

STOCK MARKET VOLATILITY: A COMPARISON OF COMPUTER AND CELLULAR HARDWARE COMPANIES

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ABSTRACT

Stock market volatility has been omnipresent in the information technology sector. This manuscript compares the stock performance of computer and cellular hardware companies across six different twenty-month periods between the years 1996-2006. The focus periods include the browser era, the Y2K era, the post-Y2K era, the post-9/11 era, the outsourcing era and the mobile/wireless era. The lowest stock market returns are in the Y2K or post-9/11 eras for all eight firms. The highest stock market returns for the eight companies in the study focus on four different eras. The results imply that while computer and cellular hardware companies have a tendency to decline in price in a down market, positive return periods in a bull market are not highly correlated within the industry.

JEL: D0; G1; L8

KEYWORDS: Abnormal Stock Returns, Cellular Hardware, Computer Hardware, Stock Market

INTRODUCTION

The information technology sector has transformed the economy and changed the basis of competition (Sampler, 1998). Information technology boosts the efficiency of the decision-making process and is perceived by many executives as an integral part of their business strategy (Molloy and Schwenk, 1995; Bartholomew, 1998). Investors have struggled to comprehend the potential and the limitations of information technology companies as the industry has continued to evolve over time. Not surprisingly, the volatility of stock prices for information technology firms has been extreme as many companies struggle to survive a couple of years after reaching a peak stock valuation. On March 10, 2000 the NASDAQ composite peaked at an intra-day high of 5,132 and declining to half of its value within a year before finding a bear market bottom on October 10, 2002 with an intra-day low of 1,108. The excessive rise and fall of information technology companies offers a unique opportunity to evaluate industry nuances associated with bear and bull markets.

The purpose of this research is to compare the stock market performance of multiple computer and cellular hardware companies across multiple information technology eras. The six period classifications are the browser era, Y2K era, post-Y2K era, post-9/11 era, outsourcing era, and mobile/wireless era. Apple, Dell, Ericsson, Hewlett-Packard, Nokia, Motorola, Qualcomm, and Sony are the eight computer and cellular hardware companies included in the study. The organization of this manuscript is into five sections. First, the related literature on financial performance of information technology companies is discussed. The next section offers background information relating to the six information technology eras applied to this study, the computer and cellular hardware industry, and the eight specific companies that are the focus of this study. The third section presents data and methodology. The fourth section puts forth results from the application of a nonparametric technique in order to compare stock market returns across different information technology eras for the eight companies. The final section offers concluding comments.

REVIEW OF THE LITERATURE

Academic research identifying structural economic changes that influence stock prices mostly focus on major crashes in the history of financial markets (Higgins & Osler, 1997; Allen & Gale, 2000; Cocca, 2005). Although a relatively new topic in for the information technology sector, there are numerous in finance theory that focus on the development of speculative bubbles and stock market volatility (Camerer, 1989; Bulow & Klemperer, 1994; Allen & Gale, 2000). Stock market volatility is explained by various approaches, which differ in essence according to assumptions made with regard to market efficiency (Sornette & Malevergne, 2001). Stock market performance of information technology companies reveals the sector has greater volatility than most other economic sectors (Demers & Lev, 2001; Ofek & Richardson, 2003; Kamssu, Reithel, & Ziegelmayr, 2003).

Cocca (2005) puts forth one of the few studies exploring potential reasons for the volatility of the stock market of information technology companies. The study uses a broad media database to analyze the informational and media environment surrounding the market highs for technology stocks and explores potential trigger events that could cause an Internet bubble to burst. Two key informational event triggers are public awareness of the human genome research results and the publication of a study by Barron's magazine about Internet companies' burn rates. Cocca (2005) concludes diffusion data of the informational events show a long-term impact of the Barron's study on media, financial analyst and consequently investor focus on attention.

Researchers are becoming more and more interested in studies relating IT investment and firm performance (Im, Dow, & Grover, 2001). The studies have produced a wide range of performance results that are negative or not conclusive (Tam, 1998), mixed (Avison, Eardley, & Powell, 1998; Bleiweiss, 1998; Ranganathan & Samarah, 2001), or positive a positive and significant relationship between IT investment and firm financial performance (Im, Dow, & Grover, 2001). Kamssu, Reithel, & Ziegelmayr (2003) explore the impact of information technology and stock returns. They conclude that Internet-dependent firms have lower excess returns than non-Internet firms do in a booming economy and that Internet stocks trade at relatively higher prices than non-Internet stocks. The explosion of Internet technology and behavior of investors and decision makers toward firms that use the Internet suggest that Internet technology must have an impact on firms' market performance.

Stock performance helps investors gauge how well their managers are handling their money. Several studies have proposed different methods to assess stock performance. Armitage & Jog (1996), Rogerson, (1997), and Clinton & Chen (1998) have used economic value as a measure of performance. The economic value added is obtained by comparing profits with the cost of capital involved in obtaining these profits (Stephens & Bartunek, 1997). Johnson & Pazderka (1993) and Sundaram, John, and Kose (1996) have employed stock market performance estimates to measure firm performance. Fama & French (1995), Loughran (1997), Zaher (1997) and Ranganathan & Samarah (2001) employ the stock excess returns based on the Capital Asset Pricing Model (CAPM) to measure stock performance. Historically, the stock values of information technology firms bear very little relationship to classical business performance measures (Savitz, 1998), which creates a need for non-traditional proxies and estimation methods.

The statistical methodology incorporated in this study employs a nonparametric approach to comparing the stock market performance of firms across a decade of six different development stages for the information technology industry. The study uses multiple years of data based on the diffusion model hypothesis that the spread of information needs time and stock price momentum reflects gradual diffusion of firm-specific information (Hong & Zhu, 2006). There is no research focusing on stock market volatility of computer and cellular hardware companies.

BACKGROUND INFORMATION

Between 1996 and 2006, several major events in the field of information technology made a lasting impact on many businesses and consumers. Six implicit periods are identified for the purposes of this study. Although somewhat arbitrary, the six periods are placed in twenty-month segments in an effort to capture stock market returns in a broad representative timeframe. The six period classifications are the browser era, Y2K era, post-Y2K era, post-9/11 era, outsourcing era, and mobile/wireless era.

The browser era is defined in the study as the 20-month period of August 1996 through March 1998. The World Wide Web was but a few years old when Mosaic, often considered the first browser, was introduced. The web was massive and complicated. Prior to Mosaic, access to the Internet was largely limited to text, with any graphics displayed in separate windows. Users needed to possess certain technical knowledge and skills to exploit available capabilities and access both the Internet and the web. Mosaic eventually became Netscape. The success of Netscape gained the attention of Microsoft, which developed the Explorer browser. A cluster of related and supporting technologies came together to make the browser a significant innovation breakthrough. The browser era developed with the assistance of computer servers, bandwidth affordability and availability, content providers, and communication links. The browser interface made it easier for users to connect to the web and created a significant critical mass of users.

The use of browsers to connect to the Internet pressured software developers and content providers to adhere to certain accepted specifications and standards. These standards and specifications enhanced the interoperability of web-related products and services. For years, enterprises struggled to find reliable, cost-effective ways to integrate and automate critical processes between different application packages. The web-enabled applications and technology provided the enterprises with the ability to integrate different systems and application types regardless of their platform, operating system, programming language or locations. In essence, the browser was the key that unlocked the World Wide Web to a massive number of users. Netscape was the most used browser to access the web. It allowed millions of users to navigate the web and was the vehicle that linked people and information. The catalyst marked the boom in the Internet. The browser made it possible for millions of users to access the web daily, to send messages and to perform business transactions that would not have been possible without the browser. The browser has changed the way society communicates, created new businesses and contributed to the demise of other businesses.

The Y2K era is defined in the study as the 20-month period of April 1998 through November 1999. In the early days of software development and hardware design, it was common practice to use standard two-digit shorthand to indicate the year. This practice infiltrated many software applications and hardware design schemas. In the early nineties, this became known as the Y2K problem. The Y2K problem implied that some software and hardware would not perform as expected after December 31, 1999. While many were relieved that the catastrophic consequence of Y2K did not materialize, it is clear that this era had profound impact on the amount of expenditures in the field of information technology. This was fueled by the commercialization of the Internet and the need to overhaul information technology infrastructure in preparation to address the potential Y2K problem. The Department of Commerce estimated that there was approximately \$100 billion spent to address the Y2K problem in the United States (Manion & Evan, 2000). The significance of Y2K is more than the expenditure amount, it also provided opportunities to shift to new computing platforms, implementing new approaches to software applications development and highlighted the relevant role of information technology to the overall enterprise's business strategy.

The post-Y2K era is defined in the study as the 20-month period of December 1999 through July 2001. The 2001 year had been a bust with the dot-com implosion and the downturn of the economy. The pre-

Y2K buildup resulted in the post-Y2K bust for many information technology companies. Many companies cut back on information technology expenditures during this era because of the significant expenditures in the preceding era. Despite the bursting of the dot-com bubble, significant advances in information technology continued during this era. The importance of critical infrastructure, the need for compliance with security regulations, the importance of business continuations plans, and data mining/warehousing were four major themes that emerged during this time.

This study defines the post-9/11 era as the 20-month period of August 2001 through March 2003. The event of September 11 accentuated the importance and the vulnerability of information technology in the event of catastrophic attack. It necessitated the need to develop plans to identify its critical infrastructure that are required to maintain minimum operation of the economy and government. The security of critical infrastructure became a vital concern. The perceived increase in risk from growing reliance on technology to support operations and from expanding market bases including growth in the global sector. Security of critical infrastructure and other resources went through extensive change to mitigate the risks. Federal regulations tightened security regulations to include many aspects of business processes and functions. Information technology was targeted as the means in which to be employed to meet the security concern.

The sense of urgency to meet security demands and concerns by the federal government made it easier to fund many of the new research and development activities by businesses. Moreover, many businesses recognized the value of computer security as a large, emerging market. During this time, the importance of data centers redundancy of data and the need for diversity of geographic concentration of information technology resources gained in relevance and significance. In addition, network infrastructure influenced businesses in very profound manner that required continued increase in computing power. Barriers that existed between firms for most of the 20th century gave way to accommodate the need for partnership-based opportunities afforded through e-business. The need for interoperability and flexibility increased during this era to exploit new business opportunities. This created a demand for new system architectures to mitigate the shortcomings of grid computing and client server technologies. The continuous decline in the storage cost of data, the increase of computing power, and the availability of broadband bandwidth reduced the incentive for firms to discard any data. The availability of stored digital data and information presented firms and government agencies with a major challenge to identify ways to make some sense of the huge amount of data. The government's heightened concern with security was instrumental in funding new developments in data mining and contributed to the increase use of business-intelligence software to mine huge amount of stored data.

The outsourcing era is defined in the study as the 20-month period of April 2003 through November 2004. In this era, companies were looking for different measures to cut costs and to improve the balance sheet. Outsourcing and off shoring became prominent business strategies to reduce operational cost, to enhance services, and to improve financial performance. In addition to the economic and market conditions, three Laws influenced this period: Moore's (growing power of computer chips), Metcalfe's (growing network usefulness) and Gilder's (growing communications bandwidth). These laws transformed processes, products and services. Combining the economic conditions and the changes in information technology made it possible to reduce cost but to continue performing certain functions of the business at the same or higher level. Businesses quickly realized the cost advantage of developing and maintaining their software applications in India, China and Eastern Europe. In looking back at that era, it is clear that notwithstanding the challenging economic conditions at the time, it marked the beginning of accepting outsourcing as a cost-reduction strategy. The outsourcing phenomena affected many areas of information technology including software development and programming, technical support, calling centers and customer services.

The mobile/wireless era is defined in the study as the 20-month period of December 2004 to August 2006. The term mobile computing can be described as the use of portable computing devices either in transit or from a remote location. Wireless technology had been around for many years but the industry-transformed society during this era. The mobile computing environment is composed of small devices that permit users to have access to information almost anywhere at any time. The increased access by users to the Internet, the innovation of wireless technology, and the high number of cellular phone services contributed to the growth of mobile computing. Moreover, the dependency and the reliance on laptops and hand-held devices to perform computing functions increased the demand for mobile and wireless products and services.

The computer and cellular hardware industry is dominated by household income and business investment. Sales depend on new products that capture the buyer's attention and warrant the expenditure to upgrade to the new product. The industry has faced declining prices for products with more features than the preceding product. However, firms that create new products with substantial increases in features and functionality are able to increase price. Because of the reliance on new product development, the industry is capital-intensive. However, the high rate of change of innovation eliminates any value to a patent. The lack of value to research and development has created a situation of co- or re-branding. Larger firms market and service the products of smaller firms who use the larger firms' distribution network for sales. As the industry has aged, computers and cell phones have begun to merge into one product. Consumers expect that one device will do multiple things and will be compatible with other devices. Firms have responded by pushing consumers to sign multiple-year contracts. This guarantees a base level of return and creates a situation where the manufacturer has some time to develop the next stage product without losing the customer. The manufacturers' goal is to create the next product while the customer is still under the longer-term contract and allow the customer to upgrade. With the constant upgrades, product life spans have decreased. The industry has had to learn to survive with customers who demand upgrades in quality and functionality but not in price.

Apple Inc. (AAPL) is an American multinational corporation that designs and manufactures consumer electronics and computer software products. The company's best-known hardware products include Macintosh computers, the iPod and the iPhone. Apple software includes the Mac operating system, the iTunes media browser, the iLife suite of multimedia and creativity software, the iWork suite of productivity software, Final Cut Studio, a suite of professional audio and film-industry software products, and Logic Studio, a suite of audio tools. The important events for Apple during the 120-month period of this study include the 1997 return of Steve Jobs to the company, the introduction of the iMac computer, the introduction of the iPod, the opening of a line of Apple retail stores, and the development of the iPhone. The uniqueness of Apple's products has been positive in terms of sales from the design innovations but negative in terms of the incompatibility of its products. Apple held the title of largest computer firm in the early 1980s but it fell out of favor with once the market became dominated by Windows-based computing.

The browser period moved the industry towards the Internet and Apple struggled during this period. It had negative earnings per share for 1996 and 1997 and had to end its dividend in 1997 after reducing it by 75% in 1996. It reduced its workforce by 30% and ended several major research & development projects. The lack of innovation and direction led to the return of Jobs. Jobs worked with Microsoft to create a Mac version of the Office Suite, which reduced the incompatibility problem for Apple. Jobs also removed the cloning license from Power Computing, which had become Apple's chief competitor for Apple software. Apple returned to profitability and saw its net profit margin increase to 7.7% by 2000. In and after the post-Y2K era, Apple experienced declining margins. While it introduced new products such as the iPod at the end of 2001, it was unable to compete with the market that had turned to laptops and a focus on security. This changed with the iPhone and its increased functionality. The iPhone combined the best of Apple's innovative design with a platform that allowed for multiple uses. Learning

the lesson of the Macintosh computer, Apple allowed others to create applications for the iPhone, further increasing its functionality and dominance. Apple's net profit margin soared to over 9% by 2005 from just 1.2% in 2003. The high earnings growth allowed both the P/E ratio to decline to a more normal level and the stock price to double in less than a year.

Dell Inc. (DELL) is a multinational technology corporation based in Round Rock, Texas. The company develops, manufactures, sells and supports personal computers and other computer-related products. Dell grew during the 1980s and 1990s to become the largest seller of PCs and servers. As of 2009, it held the second spot in computer-sales within the industry behind Hewlett-Packard. The company sells personal computers, servers, data storage devices, network switches, software and computer peripherals. Dell also sells HDTVs, cameras, printers, MP3 players and other electronics built by other manufacturers. Dell's business model of built-to-order personal computers allowed the firm to carry lower inventories of supplies and of finished products. This lowered the firm's costs and thus, increased profit margins. Dell's net profit margin grew from 6.8% in 1996 to 8% in 1998 and stayed above 7% through 2000. Dell became synonymous with home computers in the 1990s. However, as desktops evolved into laptops and features became more standard, Dell began to lose its position. Until 2007, Dell had virtually no presence in big box stores, preferring the direct-to-consumer model that had worked so well. This model worked well for business customers who bought many computers and wanted quantity discounts and a standard product. However, home customers liked the ability to see and to touch the computer before buying. Additionally, the home customer did not know about all of the different components and thus, ordering the computer by picking computers was overwhelming. Most home consumers wanted speed and reliability in a lightweight laptop at a low price.

With consumers focused on price more than on features, Dell looked to lower costs. Outsourcing, and in particular, outsourcing of call centers to India lowered costs. Dell's profit margins, which had fallen by over 20% after the tech bubble burst, rebounded to close to 6.8%. In 2008, Dell closed its Texas desktop manufacturing facility. As the industry moved to mobile networking, Dell did not have a major player in the market and its profitability quickly dropped. Dell responded by focusing to two segments, luxury laptops to compete with the high-end Apple laptops, and enterprise hardware such as work and storage systems to compete with IBM. Stock investors have not been supportive of Dell in recent years. It was once one of the four horsemen of the Nasdaq. In 1999, investors were willing to pay a P/E of over 60 for Dell. By 2009, Dell's P/E had fallen to below 20. A decrease of this magnitude is difficult for any company to overcome. Dell's future depends on if it can capture the home computing market once again. While there is no phone or video game machine that goes with the computer, Dell needs a hook into the entertainment side of computers.

Ericsson (ERIC), one of the largest Swedish companies, is a leading provider of telecommunication and data communication systems, and related services covering a range of technologies, including especially mobile networks. Directly and through subsidiaries, it also has a major role in mobile devices and cable TV and IPTV systems. Throughout the 1990s, Ericsson held a 35-40% market share of installed cellular telephone systems. Like most of the telecommunications industry, Ericsson suffered heavy losses after the telecommunications crash in the early 2000s. It was forced to do a 1-for-10 reverse stock split in 2002. On October 1, 2001 the handsets division formed a joint venture with Sony called Sony Ericsson. Ericsson is now a major provider of handset cores and an infrastructure supplier for all major wireless technologies. It has played an important global role in modernizing existing copper lines to offer broadband services and has actively grown a new line of business in the professional services area. Ericsson's focus on the hardware for networks has allowed it to survive the rough times. Its North American business is less than 10% of total sales while Europe is more than 50% of revenues. Ericsson, while considered a quality product, has never been able to make a huge dent in North America because its wireless products are functional but without the features of an iPhone or BlackBerry. In contrast, its network hardware has a strong reputation and is the growth engine for the firm. The firm's net profit

margin bounced from negative values in 2001 and 2002 to over 11% by 2004. Its focus on infrastructure hardware is profitable; the net profit margin has been close to or over 15% since 2005. U.S. investors have not recognized fully the strengths of Ericsson's business. The lack of a consumer presence has resulted in a declining P/E ratio. Ericsson's P/E ratio was close to 90 in 2000 but less than 20 since 2004. It is one of the few technology companies to pay a dividend, which increased yearly since the 2005 reinstatement. Over the entire 120-month period, Ericsson has the lowest total return.

Hewlett-Packard Company (HPQ) is a technology corporation headquartered in Palo Alto, California. HPQ is the largest technology company in the world and operates in nearly every country. Hewlett-Packard specializes in developing and manufacturing computing, storage and networking hardware, software and services. Major product lines include personal computing devices, enterprise servers, related storage devices, as well as a diverse range of printers and other imaging products. Other product lines, including electronic test equipment and systems, medical electronic equipment, solid-state components and instrumentation for chemical analysis became Agilent Technologies in 1999. Hewlett-Packard markets its products to households, small to medium size businesses and enterprises both directly, via online distribution, consumer-electronics and office-supply retailers, software partners and major technology vendors.

The important events for Hewlett-Packard during the 120-month period of this study include the \$8 billion spinoff creating Agilent, the hiring of Carly Fiorina as the first female CEO of a company in the Dow Jones Industrial Average, merger with Compaq and the outsourcing of enterprise support to lower cost workers in other countries. Of the five companies examine, HPQ has the highest correlation in stock price with the Nasdaq index at 0.91. While in all areas of IT, HPQ is almost synonymous with printers. While not a glamorous part of the technology industry, printers are a necessary component, which created a steady increase in earnings and net profit margin over the first two eras. Additionally, steady income in the form of ink purchases helped to provide income. In the post-9/11 era, HPQ lowered price in order to maintain steady sales and market share. Its net profit margin fell by more than 50%. It was during this same time that HPQ acquired Compaq, which evolved into a contentious proxy fight. HPQ's stock price declined. After the departure of Fiorina in early 2005, the new leadership of Mark Hurd refocused the firm on imaging. Printing had been a declining activity as the Internet facilitated document sharing. However, the move to the consumer in the wireless/handheld era created a need for easier imaging products. HPQ responded with docking products and the ability to print quality pictures from a home printer. Earnings and net profit margin increased resulting in the stock price doubling in 2005-06.

Nokia Corporation (NOK) is a Finnish multinational communications corporation with headquarters in Keilaniemi, Espoo, which neighbors Finland's capital city of Helsinki. Nokia is the world's largest manufacturer of mobile telephones: its global device market share was about 38% in Q2 2009, down from 40% in Q2 2008 and up from 37% in Q1 2009. Nokia produces mobile devices for every major market segment and protocol. Nokia offers Internet services that enable people to experience music, maps, media, messaging and games. Nokia's subsidiary, Nokia Siemens Networks, produces telecommunications network equipment, solutions and services. Nokia has sites for research and development, manufacture, and sales in many countries throughout the world. As of December 2008, Nokia had R&D presence in 16 countries. North America is Nokia's smallest market at less than 5% of sales. Nokia's strength lies in its ability to provide niche products around the world. Recognizing the income differences, Nokia's creates different products for lower income countries.

Nokia also demonstrates an ability to adapt to the changing market. As location-based applications have increased for smart phones, Nokia acquired NAVTEQ to improve its navigation features. The technology bubble burst hurt all technology firms, Nokia recovered quickly because of its diversified approach to products and to geography. No one product or place is the dominate revenue producer. Earnings dipped in 2001 but by 2002, Nokia's earnings had surpassed levels of the late 1990s. Earnings dipped again

during the outsourcing era as other firms lowered costs and prices but Nokia maintained prices. While sales have steadily increased, so have costs, lowering the net profit margin. Since 2003, Nokia's net profit has decreased from 13.4% to less than 10%. U.S. stock investors have not punished the firm for this decline. The P/E ratio has fluctuated in the 15 to 16 range over the same period. Stock price increases are a function of earnings growth and not P/E ratio growth. Looking ahead, the industry may be moving to an area of expertise for Nokia. Netbooks and other small computing devices focus on the interplay of portability and wireless computing at an affordable price, which is something Nokia has been providing in the lower income countries through its mobile devices.

Motorola, Inc. (MOT) is an American, multinational, telecommunications company based in Schaumburg, Illinois. It is a manufacturer of wireless telephone handsets, and designs and sells wireless network infrastructure equipment such as cellular transmission base stations and signal amplifiers. Motorola's home and broadcast network products include set-top boxes, digital video recorders, and network equipment used to enable video broadcasting and high-definition television. Its business and government customers consist mainly of wireless voice and broadband systems used to build private networks and public safety communications systems. Motorola is still a major competitor in the wireless handset market at number three in the world. Unfortunately, as the market has fractured under new competition, Motorola's market share has fallen from 22% in 2006 to 8% in 2008. Like all of the technology companies, Motorola rode the wave of the technology boom and bust. Historically, Motorola's business plan has focused on cutting costs and increasing volume.

As some of the firms began to recover, Motorola struggled until they were able to leverage their cost-cutting strategy. This strategy worked well during the outsourcing era and beginning of the wireless era as the firm was able to benefit from lower costs. As cell phones became commonplace, not all customers could afford the higher-end phones. Motorola's products met this market and its net profit margin reflects the strategy. The net profit margin increased from 1.2% in 2002 to 7.9% in 2005. Towards the end of the wireless era, the market moved to products with greater functionality and features. Motorola struggled to increase volume because its products lacked the design innovations of products such as the iPhone. As earnings growth decreased, the stock price fell but not because the P/E decreased. The P/E ratio actually increased, indicating that some investors believe that Motorola can reinvent itself. Motorola has been diversifying its product line into wireless enterprise products and television-on-demand technologies. Additionally, Motorola has been decreasing its shares outstanding, which has also provided the floor for the P/E ratio.

Qualcomm (QCOM) is a wireless telecommunications company, as well as the largest chip supplier in the world, based in San Diego, California. In 1999, Qualcomm sold its base station business to Ericsson, and later, sold its cell phone manufacturing business to Kyocera. In return, the company focused on developing and licensing wireless technologies and selling ASICs that implement them. In 2000, Qualcomm acquired Snaptrack, the inventor of the assisted-GPS system for cell phones. The Snaptrack patents describe how a cell phone acquires a GPS signal rapidly using timing information sent from the base station. This reduces the searching time for location from minutes down to roughly one second. In October 2004, Qualcomm acquired Trigenix Ltd, a mobile software company. After integrating the company, Qualcomm re-branded their interface markup language and its accompanying integrated development environment. In 2006, Qualcomm purchased Flarion Technologies in an effort to capture the Flash-OFDM wireless base station. Qualcomm's focus on research and development means that costs incurred in one time may not create a return for several periods.

What is unique about QCOM is its ability to maintain a higher than industry average net profit margin. When other firms' profitability dropped in 2001, Qualcomm's net profit margin increased. Perhaps the most important determinant for Qualcomm's stock is the P/E ratio. Qualcomm's P/E ratio rose to over 90 in 2000. By 2003, Qualcomm's net profit margin had rebounded to close to its 2000 value but the P/E

ratio had fallen to around 30. The severe drop in the P/E ratio during the post-Y2K and post-9/11 periods explains the drop in the stock price. The loss in confidence in Qualcomm as a growth engine continues even though the firm's net profit margin was above 35% in 2004 and has stayed at such high levels. Additionally, the firm instituted a dividend in 2003 and has steadily increased it since then. Dividends can be sign to investors that the growth potential of the firm is lower but QCOM's margins do not indicate this. As a supplier of components to the major wireless manufacturers, QCOM has been in a unique position of selling components to competitor firms. Patents cover the components. Qualcomm has been involved in several fights with competitors and customers over the patents, which is one reason for the downward pressure on stock price. The sellers of wireless devices have wanted more competition in the components market in order to keep input prices down. Qualcomm has resisted this trend. With the industry moving to one device doing a variety of things for consumers, QCOM has been expanding into new segments such as wireless banking and entertainment software. Qualcomm is positioning itself for the wireless applications era.

Sony Corporation (SNE) is a multinational conglomerate corporation headquartered in Minato, Tokyo, Japan and one of the world's largest media conglomerates. Sony is one of the leading manufacturers of electronics, video, communications, video game consoles and information technology products for the consumer and professional markets. Sony's principal business operations include Sony Corporation (Sony Electronics in the U.S.), Sony Pictures Entertainment, Sony Computer Entertainment, Sony Music Entertainment, Sony Ericsson, and Sony Financial. Sony has approached the computer and cellular industry from the entertainment side. Sony is used to strong competition and a fickle consumer. Through its years in electronics, Sony has built a reputation for quality, which has allowed it to charge above market prices. Each Sony product works seamlessly with other Sony products, which has created a loyal consumer base. When Sony moves into an industry, it looks to gain market share in order to control the direction of the industry. In the computer industry, Sony originally focused on gaming consoles that also played movies and music. Sony sold consumers the device and the content, creating a steady stream of inflows from the sales of one device.

Just as the technology boom was ending, entertainment consoles were converging with the personal computers. Consumers wanted computers to move from business applications to include more entertainment. Additionally, the rise of the Internet created a focus on visualization, in which Sony was already proficient through its gaming consoles and movie business. While Hewlett-Packard and Dell began to alter their focus to businesses, Sony remained in the consumer market, utilizing retail outlets to display its products. Because of its focus on consumers, Sony is more susceptible to changes in consumer spending than the firms that have significant sales to businesses. As consumer spending began to increase after 9/11, Sony's earnings increased but its P/E continued to decrease which created resistance for its stock price. In the outsourcing era, Sony's focus on costs paid off and its net profit margin doubled from 1.2% to 2.4%. However, the low margins mean that Sony has little room for error. While the VAIO laptop increased in popularity and competed with Dell, HPQ, and Apple, stock investors have been reluctant to increase its P/E ratio. In the wireless era, Sony continued its strength in areas such as electronics, gaming consoles and cameras. However, the industry move to cell phones and more interactive devices has introduced new competition for Sony. Sony has netbooks, reading devices, and portable music devices but none have the market dominance required by Sony's volume-based business model. Over the 120-month period, Sony's stock price has the second lowest price appreciation.

The firms competing in the computer and cellular hardware business are all survivors. Many competitors have disappeared, whether through bankruptcy or acquisition. To continue to survive the firms must navigate a highly competitive industry with customers who want more functionality and more features but are resistant to price increases for all items except the newest, trendiest product. Two themes dominate the industry. Value quickly migrates to the blockbuster product and firm. For the other firms, value migrates to the low cost producer.

DATA AND METHODOLOGY

Is there a difference in the stock market performance of computer and cellular hardware companies in the different period classifications? In this section, we compare the stock market returns of computer and cellular hardware companies in six different twenty-month periods between the years 1996 through 2006. Eight different information technology firms specializing in computer or cellular hardware are the focus of this study. The primary data source is the Yahoo! finance website, which offers daily and monthly closing stock prices across multiple years. The six period classifications are the browser era, Y2K era, post-Y2K era, post-9/11 era, outsourcing era, and mobile/wireless era. The statistical methodology incorporates a nonparametric approach to comparing the stock market performance of a company in the six different periods. The Kruskal-Wallis test offers the most powerful test statistic in a completely randomized design without assuming a normal distribution. A traditional event study methodology is not applicable to this specific research design because the research periods require a long time horizon instead of the narrow window associated with an event study. In addition, a nonparametric approach is more efficient given the limitation of defining all six periods in a strict twenty-month period given some eras might be somewhat longer or shorter than the twenty-months.

The Kruskal-Wallis test is sensitive to differences among means in the k populations and is extremely useful when the alternative hypothesis is that the k populations do not have identical means. The null hypothesis is that the k company stock returns in the different periods come from an identical distribution function. For a complete description of the Kruskal-Wallis test, see Conover (1980). The specific equations used in the calculations are as follows:

$$N = \sum_i n_i \text{ with } i = 1 \text{ to } k \quad (1)$$

$$R_i = \sum_j R(X_{ij}) \text{ with } j = 1 \text{ to } n_i \quad (2)$$

$$R_j = \sum_i O_{ij} R_i \text{ with } i = 1 \text{ to } c \quad (3)$$

$$S^2 = [I/(N-I)] [\sum_i t_i R_i^2 - N(N+I)^2/4] \text{ with } i = 1 \text{ to } c \quad (4)$$

$$T = (I/S^2) [\sum_i (R_i^2/n_i) - N(N+I)^2/4] \text{ with } i = 1 \text{ to } k \quad (5)$$

$$| (R_i/n_i) - (R_j/n_j) | > t_{1-\alpha/2} [S^2(N-I-T)/(N-k)]^{1/2} [(1/n_i) + (1/n_j)]^{1/2} \quad (6)$$

where R is the variable rank and N is the total number of observations. The first three equations find average ranks. Equation (4) calculates the sample variance, while equation (5) represents the test statistic. If, and only if, the decision is to reject the null hypothesis, equation (6) determines multiple comparisons of stock market returns across the various periods.

RESULTS

Table 1 offers summary statistics for the eight companies in the research cohort. Ericson is the most volatile company in the research sample with the largest standard deviation and sample variance. In fact, the monthly stock returns of Ericson represent the largest mean value, the largest median value, the smallest minimum value, the second largest maximum value and the smallest 120-month period return. Monthly returns for the companies range from a minimum of -0.5436 for Ericson to a maximum of 1.3657 for Apple. The most notable observation is the relatively large 120-month returns of more than 800% for Apple, Dell, Nokia and Qualcomm. All eight companies have a positive 120-month return although Ericson, Sony, Motorola and Hewlett-Packard clearly earn returns well below the other four companies.

The nonparametric empirical approach yields eight T-values of 34.36 (p-value = .0001) or higher, indicating a significant difference in stock market returns across the six period classifications for all companies in the study. Table 2 presents a summary of the average rank value of stock market returns for

each company across the six periods defined in this study. Assuming an alpha level of .05, the empirical results from equation 6 indicate all companies have three or more times with stock market returns that are statistically different.

Table 1: Summary Statistics for Computer and Cellular Hardware Firms Average Monthly Returns

Firm	Mean	Median	Standard Deviation	Sample Variance	Minimum	Maximum	Return for 120-month Period
AAPL	-0.0052	-0.0330	0.1928	0.0372	-0.3118	1.3657	1,020%
DELL	-0.0104	-0.0120	0.1362	0.0185	-0.3323	0.5324	974%
ERIC	0.0162	0.0015	0.2025	0.0410	-0.5436	1.0273	23%
HPQ	0.0001	-0.0040	0.1247	0.0156	-0.2613	0.4709	142%
NOK	-0.0090	-0.0195	0.1429	0.0204	-0.2980	0.5611	804%
MOT	0.0028	-0.0072	0.1199	0.0144	-0.2092	0.5044	61%
QCOM	-0.0081	-0.0245	0.1691	0.0286	-0.4858	0.6337	1,395%
SNE	0.0028	-0.0115	0.1113	0.0124	-0.3531	0.4202	46%

This table shows summary statistics for the average monthly returns of computer and cellular hardware firms. The sample period is the 120-months between August 1996 and August 2006.

The most interesting observation from Table is the consistent low relative return earned in the post-Y2K (period 3) and post-9/11 (period 4) eras. All eight companies achieve their lowest return period in the post-Y2K or post-9/11 eras. The results clearly imply companies in the same industry all face financial challenges during the declining phase of a stock market bubble. Although the consistent negative return in the two bubble eras might seem obvious, it is important to note all the companies in the study survived the stock market bubbles of the post-Y2K and post-9/11 eras. The fact that even survivors consistently struggled and not a single firm prospered is noteworthy given several firms earned high overall returns during the 120-months of the study. In fact, three companies (Dell, Nokia and Qualcomm) earned 120-month returns higher than 800% but still followed the tide of achieving their relative low return period in post-Y2K era. One of the limitations of the study is a potential survivor firm bias, where companies that did not survive the stock market bubble burst of the post-Y2K or post-9/11 eras are not part of the study. This limitation is somewhat mitigated by the observation that companies that did not survive almost certainly hit low periods in the post-Y2K or post-9/11 eras.

Table 2: Computer and Cellular Hardware Firms (Average Rank Order Value of Returns)

Firm	T-values (p-value)	Period 1 8/96 – 3/98	Period 2 4/98 – 11/99	Period 3 12/99 – 7/01	Period 4 8/01 – 3/03	Period 5 4/03 – 11/04	Period 6 12/04 – 8/06
AAPL	45.11 (.001)	29.2 -	83.7**	24.7 -	42.8 *	95.7***	87.1**
DELL	39.83 (.001)	104.0***	90.5**	17.2 -	67.0 *	60.6*	24.4 -
ERIC	34.36 (.001)	90.6**	58.0*	49.2*	17.2 -	103.8***	51.2*
HPQ	36.39 (.001)	83.9***	51.3**	38.1*	21.5 -	80.0***	85.9***
NOK	38.46 (.001)	93.9***	94.9***	25.0 -	48.1*	39.7*	64.6**
MOT	35.98 (.001)	64.0*	78.2**	18.3 -	25.8 -	101.4***	75.4**
QCOM	42.24 (.001)	75.4**	89.9***	19.1 -	28.8 -	97.5***	62.5*
SNE	35.33 (.001)	86.2**	62.4**	15.7 -	47.0*	95.1***	56.8**

This table shows average rank order value of stock market returns derived from a Kruskal-Wallis nonparametric methodology. The first column is a listing of the ticker symbols for the eight computer and cellular hardware companies included in the study. The second column is the value of the equation (5) test statistic and p-value for each company, which determines if there is a statistical difference in stock market returns across the six periods. Columns three through eight present the average rank value of the stock market returns for the six periods of the study. Asterisk(*) and negative signs (-) signify difference in average rank values as follows:

- (1) *** Indicates period with highest statistically significant return derived from equation 6.
- (2) ** Indicates period with second highest statistically significant return derived from equation 6.
- (3) * Indicates period with third highest statistically significant return derived from equation 6.
- (4) - Indicates period with lowest statistically significant return derived from equation 6.
- (5) Some periods do not have a return that is statistically significant from an alternative period.
- (6) Total return for ten year period is 102.6% for the Dow Jones Industrial Average
- (7) Total return for ten-year period is 91.3% for the NASDAQ Composite Index.

The high return period for computer and cellular hardware companies is more diverse across all firms compared to the relative low return periods. The eight companies in the study achieve their highest return period in four different eras. On the other hand, five of the eight companies achieve their highest relative return in the outsourcing era (period 5), providing moderate evidence of industry correlation during both the fall and rise of financial markets. Only Nokia and Dell do not have a relatively high return period in the outsourcing era. Nokia and Dell are two of three companies with the highest 120-month total return. The negative returns associated with a bear market decline appears to capture all information technology companies in the hardware business but positive stock market returns do not appear to be correlated in a bull market.

CONCLUDING COMMENTS

The purpose of this research is to compare the stock market performance of eight computer and cellular hardware companies across six information technology eras. The six period classifications are the browser era, Y2K era, post-Y2K era, post-9/11 era, outsourcing era, and mobile/wireless era. The statistical methodology incorporates a nonparametric Kruskal-Wallis test to compare the stock market performance of the companies in the research cohort. The primary data source is the Yahoo! finance website.

The results of this study imply the correlation of stock market prices for computer and cellular hardware companies during the time of a bear market are higher than a bull market. Growth rates and expenditures are more likely to influence stock prices in a bull market. Fear and falling valuations are the primary drive in a bear market. Specifically, all eight companies achieve their lowest return in the bear periods of the post-Y2K or post-9/11 eras. In contrast, the eight companies in the study achieve their highest return period in four different eras. The consistency of the bear market results is somewhat surprising given the ten-year variation in firm stock market return ranges from 23% to 1,395%.

One of the limitations of the study is a potential survivor firm bias, where companies that did not survive the stock market bubble burst of the post-Y2K or post-9/11 eras are not part of the study. This limitation is somewhat mitigated by the observation that companies that did not survive almost certainly hit low periods in the post-Y2K or post-9/11 eras. A second limitation of the study is the application of stock market returns across a very broad timeframe encompassing 120-months. Traditional finance event studies usually focus on daily data for a very short window of time in order to minimize the potential contamination of other events. This study requires the use of a larger than normal research window in order to compare the six different period classifications. Thus, the results should be interpreted with caution given the potential for correlation with other events that occurred in any given focus era. One avenue for future research is to examine consistency of the empirical results across alternative information technology sectors, which include semiconductor, software, network service, and vertically integrated companies.

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