Volume 1, Number 2

GLOBAL JOURNAL OF ACCOUNTING AND FINANCE

Marianne James California State University, Los Angeles Editor

> Patricia Ryan Colorado State University Co Editor

L. Murphy Smith Murray State University Associate Editor

The *Global Journal of Accounting and Finance* is owned and published by the Institute for Global Business Research. Editorial content is under the control of the Institute for Global Business Research, which is dedicated to the advancement of learning and scholarly research in all areas of business.

Authors execute a publication permission agreement and assume all liabilities. Institute for Global Business Research is not responsible for the content of the individual manuscripts. Any omissions or errors are the sole responsibility of the authors. The Editorial Board is responsible for the selection of manuscripts for publication from among those submitted for consideration. The Publishers accept final manuscripts in digital form and make adjustments solely for the purposes of pagination and organization.

The *Global Journal of Accounting and Finance* is owned and published by the Institute for Global Business Research, 1 University Park Drive, Nashville, TN 37204-3951 USA. Those interested in communicating with the *Journal*, should contact the Executive Director of the Institute for Global Business Research at info@igbr.org.

Copyright 2017 by Institute for Global Research, Nashville, TN, USA

EDITORIAL REVIEW BOARD

Shirley A. Hunter University of North Carolina Charlotte

Hafiz Imtiaz Ahmad New York Institute of Technology Abu Dhabi Campus

Robert D. Campbell Hofstra University

S. Sagathevan SRM University, India

Olga Matveieva Dnipropetrovsk Regional Institute of Public Administration of the National Academy of Public Administration

Michael Grayson CUNY--Brooklyn College

Sorinel Căpușneanu Dimitrie Cantemir Christian University, Bucharest

Hari Sharma Virginia State University

Nikhil Chandra Shil East West University, Dhaka

Andrew Perumal University of Massachusetts, Boston

Robert Marley University of Tampa

Marek Gruszczynski Warsaw School of Economics Xiaoquan Jiang Florida International University

Ron Stunda Valdosta State University

Malek Lashgari University of Hartford

Hema Rao SUNY-Oswego

Darryl J. Woolley University of Idaho

Mindy Kushniroff Western Governors University

Charles Jordan Florida State University - Panama City

Jan L. Williams University of Baltimore

Gianluca Mattarocci University of Rome Tor Vergata, Rome

Elham Farzanegan Nahavand University, Iran

Junaid M. Shaikh Curtin University, Malaysia

James A. DiGabriele Montclair State University

Rafiuddin Ahmed James Cook University, Australia Nabiyula Gichiyev Dagestan Scientific Center of the Russian Academy of Sciences

Susan Shurden Lander University

Prasoom Dwivedi University of Petroleum and Energy Studies, India

Theresa Tiggeman University of the Incarnate Word

TABLE OF CONTENTS

THE ECONOMIC IMPACT OF MILITARY BASE CLOSURES ON THE SURROUNDING METROPOLITAN AREA
Jamie Amos, Hampton University
AN EMPIRICAL ANALYSIS OF QUALITY,PRODUCTIVITY AND PROFITABILITY
Chiaho Chang, Montclair State University
IMPLIED RISK ADJUSTED DISCOUNT RATES AND CERTAINTY EQUIVALENCE IN CAPITAL BUDGETING
Timothy Gallagher, Colorado State University Hong Miao, Colorado State University Patricia A. Ryan, Colorado State University
ECONOMIC FACTORS PREDICTING INFLATION IN THE US, ENGLAND, FRANCE, AND GERMANY
Morsheda Hassan, Wiley College Raja Nassar, Louisiana Tech University
SUSTAINABILITY REPORTING PRIORITIES – A STUDY EXPLORING ACCOUNTING MAJORS' PERCEPTIONS
Marianne L. James, California State University, Los Angeles
ARTIFICIAL NEURAL NETWORK SYSTEM FOR PREDICTION OF US MARKET INDICES USING MISO AND MIMO APROACHES
Hari Sharma, Virginia State University Hari S. Hota, Bilaspur University Kate Brown, University of Maryland Eastern Shore

THE ECONOMIC IMPACT OF MILITARY BASE CLOSURES ON THE SURROUNDING METROPOLITAN AREA

Jamie Amos, Hampton University

ABSTRACT

Amidst the decline in defense spending following the end of the Cold War, military base closures have prompted some of the most vocal public concerns. Public expectations of the impact often are very bleak, and economic forecasts of the local effects seem to bolster such fears. When a military base is slated to close, the surrounding community immediately goes into panic mode and thinks it is the start of an economic domino effect that will trickle down to every part of the community. However, economic devastation is not always the case as my research has found that an economic decline is not the probable outcome. The closing of a military base is not as devastating as most predict it would be.

The Base Realignment and Closure Commission (BRAC) was created to provide an objective, thorough, accurate, and non-partisan review and analysis, through a process determined by law, to create a list of bases and military installations which the Department of Defense recommends to be closed and/or realigned. This study focuses on factors that indicate the economic health of a community and expands the scope to metropolitan areas. A "pre" and "post" closure approach is taken to compare the differences in the economy of the surrounding metropolitan area. The economic factors included in this study are unemployment rate, median home value, population, median household income, real estate taxes paid and K-12th school enrollment. Of those factors, unemployment rate and population were impacted positively, while median home value was the only factor negatively impacted. The bases closed in the year 2011 as part of the 2005 BRAC round of closure is the focus as this was the last round of closures and provides the latest information on this topic.

Depending on the extent to which a military base supports the surrounding community, it could have far-reaching financial implications for that community; however, this research suggests most communities are not impacted as much as the negative predictions seem to be.

INTRODUCTION

Catastrophic, apocalyptic, and disastrous are words used to describe the impact of military base closures on the surrounding communities. Hooker & Knetter (2001) shows that a closure has a dire initial impact that gets better over time and eventually the community will spring back to some type of normalcy as time progresses. Other studies (Bayly, 2014), (Dardia, et al., 1996), (Nijhawan & Jackson, 2011), (Soresnson & Stenberg, 2015) have viewed the impacts as long lasting at times and the community can never totally recover from the base closure. Both studies have legitimacy, depending on the extent of economic and financial influence the base exerted in that community. The size and location of the base also play a major role in the impact it has on

that community. The effects can be socioeconomic, political, direct, and indirect, along with other significances that come with a major change.

The closing and/or realignment of U. S. Military bases nationally and internationally have presented challenges for the Department of Defense (DoD) and the surrounding communities. Past research has brought about varied results, as different variables can influence the outcome of those results (Dardia, et al, 1996). This study will focus on the metropolitan areas of the bases closed in the year 2011 as part of the 2005 BRAC round of closures, with emphasis on six key economic indicators. Those economic indicators include the unemployment rate, median home value, population, median household income, property taxes paid, and K-12th school enrollment.

BACKGROUND

With the passage of the Base Realignment and Closure Act (BRAC Act. 1998), Congress instituted a new process with which to determine how military bases would be closed and/or realigned (Beaulier, Hall, & Lynch, 2011). The BRAC process can be considered as a two-stage process. Initially, a list of sites is gathered for BRAC scrutiny; then, each site is carefully considered for closure or realignment. There are four possible outcomes of the base closure and realignment process: closure, realignment resulting in a loss of employees and budget share, realignment resulting in an increase in employees and budget share, or no meaningful change (Beaulier, Hall, & Lynch, 2011).

Minimum oversight was given to Congress in the closing of military bases by the Department of Defense. Per the Department of Defense (2005), however, in 1977, Congress passed legislation requiring DoD to notify Congress if an installation became a closure or realignment candidate. These and other procedural requirements effectively halted base closures until the last several rounds between 1988 and 2005. By 1988, the Defense budget had declined for three straight years and was predicted to decline further. The Department of Defense has estimated that the four previous BRAC rounds eliminated approximately 21 percent of DoD's 1988 installation capacity. These changes required an up-front investment of \$22 billion, and through fiscal year 2001, produced net savings of approximately \$17.7 billion, including the cost of environmental cleanup. Recurring savings and cost avoidances beyond 2001 are approximately \$7.3 billion annually (Defense, 2005).

LITERATURE REVIEW

The BRAC Commission was created to provide an objective, thorough, accurate, and nonpartisan review and analysis, through a process determined by law, to create a list of bases and military installations which the Department of Defense recommends to be closed and/or realigned (Defense Base Closure and Realignment Commission, 2005). The Commission is required to assess each recommendation to ensure it meets the eight selection criteria set forth by Congress in P.L. 108-375 (Defense Base Closure and Realignment Commission, 2005). Recommendations by DoD that substantially deviate from these selection criteria can be modified or rejected by the Commission by a simple majority vote of the Commissioners. The Commission can also add installations to the closure or realignment list recommended to the President, but only through a process in which seven of nine Commissioners vote to do so, the Secretary of Defense is properly notified in writing 15 days prior to the proposed change, and only after at least two Commissioners physically visit the military installation in question (Defense, 2005).

The Commission's assessment of the selection criteria and Force Structure Plan took place in the context of a balance between the goals of realizing savings and rationalizing our military infrastructure to meet the needs of future missions. Table 1 shows United States National defense consumption between the years 2005 - 2016. U. S. national defense spending increased each year from 2005 to 2011, then decreased starting in 2012 which coincides with the year after the closing of the bases in this study.

	United States National Defense Consumption										
					\$ = bi	llions					
2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
\$608.30	\$642.40	\$678.70	\$754.10	\$788.30	\$832.80	\$836.90	\$817.80	\$767.00	\$746.00	\$732.00	\$732.20

Table 1United States National Defense Consumption

The Base Realignment and Closure process has been one of the Defense Department's most effective tools to trim excess infrastructure and better align the remaining base structure to the U.S. force structure; and over the years, these effects have provided significant savings that have been redirected to readiness (Sands, 2011).

Base closure impacts are registered in job loss, income terms, and may be disaggregated as well into direct, indirect, and induced components (Poppert & Herzog, 2003). Personal income represents the income that households receive from all sources including wages and salaries, fringe benefits such as employer contributions to private pension plans, proprietors' income, and income from rent, dividends and interest and transfer payments such as Social Security and unemployment compensation (econoday.com, 2016). According to Bradshaw (1999), the time lag from closure to reuse of a base typically means that workers cannot wait for new opportunities on the base and will seek employment elsewhere in the area or move to another region. In addition, when bases are reused, the new industries are usually quite different and need workers with different skills and sometimes specialized training; and when laid-off workers do find other work, their income is well below what they received working on the base (Bradshaw T. K., 1999). Many examples of workers affected by base closures reinforce the widespread belief that people taking new jobs often must settle for lower pay (Bradshaw T. K., 1999). One systematic study by Mackinnon (1978) showed that workers in the early waves of a base closure took jobs that on average were lower paying. According to the United States Bureau of Labor Statistics (2016), the unemployment rate is a key indicator of the local economic conditions. Because a base closure creates changes in the population and income, it also impacts the housing market which in turn affects real estate tax paid. Community vulnerability is also sensitive to the presence of a school on the base and the age distribution of the dependent populations; the greater the fraction of the local school population accounted for by military dependents, the greater the loss in government funding after those children leave the district (Dardia, et al, 1996).

RESEARCH DESIGN

A causal-comparison design is adopted for this study to show the difference between the year prior to closure to the year after. Per Fraenkel and Wallen (2006) causal-comparative research, like correlational research, seeks to identify associations among factors. A causal-comparative research attempts to determine the cause or consequences of differences that already exist between or among groups of individuals (Fraenkel & Wallen, 2006). A Wilcoxon signed-ranks test is utilized to calculate the difference between the year before and the year after the base closure to determine if there is an impact using different factors. Past research has mixed results as to the level of impact to the surrounding communities when a military base is closed if any at all. The six factors used in this study includes median home value, real estate taxes, population, median household income, unemployment rate and K-12th school enrollment; which will serve as the independent variables. The Wilcoxon signed-ranks test used to analyze the impact of base closure is suitable since the sample size is small and does not meet the stringent assumptions of normality required in a similarly paired t-test (Pett, 2016). It is a non-parametric statistical hypothesis test used when comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population means ranks differ (Laerd Statistics, 2017). In the 2005 BRAC round of closures there were six bases closed in the year 2011; and although other bases were realigned, this study only focuses on the ones that were closed during that year. It focuses only on those bases that were closed the same year which keeps other factors that could have affected the economy in that year the same, and not cause the data to be slanted by some type of anomaly. The independent variables chosen for this study provide a framework for the economic health of a community. Combining each factor will provide a collective view of the impact that was felt by each metropolitan area. The data for each variable was gathered from the United States Census Bureau and the United States Bureau of Labor Statistics.

DATA COLLECTION

The data for each variable was gathered from the United States Census Bureau and the United States Bureau of Labor Statistics. The United States Census Bureau is a principal agency of the U.S. Federal Statistical System, responsible for producing data about the American people and economy. The Census Bureau is part of the U.S. Department of Commerce. The U.S. Census Bureau is overseen by the Economics and Statistics Administration (ESA) within the Department of Commerce. The Economics and Statistics Administration provides high-quality economic analysis and fosters the missions of the U.S. Census Bureau and the Bureau of Economic Analysis. The Bureau of Labor Statistics is a unit of the United States Department of Labor. It is the principal fact-finding agency for the U.S. government in the broad field of labor economics and statistics.

STATISTICAL ANALYSIS

Growth is viewed as essential for a stable and good economy. A strong economy bolsters a strong middle class along with increasing purchasing power for all walks of life. It also allows the government to spend more money on research and spur innovation. This research used that doctrine as a guide to determine the economic variables used in this research. The data was compiled and organized by the years being compared - prior to closing (2010) and after closing (2012) by each variable. It was then loaded into SPSS and analyzed to reveal results for each variable by year. A 0.05 confidence level was used during the testing. The effect size is calculated by dividing the z-score by the square root of the total number of occurrences. In this case, it will be six data points in the year 2010 and in the year 2012, which will be a total of twelve occurrences.

FACTORS ANALYZED

Impacts of base closure have been assessed by comparing measures of local wellbeing of pre-and post-BRAC statuses. The factors for this study were chosen because they are all key economic indicators of the health of a community. Unemployment rates express the number of people who are out of work and looking for jobs. Household income represents the earnings that households receive from all sources and is a major determinant of spending. Population is one of the most direct indicator a community's vulnerability. Home values are also a great indicator of economic health because it takes other factors like unemployment and income in consideration. In connection to home values, property taxes paid is also a factor that help express the health of a local economy. Lastly, K-12th school enrollment was included as military-connected schools are also impacted by military base closures.

DISCUSSION OF RESULTS

The impact of the base closures was not as devastating as most would think. Although there is some economic downturn to the community, the catastrophic predictions did not come to fruition in this research. The mean change in the unemployment rate is 1%. With a p-value of 0.01, the test revealed a statistically significant difference in the unemployment rate, with an effect size of 0.70. The unemployment rate decreased, which means more people in the metropolitan area were working after the base closure. The mean change in median home value is \$9,567. With a p-value of 0.05, the test revealed a statistically significant difference in median home value, with an effect size of 0.58. The median home value decreased from the year prior to closing to the year after. The mean change in population is 76,988. With a p-value of 0.03, the test revealed a statistically significant difference in population, with an effect size of 0.64. The population increased in the metropolitan areas surrounding the base after closure. The mean change in median household income is \$141. With a p-value of 0.96, the test revealed there was not a statistically significant difference in median household income, with an effect size of 0.03. This indicates that there was no economic impact to the surrounding metropolitan area after the base closure on median household income. The mean change in real estate taxes paid is \$13,348. With a p-value of 0.07, the test revealed there was not a statistically significant difference in real estate taxes paid, with an

effect size of 0.52. This is an indication that there is basically no economic impact on real estate taxes paid for the surrounding metropolitan area after a base closure. The mean change in school enrollment is 1,172. With a p-value of 0.75, the test revealed that there was not a statistically significant difference in school enrollment, with an effect size of 0.09. This is an indication that there is no economic impact in the surrounding metropolitan area on school enrollment after a base closure.

UTILIZATION OF VACANT BASE FACILITIES

The Department of Defense clearly states that base closures are conducted to improve military readiness and streamline the spending of defense funds (Defense, 2005), but environmental considerations also feature in the process of evaluating and converting sites (Havlick, 2014). When closing a military base, the government looks at the preservation options of the land. According to Havlick (2014), closed military bases are converted to a variety of new uses, ranging from playgrounds or recreational facilities to housing developments, business parks, and university campuses. However, many military lands face limited options for future use due to chemicals hazards, munitions, buildings, or aging infrastructure that remain on site. Due in part to these reasons, more than 15% of the major U.S. bases closed since 1988 have been re-designated as national wildlife refuges managed by the U.S. Fish and Wildlife Service (Havlick, 2014).

Although sometimes the reuse of these lands can be made in reaction to the panic of closing the bases, instead of a methodical plan to reuse the land to the best of its ability. When communities find out that one of the major resources in their area is shutting down, they rally together to either stop the process or take the opportunity to create something better. Successful base reuse planning begins before closure; communities with strong leadership and organizational capacity minimize the panic sometimes associated with base closure and also position it for a stronger response (Mayo, 1988). Base closure generally places extraordinary demands on local governments, community organizations and economic development programs; however, it also stimulates and strengthens a community's organizational capacity and its ability to work collaboratively and in innovative ways (Bradshaw, 1999).

CONCLUSION

This study aimed to determine the economic impact of the bases closed in 2011 as part of the 2005 round of BRAC closures as it pertains to six economic factors. Using the Wilcoxon signed-ranks test, it revealed that of the six factors in the study, only three of them proved to be significant. Employment, population and median home value were all significant factors in the economic impact of the base closures. The impact on employment and population proved to be positive for the local community and the impact on median home value proved to be negative.

The mean unemployment rate decreased one full percentage point prior to closing to after closure, which suggests of the people who remained, more of them were working after the base closure. Using a Wilcoxon signed-ranks test to compare the difference between pre and post base closure, all metropolitan areas in the study expressed a negative rank for the unemployment rate showing that 2012 was less than that in 2010. Additionally, the population increased for the

6

surrounding metropolitan areas of these bases. The mean change in population between the year prior to the year after increased over 75,000, which suggests most people stayed and more people came to those metropolitan areas after the bases was closed. The test revealed that the population ranks for all metropolitan areas in the study were positive showing that the population in 2012 was greater than that in 2010 after the base closures. However, this research shows that the housing value in these metropolitan areas declines because of the base closure, with an approximate mean change of a \$10,000 price drop in median home values. The test revealed that five of the metropolitan areas in the study expressed a negative rank, while one revealed a positive rank showing that median home value in 2012 decreased from 2010. The median home value was the only factor that proved to be significant and negative, which suggests that base closures are not the "end of the world" predictions that most proposed.

The other three factors used in this study, median household income, real estate taxes paid and school enrollment K-12th did not show a significant difference from the year prior to closing to the year after. Although they didn't prove to be significant, they are still important factors to consider when deciding which bases to close. United States defense consumption has fluctuated over time and as part of that fluctuation, military bases were closed and realigned to downsize its force structure and overhead expenses (Kuhn & Akers, 1997) however; with new concerns that threaten our everyday freedoms on a regular basis, these actions must be carefully considered. Bases must be scrutinized to reflect the impact of the military structure along with the impacts to the homeland.

REFERENCES

- Bayly, J. (2014, October 17). Challenges Remain 20 Years After Loring Air Force Base Closure. *Banger Daily News*.
- Beaulier, S., Hall, J., & Lynch, A. (2011). The Impact of Political Factors on Military Base Closures. *Journal of Economic Policy Reform*, 333-342.
- Bivens, J. (2003). Updated Employment Multipliers for the U.S. Economy. Washington, DC: Economic Policy Institute.
- Bradshaw, T. (1994). Defense Industry Conversion, Base Closure, and the California Economy: Critical Issues for a Statewide Strategy. *Fisher Center Working Papers*.
- Bradshaw, T. K. (1999). Communities Not Fazed, Why Military Base Closures May Not Be Catastrophic. *Journal of the American Planning Association*, 193-206.
- Bureau of Economic Analysis. (2017, February 28). Retrieved from Bureau of Economic Analysis: https://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&90 4=2005&903=98&906=a&905=2017&910=x&911=0
- *Bureau of Labor Statistics*. (2016, December 26). Retrieved from Bureau of Labor Statistics Web Site: https://www.bls.gov/cps/cps_htgm.htm
- Census Bureau. (2016, December 8). United States Census Bureau: Metropolitan and Micropolitan. Retrieved from United States Census Bureau: http://www.census.gov/population/metro/
- Collins, D. W., & Dent, W. T. (1979). The Proposed Elimination of Full Cost Accounting In the Extractive Petroleum Industry. *Journal of Accounting and Economics*, 3-44.

- Dardia, M., McCarthy, K., Malkin, J., & Vernez, G. (1996). *The Effects of Military Base Closures* on Local Communities. Santa Monica: RAND.
- De Pedro, K. T., Esqueda, M. C., Cederbaum, J. A., & Astor, R. A. (2014). District, School, and Community Stakeholder Perspectives on the Experiences of Military-Connected Students. *Teachers College Record*, 1-32.
- Defense Base Closure and Realignment Commission. (2005, September 8). Retrieved from Defense Base Closure and Realignment Commission: www.brac.gov
- Defense, D. o. (2005). *Base Closure And Realignment Report*. Washington D.C.: Department of Defense.
- Department of Defense, U. S. (2005). 2005 Defense Base Closure and Realignment Commission Report. Arlington: Department of Defense, United States.
- econoday.com. (2016, July 11). Retrieved from 2016 Economic Calendar: http://mam.econoday.com/byshoweventfull.aspx?event_id=269&cust=mam
- Fraenkel, N. E., & Wallen, J. R. (2006). *How To Design And Evaluate Research In Education*. New York: McGraw-Hill.
- Garner, J. K., Arnold, P. L., & Nunnery, J. (2014). Schoolwide Impact of Military-connected Student Enrollment: Educators' Perceptions. *Children and Schools*, 31-39.
- Gretzel, U., Yuan, Y.-L., & Fesesmaier, D. R. (2000). Preparing for the New Economy: Advertising Strategies and Change in Destination Marketing Organizations. *Journal of Travel Research*, 146-156.
- Havlick, D. (2014, January 3). Opportunistic Conservation at Former Military Sites in the United States. *Progress in Physical Geography*, pp. 271-285.
- Hooker, M., & Knetter, M. (2001). Measuring The Economic Effects of Military Base Closures. *Economic Inquiry*, 583-598.
- Johnston, K. (2016, July 29). *Chron.* Retrieved from www.chron.com: http://smallbusiness.chron.com/low-population-growth-affect-local-business-38039.html
- Kitmitto, S., Huberman, M., Blankenship, C., Hannan, S., Norris, D., & Christenson, B. (2011). *Edcuational Options and Performance of Military-Connected School Districts*. San Mateo: American Institutes For Research.
- Knight, M., Loayza, N., & Villanueva, D. (1996). The Peace Dividend: Military Spending Cuts and Ecnomic Cuts. Washington D.C.: The World Bank Policy Research Department Macroecnomics and Growth Division and International Monetary Fund.
- Kuhn, J., & Akers, S. (1997, Winter Winter). U. S. Miliatry Spending: A Survey of Analysis and Critique. *Reference & User Service Quarterly*, p. 137.
- Laerd Statistics. (2017, May 1). Retrieved from Laerd Statistics: https://statistics.laerd.com/spsstutorials/wilcoxon-signed-rank-test-using-spss-statistics.php
- Liow, K. H. (2010). Firm Value, Growth, Profitability and Ccapital Structure of Listed Real Estate Companies: an nternational perspective. *Journal of Property Research*, 119-146.
- Matishak, M. (2016, December 26). *The Fiscal Times*. Retrieved from The Fiscal Times: http://www.thefiscaltimes.com/2016/03/08/BRAC-Back-Will-Congress-Actually-Close-More-Military-Bases

- Mayo, P. (1988). *Military Base Closure and Community Transformation: The Case of England Air Force Base in Central Louisiana*. New Orleans: University of New Orleans.
- Metcalf, T. (2016, 7 11). *Chron.com*. Retrieved from Chron.com: http://work.chron.com/job-loss-affect-community-22916.html
- *National Association of Realtors*. (2016, December 26). Retrieved from National Association of Realtors: https://www.nar.realtor/
- Nijhawan, I., & Jackson, P. (2011). Ecnomic Impact of Base Realignment and Closing On The Fort Bragg Region and The Largest Military Base In The United States. *Journal of Economics and Economic Research*, 1-12.
- Pett, M. A. (2016). Nonparametric Statistics for Healthcare Research: Statistics for Small Samples and Unusual Distributions. Thousand Oaks: Sage Publications.
- Poppert, P., & Herzog, H. W. (2003). Force Reduction, Base Closure, and the Indirect Effects of Military Installations on Local Employment Growth. *Journal of Regional Science*, 459-481.
- Sands, A. (2011). Base Realignment and Closure Dollars and Sense in a Dynamic Environment. *The Journal of the American Society of Military Comptrollers*, 12-14.
- Simmons, T., & Kayn, T. (1992). Base Realignment and Closure; The Human Impact of Relocation. *Armed Forces Comptroller*, 16.
- Small Business Profit Explosion. (2015, April 30). Retrieved from Small Business Profit Explosion: http://wjb-cpa.typepad.com/wayne_j_belisle_cpa_busin/sales_marketing/
- Soresnson, D., & Stenberg, P. (2015). The Effects of Military Base Closures on Rural County Economies: An Evaluation of the 1988-1955 Rounds of Cuts. Washington DC: International Atlantic Economic Society.
- Tadlock, C. (2012). *Military Base Closures: Socioeconomic Impacts*. Washington D.C.: Congressional Research Service.
- United States Securities and Exchange Commission. (2015, July 31). Retrieved from United States Securities and Exchange Commission: https://www.sec.gov/investor/pubs/tenthingstoconsider.htm
- Wilkerson, C. R., & Williams, M. D. (2008, Second Quarter Second Quarter). How Is the Rise in National Defense Spending Affecting the Tenth District Economy? *Economic Review*, pp. 49-79.

AN EMPIRICAL ANALYSIS OF QUALITY, PRODUCTIVITY AND PROFITABILITY

Chiaho Chang, Montclair State University

ABSTRACT

The relationship between quality, productivity and profitability receive a lot of attention. Yet the debates go on as to the compatibility of these elements and whether they are mutually reinforcing. Empirical research is difficult in this area because the relevant data (proprietary and confidential) are difficult to come by. In the early days, the research focused on manufacturing settings; more recently, it was shifted toward service businesses (airlines, banks, food services, retail businesses, etc.) This research is based on a unique data set of a manufacturing company as part of the semiconductor supply chair. We are able to test hypotheses using regression analysis techniques and obtain interesting insights into how quality, productivity and profitability relate to each other. We find out that a positive link could be established among the three key factors of success. We also derive convincing indicator of quality performance along the way.

INTRODUCTION

Competitive advantages comes from differentiation, focus and/or cost leadership (Porter, 1980). Differentiation can be accomplished by providing better quality products and services than what competitors can offer. The source of cost leadership can be found in improved productivity. Therefore quality and productivity are recognized as the key weapons against competitors. In the short run, quality will impact cost structure and productivity; in the long run, price, sales, even market share are all affected.

This research wants to explore the relationship between quality, productivity and profitability in a more concrete way by looking into a case company that has been part of a semiconductor supply chain. We manage to obtain 57 monthly observations in 2002-2007 for all the relevant variables to run regression analysis. In the following sections, we reviewe literature and develop hypotheses, describe variables used and run regression, analyze the results, and provide insights for future research. Please note that all figures and tables mentioned in the text can be found in the Appendix at the end of the paper.

LITERATURE REVIEWS AND HYPOTHESIS DEVELOPMENT

Quality is usually a fuzzy concept. Juran and Gryna (1980) consider quality to be conformance to specification and fitness for use. Morse, Roth and Poston (1987) introduce three factors concerning quality: customer expectation, product specification and actual product. Then design quality can be considered as the discrepancy between customer expectation and design specification, and conformance quality as the discrepancy between product specification and actual product. For the purpose of this research, the concept of conformance quality will be adopted for easier measurement.

Over the years, quality improvement regimes evolve around Juran, Deming, Crosby, among others, and mature into the Japanese style of management (Fine, 1985; Shank & Govindarajan, 1994). The concepts of continuous improvement (or Kaizen), total quality control or management, and zero defects are extensively discussed and applied in businesses (see Kaplan, 1983; Schelb, Snyder & Sparling, 1992; Blocher et al., 1999 for example).

Productivity (= Output / Input) measures how resources are utilized to produce output. One clear way of improving productivity is by way of quality improvement. Schmenner and Cook (1985) find out that factories which pay closer attention to quality usually exhibit higher productivity (see also Schmenner, 1988). Hayes and Clark (1986) conclude that less waste and lower defect rate lead to improved total factor productivity. More recently, Roth and Jackson (1995) and Anderson et al. (1997) study the effect of productivity on performance improvement.

The assertion that quality and productivity should be positively related, however, is usually met by skeptical managers. In service context, quality and productivity are sometimes considered conflicting roles (Luria, Yagil & Gal, 2014). Lee, Beruvides, and Chiu (2007) tentatively verify their relationship by developing a mathematical model and empirically testing the model using industry data. In light of the uncertain relationship between quality and productivity, we develop the following hypothesis:

H1 The lower the nonconformance quality, the higher the productivity.

Quality costs, according to Juran and Gryna (1980), include prevention, appraisal, internal and external failures. Prevention and appraisal costs are considered discretionary and together called conformance costs; internal and external failure costs are reactionary and together called nonconformance costs (Crosby, 1984).

Conventional wisdom dictates that quality costs money, which implies that we can only afford quality to some extent. However, from a strategic point of view, better quality (in the sense of conformance quality) can be competitive in terms of lower quality costs and higher perceived value for customers, leading to improved profitability (Buzzill & Gale, 1987; Morse, Roth & Poston, 1987). More recent studies regarding Chinese industrialization (Yu, Dosi, Grazzi & Lei, 2017), in airline industry (Scotti & Volta, 2017) and in banking industry (Watson & Nossuli, 2015) provide a positive link; however, Riahi-Belkaoui (1999) finds that productivity does not necessarily point to future profitability. As long as it is yet to be settled, we develop the following hypothesis for testing.

H2 Productivity and profitability are positively correlated.

In service organizations, the connection between quality, customer satisfaction and performance is also studied (see Zhao et al., 2004 and Voss et al., 2005, for example). Empirical results suggest that the link between quality and profitability be solid (Rust et al., 1995; Loveman, 1998; Voss et al., 2005). In particular, Parast and Fini (2010) study the effect of productivity and quality on profitability in airline industry and finds a positive relation between productivity and profitability (but no link between quality and profitability). The following hypothesis intends to address the possible link between quality and profitability.

H 3 *The lower the nonconformance quality, the higher the profitability.*

Quality improvement, by itself, is expected to reduce quality costs (Chang, 2005) as a direct result. In addition, quality activities tend to streamline the production process, resulting in less waste. Therefore, less inputs in the form of materials, labor and overhead will be needed to generate the same amount of output, meeting the goal of improved productivity. The following four corollary hypotheses will also be tested.

- *H4 Nonconformance quality and nonconformance costs are positively correlated.*
- *H* 5 *The lower the nonconformance costs, the higher the productivity.*
- *H* 6 *The higher the nonconformance quality, the worse the quality-related operational efficiency.*
- *H*7 *The better the quality-related operational efficiency, the higher the productivity.*

In summary, this research tentatively provides a framework linking quality, productivity and profitability (see Figure 1). The series of hypotheses are superimposed onto the framework to test the validity of the connections among them.

VARIABLES AND DATA COLLECTION

Semiconductor industry is the aggregate collection of companies engaged in the design and fabrication of semiconductor devices. The industry is characterized by fierce competition at a global scale, continuous growth in a cyclical patter with high volatility, high degree of flexibility and innovation, and rapid change in the market. Semiconductors are materials which have a conductivity between conductors and nonconductors or insulators.

The Asian company in the case study was established in the early 1990s with ISO 9002 certification. This high-tech company reaches annual sales of about \$150 million, capital of \$135 million and 900 salaried employees. According to Hwang and Sheng (2015), there are five major segments that constitute the semiconductor industry supply chain: IC design, Masking, IC manufacturing, IC packaging and Final testing. The subject company's main products (lead frame and mother board) feed into IC packaging process. The company is organized into nine business units with stamping and etching being its two major production processes. Using the time-series analysis adopted by Hayes and Clark (1986), this research collects firm-specific proprietary data related to quality, productivity, profitability and externally available financial data over 57 monthly observations (August 2002 – April 2007). In addition, interviews and factory visits are conducted to better understand the work flows within. The variables used in the research and their characteristics are described below.

Quality Variables

This study adopts firm-specific variables to measure quality performance. Due to data availability, quality is measured in a negative way called nonconformance quality. That is, the lower the nonconformance quality, the higher the quality in the normal sense. Four proxies for nonconformance quality are available. Defect rate and defect loss rate are internally driven variables, while customer complaint rate and customer complaint loss rate are affected by external forces due to customers and market condition. Defect rate represents the percentage of output that does not meet product specifications, while defect loss rate measures the same concept in monetary terms. Customer complaint rate is based on the percentage of sales in quantity that suffers from customer complaints, and the customer complaint loss rate is similarly measured in sales dollars. In summary,

Defect Rate = $\frac{\text{Defective units}}{\text{Total production units}}$; Defect Loss Rate = $\frac{\text{Costs of salvage due to defects}}{\text{Total costs of production units (both good and defective)}}$; Customer Complaint Rate = $\frac{\text{Number of sold units subject to customer complaints}}{\text{Total sales in units}}$; Customer Complaint Loss Rate = $\frac{\text{Sales dollars subject to customer complaints}}{\text{Net sales}}$.

Figures 2 to 5 depict the four quality variables in time series over the study period.

Quality-related Operational Efficiency Variable

Better quality is expected to improve production efficiency with less disruptions in scheduling, less idle time, and less buildup of buffer inventory, among others. A clear indicator of such efficiency improvement can be found in the faster work in process (WIP) turnover rate, calculated as

WIP Turnover Rate = $\frac{Monthly \ production \ costs \ of \ finished \ units}{(Beginning \ WIP + Ending \ WIP)/2}$.

Figure 6 shows the monthly WIP turnover rate over the study period.

Nonconformance Cost Variable

Nonconformance costs are also called failure costs and include both internal failure and external failure costs. Nonconformance costs in practice are consisted of salvage, rework, hidden costs due to defects, customer service costs due to complaints, return and opportunity costs, re-inspection, price concession and others (lawsuits, insurance claims, reimbursements, etc.)

Figure 7 provides the monthly nonconformance costs in thousand dollars over the study period.

Productivity Variable

Total factor productivity (TFP), in economic terms, is a variable which accounts for effects in total output growth relative to the growth in traditionally measured inputs of labor and capital. In this research, TFP is calculated as

 $TFP = \frac{\text{Monthly output x Base-period average price}}{\text{Total costs of materials, labor and overhead (adjusted for base period)}}.$

Figure 8 shows the monthly TFP over the study period.

Profitability Variable

Gross profit is the difference between net sales and cost of goods sold. Monthly gross profit rate is an accounting measure used as the proxy for profitability in this research. That is,

Gross Profit Rate = $\frac{\text{Gross profit}}{\text{Net sales}}$.

Figure 9 indicates the monthly gross profit rate over the study period.

Control Variables

There are three control variables in this study: average unit price, total production volume and the economic factor.

Average unit price: Gross profit rate is influenced by both the unit price and the unit production cost. To isolate and study unit production cost as a possible result of quality and productivity improvements, the unit price has to be constrained. In addition, unit price is constantly adjusted to reflect shifts in market and strategic goals which are beyond the control of the company under study or its manufacturing process.

Total production volume: In order to differentiate between lower unit cost due to quality and productivity improvements, and lower unit cost due to economy of scale, the total production volume is utilized as a control variable to signify the impact of quality and productivity initiatives.

Economic factor: This is a dummy variable used to reflect the fluctuating and rapidly changing market conditions in the semiconductor industry whenever profitability is evaluated. When the global IC industry experiences a positive growth in sales during the study period, the economic factor is designated as "1;" otherwise it was assigned "0." The

relevant source of information comes from the World Semiconductor Trade Statistics (WSTS) over the study period.

REGRESSION MODELS AND RESULTS

H1 The lower the nonconformance quality, the higher the productivity.

The regression model used to test the hypothesis is

 $Y = \alpha + \beta X_i + \varepsilon,$

where Y: TFP; X₁: Defect rate; X₂: Defect loss rate; X₃: Customer complaint rate; X₄: Customer complaint loss rate.

The results are in Table 1. Three of the four quality measures weakly support the hypothesis; that is, the lower the nonconformance quality (the better the quality), the more productive the company becomes.

H2 Productivity and profitability are positively correlated.

The regression model used for this hypothesis is

$$Y = \alpha + \beta_1 X + \beta_2 C V_1 + \beta_3 C V_2 + \beta_4 C V_3 + \epsilon,$$

where Y: Gross profit rate; X: TFP; CV_1 : Average unit price; CV_2 : Total production volume; CV_3 : Economic factor. There are three control variables in the model.

The regression results are in Table 2. The significant and positive relation between productivity and gross profit rate provides strong support for the hypothesis. Also, the higher the unit price as a control variable, the higher the gross profit, as expected. The negative correlation between total output and gross profit points to the importance of improving productivity and lowering unit cost before mass production can reach its goal.

H3 The lower the nonconformance quality, the higher the profitability.

The regression model adopted for this hypothesis is

$$Y = \alpha + \beta_1 X_i + \beta_2 C V_1 + \beta_3 C V_2 + \beta_4 C V_3 + \epsilon,$$

where Y: Gross profit rate; X₁: Defect rate; X₂: Defect loss rate; X₃: Customer complaint rate; X₄: Customer complaint loss rate; CV₁: Average unit price; CV₂: Total production volume; CV₃: Economic factor.

Table 3 shows the results. The most significant result comes from the use of defect loss rate as the independent variable whose relation with the gross profit provides strong support for

the hypothesis. That means that better quality will lower production cost and improve gross profit. The other three quality indicators (defect rate, customer complaint rate and customer complaint loss rate) show insignificant and contrary results.

The three control variables are positively correlated with the gross profit rate, as expected.

It seems that the monetary-based quality indicator such as defect loss rate offers better gauge of quality than the quantity-based measures such as defect rate and customer complaint rate. Customer complaint loss rate, however, suffers potential underestimation and becomes less reliable as a quality proxy.

H4 Nonconformance quality and nonconformance costs are positively correlated.

This hypothesis tests the direct link between nonconformance quality and nonconformance costs. The regression model used is

 $Y = \alpha + \beta X_i + \varepsilon,$

where Y: Nonconformance costs; X₁: Defect rate; X₂: Defect loss rate; X₃: Customer complaint rate; X₄: Customer complaint loss rate.

The results are in Table 4. This regression studies whether nonconformance quality affects nonconformance costs and in what direction. The result shows that defect loss rate significantly and positively influences nonconformance costs. Both the customer-related quality indicators provide some support of the hypothesis. The defect rate violates the hypothesis but is not significant. Consistent with Hypothesis 3 results, the defect loss rate provides a very good proxy for quality measurement.

H5 The lower the nonconformance costs, the higher the productivity.

The regression model used to test the hypothesis is

 $Y = \alpha + \beta X + \epsilon,$

where Y: TFP; X: Nonconformance costs.

The result is in Table 5. The regression result points to moderate support of the hypothesis showing negative correlation between nonconformance costs and productivity. Hypotheses 4 and 5 together tell us that the linkage between quality and productivity is directly and partially influenced by nonconformance costs.

H6 The higher the nonconformance quality, the worse the quality-related operational efficiency.

The regression model for this hypothesis is

 $Y = \alpha + \beta_1 X_i + \beta_2 C V + \epsilon,$

where Y: WIP turnover rate; X₁: Defect rate; X₂: Defect loss rate; X₃: Customer complaint rate; X₄: Customer complaint loss rate; CV: Economic factor.

The results are shown in Table 6. In the regression, the quality-related operational efficiency uses as proxy the work in process turnover rate. Of the four quality indicators, only the defect loss rate is consistent with the hypothesis and moderately significant. However, the overall results indicate what we already learned from Hypothesis 3. That is, the choice of quality indicators may not consistently and correctly reflect the company's true quality profile. Relatively speaking, the defect loss rate again does a good job as a better proxy for quality in this study.

H7 The better the quality-related operational efficiency, the higher the productivity.

The regression model for the hypothesis is

 $Y = \alpha + \beta X + \epsilon,$

where Y: TFP; X: WIP turnover rate.

The result in Table 7 shows a positive and highly significant relation between the company's work in process turnover and productivity, providing a strong support of the hypothesis. That is, the better the quality-related operational efficiency, the more productive it will become. It can also be concluded (from Hypotheses 6 and 7 together) that the linkage between nonconformance quality and productivity is somewhat indirectly influenced by the quality-related operational efficiency.

CONCLUSIONS

This research sets out to study the relationship between quality, productivity and profitability in a manufacturing environment with a unique data source. The regression models are used to test the hypotheses. It seems that nonconformance quality and productivity are somewhat negatively correlated, productivity and profitability are strongly and positively correlated, while nonconformance quality and profitability are highly and negatively correlated. It provides a fuller picture of the three key factors of success for any business. Also, the results demonstrate that quality influencea productivity by way of both direct (via nonconformance costs) and indirect (via quality-related operational efficiency) impacts.

Since the proxies used for quality measurement shows inconsistent results, we would recommend the use of defect loss rate to better reflect the case company's quality performance. In reality, the financial impact of poor quality is better received by the management while the nonfinancial indicators (defect rate, customer complaint rate) provides employees with clearer guidance for future improvement.

The conclusions drawn are obviously limited by the data source and the time frame involved. However, this research does point out the clear connection between quality, productivity and profitability in a high-tech manufacturing setting. The findings are also consistent with other

empirical studies in both manufacturing and service industries. For future research, more in-depth case studies and large-scale statistical analyses will help clarify the issues further.

REFERENCES

- Anderson, E.W., C. Fornell & R.T. Rust (1997). Customer Satisfaction, Productivity and Profitability: Differences between Goods and Services. *Marketing Science*, 16(2), 129-145.
- Blocher, E.J., K.H. Chen & T.W. Lin (1999). Total Quality Management. Cost Management: A Strategic Emphasis, 162-187.
- Buzzill, R. & G. Gale (1987). Quality Is King. The PIMS Principles: Linking Strategy to Performance, 103-134.
- Chang, C. (2005). High Quality and Low Costs? An Application. *Journal of the Academy of Business and Economics*, 5(2), 172-187.
- Crosby, P. (1984). Quality without Tears. New York: McGraw-Hill.
- Fine, C. (1985). Managing Quality: A Comparative Assessment. *Booz Allen Manufacturing Issues*, New York: Booz Allen.
- Hayes, R. & K. Clark (1986). Why Some Factories Are More Productive Than Others. *Harvard Business Review*, September October, 66-73.
- Huang, B. & Y. Shen (2015). Decision Making for Third Party Logistics Supplier Selection in Semiconductor Manufacturing Industry: A Nonadditive Fuzzy Integral Approach. *Mathematical Problems in Engineering*, February, 1-12.
- Juran, J & F. Gryna (1980). Quality Planning and Analysis. 2nd ed., New York: McGraw-Hill.
- Kaplan, R. (1983). Measuring Manufacturing Performance: A New Chgallenge for Management Accounting Research. *The Accounting Review*, October, 688-705.
- Lee, W., M.G. Beruvides & Y.D. Chiu (2007). A Study on the Quality-Productivity Relationship and Its Verification in Manufacturing Industries. *Engineering Economist*, 52(2), 117-139.
- Loveman, G. (1998). Employee Satisfaction, Customer Loyalty and Financial Performance. *Journal of Service Research*, 1(1), 18-31.
- Luria, G., D. Yagil & I., Gal (2014). Quality and Productivity: Role Conflict in the Service Context. *Service Industries Journal*, September, 34(12), 955-973.
- Martin, J., W. Wchelb, R. Snyder & J. Sparling (1992). Comparing U.S. and Japanese Companies: Implications for Management Accounting. *Cost Management*, Spring, 6-14.
- Morse, W., H. Roth & K. Poston (1987). *Measuring, Planning and Controlling Quality Costs*. National Association of Accountants.
- Parast, M.M. & E.H. Fini (2010). The Effect of Productivity and Quality on Profitability in US Airline Industry: An empirical Investigation. *Managing Service Quality*, 20(5), 458-474.
- Porter, M.D. (1980). Competitive Strategy: Techniques for Analyzing Industries and Competitors. New York: Free Press.
- Riahi-Belkaoui, A. (1999). Productivity, Profitability and Firm Value. Journal of International Financial Management & Accounting, Autumn, 10(3), 188-201.
- Roth, A.V. & W.E. Jackson, III (1995). Strategic Determinants of Service Quality and Performance: Evidence from the Banking Industry. *Management Science*, 41(11), 1720-1733.
- Rust, R.T., A.J. Zahorik & T.L. Keiningham (1995). Return on Quality: Making Service Quality Financially Accountable. *Journal of Marketing*, 59(2), 58-70.
- Schmenner, R.W. (1988). The Merit of Making Things Fast. Sloan Management Review, Fall, 30(1), 11-17.
- Schmenner, R.W. & R.L. Cook (1985). Explaining Productivity Differences in North Carolina Factories. *Journal of Operations Management*, 5(3), 273-289.
- Scotti, D. & N. Volta (2017). Profitability Change in the Global Airline Industry. *Transportation Research*, June, 102, 1-12.
- Shank, J. & V. Govindarajan (1994). Measuring the Cost of Quality: A Strategic Cost Management Perspective. Cost Management, Summer, 5-17.

- Voss, C., N. Tsikriktsis, B. Funk, D. Yarrow & J. Owen (2005). Managerial Choice and Performance in Service Management: A Comparison of Private Sector Organizations with Further Education Colleges. *Journal of Operations Management*, 23(2), 179-795.
- Watson, M. & B. Nossuli (2015). The Road Trip to Profitability: Sales Productivity and Loan Officer Turnover are Key Challenges Facing Lenders As They Seek to Engineer Sustained Profitability. *Mortgage Banking*, November, 76(2), 56-63.
- Yu, X., G. Dosi, M. Grazzi & J. Lei (2017). Inside the Virtuous Circle Between Productivity, Profitability, Investment and Corporate Growth: An Anatomy of Chinese Industrialization. *Research Policy*, June, 46(5), 1020-1038.
- Zhao, X., A.C.L. Yeung & T.S. Lee (2004). Quality Management and Organizational Context in Selected Service Industries in China. *Journal of Operations Management*, 22(6), 575-587.

APPENDIX

Figure 1 A framework of quality, productivity and profitability



Figure 2 Defect Rate



Figure 3 Defect Loss Rate

















Figure 8



Table 1 Regression Results between Nonconformance Quality (X) and Productivity (Y)

		Coefficients	t	Adjusted R ²
Y	X_1	1.7680	0.7520#	0.0102
Y	X ₂	-0.1272	-0.4774	0.0041
Y	X3	-0.2927	-0.5971	0.0064
Y	X4	-0.1412	-8.8245	0.0122

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

Table 2 Regression Results between Productivity (X) and Profitability (Y)

		Coefficients	t	F	Adjusted R ²
	Х	0.3969	6.0955***		
v	CV_1	0.3763	2.1503**	12 0462***	0.4410
I	CV ₂	-0.0000	-1.8615*#	12.0402	0.4410
	CV ₃	-0.0014	-0.0612#		

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

	,	Coefficients	t	F	Adjusted R ²
	X1	0.8692	0.6519#		
v	CV_1	0.3404	1.4373	1 7777	0.0404
I	CV ₂	0.0000	0.2142	1./2//	0.0494
	CV ₃	0.0442	1.5834		
	X2	-0.7084	-6.4006***		
Y CV CV CV	CV ₁	0.5182	3.0006***	12 1170***	0.4640
	CV ₂	0.0000	1.9875*	13.1172	
	CV ₃	0.0646	3.1416*		
	X3	0.0557	0.1804#		
v	CV ₁	0.3569	1.3347	1 6175	0.0422
1	CV ₂	0.0000	0.1122	1.0175	0.0422
	CV ₃	0.0479	1.7503*		
	X4	0.0459	0.4619#		
v	CV ₁	0.3349	1.3383	1 6693	0.0456
I	CV ₂	0.0000	0.0874	1.0005	0.0430
	CV ₃	0.0497	1.8152*		

 Table 3

 Regression Results between Nonconformance Quality (X) and Profitability (Y)

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

 Table 4

 Regression Results between Nonconformance Quality (X) and Nonconformance Costs (Y)

		Coefficients	t	Adjusted R ²
Y	\mathbf{X}_1	-46.6688	-0.4533#	0.0034
Y	X2	86.7918	27.3015***	0.9313
Y	X3	8.4156	0.3771	0.0026
Y	X4	8.4533	1.0915	0.0212

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

	Т	able 5	
Regression Result	s between Noncon	formance Costs (X) and Productivity (Y)
	Coofficients	t	A directed D ²

		Coefficients	t	Adjusted R ²
Y	Х	-0.0004	-0.1315	0.0003
i and fi a	amaa I .	33331 * 0 1 * * 0 05	. ***. 0 01. #. Ca	nturamenta arena artatia

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

 Table 6

 Regression Results between Nonconformance Quality (X) and Quality-Related Operational Efficiency (Y)

		Coefficients	t	F	Adjusted R ²
v	X_1	12.0201	4.0940***#	12 9517***	0.2074
I	CV	0.1498	2.4806**	12.0317	0.2974
v	X ₂	-0.6626	-1.7512*	5 120/***	0.1288
1	CV	0.2090	3.0341***	5.1594	0.1200
v	X3	3.4163	6.6202***#	28 00/8***	0.4018
1	CV	0.1817	3.5635***	28.0948	0.4918
v	X4	0.7656	3.4343***#	10.0546***	0.2444
Ĩ	CV	0.2112	3.3607***	10.0340	0.2444

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

 Table 7

 Regression Results between Quality-Related Operational Efficiency (X) and Productivity (Y)

		Coefficients	t	Adjusted R ²		
Y	Х	0.2937	3.5945***	0.1755		
· · · · ·						

Significance Level *: 0.1; **: 0.05; ***: 0.01; #: Contrary to expectation

IMPLIED RISK ADJUSTED DISCOUNT RATES AND CERTAINTY EQUIVALENCE IN CAPITAL BUDGETING

Timothy Gallagher, Colorado State University Hong Miao, Colorado State University Patricia A. Ryan, Colorado State University

ABSTRACT

Incorporating risk into the capital budgeting process is a standard part of financial decision making. This article shows how the certainty equivalent and the risk adjusted discount rate approach convert to one another. Although theoretically the two approaches are different and many studies in the literature argue that the certainty equivalent is superior to the risk adjusted discount rate approach, it is shown the methods are mathematically equivalent if inputs are properly measured. It is shown that if the certainty equivalents of the cash flows are known, the corresponding implied risk adjusted discount rate is computable and rational in application.

INTRODUCTION

In the determination of an optimal cost of capital, certainty equivalence (CE) is theoretically superior to risk adjusted discounted rates (RADR) in common valuation situations, however RADR predominates due to ease of use. Keown, Martin, and Petty (2016) comment the reason that RADR is more popular than certainty equivalent risk adjustment is "purely and simply its ease of implementation". If the theoretically superior certainty equivalent model can be used to develop an implied risk adjusted discount rate, the elements of time and risk would be clearly distinguishable. Such an implied rate could vary across time and according to projected certainty equivalents could provide a superior cost of capital measure. The goal of this article is to review the basis of each methodology and develop an implied risk-adjusted certainty equivalent discount rate to assist in capital investment decisions.

Emphasis on the separation of risk and time is emphasized in Andreoni and Sprenger (2012) and Miao and Zhong (2015) who use utility theory to measure the two components. The present is known while the future is inherently risky. This is problematic when studying time preferences since uncontrolled risk can generate apparently present-biased behavior. Damodaran (2005) states the cost of capital is the main input in which analysts adjust for risk. Since this variable is sensitive to risk and the market risk premium reflects non-diversified risk, the payoff for risk management is hard to trace. It is therefore arguably important to separate the risk and time components.

The RADR method *simultaneously* adjusts for time and risk whereas the certainty equivalent method *separates* the two (Beedles and Joy, 1982). When there is a simultaneous adjustment for time and risk, there is interplay between the two that is not consistent with economics principles. The time and risk adjustment embedded in the RADR figure will be affected differently when N varies. There is no economic rationale for these effects. For example, if the RADR is assumed to be 10% of which 4% is the risk free rate and 6% is the adjustment for risk.

The risk adjustment has a largely different effect depending on the number of periods the cash flow is from the present. In large, multi-year capital investment projects, the risk adjustment using the RADR is arguably not an accurate representation of the risk adjustment. The certainty equivalent method provides a method to fix this problem be extricating time and risk into two separate components.

Gitman and Zutter (2015), Sick (1986), Ben-Tal and Teboulle (2007) and Megginson (1997) agree CE is theoretically superior to RADR. Both note the popularity of RADR stems from two main issues: acceptance by financial decision makers and ease of estimation and application. Firms like to develop several risk classes and then force all projects into one of these classes. This is inconsequential if all errors cancel out across projects and estimation bias is limited which is a reasonable assumption in a large normally distributed sample, but not a singular risky project. Importantly, financial managers should be aware of the large changes in the implied interest rate that result from significant decreases in the certainty equivalent, especially over shorter investment horizons.

This article illustrates why certainty equivalence separates the time and risk components in cost of capital calculations. Furthermore, we illustrate how an implied risk adjusted discount rate may be used to discount risky cash flows of different certainty equivalents. The article proceeds as follows. We first present the background of certainty equivalence and risk adjusted discount rates, then the theoretical development and illustrative examples, followed by the development of the implied risk adjusted rate that allows for different certainty equivalent proportions and risk free discounting for capital investment decisions.

CERTAINTY EQUIVALENCE & RISK ADJUSTED DISCOUNT RATES

In examining a capital budgeting decision using certainty equivalents, the cash flow (in the numerator of the present value calculation) is adjusted to reflect the risk of the cash flow. Once this risk adjustment is made, the cash flow is discounted at the risk free rate to reflect time differentials. This methodology appropriately separates the time and risk factors, allowing for linear adjustments for risk. The certainty equivalent is the value of a certain prospect that yields the same level of utility as the expected utility of an uncertain prospect. For the risk averse investor, this value will always be lower than the expected value of a risky positive cash flow. On the other hand, RADR methodology does not adjust the cash flow in the numerator, but rather adjusts the discount rate in the denominator. The implicit assumption in RADR is that risk increases as time increases as developed in Harris and Pringle (1985).

The debate about appropriate risk adjustment is not new in the finance literature. Robichek and Myers (1966) discussed the problems associated with RADR and since that time, there have been numerous studies published that address the difficulties of application of RADR. Fama (1977) discussed the valuation of multi-period cash flows. Brealey and Myers (2015) state the use of a single risk-adjusted discount rate for long-lived assets will not work when there are multiple phases of project design, in essence presenting a binomial model. If market risk were to change over the life of the project, RADR will not accurately depict the new level of risk. Lewellen (1977, 1979) argued that risky outflows require higher RADR's, while Celec and Pettway (1979) and Hartl (1990) argue the opposite. Berry and Dyson (1980, 1983) and Booth (1982, 1983) continue this debate. Beedles (1978 a, b) suggests that certainty equivalents are superior for estimating the present value of risky cash outflows and Miles and Choi (1979) debate his conclusion. Gallagher and Zumwalt (1991) illustrate how large negative discount rates applied to risky cash outflows may lead an unbounded present value and sensitivity to the number of time

periods. We present an application of certainty equivalents that appropriately adjust for risk and provide an implied risk adjusted discount rate which separates the dimensions of time and risk.

Implications of RADR application are numerous. First, there is not a clear sign in the literature as to the direction of adjustment for risky cash outflows. While there is a general consensus that an upward adjustment is appropriate for risky cash inflows, there is not general agreement in the literature as to handle risky cash outflows. Most corporate finance texts advocate lower RADRs for risky cash outflows. Second, the application of a risk adjustment with RADRs is highly arbitrary; generally a 2-4 percentage point adjustment. We show this adjustment is not nearly enough if the certainly equivalent is below 0.95. We advocate that managers apply certainty equivalents in order to more fully grasp the true risk of an investment and to adequately separate the risk and timing components. Such an application could potentially have limited exposure to some of the turmoil in the technology sector; an industry with arguably low certainty equivalents.

Utility functions are not an issue with certainty equivalents or RADR. The necessary variables include the end of period cash payoff, the quantifiable amount of risk, the risk free rate of interest and the price of risk as determined by the market. Since classes of individuals comprise the market, the composite of those classes can quantify individual risk classes. The separation theorem allows for separation of calculation from attitudes toward risk. If there were guaranteed to be an efficient secondary market, only one-period analysis would be necessary. There are many instances in which the secondary market is not efficient on an period by period basis, especially with projects that involve large negative cash outflows many years in the future.

The certainty equivalent level of wealth is the amount at which the investor is indifferent between the risky outcome and the risk free outcome. The investor decides what risk free cash flow he would be willing to accept in exchange for a risky cash flow. For example, if an investor has a 1/300 probability of winning a \$10 million lottery, the certain equivalent for a risk neutral investor would be \$33,333.33, which is the expected value of a fair game. The period before the drawing of the lottery winner, one has the choice to cash out. What amount would he require to cash out and leave the game? The cash out amount is the certainty equivalent. Given the risk averse utility curve, the certainty equivalent might be \$20,000 or some similar number, which is considerably below the expected value of \$33,333.33. The certainty equivalent of \$20,000 is the cash flow of \$33,333.33 adjusted for risk. This amount is then adjusted for time value, by discounting at the risk free rate.

The certainty equivalence principle is applied in Benth, Cartea and Kiesel (2008) in pricing forward contracts. Their limited usage in both personal and corporate financial management is blamed on the relative difficulty of application and determination of certainty equivalents for risky cash flows. In the next section, we will show how the certainty equivalent methodology can and should be properly used to arrive at an implied risk adjusted discount rate.

A BRIDGE BETWEEN CERTAINTY EQUIVALENT AND RISK ADJUSTED DISCOUNT RATE

Although there are debates about whether the certainty equivalent (CE) or the risk adjusted discount rate (RADR) approach should be used to value projects, we can convert one approach to the other. Suppose a possible project requires initial investment I_0 and will generate expected cash flows, CF_i at time $0 \le i \le n$. We can value the project by both the certainty equivalent and the risk adjusted discount rate approach.

We first value the project by the certainty equivalent approach. Let α_i define the certainty equivalent factor of the ith expected cash flow, then, the certainty equivalent of the ith expected cash flow is $CECF_i = \alpha_i CF_i$. The present value of $CECF_i$ is $CECF_i$ discounted by the risk-free rate, R_f . Therefore, the net present value of the project is:

$$NPV_{CE} = \sum_{i=1}^{n} \frac{CECF_i}{(1+R_f)^i} - I_0 = \sum_{i=1}^{n} \frac{\alpha_i CF_i}{(1+R_f)^i} - I_0.$$

Here, NPV_{CE} is the net present value of the project calculated by the certainty equivalent approach. Similarly, one can use the risk adjusted discount rate method to value the same project. Let $RADR_i$ define the risk adjusted discount rate for the ith expected cash flow, then the present value of the same project can be calculated as:

$$NPV_{RADR} = \sum_{i=1}^{n} \frac{CF_i}{(1 + RADR_i)^i} - I_0.$$

Here, NPV_{RADR} is the net present value of the project calculated by the risk adjusted discount rate approach.

To value a project, we need to decide the certainty equivalent factor, α_i , $0 < i \leq n$, or the risk adjusted discount rate, $RADR_i$, $0 < i \leq n$. The value of a project depends on α_i or $RADR_i$. Thus, one project can have different values using different methods. However, we can always artificially make the present values calculated by the two approaches equal. That is,

$$\sum_{i=1}^{n} \frac{CF_i}{(1+RADR_i)^i} = \sum_{i=1}^{n} \frac{\alpha_i CF_i}{\left(1+R_f\right)^i}.$$

One solution for the above is:

$$\frac{\alpha_i CF_i}{\left(1+R_f\right)^i} = \frac{CF_i}{\left(1+RADR_i\right)^i}$$

This solution also guarantees that the present values of each period calculated by the two different approaches are the same and as such implies that:

$$RADR_{i} = \frac{1 + R_{f}}{\alpha_{i}^{1/i}} - 1,$$

or,
$$\alpha_{i} = \left(\frac{1 + R_{f}}{1 + RADR_{i}}\right)^{i}$$

which indicates the following properties of the two valuation approaches:

a. The CE factor (α_i) is always greater than zero.

b. When the certainty equivalent factor is a decreasing (increasing) function of time, the corresponding risk adjusted discount rate is an increasing (decreasing) function. That is, if $\alpha_{i+1} < \alpha_i$, then $RADR_{i+1} > RADR_i$.

c. When $\alpha_i = 0$, $RADR_i = R_{f}$. That is, if the investor is indifferent between certain and uncertain cash flows, the cash flows should be discounted by the risk-free interest rate and no adjustment is necessary.

d. Since expected cash flows are discounted by the $RADR_i$, time and risk are not separated and thus may not compound properly. The *CE* method allows for the separation of risk and time by placing risk in the numerator and time in the denominator and discounting at the risk free rate. This is the main argument in favor of the certainty equivalent approach.

In reality, constant risk adjusted discount rates are commonly used. In this case, a constant risk adjusted discount rate could be found by solving (using EXCEL Solver, for instance) the following equation:

$$\sum_{i=1}^{n} \frac{CF_i}{(1+CRADR)^i} = \sum_{i=1}^{n} \frac{\alpha_i CF_i}{(1+R_f)^i}.$$

Figures 1 and 2 illustrate various certainty equivalents and implied interest rates for periodic model, specifically for the risk free rates of 5% and 10%, respectively. The model assumes an expected but uncertain cash flow of \$1,000 with CE factors (α_i) ranging from .95 to .05. Figure 1 shows a graphical representation of the implied risk adjusted rate using 1, 2, 3, 10, and 20 periods for the 5% risk free rate. As is seen, the implied rate rises nearly exponentially as the number of period increase and the CE factor decrease. The greater degree of risk aversion the lower the certainty equivalent. For illustrative purposes, one set of numerical calculations is presented in Table 1. In these calculations, it is shown how the single period model varies for a risk free rate of 5% with certainty equivalents ranging from 0.95 to 0.05. The implied rate for a 0.95 CE is 10.53%, representing a 5% reduction for risk and a 5% discount rate. The table shows a dramatic increase in implied rates as the CE's decrease. This increase in implied rates is perhaps greater than intuitively expected. It is definitely larger than the common +/-2 percentage point adjustment used in RADR. With a CE of 0.50, the implied rate soars to 110%. This is neither complex nor difficult, but illustrative of how the implied rate increases dramatically with decreases in CE's. Intuitively pleasing, this also allows for the separation of risk and time. Figure 2 further illustrate how the implied rate is an increasing function of the risk free rate for risk free rates of 10%, respectively. Again, we see implied rates rise exponentially as CE factors decrease and secondly as the number of periods increases. The graphs illustrate that implied interest rates very sensitive to the certainly equivalent, even for mid-term investments of 2, 3, and 10 years. Since investors are generally interested in returns over more than one year, multi-period models are important.

Table 2 is a multi-period illustration. To illustrate the difference between the implied riskadjusted discount rates $(RADR_i)$ and the constant risk-adjusted discount rate (CRADR), we suppose the risk free rate is 5%, and the CE factor, $\alpha_i = 1 - 0.5 \times year$, which is a decreasing function of the year. The $RADR_i$ is calculated for each period. The equivalent CRADR is 13.06%. From Table 2, we see that although the NPV is equal, the implied $RADR_i$ approach discounts the long maturity cash flows more heavily than the CRADR method while the CRADR method discounts the short maturity cash flows more heavily than the CE approach. Intuitively, the longer the maturity, the riskier the cash flow.

CONCLUSION

This paper discusses the two most popular discount rate approaches: the certainty equivalent approach and the risk adjusted discount rate approach. We show that although the theoretical means of these two approaches are different, analysts can convert one to the other, and for any project, there is a one to one map between the certainty equivalent factor and the implied risk adjusted discount rate. In separating the components of time and risk, an implied risk adjusted discount rate is determined to properly account for both elements. This offers executives, especially those in industries with lower certainty equivalents such as pharmaceuticals and technology, the opportunity to accurately price time and risk in modeling for an accurate discount rate.



Figure 1: Implied risk adjusted rates using risk-free rate of 5% for 1, 2, 3, 10 and 20 years.

Figure 2: Implied risk adjusted rates using risk-free rates of 10% for 1, 2, 3, 10, and 20 years.


Table 1

IMPLIED RISK ADJUSTED DISCOUNT RATES AT A 5% RISK FREE RATE

This table reports the corresponding risk adjusted discount rates assuming a cash flow of \$1,000 with CE factors (α) ranging from .95 to .05. The expected certainty equivalent, ECE, is calculated by multiplying the cash flow by the CE factor (α). The present value of the CE (PV CE) is calculated by dividing the CE by (1+R_f). The implied rate is calculated as follows: {[(1+R_f)/ α] -1}. The check is calculated as follows: (CE/PV CE). The annuity rate for the 1 period model is the previously calculated implied rate.

Cash Flow	CE-factor	ECE	Risk-free	PV CE	Implied Rate
\$1,000	0.95	\$950	0.05	\$905	10.53%
\$1,000	0.90	\$900	0.05	\$857	16.67%
\$1,000	0.85	\$850	0.05	\$810	23.53%
\$1,000	0.80	\$800	0.05	\$762	31.25%
\$1,000	0.75	\$750	0.05	\$714	40.00%
\$1,000	0.70	\$700	0.05	\$667	50.00%
\$1,000	0.65	\$650	0.05	\$619	61.54%
\$1,000	0.60	\$600	0.05	\$571	75.00%
\$1,000	0.55	\$550	0.05	\$524	90.91%
\$1,000	0.50	\$500	0.05	\$476	110.00%
\$1,000	0.45	\$450	0.05	\$429	133.33%
\$1,000	0.40	\$400	0.05	\$381	162.50%
\$1,000	0.35	\$350	0.05	\$333	200.00%
\$1,000	0.30	\$300	0.05	\$286	250.00%
\$1,000	0.25	\$250	0.05	\$238	320.00%
\$1,000	0.20	\$200	0.05	\$190	425.00%
\$1,000	0.15	\$150	0.05	\$143	600.00%
\$1,000	0.10	\$100	0.05	\$95	950.00%
\$1,000	0.05	\$50	0.05	\$48	2000.00%

Table 2

IMPLIED RISK-ADJUSTED DISCOUNT RATES FOR MULTI PERIODS

For different periods of cash flows, we apply different CE factors and calculate the corresponding risk-adjusted discount rates. PVCECFi is the present value of the certain equivalent cash flows using a 5% risk free rate. PVCFi is the present value of the cash flows calculated by the implied risk-adjusted discount rates. The NPV of those 19 periods cash flow is \$6,914.68. The constant risk-adjusted discount rate is CRADR=13.06%. The last column is the present values of the cash flows calculated by the CRADR.

Year(i)	CFi	Alpha _i	CECFi	PVCECF _i	RADR	PVCFi	PVi
1	1000	0.95	950	904.76	10.53%	904.76	884.51
2	1000	0.9	900	816.33	10.68%	816.33	782.35
3	1000	0.85	850	734.26	10.85%	734.26	691.99
4	1000	0.8	800	658.16	11.02%	658.16	612.07
5	1000	0.75	750	587.64	11.22%	587.64	541.38
6	1000	0.7	700	522.35	11.43%	522.35	478.86
7	1000	0.65	650	461.94	11.66%	461.94	423.55
8	1000	0.6	600	406.10	11.92%	406.10	374.63
9	1000	0.55	550	354.53	12.21%	354.53	331.37
10	1000	0.5	500	306.96	12.54%	306.96	293.10
11	1000	0.45	450	263.11	12.91%	263.11	259.25
12	1000	0.4	400	222.73	13.33%	222.73	229.30
13	1000	0.35	350	185.61	13.83%	185.61	202.82
14	1000	0.3	300	151.52	14.43%	151.52	179.40
15	1000	0.25	250	120.25	15.17%	120.25	158.68
16	1000	0.2	200	91.62	16.11%	91.62	140.35
17	1000	0.15	150	65.44	17.40%	65.44	124.14
18	1000	0.1	100	41.55	19.33%	41.55	109.80
19	1000	0.05	50	19.79	22.93%	19.79	97.12
							\$6,914.68

REFERENCES

- Andreoni, J., & Sprenger, C. (2012). Estimating time preferences from convex budgets. *The American Economic Review*, 102(7), 3333-3356.
- Beedles, W. L. (1978). Evaluating negative benefits. Journal of Financial and Quantitative Analysis, March, 173-176.
- Beedles, W. L. (1978). On the use of certainty equivalent factors as risk proxies. *The Journal of Financial Research*, 1(1), Winter, 15-21.
- Beedles, W. L. and O. M. Joy. (1982). Compounding risk over time: a note. *Journal of Business Finance & Accounting*, 9(3), 307-311.
- Ben-Tal, a, and M, Teboulle. (2007). An old-new concept of convex risk measures: The optimized certainty equivalent, *Mathematical Finance* 17(3), 449-476.
- Benth, F. E., A. Cartea, and R. Kiesel. (2008). Pricing forward contracts in power markets by the certainty equivalence principle: Explaining the sign of the market risk premium. *Journal of Banking and Finance* 13, 2006-2021.
- Berry, R. H. and R. G. Dyson. (1980). On the negative risk premium for risk adjusted discount rates. *Journal of Business Finance & Accounting*, 7(3), 427-436.
- Berry, R. H. and R. G. Dyson. (1983). On the negative risk premium for risk adjusted discount rates. *Journal of Business Finance & Accounting*, 10(1), 157-159.
- Booth, L. D. (1982). Correct procedures for the evaluation of risky cash outflows. *Journal of Financial and Quantitative Analysis*, v. 17, n. 2, June, 287-300.
- Booth, L. D. (1983). On the negative risk premium for risk adjusted discount rates: A comment and extension. *Journal* of Business Finance & Accounting, 10(1), 147-155.
- Brealey, R. A. and S. C. Myers. (2015). Principles of Corporate Finance, eleventh edition, McGraw-Hill.
- Celec, S.E. and R. H. Pettway. (1979). Some observations on risk-adjusted discount rates: A comment. *The Journal of Finance*, 34(4), September, 1061-1063.
- Damodaran, A. (2005). Value and risk: Beyond betas. Financial Analysts Journal, March/April, 38-43.
- Fama, E. F. (1977). Risk-adjusted discount rates and capital budgeting under uncertainty. *Journal of Financial Economics*, 5, 3-24.
- Gallagher, T. J. and J. K. Zumwalt. (1991). Risk-adjusted discount rates revisited. *The Financial Review*, 26(1), February, 105-114.
- Gitman, Lawrence J., C. Zutter. (2015). Principles of Managerial Finance, 13th edition, HarperCollins.
- Harris, R. S. and J. J. Pringle. (1985). Risk-adjusted discount rates—Extensions from the average-risk case. *The Journal* of *Financial Research*, 3(3), Fall, 237-244.
- Hartl, Robert J. (1990). DCF analysis: The special case of risky cash outflows. *The Real Estate Appraiser and Analyst*, 56(2), Summer, 67-72.
- Keown, A. J., J.D. Martin, and J.W, Petty, 2016. Foundations of Finance, 10th Edition, Prentice Hall.
- Lewellen, W. G. (1979). Reply to Pettway and Celec. The Journal of Finance, 34(4), September, 1065-1066.
- Lewellen, W. G. (1979). Some observations on risk-adjusted discount rates. *The Journal of Finance*, 32(4), September, 1331-1337.
- Megginson, W. L., (1997). Corporate Finance Theory, Addison-Wesley, 277-281.
- Miao, B., & Zhong, S. (2015). Comment on "risk preferences are not time preferences": separating risk and time preference. *The American Economic Review*, 105(7), 2272-2286.
- Miles, J. and D. Choi. (1979). Comment: Evaluation negative benefits. *Journal of Financial and Quantitative Analysis*, 14(5), December, 1095-1099.
- Robichek, A. A. and S. C. Myers. (1966). Conceptual problems in the use of risk-adjusted discount rates. *The Journal* of *Finance*, 21(1), March, 727-730.
- Sick, G. A. (1986). A certainty-equivalent approach to capital budgeting. Financial Management, Winter, 23-32.

ECONOMIC FACTORS PREDICTING INFLATION IN THE US, ENGLAND, FRANCE, AND GERMANY

Morsheda Hassan, Wiley College Raja Nassar, Louisiana Tech University

ABSTRACT

In this study, the authors investigated the relationship between inflation and macroeconomic factors (namely, short and long term interest rates, unemployment, GDP, and percent debt) for France, Germany, England, and the United States. Time series and autoregressive analysis procedures were used to determine, for each country, the best predictive model over a 5 year period relating inflation as the dependent variable to macro-economic factors as the independent variables. Results showed that for England and the United States, GDP and year were good predictors of inflation. In France, factors that predicted inflation were growth rate and 10-year bond rate and in Germany the factors for predicting inflation for the US and England. Prediction of inflation for France and Germany, was not as good as that for England and the United States

INTRODUCTION

Inflation rate is a major economic variable or indicator used in decision making. Inflation has an effect on economic growth. Therefore, control of inflation is of primary concern for any economy. Most economists agree that inflation is related to money growth. The reserve bank in the US and central banks in other countries use interest rate in order to regulate inflation dynamics. There is interest on the part of these institutions to accurately forecast inflation rate for decision making. There have been many attempts in the literature to model inflation in order to understand its dynamics. These modeling attempts were mostly univariate in the sense that inflation was expressed as a function of its own lags. There are factors or exogenous variables that can affect inflation dynamics. Interest rate, GDP, and unemployment are among such factors. Hence, multivariate models including such exogenous variables to simulate inflation dynamics may be more accurate than univariate models. In this paper, we use time series multivariate modeling techniques to study the relationships between inflation and economic variables in order to predict the dynamics of inflation in developed countries, namely the US, Great Britain, France, and Germany. We also test the predictive accuracy of each model.

REVIEW OF RELEVANT LITERATURE

P<u>incheira</u> and <u>Medel (2015)</u> evaluated the inflation forecasting ability of univariate time series models in the US and several other countries. The authors used what they termed Driftless Extended Seasonal ARIMA (DESARIMA) model and showed that their model short horizon

forecasts were better than existing univariate models in the literature. Forecasting accuracy was mixed over longer horizons. The forecasting accuracy was higher in countries where inflation was stable. Ang et al. (2007) used ARIMA models, regression, structure models, and survey-based measures in forecasting inflation in the US. They reported that surveys outperformed the other methods in forecasting. Anderson et. al. (2007) applied univariate autoregression time series models to evaluate the accuracy of the Ricksbank's forecasts.

<u>Bipradas</u> (2014) used a GARCH model and Granger test to study the relation between inflation, inflation uncertainty, and output growth in India. Results showed that there was no significant relationship between inflation uncertainty and growth rate. However, there was evidence that an increase in inflation increased inflation uncertainty.

Muthucattu et al. (2014) applied a co-integration and vector error correction modeling approach to study the effects of exchange rate (Australian dollar/ Fijian dollar), consumer price index in Australia, GDP plus (import – export), and a dummy 0,1 variable for the devaluation years in Fiji. Results showed that inflation in Fiji was affected by the exchange rate and the GDP.

Pintilescu et. al. (2014) used Granger causality tests and a vector autoregressive (VAR) model to study the relationships among inflation, GDP and their uncertainties in ten European countries with emerging economies. Uncertainty of GDP or inflation was estimated from the conditional variance using a Garch model. Results showed that inflation Granger-causes inflation uncertainty, confirming the Friedman–Ball hypothesis. Ikechukwu and Adedoyin (2014) modeled inflation using a univariate ARIMA time series model and a VAR bivariate model where the series were inflation and broad money supply in Nigeria. Results indicated that VAR was a better model for inflation than the univariate ARIMA.

<u>Deepak</u> and <u>Joice</u> (2014) investigated factors that could affect inflation in India using quarterly data over the years 1997-2014. Authors used a structural vector autoregression (SVAR) model where the factors were crude oil prices, output gap, and monetary policy. Further, they modeled inflation dynamics over time by considering an SVAR with time varying parameters. Simionescu (2014) used the Granger test to show that unemployment caused inflation and inflation caused unemployment in Romania. Accordingly, a VAR (1) was used to model the bivariate time series.

<u>Kichian</u> and <u>Rumler</u> (2014) showed that the New Keynesian Phillips Curve (NKPC) equation outperformed the random walk and other conventional time series models in forecasting inflation in Canada. Odhiambo (2013) studied the relationship between inflation and economic growth in the presence of unemployment in South Africa. Using the Granger causality test, it was found that there was a bi-directional causal relationship (in the short or long run) between inflation and economic growth. Hossain (2014) reported that the persistence of inflation in Australia is not due to a unit root, but to a slow dissipation rate after a shock. Results indicated that there was a feedback between inflation and inflation volatility and that the latter effects unemployment and economic growth. Durčová (2012) using vector autoregression modeling approach studied the effect of a shock in interest rate on 3-month money market and Euribor interest rates, GDP, nominal effective exchange rates (NEER), and inflation in Germany, France, Netherlands, Belgium and Luxembourg. Results did not show a clear effect of a shock in interest rate on the

36

chosen macro markers. Any manifested effect was weak, which did not indicate an efficient transmission mechanism of the shock with regard to the selected economic variables.

Kalimeris D. (2012) investigated the relationship among inflation, inflation uncertainty and government bond rates in Greece in the last 19 years. The author used a time series approach, namely the E-GARCH and the VAR methods. Results showed a strong relationship between government bonds and inflation as well as inflation uncertainty. Also, there was a relationship between inflation and inflation uncertainty. Vizek and Broz (2009) studied the quarterly inflation in Croatia. They reported that inflation inertia and inflation of Croatian trading partners were important for explaining inflation behavior in the short run. Also, excess money, output gap, nominal exchange rate, and broad money contributed to the inflation dynamics in the short run.

Baghestan and AbuAl-Foul (2010) reported on factors used in federal reserve long term inflation forecasts. They included growth forecasts of unit labor cost and aggregate demand as well as monetary policy and the preceding inflation forecast. Zhang and Clovis (2009) modeled the inflation dynamics in the US using an AR process. Results showed that there was a significant decline in inflation over the recent period which may have been associated with US monetary policy.

Christiano and Fitzgerald (2003) studied the inflation dynamics before and after 1960 in the US. They reported that inflation was lower in the early period (before 1960) than in the later period. Also, inflation and unemployment were negatively correlated in the early period, but were positively related in the later period. These results were reported to have been accounted for by the notion that monetary policy in the early period was committed to low inflation, while not so in the later period.

METHODS

Time series model

A time series model relating an output series y to k input series x_i (i = 1, 2, ...,k) can be expressed in general as

$$y_t = \sum_i^k c(B)_i x_{it} + a_t \tag{1}$$

Here, $c(B) = \sum c_j B^j$, where B is the backshift operator, $Bx = x_{t-1}$.

The function $c(B)_i$ with its lags is determined from the cross correlations between x_{it} and y_t , (i = 1,2,'''k), namely the significance at a given lag and the pattern of the cross correlations over lags (Wei, 1994).

Once $c(B)_i$ is identified, one can express a_t in Eq. (1) as

$$a_t = y_t - \sum_i^k c(B)_i x_{it}$$
⁽²⁾

and identify the appropriate time series model for Eq. (2). With a_t known, one can determine the final model in Eq. (1). The time series variables are assumed to be stationary. Differencing is used if needed to make a series stationary,

Autoregression

Another modeling approach for time series is the use of linear multiple regression where the error is auto correlated. The model takes the form

$$Y_{t} = a + b_{1}X_{1}t + b_{2}X_{2t} + \dots b_{k}X_{kt} + V_{t}, \qquad (3)$$

where

$$V_t = \Phi_1 V_{t-1} + \Phi_2 V_{t-2} + \dots + \Phi_1 V_{t-n} + e, \qquad (4)$$

and e is random noise.

Here, V_t is an autoregressive model.

The order n is determined from the Durbin-Watson statistic

Data Analysis

Data for this study were obtained from the Federal Reserve Economic Data-<u>St. Louis Fed</u> for England, France, Germany, and the United States. It spanned the time period 1955-2014.

In this analysis, CPI or inflation was the dependent variable. The independent variables were GDP, or growth rate for France, percent debt, short and long term interest rates, and unemployment rate. Each data set was modeled using the time series approach (Equations 1 and 2). The auto regression approach (Equations 3 and 4) and the autoregressive model (Equation 4). In all cases the last five years were left out of the data and used to check the prediction accuracy of the model. From the models developed for each data set, only the model that gave the best prediction is presented. Only independent variables that had a significant effect on the dependent variable were retained in each model. The R-squared goodness of fit values for all auto regression models presented below were good (larger than 0.9). The SAS software was used for the data analysis

MODELS

United States

The best model for the US was the autoregressive model expressed as

$$CPI_t = -1472 + 0.7582 Y_t + 0.00329 GDP_t + V_t,$$
(5)

where Y_t is year t and $V_t = 0.9694 V_{t-1} + e_t$ or $V_t = e_t / (1 - 0.9694 B),$ (6)

where B is the back shift operator $(BV_t = V_{t-1})$ and e is random noise.

Combining (6) and (5) and simplifying, one obtains the model

$$CPI_{t} = -45.04 + 0.9694 CPI_{t-1} + 0.7582 Y_{t} - 0.7350 Y_{t-1} + 0.00329 GDP_{t} - 0.00319 GDP_{t-1} + e_{t}$$
(7)

England

The autoregression model (form Equations 3 and 4) was the best model in predicting inflation.

The model obtained is expressed as

$$CPI_t = -2991 + 1.5286 Y_t + .0127 GDP_t + V_t,$$
(8)

Where

$$V_{t} = 1.804 V_{t-1} - 0.8368 V_{t-2} + e_{t}$$

= $e_{t} / (1 - 1.804 B + 0.8368 B^{2})$ (9)

Here, $BV_t = V_{t-1}$ and $B^2V_t = V_{t-2}$

Combining (8) and (9) and simplifying, one obtains the following model

$$CPI_{t} = -98.1 + 1.804 CPI_{t-1} - 0.8368 CPI_{t-2} + 1.5286 Y_{t} - 2.7576 Y_{t-1} + 1.2791 Y_{t-2}$$

$$+ 0.0127 \text{ GDP}_{t} - 0.0229 \text{ GDP}_{t-1} + 0.0106 \text{ GDP}_{t-2} + e_{t}$$
(10)

(16)

France

The best model was determined using the auto regression analysis. The model is expressed as

$$INF_{t} = -1.0397 - 0.2927 \text{ GR}_{t} + 0.8598 \text{ BR}_{t} + V_{t}, \qquad (11)$$

where, INF is inflation, GR is growth rate, BR is 10-year bond rate and

$$V_{t} = 0.8697 V_{t-1} + e_{t}$$

$$= e_{t} / (1 - 0.8697B)$$
(12)
Substituting (12) in (11) and simplifying, one obtains
$$INF_{t} = -0.1355 + 0.8697 INF_{t-1} - 0.2927 GR_{t} + 0.2545 GR_{t-1}$$

$$+ 0.8598 BR_{t} - 0.7478 BR_{t-1} + e_{t}$$
(13)

Germany

The best model was obtained from the time series analysis outlined in Equations (1) and (2) above. The model is expressed as

$$CPI_t = 0.1969 BR_t + 0.2912 IBR_t + a_t,$$
(14)

where BR is 10-year bond rate, IBR is inter bank rate and

 $+ 0.2912 IBR_t - 0.2217 IBR_{t-1} + e_t$

$$a_t = e_t / (1 - 0.7614 \text{ B}) \tag{15}$$

Combining (11) and (12) and simplifying, one obtains the expression

$$INF_t = 0.7614 INF_{t-1} + 0.1969 BR_t - 0.1499 BR_{t-1}$$

RESULTS AND DISCUSSION

Figures in the Appendix are plots of CPI and other independent variables that appeared in the model for each country over years. It is interesting to see that there is an upward trend for the

US and England, but no trend for Germany and France. This may have to do with differences in monetary and fiscal policies between EU members (France and Germany) and non-EU members (England and the US). EU countries have austere measures dictated by the Maastricht treaty of 1992.

Table 1 presents the observed and predicted values for CPI or inflation for the years that were not included in the data set used to determine the model equation.

The model equation used to predict CPI for England is equation (10). It is seen that the model which includes year and GDP as independent variables gave an excellent prediction of inflation over 5 years. Year may be regarded as a proxy for other factors not in the data set. The effect of GDP on inflation is as expected. It is interesting that interest rate was not a factor affecting inflation in this case. The CPI in the model relates to its two lags, to the first and second lags of year and to the first and second lags of GDP. The positive effects of GDP and year on CPI from equation (8) are reflected in the trends in Figure 1.

Table 1				
Observed and pred	licted values for CPI of	r inflation for each coun	try. Predicted values are	e obtained from the
1		model for each country	7	
England	Year	Observed	Predicted	Absolute value:
-				(Obs-Pred)/Pred
	2010	100.00	100.19	0.0019
	2011	104.48	103.25	0.012
	2012	107.48	105.91	0.015
	2013	110.17	108.70	0.013
	2014	111.78	111.59	0.0017
United States	2010	100.00	100.41	0.0041
	2011	103.15	103.07	0.00078
	2012	105.29	105.96	0.0064
	2013	106.83	108.54	0.016
	2014	108.56	111.48	0.027
France	2009	2.17	2.33	0.074
	2010	1.52	1.36	0.105
	2011	2.12	1.90	0.104
	2012	1.95	1.44	0.262
	2013	0.86	0.96	0.116
Germany	2010	1.11	0.71	0.360
	2011	2.08	1.33	0.360
	2012	2.01	1.84	0.085
	2013	1.51	2.15	0.424
	2014	0.91	2.31	1.538

As for England, prediction of CPI for the United States from the model in equation (7) was very good. Here again year and GDP were the factors affecting the dynamics of inflation. Interest rate had no effect in this case. From equation (7), it is seen that CPI is related to its own lag, to

year and its first lag, and to GDP and its first lag. The positive effects of GDP and year on CPI from equation (5) are reflected by the trends in Figure 2.

The prediction for inflation in France from the model in equation (13) was not as good as that for the US and England. The prediction error can be as high as 26% of the observed value. The factors determining the inflation dynamics are the growth rate and the 10-year bond rate. Inflation in the model is related to its own lag, to BR and its lag, and to growth rate and its lag.

The negative effect of growth rate and the positive effect of bond rate from equation (11) are reflected in the trends in Figure 3.

The model for Germany from equation (16) showed that inflation was related to its own lag, 10-year bond rate and its lag as well as inter bank rate and its lag. The model, however, was a poor predictor of inflation. The positive effects of BR and IBR from equation (14) are supported by the trends in Figure 4.

It is interesting to note that inflation was harder to predict for the two European countries, France and Germany, which have a strict monetary and fiscal policies as dictated by the Maastricht treaty. Their economic policy falls more under austerity by comparison to the US and England. Further, both Germany and France had their central banks before joining the EU and one European central bank after joining. As a result, the monetary or fiscal policy was not the same over the years used in this study. Also, the re-unification of Germany in 1990 caused a severe stress on its economy. All these events may explain the presence of other factors, not in the data set, that may have contributed to the dynamics of inflation

CONCLUSION

Time series analysis was used to model and predict inflation over years for the United States, England, Germany, and France. The models developed were very good in predicting inflation 5 years ahead for England and the United States. Prediction for France was fair and that for Germany was poor. The reason for less than satisfactory predictions for Germany and France may have been due to the fact that Germany and France belong to the EU and have austere monetary and fiscal policies dictated by the Maastricht treaty and they do not have their own central bank. Also, the German unification in 1990 may explain the presence of outside factors, not in the data set, that had an influence on the dynamics of inflation in this country. For the US, England and France, GDP and its lags had an effect on inflation. For Germany, only 10-year bond rate and inter bank rate had an effect on inflation. Both these variables, however, were poor predictors of inflation.

REFERENCES

- Ang, A., Bekaert, G., and Wei, M. (2007). Do macro variables, assets markets, or surveys forecast inflation better? Journal of Monetary Economics, 54, 1163-1212.
- Andersson, M., Karlsson, G., and Svensson, J. (2007). The Riksbank forecasting performance. Economic Review, 3, 59-75.
- Pincheira, P. M. and Medel, C. A. (2015). Forecasting inflation with a simple and accurate benchmark: the case of the US and a set of inflation targeting countries.

Czech Journal of Economics & Finance. 65, 2-29.

Simionescu, M. (2014). A strategy to improve the inflation rate forecasts in Romania.

Internal Auditing & Risk Management. 9, 197-209.

- <u>Bipradas</u>, R. (2014). The relationship between inflation, inflation uncertainty and output growth in India. <u>Economic</u> <u>Affairs: A Quarterly Journal of Economics</u>, 59, 465-477.
- <u>Paul, M. T.</u>, <u>Pin, Yih, Tang</u>, Y.P. and <u>Bhatt, M.</u> (2014). A study of the relation between inflation and exchange rates in the fiji islands: a cointegration and vector error correction approach. <u>Journal of Developing Areas</u>, 48, 1-20.
- Pintilescu, C., Jemna, D., Viorică, E. and Asandului, M. (2014). Inflation, Output Growth, and Their Uncertainties: Empirical Evidence for a Causal Relationship from European Emerging Economies. Emerging Markets Finance & Trade. Supplement, 50, 78-94
- Muthucattu ,T. P and Timiti, U. (2014). An Empirical Study of the Interrelationships, Integration and The Efficiency Of Stock And Foreign Exchange Markets In Fiji Journal of Quantitative Economics, 12, 154-167.
- Ikechukwu, K, and Adedoyin, S. (2014). Time Series Modeling And Forecasting Inflation: Evidence From Nigeria. International Journal of Business & Finance Research (IJBFR). 8, 41-51.
- <u>Deepak</u>, M. and <u>javascript:__doLinkPostBack(",'ss~~AR %22John%2C</u> <u>Joice%22%7C%7Csl~~rl',");</u> Joice, J. (2015). Determinants of inflation in India. <u>Journal of Asian</u> Economics, 36, 86-96.
- Kichian, M. and Rumler, F. (2014). Forecasting Canadian inflation: A semi-structural NKPC approach. Economic Modelling. 43, 183-191.
- Odhiambo, N. M. (2013). Inflation And Economic Growth In South Africa: An Empirical Investigation. <u>Economics</u>, <u>Management & Financial Markets</u>. 8, 27-41.
- Hossain, A. A. (2014). Monetary policy, inflation, and inflation volatility in Australia Journal of Post Keynesian Economics. 36, 745-779.
- <u>Ďurčová, J.</u> (2012). Macroeconomic Impacts Of The Interest Rate Shocks In The Selected Euro Area Countries. Journal of Advanced Studies in Finance. 3, 140-150.
- Kalimeris, D. (2012). Modeling Inflation Uncertainty and the Effect of Government Bond Rates: A Case Study of Greece. Int. J. Buss. Mgt. Eco. Res. 3, 506-515.
- Christiano, L. J. and Fitzgerald, T. J. (2003). Inflation and monetary policy in the twentieth century. Economic Perspectives. 1st Quarter, 27, 22- 24.
- Vizek, M. and Broz, T. (2009). Modeling Inflation in Croatia. Emerging Markets Finance & Trade, 45, 87-98.
- Baghestani, H. and Bassam, A. (2010). Factors influencing Federal Reserve forecasts of inflation. Journal of Economic Studies. 37, 196-207.
- Zhang , C. and Clovis, J. (2009). Modeling US inflation dynamics: persistence and monetary policy regimes. Empir Econ , 36, 455–477
- Wei, W.S. (1994). Time Series Analysis: Univariate and multivariate methods. Addison-Wesley.

APPENDIX

Figure 1 England. CPI (black dot), GDP (10 billions of Pounds), + symbol



Figure 2 United States. CPI (black dot), GDP (100 billions of Dollars), + symbol



Figure 3 France. CPI (black dot), GDP growth rate (+ symbol), and bond rate (open circle)



Figure 4 Germany. CPI (black dot), inter bank rate (+ symbol), and bond rate (open circle)



SUSTAINABILITY REPORTING PRIORITIES – A STUDY EXPLORING ACCOUNTING MAJORS' PERCEPTIONS

Marianne L. James, California State University, Los Angeles

ABSTRACT

Sustainability reporting continues to gain global significance. Diverse stakeholders expect that entities of all types and sizes behave responsibly and add value while minimizing their negative impact on scarce resources. Increasingly, stakeholders also expect that entities report information about their comprehensive effect on the environment, employees, the community, and other stakeholders. Accounting professionals' involvement with the selection, derivation, and reporting of sustainability related information is expanding and presents significant opportunities for current and future accounting professionals. Accounting professionals' perceptions regarding sustainability reporting may influence the nature and extent of reporting; hence, their perceptions are important.

This study investigates the perceptions of accounting majors regarding broad as well as specific aspects of sustainability reporting by business entities. The study finds that accounting majors tend to support sustainability reporting by public companies, perceive that entities should report information about failures as well as achievements, and that the information should be audited. In response to open-ended queries, accounting majors specified several types of information with high reporting priority for each major sustainability area - environment, labor, society, human rights, and product responsibility.

The findings from this study provide important insights into the perceptions of future accounting professionals, which may be useful to standard setters, policy makers, educators, business organizations, and other stakeholders.

INTRODUCTION

Sustainability, also referred to as sustainability development, corporate social responsibility (CSR), accountability, and stewardship continues to be of paramount importance to diverse stakeholders. The World Commission on Environment and Development (also referred to as the Brundtland Commission), formally defined sustainability development as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987, 37). Interest in and demand for organizations to minimize their negative impact on the environment, on employees and the regional as well as the global community continues to grow. Annual summits, such as the recent Sustainability Summit held in London, are attended by world leaders, researchers, and other stakeholders; and highlight the need for global solutions to global issues.

Stakeholders of business organizations expect and demand that organizations discharge their obligations to stakeholders responsibly and implement programs that minimize their negative impacts, while maximizing positive results. In response to these expectations and for other reasons such as cost savings and operational efficiencies, organizations of all types and sizes implement and monitor programs that minimize their negative impact on the environment, their employees and the community. In addition, formal and informal reporting on organizations' sustainability programs has grown tremendously. Stakeholder theory and legitimacy theory provide some theoretical explanations for the trend toward increased sustainability reporting.

Accounting professionals' involvement in sustainability reporting is increasing. Large public accounting firms and some smaller accounting and consulting firms have developed service offerings addressing the sustainability reporting needs of their clients. Professional organizations, such as the American Institute of Certified Public Accountants (AICPA), also provide valuable sustainability reporting information. Accounting professionals' involvement in sustainability and sustainability reporting likely will continue to rise. Their perceptions regarding the need for and value of formal reporting will tend to influence the extent and quality of sustainability reporting. Accounting majors, who represent the future accounting professionals and many of whom will directly or indirectly become involved with sustainability, will help influence reporting substance and quality. Thus, their perceptions are important and information about their perceptions provide valuable insights useful to academia, standard setters, and other stakeholders.

This study explores accounting students' perceptions of sustainability reporting with respect to broad and specific issues, including the need for reporting specific types of sustainability related information. The results suggest that accounting majors tend to support mandatory reporting of audited sustainability information by public companies. Accounting majors also appear to recognize the importance of reporting information about sustainability related failures as well as achievements. Study participants indicated multiple issues for which companies should provide information with respect to the environment, labor, human rights, society, and product responsibility and ranked them based on priority. The most frequently mentioned and top ranked sustainability issues with respect to the environment related to "harmful emissions," with respect to labor related to "employee benefits," with respect to society related to "community involvement and charitable work," with respect to human rights related to "prevention of discrimination," and with respect to product responsibility related to "product recalls." Findings from this study provide important insights into the perceptions of future accounting professionals that may be useful to educators, policy makers, information providers, and stakeholders who benefit from reporting of comparable high-quality information.

BACKGROUND

Concern about the comprehensive impact of organizations of all types and sizes on the environment, on people, and the community in which they operate continues to be of high importance. Global concerns about increased pollution levels in especially developing nation and the availability and preservation of scarce natural resources continue to proliferate in light of the persistent increase in the world population and increase in demand for scarce resources. According

to the World Resource Institute (n.d.), during the past decade, water use has increased twice as fast as the world population. Global leaders try to address these issues primarily through agreements among nations and through national regulation. The extent and enforcement of regulation pertaining to sustainability related issues vary considerably among nations. In addition to governmental mandated regulation, sustainable behavior by business and non-business entities has in recent years been motivated by the demand and expectations of stakeholders.

These governmental and stakeholder motivated expectations appear to have been fulfilled. Increasingly, individuals, governmental units, for profit, and not-for-profit organizations participate in efforts to help alleviate the global consequences associated with resource shortages, waste, and pollution; and address issue to enhance employee and community well-being. Extensive recycling programs, investment in renewable energy and energy-efficient equipment, low-flow water systems, utilization of low emission equipment, employee and community oriented programs that improve the health and quality of individuals, and voluntary product recalls are examples of sustainability in action. Global investment in new clean energy rose from \$61.86 billion in 2004, to \$328.93 billion by the end of 2015 (Bloomberg, 2016). Complementing the trend toward enhance sustainability is the trend to formally report sustainability related information to stakeholders.

Sustainability Reporting – Current Status

For decades, companies have publicized their sustainability related efforts to customers and other stakeholder as part of promotional materials, in advertisements, on product packing and other highly visible media, frequently emphasizing only positive achievements. This is supported by past research (e.g., Merkl-Davies & Brennan, 2007). Many of these companies also provide information on their corporate websites. However, increasingly, entities report on their sustainability efforts by issuing formal periodic sustainability reports. The prevalence of formal reporting various considerably among nations. The highest incidence of formal reporting tends to be by companies located in countries that require some level of reporting. For example, the Danish Financial Statements Act requires that large companies disclose sustainability-related information, which led to a significant increase in sustainability reporting in Denmark (KPMG et al., 2015). In South Africa, sustainability reporting is mandated by stock-market regulators (KPMG et al., 2015).

Selected sustainability related disclosures are required by the U.S. Securities and Exchange Commission (SEC). SEC Regulation S-K, Section 101, "Description of Business," which SEC registrants must comply with, states that: "Appropriate disclosure also shall be made as to the material effects that compliance with Federal, State and local provisions which have been enacted or adopted regulating the discharge of materials into the environment, or otherwise relating to the protection of the environment, may have upon the capital expenditures, earnings and competitive position of the registrant and its subsidiaries." (SEC, n.d. paragraph 229, item 101 (c) (1) (xii)). In addition, regulation S-K requires that SEC registrants disclose material environmentally-related legal actions (SEC, n.d., paragraph 229, item 103). While SEC reporting companies must disclose information required by the SEC, many business entities that do not report to the SEC choose to issue formal sustainability reports. Furthermore, many SEC reporting and non-SEC companies"

issue sustainability reports that include more extensive and diverse disclosures than those required by the regulator.

Motivation for Voluntary Sustainability Reporting

Prior literature identifies primarily two theories that help explain entities' motivation for sustainability reporting -- legitimacy theory and stakeholder theory. Dowling and Pfeffer (1975, 122) define organizational legitimacy theory as: "a condition or status which exists when an entity's value system is congruent with the value system of the larger social system of which the entity is a part." Dowling and Pfeffer view a disparity between actual and perceived value systems that are pertinent to the entity as threats to the entity's legitimacy. Thus, legitimacy theory may explain, in part, why companies react to the global demand for sustainable practices by reporting. In essence, companies may be reporting about sustainability to address or prevent an actual or perceived discrepancy between their value system and that of key stakeholders.

Some research supports this theory. For example, Cho and Patten (2007) found evidence suggesting that companies with poor environmental performance tend to report more extensively about their programs to alleviate their negative environmental impact. Cho et al. (2010) found evidence suggesting "language manipulation" by companies with poor environmental performance. Furthermore, Cho et al., (2012) found evidence of companies with weak social performance utilizing "impression management" in their social responsibility graphs. Thus, entities whose actions are perceived as contrary to those of key stakeholders may be using sustainability reporting to improve their reputation and stakeholders' perception about value system congruence.

Stakeholder theory, which is attributed to R. Edward Freeman (1984), also provides support for entities' motivation to report on sustainability. In the context of sustainability reporting, stakeholder theory suggests that entities report on sustainability in response to stakeholder expectations and demand. Furthermore, entities tend to be more likely to meet the expectations of those stakeholders that are perceived as most powerful and important. Some prior research (e.g., Chen and Roberts, 2010) supports this view. While taking a somewhat different focus, both stakeholder theory and legitimacy theory are closely related. In the context of sustainability reporting, legitimacy theory may explain why companies who perceive the need to address reputation issues will report information that may enhance their reputation, while stakeholder theory may explain why companies hold sustainability-related expectations tend to comply with those expectations.

Recent surveys appear to support stakeholder theory. Findings from a survey by Ernst & Young and Boston College Center for Corporate Citizenship (2013) suggest that "transparency with stakeholders" represents the most important motivation for both large and smaller companies to report about sustainability. Specifically, in their survey, nearly 80% of the large and 60% of the smaller companies that report on sustainability indicated "transparency with stakeholders" as an important reason for reporting (EY & Boston College for Corporate Citizenship, 2013). Furthermore, analysis of shareholder-initiated proposals shows that in 2016, sustainability

represented the top category, with 41% of shareholder proposals dealing with environmental and social issues (E&Y, 2016).

Commitment of entities' decision makers to sustainability reporting will likely depend on their perceptions that reporting will yield tangible and/or intangible benefits in excess of reporting related costs. These benefits may include enhanced reputation, mitigation of negative stakeholder and regulator perceptions, cost savings, and employee and investor goodwill. Sustainability reporting may also affect a company's cost of capital. A recent study (Dhaliwal et al., 2011) suggests that entities with high cost of capital that voluntarily start reporting about superior social responsibility programs will tend to experience a decrease in their cost of capital.

Sustainability Reporting Guidelines

The usefulness of sustainability reporting strongly dependents on the relevance, faithful representation, and comparability of the information provided. The availability and consistent application of reporting guidelines are necessary to achieve a high level of comparability. Efforts by several organizations support this objective.

Since its establishment nearly two decades ago, the Global Reporting Initiative (GRI) has developed and periodically updated its sustainability reporting guidelines. GRI's mission is "...to empower decision makers everywhere, through our sustainability standards and multi-stakeholder network, to take action towards a more sustainable economy and world" (GRI, n.d.). Its newest set of guidelines is referred to as "G4 Sustainability Reporting Guidelines" (GRI, n.d.). The GRI guidelines are widely used. A study by Ernst & Young and Boston College of Corporate Citizenship (2013) found that approximately 63% of the S&P 500 companies that issue formal sustainability reports utilize GRI's guidelines. Another study (James, 2015b) found that of a sample of medium-sized entities that issue formal sustainability reports, 62% utilized GRI guidelines.

In the U.S., the Sustainability Accounting Standards Board (SASB) is currently developing industry-specific sustainability reporting standards that can be utilized for SEC reporting (SASB, n.d.). The availability of standards that address industry specific issues may further enhance formal reporting and comparability. In addition, the International Integrated Reporting Council (IIRC), established in 2010 as part of the Prince of Wales' *Accounting for Sustainability Project,* developed a framework for integrated reporting. Its guidelines for integrating both financial and sustainability related information into one report were issued in 2013 (IIRC, 2013). Accounting professionals play an instrumental role in helping companies select sustainability reporting guidelines and selecting, compiling and reporting company specific information.

Importance of Accounting Professionals' Involvement

Accounting professionals' involvement in sustainability reporting tends to be very beneficial to organizations and their stakeholders. The AICPA views CPAs role with respect to sustainability as follows: "Members in public accounting practice - can add value to their clients by providing services related to the development of sustainable business strategies, sustainability

accounting and reporting, and assurance" (AICPA, n.d.). A study (Ballou et, al., 2012) emphasizes the value of accounting professionals' involvement with corporate sustainability. Their study involving 178 corporate responsibility officers (Ballou et al., 2012) suggests that accounting professionals' involvement with the integration of sustainability projects is positively related to a "strategic integration" of sustainability projects. The authors further assert that additional involvement by accounting staff in sustainability initiatives may benefit companies and their stakeholders (Ballou et al., 2012).

Accountants' perceptions of sustainability tend to influence their involvement with and support for sustainability and sustainability reporting. As the importance of sustainability-related projects and the prevalence of formal reporting continue to increase, current and future accounting professionals will encounter enhanced opportunities for adding value to entities' sustainability goals and reporting efforts. Accounting majors represent future accounting professionals; hence their perceptions are important. This study investigates accounting majors' perceptions regarding sustainability reporting.

METHODOLOGY

Research Instrument and Validity

The researcher developed a survey instrument that addresses sustainability-related corporate reporting issues. The questionnaire consisted of three sections; a brief instructional/explanatory paragraph preceded each section of the questionnaire.

The first section of the questionnaire addressed the overall benefits of sustainability reporting for investors, the need for mandatory sustainability reporting, the desirability of issuing an integrated report, the need for external review of sustainability-related information, and the importance of reporting both successes and failures. Brief affirmative statements addressed these issues. Study participants were asked to indicate their level of agreement with each statement. A 5-point Likert rating scale was used, with "5" defined as strongly agree, "4" defined as agree, "3" defined as neutral, "2" defined as disagree, and "1" defined as strongly disagree. Students' perceptions regarding these issues are important because their perceptions will influence their support for reporting sustainability related information.

The second section of the questionnaire was organized into five categories addressing sustainability-related reporting areas. The five categories were (1) environment related information, (2) labor related information, (3) society related information, (4) human rights, and (5) product responsibility. These categories were selected because they represent areas of concern to a broad range of stakeholders and address common reporting themes. In addition, they represent subcategories included in the GRI's sustainability reporting guidelines and are often reported in company reports. Ample space was provided between the sub-categories to encourage participants to indicate multiple specific types of information.

Study participants were instructed to indicate the type of information that they believed should be reported by companies. Participants also were reminded that compiling and reporting of information will incur short-term and long-term costs. The participants were asked to rank their

answers with respect to priority and importance of reporting a particular type of information and to utilize each rank only once. The highest importance/priority was defined as "rank 1," the second most important as "rank 2" and continued in that manner. A prior study (James, 2015a) focused on students' perceptions regarding specific GRI performance indicators and asked participant to indicate the importance of each on a 5-point scale. This study asks participants in an open-ended format to indicate the specific issues for which companies should report information and to rank each item based on perceived priority.

The third section consisted of demographics type questions, including gender, major/minor, academic standing, and career aspirations. The research instrument was piloted with two accounting educators and three students to ensure the clarity of each question or statement. Based on their feedback, some of the statements were slightly modified to enhance clarity and understandability.

Sample Selection and Administration of Research Instrument

All accounting majors at a Western Region State University, at which this study was conducted, complete Intermediate Accounting I and II. Class discussions in Intermediate II includes significant current and emerging reporting trends, including the continued global dominance of IFRS and the convergence of international standards and U.S. GAAP, private company reporting rules, and sustainability as well as integrated reporting. Discussions related to sustainability and integrated reporting focus on the global trend toward increased reporting; motivation for reporting on sustainability such as stakeholder demand and perceived effect on reputation; availability of reporting guidelines such as the GRI, IIRC, and SASB; examples of companies who extensively report on sustainability; variations in the extent and quality of reporting in the U.S., and opportunity for involvement by accounting professions.

Students enrolled in Intermediate Accounting II were chosen to participate in this study for several reasons. First, the vast majority of students enrolled in Intermediate Accounting II have declared accounting as their major or minor and thus are likely to become future accounting professionals. Second, as future accounting professionals, accounting majors will (in the future) influence the nature, extent, and quality of sustainability projects, as well as sustainability reporting. Thus, their perceptions in terms of the need for quality reporting and the type of information that should be reported are important. Third, participation in this survey may motivate accounting students to reflect on corporate responsibility programs and the need for reporting on those programs; furthermore, it also helps support currency in their future profession.

During the Summer and Fall 2015 and Winter and Spring 2016 academic quarters, 214 students enrolled in eight sections of Intermediate Accounting II completed the survey instrument. Participation in the survey was voluntary and students' responses were anonymous. The survey was administered during the last week of instruction. The surveys were reviewed for completeness and those with duplicate rankings in the same sustainability reporting subcategory were eliminated from the sample. Information from 195 usable surveys was input into Microsoft Excel and analyzed.

Demographics

The study participants were asked to indicate their major, academic standing, gender, and work status. Ninety-five percent of the students who completed the survey indicated accounting as their declared major, 4% indicated accounting as their minor field of study, and 1% indicated another major, such as aviation, health care management, and mathematics. Seventy-three percent of the study participants indicated that they were juniors, 24% indicated that they were seniors, and 3% that they were graduate students. Forty-eight percent of the study participants were female and 52% were male. Study participants indicated a wide spectrum of career aspirations, including taxation, external and internal audit, consulting, cost accounting, and working as sole proprietors. Some participants indicated that they were undecided about their career aspirations and a few indicated that they planned to continue their education to earn a law degree.

Statistical Tests Utilized

Student responses to the survey questions were summarized and statistically evaluated using Microsoft Excel statistical tests. Means and standard deviations were derived to report descriptive statistics. Correlations were evaluated at a 0.05 significance level.

EMPIRICAL RESULTS

This section presents empirical results.

The Benefits of Sustainability Reporting

The first section of the questionnaire addressed the overall benefits of sustainability reporting for investors; and the need for (1) mandatory reporting, (2) the information to be audited, (3) reporting of sustainability-related failures as well as successes, and (4) combining sustainability reporting with financial reporting. Students' mean ratings and the related standard deviations are presented in Table 1.

Table 1					
SUSTAINAIBLITY REPOI	RTING RELATED ISSUES				
QUESTION/STATEMENT MEAN RATINGS STAN					
	5 = strongly agree	DEVIATION			
	N = 195				
Investors benefit from sustainability reporting	4.09	0.88			
Reporting should be mandatory for public companies	4.14	0.89			
Reporting should be mandatory for private companies	3.80	1.10			
Publicly available sustainability reports should be	4.13	0.87			
audited					
Both successes and failures should be reported	4.27	0.98			
Companies should combine financial and	2.92	1.09			
sustainability-related information in one report					

Based on the results, on average, students tended to agree with the statement that investors benefit from sustainability reporting. Students also tended to agree that sustainability reporting should be mandatory for public companies; support for reporting by private companies was less strong. These findings are consistent with those of James (2015a) whose study involving a sample from a comparable population also found support for mandatory public company reporting. Thus, results appear to be stable over time.

On average, study participants also agreed that publicly available sustainability reports should be audited. With a mean rating of 4.27, the strongest support was for reporting both successes and failures related to sustainability. Support for combining sustainability reporting with financial reporting was somewhat below neutral, suggesting that on average, students did not perceive a need for companies to publish combined (i.e., integrated) reports.

Reporting Priorities of Sustainability-Related Information

Students were asked to indicate what they perceived as the most important sustainabilityrelated information that companies should report with respect to each of five categories: (1) environment related information, (2) labor related information, (3) society related information, (4) human rights, and (5) product responsibility. Study participants were asked to list as many types of information within each of the five sustainability areas as they perceived should be reported and then to rank their responses based on importance (priority) of reporting. A rank of "1" was defined as the most important information in that sub-category, a "2" as the second most important, and so on. Students were encouraged to indicate as many types of information within each sustainabilityrelated issue as they deemed necessary, while considering the constraints of reporting cost. Prior class discussions on reporting cost focused on the cost/benefit principle and staff-related resources.

Students' responses were analyzed for common themes and frequency. Responses that addressed identical or highly similar issues were combined. For example, responses indicating "air pollution," "green-house gases," and "CO₂ emissions" where combined under "harmful emissions - air." On average, students listed 5.8 items related to environment, 4.3 related to labor, 3.7 related to society, 4.2 related to human rights and 4.4 related to product responsibility. If students listed

several items that were similar, they were combined and only counted once. The top ranked issues, organized by sustainability-related area, are shown in the next sub-section.

Reporting of the Most Important Environment Related Sustainability Information

Study participants were first asked to indicate what type of information should be reported with respect to environment related sustainability and to rank them in order of importance/priority. Table 2 presents the most frequently indicated information, as well as the mean and associated standard deviation for each.

Table 2 Frequently Indicated Environmentally Related Sustainability Information					
	Number of Usable Responses	Percent of all Participants	Mean Rankings	Standard Deviations -	
		Ranking this Issue	important	Kankings	
Harmful Emissions – Air	169	87%	1.95	1.14	
Water Usage and Contamination	156	79%	2.29	1.31	
Use of Scarce Resources	140	72%	2.50	1.18	
Land Destruction/contamination	85	30%	3.23	1.05	
Waste Generation and Waste disposal	55	28%	2.60	1.21	
Global Warming	51	26%	2.64	1.32	

Study participants most frequently indicated "harmful emissions" as the environment related issue for which companies should report information. Second and third most frequently listed issues were "water usage and contamination" and "use of scarce resources." Based on study participants' rankings for each environmental issue they listed, mean rankings and associated standard deviations were calculated. A lower numeric mean indicates a higher perceived priority of reporting on a particular environment related sustainability issue. Thus, on average, students who participated in the study and indicated the particular issues, ranked information about organizations' harmful emissions, water usage and contamination, and use of scare resources of primary importance.

Because means may not fully capture study participants' perceptions of the most important environment related information that companies should report on, frequencies and related percentages for each rank assigned to frequently mentioned issue were derived. Table 3 presents the number of participants who ranked reporting of specific sustainability related issues as No. 1 or No. 2 in terms of importance. The percentages indicate the percent of those listing a specific issue and assigned either rank 1 or rank 2.

Table 3						
Environmental Issues – Rankings						
Environment Related Sustainability Issue Number (percent) of those Number (percent) Rank 1 or 2						
	indicating the issue who	who ranked issue	percent			
	assigning rank No. 1 - most	No. 2				
	important					
Harmful Emissions - Air	73 (43)	55 (30)	73%			
Water Usage and Contamination	55 (36)	37 (26)	62%			
Use of Scarce Resources	30 (21)	43 (31)	52%			
Waste generation and Waste Disposal	19 (16)	19 (35)	51%			
Global Warming	13 (25)	10 (20)	45%			

As shown in table 3, study participants most frequently ranked information about harmful emissions as the most important environment related sustainability issue that should be reported by companies; this is consistent with the findings based on overall means. Of those who indicated that companies should report on "harmful emissions," 73% assigned a rank of either one or two. The second most frequently highly ranked information in terms of importance of reporting was information about water usage and water contamination. Of those who indicated that companies should report on "water usage and contamination," nearly 62% assigned a rank of either one or two. Furthermore, nearly 52% ranked information about the use of scarce resources among the top two most important issues; and nearly 51% ranked information about waste generation and waste disposal among the two most important issues.

Reporting of the Most Important Labor Related Sustainability Information

Study participants were asked to indicate what type of information should be reported with respect to labor related sustainability and to rank them in order of importance. Table 4 presents the most frequently indicated information, as well as the mean and associated standard deviation for each.

Table 4					
Frequently Indicated Labor Related Sustainability Information – Organized by Frequency					
Labor Related Sustainability Issue	lated Sustainability Issue Number of Usable Percent of all Mean Rankings Stan				
	Responses	Participants	1 = most	Deviations	
		Indicating and	important		
		Ranking this Issue			
Employee Benefits	175	90%	1.86	1.11	
Work-related Injuries	148	76%	2.25	1.23	
Compensation/fair Pay	92	47%	2.18	1.04	
Working Conditions and Training	65	33%	2.43	1.21	

As with the environment related sustainability means, a lower numeric mean indicates a higher perceived importance of reporting on a particular labor related sustainability issue. Thus,

on average, the students who participated in the study perceived information about organizations' employee benefits as the most important labor related issue for which companies should report information. It was also the most frequently indicated type of information. The second most important labor related issue based on mean rankings relates to compensation and especially fairness of compensation. However, only 47% of the respondents indicated the need for reporting on compensation and fair pay. More frequently mentioned was the need to report information on work-related injuries, with 76% of the study participants listing it as an area for which companies should report information; the mean ranking was 2.25. Information about working conditions and employee training was listed by 33% of the study participants; the mean ranking was 2.43.

As with environment related sustainability issues, frequencies and related percentages for each rank assigned to frequently mentioned labor related issue were derived. Table 5 presents the number of participants who ranked specific labor related information as No. 1 or No. 2 in terms of importance. The percentages indicate the percent of those who listed a specific issue who assigned either rank 1 or rank 2.

Table 5					
Labor Issues – Rankings					
Environment Related Sustainability Issue	Number (percent) of those	Number (percent)	Rank 1 or 2 in		
	indicating the issue who	who ranked issue	percent		
	assigning rank No. 1 –	No. 2			
	most important				
Employee Benefits	85 (49)	50 (28)	77%		
Work-Related Injuries	46 (31)	47 (32)	63%		
Compensation/fair pay	28 (30)	29 (32)	62%		
Working Conditions and Training	16 (25)	20 (31)	56%		

Reporting of the Most Important Society Related Sustainability Information

Study participants were first asked to indicate what type of information should be reported with respect to society related sustainability and to rank them in order of importance. Table 6 presents the most frequently indicated information, as well as the mean and associated standard deviation for each.

Table 6						
Frequently Indicated Society Related Sustainability Information – Organized by Frequency						
Society Related Sustainability Issue	Number of Usable	Percent of all	Mean Rankings	Standard		
	Responses	Participants	1 = most	Deviations		
		Indicating and	important			
		Ranking this				
		Issue				
Community Involvement/charitable	167	86%	1.25	0.78		
Work						
Truthful Reporting	27	14	2.00	0.66		
Effect (harm) of Product or Service	21	11	2.14	0.90		
on Community						

As with the environment and labor related sustainability means, a lower numeric mean indicates a higher perceived importance of reporting on a particular society related sustainability issue. Thus, on average, the students who participated in the study perceived information about organizations' and employees' community involvement and charitable work as the most important society related issue for which companies should report information. It was also the most frequently indicated type of information, with 86% of all participants indicating that reporting on this issue was important. The second most important society related issue based on mean rankings relates truthful reporting. However, only 14% of the respondents indicated the need for truthful reporting. The only other type of information listed more than a few times was reporting on the effect of harm caused by companies' products or services. This issue more frequently mentioned in the sub-category of product responsibility.

As with environment and labor related sustainability issues, frequencies and related percentages for each rank assigned to frequently mentioned society related issue were derived. Table 7 presents the number of participants who ranked society related information as No. 1 or No. 2 in terms of importance. The percentages indicate the percent of those who listed a specific issue who assigned either rank 1 or rank 2.

Table 7 Societal Issues – Bankings					
Society Rspecelated Sustainability Issue	Number (percent) of those indicating the issue who assigning rank No. 1 – most important	Number (percent) who ranked issue No. 2	Rank 1 or 2 in percent		
Community Involvement/charitable Work	145 (87%)	9 (5%)	92%		
Truthful Reporting	4 (15%)	17 (63%)	78%		
Effect (harm) of Product or Service on Community	3 (14%)	12 (57%)	71%		

Reporting of the Most Important Human Rights Related Sustainability Information

Study participants were asked to indicate what type of information should be reported with respect to human rights related sustainability and to rank them in order of importance. Table 8 presents the most frequently indicated information, as well as the mean and associated standard deviation for each.

Table 8						
Frequently Indicated Human Rights Related Sustainability Information – Organized by Frequency						
Human Rights Related Sustainability Number of Usable Percent of all Mean Rankings Standard						
Issue	Responses	Participants	1 = most	Deviations		
		Indicating and	important			
		Ranking this Issue				
Discrimination Prevention	161	83	1.87	1.09		
Safety reviews	133	68	1.82	1.16		
Work Place Adequacy	56	29	2.47	0.84		
Human Trafficking/child Labor	50	26	2.33	0.97		

As with the environment, labor, and society related sustainability means, a lower numeric mean indicates a higher perceived importance of reporting on a particular human rights related sustainability issue. Thus, on average, the students who participated in the study perceived information about organizations' rules and records related to the prevention of discrimination as an important human rights related issue for which companies should report information. It was also the most frequently indicated type of information. The second most frequently mentioned issue with high importance dealt with safety reviews. While some participants indicated safety with respect to labor related issues, 133 participants listed safety as a human rights related sustainability issue; the mean rating was 1.82, which is the lowest for this category. The two other most frequently indicated type of information that companies should report related to human rights were work place adequacy and human trafficking and child labor.

As with environment, labor, and society related sustainability issues, frequencies and related percentages for each rank assigned to frequently mentioned human rights related issue were derived. Table 9 presents the number of participants who ranked human rights related information as No. 1 or No. 2 in terms of importance. The percentages indicate the percent of those who listed a specific issue who assigned either rank 1 or rank 2.

Table 9						
Human Rights Issues – Rankings						
Human Rights Related Sustainability Issue Number (percent) of those Number (percent) Rank 1 or 2						
	indicating the issue who	who ranked issue	percent			
	assigning rank No. 1 –	No. 2				
	most important					
Discrimination Prevention	72 (45%)	52 (32%)	77%			
Safety Reviews	67 (50%)	39 (29%)	79%			
Work Place Adequacy	7 (13%)	23 (41%)	54%			
Human Trafficking/child Labor	10 (20%)	20 (40%)	60%			

Reporting of the Most Important Product Responsibility Related Sustainability Information

Study participants were first asked to indicate what type of information should be reported with respect to product responsibility related sustainability and to then rank them in order of importance. Table 10 presents the most frequently indicated information, as well as the mean and associated standard deviation for each.

Table 10 Frequently Indicated Product Responsibility Related Sustainability Information – Organized by Frequency						
Product Responsibility Related	Number of Usable	Percent of all	Mean Rankings	Standard		
Sustainability Issue	Responses	Participants	1 = most	Deviations		
		Indicating and	important			
		Ranking this				
		Issue				
Product Recalls	164	84%	1.97	1.10		
Product related Injuries	149	76%	1.75	1.09		
Monitoring and Testing	72	37%	2.46	1.16		
Product Information and Labeling	65	33%	2.42	0.93		
Marketing and Communication	43	22%	2.56	1.38		

As with the environment, labor, society, and human rights related sustainability means, a lower numeric mean indicates a higher perceived importance of reporting on a particular product responsibility related sustainability issue. Thus, the study participants most frequently indicated that companies need to report information about product recalls; the mean rating was 1.97. The second most frequently mentioned reportable issue dealt with product related injuries; the mean score was the lowest (1.75) among the product responsibility category. Some participants indicated that organizations should report about their product testing, labeling, and marketing strategies.

As with environment, labor, society, and human rights related sustainability issues, frequencies and related percentages for each rank assigned to frequently mentioned product responsibility related issue were derived. Table 11 presents the number of participants who ranked

specific product related information as No. 1 or No. 2 in terms of importance. The percentages indicate the percent of those who listed a specific issue who assigned either rank 1 or rank 2.

Table 11						
Product Responsibility Issues – Rankings						
Product Responsibility Related Sustainability	Number (percent) of	Number (percent)	Rank 1 or 2 in			
Issue	those indicating the	who ranked issue	percent			
	issue who assigning	No. 2				
	rank No. 1 – most					
	important					
Product recalls	65 (40%)	61 (37%)	77%			
Product related injuries	72 (48%)	53 (36%)	84%			
Monitoring and testing	18 (25%)	21 (29%)	54%			
Product information and labeling	12 (18%)	20 (31%)	49%			
Marketing and communication	10 (23%)	10 (23%)	46%			

Significant Associations

Correlation tests found significant correlation between students' perceptions that sustainability reporting is beneficial for investors and (1) the need for mandatory reporting and (2) that the information should be audited. Gender, academic standing, and career goals were not significantly correlated to student perceptions.

DISCUSSION AND CONCLUSION

Overall, accounting majors participating in this study agreed with the statement that investors benefit from sustainability reporting, that reporting should be mandated for public companies, and that the information should be audited. Based on the mean ratings, strongest agreement was for the statement that companies should report sustainability failures in addition to successes. This shows awareness of the importance of reporting both types of results, which is incongruent with the current reporting practices of some entities.

In response to open-ended questions, study participants most frequently indicated and ranked "harmful emissions – air" as the most important environment related reporting priority, "employee benefits" as the most important labor related reporting priority, "community involvement and charitable work" as the most important community related reporting priority, "prevention of discrimination" as the most important human rights related reporting priority and "product recall information" as the most important product responsibility related priority.

Findings from this study suggest that current accounting majors, who represent the future accounting professionals, perceive reporting of specific types of sustainability related information of high importance, which may influence their future involvement and support for sustainability and sustainability reporting.

Limitations

The primary limitations of this study relate to the sample, which was selected from a limited population, i.e., accounting majors enrolled at one university. However, accounting majors who participated in this study tend to have a diverse, global background, which somewhat mitigates the limitation and enhances the validity to the results. Thus, their responses reflect important insights regarding globally important reporting issues. As sustainability and sustainability reporting continues to gain importance, the study should be repeated with a larger sample draws from a broader population.

REFERENCES

- American Institute of Certified Public Accountants (AICPA) (n.d.). Sustainability Accounting and Reporting FAQ.

 Retrieved
 August
 14,
 2016,
 from

 https://www.aicpa.org/InterestAreas/BusinessIndustryAndGovernment/Resources/Sustainability/Pages/Sust
 ainabilityFAQs.aspx
- Ballou, B., R. Casey, R. J. Grenier, J. H., & L. Dan. (2012). Exploring the Strategic Integration of Sustainability Initiatives: Opportunities for Accounting Research. Accounting Horizons. 26(2), 265-288.
- Bloomberg (2016). Clean Energy Investment by the Numbers. Retrieved on September 21 2016, from https://www.bnef.com/dataview/clean-energy-investment/index.html
- Chen, J. C. and R. W. Robert (2010). Toward a more coherent understanding of the organization-society relationship: A theoretical consideration for social and environmental accounting research *Journal of Business Ethics*. 97(4), 651-665.
- Cho, C.H., G. Michelon, and D.M. Patten (2012). Impression Management in Sustainability Reports: An Empirical Investigation of the Use of Graphs. *Accounting and the Public Interest*. 12, (2012), 16-37.
- Cho, C.H., R. W. Roberts, and D.M. Patten (2010). The language of U.S. corporate environmental disclosure. Accounting, Organizations and Society 35 (4); 431-433.
- Cho, C.H., and D.M. Patten (2007). The role of environmental disclosures as tools of legitimacy: A research note. *Accounting, Organizations and Society* 32 (7/8), 639-647.
- Dhaliwal, D., O. Z. Li, A. Tsang, & Y. G. Yang (2011). Voluntary Nonfinancial Disclosure and the Cost of Equity Capital: The Initiation of Corporate Social Responsibility Reporting. *The Accounting Review*, 86(1), 59-100.
- Dowling, J. and J. Pfeffer (1975). Organizational legitimacy: Social values and organizational behavior. *Pacific Sociological Review*. 18, 122-136.
- Ernst & Young (EY) (2016). Four takeaways from proxy season 2016. Retrieved October 2, 2016, from <u>http://www.ey.com/Publication/vwLUAssets/EY-four-takeaways-from-proxy-season-2016/\$FILE/EY-four-takeaways-from-proxy-season-2016.pdf</u>
- Ernst & Young (EY) & the Boston College Center for Corporate Citizenship (2013). The Value of Sustainability Reporting. Retrieved August 21, 2013, from <u>http://www.ey.com/US/en/Services/Specialty-Services/Climate-Change-and-Sustainability-Services/Value-of-sustainability-reporting</u>
- Freeman, R.E. (1984). Strategic Management: A Stakeholder Approach. Cambridge University Press: New York.
- Global Reporting Initiative (GRI) (n.d.) About GRI. Retrieve January 21, 2016, from https://www.globalreporting.org/information/about-gri/Pages/default.aspx
- Global Reporting Initiative (GRI) (n.d.). G4 Sustainability Reporting Guidelines. Retrieved January 24, 2016, from https://www.globalreporting.org/standards/g4/Pages/default.aspx
- International Integrated Reporting Council (2013). International IR Framework. Retrieved March 4, 2016, from http://integratedreporting.org/resource/international-ir-framework/
- James, M. L. (2015a). The Benefits of Sustainability and Integrated Reporting: An Investigation of Accounting Majors' Perceptions. *Journal of Legal, Ethical and Regulatory Issues, 18*(1), 1-20.

- James, M. L. (2015b). Sustainability Reporting by Small and Midsize Companies Methods, Nature, and Extent of Reporting. *Business Studies Journal*. 7(2), 1-18.
- KPMG (2015). Currents of Change. The KPMG Survey of Corporate Responsibility Reporting. Retrieved August 17, 2016, from <u>https://assets.kpmg.com/content/</u> dam/kpmg/pdf/2016/02/kpmg-international-survey-of-corporate-responsibility-reporting-2015.pdf
- Merkl-Davies, D. M. and N. M. Brennan (2007). Discretionary disclosure strategies in corporate narratives: Incremental information or impression management? *Journal of Accounting Literature*. 116-196.
- Securities and Exchange Commission (SEC) (n.d.). Regulation S-K. Retrieved September 29, 2013, from http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=20c66c74f60c4bb8392 bcf9ad6fccea3&rgn=div5&view=text&node=17:2.0.1.111&idno=17
- Sustainability Accounting Standards Board (SASB) (n.d.). Vision and Mission. Retrieved December 30, 2013, from http://www.sasb.org/sasb/about/
- United Nations (1987). Our common future. Report of the Commission on Environment and Development: Brundtland Report. Retrieved August 21, 2012, from, conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf
- World Resource Institute (n.d.). Water: critical shortages ahead? Retrieved August 19, 2013, from http://www.wri.org/publication/content/8261

ARTIFICIAL NEURAL NETWORK SYSTEM FOR PREDICTION OF US MARKET INDICES USING MISO AND MIMO APROACHES

Hari Sharma, Virginia State University Hari S. Hota, Bilaspur University Kate Brown, University of Maryland Eastern Shore

ABSTRACT

Advocates of fundamental analysis depreciate technical analysis as a superficial study of trends and patterns depicted by charts without any conclusive proof of efficacy. However, technical trading is one of the ancient trading techniques and the advancements in technical trading are growing exponentially in the age of superfast computers. Predicting the movements of stock prices precisely using sophisticated techniques needs continuous improvement to capture trends. Technical trading techniques using fuzzy models are gaining prominence in predicting non-linear trends in stock markets because of the capability of extracting meaningful information from a large set of data. Artificial neural network (ANN) integrated models are serving the needs of learning non-linear patterns and helping in making better predictions. This research paper focuses on designing models using the architecture of ANN techniques, specifically Error Back Propagation Network (EBPN) and Radial Basis Function Network (RBFN), from Multi Input Multi Output (MIMO) and Multi Input Single Output (MISO) perspectives. The tests of the models developed in this study were performed using the key variable of open, close, high and low prices of DOW30 and NASDAQ100. We used two measures of predictability: Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE). Based on the results, we observed that EBPN outperformed RBFN in predicting the future prices. The results of MIMO approach were also precise than MISO for both systems.

Keywords: Artificial Neural Network (ANN), Error Back Propagation Network (EBPN), Radial Basis Function (RBFN), Multi Input Single Output (MISO), Multi Input Multi Output (MIMO).

INTRODUCTION

Volatility has several aspects for trading including predicting the stock market direction for investing. The prediction of the market gives an idea of the direction of the economy. Therefore, volatility of the stock market has implications beyond the stock market. Volatility can be defined for a single stock and its performance relative to industry, sector and the market. However, the volatility of the overall market is an indicator of the direction of the economy. A volatile market presents the uncertainty and risk to the investors whether individuals or institutions. Researchers continue to explore innovative tools and techniques to recognize trends to predict future trends to help investors, financial professionals and fund managers. Recently, researchers have been trying to design models using sophisticated tools to make improved predictions so that investors can manage their portfolios for the maximum possible returns for a given level of risk. Due to high volatility in the stock market, there is a need to design and develop models that can decipher non-linear trends in the stock market more precisely. The use of Artificial Neural Network (ANN) techniques has taken prominence because of its ability to capture the non-linear trends of stock market data better than traditional techniques. The study of the existing literature reveals that applications of ANNs are more promising alternatives than time series forecasting (Trippi and Turban, 1996). ANN has received the attention of researchers for forecasting market indices because of its trend learning capabilities for non-linear and noisy data, and its massive interconnectivity and parallel processing power (Principe et al., 1999). Researchers are using supervised and unsupervised ANNs for predicting trends in stock index data.

Guresen et al. (2011) conducted a thorough review of ANN models being used in the forecasting of stock market indices. The study revealed a brief description of models developed by using ANN for forecasting of indices data of different countries. White (1988) demonstrated an application of a simple neural network to analyze the daily returns of IBM. Trippi and DeSieno (1992) accomplished technical analysis to demonstrate the effectiveness of an ANN trading system designed for S&P 500 index futures contracts. Lin and Lin (1993) developed a model integrating neural networks to forecast the trends of then Dow Jones Industrial Average (DJIA). Lam (2004) tested the predictability of neural networks for financial performance trendsby combining variables used in fundamental and technical analysis. Ghiassi et al. (2005) compared techniques developed using ANN, ARIMA and DAN2 (Dynamic Architecture of ANN) and established that DAN2 predictions outperformed the other methods. Kumar and Ravi (2007) conducted a review on bank bankruptcy to demonstrate the ability of ANN in financial forecasting. Zhu et al. (2008) developed the model using neural networks to predict the trends of several market indices includes NASDAQ, DJIA and STI. Manjula et al. (2011) integrated a neural network in developing a model for predicting the trends of the daily returns of the Bombay Stock Exchange, SENSEX. They used a multilayer perceptron network to design the architecture of the model and used multiple linear regression (MLR) for training to provide a better option for weight initialization. Qing et al. (2011) scanned the predictive power of several well-established models, including dynamic versions of a single-factor CAPM-based model and Fama and French's three-factor model. They further compared the predictive power of the Multiple Output (MIMO) and Multi Input Single Output (MISO). Sharma and Rababaah (2014) developed a model integrating signal processing with ANN for predicting trends in the US stock market. Further, Rababaah and Sharma (2015) enhanced the predictive power of the model by incorporating two different signal processing techniques with ANN.

This paper emphasized the architectural design of ANN as MISO and MIMO (MIMO1 and MIMO2), based on various important predictors, where investors can select a suitable model based on their requirements or trading needs. For example, some investors may be interested in the Next-Day-Close price while others are interested in both Next-Day-Close price and the Next-Day-Open price and so on. It was assumed that ANN will map an input pattern with its corresponding output pattern in a more associative manner with a higher number of predictors. Three designed architectures of ANN were trained using two stock indices data: DOW30 and NASDAQ100. Simulated results were analyzed in terms of MAPE and found that the performance of predictors were better in the case of MIMO2 as compared to others (MISO and MIMO1). It was also noted that EBPN produces more consistent results than RBFN at both training and testing stages and was always higher in case of testing rather than training.
EXPERIMENTAL SETUP

Data Description: Index data for the DOW30 and NASDAQ100 indices were downloaded from the online source Yahoo Finance (http://finance.yahoo.com) from January 1, 2000 to January 31, 2012 and used in this research work. A total of 3000 samples were collected for both indices, out of which latest 600 samples (20%) were used to test the ANN models and remaining 2400 samples (80%) were used to train the models. Data were normalized using simple normalization method by dividing each sample with maximum value of the data. This is required due to the non-linear nature of time series data with different magnitudes, where larger magnitude variables may dominate the smaller variables (Bashah et al., 2015).

Performance Measures: The predictive model was verified with using two well-known measures: Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE). Equations 1 and 2 were written based on actual index price Y(t) and predicted index price Y'(t) with T as total number of samples. A lower value of these measures indicates that the model is more accurate. When results of measures are not consistent, we can consider MAPE suggested by Makridakis (1993) as the benchmark which provides relatively more stable value than other measures.

$$MAE = \sum_{t=1}^{T} |Y(t) - Y'(t)| / T$$
(1)

$$MAPE = \sum_{t=1}^{T} |Y(t) - Y'(t)/Y(t)|/T$$
(2)

ANN Techniques: In the past two decades ANN techniques have been attracting researchers for time series data forecasting due to their ability to learn non-linear patterns. The following two ANN techniques were used in the current research work for forecasting US stock price index data.

(i) Error Back Propagation Network (EBPN): EBPN (Shivanandam et al., 2011) is probably the most popularly used MLP for financial time series data forecasting in which the logistic or tangent hyperbolic function are used as the activation function in the hidden layer and output layer and which performs the training process in a supervised manner using an error back propagation algorithm in two different stages. (i) Forward pass: In which input is received by the neurons of hidden layer and output is calculated. These outputs are forwarded to outer layer neuron to produce the final output of the model based on the activation function in the outer layer. The actual index value is compared with predicted index value in order to calculate the error. (ii) Backward pass: In which the error calculated in first stage is sent back to previous layer (hidden layer) to adjust synaptic weights. There is a significant amount of literature available which concentrates either EBPN as individual model or as a combination with other techniques like fuzzy logic, genetic algorithm and wavelet transforms.

(ii) Radial Basis Function Network (RBFN): Radial basis function (RBF) networks (Shivanandam et al., 2011) are feed-forward networks trained using a supervised training algorithm. These have a single hidden layer generally with a special type of activation functions known as basis functions. A suitable basis function could be radial basis, polynomial and sigmoid and linear basis function determined by the data pattern. These are also known as kernel type and can be changed to tune the network. In comparison to back propagation in many respects, radial basis function networks have several advantages. They usually train much faster than back propagation networks. They are less susceptible to problems with non-stationary inputs because

of the behavior of the radial basis function in hidden units. Also, the set-up of RBFN topology is very simple and straight forward. Many researchers are using RBF network for the prediction and classification problem and it has proven to be a useful neural network architecture. In RBFN, each unit of hidden layers acts as a locally tuned processor that computes a score for the match between the input vector and its connection weights or centers. In effect, the basis units are highly specialized pattern detectors.

ANN Model Development: An ANN model learns from the relationship of input and output, where each input is mapped with output (Bashah et al., 2015). A suitable architecture is always expected from the network designer for predicting more accurate results. The architecture of model is a network between input, hidden and output layer (Bashah et al., 2015). Neurons at the input layer and output layer depend upon elements in the input and output vector respectively. The number of neurons at the hidden layer may be decided using trial and error methods or other methods. Forming a suitable set of input and output pattern based on available input and output may improve the performance of model. Performance of ANNs may vary by mapping the input pattern with a single output and mapping input patterns with multiple outputs. It is to be assumed that the mapping of the input pattern with more than one output may improve the overall performance of the ANN. Keeping this in mind three ANN architectures were designed as Multi Input Single Output (MISO) and Multi Input Multi Output (MIMO1 and MIMO2) as shown in Figure 1 (a) and (b) with Error Back Propagation Network (EBPN) and Radial Basis Function Network (RBFN). MISO produces one output while MIMO1 and MIMO2 produce two and three outputs respectively with four inputs and four neurons at the hidden layer. These form 4X4X1, 4X4X2 and 4X4X3 architectures of ANN for MISO, MIMO1 and MIMO2. One predictor as Next-Day-Close is considered for MISO, two predictors as Next-Day-Close, Next-Day-Open are considered for MIMO1 while three predictors as Next-Day-Close, Next-Day-Open and Next-Day-High are considered for MIMO2, keeping in mind that these predictors are important for investors and fund managers (Sharma et. al, 2013).



Figure 1: Three layer MLP-ANN MIMO architecture for Stock Index Forecasting (a) MISO (b) MIMO

SIMULATION WORK AND RESULT ANALYSIS

Simulation work was done using Clementine Data Mining software by creating a stream and by feeding Stock Price Index data through MS-Excel files. As stated above, data were splits as training and testing samples. The Clementine stream produced predicted output which were compared against the expected output in terms of MAE and MAPE using equations 1 and 2 and are shown in Table 1 and Table 2 respectively. For most of the predictors MAE and MAPE at the testing stage were always higher than MAE and MAPE at training stage for both the ANN models, especially for DOW30 data set and partially for NASDAQ100 data set. Results of EBPN were more consistent than that of RBFN at both training and testing stages.

A comparative result analysis of the work as per data presented in Tables 1 and 2 can be explained in two different viewpoints as follows:

Dataset	Architecture Type	Predictor	EBPN		RBFN	
			Training	Testing	Training	Testing
DOW30	MISO	Next-Day-Close	95.145	92.680	99.690	97.890
	MIMO1	Next-Day-Close	94.730	92.234	99.664	99.011
		Next-Day-Open	30.355	26.399	45.140	46.020
	MIMO2	Next-Day-Close	92.417	90.331	23.246	99.698
		Next-Day-Open	23.467	17.534	17.290	45.175
		Next-Day-High	64.759	65.534	15.482	71.152
NASDAQ100	MISO	Next-Day-Close	31.640	26.834	36.720	44.540
	MIMO1	Next-Day-Close	31.107	24.145	36.505	47.518
		Next-Day-Open	18.131	19.073	25.783	26.129
	MIMO2	Next-Day-Close	29.763	23.246	35.581	25.638
		Next-Day-Open	16.290	17.290	25.138	19.196
		Next-Day-High	20.876	15.482	26.579	21.843

Table1: A Comparative Results ShowingMAE of MISO and MIMO

Dataset	Architecture		EBPN		RBFN	
	Туре	Predictor				
	<i></i>		Training	Testing	Training	Testing
DOW30	MISO	Next-Day-Close	0.939	0.831	0.989	0.879
	MIMO1	Next-Day-Close	0.937	0.826	0.987	0.890
		Next-Day-Open	0.293	0.229	0.439	0.413
	MIMO2	Next-Day-Close	0.917	0.811	1.103	0.894
		Next-Day-Open	0.225	0.154	0.809	0.405
		Next-Day-High	0.627	0.578	0.731	0.630
NASDAQ100	MISO	Next-Day-Close	1.801	1.256	1.942	2.048
	MIMO1	Next-Day-Close	1.777	1.140	1.926	2.161
		Next-Day-Open	1.118	0.883	1.406	1.199
	MIMO2	Next-Day-Close	1.670	1.103	2.043	1.221
		Next-Day-Open	0.982	0.809	1.488	0.898
		Next-Day-High	1.197	0.731	1.465	1.018

Table 2: A Comparative Results ShowingMAPE of MISO and MIMO

(a) Comparative Analysis of two ANN Techniques: Out of the two ANN techniques considered in this piece of research work, EBPN outperformed RBFN in terms of MAE and MAPE as shown in Table 1-2 and Figure 1-2. MAPE of EBPN was always less than that of RBFN for all the ANN architectures for both the indices in the case of training and testing for predictors: Next-Day-Close (Figure 1(a) and 2(a)), Next-Day-Open (Figure 1(b) and 2(b)) and Next-Day-High (Figure 1(c) and 2(c)). For example, Next-Day-Close price in case of MISO, MIMO1 and MIMO2 (Figure 1(a)) are 0.831,0.826 and 0.811 respectively using EBPN and are 0.879, 0.890 and 0.894 respectively using RBFN for DOW30 Index data. Similarly, the results of EBPN were better than RBFN for NASDAQ100 Index data. These results also showed that EBPN produced more consistent results than RBFN, demonstrating that EBPN is more reliable than RBFN.





Figure 1: Comparative MAPE of different ANN techniques simulated for DOW30 Stock Index Data based on various architectures of ANN (At testing stage) for predictor (a) Next-Day-Close (b) Next-Day-Open (c) Next-Day-High.







Figure 2: Comparative MAPE of different ANN techniques simulated for NASDAQ100 Stock Index Data based on various architectures of ANN (At testing stage) for predictor (a) Next-Day-Close (b) Next-Day-Open (c) Next-Day-High.

(b) Comparative Analysis of different predictors in case of EBPN: Having demonstrated that EBPN was the better prediction model for Stock Price Index forecasting, the predicted MAPE values were analyzed to compare MISO and MIMO results, i.e., to analyze whether the results improved with an increasing number of predictors. The hypothesis was that MAPE should decrease as the number of predictors was increased. This comparative analysis is shown in

Figure 3 and 4 in form of bar chart at both training and testing stages. Figures 3 and 4 clearly reflect that MAPE of predictors Next-Day-High, Next-Day-Open, Next-Day-Close were continuously decreasing in the case of MISO, MIMO1 and MIMO2 respectively. For example, Next-Day-Close price (Figure 3(c)) in case of MISO is 0.831 while it is 0.826 and 0.811 respectively for MIMO1 and MIMO2 for DOW30 while these are (Figure 4(c)) 1.256, 1.140, 1.103 for NASDAQ 100. Results for other predictors are also promising and consistent (See Figures 3 (a), (b) and 4 (a), (b)).







Figure 3: A Comparative MAPE In Case of different ANN architectures simulated for DOW30 Index data Using EBPN for predictor (a) Next-Day-Close, (b) Next-Day-Open, (c) Next-Day-High.







Figure 4: A Comparative MAPE in case of different ANN architectures simulated for NASDAQ100 Index Data Using EBPN for predictor (a) Next-Day-Close, (b) Predictor Next-Day-Open, (c) Predictor Next-Day-High.

CONCLUSION

Artificial Neural Network (ANN) is a widely used technique for financial data forecasting specifically for technical trading perspectives. This study has used a three layer feed forward neural network: Radial Basis Function Network (RBFN) and Error Back Propagation Network (EBPN) for forecasting of two US stock indices, DOW30 and NASDAQ100, based on the architectural design of ANN. We concluded that the results of EBPN technique were better than RBFN. The results showed that predicted values were better in the case of MIMO2 followed by MIMO1 and MISO. Hence, an EBPN based MIMO2 model may be considered better than one of MIMO1 and MISO for predicting trends in US stock market.

REFERENCES

- Bashah, N.A.A., Othman, M.R. & Aziz, N. (2015), Feed Forward Neural Network Model for Isopropyl Myristate Production in Industrial-scale Semi-batch Reactive Distillation Columns, Journal of Engineering Science, Vol. 11, 59-65.
- Ghiassi, M., Saidane, H. & Zimbra, D. K. A dynamic artificial neural network model for forecasting time series events. *International Journal of Forecasting*. 2005, vol. 21, num. 2, 341-362.
- Guresen, E., Kayakutlu, G., & Daim, T.U. (2011). Using artificial neural network models in stock market index prediction, *Expert Systems with Applications*, 38(8), 10389-10397.
- Kumar, R. and Ravi, V. (2007) Bankruptcy prediction in banks and firms via statistical and intelligent techniques-A review, European Journal of Operational Research, vol. 180, no. 1: 1-28
- Lam M. (2004). Neural network techniques for financial performance prediction: integrating fundamental and technical analysis. *Decision Support Systems* 37, 567–581.
- Lin F.C., & M. Lin (1993), Analysis of financial data using neural nets, AI Expert, 36-41.
- Manjula, B., S.S.V.N. Sarma, R. Lakshman Naik, & G. Shruthi (2011). Stock Prediction using Neural Network. International Journal of Advanced Engineering Sciences and Technologies, 10 (1), 13–18.
- Makridakis, S. (1993). Accuracy measures: theoretical and practical concerns. *International Journal of Forecasting*, 9, 527-529.
- Principe, J.C., Euliano, N.R., Lefebvre, W.C. (1999). Neural and Adaptive Systems Fundamentals Through Simulations, John Wiley and Sons, Inc.
- Qing, C., Mark, E.P., & Karyl B.L. (2011). The three-factor model and artificial neural networks: predicting stock price movement in China. *Annals of Operations Research*, 185(1), 25-44.
- Rababaah, A. and D.K. Sharma (2015). Integration of Two Different Signal Processing Techniques with Artificial Neural Network for Stock Market Forecasting. *Journal of Management Information and Decision Sciences*, 18(2), 63-80.
- Sharma, Dinesh K., Sharma, H. and Hota, H., (2013) Traditional Versus Artificial Neural Network Techniques: A Comparative Study for Stock Market Predictions, Paper presented at the 44th Annual Meeting of the Decision Sciences Institute, Baltimore, Maryland, November, 16-19.
- Sharma, Dinesh K. & A. Rababaah (2014). Stock Market Predictive Model Based on Integration of Signal Processing and Artificial Neural Network. *Academy of Information and Management Sciences Journal*, 17(1). 51-70.
- Shivanandam, S. & S. Deepa (2011). Principles of soft computing, Second Edition, New Delhi: Wiley India publication.

- Trippi, R. & D. DeSieno (1992). Trading equity index futures with a neural network. *Journal of Portfolio* Management, 27-33.
- Trippi, R. & E. Turban (1996). Neural Networks in Finance and Investing. Chicago: Probus Publishing Company.
- White, H. (1998). Economic prediction using neural networks: the case of IBM daily stock returns. *Proceedings of the Second IEEE International Conference on Neural Network*, II451–II458.
- Zhu, X., H. Wang, L. Xu & H. Li (2008). Predicting stock index increments by neural networks: The role trading volume under different horizons. *Expert Systems with Applications*, 34, 3043–3054.