.5	4.0	4.0	4.0	4.0	4.0	8.5	4.0
10-Feb	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
11-Feb	4.5	4.5	4.5	4.5	4.5	4.5	4.5	9.0	4.5
12-Feb	4.0	4.0	4.0	8.5	4.0	4.0	4.0	4.0	8.5
13-Feb	9.0	4.0	4.0	4.0	4.0	8.0	4.0	4.0	4.0
14-Feb	4.5	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5
16-Feb	9.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
19-Feb	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5	4.5
20-Feb	4.5	4.5	4.5	4.5	9.0	4.5	4.5	4.5	4.5
R_j^2	269.0	188.5	197.0	175.0	206.0	232.5	178.5	205.0	193.5

Table 11. Squaring Ranks

Date	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other	
2-Jan	16.00	16.00	72.25	16.00	72.25	16.00	16.00	16.00	16.00	256.5
3-Jan	64.00	12.25	64.00	12.25	64.00	12.25	12.25	12.25	12.25	265.5
4-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
5-Jan	16.00	16.00	64.00	16.00	16.00	81.00	16.00	16.00	16.00	257.0
6-Jan	16.00	16.00	16.00	16.00	16.00	16.00	16.00	64.00	81.00	257.0
7-Jan	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	81.00	243.0
8-Jan	64.00	12.25	12.25	12.25	12.25	12.25	12.25	64.00	64.00	265.5
9-Jan	81.00	9.00	9.00	9.00	49.00	49.00	9.00	49.00	9.00	273.0
10-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
11-Jan	72.25	16.00	16.00	16.00	16.00	72.25	16.00	16.00	16.00	256.5
12-Jan	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	81.00	243.0
13-Jan	72.25	16.00	16.00	16.00	16.00	16.00	16.00	72.25	16.00	256.5
14-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
15-Jan	64.00	12.25	12.25	12.25	64.00	12.25	12.25	64.00	12.25	265.5
16-Jan	64.00	16.00	81.00	16.00	16.00	16.00	16.00	16.00	16.00	257.0
17-Jan	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
18-Jan	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
19-Jan	20.25	20.25	81.00	20.25	20.25	20.25	20.25	20.25	20.25	243.0
20-Jan	81.00	16.00	16.00	16.00	16.00	16.00	64.00	16.00	16.00	257.0
21-Jan	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
22-Jan	64.00	12.25	12.25	12.25	64.00	64.00	12.25	12.25	12.25	265.5
23-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
24-Jan	81.00	16.00	16.00	16.00	16.00	16.00	64.00	16.00	16.00	257.0
26-Jan	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
27-Jan	64.00	64.00	12.25	12.25	12.25	64.00	12.25	12.25	12.25	265.5
28-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
29-Jan	20.25	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	243.0
30-Jan	16.00	16.00	16.00	16.00	72.25	72.25	16.00	16.00	16.00	256.5
31-Jan	81.00	16.00	16.00	16.00	16.00	64.00	16.00	16.00	16.00	257.0
1-Feb	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
3-Feb	81.00	12.25	56.25	12.25	12.25	12.25	12.25	56.25	12.25	267.0
4-Feb	20.25	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
7-Feb	16.00	72.25	16.00	16.00	16.00	16.00	16.00	72.25	16.00	256.5
10-Feb	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
11-Feb	20.25	20.25	20.25	20.25	20.25	20.25	20.25	81.00	20.25	243.0
12-Feb	16.00	16.00	16.00	72.25	16.00	16.00	16.00	16.00	72.25	256.5
13-Feb	81.00	16.00	16.00	16.00	16.00	64.00	16.00	16.00	16.00	257.0
14-Feb	20.25	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
16-Feb	81.00	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	243.0
19-Feb	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	20.25	243.0
20-Feb	20.25	20.25	20.25	20.25	81.00	20.25	20.25	20.25	20.25	243.0
	1961.00	945.25	1041.50	772.00	1145.00	1497.25	811.75	1124.50	1010.25	10308.5

Formulas

Summation of squared ranks for all variables

A2= 10308.50

$$A2 = \sum_{i=1}^{b}\sum_{j=1}^{k}\left[R\left(X_{ij}\right)\right]^2$$

$$A2 = 1961.00 + 945.25 + \ldots + 1124.50 + 1010.25$$
$$A2 = 10308.50$$

B2= 9393.88

$$B2 = \frac{1}{b}\sum_{j=1}^{k} R_j^2$$

$$B2 = ((1/41)(269^2)) + \ldots + ((1/41)(193.5^2))$$
$$B2 = 1764.90 + \ldots + 913.91$$
$$B2 = 9393.88$$

T2= 7.39

$$T2 = \frac{(b-1)\left[B_2 - bk(k+1)^2/4\right]}{A_2 - B_2}$$

$$F(\alpha, k-1, (b-1)(k-1)) = F(0.05, 8, 320) = 1.94$$

DECISION RULE: If T2 > test statistic, then reject null hypothesis (no differences in causes of train delays)

T2= 7.39, test statistic = 1.94
7.39>1.94, therefore, null hypothesis is rejected.

**CONCLUSION: There are differences between the factors causing train delays.

Figure 8. Friedman's Rank Test Equations

Comparisons Formula

30.01 $$\left|R_j - R_i\right| \rangle t_{1-\alpha/2}\left[\frac{2b(A_2 - B_2)}{(b-1)(k-1)}\right]^{\frac{1}{2}}$$

$$t(1-\alpha/2;(b-1)(k-1)) = t(.975;320) = 1.96$$

A2=10308.50
B2=9393.88
b=41 (# of samples (days))
k=9 (# of independent variables))

$$t_{1-\alpha/2}\left[\frac{2b(A_2-B_2)}{(b-1)(k-1)}\right]^{1/2} =$$

$$1.96\left[\frac{82(10308.50-9393.88)}{(40)(8)}\right]^{1/2} =$$

$$1.96\left[\frac{82(914.62)}{320}\right]^{1/2} = 1.96[234.37]^{1/2} = 1.96(15.31) = 30.01$$

	Power	Crew Rest	Dispatch Held	Rail Window	Ramp Release	Late Set	Extra Car	Bad Order	Other
Power		80.5	72.0	94.0	63.0	36.5	90.5	64.0	75.5
Crew Rest	80.5		8.5	13.5	17.5	44.0	10.0	16.5	5.0
Dispatch	72.0	8.5		22.0	9.0	35.5	18.5	8.0	3.5
Rail Window	94.0	13.5	22.0		31.0	57.5	3.5	30.0	18.5
Ramp Release	63.0	17.5	9.0	31.0		26.5	27.5	1.0	12.5
Late Set	36.5	44.0	35.5	57.5	26.5		54.0	27.5	39.0
Extra Car	90.5	10.0	18.5	3.5	27.5	54.0		26.5	15.0
Bad Order	64.0	16.5	8.0	30.0	1.0	27.5	26.5		11.5
Other	75.5	5.0	3.5	18.5	12.5	39.0	15.0	11.5	

A2
10308.50

$$\left|R_j - R_i\right|$$

$$269.0-188.5=80.5, 269.0-197.0=72.0, 269.0-175.0=94.0, 269.0-206.0=63.0, etc.$$

$$188.5-269.0=80.5, 188.5-197.0=8.5, 188.5-175.0=13.5, etc.$$

$$197.0-269.0=72.0, 197.0-188.5=8.5, etc.$$

Figure 9. Comparative Statistics Formulas

Appendix E

Table 12. Data Observations For Linear Regression (15 Jan Data Point Deleted)

Date	Train Delay (Min)	# 36 Hr Cars
2-Jan	770	102
3-Jan	540	97
4-Jan	150	89
5-Jan	530	93
6-Jan	430	60
7-Jan	50	61
8-Jan	540	58
9-Jan	515	8
10-Jan	480	109
11-Jan	40	25
12-Jan	90	57
13-Jan	95	70
14-Jan	40	62
16-Jan	455	62
17-Jan	150	97
18-Jan	120	24
19-Jan	255	107
20-Jan	105	55
21-Jan	210	2
22-Jan	410	36
23-Jan	90	55
24-Jan	320	37
25-Jan	0	28
26-Jan	320	39
27-Jan	50	73
28-Jan	30	29
29-Jan	80	18
30-Jan	40	0
31-Jan	840	64
1-Feb	330	6
2-Feb	0	49
3-Feb	425	17
4-Feb	30	40
5-Feb	0	9
6-Feb	0	1
7-Feb	280	0
8-Feb	0	0
9-Feb	0	56
10-Feb	130	10
11-Feb	75	51
12-Feb	170	2
13-Feb	170	8
14-Feb	115	6
15-Feb	0	17
16-Feb	80	5
17-Feb	0	22
18-Feb	0	34
19-Feb	105	2
20-Feb	140	10

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.402
R Square	0.162
Adjusted R Square	0.144
Standard Error	30.564
Observations	49.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.000	8463.619	8463.619	9.060	0.004
Residual	47.000	43906.300	934.177		
Total	48.000	52369.918			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	27.603	6.012	4.592	0.000	15.510	39.697
X Variable 1	0.062	0.021	3.010	0.004	0.021	0.104

DECISION RULE:

Test for slope of line. If slope is other than zero, then a positive relationship exists between delayed trains and number of "36-hour cars."

If t-Statistic > critical value (from t-distribution tables), then beta not is rejected.

$$B_0 = 0$$
$$B_1 \neq 0$$

$$\alpha = \alpha / 2$$
$$\alpha = .05 / 2$$
$$\alpha = .025$$

p=degrees of freedom
n=no. of samples

$$p = n - 2$$
$$p = 49 - 2$$
$$p = 47$$

t Statistic for slope of train delay (min) equals 3.01.

critical value from t-Distribution table is interpolated to be 2.013.

3.01 > 2.013

therefore beta not is rejected, the slope is not equal to zero, and a positive relationship exists between train delays and number of "36-hour cars."

Figure 10. Regression Results (15 Jan Data Point Deleted)

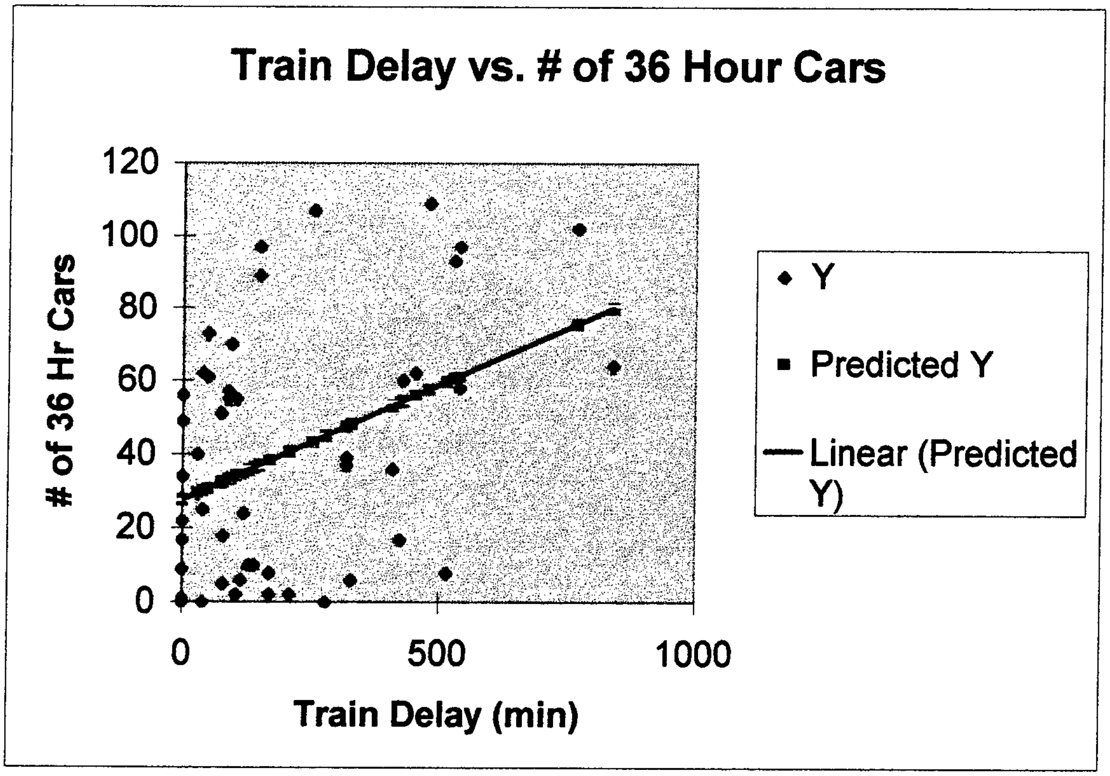

Figure 11. Regression Chart (15 Jan Data Point Deleted)

Appendix F

Data Point	Qty
15-Jan	155.0

Predicted Value
y = a + b (x)
y = 33.17 + .05 (x)
y = 33.17 + .05 (190)
y = 33.17 + 9.5
y = 42.67

Residual Value
155.0 - 42.67 = 112.33

Outlier found. Since the 15 Jan data point exceeds 3 standard deviations from the expected value, the data point can be deleted from the sample.

Figure 12. Exploratory Analysis Results

Appendix G

Table 13. Data Observations For Linear Regression (Includes 15 Jan Data Point)

Date	Train Delay (Min)	# 36 Hr Cars
2-Jan	770	102
3-Jan	540	97
4-Jan	150	89
5-Jan	530	93
6-Jan	430	60
7-Jan	50	61
8-Jan	540	58
9-Jan	515	8
10-Jan	480	109
11-Jan	40	25
12-Jan	90	57
13-Jan	95	70
14-Jan	40	62
15-Jan	190	155
16-Jan	455	62
17-Jan	150	97
18-Jan	120	24
19-Jan	255	107
20-Jan	105	55
21-Jan	210	2
22-Jan	410	36
23-Jan	90	55
24-Jan	320	37
25-Jan	0	28
26-Jan	320	39
27-Jan	50	73
28-Jan	30	29
29-Jan	80	18
30-Jan	40	0
31-Jan	840	64
1-Feb	330	6
2-Feb	0	49
3-Feb	425	17
4-Feb	30	40
5-Feb	0	9
6-Feb	0	1
7-Feb	280	0
8-Feb	0	0
9-Feb	0	56
10-Feb	130	10
11-Feb	75	51
12-Feb	170	2
13-Feb	170	8
14-Feb	115	6
15-Feb	0	17
16-Feb	80	5
17-Feb	0	22
18-Feb	0	34
19-Feb	105	2
20-Feb	140	10

SUMMARY OUTPUT with outlier included

Regression Statistics	
Multiple R	0.357
R Square	0.127
Adjusted R Square	0.109
Standard Error	34.459
Observations	50.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.000	8325.061	8325.061	7.011	0.011
Residual	48.000	56996.159	1187.420		
Total	49.000	65321.220			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	30.017	6.738	4.455	0.000	16.469	43.566
X Variable 1	0.062	0.023	2.648	0.011	0.015	0.109

DECISION RULE:

Test for slope of line. If slope is other than zero, then a positive relationship exists between delayed trains and number of "36-hour cars."

If t-Statistic > critical value (from t-distribution tables), then beta not is rejected.

$$B_0 = 0$$
$$B_1 \neq 0$$

$$\alpha = \alpha / 2$$
$$\alpha = .05 / 2$$
$$\alpha = .025$$

p=degrees of freedom
n=no. of samples

$$p = n - 2$$
$$p = 50 - 2$$
$$p = 48$$

t Statistic for slope of train delay (min) equals 2.65.

critical value from t-Distribution table is interpolated to be 2.012.

2.65 > 2.012

therefore beta not is rejected, the slope is not equal to zero, and a positive relationship exists between train delays and number of "36-hour cars."

Figure 13. Regression Results (15 Jan Data Point Included)

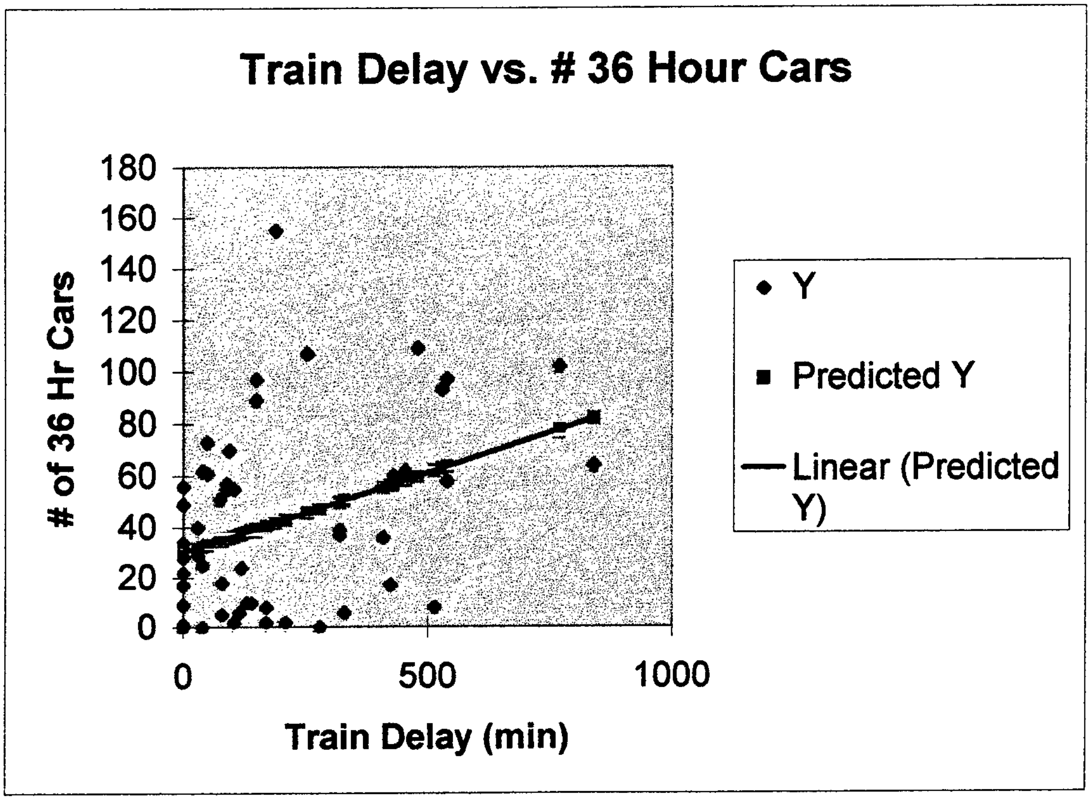

Figure 14. Regression Chart (15 Jan Data Point Included)

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