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Testing Major Factors for Reducing Obstacles to Product Innovation Success

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ABSTRACT

The literature on strategic leadership, competitive intelligence, management of technology, and specific characteristics of the company's change process propose their importance in successfully implementing business innovation. While these factors may indeed be important to enhance company competitiveness, the existing literature contains practically no empirical evidence supporting their relationship to reducing the many problems companies encounter implementing product innovation (PI). A field test was designed with the primary objective of empirically testing the theoretical model addressing which factors, if managed appropriately, will help reduce the obstacles to PI in practice. A questionnaire was developed, pilot tested, and used to collect data from 47 product innovation managers. The results support the theoretical importance of strategic leadership, competitive intelligence, management of technology, and specific characteristics of the company's change process to reducing the problems/obstacles to successful PI. The items used for measuring the main constructs provide further insights into how managers should go about developing these areas within their organizations.

Based on the results recommendations are made to practitioners and researchers in this important area.

INTRODUCTION

Product Innovation (PI) is the first step in the overall process of product life cycle management as presented by Parry et.al. (2009). It should be viewed as a critical step having a major impact on a firm's competitive position (Slack et al., 2006; Cooper and Chew, 1996). It is well understood that PI is not a simple event but a process, requiring that it be managed as such. Tidd et al. (2008) proposed that the PI management process involves: searching for a strategic approach for innovation and the challenge of its management; developing mechanisms and structures of effective implementation; and developing an organizational context which supports innovation and constructing effective external interfaces. It is also widely accepted that the process is related to managerial action: actions directed by clear strategies, objectives and vision; disciplined by systematically collecting information; and action that renews the organization now and again by changes (Tushman and Anderson, 1997).

At the company operational level, many authors focused on specific PI sub-processes as critical to success. Cooper and Edgett (2008) considered the monitoring of consumption tendencies important in the early stages of product innovation, followed by the importance of capturing ideas from external sources. Matta (2008) proposed dynamic allocation of mobilized resources between activated projects. Cooper (2009) focused on the implementation stage and proposes the use of stage gates, cross-functional teams, the involvement of suppliers and the use of project management tools. Blindenbach-Driessen and Van Den Ende (2010) and Adams et al. (2006) focused on evaluating results in learning from past projects, proposing the importance of evaluation metrics for project success, the use of discussion sessions, and the registering of lessons learned.

Therefore, despite the technical obstacles inherent in the innovation process, most of the failures are due to the way it is managed (Tidd et al., 2008).

At the company strategic level, the literature on strategic leadership, competitive intelligence, management of technology, and specific characteristics of the company's change process, propose their importance in successfully implementing business innovation. While these factors may indeed be important to enhance company competitiveness, the existing literature contains practically no empirical evidence supporting their relationship to reducing the many problems companies encounter implementing product innovation (PI). While most authors would agree that the change process has to bear certain characteristics, another large body of literature deal with the many factors important to innovation success or failure from a broader perspective. Many researchers have looked to improvements in strategic leadership as critical to developing an organization environment conducive to innovation (Waldman et al., 2001; Williams, 2004). To help define and prioritize important problems and opportunities to the organization, many have proposed Competitive Intelligence (CI) programs as important to company success (Tarraf & Molz, 2006; duToit, 2003; Vedder & Guynes, 2002; Guimaraes & Armstrong, 1998). Further, effective Management of Technology (MOT) is thought to be a critical requirement for successfully implementing most modern business changes (Beattie & Fleck, 2005). While these propositions are exceedingly important, the existing literature needs more empirical evidence supporting them. While the constructs being studied are well established, much can be done for empirically testing the proposed relationships among them. Particularly useful might be testing these factors in terms of their effects in reducing the obstacles/problems for increasing the likelihood of PI successful implementation. This field test was specifically undertaken to meet that goal.

THEORETICAL BACKGROUND AND PROPOSED HYPOTHESES

In this section we define the theoretical model proposed in this study, the major constructs involved, and the hypotheses to be tested.

Dependent Variable: Obstacles Encountered In Product Innovation

There is a large collection of studies addressing the organization obstacles (problems) to successful product innovation. For example, Galia and Legros (2004) and Segarra-Blasco et al. (2008) address these problems with the objective of developing a better understanding and sustain public policy proposals. Table 1 summarizes the main problems in product innovation that researchers have reported managers encounter in practice, and their respective primary literature sources. Please note that various authors address specific obstacles in product innovation, i.e. Galia and Legros (2004) focus on the lack of information about the market, the relevant technologies, and the consumer himself/ herself. Cooper (2009) focuses on the difficulty in turning good ideas into actual products, while Adams et al. (2006) focus is on the difficulty of measuring results and innovation performance.

Figure 1
The Research Model

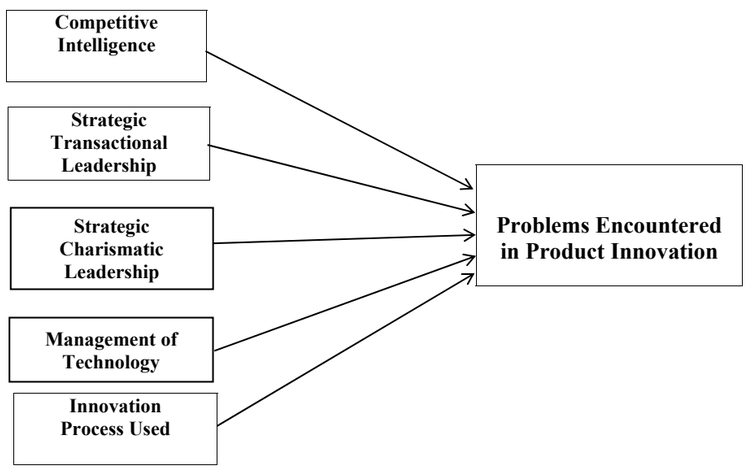

Table 1

Encountered Problems/Obstacles In Product Innovation	Source References
Difficulty dealing with uncertainty and risk.	Stringer(2000); Sharma (1999).
Lack of market information.	Galia and Legros (2004).
Lack of information about technology.	Galia and Legros (2004).
Lack of information about the consumer.	Galia and Legros (2004).
Difficulty generating truly new ideas.	Nemeth (1997).
Difficulty evaluating/selecting the best ideas.	Sharma (1999).
Difficulty connecting the portfolio of projects to strategic objectives.	Cooper, Edgett and Kleinschmidt (2001).
Difficulty turning selected good ideas into innovative products.	Cooper (2009).
Difficulty measuring results and performance in innovation	Adams et al. (2006)
Lack of qualified staff.	Galia and Legros (2004).
Difficulty orchestrating/co-ordinating the various areas for innovation.	Thamhain (2003).

On the other hand, the practitioner and academic literature also proposes (Guimaraes, 2008, 2011) that to manage change effectively and to reduce potential problems to their innovation efforts, organizations need to:

1. Be in touch with their markets, customers, competitors, new products, etc.;
2. Have adaptive leadership which promotes innovation;
3. Manage technology effectively in supporting the necessary changes; and
4. Follow some basic prescriptions while implementing the change process.

Each one of these are correspondingly represented by the independent variables in this study. These are separately defined below, each followed by the hypothesis representing the expected inverse relation to PI problems encountered in practice. This section, in turn, will be followed by a description of the methodology used in this study, the results, and the conclusions and recommendations.

Independent Variable: Company Competitive Intelligence

The evolution of competitive intelligence has been discussed widely (Calof and Wright, 2008; Nemutanzhela & Iyamu, 2011). Competitive intelligence (CI) is a tool that provides a competitive advantage to enterprises and helps decision-makers (Fleisher & Wright 2009; Haataja, 2011). There are many definitions of CI in the literature (Weiss & Naylor, 2010) and none has achieved worldwide acceptance (Roitner, 2008). Haddadi, Dousset and Berrada (2010) conclude that the lack of a universally accepted definition of CI makes it a field with unstable borders. CI is frequently confused with industrial espionage (Colakoglu, 2011).

The importance of competitive intelligence as a key asset is increasingly recognized by managers as useful to keep in touch with what is going on in their markets (Guimaraes, 2011; Tarraf & Molz, 2006; Swartz, 2005; duToit, 2003; Vedder & Guynes, 2002; Darling, 1996). With the increase in business competition, company survival and success is now determined by its rate of learning. If it is faster than external changes, the organization will experience long term success (Darling, 1996). Ironically, even though as much as 68% of U.S. companies have an organized approach to providing information to decision makers (Westervelt, 1996), acccording to Ettorre (1995), probably less than 10 percent of American corporations managed the CI process well and effectively integrated the information into their strategic plans in the past. According to Fuld and Company (2013), competitive intelligence is a function within large corporations around the globe that serve to track and analyse the competition, provide early warning to management, as well as report to management on both opportunities and threats, both tactical and strategic. It is a function that delivers analyses and conducts strategic exercises such as war games and longer term scenario assessments.

The antecedents and consequences of competitive intelligence dissemination has been studied by Maltz & Kohli (1996). Competitor Analysis (CA) was proposed

by Ghoshal & Westney (1991), and other approaches useful for companies to collect information from competitors were addressed by Heil & Robertson (1991). The importance of organization intelligence to financial performance was also demonstrated many years ago. Companies with well-established CI programs on the average showed earnings per share of $1.24, compared to those without CI programs which lost 7 cents (King, 1997).

Over time the importance of CI has grown steadily in Asia and in Europe where companies with intelligence budgets of more the $2 million or more did not exist five years ago but today represent 2-3 percent of all intelligence budgets. Further, in North America, programs that spend more than one-million dollars increased from approximately 5-percent of all corporate intelligence program budgets to nearly 10-percent of all budgets (Fuld and Company, 2013). Despite its importance and steady adoption all over the world (Pellissier & Nenzhelele, 2013), CI is no panacea and has its prerequisites (Nemutanzhela & Iyamu, 2011).

The literature contains many examples of benefits that can be derived from CI. Among these are improved competitive edge (Fuld and Company, 2013; Pellissier & Nenzhelele, 2013, Editors, 2004; duToit, 2003; McCune, 1996; Sawka, 1996; Westervelt, 1996) and improved overall company performance (Davison, 2001; Guimaraes & Armstrong, 1998; Babbar & Rai, 1993), two essential company goals that can be brought about with effective application of competitive intelligence. More specific benefits of CI include: uncovering business opportunities and problems that will enable proactive strategies (Ellis, 1993; Westervelt, 1996); providing the basis for continuous improvement (Babbar & Rai, 1993); shedding light on competitor strategies (Harkleroad, 1993; Westervelt, 1996); improving speed to markets and supporting rapid globalization (Baatz, 1994; Ettorre, 1995); improving the likelihood of company survival (Westervelt, 1996); increasing business volume (Darling, 1996); providing better customer assessment (Darling, 1996); and aiding in the understanding of external influences (Sawka, 1996). Benefits such as these provide the basis for firms to better understand the potential impact of the proposed changes and the means by which they can be infused into the company's fabric. Based on the above discussion, we propose the following hypothesis:

H1: Company CI effectiveness is inversely related to problems encountered in product innovation.

Independent Variable: Strategic Leadership

There is a substantial body of knowledge proposing the importance of effective leadership as an ingredient to successful organization change (Guimaraes, 2011; Waldman, et al., 2001). There are many types of leadership (i.e. formal/informal, based on specific skills, social status, etc) arising from the circumstances in which leaders/followers find themselves. However, for the purposes of this study the relevant construct is company strategic leadership. Pawar & Eastman (1997) proposed transactional strategic leadership as the one to be operational within an existing organizational system or culture instead of trying to change it. It attempts to satisfy the current needs of followers by focusing on exchanges and contingent reward behavior. It pays close attention to exceptions or irregularities and takes action to make corrections (Bass, 1985; Burns, 1978). Conceptually similar to the cultural maintenance form of leadership described by Trice & Beyer (1993), transactional leadership acts to strengthen existing organization processes, structures, strategies, and culture.

The second form of strategic leadership is transformational or "charismatic" leadership (Pawar & Eastman, 1997). According to Waldman et al., (2001) the leader articulates "a vision and sense of mission, showing determination, and communicating high performance expectations" (p.135). The followers reply with confidence in the leader and strong admiration or respect. Also they identify with the leader's vision and with the organization itself, creating a high level of collective cohesion. This cohesion and the leader's expressions of confidence in the followers' ability to attain the vision produce, in turn, a heightened sense of self-efficacy (Podsakoff et al., 1990). Further, charismatic leaders are likely to show persistence and enthusiasm in pursuing goals and be demanding of others through the communication of high performance expectations (Kanter, 1983; Trice & Beyer, 1993). There is evidence that charismatic leadership at the top executive level is important for company performance (Day & Lord, 1988; Hambrick & Finkelstein, 1987; Yukl, 1998). Katz & Kahn (1978) argued that while charismatic leadership may be more relevant to situations where organization change is important, both transactional and transformational (charismatic) leadership are potentially important at the strategic level, that it is particularly important as a means of mobilizing an organization to meet the demands of its environment. Bass (1985) viewed transactional and charismatic leadership as being somewhat complementary in that both could be displayed by the same individual leader. Similarly, Trice & Beyer (1993) acknowledged that both maintenance- and innovation-oriented leadership could be shown by a given leader over time. Based on the above discussion both types of strategic leadership are tested and we propose:

H2: Strategic transactional leadership is inversely related to problems encountered in product innovation; and

H3: Strategic charismatic leadership is inversely related to problems encountered in product innovation.

Independent Variable: Management of Technology (MOT) To Support Business Change

As business competitiveness increases, many business organizations have used technology for redesigning business processes, provide new products and services, and improve the organization work environment. Many authors have proposed the importance of a wide variety of technologies to support business innovation (Li-Hua & Khalil, 2006; Khalil & Ezzat, 2005). Computer Telephony Integration has been touted as a powerful tool to improve the relationship with customers (McCarthy, 1996). The effects of computer technology on organization design, intelligence and decision making have long been of interest to researchers (Huber, 1990). The use of computers for data mining and warehousing is seen as essential for decision support (Anonymous, 1995). Friedenberg & Rice (1994) and Guimaraes et al., (1997) have proposed Expert Systems as viable implementation vehicles for business change because they are effective in capturing and distributing knowledge and knowledge processing capability across an organization. The list of technologies available to support the necessary business changes is endless. For business changes requiring technology, without effective MOT the change implementation processes would be severely hindered and in many cases rendered impossible. Based on the above discussion the following is proposed

H4: MOT effectiveness is inversely related to problems encountered in product innovation.

Independent Variable: Important Characteristics of the Change Process

For improving the success rate of changes in organizations, the literature (Guimaraes & Armstrong, 1998; Guimaraes, 2011) proposes several pre-requisites for the process used for implementing change, i. e. conformity to company objectives, employee and department participation in the change process, customer input, reasonably balancing risk taking with cost benefit analysis, monitoring progress, and communication regarding the change process. In other words, how change is implemented is an important determinant of success. Specifically, as proposed by Guimaraes & Armstrong (1998), the important characteristics of the change process enumerated above are expected to influence the company's ability to change its products. Thus, we have: H5: The extent to which the change process bears the desirable characteristics will be inversely related to problems encountered in product innovation.

STUDY METHODOLOGY

This section provides an overview of the field-test procedure used and a brief description of the sample supporting this study. A description of how the variables were measured, the data analysis procedures, and the discussion of the study results are presented later.

The Data Collection Process

This field test used a questionnaire to collect the relevant data from a convenience sample of 47 product development managers from 32 organizations with global business operations headquartered in the United States. The questionnaire was developed based on a survey of the literature and it was tested for readability and content relevancy and completeness in relation to the study objectives. This testing was conducted through several meetings and phone conversations with four managers presently directly involved in new product development. The questionnaire had a cover letter describing the purpose of the study and providing instructions for the respondents, nevertheless the data was collected mostly through personal interviews with the respondents. Many of the participants are known personally to the researchers from seminars in product and business process innovation, and some are known to have considerable knowledge and experience about their respective company's policies, processes and activities in product innovation.

Sample Description

The companies represented in the sample range widely in terms of their industry sector and size. Forty two percent of the firms identified their primary business as manufacturing with the remaining companies distributed fairly evenly across the sectors of communications (11%), health care (6%), retail (8%), banking and finance (11%), and other (22%). In terms of gross revenues, twenty nine percent of the firms were two hundred million dollars in annual sales or less, forty six percent were between two hundred million and 800 million dollars and the remaining twenty five percent were above 800 million dollars. Twenty six percent of the respondent identified that their number of employees were 500 or less, thirty nine percent of the companies employed between 500 and 1000 people, and the remaining companies (35%) had more than 1000 employees.

Construct Measurement

The measuring scale and components for each major variable in this study are presented next. As discussed earlier, the major constructs and their subcomponents have been

collected from the existing literature, have been validated and used by prior studies, and provided the theoretical framework for the model empirically tested here.

Obstacles Encountered in Product Innovation were collected from the literature as referenced in Table 1. Respondents were asked to "Please rate the difficulty of the following product innovation problems your company actually encountered over the last three years, in comparison with the closest competing organizations you are aware of." The list of 11 items to be rated includes:

1. Dealing with uncertainty and risk,
2. Lack of market information,
3. Lack of information about technology,
4. Lack of information about consumers,
5. Difficulty to generate truly new ideas,
6. Difficulty to evaluate and select best ideas,
7. Difficulty to connect the portfolio of projects to strategic objectives,
8. Difficult to turn selected good ideas into innovative products,
9. Difficult to measure results and performance in innovation,
10. Lack of qualified staff, and
11. Difficulty orchestrating/co-ordinating the various areas for innovation.

This was done using a seven-point Likert-type scale ranging from 1 to 7.

1. extremely lower than average,
2. much lower,
3. somewhat lower,
4. average,
5. somewhat higher than average,
6. much higher, and
7. extremely higher.

The ratings for these items were averaged to produce a single measure for "problems/obstacles encountered."

Strategic Leadership represents the ability of the top management team to provide leadership when the organizational environment requires change. Environments perceived as highly uncertain (requiring major changes) tend to be perceived as risky, where wrong decisions could be costly. Such environments probably generate a high degree of stress. Charismatic leadership would tend to reduce stress and generate confidence, and perhaps show how uncertainty can be turned into a vision of opportunity and success (Bass, 1985). While charismatic leadership may be more relevant to situations where organization change is of major importance, both transactional and transformational (charismatic) leadership are potentially important at the strategic level. Further, Bass (1985) viewed transactional and charismatic leadership as being somewhat complementary in that both could be displayed by the same individual leader. The same items proposed by Waldman et al., (2001) were used to measure the two types of strategic leadership: It was assessed by asking the respondents to rate the extent to which their top managers in general exhibit the particular behavior when compared to managers of main competing organizations.

Transactional leadership:

1. Takes actions if mistakes are made.
2. Points out what people will receive if they do what needs to be done.
3. Reinforces the link between achieving goals and obtaining rewards.
4. Focuses attention on irregularities, exceptions, or deviations from what is expected.
5. Rewards good work.

Charismatic leadership:

1. Shows determination when accomplishing goals.
2. I have complete confidence in them.
3. Makes people feel good to be around them.
4. Communicates high performance expectations.
5. Generates respect.
6. Transmits a sense of mission.
7. Provides a vision of what lies ahead.

Characteristics of the Change Process is defined as the degree to which companies promote "desired" change process activities. It was assessed by asking the respondents to rate the importance or focus that the company places on ten areas of change process characteristics. These consisted of all significant changes must conform to company objectives, all affected departments participate in the change process, individual employee input is considered important, customers input is considered important, business partners input is considered important, ability to balance risk taking with cost/benefit, clearly defined measures to monitor progress, change objectives and progress are clearly communicated, responding quickly to required change, and responding effectively to required change. The same seven-point Likert-type scale was used, and the overall rating of characteristics of the change process for each firm was determined as the average of the ten areas.

MOT Effectiveness in Supporting Business Change is the extent to which the company's needs for technology while implementing business change have been met. It was measured by asking the respondents to rate this for the overall company and in four specific areas: technology leadership in the industry, knowledge of how to get the best technology, effectiveness with which technology has been used over the years, and effectiveness in using technology in comparison with main competitors. The respondents were asked to use the same seven point scale described above. The measure for MOT effectiveness in supporting business activities is the average of the ratings for these four items.

Construct Validity

Several precautions were taken to ensure the validity of the measures used. Many of the recommendations by Carmines & Zeller (1979) were followed. To ensure content validity, a thorough survey of the relevant literature was undertaken to understand the important aspects of each major variable and its components, and not neglect important dimensions of any variable. To further reduce the possibility of any non-random error, the main source of invalidity (Carmines & Zeller, 1979, p. 15), a group of practitioners from different companies with extensive experience in managing PI reviewed the questionnaire for validity (measuring the phenomena intended), completeness (including all relevant items), and readability (making it unlikely that subjects will misinterpret a particular question). Some questions were reworded to improve readability; otherwise, the items composing each major variable remained as derived from the literature.

As proposed by Carmines & Zeller (1979), "construct validation focuses on the extent to which a measure performs in accordance with theoretical expectations" (p.27). To ensure construct validity, the theoretical relationships between the constructs should have been previously established, and these relationships hopefully have been empirically supported by different studies over time. As discussed earlier, the theoretical underpinnings of this study are relatively well established, with most of the items in each construct having been addressed before by several authors. Second order factor analyses on the two types of strategic leadership (transactional and charismatic leadership) have been performed by prior studies (Guimaraes, 2008; Guimaraes, 2011) using larger sample sizes and the results indicated that they can be combined into a single factor as done in this study.

Data Analysis Procedures

The relatively small sample size (n = 47) requires the use of simple but robust statistical analysis. Pearson's correlation coefficients were used to statistically test the possible relationship between the main constructs. T-tests and Chi-square statistics for cross-tabulations were used to test the hypotheses. Responses from each manager regarding the main constructs were classified into two groups: above and below the mean to produce the cross-tabulation tables.

RESULTS

Table 2 lists the Pearson's correlation coefficients, and the means and standard deviations for the six major research variables. On the average, the companies in the sample are thought to be performing slightly above average in the areas of competitive intelligence, both components of strategic leadership, management of technology, and specific characteristics of the company's change process. On the other hand, on average, the companies in the sample tend to be "somewhat high" in terms of encountering the obstacles to product innovation identified in this study. It is also notable that the relatively large standard deviations (mostly above 1.0) indicate significant differences in performance from company to company. One possible explanation for the "somewhat high" average regarding the identification

Table 2
Correlations Between Major Variables

Major Variables	Mean	Std.Dev.	1	2	3	4	5
1. PI Problems Encountered	4.7	0.83					
2. Competitive Intelligence	4.2	1.12	-.23*				
3. Transactional Leadership	4.5	0.98	-.20*	NS			
4. Charismatic Leadership	4.1	1.22	-.35**	.36**	NS		
5. Management of Technology	4.4	1.07	-.26**	NS	.18*	.13*	
6. Change Process Features	4.3	0.98	-.33**	.27**	.14*	.23*	.15*

of obstacles to product innovation may be that the industry seminars attended by the product managers may have raised their own performance expectations and problem awareness.

Hypothesis H1 proposes that a company's performance in Competitive Intelligence (CI) is inversely related to problems encountered in product innovation. Table 3 shows the results of the cross-tabulations for these two major variables.

In Table 3 the number of observations falling in each table cell corroborates that companies performing above average in the performance of CI tend to be below average in terms of encountering problems during product innovation. The same inverse relationship tends to hold for companies performing below average in CI, thus encountering more difficulty in product innovation. About half as many (8 versus 15) organizations report encountering above average product innovation problems when they are performing above average in CI. However, this also shows that higher than average overall performing in CI is apparently no guarantee that a company will also not encounter above average problems in product innovation. On the other hand, below average performance in CI shows a threefold (6 versus 18) increase in higher than average encounters with product innovation problems.

Table 3
Cross-Tabulation of Performance in Competitive Intelligence and PI Problems (Hypothesis 1)

		Product Innovation Problems Encountered	
		Below Average	Above Average
Performance in Competitive Intelligence	Below Average	6	18
	Above Average	15	8
		Chi-square = 7.68 (p = 0.00)	

As shown in Table 4, t-tests were used to further test the significance of this relationship between the company

Table 4
T-Tests for Performance in Competitive Intelligence and Each Product Innovation Problem Encountered

Aggregated Variable and Individual Items	Competitive Intelligence Below Average Performance	Competitive Intelligence Above Average Performance	p-Value
Problems encountered in product innovation:	4.7	4.1	0.03
Difficult to deal with uncertainty and risk.	5.1	4.5	0.02
Lack of market information.	5.3	3.5	0.00
Lack of information about technology.	4.7	3.6	0.01
Lack of information about the consumer.	5.2	3.7	0.01
Difficult to generate truly new ideas.	4.5	4.3	Not Significant
Difficult to evaluate and select the best ideas.	4.6	4.8	Not Significant
Difficulty to connect the portfolio of projects to strategic objectives.	4.9	4.3	Not Significant
Difficult to turn selected good ideas into innovative products.	4.3	4.4	Not Significant
Difficult to measure results and performance in innovation.	4.8	4.0	0.01
Lack of qualified staff.	4.5	3.9	0.02
Difficult to orchestrate and co-ordinate the various areas for innovation.	4.0	3.8	Not Significant

* means p<.05, ** means p< .01

performance in CI and product innovation problems encountered. Respondents in the two groups, above and below the average performance in CI are compared in aggregate and along each of the product innovation problems identified in the literature. The results clearly demonstrate that compared to below average firms, companies with above average performance in CI have encountered product innovation problems at a significantly lower level on many of the product innovation problems identified. Based on the above results, we find strong support for hypothesis one.

Results from Hypothesis Two Testing

Hypothesis two proposes that performance in overall company Strategic Transactional Leadership is inversely related to problems encountered in product innovation. This was tested in a similar manner as for hypothesis one: respondents were placed in two groups based on their above or below average ratings in Strategic Leadership. Table 5 shows the results of the cross-tabulations between the two major constructs. Sixteen of the 24 companies that were below average Transactional Leadership performance are above average in terms of encountering product innovation problems. On the other hand, some companies (13) with a below average Transactional Leadership performance somehow were able to avoid having above average encounters with product innovation problems. Further, above average Transaction Leadership in 6 organizations has not precluded them from encountering above average product innovation problems.

Table 5
Cross-Tabulations of Transactional Leadership and Product Innovation Problems (Hypothesis 2)

		Product Innovation Problems Encountered	
		Below Average	Above Average
Transactional Leadership	Below Average	8	16
	Above Average	13	6
		Chi-square = 5.2 (p = 0.02)	

As shown in Table 6, t-tests were used to further test the significance of the relationship between a company's higher or lower than average Transactional Leadership and specific product innovation problems encountered. The two groups are compared in aggregate and along each of the product innovation problems identified in the lit-

Table 6
T-Tests for Transactional Leadership and Each Product Innovation Problem Encountered

Aggregated Variable and Individual Items	Transactional Leadership Below Average Performance	Transactional Leadership Above Average Performance	p-Value
Problems encountered in product innovation:	4.7	4.2	0.04
Difficult to deal with uncertainty and risk.	5.3	4.4	0.01
Lack of market information.	4.4	4.2	Not Significant
Lack of information about technology.	4.7	4.3	Not Significant
Lack of information about the consumer.	4.3	3.9	Not Significant
Difficult to generate truly new ideas.	4.5	4.2	Not Significant
Difficult to evaluate and select the best ideas.	4.6	4.4	Not Significant
Difficulty to connect the portfolio of projects to strategic objectives.	5.0	4.1	0.01
Difficult to turn selected good ideas into innovative products.	5.1	4.4	0.01
Difficult to measure results and performance in innovation.	4.9	4.2	0.01
Lack of qualified staff.	4.6	4.3	Not Significant
Difficult to orchestrate and co-ordinate the various areas for innovation.	4.7	3.5	0.01

erature. The results clearly demonstrate that compared to below average firms, companies with higher than average Transactional Leadership have encountered product innovation problems at a significantly lower level along many of the product innovation problems identified. The above results corroborates hypothesis two.

Results from Hypothesis Three Testing

Hypothesis three proposes that firms having strong charismatic leadership is inversely related to encountering problems in product innovation. This has been tested in a similar fashion as hypotheses 1 and 2. Table 7 shows the results of the cross-tabulations for below/above average company resources availability and below/above average encounters with product innovation problems. Similar to the cross-tabulations used for testing the hypotheses addressing the other major constructs, the results in this case confirm expectations and should be interpreted accordingly.

As shown in Table 8, t-tests were again used to further test the significance of this relationship between Charismatic Leadership and specific product innovation problems encountered. The results clearly demonstrate that compared to below average firms, companies with above average Charismatic Leadership have encountered product innovation problems at a significantly lower level along many of the product innovation problems identified. While the small sample size has resulted in several non-significant comparisons, in no case the comparison contradicted the general hypothesis. Based on the above results, we also find strong support for hypothesis three.

Table 7
Cross-Tabulations of Charismatic Leadership and Product Innovation Problems (Hypothesis 3)

		Product Innovation Problems Encountered	
		Below Average	Above Average
Charismatic Leadership	Below Average	7	15
	Above Average	16	9
Chi-square = 4.8 (p = 0.03)			

Results from Hypothesis Four Testing

Tested in similar fashion, hypothesis four proposes that having effective management of technology is inversely related to encountering problems in product innovation. Table 9 shows the results of the cross-tabulations for below/above average management of technology effectiveness and below/above average encounters with product innovation problems. Similar to the cross-tabulations used for testing the hypotheses addressing the other major constructs, the results in this case confirm expectations and should be interpreted accordingly.

As shown in Table 10, t-tests were again used to further test the significance of this relationship between the company MOT effectiveness and specific product innovation problems encountered. The results clearly demonstrate that compared to below average firms, companies with above average MOT performance have encountered product innovation problems at a significantly lower level along many of the product innovation problems identified. Based on the above results, we also find strong support for hypothesis four.

Table 9
Cross-Tabulations of Management of Technology and Product Innovation Problems (Hypothesis 4)

		Product Innovation Problems Encountered	
		Below Average	Above Average
Management of Technology	Below Average	9	14
	Above Average	18	8
Chi-square = 4.5 (p = 0.03)			

Results from Hypothesis Five Testing

Hypothesis five proposes that having a product change process with the desirable characteristics is inversely related to encountering problems in product innovation. This has been tested the same way. Table 11 shows the results of the cross-tabulations for below/above average product change process and below/above average encounters with specific product innovation problems. The results in this case confirm expectations and should be interpreted accordingly.

As shown in Table 12, t-tests were again used to further test the significance of this relationship between the product change process and specific product innovation problems encountered. C to below average firms, companies with

Table 8
T-Tests for Charismatic Leadership and Each Product Innovation Problem Encountered

Aggregated Variable and Individual Items	Charismatic Leadership		p-Value
	Below Average	Above Average	
Problems encountered in product innovation:	5.0	3.9	0.01
Difficult to deal with uncertainty and risk.	5.2	4.1	0.01
Lack of market information.	4.9	4.2	0.01
Lack of information about technology.	5.0	4.0	0.02
Lack of information about the consumer.	4.7	3.8	0.01
Difficult to generate truly new ideas.	4.8	3.8	0.01
Difficult to evaluate and select the best ideas.	5.1	4.1	0.01
Difficulty to connect the portfolio of projects to strategic objectives.	5.2	3.8	0.01
Difficult to turn selected good ideas into innovative products.	5.1	4.3	0.01
Difficult to measure results and performance in innovation.	4.7	3.7	0.01
Lack of qualified staff.	5.2	3.6	0.01
Difficult to orchestrate and co-ordinate the various areas for innovation.	5.0	3.5	0.01

Table 10
T-Tests for Management of Technology and Each Product Innovation Problem Encountered

Aggregated Variable and Individual Items	Management of Technology		p-Value
	Below Average	Above Average	
Problems encountered in product innovation:	4.6	4.0	0.03
Difficult to deal with uncertainty and risk.	4.8	3.4	0.01
Lack of market information.	4.6	3.5	0.01
Lack of information about technology.	5.2	3.6	0.00
Lack of information about the consumer.	4.3	4.1	Not Significant
Difficult to generate truly new ideas.	4.7	4.0	Not Significant
Difficult to evaluate and select the best ideas.	4.3	4.2	Not Significant
Difficulty to connect the portfolio of projects to strategic objectives.	4.5	4.3	Not Significant
Difficult to turn selected good ideas into innovative products.	4.6	4.1	0.04
Difficult to measure results and performance in innovation.	4.8	4.2	0.03
Lack of qualified staff.	4.7	4.4	Not Significant
Difficult to orchestrate and co-ordinate the various areas for innovation.	4.3	4.1	Not Significant

above average performance in product change process have encountered product innovation problems at a significantly lower level along many of the product innovation problems identified. Based on the above results, hypothesis five is corroborated.

DISCUSSION, MANAGERIAL RECOMMENDATIONS, AND FURTHER RESEARCH

Despite the relatively small sample size, the results provide strong evidence regarding the importance of strategic leadership, competitive intelligence, management of technology, and specific characteristics of the company's change process to the success of product innovation. Given the importance of effectively implementing business innovation in these days of hyper competitiveness, it behooves top managers to do whatever they can to improve their companys' performance in the areas of strategic leadership, competitive intelligence, management of technology, and characteristics of the process used to reduce problems encountered with the product innovation process so vital to company performance.

Table 11
Cross-Tabulations of Change Process Features and Product Innovation Problems (Hypothesis 5)

		Product Innovation Problems Encountered	
		Below Average	Above Average
Change Process Features	Below Average	8	15
	Above Average	17	9
Chi-square = 4.6 (p = 0.03)			

In the area of strategic leadership, several implications can be derived from this study. Charismatic leadership (showing determination while accomplishing goals, inspiring confidence, making people feel good around you, communicating expectations for high performance, generating respect, transmitting a sense of mission, and providing a vision of what lies ahead) is on average and as a whole relatively scarce in industry today, and judging by its nature it should be difficult to develop. Nevertheless, managers must try, particularly in high clockspeed industry sectors (Guimaraes et al., 2002) requiring continuous innovation. Also apparently important for successful product innovation, transactional leadership (taking action if mistakes are made, pointing out what people will receive if they do what needs to be done, reinforcing the link between achieving goals and obtaining rewards, focusing attention on deviations from what is expected, and rewarding good work) by its nature should be easier to develop. Pawar & Eastman (1997) proposed that transactional leadership is

Table 12
T-Tests for Change Process Features and Each Product Innovation Problem Encountered

Aggregated Variable and Individual Items	Change Process Features		p-Value
	Below Average	Above Average	
Problems encountered in product innovation:	4.9	4.0	0.01
Difficult to deal with uncertainty and risk.	5.1	4.2	0.01
Lack of market information.	4.9	4.0	0.01
Lack of information about technology.	5.0	4.1	0.01
Lack of information about the consumer.	4.8	3.7	0.01
Difficult to generate truly new ideas.	4.7	4.0	0.01
Difficult to evaluate and select the best ideas.	5.2	4.3	0.01
Difficulty to connect the portfolio of projects to strategic objectives.	4.9	3.8	0.01
Difficult to turn selected good ideas into innovative products.	5.0	4.3	0.01
Difficult to measure results and performance in innovation.	4.8	3.9	0.01
Lack of qualified staff.	4.7	3.7	0.01
Difficult to orchestrate and co-ordinate the various areas for innovation.	5.2	4.1	0.01

more relevant within an existing organization environment instead of one attempting to implement changes. Katz & Kahn (1978) argued that charismatic leadership may be more relevant where organization change is important, but that both types of strategic leadership are potentially important. Our results indicate that indeed for more successful (less problems encountered) product innovation both types of leadership are important.

Regarding CI, there are also some major implications from this study results. To improve their CI programs, managers need to consider the collection of market intelligence based on the six areas addressed in this study: the traditional industry competitors, emerging competitors, traditional customer needs and wants, non-traditional customer needs and wants, relationships with business partners, and new product or service development. The importance of any one of these areas may be relatively higher or lower, and in some cases some of these sources may be irrelevant, depending on the company's specific industry sector, line of business, products, and processes being considered. Good performance in these areas, whenever applicable to the company's industry sector and lines of business, are likely to reduce problems encountered which, in turn, is likely to lead to more product innovation.

To improve technology management which is found to be useful reducing product innovation problems, managers must look at company performance in terms of its technology leadership position in its main industry sectors, knowledge of how to get the best technology available, effective use of specific technologies, and benchmarking the use of specific technologies against the company's main competitors or best-in-class target organizations. An important requirement to accomplish these objectives is the clear definition of the more important technologies necessary to support and enhance the company's products. Another important requirement is management recognition that the implementation of each of the various technologies deemed important to the organization are dependent on specific success factors. The success factors for the various technologies have been identified and discussed elsewhere (Guimaraes, Igbaria & Lu, 1992; Guimaraes & Igbaria, 1997; Yoon, Guimaraes, & Clevenson, 1998; Yoon, Guimaraes, & Clevenson, 1995; Yoon, Guimaraes & O'Neal, 1995; Udo & Guimaraes, 1994) and are considered beyond the scope of this paper.

Last, top managers must ensure that their companys' product change process bear the desirable characteristics studied here: all significant changes must conform to company objectives, all affected departments participate in the change process, individual employee input is considered important, customers input is considered important, business partners input is considered important, managers ability to balance risk taking with cost/benefit, the existence of clearly defined measures to monitor progress, that change objectives and progress are clearly communicated, and that the product innovation teams respond quickly and effectively to required change. These guidelines must be widely disseminated and enforced by project managers and employees involved in product changes.

The primary objective of this research has three interrelated components: 1) to identify and assess the variety of problems encountered by companies while performing the vital process of product innovation, 2) to identify and assess the major factors proposed in the literature as necessary to increase the likelihood of success in product innovation, and 3) to test if these literature proposed success factors for product innovation also show a positive impact by reducing the problems associated with the product innovation process in practice. Thus it is safe to assume that the measures for each of the major constructs studied here, derived from a large number of separate studies, represent an important contribution to future researchers and practicing product innovation managers aiming to improve their company effectiveness in this critical area.

During the process of conducting this research, informal discussions with several of the product development managers made abundantly clear that over time success in product development can only be achieved by a complex combination of many factors stemming from three major areas: human/organizational, technological, and market knowledge elements. This multidimensional requirement for success, as well as an intrinsic presence of risk and the need to find tangible and intangible resources is a huge challenge for product innovation management in general. As the results from this study indicated, all the major factors addressed here are important, but do not by themselves ensure successful product innovation. It seems to be rather analogous to a case where basic components must be in combination transformed into improved products which provide greater value to the market place.

STUDY LIMITATIONS AND OPPORTUNITIES FOR FURTHER RESEARCH

Based on an extensive survey of the relevant literature, this study is a first attempt at empirically testing the importance of strategic leadership, competitive intelligence, management of technology, and specific characteristics of the company's change process for the success of product innovation. The theoretical model proposed here addresses five major determinants of how to reduce obstacles/problems for successful PI based on the existing literature. There might be other important factors for reducing the PI problems defined in this study. Given the importance of the

topic, future research should strive to identify and include these potential factors in an expanded theoretical model.

Another opportunity for future research stems from the fact that, even though the relatively small sample in this study has shown very encouraging statistically significant results, larger sample sizes will be much more convincing. Therefore, we strongly recommend new research projects with larger sample sizes capable of supporting multivariate analyses, expanded theoretical models, and enable the assessment of more complex relationships among the important constructs addressed in this study. Perhaps the use of a path analytic modeling technique would be applicable in this case. The results should provide valuable information on the extent to which strategic leadership can positively influence the effective use of technology and CI programs for companies to improve their business competitiveness while ensuring that the change process follow prescribed guidelines suggested in this study.

Finally, a third area of future research opportunity deals with the integration and expansion of theoretical models relating the many determinants of success in product innovation to include the new construct of "obstacles to product innovation" as a likely moderating variable in these theoretical models. Combined, these three areas of research opportunity should support a host of research studies important not only to the academic community but also to product innovation managers.

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Acceptance of Change: Exploring the Relationship among Psychometric Constructs and Employee Resistance

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ABSTRACT

Change is inevitable and can influence numerous events inside and outside an organization. The contrasting attitudes of acceptance and resistance to change are an increasingly interesting topic in today's global, ever-changing, and competitive environment. Discovering the behavioral origins of employees' reactions to change is an integral part of understanding the way in which individual mindset may play a role in coping with organizational change and resistance. This body of knowledge may give organizations insight for creating a competitive advantage over their counterparts.

Conceivably, it can be argued that some researchers view change as a process of gradual adaptation that is largely influenced by people in organizations who react to internal and external pressures, while others view it as an emergent event due to environmental selections (Demers, 2007). Through both concepts, successful navigation through change events relies on the manner in which humans respond to these occasions.

The current study employed a descriptive, non-experimental, correlational design to examine individuals' self-rating of their level of mindfulness, tolerance of ambiguity, and resistance to change in four industries located in Kentucky. The quantitative study sought to identify the strengths of the relationship of the chosen variables using validated instruments – Langer's (Pirson, Langer, Bodner, & Zilcha-Mano, 2012) Langer Mindfulness Scale (LMS14), Budner's (1962) Tolerance of Ambiguity Scale (TOA), and Oreg's (2003) Resistance to Change Scale (RTC). Regression models were utilized to evaluate multivariate relationships among the variables. Based on the findings in the current study, the results indicated that no differences lie between group comparisons of organizational or demographic factors when examining the relationship among the elements of mindfulness, tolerance of ambiguity, and resistance to change. Bivariate correlations yielded both strong positive and negative relationships among the three scales assessed by salary (exempt and non-exempt) employees located across the different industries ($p < .01$).

INTRODUCTION

Nothing stays the same; part of the human condition involves adjusting to change. Yet, human resistance to change is both intense and natural. Perhaps examples of this resistance occur in employees' personal lives or arise as they approach new ideas or changes at work. Through a myriad of changes, characterized by global demands, unpredictable environments, the onset of technological advances, and operational developments, managing change and resistance has become a way of life for many organizations (Judge, Thoresen, Pucik, & Welbourne, 1999). Organizations must depend on capable leadership to guide them through these unprecedented times. The evolution of change requires employees at all levels to embrace new techniques of working by promoting different mindsets (Kets de Vries, Ramo, & Korotov, 2009). Gondo, Patterson, and Palacios (2013) suggested that some organizations fail to adapt to change and prepare their leadership and employees for a more uncertain future. Yet, their study summarized that successful change involves support of formulated strategies and the facilitation of change recipients being mindful during change efforts. In the face of intense global competition, it is criti-

cal for organizations to have the dexterity to accept new changes and adapt to survive (Gondo et al., 2013; Jacobs, 2005). Discovering the behavioral origins of employee reactions to change is an integral part of understanding the recipe for flexibility, longevity, and organizational success. Researchers have separately alluded to varying degrees of social psychological constructs—particularly elements of mindfulness and tolerance of ambiguity—and their influence on individuals' attitudes toward change and resistance (Banning, 2003; Langer, 1993).

BACKGROUND

By its nature, change in organizations is inherently stressful, causing increased anxiety among employees at each level of the organization. This environment of uncertainty can threaten the balance of control, often distracting organizations from obtaining the stability needed to survive and adapt to change. Researchers have analyzed several techniques for strengthening the idea of overcoming uncertainty. Carson and Langer (2006) stated, "Actively thinking about paradoxes increase one's ability to tolerate ambiguity and decreases the anxiety associated with uncertainty. In a separate study, Weinstein, Brown, and Ryan (2009) contended that increased mindfulness in individuals promoted greater attention and awareness in situations (organizational change, for example) perceived as stressful or threatening.

Leaders throughout organizations must possess the skills and cognitive experience to manage varying degrees of uncertainty and balance the levels of tolerance within their organizations (Lane & Klenke, 2004). This notion is reinforced by Topping (2002) in that change implies uncertainty, and uncertainty can drive individuals to feel afraid, uncomfortable, threatened, anxious; and, as a result, resistant to change. On the contrary, acknowledging uncertainty can lead to the exploration for clarity and challenges of the status quo (Geller, 2002). A rapidly growing amount of literature is available on mindfulness, which insinuates how this construct could aid in navigating through areas of uncertainty (Brown & Ryan, 2004; Lane & Klenke, 2004; Langer, 1993; Weinstein et al., 2009). Brown and Ryan's (2004) multifaceted definition of mindfulness recognized it as, "a phenomenon with functional import for outcomes as diverse as physical health, psychological well-being, work and sports performance, and relationships" (p. 242).

The process of conforming to change or an innovation may seem difficult for individuals within organizations, yet examples exist in which individuals adapt very easily and seem to flourish within this environment. Judge et al. (1999) explained that organizational change has been predominately conducted at a middle range or macro level, rather than at the micro individual level. Changes in organizations are not always clear, even for the leaders. Through the vagueness of change, innovative organizations deliberately take actions to avoid misinterpretations and to improve the process (Limerick, Passfield, & Cunnington, 1994). "As organizational structures become less hierarchical and more fluid and amorphous, tolerance for ambiguity and uncertainty is likely to emerge as a quality that differentiates effective from ineffective leaders," according to Lane and Klenke (as cited in Ehrlich, Meindl, & Viellieu, 1990, p. 69). As organizations are naturally subject to uncertainties, the concept of increasing employees' abilities to deal with ambiguous situations may lead to more success or important gains in knowledge about organizations.

Resistance to Change

The literature presents an enduring consensus on the premise that it is human nature to resist change and elements related to the process of change (Coch & French, 1948; Conner, 1992; Oreg, 2003; O'Toole, 1995; Zander, 1950). This notion of natural resistance is supported by Kotter (1995), as he described change as the force of shifting conditions within the human communities. Contested by Dent and Goldberg (1999), the phrase resistance to change should be reevaluated under a more conventional definition. Although the researchers supported the belief that resistance is natural, their views have challenged the idea of the way in which individuals resist change. Blindly supporting the belief that one can resist change may be counterproductive and may direct the focus of organizations away from the actual issues. The idea of contradicting this belief opens the possibilities that inefficiencies in the process of change and its impact on individuals should be acknowledged and explored (Mabin, Forgeson, & Green, 2001). As a whole, regardless of the process, resistance to change is driven at the individual level and is leveraged by organizations to foster change (Conner, 1992; Judson, 1991).

Employees of organizations may withdraw from the fear of ideas they do not fully understand or act rebellious toward seemingly unclear decisions made by management without proper cause. Ideally, change within organizations should be straightforward, clear, and concise prior to implementation. More often, this is not the case for individuals who implement the groundwork or for those who are being impacted by the change (Judson, 1991). Alternately, studies have demonstrated that some employees with a higher tolerance of ambiguity are more susceptible to change and may even thrive within this environment (Oreg, 2003). As a whole, organizations have struggled with implementing new ideas, changing their culture, and

reacting to market demands; nevertheless, many are willing to change to remain competitive.

Dent and Goldberg (1999) found that, at the individual level, resistance to change can arise from those whose jobs are directly impacted and can cause a rippling effect through the organization. Fundamentally, individuals are creatures of habit and are annoyed by pressures in organizations that force employees to choose a different behavior or accept a reward system that may not seem beneficial. However, they are willing to change their behaviors when their beliefs of the benefits of the change outweigh the benefits in their current environment (Armenakis & Bedeian, 1999). In other words, attitude toward the change affects one's willingness to consider and even implement the change.

ATTITUDES AND CHANGE

Some change efforts within organizations are successful; some are not. Kotter (1995) monitored approximately 100 companies over a decade to observe the fundamental changes made in fluctuating business environments. The research included examples of successes, examples of failures, and illustrations of companies that remained stagnant as they suffered through misguided steps. Outlined by Kotter (1995), successful changes within companies encompassed eight steps: (a) creating a sense of urgency; (b) forming a guiding coalition; (c) creating a compelling vision; (d) communicating the vision for buy-in; (e) empowering and acting on the vision; (f) creating quick wins; (g) increasing credibility through small wins; and (h) linking success to new approaches. In an earlier approach, Judson (1991) proposed five steps to enhance the process of change by engaging employees' active participation through (a) analyzing and planning the change; (b) communicating the plan for change; (c) gaining buy-in and acceptance; (d) changing the status quo to the desired state; and (e) institutionalizing the new state of change. Through these steps, the common link described for successful changes involved employees' comprehension of the change and their personal adaptation to the new way of thinking and working.

Iverson (1996) supported the concept that organizational change could be easier when employees have higher personal commitments through healthy professional relationships, positive employee morale, job satisfaction, and positive recognition. Moreover, employees who have a solid desire to perform well and are willing to embrace new challenges, even in the absence of clarity, also understand the importance of change within organizations. Furthermore, Gärtner (2013) reinforced the concept that employees' attitudes and perceived flexibility toward change were influenced through a subset of mindfulness. Although it is not a new term, mindfulness supports the concepts attributed to attention, awareness, engagement, and being comfortable with new ideas that may impact areas within an individual's control (Langer, 1993).

The Problem Defined

With the continuous expansion of globalization and the rising unpredictability of consumer demands, economic pressures, and technological advancements, organizations have been required to change to remain competitive. Change is inevitable. The organizations that master agility and are adaptive to the ever-changing environment will possess the recipe to emerge triumphant over their competitors. In reality, every organization must change; yet, the process is not always smooth or effective. Hypothetically, within the organizational structure, there are individuals who visualize the change, others who develop and organize the change, and those who implement and perform the change (Isabella, 1990). At times, roles of individuals may overlap due to the size of the organization and the responsibilities entailed within each role. Directly or indirectly, everyone throughout the organization is impacted by the change; perhaps some individuals are able to cope with change better than others. A study of the related factors of mindfulness and tolerance of ambiguity may lead to insights about individuals' resistance to change.

Defining the Problem of Resistance

Resistance to change refers to adverse human forces that impact the processes of change. Kotter (1995) emphasized that organizational resistance is often helped along through the mismanagement of change and by ignoring its impact on the processes. Maurer (2009) suggested that resistance will happen, often due to failures from previous change implementations. Lewin (1947), one of the most influential early researchers of change, realized that change was not an event, but rather, a living process. He conceptualized the process of change through a model composed of three steps: unfreezing, change, and refreezing. His initial step introduces the idea of resistance; individuals must give up something before accepting something new. Though simple, his ideas have been expanded upon by numerous researchers and have been developed into various theories of change. Zander, a close colleague of Lewin, defined resistance to change as "behavior which is intended to protect an individual from the effects of real or imagined change" (as cited by Dent & Goldberg, 1999, p. 34).

Mabin et al. (2001) found that seemingly rebellious employees manifest their fears of change due to uncertainty. In addition, perceived resistance may be disguised through

the camouflage of untimely surprises, past resentment, additional job duties, or the exposure of personal vulnerabilities. In isolated cases, changes within the organization may cause a true threat to safety, quality, cost, or the company's reputation. Ignoring the symptoms of resistance within the change process could have disastrous results. Judson (1991) agreed that resistance to change is not the fundamental problem, but a symptom hiding basic underlying circumstances. He also developed a continuum of reactions to change ranging from indifference (no resistance) to active, even aggressive resistance.

Research has validated the importance of evaluating the reactions and the attitudes of individuals toward organizational change and their desire to succeed (Judge et al., 1999; Oreg, 2006). Developed and validated by Oreg (2003), the Resistance to Change scale has been widely used and accepted by academic works to measure an individual's disposition toward resistance to change. Furthermore, Oreg outlined four subscales as an exploratory analysis to categorize an individual's reaction to resist change: (a) routine seeking, (b) emotional reaction to impose change, (c) cognitive rigidity, and (d) short-term focus. Supportive research (cited in Oreg, 2003) has found the factors of openness to change, tolerance of ambiguity, and risk aversion as predictors for managers coping with the stress of change within their organizations. An exhaustive amount of research has been conducted on the broad topic of resistance to change, yet little is known on the relationship of how the psychological constructs of mindfulness and tolerance of ambiguity influence resistance to change within organizations. Early researchers such as Coch and French (1948) viewed resistance to change as an obstacle of contention during the process of changes within organizations. One of their studies, conducted in a sewing factory, revealed that employees retaliated against change through acts of aggression, controlling restrictions of throughput, high turnover rates, increased complaints, and reports of dissatisfaction with management. In line with earlier studies, the use of the term resistance to change gained popularity beginning in the 1950s following Lewin's (1947, 1951) works related to field theory and social sciences. Resistance to change is commonly accredited to the unfreezing stage of Lewin's (1951) change model (Armenakis & Bedeian, 1999). Naturally portrayed as a negative barrier to change, resistance to change is frequently defined using Lewin's physical science-related terminology as a restraining force to maintain the current state of equilibrium (Dent & Goldberg, 1999). Since that time, resistance to change has been widely acknowledged and associated with the process of change, organizational development, and change theories and models. Other scholars have conceptualized resistance to change as an emotional reaction rather than a behavioral response. As an example, Argyris and Schon (1978) suggested resistance in terms of defensive routines and frustration during the process of change. Kanter (1985) supported this notion, describing feelings of uncertainty and loss of control for individuals facing change. In other terms of defining resistance, Lawrence (1954) used an analogy to compare resistance to change as pain within the human body that is used as a signal to communicate that something is wrong: "The resistance, like the pain, does not tell what is wrong, but only that something is wrong. And it makes no more sense to try to overcome such resistance than it does to take a pain killer without diagnosing the bodily ailment" (p. 56). This analogy highlighted the parallels between resistance and overcoming it through a practicable solution.

Mindfulness

Mindfulness is a concept in educational psychology that has been primarily defined by Dr. Ellen Langer, a social psychology professor at Harvard University. Langer (1993) defined mindfulness as "an open, creative, probabilistic state of mind in which the individual might be led to finding differences among things thought similar and similarities among things thought different" (p. 44). Langer (1997) further explained three characteristics of mindfulness: "(a) continuous creation of new categories, (b) openness to new information, and (c) having an implicit awareness of more than one perspective" (p. 4). The Mindfulness Scale, validated by Pirson et al. (2012), operationalizes the construct and identifies the four subscales of novelty-seeking, engagement, novelty-producing, and flexibility to explain the broad psychometric construct. Brown and Ryan (2003) defined mindfulness as, "a quality of consciousness that is characterized by clarity and vividness of current experience and thus stands in contrast to the mindless" (p. 823). Different from Langer's definition that evaluates dispositional differences in reflective consciousness behavioral routines over time, Ryan and Brown focused on the presence or absence of attention to and the awareness of events occurring in the present moment. For the purpose of the current study, the ideas of mindfulness were presented through the literature of Langer. Furthermore, mindfulness is believed to play an important role in disengaging individuals from automatic thoughts, habits, and unhealthy behavior patterns and may contribute to well-being and happiness in a direct way (Brown & Ryan, 2003).

Tolerance of Ambiguity

Tolerance of ambiguity describes an individual's behavior in unclear or insecure situations and how one reacts to the lack of clarity or uncertainty (Banning, 2003). Developed by Frenkel-Brunswik (1948), tolerance of ambiguity has gained attention from researchers over the past 60 years. Frenkel-Brunswik was one of the first to present a comprehensive analysis of ambiguity and was influenced by earlier works of Germany psychologist Erich Jaensch. Frenkel-Brunswik described tolerance of ambiguity as an "emotional and perceptual personality variable" (cited in Furnham & Ribchester, 1995, p. 180).

Budner (1962) later defined tolerance for ambiguity as "the tendency to perceive ambiguous situations as desirable" and intolerance for ambiguity as "the tendency to perceive ambiguous situations as sources of threat" (p. 29). Budner developed the Tolerance of Ambiguity Scale to further interpret the complex concept of ambiguity and individuals' responses to it. Through the development of the Tolerance of Ambiguity Scale, three subscales (i.e., novelty, complexity, insolubility) emerged to provide insight into the more abstract larger construct. A decade later, Norton (1975) defined tolerance of ambiguity as the degree to which an individual is cognitively willing to tolerate uncertainty, vagueness, or nebulous information and is able to act upon the knowledge.

Employees resist change at all levels of the organization. Although some individuals openly accept change, many do not. Determining the varying degrees of each psychometric construct on resistance, along with their combination toward resistance to change, may reveal common areas of opportunity related to organizational change. The following general research question is offered: How are the psychometric constructs of mindfulness and tolerance for ambiguity related to resistance to change within organizations?

Empirical Studies and Questions

Numerous studies have alluded to resistance to change; some have focused on the individuals (e.g., Bovey & Hede, 2001; Coghlan, 1993; Ford, Ford, & McNamara, 2002), while others have explored organizations (e.g., Armbruster, Bikfalvi, Kinkel, & Lay, 2008; Coch & French, 1948; Greenwood & Hinings, 1996; Lawrence, 1954; Stanley, Meyer, & Topolnytsky, 2005). Van Dam, Oreg, and Schyns (2008) stated, "A review of the past empirical research reveals that resistance to change has been conceptualized in three ways: as a cognitive state, as an emotion, as a behavioral intention" (p. 316). As an emotion, some studies have revealed that employees who display negative perceptions toward organizational change may have an overall negative outlook on change, thus perpetuating resistance (Armenakis, Harris, & Mossholder, 1993; Stanley et al., 2005). Extreme measures of resistance to organizational change have been displayed in other studies through sabotage, slowdowns, and strikes (Armenakis et al., 1993). Universally, resistance to change has been recognized to have a significant impact on the outcomes of organizational change, yet individuals within the organization are perceived to be the major blockage or impediment (Mabin et al., 2001). Based on the literature concerning the analysis of change, empirical studies have identified a wide range of factors—namely, organizational, managerial, behavioral, and individual—that promote or impede resistance in organizations.

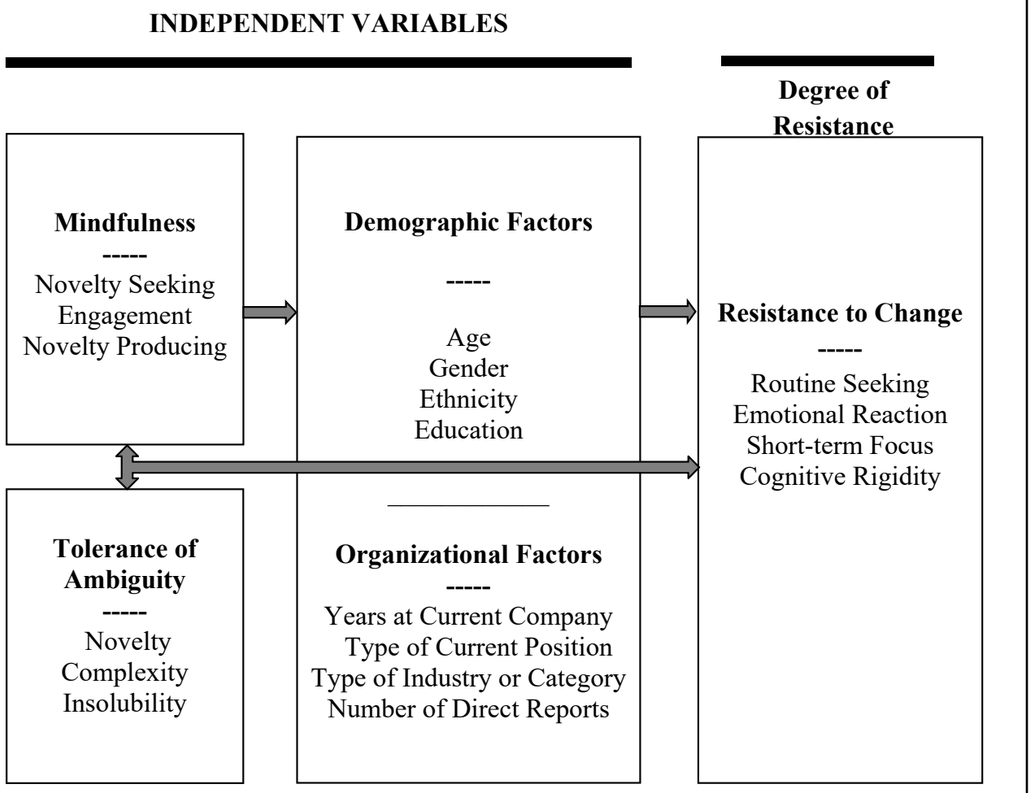
Organizations are faced with the challenges of changing and responding to current and future trends at an unprecedented rate in today's global environment (Burke, 2014). Twenty-five years ago, Offermann and Gowing (1990) found that American organizations alone had spent over a record 210 billion dollars to prepare leaders to thrive in organizational change. In addition to money, an immeasurable amount of time and energy have been dedicated to nurturing leadership and key individuals to navigate others through this complex but important process. Nonetheless, the blueprint is far from perfect. The readiness of individuals within the organization to plan and implement proactive measures, may determine the organization's competitiveness. The current study examines the factors of mindfulness and tolerance of ambiguity and how they relate to individuals' perceptions of resistance to change. The specific research questions are the following:

1. How do demographic factors of the respondents and the organizational factors under which they work relate to the psychometric scales of Mindfulness and Tolerance of Ambiguity and their influence on Resistance to Change?
2. After controlling for demographic factors, how does psychometric mindset (Sub-constructs of Mindfulness and Tolerance of Ambiguity) influence individual Resistance to Change: (a) Routine seeking, (b) Emotional reaction, (c) Short-term focus (d) Cognitive rigidity?
3. What is the degree of relationship among these measures of Mindfulness and Tolerance of Ambiguity?
4. The following model characterizes the current study:

Highlights of the Methodology

When considering the measurement of the perceptions of resistance to change within organizations, various methods have been utilized to illustrate relationships among different constructs (Oreg, 2003; Oreg, Vakola, & Armenakis, 2011). In the current quantitative, non-exper-

Figure 1
Logic model for hypothesized relationships among Psychometric Constructs, Demographic Controls, and Degree of Resistance to Change.



imental study, data were collected from three validated instruments – Langer's (Bodner & Langer, 2001) Langer Mindfulness Scale (LMS), Budner's (1962) Tolerance of Ambiguity Scale (TOA), and Oreg's (2003) Resistance to Change (RTC) scale. Regression models were used to assess the univariate relationships among the constructs. Additionally, descriptive statistics were used to include the mean, median, mode, standard deviation, and other selected variables. A multiple linear regression analysis determined the relationship between factors of mindfulness and tolerance of ambiguity and their influence of resistance to change. Bivariate correlations were used to compute the psychometric scores from each instrument and resistance to change ratings to test the significance of the relationships between each subscale. Overall, statistical analyses were conducted in multiple phases to investigate the relationship between the individual psychometric traits and resistance for salary exempt and non-exempt employees in industrial sites located in Kentucky.

Participants in the Study

The population represented a microcosm of several industries in the manufacturing sector within the proximity of Warren County. The data collected were based on a convenient sample. A total of 65 participants volunteered to complete an electronic survey that was designed to capture complete responses to a total of 48 questions. Participants were not allowed to proceed to the next page of the survey unless all questions on the current page were completed. Three participants did not complete the survey, and their responses were not included in the end results. From the

population of 183 salaried (exempt and nonexempt) employees, 65 surveys were officially returned, constituting a response rate of 36%. Managerial-type jobs dominated 36% of the sample population, followed by roles in technical support, which reflected 16.9%. Six categories of job types and an "Other" category were used for the respondents.

Scoring Method for Each Scale

Resistance to Change Scale

Oreg's (2003) Resistance to Change Scale is comprised of 17 items with four subscales – routine seeking, emotional reaction, short-term focus, and cognitive rigidity. Each subscale relates to the extent to which individuals seek routines, react to emotions during change, encompass short-term focus during change, and the frequency to which individuals change their minds. The overall range of the scale, including the subscales, is scored between 1 and 6, with 1 representing the least level of resistance. Individuals scoring higher on the overall scale or subscales indicate a higher resistance to change.

Langer Mindfulness Scale

The Langer Mindfulness Scale (Pirson et al., 2012) contains 14 items and is composed of three subscales – novelty seeking, engagement, and novelty producing. The 7-point scale is scored such that higher scores indicate a greater level of awareness toward thinking. High scores for novelty producing insinuate one would perceive new situations as opportunities to learn new information. Individuals with high scores for engagement are more susceptible to noticing details within their environment, as opposed to others. Higher novelty producing scores indicate that individuals are likely, more creative, and predisposed to generating new ideas when faced with new information.

Tolerance of Ambiguity Scale

Budner's (1962) Tolerance of Ambiguity Scale is a 16-item scale with ratings ranging from 1 to 7; 1 represents strong disagreement, indicating a greater tolerance for ambiguity. It is important to note that higher scores relate to greater intolerances for ambiguity. All results were reported at the aggregate level.

RESULTS

Statistical data analyses were performed on survey data comprised of the following three instruments: Langer Mindfulness Scale (LMS14), Tolerance of Ambiguity Scale (TOA), and Resistance to Change (RTC) scale. Findings were reported from the analyses of data collected from 65 participants responding to the Qualtrics Web-based survey. In particular, analyses were conducted through bi-variant correlation analyses (also known as Pearson's r), independent t-tests, and Cronbach's alpha. The strengths of the relationships were predicated on Cohen's (1988) interpretation. Coefficient values between .10 and .29 were considered small or weak, those between .30 and .49 were considered moderate, and those between .50 and 1.0 were considered large or strong.

Analysis of Each Research Question

The first research question explored the relationship of demographic and organizational factors to the psychometric scales of Mindfulness and Tolerance of Ambiguity and their influence on Resistance to Change. Descriptive statistics reflected both demographic and organizational factors – gender, education, years at the company, and direct reports—for the 65 employees who participated in the current study. The distributions of variables were distributed evenly between only two variables: years at the company and direct reports. Other demographic variables, including ethnicity and age, were recorded. A statistical analysis was not conducted due to the uneven distribution of the variables. Of the 65 participants, 59 were Caucasian and the remaining 6 were minorities. The ages of the participants ranged from 28 years to 65 years. Additionally, frequency distributions and data analyses were not conducted for individual sites to protect anonymity. All results were reported at the aggregate level and included the following categories for the participating industries: Cup Manufacturing, Personal Care Manufacturing, Construction, and Rubber to Metal Bonding Manufacturing.

Gender Male and Female

Although more than twice as many males than females participated in the current study, independent t-tests were conducted to determine whether differences existed between the mean scores of the scales and subscales for male and female employees. No statistically significant differences were found between the outcome of the psychometric constructs (Mindfulness and Tolerance of Ambiguity) and Resistance to Change, except on one subscale. Cognitive rigidity revealed a statistical difference between the scores of males ($n = 45$, $M = 3.81$, $SD = 0.63$) and females ($n = 20$, $M = 3.36$, $SD = 0.86$), $t(63) = 2.34$, $p = .05$, $\alpha = .05$.

Table 1
Descriptive Statistics and Correlations among Responses of Tolerance of Ambiguity Scale, Langer Mindfulness Scale and Subscales, and Resistance to Change and Subscales

Scales	LMS_NS	LMS_NP	LMS_E	TOA_ Tot	RTC_RS	RTC_ER	RTC_STF	RTC_CR
LMS_NS	(.77)							
LMS_NP	.76**	(.72)						
LMS_E	.49**	.51**	(.69)					
TOA_Tot	-.48**	-.53**	-.32**	(.72)				
RTC_RS	-.51**	-.50**	-.41**	.65**	(.85)			
RTC_ER	-.36**	-.37**	-.36**	.41**	.71**	(.88)		
RTC_STF	-.53**	-.47**	-.38**	.60**	.77**	.80**	(.90)	
RTC_CR	-.28*	-.26*	-.04	.44**	.51**	.45**	.41**	(.86)
# of Items	5	5	4	16	5	4	4	4
Mean	5.98	5.04	5.56	3.76	3.42	2.85	3.67	3.22
SD	0.71	.94	1.02	.71	1.10	1.04	.73	.81

Note. N = 65. Cronbach's alpha reliabilities for each dimension/construct are listed in parentheses on diagonal. Cronbach's Alpha measures indicated a high internal consistency among the items reflected in each scale.
*p < .05 level (two-tailed)
**p < .01 level (two-tailed)

Table 2
Descriptive Statistics and Correlations among Responses of the Total Tolerance of Ambiguity Scale, Langer Mindfulness Scale, and Resistance to Change

	LMS_Tot Mean	TOA_Tot Mean	RTC_Tot Mean
LMS_MeanTotal	(.86)		
TOA_Meantotal	-.53**	(.72)	
RTC_Meantotal	-.53**	.62**	(.93)
Number of items	14	16	17
Mean	5.52	3.76	3.01
Standard Deviation	.75	.71	.91

Note. N = 65. Cronbach's alpha reliabilities for each dimension/construct are listed in parentheses on diagonal. No subscales for Tolerance of Ambiguity were referenced in research. Cronbach's Alpha measures indicated a high internal consistency among the items reflected in each scale.
*p < .05 level (two-tailed)
**p < .01 level (two-tailed)

Table 3
Descriptive Statistics and Correlations among Responses Related to Operational and Demographic Factors, Tolerance of Ambiguity Scale, Langer Mindfulness Scale and Subscales, and Resistance to Change and Subscales

	MEAN	SD	AGE	YRSWRK	DRRPTS	TOA_M	LMS_M	LMS_NS	LMS_NP	LMS_E	RTC_M	RTC_RS	RTC_ER	RTC_STF	RTC_CR
AGE	45.71	7.82	1.00												
YRSWRK	12.83	9.43	.52	1.00											
DRRPTS	10.05	21.62	-.18	.01	1.00										
TOA_M	3.76	.71	.15	.11	-.02	1.00									
LMS_M	5.52	.75	-.07	-.07	.10	-.53	1.00								
LMS_NS	5.98	.71	-.12	-.12	.04	-.48	.87	1.00							
LMS_NP	5.04	.94	-.05	.01	.18	-.53	.90	.76	1.00						
LMS_E	5.56	1.02	-.01	-.10	.01	-.32	.78	.49	.51	1.00					
RTC_M	3.22	.81	-.14	-.10	-.08	.62	-.53	-.51	-.48	-.37	1.00				
RTC_RS	3.01	.91	-.13	-.07	-.04	.65	-.55	-.51	-.50	-.41	.90	1.00			
RTC_ER	3.42	1.10	-.23	-.17	-.07	.41	-.43	-.36	-.37	-.36	.90	.71	1.00		
RTC_STF	2.85	1.04	-.05	.00	-.06	.60	-.54	-.53	-.47	-.38	.91	.77	.80	1.00	
RTC_CR	3.67	.73	-.07	-.08	-.14	.44	-.23	-.28	-.26	-.04	.65	.51	.45	.41	1.00

Note. N = 65. The correlation coefficient ranges from -1 to +1, with -1 indicating a perfect negative correlation; +1 indicating a perfect positive correlation, and 0 indicating no correlation.

Education

Due to the imbalanced distributions of participants, statistical analysis for Education was not performed. The frequency distribution reflected that 52.31% (34) of the participants possessed a four-year degree, 12.31% (8) obtained a master's degree or higher, 26.15% (17) possessed a two-year degree or some college, while the reaming 9.23% (6) were high school graduates.

Direct Reports and No Direct Reports

An individual variances t-test was conducted and failed to reveal a statistically reliable difference between the mean scores of salaried employees without direct reports and salaried employees with direct reports. As an example, scores from routine seeking, a subscale of resistance to change, were not significantly different between employees without direct reports (n = 32, M = 3.12, SD = 0.96) and employees with direct reports, (n = 33, M = 2.91, SD = 0.85), t (65) = 0.93, p = 0.37.

Years at the Company

A one-way analysis of variance (ANOVA) was calculated on participants' ratings of the psychometric constructs and resistance to change as a comparison to the number of years at the company. Comparisons indicated no statistically significant differences were presented between groups of 0 to 4 years, 5 to 10 years, 11 to 20 years, and 21 years and greater. As an example, on novelty-seeking, a subscale of the Langer Mindfulness Scale, the analysis was not significant between the four groups, F(3, 61) = .31, p = .82

The second research question used bivariate correlations to determine the strength of the relationships between the psychometric constructs (Mindfulness and Tolerance of Ambiguity) and Resistance to Change, including the four subscales. All of the Pearson correlations were significant across each of the findings, with the exception of the LMS scale and Cognitive Rigidity of Resistance to Change subscale, r(65) = -.225, p = .072. The overall LMS scales reflected a strong negative relationship, r(65) = -.530, p < .001, with the RTC scale. The TOA scale revealed a mod-

erate positive correlation r(65) = .624, p <.001. Further bivariate analyses for LMS explored the strength of the relationships between the subscales of the Langer Mindfulness Scale and the subscales of the Resistance to Change scales. The correlational analysis was statistically significant between all variables except Engagement of the LMS and Cognitive Rigidity of RTC, r(63) = -.35, p = .781, concluding that the variables were unrelated.

The last research question explored the degree of the relationship between Mindfulness and Tolerance of Ambiguity. Bivariate analyses were used to correlate the relationship between the two psychometric constructs. The correlations revealed a significantly strong negative relationship between the total mean score of the LMS and the total mean score of the TOA, r(63) = -.53, p < .01. The mean scores for each of the LMS subscales, compared to the total mean of the TOA, showed the following: Novelty-seeking and TOA, r(63) = -.48, p < .01; Novelty-producing and TOA, r(63) = -.53, p < .01; and Engagement and TOA, r(63) = -.32, p < .01. It is important to note that higher scores on the Tolerance of Ambiguity scale indicate a greater intolerance of ambiguity. Tables 1 and 2 display a descriptive analysis and correlations for each of the scales and subscales. The correlations between variables are presented in Table 3.

LIMITATIONS OF THE STUDY

Research inherently contains limitations. The current study is no exception. First, the nature of measuring psychometrics is subjective. Since psychometrics studies measure the way in which individuals think and act (Norton, 1975), influences of the organization's environment could affect individuals' responses to questions. Additionally, external variables at the time of data collection not related to the study itself can skew the responses and influence the outcomes. Other views of limitation rest on the generalizability of the results, which may be limited for the following reasons: (a) the unit of analysis is at the individual level, (b) data were collected from a limited number of operations within the state of Kentucky through convenience sampling, and (c) individual biases that may be introduced at the time of testing.

The unit of analysis for data collection rests at the individual level, rather than the group level, due to the accessibility of the employees. Although the survey collection method allows for comparison with larger groups, it limits the opportunity to explore issues in depth; therefore, assumptions are made for individuals in similar groups. Next, the data collected represents limited industries in the state of Kentucky, restricting the number of participants and the ability to generalize outcomes to other industries different than those outlined in the current study. Last, respondents' values, interests, and beliefs regarding the online self-administered surveys may introduce biases unknown by the researcher. As a consequence of these limitations and the collection of data during one point in time, the results are generalizable only to the groups or populations that are similar to those in the current study.

SUMMARY AND CONCLUSION

Change within organizations is inevitable. That reality will remain constant in organizations—and in one's personal and professional life (Conner, 1992). The way in which one chooses to cope with change could be a deciding factor of success, failure, or choosing to remain the same—which in organizations tends to equate with failure, particularly if change means simply improving. Resistance is a natural reaction to change and is part of the human psyche. Research and literature support this notion of human nature to resist change and elements related to the process of change (Coch & French, 1948; Conner, 1992; Oreg, 2003; O'Toole, 1995; Zander, 1950). It is possible that a greater understanding of mindfulness and tolerance of ambiguity could increase the possibilities of new ideas to drive lower resistance to change. The current study explored the two psychometric constructs of mindfulness and tolerance of ambiguity and their relationship to resistance to change within industrial settings. Bivariate correlations yielded both strong positive and negative correlations among the three scales assessed by salaried employees located across different industries. The Langer Mindfulness Scale, Budner's Tolerance of Ambiguity Scale, and Oreg's Resistance to Change scale were attributed to the foundation of the current study. The results contributed to the practical and theoretical significance of individuals' responses to change through the measurement of the aforementioned constructs. To the extent the findings in the current research could be extrapolated to other industries or organizations, a final suggestion should be noted. When considering future directions for research related to probing psychometric constructs and resistance to change, the current study may have relevance across different nationalities and cultures. The elements of change will continue to challenge the fabric of organizations, while the internal and external pressures of rising costs, variations in supply and demand, relentless competition, and developing technology test the resolve for survival. The readiness of individuals within organizations and their ability to challenge perceptions of change and resistance, may determine their competitiveness and, ultimately, their success.

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The Origin and Construct of Cloud Computing

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ABSTRACT

Cloud computing is one of the most talked about information technology topics these days. A literature review reveals an endemic confusion of what cloud computing stands for. This paper tries to shed light on why the term is so confusing. We try to find where the phrase cloud computing came from and how it found currency in the IT community. We trace cloud computing to early timesharing and Application Service Provider (ASP) in the last decade, and posit a future of utility computing. This paper also provides a comprehensive definition of the term and its main building blocks.

INTRODUCTION

Cloud computing is one of the most talked about information technology topics these days [7, 24]. Early literature review reveals an endemic confusion of what cloud computing is, does, and what it stands for. We posit that the cloud metaphor [3, 20] fosters a confusion that persists even today.

The goal of this research paper is to look back and make historical sense of cloud computing. We try to find the lineage of cloud computing, where the phrase cloud computing came from, who came up with the term, and how it found currency in the IT community. We trace cloud computing to early timesharing and Application Service Provider (ASP) in the last decade, and posit a future of utility computing.

Additionally, we try to shed light on the current state of cloud computing, provide a comprehensive definition of the term and its main building blocks..

CLOUD COMPUTING IN THE ACADEMIC LITERATURE

A metaphor

In an article by Ian Foster and Steven Tuecke [3], the authors start by describing the well-known elephant fable where a group of blind people are asked to describe an elephant, and, not surprisingly each provides a different view.

The cloud is a metaphor for the Internet. It's a rebranding of the Internet that is why there is a raging debate. By virtue of a metaphor, it's open to different interpretations [20].

Confusion and Frustration

The word "cloud" in cloud computing informs very little, and it may even misinform. "I hated it, but I finally gave in," says Carl Bass, President and CEO of Autodesk. He adds, "I didn't think the term helped explain anything to people who didn't already know what it is"[20].

Giving the 'cloud' name to the old concept of large, shared, distributed systems is misleading [4, p. 26].

Larry Ellison Oracle's CEO, "The interesting thing about cloud computing is that we've redefined cloud computing everything that we already do...I don't understand what we would do differently in light of cloud computing other than change the wording of some of our ads" [1, p. 50].

In an article in Harvard Business Review (HBR) [22] the author asks a rhetorical question: "What the heck does it mean to have a 'cloud'? It means that the functions you want like storage, communications, and applications, don't need to live on the device you have in front of you. You can get them on demand from the network." We should ask the question, "in a typical, non-cloud, IS environment, do we really, have the stated functions on the device in front of us?"

Cloud Computing is often confused with Utility Computing but they are not the same—rather the latter forms part of the former [2].

No Definition

Realizing the elephantine nature of cloud computing there is a reluctance to define it. Question: How would you define cloud computing? Answer: Cloud computing

is not so much a definition of a single term as it is a trend in service delivery taking place today [3 p. 52].

An Old Concept

Cloud computing is an old concept, it "is a throwback to the mainframe model of computing" [19, p. 78]. Clearly, *cloud computing is simply remote computing* [4, p. 26.]

Internet or Network Computing

Cloud computing as a term for Internet-based computing service, was launched by industry giants, Google, Amazon, etc. in late 2006 [24.] "It is the movement of application services onto the Internet and the increased use of the Internet..."

The Earliest Publications

In the first article on Cloud Computing in the Communications of ACM [9], it is referred to as "the compute cloud" and is deemed synonymous with "on-demand computing, software as a service, or the Internet as a platform." Though these other naming conventions are self-explanatory cloud computing is not.

The cloud computing is understood as a shift of the geography of computing. It begs the question if it is about moving delivery of a wide variety of information services onto to the Internet, why don't we call it "Internet Computing?"

The first time cloud computing showed up in a HBR publication was in a digital article in April 2008 [14]. The author states that the move to cloud computing would be disruptive to incumbent players of shrink-wrapped gaming software, assuming his readers understand what cloud computing entails.

A BRIEF HISTORY OF COMPUTING

In the early days of computers, they were big and expensive. So, sharing this big, expensive gadget was a normal practice. Most organizations did not usually own this big machine, but those who did had to share it across an enterprise. That was the era of timesharing.

However, as computers got cheaper and more affordable, every company, every department, and then finally every person decided to have their own computer. However, standalone computers are of limited use. So, we networked them, first locally, in a Local Area Network (LAN) environment, and then far and wide, Wide Area Network (WAN). Then we networked the network and the World Wide Web was born.

At the same time, in a different parallel universe, something else was happening. In the early years, no commercial, off-the-shelf software (COTS) was available. Every organization had to write its own software program. So, if you wanted to computerize your accounting, general ledger, payables and receivables, or run your inventory, you had to write your own applications.

Buying off-the-shelf applications was also considered "outsourcing." Why? Because you were having others do the work for your organization, which was supposed to be doing this work for itself. So, over the years, most application development have been outsourced to burgeoning software companies, such as, IBM, Oracle, and SAP.

OUTSOURCING AND ASP

In a general sense, IS outsourcing is nothing new—it has always been considered an option for IT solutions [11]. Electronic Data Systems was handling data processing services for Frito-Lay and Blue Cross as early as 1963. IS outsourcing soon became widely known as the second of a three-phase outsourcing phenomenon—traditional outsourcing being the first phase and application outsourcing being the third [6].

In the early years of the last decade, xSPs, service providers of all stripes, were leading into a new generation of IT, where it really did not matter where the applications reside, as long as we had access to accomplish what we wanted [24/7]. However, back then, an Application Service Provider (ASP) was thought, by some, to be another reincarnation of the old "timesharing" leveraging network technologies [22].

However, the understanding of an evolving net-centric computing was already there. In their book published in 2002, aptly titled *NetSourcing*, authors, Kern, Lacity, and Willcocks [7] define a computing framework and services stack that's similar to Cloud Computing. The authors state, "We selected the term "Netsourcing" as the overarching name because the common element of any xSP is the delivery of a product or service over a network" (p. 3). The "network," however, is now synonymous with the "Internet."

Today, cloud computing is about getting the job done in whatever way, shape, or form that may be required. Organizations and individuals need the utility of computing, and where it comes from, by and large, is of no concern. As early as 1961, Professor John McCarthy predicted that computation may someday be organized as a public utility. "Each subscriber needs to pay only for the capacity he actually uses, but he has access to all programming languages characteristics of a very large system ... Certain subscribers might offer services to other subscribers ... The computer utility could become the basis of a new and important industry [8]. McCarthy's notion of "utility computing" is here right now—that is, "cloud computing."

This point is confirmed by others [1 p. 51], "The data center hardware and software is what we consider a *cloud*. When a cloud is made available in a pay-as-you-go manner to the general public, we call it *utility computing*."

CLOUD COMPUTING: ORIGIN OF THE PHRASE

Coinage of the term "cloud computing" has been traced to two individuals who, at the time they came up with this term, worked for Compaq Computer: George Favaloro, a Compaq marketing executive, and Sean O'Sullivan, the founder of the now defunct business, NetCentric [20].

A Compaq internal document, marked as confidential, dated November 14, 1996, and provided by Sean O'Sullivan, contemplates a Cloud Computing "strategy."[10]

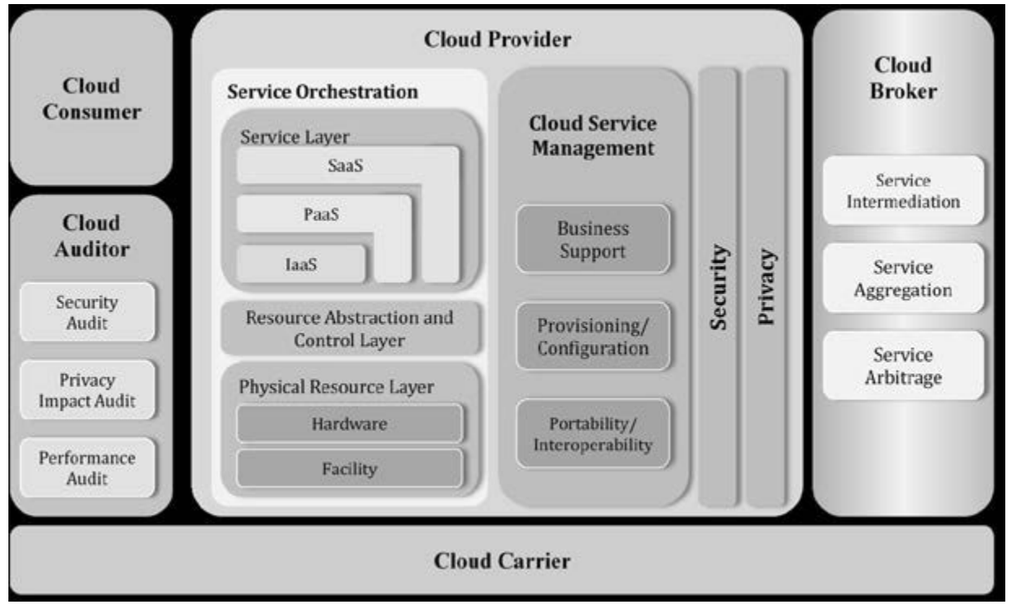
But the creation of this term did not find currency for another decade. Many believe the first use of "cloud computing" in its modern context occurred on August 9, 2006, when then Google CEO Eric Schmidt introduced the term at an industry conference. "What's interesting [now] is that there is an emergent new model," Schmidt said, "I don't think people have really understood how big this opportunity really is. It starts with the premise that the data services and architecture should be on servers. We call it cloud computing—they should be in a "cloud" somewhere." [19]

CLOUD COMPUTING DEFINITION

The National Institute of Standards and Technology (NIST SP 800-145) defines Cloud Computing in the following way: "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models." [17]

The following diagram places all the pieces together in a visual form.

THE CONCEPTUAL REFERENCE MODEL



Cloud Computing Reference Architecture; NIST Special Publication 500-292

Cloud Computing Reference Architecture; NIST Special Publication 500-292

NIST Special Publication 500-292 states that "the definition is widely accepted as a valuable contribution toward providing a clear understanding of cloud computing technologies and cloud services. It provides a simple and unambiguous taxonomy of three service models available to cloud consumers: cloud software as a service (SaaS), cloud platform as a service (PaaS,) and cloud infrastructure as a service (IaaS.) It also summarizes four deployment models describing how the computing infrastructure that delivers these services can be shared: private cloud, community cloud, public cloud, and hybrid cloud." [18] Finally, the NIST definition also provides a unifying view of five essential characteristics that all cloud services exhibit: on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. [18]

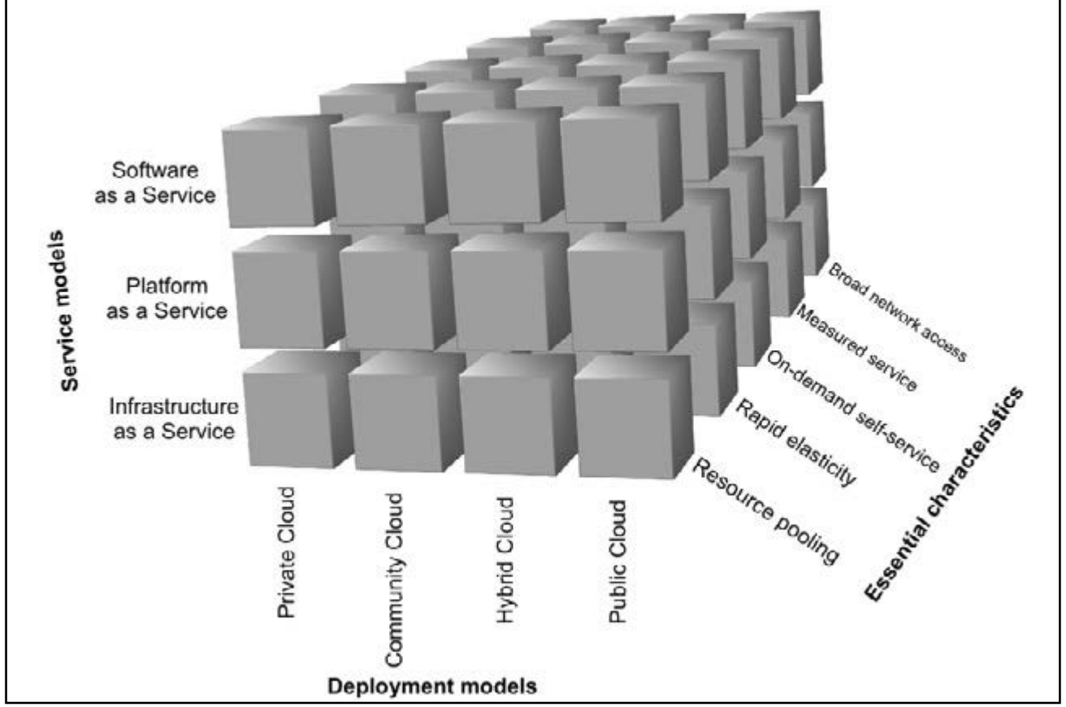
This publication further states that "These services and their delivery are at the core of cloud computing. In the cloud computing model, the primary focus is a more economic method of providing higher quality and faster services at a lower cost to the users."

The Cloud Security Alliance [21] provides a more transparent narrative of what Cloud Computing is: "a model for enabling ubiquitous, convenient, on-demand network access to [a] shared pool of configurable computing resources ... [it] has the potential to enhance collaboration, agility, scaling, and availability, and provides opportunity for cost-reduction ... the model envisages a world where components can be rapidly orchestrated, provisioned, implemented and decommissioned, scaled up or down to provide an on-demand utility-like model."

A SPATIAL VIEW OF CLOUD COMPUTING

The NIST Computing Reference Architecture is a flat depiction of the cloud computing model. A three dimensional view of the model by Craig-Wood [2] is a spatial depiction. Here, you can see the three dimensions of cloud computing that renders the elephant fable.

CLOUD COMPUTING MODEL (ADAPTED FROM CRAIG-WOOD)



Computing Services Framework

Infrastructure as a Service (IaaS): As the word "infrastructure" implies, this is the most basic of services. Customers can buy processing, storage, and network services and then build their own systems on top of this infrastructure. A pioneer in the IaaS field is Amazon, with its Amazon Elastic Compute Cloud (EC2).

However, most big names in the IT field, from Microsoft (Azure) to Google (App Engine) provide IaaS. Here, customers are not renting specific servers, hard drives, and network switches, or any particular equipment, but instead they are utilizing the infrastructure that is most certainly simulated by virtualization software, allowing multiple customers to be served by the same array of physical devices. IaaS provides the raw power of computing—storage included.

Cloud Computing would not be possible without ***virtualization***. Virtualization is the ability to make a virtual machine (VM) act like a physical computer. Just like a physical computer with its own processor, operating system, and storage, each VM has its own components, too. The benefit of virtualization, though, is that you can put much more than only one VM, even with different operating systems, on the same server. Doing so dramatically increases each server's potential for serving clients' on-demand needs (8).

Platform as a Service (PaaS): The next level up is where vendors provide not only the raw power—the infrastructure—but preconfigured systems running operating systems, databases, and platforms (programming languages) for building applications. For example, Microsoft's Azure service provides preconfigured computers running Windows and SQL Server. And Salesforce.com has Force.com as its own custom application development platform.

In practice, the boundary between IaaS and PaaS is not always clear. Because IaaS providers most often provide other services, such as operating systems, database or application development platform that fall in the PaaS category. In its purest form IaaS can be considered as virtual machines (raw processing power and storage) that can be scaled up and down as you need.

Software as a Service (SaaS): Another higher layer is where vendors provide full applications running on cloud infrastructure—their own, or rented from the likes of Amazon. Salesforce.com has long been considered one of the most successful SaaS provider. Salesforece.com CRM was one of the early entrants into the market. Salesforce.com prides itself on being a pioneer in Cloud Computing. At Salesforce.com, it's all about the Cloud. However, in their collateral literature, dated circa 1993-94, you won't find any mention of the word "cloud."

CLOUD COMPUTING CONCERNS

In survey after survey, security is listed as the top concern of Cloud Computing. However, Cloud Security Alliance (CSA), the industry group that provides security guidelines and education, states that "security controls for the cloud computing are, for, in most part, no different than the security controls in any IT environment, ...[however] cloud computing may present different risks to an organization than traditional IT solutions" [21, p. 21].

CIOs, or CEOs for that matter, may feel safer when they "own" versus "rent" their IT assets. However, when you deploy your assets on the Internet, for which you eventually will have little choice, you will inherit a set of vulnerabilities that are not all that different from the Cloud's. Ownership has its own set of financial risks in the form of capital expenditures (CAPEX) that need to be budgeted and spent up front. Compare that risk with the far smaller risk of renting (OPEX), which, by and large, can be discontinued if needed.

Cloud computing technology does not require the use of public networks. If your data is too strategically critical and sensitive to be deployed on the Internet, you could instead deploy a **private cloud** that is strictly for your organization. Obviously, a Private Cloud is more expensive and it needs trained staff. However, a private cloud lets an organization benefit from cloud technology without the risk of possible public disclosure of its data.

Another alternative could be a **community cloud**—a private cloud that is shared by several organizations for specific needs. For example, a group of hospitals might create a community cloud to hold patient's medical records.

CONCLUSION

Cloud Computing is here to stay and grow. Clouds are more versatile than traditional IT networks on many dimensions: They are far more convenient to deploy, they have far more potential for collaboration, and they are far more scalable than traditional IT ever was. The delivery of services is provisioned on global telecommunication networks that, these days, have morphed into the Internet. And when they mature, they will provide a computing utility when and where it is needed.

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Optimal Portfolios and the R Programming Language

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ABSTRACT

This paper develops a program in the freely available open-source R programming language to calculate weights for optimal stock portfolios. The program retains the advantages the Thompson and El-houbi (2012) SAS program has over similar programs in Excel, but avoids the potential problem of limited access to SAS that some students and researchers may face. The R program also extends the Thompson and El-houbi program by including the ability to accommodate short-sale restrictions and position limits.

INTRODUCTION

In their paper "SAS and the Efficient Portfolio," Thompson and El-houbi (2012) develop a SAS program to calculate portfolio weights for efficient stock portfolios. Their program improves on existing public domain SAS programs of this type by allowing for portfolios with a relatively large number of securities. Thompson and El-houbi also claim that their SAS program is an improvement over the Excel programs used to calculate portfolio weights, which are sometimes included in investment textbooks. They note that users concur that their program is easier to use than those Excel programs, which either limit the number of securities that can be included in a portfolio, require "corrections" or "adjustments" to overcome some quirks in the Excel Solver routine, or require multiple user interventions.

The Thompson and El-houbi program is certainly more elegant and user friendly than the equivalent Excel programs and will provide those with access to the SAS programming language a valuable tool for learning portfolio management. The disadvantage of a SAS program, however, is that many students will not have easy access to the SAS programming language. Students at smaller universities may not have any access to SAS, while students at many larger universities may only be able to access SAS at a computer lab on campus.

In this paper, I modify the Thompson and El-houbi SAS program for use in the open-source R programming language, which is available free of charge for anyone with access to the internet. Using the R language program to compute portfolio weights for efficient portfolios maintains the elegance of the Thompson and El-houbi SAS program while overcoming the disadvantage of limited SAS availability. In addition, I extend the Thompson and El-houbi program by making use of a quadratic programming package available in R to provide a program that can accommodate short-sale restrictions and position limits.

THE R PROGRAMMING LANGUAGE

R is a free programming language for statistical analysis and graphics and runs on many UNIX platforms, and on Windows and MacOS. It is available under the terms of the Free Software Foundation's GNU General Public License. R was developed initially by Robert Gentleman and Ross Ihaka, both of the University of Auckland (New Zealand) and is based on the S programming language developed at Bell Labs by John Chambers. Since its initial development, the popularity of R has grown considerably, largely because of its ease of use and because of the availability of many add-on packages that allow users to tackle very sophisticated projects.

The base R package may be downloaded at http://cran.us.r-project.org/. That web page also provides links to sources of information about R and basic user manuals. There are also many books and manuals now available for purchase that offer information on both basic and specialized uses of the language. In fact, Vance (2009) suggests that the growing popularity of the R language at universities language could even result in noticeably lower demand for SAS.

THE MARKOWITZ PORTFOLIO PROBLEM

As Markowitz (1952) notes, an investor following the "expected returns-variance of returns rule" will choose an ef-

ficient portfolio, that is, a portfolio with maximum expected return for a given variance, or one with minimum variance for a given expected return. The minimum variance formulation of the portfolio choice problem therefore requires that the investor choose portfolio weights to minimize the variance of a portfolio with a given expected return. The problem also requires that all money be invested (which means that the portfolio weights must sum to one). In matrix notation, the optimization problem is

$$\text{Min } w'Vw$$
$$\text{s.t. } Rw = M,$$

where w, the choice variable, is a $k \times 1$ vector of the weights invested in the k securities in the portfolio, V is the portfolio variance-covariance matrix, and R is a $2 \times k$ matrix whose first row is a vector of ones and whose second row contains the expected returns of each security in the portfolio. M is a 2×1 vector whose first element is one (corresponding to the constraint that the portfolio weights sum to one) and whose second element is the chosen portfolio expected return. For now, there are no restrictions on short sales, so some portfolio weights may be negative.

The Lagrangian for the problem is

$$L = w'Vw + \lambda'(M - Rw),$$

where λ is a 2×1 vector containing the Lagrangian multipliers. The first-order conditions for a minimum (which are also sufficient conditions in this case) are

$$\frac{\partial L}{\partial w} = 2Vw - R'\lambda = 0$$
$$\frac{\partial L}{\partial \lambda} = M - Rw = 0.$$

Solving the first-order conditions for w and λ yields

$$w = V^{-1}R'\left(RV^{-1}R'\right)^{-1}M$$
$$\lambda = 2\left(RV^{-1}R'\right)^{-1}M.$$

Thompson and El-houbi, following Stephens (1998), let $H = RV^{-1}R'$, so that

$$w = V^{-1}R'H^{-1}M$$
$$\lambda = 2H^{-1}M.$$

Stephens (1998, p. 36) shows how the elements of the H matrix may be used "to fix any mean/variance point on the efficient frontier."

THE BASIC R PORTFOLIO OPTIMIZATION PROGRAM

The R programming language lends itself very easily to matrix manipulation and matrix computation, removing much of the difficulty in solving the standard Markowitz portfolio problem. The following R program calculates the portfolio weights for an efficient portfolio, using stock return data to estimate expected returns and the variance-covariance matrix. The user must specify the desired portfolio expected return. The program can accommodate portfolios up to about 50 stocks. Beyond that number, precision limitations of the R language may make the variance-covariance matrix "computationally singular" and unable to be inverted.

The first step in the program is to read in the return data. R can input data from many file types, but in the present example, the data are stored in a comma-delimited Excel file called "Returns.csv" which contains stock return data. In this case, the Excel file includes a header row labeling each column of returns with identifying information, but no row names. The program first reads in the data and then determines the number of securities (number of columns in the matrix) as shown on the facing page:

ADDING SHORT-SALE CONSTRAINTS AND POSITION LIMITS

The above formulation of the portfolio choice problem places no restrictions on short sales and does not accommodate position limits. In reality, individual investors and some fund managers may face requirements prohibiting short sales. Fund managers may also face requirements that either limit the amount that may be invested in one security or sector or instead that a minimum percentage of funds be invested in a certain security or sector. Dai, Lin, and Liu (2011) list several examples of real-world position limits, such as a requirement that a small-cap mutual fund invest at least a minimum percentage of its funds in small-company stocks. In mathematical terms, these short-sale restrictions and position limits can be expressed as a series of inequality constraints. While reformulating the portfolio choice problem to add inequality constraints is not difficult, doing so makes actually solving the problem considerably more difficult.

With short-sale restrictions and position limits, the portfolio choice problem becomes

$$\text{Min } w'Vw$$
$$\text{s.t. } Rw = M$$
$$Sw \geq w_0$$

THE BASIC R PORTFOLIO OPTIMATION PROGRAM

Returns <– read.table("Returns.csv", header = TRUE, sep = ",")	
Rmat <– as.matrix(Returns)	Converts the data to matrix form
k <– ncol(Rmat)	Number of columns (number of securities in the portfolio)
Now the program calculates the estimate of the variance-covariance matrix (V), the M vector, and the R matrix, which includes the estimate of the expected returns:	
V <– var(Rmat)	Calculates the sample variance-covariance matrix, which is used as the estimate of the variance-covariance matrix.
Erp <– 0.01	Sets the desired expected portfolio return. The user can change this value as desired.
M <– rbind(1, Erp) Ones <– rep(1, k) Ravg <– colMeans(Rmat)	Defines the M matrix, including the required portfolio return. Defines a 1 x k matrix of ones. Calculates average returns by column, giving a 1 x k matrix. of estimated expected returns.
R <– rbind(Ones, Ravg)	Combines Ones and Ravg into the 2 x k matrix R.
Finally, the program calculates the portfolio weights and the portfolio variance.	
VINV <– solve(V)	Calculates the inverse of the estimated variance-#covariance matrix.
H <– R%*%VINV%*%t(R)	Calculates the H matrix.
HINV <– solve(H)	Calculates the inverse of H.
w <- VINV%*%t(R)%*%HINV%*%M	Calculates the portfolio weights.
Pvar <- t(w)%*%V%*%w	Calculates the portfolio variance.
The following commands display the results of the calculations:	
print(w)	Prints the elements of the w vector.
print(Pvar)	Prints the variance of the portfolio formed using the weights w.

where w is still the choice variable, S is an m × k matrix that defines both the short-sale constraints on the k securities in the portfolio and m − k other restrictions. If there are short-sale constraints, but no other restrictions, the S matrix is simply a k × k identity matrix, which, when multiplied by the vector w results in the requirement that $w_i \geq 0 \forall i$. If there are other restrictions, the sub-matrix of S consisting of the first k rows and k columns of S is an identity matrix and the other restrictions are specified by suitable choices of the elements of the remaining rows of S. For example, suppose there is a position limit placing a maximum of p on the percentage invested in the seventh security, so that $w_7 \leq p$. Since the constraints in the optimization problem above have been expressed as non-negativity constraints, this position limit must instead take the form $-w_7 \geq -p$. The row of S corresponding to the position limit will consist entirely of zeros except for the seventh element, which will be −1, and corresponding element of the w0 vector would be p.

Introducing other forms of position limits simply requires adding the appropriate rows to the S matrix. For example, if there is a requirement that the total percentage invested in the first and third securities equal or exceed a certain percentage q , then one row of S should be [1 0 1 0 ··· 0]and the corresponding element of the w0 vector would be q. If there is instead a requirement that the total percentage invested in the first and third securities not exceed a certain amount q, the required row of S would be [-1 0 -1 0 ··· 0] and the corresponding element of the w0 vector would be −q. Other restrictions may be specified similarly. For problems that include position limits, each of the first k el-

ements of the wØ vector will be zero, corresponding to the non-negativity constraints, and the remaining elements will equal the percentages associated with the position limits, entered as positive or negative numbers depending on whether the position limits establish minimums or maximums.

The Lagrangian for this problem is

$$L = w'Vw + \lambda'(M - Rw) + \mu'(w_0 - Sw),$$

where λ is a 2 × 1 vector containing the Lagrangian multipliers on the equality constraints and μ is an *m × 1 vector of the Lagrangian multipliers on the k short-sale constraints and the m – k position limits. The first-order necessary conditions for this problem are the Kuhn-Tucker conditions*

$$\frac{\partial L}{\partial w} = 2Vw - R'\lambda - S'\mu = 0$$

$$\frac{\partial L}{\partial \lambda} = M - Rw = 0$$

$$\frac{\partial L}{\partial \mu} = w_0 - Sw \le 0,\ \mu \ge 0,\ \text{and}\ \mu'(w_0 - Sw) = 0.$$

The final set of conditions are known as the complementary slackness conditions, since if an element of $\partial L/\partial \mu$ does not equal zero (i.e., if the required condition is slack), then the corresponding element of μ must equal zero and vice versa. Because of the complementary slackness conditions, in order to find a solution to the optimization problem, each condition must be checked individually to determine the possible solutions. If there are more than a very few constraints, finding the candidate solutions manually becomes extremely tedious.

Fortunately, it is possible to use numerical methods to solve this type of non-linear programming program. This is where the strength of the R programming language becomes very evident. The R language provides access to an extensive number of add-on packages developed by R users around the world. In particular, there are several packages that implement numerical methods to find solutions to optimization problems with inequality constraints. Perhaps the package that most easily lends itself to solving the current problem is the "quadprog" package. According to the documentation included with the package, the quadprog routine "implements the dual method of Goldfarb and Idnani (1982, 1983) for solving quadratic programming problems of the form $\min(d'b+½b'Db)$) with the constraints $A'b>b_0$." For the optimization problem currently under consideration, the *d* vector will be a zero vector, the *b* vector will be the *w* vector of portfolio weights, the *D* matrix will be the variance-covariance matrix *V* and the matrix *A'* will equal a matrix formed by combining the *R* matrix and the *S* matrix such that $A' = \begin{bmatrix} R \\ S \end{bmatrix}$ and $A = [\ R' \quad S']$. . Since the *V* matrix is symmetric, the term *½b'Db = ½w'Vw* is a quadratic form. Also, because the d vector is a zero vector, the presence of the ½ term in the quadratic form does not change the value of the solution to the current portfolio optimization problem. That is, the weights that minimize *½w'Vw* subject to the constraints will also minimize *w'Vw* subject to the constraints.

THE R PORTFOLIO OPTIMIZATION PROGRAM WITH PACKAGE "QUADPROG"

The "Quadprog" package is one of many add-in packages available to R users. To use add-in packages in R, the user must first download and install the chosen package. This is done through the "Packages" command in the menu bar of the console window. Selecting the "Install package(s)" command from the drop-down box will bring up a list of download locations. After selecting a download location, the user selects the package(s) to download and install. Finally, once the selected package is downloaded and installed, it must be loaded for use in the current R session, which is done by choosing "Packages" command on the menu bar and then choosing the "Load package" command from the drop-down box. A list of available packages will then appear and the user should select the desired package, in this case, the "quadprog" package. Once the quadprog package is loaded, the following program will solve the portfolio problem with short-sale restrictions and position limits.

In the present example, the short-sale constraint requires that all elements of the *w* vector be non-negative. In addition, there are three position limits. The first position limit requires that no more than 5% of total funds be invested in the seventh security. The second position limit requires that no more than a total of 4Ø% of available funds be invested in the first and third securities. The third position limit requires that total of at least 3Ø% of available funds be invested in the second and fourth securities.

The program will make use of the *M* matrix and the variance-covariance matrix *V* from the earlier program, so those variables must be saved by the user or the following program must be run after running the previous program and before exiting R. The new program first sets the position limits, as shown on the facing page:

THE R PORTFOLIO OPTIMIZATION PROGRAM WITH PACKAGE "QUADPROG"	
npl <– 3	Sets the number of position limits. The user sets this value.
plmat <– matrix (rep(Ø, npl*k), nrow=npl, ncol=k)	Initializes the matrix that will be used to define the position limit(s).
plmat[1,7] = -1	Places the required elements into the proper places in the lmat[2,1] = plmat[2,3] = -1 position limits matrix. In this example, the first position
plmat[3,2] = plmat[3,4] = 1	limit will set a maximum on the total percentage invested in the seventh security. The second position limit will set a maximum on the total percentage invested in the first and third securities. The third position limit will set a minimum on the total percentage invested in the second and fourth securities.
pl <– c(-Ø.Ø5, -Ø.4, Ø.3)	Sets the values of the position limits. The value the user enters should be positive if the position limit specifies a inimum and should be negative if the position limit specifies a maximum.
Next, the inequality constraints are placed in matrix form:	
S <– rbind(diag(k), plmat)	Defines the S matrix.
wØ <– c(rep(Ø, k), pl)	Creates a vector whose elements are the values of the inequality constraints.
Next, the arguments required by the solve.QP function that solves the programming problem are defined and the programming problem is solved:	
dvec <– rep(Ø, k)	Defines the d vector, which is a necessary input for the quadprog package. For portfolio optimization problems, the elements of the d vector will all be zeros.
Amat <– colbind(t(R), t(S))	Forms the Amat matrix
bvec <– c(M, wØ)	Joins the M matrix and the wØ matrix to form the bvec vector.
ICSol <– solve.QP(V, dvec, Amat, bvec, meq=2)	Solves the quadratic programming problem. The argument "meq" specifies that the first two constraints are equality constraints. In this example, the equality constraints are that the weights sum to one and that the portfolio expected return equal a specified amount.
print(c(ICSol[1], 2*ICSol[[2]], ICSol[5], ICSol[6]))	Prints selected output from the solve. QP function: the weights, the portfolio variance, the values of the Lagrangian multipliers, and the index numbers of the binding constraints.

The output of the "solve.QP" function includes the values of *w* and the Lagrangian multipliers for each constraint. If the value of a Lagrangian multiplier is zero, the constraint associated with that multiplier is not binding, otherwise the constraint is binding. Though checking the values of the Lagrangian multipliers allows the user to determine which constraints are binding quite easily, the function's output also includes a listing of the binding constraints by index number.

CONCLUSION

This paper provides an R language program to calculate portfolio weights for efficient portfolios. The program can also accommodate short-sale constraints and position limits. Users must choose the desired portfolio expected return and must specify any other constraints. A strong advantage of the program is that because the R programming language is freely available to anyone with access to the internet, students and others who wish to use the program will be able to do so easily.

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APPENDIX 1
DATA

The data used in the R program come from the CRSP monthly stock file and consist of 60 months of return data, from January 2008 to December 2012. The stocks in the 10-stock portfolio are the first 10 stocks in the CRSP monthly file (listed by PERMNO) for which 60 continuous months of returns are available. The stocks in the 50-stock portfolio are the first 50 stocks for which 60 continuous months of returns are available. Table 1 below lists the PERMNOS, current company name, and current ticker of the included stocks, as well as the exchange where the stock trades.

Table 1
Stocks in the Portfolio

NO.	PERMNO	CURRENT COMPANY NAME	TICKER	EXCHANGE
1	10001	GAS NATURAL INC	EGAS	AMEX
2	10002	BANCTRUST FINANCIAL GROUP INC	BTFG	NASDAQ
3	10025	A E P INDUSTRIES INC	AEPI	NASDAQ
4	10026	J & J SNACK FOODS CORP	JJSF	NASDAQ
5	10032	PLEXUS CORP	PLXS	NASDAQ
6	10044	ROCKY MOUNTAIN CHOCOLATE FAC INC	RMCF	NASDAQ
7	10051	HANGER INC	HGR	NYSE
8	10065	ADAMS EXPRESS CO	ADX	NYSE
9	10100	AMERICAN LEARNING CORP NY	ALRN	NASDAQ

Table 1
Stocks in the Portfolio

NO.	PERMNO	CURRENT COMPANY NAME	TICKER	EXCHANGE
10	10104	ORACLE CORP	ORCL	NASDAQ
11	10107	MICROSOFT CORP	MSFT	NASDAQ
12	10138	T ROWE PRICE GROUP INC	TROW	NASDAQ
13	10145	HONEYWELL INTERNATIONAL INC	HON	NYSE
14	10147	E M C CORP MA	EMC	NYSE
15	10180	AKORN INC	AKRX	NASDAQ
16	10182	TECH DATA CORP	TECD	NASDAQ
17	10200	REPLIGEN CORP	RGEN	NASDAQ
18	10207	ROYCE FOCUS TRUST INC	FUND	NASDAQ
19	10225	BEAM INC	BEAM	NYSE
20	10232	ELMIRA SAVINGS BANK NY	ESBK	NASDAQ
21	10239	BALDWIN & LYONS INC	BWINB	NASDAQ
22	10252	INDEPENDENT BANK CORP MA	INDB	NASDAQ
23	10253	DOCUMENT SECURITY SYSTEMS INC	DSS	AMEX
24	10257	D L H HOLDINGS CORP	DLHC	NASDAQ
25	10258	CELLDEX THERAPEUTICS INC	CLDX	NASDAQ
26	10259	SIGMA DESIGNS INC	SIGM	NASDAQ
27	10294	HAVERTY FURNITURE COS INC	HVT	NYSE
28	10297	NEW HAMPSHIRE THRIFT BNCSHRS INC	NHTB	NASDAQ
29	10299	LINEAR TECHNOLOGY CORP	LLTC	NASDAQ
30	10302	CYPRESS SEMICONDUCTOR CORP	CY	NASDAQ
31	10308	TOMPKINS FINANCIAL CORP	TMP	AMEX
32	10318	BALCHEM CORP	BCPC	NASDAQ
33	10333	XOMA CORP	XOMA	NASDAQ
34	10355	DAILY JOURNAL CORP	DJCO	NASDAQ
35	10363	A M A G PHARMACEUTICALS INC	AMAG	NASDAQ
36	10375	T C F FINANCIAL CORP	TCB	NYSE
37	10382	ASTEC INDUSTRIES INC	ASTE	NASDAQ
38	10395	NAVIGATORS GROUP INC	NAVG	NASDAQ
39	10397	WERNER ENTERPRISES INC	WERN	NASDAQ
40	10421	SKYWEST INC	SKYW	NASDAQ
41	10443	PATRIOT TRANSPORTATION HLDG INC	PATR	NASDAQ
42	10463	RESEARCH FRONTIERS INC	REFR	NASDAQ
43	10501	AMERICAN WOODMARK CORP	AMWD	NASDAQ
44	10507	MEDICAL ACTION INDS INC	MDCI	NASDAQ
45	10514	TRANS WORLD ENTERTAINMENT CORP	TWMC	NASDAQ
46	10516	ARCHER DANIELS MIDLAND CO	ADM	NYSE
47	10517	AARONS INC	AAN	NYSE
48	10530	MERIDIAN BIOSCIENCE INC	VIVO	NASDAQ
49	10547	CLEARFIELD INC	CLFD	NASDAQ
50	10550	PRO DEX INC COLO	PDEX	NASDAQ

APPENDIX 2
COPY OF THE FULL PROGRAM

The full program is shown below, without comments. Users can easily copy the program that is between the solid lines and paste it into the R Editor window. It will probably be necessary for each user to change the name of the data file in the read.table command. Also, the user can change the portfolio expected return and the number, type, and value of the inequality constraints as desired.

```
Returns <– read.table("Returns.csv", header = TRUE, sep = ",")
Rmat <– as.matrix(Returns)
k <– ncol(Rmat)
V <– var(Rmat)
Erp <– 0.01
M <– rbind(1, Erp)
Ones <– rep(1, k)
Ravg <– colMeans(Rmat)
R <– rbind(Ones, Ravg)
VINV <– solve(V)
H <– R%*%VINV%*%t(R)
HINV <– solve(H)
w <- VINV%*%t(R)%*%HINV%*%M
Pvar <- t(w)%*%V%*%w
print(w)
print(Pvar)

npl <– 3
plmat <– matrix (rep(0, npl*k), nrow=npl, ncol=k)
plmat[1,7] = -1
plmat[2,1] = plmat[2,3] = -1
plmat[3,2] = plmat[3,4] = 1
pl <– c(-0.05, -0.4, 0.3)

S <– rbind(diag(k), plmat)
w0 <– c(rep(0, k), pl)
dvec <– rep(0, k)
Amat <– cbind(t(R), t(S))
bvec <– c(M, w0)
ICSol <– solve.QP(V, dvec, Amat, bvec, meq=2)
print(c(ICSol[1], 2*ICSol[[2]], ICSol[5], ICSol[6]))
```

APPENDIX 3
RESULTS FOR THE 10-STOCK PORTFOLIO

Results for the 10-stock portfolio with a monthly expected return of 1% are shown at the top of the facing page. First shown is the variance-covariance matrix (V), followed by its inverse, (V^{-1}).

Table 2 shows the return averages of each stock and the calculated portfolio weights both for the portfolio with no short-sale constraints or position limits and the portfolio with short-sale constraints and three position limits: (1) a requirement that the percentage invested in the seventh security not exceed 5%, (2) a requirement that the total percentage invested in the first and the third securities not exceed 40%, and (3) a requirement that the total percentage invested in the second and fourth securities be at least 30%. Note that when short-sale constraints and position limits are imposed, there may no longer be a portfolio that meets all the constraints, that is, the feasible set may be null. In that case, the R program will return an error message stating that the constraints are inconsistent.

Table 3 lists the inequality constraints and the associated Lagrangian multipliers along with an indication of whether the constraint is binding. In this example, the constraint that there be a minimum of 30% invested in the second and fourth securities is not binding.

$$V = \begin{bmatrix}
0.0046 & -0.0019 & -0.0002 & 0.0006 & 0.0035 & -0.0004 & 0.0011 & 0.0008 & -0.0018 & 0.0019 \\
-0.0019 & 0.0364 & 0.0013 & 0.0037 & -0.0002 & -0.0004 & 0.0003 & 0.0001 & -0.0100 & 0.0007 \\
-0.0002 & 0.0013 & 0.0161 & 0.0024 & 0.0076 & 0.0035 & 0.0013 & 0.0041 & -0.0038 & 0.0033 \\
0.0006 & 0.0037 & 0.0024 & 0.0058 & 0.0051 & 0.0010 & 0.0016 & 0.0021 & -0.0028 & 0.0029 \\
0.0035 & -0.0002 & 0.0076 & 0.0051 & 0.0217 & 0.0009 & 0.0048 & 0.0052 & -0.0024 & 0.0064 \\
-0.0004 & -0.0004 & 0.0035 & 0.0010 & 0.0009 & 0.0087 & 0.0018 & 0.0022 & -0.0027 & 0.0012 \\
0.0011 & 0.0003 & 0.0013 & 0.0016 & 0.0048 & 0.0018 & 0.0113 & 0.0013 & 0.0055 & 0.0018 \\
0.0008 & 0.0001 & 0.0041 & 0.0021 & 0.0052 & 0.0022 & 0.0013 & 0.0033 & -0.0003 & 0.0034 \\
-0.0018 & -0.0100 & -0.0038 & -0.0028 & -0.0024 & -0.0027 & 0.0055 & -0.0003 & 0.0850 & -0.0020 \\
0.0019 & 0.0007 & 0.0033 & 0.0029 & 0.0064 & 0.0012 & 0.0018 & 0.0034 & -0.0020 & 0.0068
\end{bmatrix}$$

$$V^{-1} = \begin{bmatrix}
286.7001 & 16.1224 & 27.9311 & 15.3314 & -40.8660 & 14.8438 & -13.1874 & 24.6057 & 8.3608 & -74.0152 \\
16.1224 & 32.1169 & -2.3967 & -25.1277 & 3.9387 & 5.5190 & -3.3449 & 10.7899 & 3.6378 & -3.9718 \\
27.9311 & -2.3967 & 99.1158 & 10.9233 & -18.9872 & -10.0249 & 2.2208 & -119.6782 & 4.1342 & 19.8294 \\
15.3314 & -25.1277 & 10.9233 & 275.7210 & -31.9797 & 0.3010 & -13.9907 & -96.9199 & 5.6520 & -41.6534 \\
-40.8660 & 3.9387 & -18.9872 & -31.9797 & 97.7494 & 32.5171 & -24.7388 & -109.8965 & 2.6657 & -0.4097 \\
14.8438 & 5.5190 & -10.0249 & 0.3010 & 32.5171 & 164.4368 & -31.1333 & -180.3329 & 9.1576 & 42.8583 \\
-13.1874 & -3.3449 & 2.2208 & -13.9907 & -24.7388 & -31.1333 & 109.3506 & 42.6730 & -10.0681 & -16.2364 \\
24.6057 & 10.7899 & -119.6782 & -96.9199 & -109.8965 & -180.3329 & 42.6730 & 1164.0904 & -23.3195 & -378.9283 \\
8.3608 & 3.6378 & 4.1342 & 5.6520 & 2.6657 & 9.1576 & -10.0681 & -23.3195 & 13.8635 & 7.3382 \\
-74.0152 & -3.9718 & 19.8294 & -41.6534 & -0.4097 & 42.8583 & -16.2364 & -378.9283 & 7.3382 & 368.5519
\end{bmatrix}$$

Table 2
Average Returns and Weights for the Ten-Stock Portfolios

Stock No.	Permno	Average Returns	Weights (SS Allowed)	IC Weights (No SS, 3 PLs)
1	10001	0.0064	0.3817	0.3406
2	10002	-0.0054	0.0311	0.0406
3	10025	0.0183	0.0908	0.0594
4	10026	0.0156	0.2525	0.2625
5	10032	0.0095	-0.1410	0.0000
6	10044	0.0012	0.0649	0.1379
7	10051	0.0206	0.1000	0.0500
8	10065	0.0018	0.1933	0.0492
9	10100	0.0270	0.0422	0.0568
10	10104	0.0104	-0.0155	0.0031

Table 3
Constraints and Lagrangian Multipliers

Constraint	Lagrangian Multiplier	Constraint Binding?
Portfolio weights sum to one	0.0015	Yes
Portfolio expected return equals 1%.	0.0443	Yes
$w_1 \geq 0$	0.0000	No
$w_2 \geq 0$	0.0000	No
$w_3 \geq 0$	0.0000	No
$w_4 \geq 0$	0.0000	No
$w_5 \geq 0$	0.0015	Yes
$w_6 \geq 0$	0.0000	No
$w_7 \geq 0$	0.0000	No
$w_8 \geq 0$	0.0000	No
$w_9 \geq 0$	0.0000	No
$w_{10} \geq 0$	0.0000	No
$w_7 \leq 0.05$	0.0003	Yes
$w_1 + w_3 \leq 0.4$	0.0002	Yes
$w_2 + w_4 \geq 0.3$	0.0000	No

The portfolio variances are:

No short-sale constraints:	0.001607
Short-sale constraints and three position limits:	0.001856

APPENDIX 4
RESULTS FOR THE 50-STOCK PORTFOLIO

Results for the 50-stock portfolio with a monthly expected return of 1% are shown in Table 4 below. The first table shows the return averages of each stock and the calculated portfolio weights both for the portfolio with no short-sale constraints or position limits and the portfolio with short-sale constraints and three position limits: (1) a requirement that the percentage invested in the seventh security not exceed 5%, (2) a requirement that the total percentage invested in the first and the third securities not exceed 40%, and (3) a requirement that the total percentage invested in the second and fourth securities be at least 30%.

Table 5 shows the Lagrangian multipliers on the equality constraints and the position limit constraints. To save space, for the 50-stock portfolio, the Lagrangian multipliers on the short-sale constraints are not listed. Simply checking Table 4 to see if the weight on a particular stock is zero gives an almost certain indication of which short-sale constraints are binding. In this example, both the constraint that there be no more than 5% invested in the seventh security and the constraint that there be no more than a total of 40% invested in the first and third securities are not binding.

Table 4
Average Returns and Weights for the 50-Stock Portfolios

Stock No.	Permno	Average Returns	Weights SS Allowed	IC Weights No SS, 3 PLs
1	10001	0.0064	0.1934	0.1307
2	10002	-0.0054	-0.0179	0.0367
3	10025	0.0183	-0.0189	0.0000
4	10026	0.0156	0.2873	0.2633
5	10032	0.0095	0.0503	0.0000
6	10044	0.0012	-0.0185	0.0000
7	10051	0.0206	-0.0136	0.0228
8	10065	0.0018	1.0920	0.0000
9	10100	0.0270	0.0306	0.0423
10	10104	0.0104	0.1467	0.0000
11	10107	-0.0001	-0.2023	0.0000
12	10138	0.0085	-0.5619	0.0000
13	10145	0.0065	-0.3910	0.0000
14	10147	0.0088	-0.2693	0.0000
15	10180	0.0290	-0.0290	0.0000
16	10182	0.0076	0.1181	0.0000
17	10200	0.0082	0.1409	0.0409
18	10207	0.0020	-0.1551	0.0000
19	10225	0.0098	0.0285	0.0000
20	10232	0.0159	-0.0021	0.0000
21	10239	0.0051	0.1624	0.0000
22	10252	0.0084	0.0955	0.0000
23	10253	0.0058	0.0121	0.0000
24	10257	-0.0008	-0.0236	0.0000
25	10258	0.0196	-0.0157	0.0000
26	10259	-0.0300	-0.1339	0.0000
27	10294	0.0179	-0.0414	0.0000
28	10297	0.0061	0.1854	0.1467
29	10299	0.0074	0.0826	0.0000
30	10302	0.0165	0.0201	0.0000
31	10308	0.0073	0.1255	0.0141
32	10318	0.0194	-0.1389	0.0000
33	10333	-0.0203	-0.0205	0.0000
34	10355	0.0299	-0.0545	0.0360
35	10363	-0.0151	-0.0167	0.0000
36	10375	0.0010	-0.0495	0.0000
37	10382	0.0046	0.0267	0.0000
38	10395	-0.0022	0.0886	0.0423
39	10397	0.0134	0.1296	0.0849
40	10421	-0.0036	-0.1045	0.0000
41	10443	0.0021	0.1389	0.0000
42	10463	0.0013	0.0417	0.0000
43	10501	0.0176	-0.0458	0.0000
44	10507	-0.0228	-0.0397	0.0000
45	10514	0.0100	0.0731	0.0078
46	10516	-0.0034	-0.0148	0.1192
47	10517	0.0208	0.0629	0.0000
48	10530	0.0005	0.0032	0.0000
49	10547	0.0418	0.0032	0.0125
50	10550	-0.0028	0.0397	0.0000

Table 5
Constraints and Lagrangian Multipliers

Constraint	Lagrangian Multiplier	Constraint Binding?
Portfolio weights sum to one	0.000503	Yes
Portfolio expected return equals 1%.	0.031954	Yes
$w_7 \leq 0.05$	0.000000	No
$w_1 + w_3 \leq 0.4$	0.000000	No
$w_2 + w_4 \geq 0.3$	0.000963	Yes

The portfolio variances are:

No short-sale constraints:	0.00002997
Short-sale constraints and three position limits:	0.00111119

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JOINT CONFERENCE
May 25th, 26th and 27th 2016 in Nashville, TN

Academic Business World International Conference (ABWIC.org)

The aim of Academic Business World is to promote inclusiveness in research by offering a forum for the discussion of research in early stages as well as research that may differ from 'traditional' paradigms. We wish our conferences to have a reputation for providing a peer-reviewed venue that is open to the full range of researchers in business as well as reference disciplines within the social sciences.

Business Disciplines

We encourage the submission of manuscripts, presentation outlines, and abstracts pertaining to any business or related discipline topic. We believe that all disciplines are interrelated and that looking at our disciplines and how they relate to each other is preferable to focusing only on our individual 'silos of knowledge'. The ideal presentation would cross discipline. borders so as to be more relevant than a topic only of interest to a small subset of a single discipline. Of course, single domain topics are needed as well.

International Conference on Learning and Administration in Higher Education (ICLAHE.org)

All too often learning takes a back seat to discipline related research. The International Conference on Learning and Administration in Higher Education seeks to focus exclusively on all aspects of learning and administration in higher education. We wish to bring together, a wide variety of individuals from all countries and all disciplines, for the purpose of exchanging experiences, ideas, and research findings in the processes involved in learning and administration in the academic environment of higher education.

We encourage the submission of manuscripts, presentation outlines, and abstracts in either of the following areas:

Learning

We encourage the submission of manuscripts pertaining to pedagogical topics. We believe that much of the learning process is not discipline specific and that we can all benefit from looking at research and practices outside our own discipline. The ideal submission would take a general focus on learning rather than a discipline-specific perspective. For example, instead of focusing on "Motivating Students in Group Projects in Marketing Management", you might broaden the perspective to "Motivating Students in Group Projects in Upper Division Courses" or simply "Motivating Students in Group Projects" The objective here is to share your work with the larger audience.

Academic Administration

We encourage the submission of manuscripts pertaining to the administration of academic units in colleges and universities. We believe that many of the challenges facing academic departments are not discipline specific and that learning how different departments address these challenges will be beneficial. The ideal paper would provide information that many administrators would find useful, regardless of their own disciplines