International Conference on Industry, Engineering, and Management Systems

March 22-26, 2015

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It is with pleasure that we present to you the Proceedings of the 2015 International Conference on Industry, Engineering and Management Systems (IEMS). The papers presented this year consistently represented high quality scholarship in the authors' respective fields. The papers covered a wide range of topics in the business and engineering disciplines, integrating concepts that further the mission of the IEMS Conference.

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These proceedings would not have been made possible without the valuable contributions of our Track Chairs for the time and effort they spent reviewing the papers and coordinating our conference sessions. Thank-you also to our Administrative Coordinator, Elki Issa, whose work behind the scenes helps make our Conference a success.

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Warmest Regards,

Sandy Furterer, Ph.D., MBA
IEMS Publications Editor

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The Design and Prototyping of a Novel Chord-Forming Guitar Capo for Intermediate to Advanced Guitar Players

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Abstract

This paper presents the design, prototyping, and verification and validation of a unique chord-forming capo, an accessory for the guitar. The original concept of the device was developed through the ideation, selection of alternatives, rapid prototyping fabrication with design improvement, performance testing, and consumer acceptance verification phases. The current state of the art of guitar capos was explored, leading to a proposal of the value of this new capo design to fill an evident gap in the capo market. The new design was then explained in detail, with explanations for each relevant design choice. Custom 3D printing allowed for three rapid prototyping iterations of the design. The main load-bearing part of the prototype was tested to find its critical allowable pressure and resistance to bending stress. From this, the device was found to be not in danger of failure and more than strong enough for normal operational use. A user acceptance survey was developed and administered to guitarists – mostly employees of music stores – validating of the advantages of the new design as well as presenting valuable comments concerning various aspects of the design. A number of business considerations were drawn from a business plan developed around the new device as a commercial product. Finally, accommodations and deficiencies of the product were addressed. Future work is presented as improvements to be made to the design. Options concerning other manufacturing methods more fit for mass production are evaluated.

1. Introduction

A capo raises the pitch of the open guitar strings by a desired interval, creating the effect of retuning the strings while avoiding the time required for a traditional retuning. The device works as a clamp, pressing down the strings as a guitarist would and thus activating the selected notes. The capo mechanically holds down the notes through a compressive force, allowing the guitarist to play other notes above those being held down by the device.

The guitar capo is a core accessory for many guitarists. It gives the player more versatility and freedom in his playing of and developing skills with chords, scales, and chord progressions while practicing and performing guitar. It works by pressing certain notes when applied, effectively changing the open tuning of the guitar.

The objective of this research is to fully develop a novel chord-forming capo design through prototyping and other design considerations. The scope of this paper is

limited to basic, six string guitar (although capos are made for all types of guitars and guitar-like instruments).

2. State of the art

There are a variety of types of capos on the market today, each with its set of advantages. The three main capo categories are: basic, full bar (compressing all six strings in a linear fashion); partial (compressing fewer than six strings in a linear fashion); and advanced style capos (building on the basic idea but with the ability to form complex, rather than simply linear, chord forms by working across multiple frets).

The five types of basic, full bar capos (Jeff Owens, 2010) – strap-on, spring-clamp/trigger (Figure 1), Schubb, screw on/c-clamp, and roller – have considerable differentiations in design. Strap-on and trigger capos forgo pressure precision for quickness of setup time. Schubb and c-clamp capos are just the opposite, preferring more precise pressures (leading to more accurate music pitches) for the cost of longer setup times. The roller capo can roll up and down the neck while attached, allowing the guitarist to change its position easily even mid-song.

Figure 1: Basic (Spring Clamp) Capo

Partial capos shown in Figure 2 (Harvey Reid, 2014) use the form of spring-clamp, Schubb, or c-clamp capos, but press less than six strings, allowing for other chord-forms than just the one basic capos provide. A recent innovation is the articulated partial capo (by the brand names of “Third Hand” and “Spider” capos); these allow the user to turn the capo on and off each string separately from the others. This binary option permits 2^6(64) combinations across a given fret position.

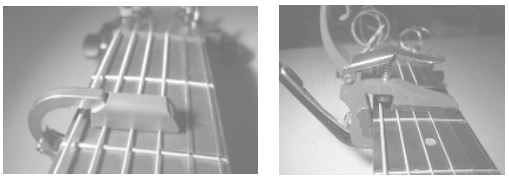


Figure 2: Basic Partial Capos

There are also a number of advanced style capo offerings. The “Transpo” Capo is the simplest: it is basically a single position (basic) capo, but in the shape of the most common guitar chord, it has no additional configurability. Another advanced option is using multiple articulated partial capos. Since each string can be turned on and off separately, multiple of these capos can be used to create complex chord shapes. A third advanced option is the Capo Clip: a chord forming device with separate permutations for each chord form. Each Capo Clip has the shape of a certain chord, using a trigger style basic capo for compression allows the guitarist to lock that chord in place for operation.

The final advanced style capo is the VOICE chord-forming capo (Figure 3). This is a large box with a relatively complex network of buttons, springs, shims, and pads covering the first four frets of the guitar. Pressing the buttons over the desired notes allows a guitarist to lock any desired chord into place.

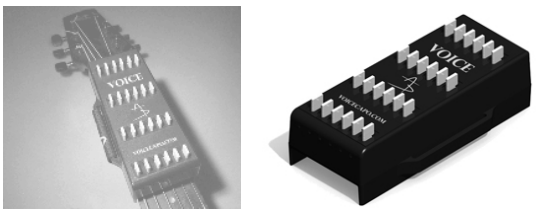


Figure 3: VOICE Capo

The current state of the art of guitar capos have a number of short-comings. All capos except for the Capo Clips and VOICE are very limited in chord-shape functionality. The most advanced VOICE requires excessive initial setup time and blocks the first four guitar frets entirely. Many customer review online for the VOICE claim it to be not secure when installed and that it doesn't work properly once set up (Customer Reviews: VOICE Capo, 2014). It was also the most expensive of all the single capos ($99), twice as much as the second most expensive "Transpo" capo.

3. Proposal of new design

These shortcomings add up to a glaring gap in the market. The intention of this endeavor is to create a fully configurable, low-complexity, low cost alternative to the capos currently available.

A few choices have to be made concerning the design: the compression mechanic and the chord-forming mechanic.

For compression, the strap-on mechanic was selected since its ease and simplicity of use allows for more concentrated focus of other design parts during prototyping and redesign.

The choice of chord-forming mechanic is more crucial because this is where the value and differentiation of the device is derived, it is where the innovation occurs and where most development difficulty would likely occur. After brainstorming and analyzing various original potential chord forming mechanics (Figure 4), the interchangeable member concept was selected. The grid concept was considered infeasible; the extendable-retractable concept was too complex to manufacture given the constraints of this project (time, size, and strength required), leaving the interchangeable member concept as most ideal.

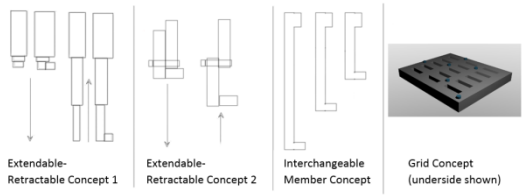


Figure 4: Chord Forming Mechanic Alternatives

The interchangeable members were originally designed for four sizes to accommodate various chord shapes.

User friendliness was to be attained through simplicity and straightforwardness in the design process: only essential parts in their bases form were to be included.

The design was also for manufacturability. Simple rectangular prismatic shapes were preferred wherever possible. This allows for ease of reproduction given any of a range of manufacturing methods. The main purpose of the prototype is to show the functional utility of the device, so utility superseded the aesthetic design of the device during the prototyping stage.

4. Prototyping fabrication

The authors selected to base the capo on the dimensions of a Fender acoustic guitar: this guitar was readily available; and acoustic guitars are generally wider than electric guitars, allowing for easier designing due to more useable space.

3D printing was deemed the optimal fabrication method, it allows for manufacturing directly from computer designs with high precision and strength. Any and all printed parts could be duplicated with ease, and changes or updates are as instant as updating the computer files. Blender 3D was the choice for 3D modeling because of its rapid, complex modeling capabilities and the inventor's familiarity with it.

Three prototype iterations were created, the final iteration is presented in Figure 5. The extension members (and optional spacers)

making up the accepted chord are ordered as desired and set in the base plate. A lock bark secures the members into place. The base plate is secured by Velcro around the neck of the guitar. The compression plate is secured in the same way, applying the appropriate pressure to make the chord sound as desired.

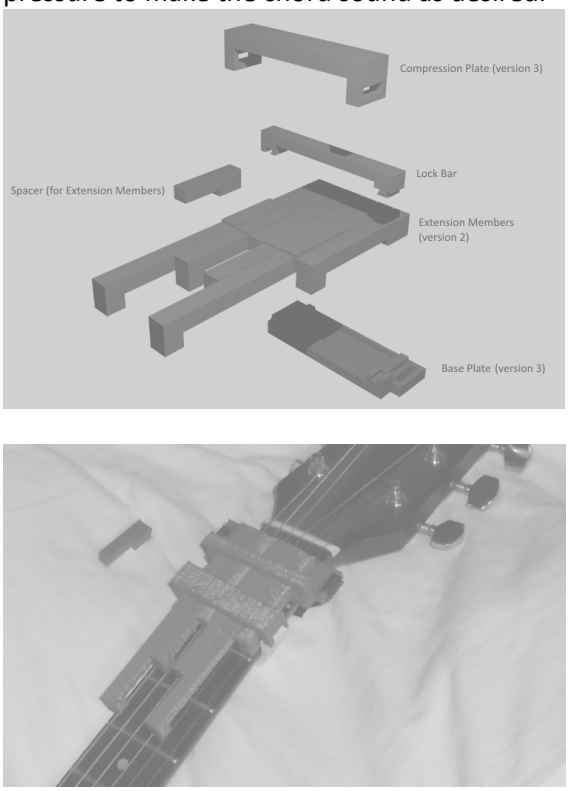


Figure 5: Prototype CG model and Photograph

Slim layers of materials added to the longer extension members where they contact the compression plate compensate for the bending of the plastic in order to appropriately distribute the pressure. The original four member sizes were changed to three in order to further reduce the pressure variation.

5. Testing and performance comparison

Having created the functional prototype, a number of considerations have yet to be addressed: the integrity of the material used when subject to force, market acceptance of the device, and the various business concerns in bringing the product to market. A series of tests were devised to answer to these concerns.

5.1. Extension member strength test

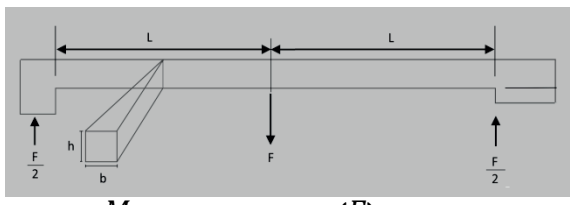
A simple setup using spring balance scales allowed for testing of the longest extension member: since longer members are more subject to deflection and failure, this member was treated as the critical case. A 20 lb scale was maxed out without failure and with minimal plastic deformation, considered still functional.

The force required to hold certain chords (Table1) were also found using spring scales. Since the force on each member is approximately one-sixth of the total chord force, the max functional force on a given member is roughly 2.583 lbs (9.5 lbs/6).

Table 1: Forces Required to Hold Chords

Chord	Force required to hold chord
All short members	5 lbs
All long members	7.5 lbs
Short-med-long-short-med-long	9.5 lbs

The strength test information was also applied toward calculating the bending stress of the member as shown in Figure 6 (Hibbeler, 2003).



$$\sigma_{max} = \frac{Mc}{I}, \quad where\ M = \left(\frac{F}{2}\right)L,$$
$$c = \left(\frac{h}{2}\right), and\ I = \frac{1}{12}bh^3$$

Figure 6: Normal Stress Critical Values

Only M varies with a change in force, the other variables are constant. Considering the upper limit of testing, the member has been found to withstand an σ_{max} of 4.725 ksi. The critical value of σ required for device operation (F = 1.583 lbs) is 0.374 ksi. This data implies a factor of safety $\left(\frac{total\ stress}{critical\ stress}\right)$ of 12.6. The stress is therefore well out of the failure range factor of safety of < 1, and the members under stress are well within range suitable for long term use. After confirming the material used can withstand the forces, the prototype was tested under normal operating conditions, verifying the mechanical utility and capability of the design.

5.2. User acceptance survey

A user acceptance survey was created in order to get a more accurate perspective of the end users' estimation of the prototype. Twelve guitarists were surveyed: most work in music stores, a few less experienced players were included in order to also get their impressions.

Along with details about the guitarists and their familiarity with capos in general, the survey directly compared the capo prototype with the VOICE capo (its most direct competition). There was also room for participant comments of any kind.

The two capos were compared on three main points by way of 1-to-10 Likert scales(Likert, n.d.): “How clear is it to you how to set up the capo?” (device set up clarity), How Clear is it how to set up different chord shapes?” (chord set up clarity), and “How simple is the design of the capo?” (design simplicity). The distributions for the prototype had much higher standard deviation than those for the voice, showing considerable variation in opinion among the participants. Comparing the sums of the Likert scales, the prototype is substantially better than the VOICE in device set up clarity, slightly better in chord set up clarity, and equivalent in device simplicity. Thus, the device is the statistically preferred of the two designs in these concerns.

The survey provided other valuable information as well. Nearly all those who used a capo used full bar (basic) capos, and of those only spring-clamp, c-clamp, and Schubb capos. Only a few had used partial (non-articulating) or advanced (Capo Clip) capos. Concerning how likely the participants were to use a chord-forming capo: while two-thirds of participants considered themselves ‘familiar’ with such capos, less than 20% were open to the possibility of using them. This shows just how much of a niche product these capos currently are. Many minor comments were also gained through the survey.

5.3. Business plan highlights

The business plan created for the device is a ‘test’ in that it is an evaluation of the product’s viability in the market; these business aspects would be crucial to the future success of the finished product if it were ever released in the market. The following summarized information was gained through the business plan development and is found in the plan.

The guitar is the second most popular instrument in the world, and outside of necessary parts and guitar picks, capos are the most popular guitar accessory available. Direct Selling (through the internet) with efficient marketing can grow the company with little initial cost, and later entry into music instrument supply stores can enhance the product’s positioning and get the product in front of the greater general public. Gaining celebrity endorsers would greatly raise awareness and engender legitimacy during the company’s critical first years. If the company assumes the form of an LLC (Limited Liability Corporation), the owner would be protected from lawsuits and the earned income from double taxation. Based on preliminary

numbers, the Ultimate Capo can be sold commercially for less than half of the price of the VOICE capo while still priced more than double the manufacturing cost. The uniqueness of the product aids in product differentiation and protects it from any immediate danger of commoditization. Based on pro forma financials, given sufficient initial investment the company is projected to become profitable by its third year of operation. The SWOT analysis in Table 2 (Dyson, 2004) considers strengths, weaknesses, opportunities, and threats of the business and can assist business strategy formulation while ensuring all four areas are considered. All of the items listed on the table are relevant and important for the business going forward.

Much more information was also presented in the plan regarding strategy, marketing, management and operations, and financials. The main takeaways gained from the development of the business plan are that the projected cost of production and the sales present the product as a viable one, and its uniqueness and niche sector can allow it a competitive presence in the market.

Table 2: SWOT analysis

Strengths	**Weaknesses**
- The product is highly functional while affordable - The product's capabilities are very rare in the current state-of-the-art - The product is to be much less expensive than the only direct competitor, the VOICE capo - The prototype is well-designed, with engineering considerations taken into account	- The product has yet to be developed into a final, designed form - Mass production planning is needed - The company starts off with very little capital - A new, single-product company starts with zero respect and zero reputation
Opportunities	**Threats**
- Build a brand synonymous with quality and value - The product's market sector is a largely untapped niche sector: there is much opportunity for sector dominance - The product can be resized for differently dimensioned guitars	- Other guitar accessory companies may attempt to break into this niche market sector - Current companies have large marketing budgets with which they can crush smaller competitors - Product could be thought of as a novelty and not taken serious by guitar

6. Results and Discussion

The proposed design has been proven functional and practical with respect to its design requirements. 3D printing allowed for rapid redesign and ease of production of complex parts directly from computer models. The forces acting on the capo members have been shown to be well within the acceptable limits: the ABS plastic tested is only subject to 7.912% of the force needed to noticeably deform a member and the factor of safety concerning bending stress is 12.6, well within the safe range.

The capo's functionality/working capacity has also been established directly by its use under normal operating conditions. Problems found early in the prototyping cycles were designed out in the successive prototypes. The redesign of the extension members (with added material to more appropriately distribute the chord pressure) resulted in a more effective prototype producing improved, more consistent sound quality, and other design changes created a better overall design.

It has also been shown, if only roughly, that the marketing and business aspects of the design support its potential to be a viable consumer product if released into the market. The survey administered captured the thoughts and concerns of a range of guitarists, the large majority of whom were guitar music store employees with an experienced perspective as well as familiarity with guitar consumer behavior. The survey resulted in the valuable insight that these capos are niche products, rarely used by serious guitarists. The prototype is considered better than the VOICE in device and chord set up clarity. Important business considerations were thoughtfully considered, resulting in the conclusion that this new product could fare well in the marketplace.

7. Conclusions and Recommendations

7.1. Conclusions

This project has been a definite success. All of the intended project goals were accomplished: the chord-forming capo idea was developed into a fully-functioning prototype. Design flaws were registered and designed out through successive prototyping iterations. The research and development resulted in a robust, well-designed device which fully performs its intended function.

The various, currently available guitar capos were evaluated both for strengths and weaknesses. Knowledge of the current market offerings gives the perspective needed to create and evaluate this novel capo design. The new device variation is of the chord-forming type: it has the functionality that only the most advanced capo (the VOICE) claims to have. The device's compression mechanic most closely resembles the strap-on mechanic; this more evenly distributes the compressive force than the trigger or Shubb types. Force distribution is key as high precision is needed for the device to work properly. For a device with so much functionality, the projected low price (half that of the direct competitor the VOICE) gives it another major advantage. The strategy of choosing the best choices for each design concern resulted in a truly innovative and competitive product offering.

The idea went through conception, ideation, and prototyping. It has become a fully functioning device, a great addition to the state of the art of guitar technology.

7.2. Recommendations

While much progress has been made through the design and prototyping stages, a number of non-idealities still exist. These problems can be attended to in future work to improve the device considerably.

The pressure distribution for the strings still requires fine tuning. The new extension member design with added material for pressure alignment was a single iteration process: further iterations would result in more precision and better pressure distribution.

Another way to improve the extension members concerns the part that touches the strings. Currently, a flat, square surface is in touch with the strings. There is neither any give nor anywhere for the capo to lock on to the strings. One possible way to improve the design could be to have a different material touching the strings. A softer plastic – like that is used in a hot glue gun – would give a little under pressure, helping to further distribute the pressure across the entire chord as well as gripping the strings better.

Different methods of production can be explored as well. 3D printing is very slow compared to certain other production methods; if the product is to be produced on a large scale, another method would be more effective. The prototype is designed for manufacturing (with all rectilinear shapes and minimal complexity), so traditional machining is one option. Traditional machining uses machines such as a lathe and mill to subtract material from stock metal shapes. The most popular traditional capo, the Kyser, uses aluminum coated with enamel; aluminum is a good choice because it is easily machined, light, and somewhat inexpensive. Using a CNC is another option. The Computer-Numerical-Controlled machine integrated traditional machining with the automation of a computer. It removes the need for many machinists and is consistent concerning output pace and quality control, but the machines can be very expensive. There are also other additive manufacturing options, including Selective-Laser-Sintering and Direct-Metal-Laser-Sintering, which use lasers to heat up and bind powder to create solid structures (Rain Noe, 2014). These technologies are still very new and improving, but may be considered as an alternative.

The prototype has to be transformed into a fully developed product. The current prototypes were designed for utility and proof of concept. Industrial design considerations have to be addressed: The product has to be consumer-friendly. The color scheme and design aesthetics of the device has to be addressed. Packaging and any included accessories (such as a bag for ease of carrying all of the pieces) have to be finalized. The manufacturing for all of these industrial design aspects has to be planned out as well.

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Implementing a Decentralized Budget Model in a University Department: An Applied Activity-Based Approach Using R

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Abstract

A Decentralized Budget Model (DBM) for budgeting and cost-revenue management allows its users to be more efficient in decision making, planning, and overall business activities. There are also needs for efficient strategic planning and risk management systems to assure stability and effectiveness of a university department. Implementing an activity-based approach using R, a free software environment for statistical computing and graphics, provides an opportunity for analysis in a hardly predictable environment. This software application allows uncertainty distributions to be assigned to the numbers used in the calculations, representing the inherent uncertainty in the model. The effect of uncertainty on cost, net revenue, and model behavior are investigated in this study.

1. Introduction

During the past decade the structure of revenue streams has changed due to decreasing trends in state support appropriation funds for universities in the United States. Efficient economic analysis for decision-making and strategic planning of university business activities becomes especially important due to increased competition in educational services.

There are over 4,500 institutions of higher education in the United States (U.S.). According to statistical analysis of data and projections made in analytical reports over the past 35 years, there is evidence supporting upward trends for the number of higher education institutions, number of programs, and total full time enrollment (U.S. Census Bureau, 2010). Meanwhile, the amount of federal and state support funds has declined during this period (U.S. Department of Education, 2013). In response, universities began to investigate new methods to manage their costs and revenues as a way to stay cost effective. Budget planning and fund allocation models can stimulate competitiveness within and between university programs. In an analogy with manufacturing enterprises, new products (programs and courses) can be developed and added, but at the same time all products should be evaluated in terms of competitiveness, usefulness, and marketability (Orr, Jaeger, & Schwarzenberger, 2007; Tatikonda & Tatikonda, 2001). Integration of information from different activity levels is very important for strategic risk management and decision making at the departmental level and for a university overall.

The purpose of this applied research is to support administrators with the implementation of the new Decentralized Budget Model (DBM), which includes risk analysis, and provide more options for DBM implementation at the departmental level.

2. Problem statement

The problem statement for this research is to develop an approach to risk analysis to

support decision-making at a strategic level for implementation of a decentralized budget model in a university department.

3. Background

Many U.S. public universities are adopting new costing and budgeting models for better quality and productivity of operations (Balderston, 1974; Krishnan, 2006; Capaldi & Abbey, 2011). Over 40 universities in the United States have implemented or are implementing decentralized budgeting or activity-based budgeting (Portland State University, 2012). The average time for the development and implementation of these systems is three years.

3.1. Activity-based approach for decentralized budgeting

An activity-based approach is the most common technique for implementation in the service sector, particularly in higher education institutions. (Roztocki, 2001; Krishnan, 2006; Cugini, Carù, & Zerbini, 2007; Chandra & Pattanayak, 2010; Tatikonda & Tatikonda, 2001). The first important step is to shift overall cost analysis to particular activity levels: core services, facilitating services, and supporting services levels (Maguire & Rouse, 2004). Vonasek (2011) described responsibility center activities for overhead cost allocation. Levy (2008) provided typical cost classifications for universities and showed cost functions by college with classifications for instruction, research, service, and other functions. Tatikonda and Tatikonda (2001) described major cost categories within activity-based costing methodology for higher education institutions.

Many researchers considered revenue management together with cost management in higher education institutions and highlighted the importance of an integrated approach to cost-revenue management and budgeting at universities for decision-making and strategic planning purposes (Firmin, Goodman, Hendricks, & Linn, 1968; Maguire & Rouse, 2004; Cheslock, 2006; Szatmary, 2011). Revenue analysis in public universities is focused on the determination of the contribution of different activities into net revenue of nonprofit universities and for justification of continued state appropriations. Revenue-cost analysis also identifies profit-generating units within the institution and helps to support mission-centered activities even if they result in negative net revenue when offset by state appropriation allocations (Cheslock, 2006).

A schematic representation of the decentralized budget model is illustrated in Figure 1.

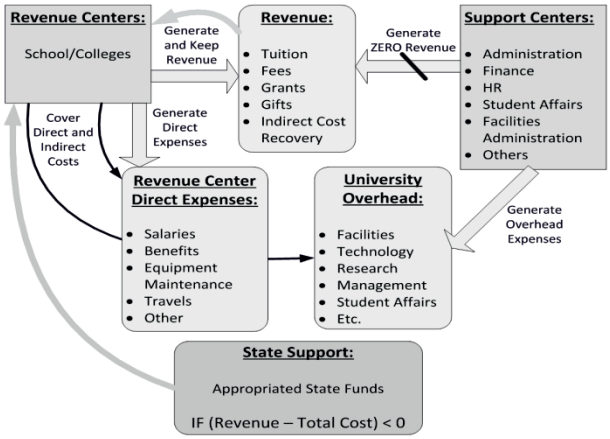

Figure 1. Decentralized Budget Model

This model is built on principles of activity-based budgeting and integrated revenue-cost management. It shows financial flow within the system, sources of revenue, elements of direct and overhead cost, and conditions for allocating appropriated state funds. Key components of this framework include risk analysis and strategic management for core units of a university to stay financially efficient and competitive in the higher education services market.

3.2. Risk analysis

In the proposed framework, risk is accounted for as one of the factors of decision making on the strategic level. Risk analysis was

a subject of some studies reviewed here. For instance, Alarcon, Ashley, Sucre de Hanily, Molenaar, and Ungo (2011) described an approach to identification of potential risks and a model which allows managers to narrow down this list to primary risks for the particular project. The authors performed a Monte Carlo simulation for risk analysis using @ Risk software which was utilized for the purposes of this study as well. Martin (2012) considered principles of risk management and the interrelationships of risk and quality. These principles include understanding of current conditions and uncertainty, determination of risk appetite and demand transparency, correct balancing of them, and shared responsibility for made decisions.

Mattie (2007) examined a higher-education-specific Enterprise Risk Management (ERM) framework. One part of this framework includes analysis of the internal environment, organizational goals and risk appetite, as well as identification of activities with a high impact on achieving these goals. Rindfleish (2003), in her study on strategic risk reducing methodology for higher education, demonstrated a segment profiling marketing technique. This is a low-cost risk management technique which allows the user to identify a potential customer profile for strategic revenue generation and program offering planning based on market analysis results. Kerr and Hosie (2013) proposed that a university's risk mitigation approach is generally based on best practices from other sectors, such as finance, property management, tourism, fast food, and government. Risk avoidance using cross-sector benchmarking could be a good cost-saving risk management strategy in fast changing market environments.

To support decision-making at a strategic level of decentralized budgeting for a university department, a simulation model of risk analysis utilizing the activity-based budgeting framework was developed for this study. Two options for implementation were proposed and tested.

4. Simulation model structure

An Excel-based simulation model was created using activity-based approach principles and the guidelines of the decentralized budget model determined by university administration. The simulation model is a set of interconnected tables and worksheets with an assigned algorithm of calculations based on input data.

The objective function of the analysis is net revenue of department activities. Costs and revenue represent dependent variables; independent variables are cost and revenue drivers.

The optimal value of the objective function is the maximum value that falls within the constraints defined for the department's integrated cost-revenue management system.

4.1. @Risk based simulation model

A risk analysis module was incorporated into the Microsoft Excel simulation model developed on the basis of the DBM framework. This module is implemented using the Excel add-in @Risk. The output of the risk analysis is a probability of positive net revenue for a university department.

The @Risk software performs risk analysis based on a probability distribution of uncertain input. In this case, uncertain input is student enrollment, percentage increase for tuition, fees, and costs for the next five years. The software runs 1000 iterations using random numbers for the input within assigned parameters, and computes a probability of net revenue for the following five years.

Statistical data from the output shows a prediction of minimum, maximum, and mean values of net revenue for current year and for the next five years.

4.2. R-based simulation model

An R program was written to emulate the simulations performed in @Risk. The following algorithm was implemented:

1. Estimate projected growth in tuition, fees, and cost using normal distributions.
2. For each replicate, indexed $r = 1,\ldots,1000$:
   a. Estimate enrollment using the triangle distribution;
   b. Calculate the total number of credit hours;
   c. For current year and next five years:
      i. Calculate revenue from tuition and fees;
      ii. Calculate net revenue;
3. Compute summary statistics, percentiles, and histograms.

The decision to use R was based upon its availability as an open-source software environment for data analysis, statistical computing, and graphics (R Core Team, 2015).

An application of the risk analysis simulation model in a real-time university department budget cycle using both @Risk and R software is demonstrated in the "Case study" section.

5. Case study

A case study was performed at a public land-grant university which has been transitioning to a Decentralized Budgeting Model (DBM) since May 2012. The anticipated implementation is expected to be complete for fiscal year (FY) 2015. The DBM was in its testing phase during FY 2014. The university administration defined budget and finance policy and determined a proportion of cost and revenue allocation among all units. There are six core units (colleges) and thirteen support centers at the university. This case study represents data analysis for one academic unit: a department, which is one of five departments within a College of Engineering (core unit).

The department has four undergraduate programs, one non-degree service program, and one graduate program. There are thirteen faculty members and four staff personnel in the department. Approximately 350 students are enrolled in the department's programs.

Risk analysis for strategic planning was performed using both @Risk and R simulations for the department for FY15 and each of the next five years. The results of @Risk simulation are presented in Figure 2. There is a 90% probability of net revenue in the interval from $844,338 to $1,132,988 for the analyzed year and positive net revenue for the next five years.

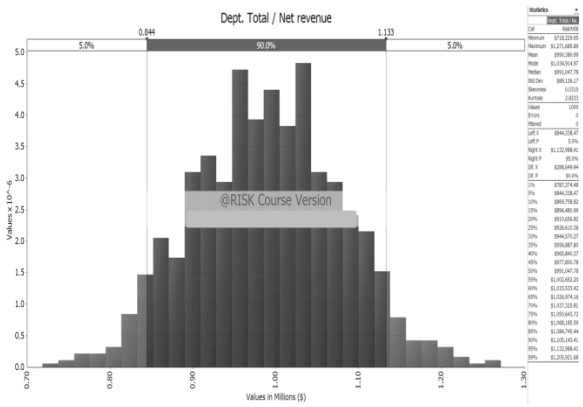

Figure 2. @Risk Output

The results of simulations performed using R are presented in Figure 3. There is a 90% probability of net revenue in the interval from $849,449 to $1,127,983 for the analyzed year and positive net revenue for the next five years.

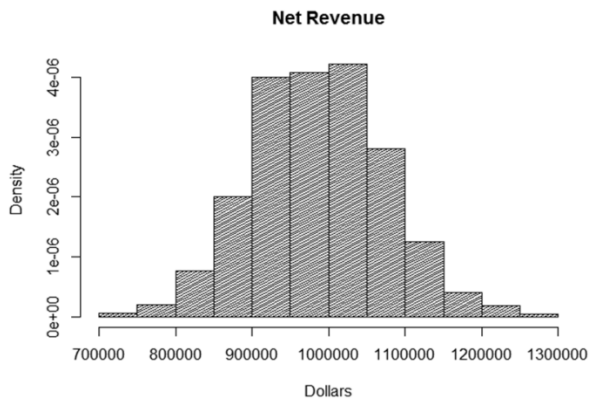

Figure 3. Using R Output

Summary statistics for both methods are presented in Table 1.

Table 1. Summary Statistics

	n	Sample Mean	Sample Std. Dev.
@Risk	1000	990,381	89,136
R	1000	987,600	86,566

A two-sample t test was used to test the following hypotheses:

$$H_0: \mu_{@Risk} = \mu_{Using\ R}$$
$$H_a: \mu_{@Risk} \neq \mu_{Using\ R}$$

We fail to reject the null hypothesis and conclude that the population means are the same (P-value=0.24). An F test was used to test the following hypotheses:

$$H_0: \sigma^2_{@Risk} = \sigma^2_{Using\ R}$$
$$H_a: \sigma^2_{@Risk} \neq \sigma^2_{Using\ R}$$

We fail to reject the null hypothesis and conclude that the population variances are the same (P-value=0.18). Thus, these population parameters are the same for both simulation methods.

6. Results

A quantile-quantile (Q-Q) plot (NIST, 2015) is a graphical technique to compare two distributions. We use this technique to plot the quantiles of the @Risk data against the quantiles of the data Using R for distributions of current year net revenue. If the two data sets come from the same distribution, the points should fall approximately along a 45-degree reference line. The power of the Q-Q plot in examining distributional shape stems primarily from the eye's ability to detect deviations from linearity (Easton & McCulloch, 1990). In addition, several common kinds of differences between distributions such as skewness or heavy tails show up in easily identifiable ways. As Figure 4 shows, the points tend to follow a straight line so the distributions are equivalent.

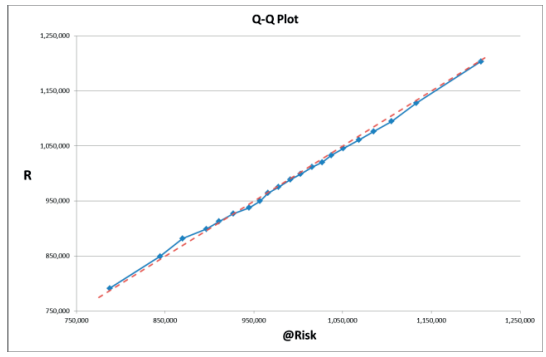

Figure 4. Comparison of Two Sampling Distributions

Next, we investigated the null hypothesis that the data generated by each simulation method are from normal distributions. A quantile-quantile plot is used to plot sample quantiles against quantiles of the Standard Normal distribution. As Figure 5 shows, the points for each method tend to follow a straight line so the data are from Normal distributions. Sample quantiles from @Risk are plotted using triangles and those from using R are circles.

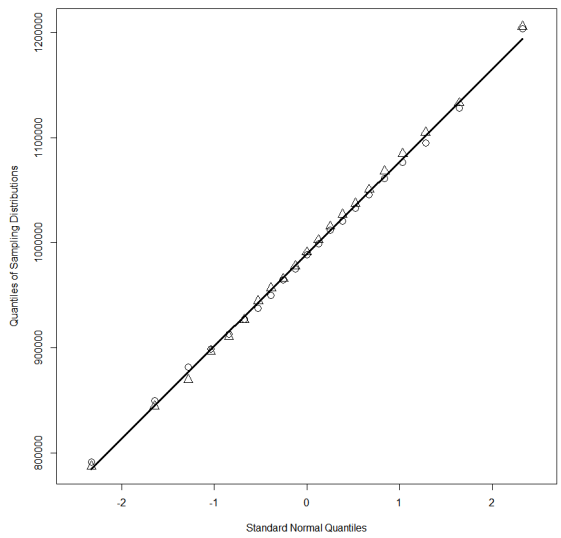

Figure 5. Comparison of Sampling Distributions with Normal Distribution

Thus, we conclude that the data from both simulation methods are from the same Normal distribution. This led us to an investigation of the differences between the respective

quantiles for the two simulation methods to determine if anything unusual was happening in any part of the distributions.

Since a formal statistical procedure to compare several quantiles simultaneously is not readily available, a Monte Carlo procedure (Rizzo, 2008) was used to develop the distribution of differences for all quantiles reported by both software programs. These quantiles are reported in Table 2, where Q represents quantile.

Table 2. Quantiles of @Risk and R for Current Year Net Revenue Distributions

Q	**0.01**	**0.05**	**0.10**	**0.15**
@Risk	787,374	844,338	869,759	896,481
R	791,245	849,449	881,817	899,066
Q	**0.20**	**0.25**	**0.30**	**0.35**
@Risk	910,657	926,610	944,570	956,888
R	912,955	926,886	937,607	949,823
Q	**0.40**	**0.45**	**0.50**	**0.55**
@Risk	965,840	977,801	991,048	1,002,652
R	964,640	975,251	988,684	998,924
Q	**0.60**	**0.65**	**0.70**	**0.75**
@Risk	1,015,533	1,026,974	1,037,326	1,050,644
R	1,011,693	1,020,347	1,033,061	1,045,479
Q	**0.80**	**0.85**	**0.90**	**0.95**
@Risk	1,068,186	1,084,745	1,105,143	1,132,988
R	1,060,920	1,076,387	1,094,893	1,127,983
Q	**0.99**			
@Risk	1,205,922			
R	1,203,732			

An R program was written for the Monte Carlo study based on the following algorithm:

1. Estimate parameters for common normal distribution as the overall mean and pooled standard deviation from Table 1:

$$\hat{\mu} = \frac{(990{,}381 + 987{,}600)}{2} = 988{,}990.5$$

$$\hat{\sigma}_p = \sqrt{\frac{(89{,}136^2 + 86{,}566^2)}{2}} = 87{,}860.4$$

2. For each replicate, indexed $r = 1,\ldots,1000$:
   a. Obtain two independent samples of 1000 observations each from a $Normal(\hat{\mu},\hat{\sigma}_p^2)$ distribution,
   b. Compute quantiles and calculate differences for each quantile listed in Table 2,
3. Extract 0.025 and 0.975 quantiles for each distribution of quantile differences as 95% confidence intervals and prepare graphical summaries.

Figure 6 shows that the observed difference between the 0.01 quantiles is near the center of the distribution of differences for this quantile.

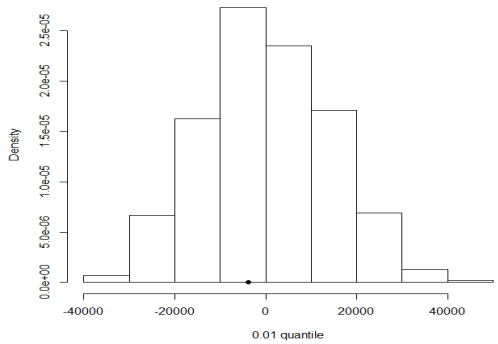

Figure 6. Comparison of Observed 0.01 Quantile Difference (solid dot) and Distribution of Simulated Differences

Figure 7 gives all observed quantile differences and 95% empirical confidence limits for each quantile. All of the observed differences for the respective quantiles fall within these limits.

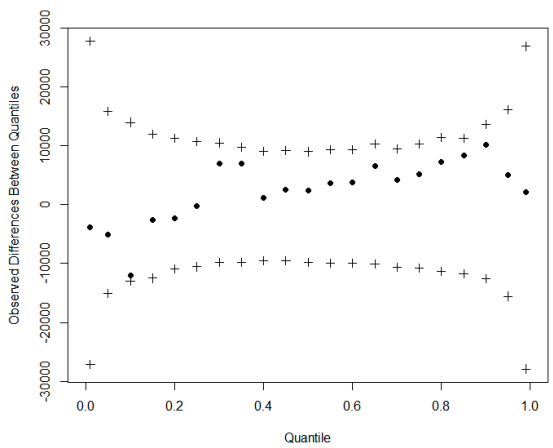

Figure 7. Comparison of Observed Quantiles (solid dots) and Simulated 95% Confidence Limits

All statistical tests confirm that there is no difference between the @Risk output and output using R. Thus, we conclude both models are valid and can be used for risk analysis at the departmental level of a university.

7. Conclusion

Risk analysis option in the developed model allows administrators estimate net revenue earned by the department in a long-term perspective. Three major scenarios are considered for risk analysis: best case, most likely, and worst case. Based on a probability distribution for each scenario and on the probability of tuition, fees, and cost growth rates, the probability of receiving positive net revenue is calculated for each time range.

Based on the analyses results, a department head becomes informed about potential problems and can take appropriate actions to increase revenue (e.g., more advertising of the program, offering additional courses in Spring or Fall semester, etc.), or decreasing cost (e.g., elimination of unused space and equipment) in an operational and strategic perspective.

Specific conclusions from the case study reveal that the time spent by the department head for budget preparation decreased by 30%; productivity of the department head for the budget analysis process increased by 95%; using R provided an additional option for implementation; and the current model based on Excel with the @Risk add-in has been validated.

8. Limitations and future research

In Section 4 the simulation model is described as a set of interconnected tables and worksheets with an assigned algorithm of calculations based on input data. A limitation of migrating this type of model to R is that it is not easy to import multiple tables from a single Excel worksheet into R and maintain their interconnected relationship.

Future research will incorporate multiple variables and their interactions into Net Revenue calculations, simplify migration of information from Excel worksheets into R, and develop enhanced graphics and tabular output using R.

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Decision Support Model for Managing the Security Risk in the Global Container Supply Chain: A Case Study

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Abstract

The increase outsourcing of manufacturing to lower cost economies has brought enormous economic benefits to billions of people. This process of globalization has increased container shipments among countries. However, the rapid growth in container flows has created more pressure on the transportation network and, increasingly, escalating security risks for the global container supply chain (GCSC) security. This research contributes significantly to the study of an important aspect of the supply chain cargo container shipment security and, hence, increases its visibility. We proposed a decision support model to examine sensitivity analysis of the most risks that adversely affect global container supply chain security. Results from this study can be used by supply chain managers to enhance the security and resilience of their supply chains in an uncertain world.

I. Introduction

The increase outsourcing of manufacturing to lower cost economies has brought enormous economic benefits to billions of people. This process of globalization has increased container shipments among countries. However, the rapid growth in container flows has created more pressure on the transportation network and, increasingly, escalating security risks for the global container supply chain (GCSC) security. Today the maritime transportation system has become the centerpiece of the global supply chain and accounts for the movement of more than 90% of global commerce (International Maritime Organization, 2008).

Increasingly, the international container supply chain has been characterized by turbulence and uncertainty. Essentially, the GCSC networks seem to be more vulnerable to disruption than was the case in the past. As the containerized cargo system has become so efficient and inexpensive, it was adopted as the primary means of global transport port and considered to be the key component in intermodal transportation. These cargo containers are subject to

numerous transfers within the transport chain, which makes them vulnerable to being subverted from their legitimate commercial purposes (Kumar and Verruso, 2008).

This research contributes significantly to the study of an important aspect of the supply chain cargo container shipment security and, hence, increases its visibility. We proposed a decision support model to examine sensitivity analysis of the most risks that adversely affect global container supply chain security. Results from this study can be used by supply chain managers to enhance the security and resilience of their supply chains in an uncertain world.

The purpose of this paper is to add to the current body of literature on supply chain security through risk management of the GCSC. We structured the remainder of the paper in the following sections, beginning with a brief review of the relevant literature on the sources of risks in the GCSC. We present the research methodology and data collection in the third section. The empirical results are in section four. Conclusions and managerial implications are in the final section.

II. Literature Review

2.1 Supply Chain Risks in an Uncertain Global Supply Chain Environment

The complex nature of GCSC networks are more vulnerable and susceptible to higher risks because of greater uncertainties in supply and demand, globalization of the market, shorter product and technology life cycles, lean practices, supplier base reduction, and the increased use of manufacturing, distribution and logistics partnerships (Christopher, 2002).

According to the Organization of Economic Cooperation and Development (2003) a typical door-to-door journey delivery using a shipping container will involve the interaction of approximately 25 different actors, generate 30- 40 documents, use 2-3 different modes and be handled at as many as 12-15 physical locations. This complex operation is illustrated by Fig .1 which shows a high-level interaction between various stakeholders in the end-to-end Interaction Between Stakeholders in the Global Container Supply Chain (Willis and Ortiz, 2004).

A good number of these stakeholders are legitimate businesses that can help improve the efficiency of the supply chain performance. Arguably, however, the increase in the number of members of the GCSC tends to impose additional layers that diminish visibility and escalate security risks. According to the European Conference of Ministers of Transport (2005), terrorist groups can use containers in “legitimate” or illegal trade to generate revenue in support of their activities. They can also use shipping containers to launder illegitimate funds (much as drug smugglers have done) and/or provide logistical support for their operations. Indeed, up until now, this has been the only way that containers have been used by terrorists. The European Conference of Ministers of Transport (2005) posits that a container could be used as a weapon to attack a port or any other facility along a transport chain after unloading from a ship or even while still on the ship before inspection. Many ports are located in major population and industrial centers and contain significant quantities of oil and other vital commodities. Such attacks could be conducted using WMD or large quantities of conventional explosives. Attacks could also be launched on a vulnerable target from a container on a truck, train, or barge.

In the GCSC, it can be argued that a compromise at any link can affect the entire

chain. The fact that no single member of the container supply chain has the full responsibility for security from the beginning to the end creates significant challenges for safeguarding the global trade. Hence, designing a well-developed approach to assist in identifying potential risks and establish the interrelationships between risks in the GCSC has become has become a need for companies nowadays.

III. Research Methodology

A decision support model such as the analytic hierarchy process (AHP) model developed by Saaty (1980) is proposed for this paper to quantify risks in the GCSC and perform the sensitivity analysis (SA). AHP is selected because it permits the decision-makers in the GCSC to use data, experience, insight, and intuition in a more logical and thorough manner and, therefore, enhances the process of making effective decisions regarding the security of their supply chain. AHP is known for its qualitative and quantitative characteristics.

3.1. Description of Major Objectives, Sub-Objectives, and Alternative Options

Our proposed AHP model is composed of three levels. 1) The overall goal of managing the security risk in the GCSC is represented in the first level. 2) The major decision criteria or objectives occupy the second level of the hierarchy. We have used the Cause and Effect Diagram proposed by Kumar et al. (2008) to identify the major potential failure points in the GCSC as shown in Figure 2. 3) The alternative options occupy the lowest or third level of the hierarchy of selecting the best strategy to manage the security risk in the GCSC. The alternative options proposed to manage the security risk in the GCSC are:

Customs-Trade Partnership against Terrorism: C-TPAT or the so called customs-to-business relationship (CBR) is a voluntary and cooperative program between the U.S. government and the international trade community in which all the entire supply chain actors, ranging from importers, brokers and warehouse operators to overseas manufacturers and suppliers, agree to preserve the security of their global supply chain logistics (GSCL) in exchange for reduced inspection of their containers or reduced import inspection. Indeed, it requires organizations to assess and handle vulnerabilities in their GSCL. Essentially, GSCL partners are required to develop and implement policies that can improve and enhance security within their operations as well as with their partners.

Authorized Economic Operators (AEO): The European Union's AEO is comparable to the U.S. C-TPAT program. The intent of the AEO measure is to protect the safety and security of containers for the European market. The AEO is the so-called pushing back the borders to the point of origin. The intent is to identify cargo containers that may pose great risk and then determine whether containers comply with the guidelines and standards of the World Customs Organization (WCO) relating to container security. Container Security

These two value chain protocols are important because of 1) the increasingly global economy depends on the free flow of materials/products, information, and finance, 2) organizations around the world rely on efficient and uninterrupted GSCL operations, and 3) increased terrorist threats can have significant implications for homeland and global security (Closs and Mcgarrell, 2004).

3.2. Sensitivity Analysis

SA represents one of the methods used in risk management evaluation when values of the coefficients are subject to variation (Rappaport, 1967). The AHP can support SA of the various criteria, thus allowing decision makers to investigate the effects of making different assumptions about the relative importance of different criteria (Dunlop et al., 2004). Erkut and Tarimcilar (1991) assert that SA can be a relevant tool in eliminating alternatives, enhancing a group decision process and/or in providing actionable information as to the robustness of a decision. SA of the GCSC risk can be used as a valuable tool to assist supply chain managers in enhancing the security and resilience of their supply chains in an uncertain world.

In this study, a Sensitivity Analysis (SA) approach was used as a powerful tool to study the impact of the variability of decision criteria (i.e., factors contributing to the failure of the GCSC) on the optimal decision (i.e., C-TPAT and AEO). The SA was carried out using the Expert Choice Software to see how sensitive the alternative options are to changes in the importance of the decision criteria. The SA can be performed by varying the priorities of the decision criteria to observe the effect on the priorities of the alternatives. Expert Choice Software can provide sensitivity graphs showing the information in different formats namely; dynamic, gradient, head to head and two-dimensional (2d Plot). For this decision model the SA was performed using the performance and gradient sensitivity.

3.3.3. Data Source and Description

The focal firm for this paper is the world largest retailer and grocery chain. It has more than 6,000 stores worldwide. It has a workforce of more than 1,500,000 people and annual revenues of more than $300 billion. The firm offers a range of general merchandise including groceries, clothing, 14 sporting goods, toys, small appliances, automotive supplies, and consumer electronics. We used a case study methodology to perform an in-depth analysis of the GLCS security risk sources in the focal firm. Becker (1970) posits that case study refers to a detailed analysis of an individual case supposing that “one can properly acquire knowledge of the phenomenon from intensive exploration of a single case”. Bonoma (1985) contends that “case studies prove valuable as it can often provide in-depth contextual information where existing knowledge is limited, which may result in a superior level of understanding.” From the hierarchy structure of the GCSC security risk model, a questionnaire was developed to enable pairwise comparisons between all the decision criteria at each level in the hierarchy. A survey questionnaire technique approach was used for gathering relational data to assess the order of importance of the GCSC security risks. The result of the survey questionnaire technique was used as input for the AHP. The questionnaire has 21 questions bifurcated into three sections, including questions regarding preferences of measurement risk, environment risk, personnel risk, material risk, method risk, and machine risk. In each question, the experts were elicited to compare each criterion with other criteria with respect to the major goal. Section 2 consisted of questions designed to elicit preferences for security risk mitigation strategy alternatives with respect to each criterion of the six major criteria. Essentially, survey questionnaires were mailed to ten (10) supply chain experts within the

multinational firm, including Vice President for Compliance & Enterprise Risk Management & Chief Compliance Officer, Director for Global Manufacturing and Supply, Vice President for Supply Chain and Contract Manufacturing, Global Supply Chain Project Manager, Director of Global Supply Chain Security, among others. Of the 10 questionnaires mailed to the above experts, seven were returned. Such a response rate was considered satisfactory to carry out the analysis (Duke and Aull-Hydeb, 2002) Consistent with AHP methodology, the opinions or judgments of the seven experts were adequate to carry out the analysis.

IV. Empirical Results and Discussions

Table 1 shows the priorities of major risk criteria with respect to the goal. For the major risk criteria, personnel risk is the most important, followed by environment and material risks. The consistency ratio (CR) of 0.09 is less than 0.10 recommended by Saaty's (1980). Based on Saaty's (1980) recommendation that a CR equals or less than 0.10 is acceptable, the foregoing pairwise comparisons to derive criterion weights are therefore consistent. As shown in table 1, C-TPAT turns out to be the most preferable risk management strategy option among the two alternatives, with an overall priority score of 0.6402.

4.1.1 Performance Sensitivity

The performance sensitivity shows the relative importance of each of the six decision criteria (measurement, environment, personnel, material, method, and machine) as bars, and the relative priority for each alternative option (C-TPAT and AEO) with respect to each decision criterion as shown in Fig.3. It shows the performance of each option with respect to the goal for criteria below the goal.

The performance graph is also dynamic, so we can temporarily alter the relationship between the alternatives and their decision criteria by dragging the objective bars up and down. The lines connecting the alternatives from one decision criterion to another have no meaning; they are included to help us find where a particular alternative lies as we move from one decision criterion to another (Expert Choice, 2009).

The "left y-axis" can be used to read each decision criterion's priority, whereas the "right y-axis" is used to read the alternative priorities with respect to each decision criterion. The overall alternative preferences are shown at the right. As an example, C-TPAT has the highest relative importance for the "personnel" decision criterion, while the height of the "personnel" vertical bar indicates an approximate relative importance (priority) of 0.3189. The importance of the personnel risk can be easily seen in this graph. While most of the decision criteria have a criteria ranking of approximately 7-19%, the "personnel" decision criterion has a criteria ranking of approximately 31.89%. It should be noted that, as with all AHP priorities, these priorities are ratio scale priorities meaning that not only do the priorities show order, but differences and ratios are meaningful as well. For example, from the graph, it can be seen that the "personnel" risk is roughly two times more important than the "measurement" risk.

Using this sensitivity chart, experts in the GCSC can view the effect of changing the degree of importance of the decision criteria and impact on the priorities of the alternatives. As an example, Fig.4 shows the same graph as Fig.2, except the relative importance of "environment" and "machine"

has been increased. In this scenario, C-TPAT comes out as the preferred alternative over AEO.

4.1.2 Gradient Sensitivity

Fig.5 shows a gradient SA of the results with respect to the importance of the "personnel" decision criterion. The vertical dashed line portrays the priority of the personnel decision criterion and is read from the X-Axis intersection. The priorities for the alternatives are read from the Y-Axis; it is determined by the intersection of the alternative's line with the decision criterion's (vertical) priority dashed line. The graph shows that the current priority for "personnel" is less than 0.32 (32%). The height of the intersection of the vertical dashed line (decision criterion line) with the alternative lines shows the alternatives' priorities. Therefore, C-TPAT is the preferred alternative followed by AEO. If "personnel" decision criterion were to become more important, then the overall preference for increases while that of the AEO decreases. The overall priority of the C-TPAT in this scenario is increasing.

Similar processes can be performed for the rest of the major decision criteria (material, environment, method, machine, and measurement risk). However, if the priority of the "material" were to increase from 18.34% to 70%, then the AEO would be the preferred alternative. (see Fig.6). Since it would take a significant change in the priority of "material" in order to change the ranking of the alternatives, we can say that the results are not very sensitive to small changes in the priority of "material" risk.

With respect to environment in Fig.7, the initial ranking is same as in fig.5. That is, 1) C-TPAT and 2) AEO. Increasing the priority of environment risk in Fig. 7 from 19.53% to 70%, did not change the initial ranking, though it increases the gap between both initiatives. Thus, suggesting that it is stable or robust. Similarly, increasing the priority of method risk in Fig.8 from 7.67% to 70% did not change the initial ranking of risk management alternatives. This means that the method risk is insensitive or robust. Increasing the priority of machine risk in fig.9 and measurement in Fig.10 from 7.93% to 70% and from 14.65% to 70%, respectively, did not change the choice of the alternative with respect to the machine and measurement risks. Therefore, based on the entire gradient sensitivity analyses, the overall priority of alternative is robust or stable to changes in the importance of all the criteria.

V. Conclusions and Managerial Implications

This study evaluates an actual retailer and grocery chain to select the appropriate GCSC risk management strategy options. Accomplishing this goal required developing an extension of an existing multi-criteria decision making model such as AHP. A SA was carried out using the Expert Choice Software to see how sensitive the alternatives options are to changes in the importance of the decision criteria. The initial performance and gradient sensitivity result suggest that C-TPAT is the preferred alternative followed by Smart Containers and AEO, respectively. If "personnel" decision criterion were to become more important, then the overall preference for AEO decreases. The overall priority of the C-TPAT in this scenario is increasing. The findings of this paper explain the increase of voluntary and cooperative program between the government and the international trade community in which the entire supply chain actors agree to preserve the security of their GCSC in exchange for reduced inspection of their containers or reduced import

inspection. Essentially, GCSC partners are required to develop and implement policies that can improve and enhance security within their operations as well as with their partners.

By assessing the security risk in the GCSC through the use of AHP model and SA, this study can be seen as a valuable tool to build on for assisting supply chain managers to enhance the security and resilience of their supply chains in an uncertain world. Increasingly, C-TPAT and AEO measures focus more on improving the security of ports and shipping by controlling container traffic through advance information, pre-inspection for loading of selected containers and improved transparency along the supply chain. However, some developing countries will be affected by the security measures of these initiatives as they will not comply with the new rules. According to the National Board of Trade (2008) many developing countries already have a difficult trade situation. Difficult terrain, shortcomings in infrastructure and considerable distances from trade partners are serious trade barriers for many developing countries and therefore transport costs constitute a larger proportion of the value of goods in these countries compared to richer countries. One central issue is how the economies of developing countries are affected, and whether these countries are particularly negatively affected by stricter security requirements.

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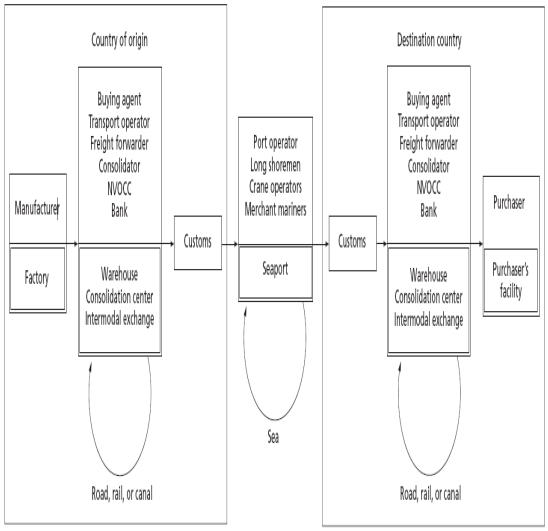
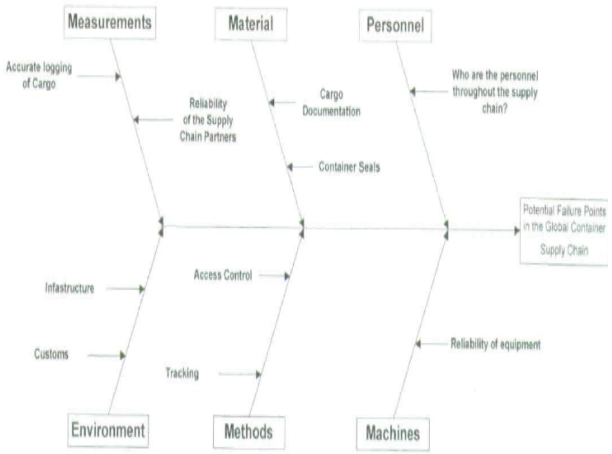


Source: Willis and Ortiz (2004)

Figure1.InteractionBetween Stakeholders in the Global Container Supply Chain



Source: Kumar et al. (2008)

Figure 2. Cause-and-Effect Diagram for Supply Chain Security Risks

Table 1. Global Container Supply Chain Risk Priorities

Criteria	Level 2 Priorities	Decision Criteria	Level 3 Priorities
1. Personnel	0.3189	C-TPAT	0.75
		AEO	0.25
2. Environment	0.1953	C-TPAT	0.75
		AEO	0.25
3. Material	0.1834	C-TPAT	0.25
		AEO	0.75
4. Measurement	0.1465	C-TPAT	0.6667
		AEO	0.3333
5. Machine	0.0793	C-TPAT	0.6667
		AEO	0.3333
6. Method	0.0767	C-TPAT	0.75
		AEO	0.25
Ideal Synthesis with Respect to the Goal		C-TPAT	0.6402
		AEO	0.3598
Overall Consistency=0.09			

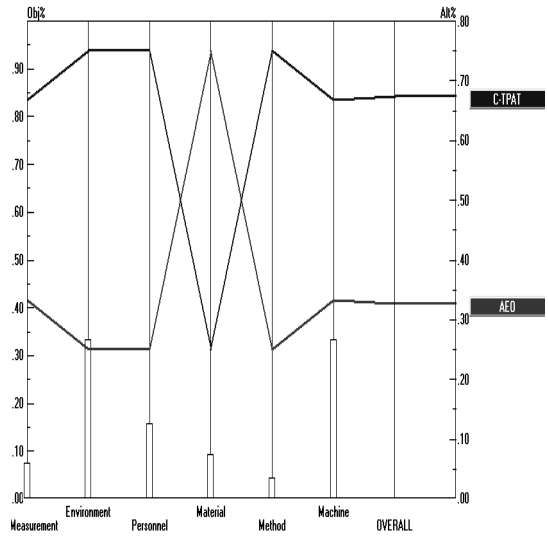


Figure 4. Performance Sensitivity Analysis with the Relative Importance of "Environment" and "Machine"

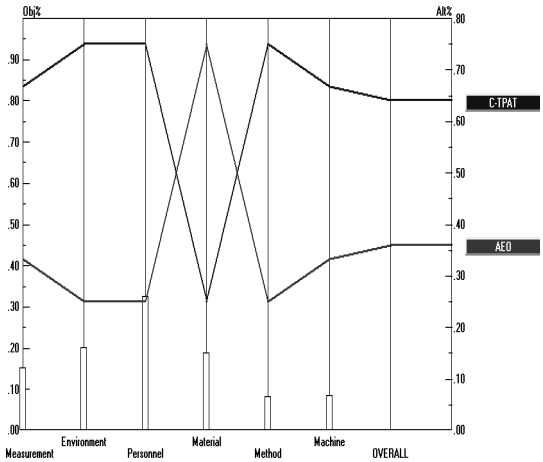


Figure3. Performance Sensitivity Analysis

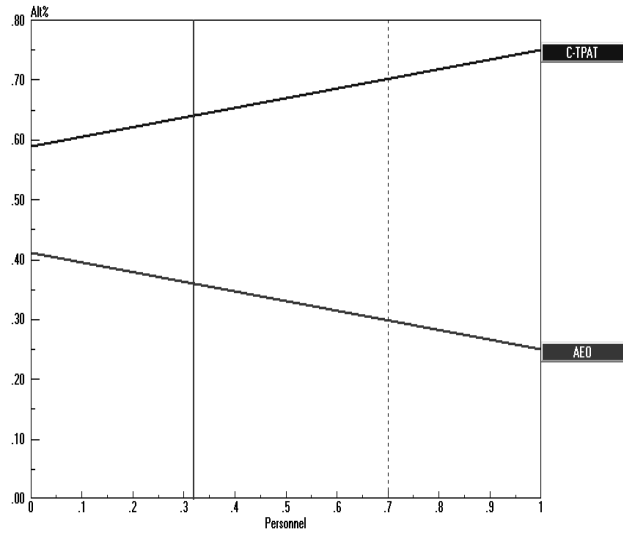


Figure 5. Gradient Sensitivity Graph for the Personnel Decision Criterion

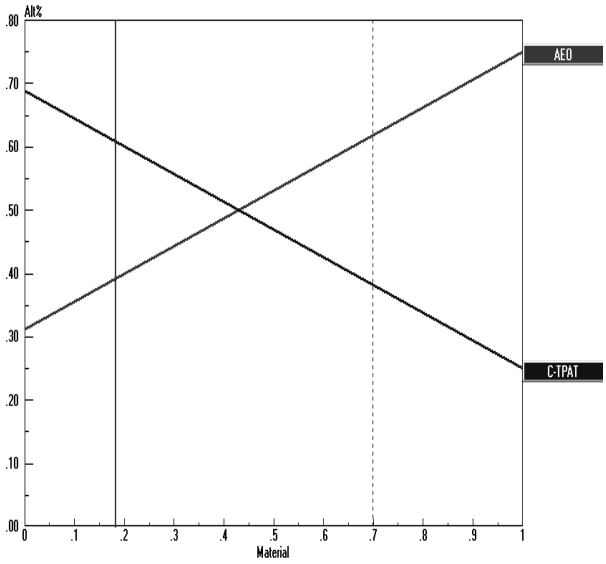


Figure 6. Gradient Sensitivity Graph for the Material Decision Criterion

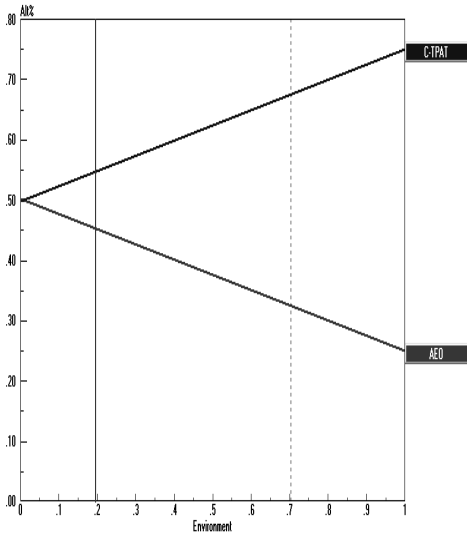


Figure 7. Gradient Sensitivity Graph for the Environment Decision Criterion

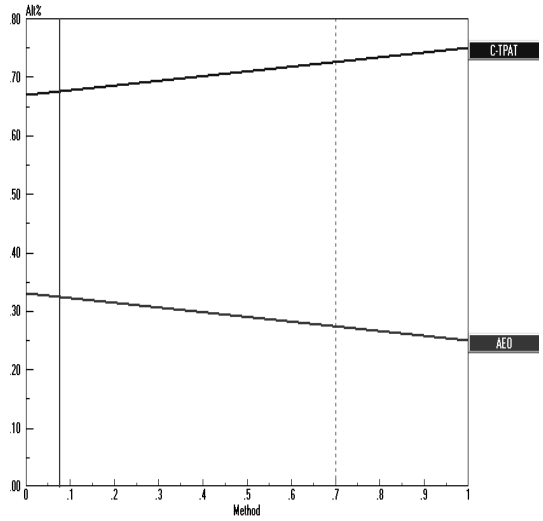


Figure 8. Gradient Sensitivity Graph for the Method Decision Criterion

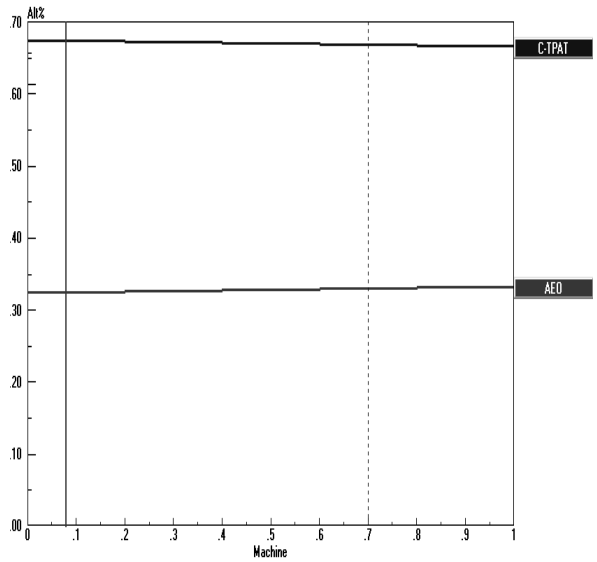


Figure 9. Gradient Sensitivity Graph for the Machine Decision Criterion

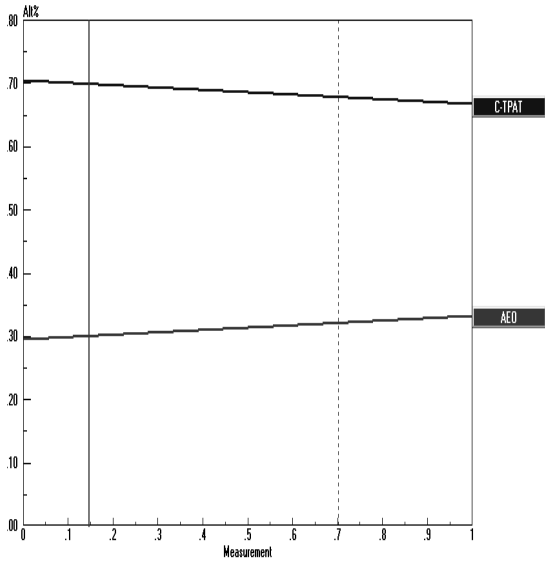


Figure 10. Gradient Sensitivity Graph for the Measurement Decision Criterion

Comparison of Energy Fractions for Gasoline and Ethanol – I

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Abstract

It has become a commonplace belief that the production and consumption of ethanol is good for the environment because the combustion of ethanol releases fewer hydrocarbons into the atmosphere. However, several assumptions underlying this belief are highly questionable. One of these assumptions is that the amount of energy derived from the combustion of a gallon of ethanol is greater than that for a gallon of a hydrocarbon fuel. In this paper, we test this assumption using a comparison quantity called the energy fraction.

1. Introduction

The production of ethanol began in the early 1980s, and has become a worldwide enterprise. Ethanol production began as a response to the notion that the earth was warming due to the accumulation of carbon dioxide (CO_2) in the atmosphere. Carbon dioxide results from several sources, but it was claimed that the chief source was the combustion of "fossil fuels," viz, petroleum based fuels. Carbon dioxide is, of course, a by-product of the combustion of petroleum based fuels. Therefore, it was claimed that limitations should be placed upon combustion by-products of petroleum-based fuels in order to prevent further warming.

While the warming of the earth is a dubious proposition all by itself (Idso, et al, 2013), nonetheless the production and consumption of ethanol has grown since its inception in the early 1980s. There are, however, some questions about the use of ethanol itself. For example, it is claimed that the combustion of ethanol causes less CO_2 in the atmosphere. This statement, however is imprecisely framed, and does not, therefore, have a precise answer. The real issue is whether less CO_2 results in the atmosphere from the production and expenditure of a unit of energy derived from ethanol, than results from the production and expenditure of a unit of energy derived from gasoline.

Originally the plan for this analysis was to answer the following questions: 1) what is the energy fraction for the combustion of a unit volume of ethanol, the energy fraction being defined as …

2) The cost of producing one unit volume of ethanol, as compared with an equivalent volume of gasoline to yield the same amount of energy; 3) the question raised above regarding the total amount of CO_2 released into the atmosphere to obtain the energy from a unit volume of ethanol. However, as the literature search proceeded, it became evident that the opinions and literature on these subjects were so divergent as to require substantially more study and analysis than that

originally contemplated. As a consequence, the original plan has been modified so that this paper will be aimed at evaluating the literature of the subject of ethanol production, so as to define the state of the debate. Once this has been done, three subsequent papers will deal with answering each of the three questions raised above.

Any analysis dealing with the production of ethanol must first introduce the reader to the production process. The dry grind process was selected for analysis because it is known to be the more efficient of the two. Thus, any conclusions reached through comparing its energy fraction, CO_2 emissions or cost would be equally valid for the dry grind process. **Figure 1** below provides a schematic of a typical dry grind process for ethanol production (Kwiatkowski, et al, 2006).

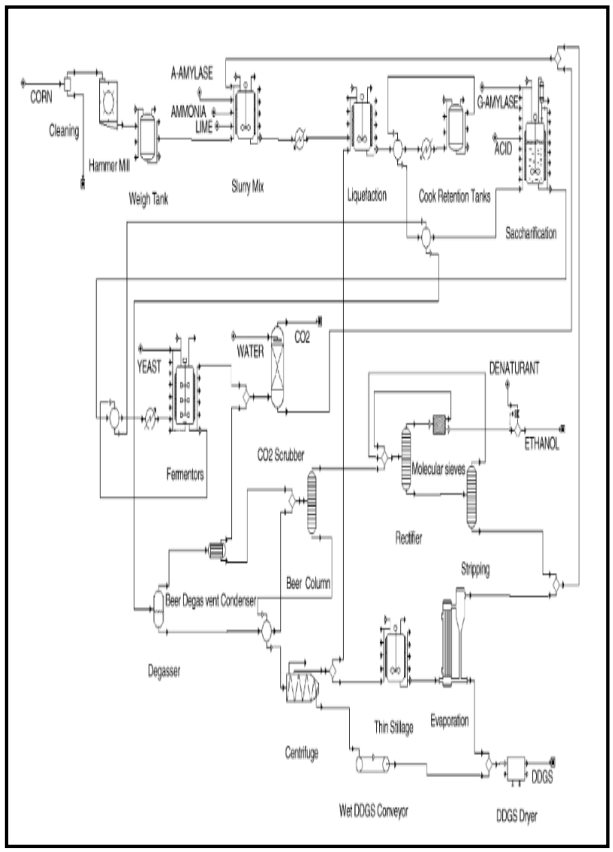

Figure 1: Typical dry-grind process for ethanol production

The following discussion provides a functional description of the each of the steps from Figure 1 involved in the dry-grind process of ethanol production

Corn delivery – Corn (or other grain) is delivered to the ethanol production facility where it is deposited in containers and cleaned.

Milling – The grain is screened to remove debris, then milled into ground material to allow water and enzymes to contact and to react with starch in the ground material.

Slurry Tanks – In slurry tanks, the ground material is mixed with recycled water and enzymes. The contact and reaction of these components cause starch gelatinization.

Milling Operation – The slurry flows through a separation device, where solids are selectively separated and ground further in a mechanical milling device, and then returned to the process stream.

Primary Liquefaction – In liquefaction tanks, the process hydrolyzes the gelatinized starch into glucose to produce mash.

Saccharification & Fermentation – The glucoamylase enzyme breaks down the dextrins to form simple sugars. Yeast is added to convert the sugar to ethanol and carbon dioxide. The mash is then allowed to ferment for 50–60 hours, resulting in a mixture that contains about 15% ethanol as well as the solids from the grain and added yeast.

Distillation – The fermented mash is pumped into a multi-column distillation system where additional heat is added. The columns utilize the differences in the boiling points of ethanol and water to boil off and separate the ethanol. By the time the product stream is ready to leave the distillation columns, it contains about 95% ethanol by volume (190-proof). The residue from this process, called stillage, contains non-fermentable solids and water and is pumped out from the bottom of the columns into the centrifuges.

Molecular Sieves – The 190-proof product stream is pumped into the molecular sieve system. These specialized tanks contain molecular sieve beads that adsorb water molecules from the process stream while ethanol molecules pass through unaffected. When the product stream leaves the molecular sieves, it contains approximately 99% ethanol by volume (200 proof).

Denaturant – Before the ethanol is sent to the storage tanks, a small amount of denaturant is added, making it unfit for human consumption.

Storage – Most ethanol plants' storage tanks are sized to allow storage of 7-10 days of production capacity.

Centrifuge – The stillage from the bottom of the distillation columns contain solids from the grain and added yeast, as well as liquid from the water added during the process. This mixture is sent and separated through the centrifuges into thin stillage (a liquid with 5-10% solids) and wet distillers' grain.

Evaporators – The liquid that is not routed back to the cook/slurry tanks is sent through a multiple-effect evaporation system where it is concentrated into syrup containing 25-50% solids.

Syrup Tanks – The syrup, which is high in protein and fat content, is then mixed back in with the wet distillers grain.

Grain Drying – The wet cake is conveyed to dryers where it is converted into a low-moisture (10-12%) product called dried distillers grains with solubles.

Bio-Oil Recovery – Separates oil from the post-fermentation syrup stream as it leaves the evaporators. The oil is routed to settling tanks, and the remaining concentrated syrup is routed to your plant's existing syrup tank.

Oil Recovery – Breaks the emulsion concentrate (a mixture of water, oil, soluble proteins, sugars, and starches), dramatically increasing the volume of oil recovered from the plant's process stream.

Settling Tanks – The bio-oil is then pumped to settling tanks where majority of residual solids and wax-bound oil have settled out and pumped to another tank. Then, high quality bio-oil in the settling tanks is transported via tanker trucker or rail.

2. Literature Survey

Corn has been used as a food staple for thousands of years: its use dates back to the dawn of recorded history. However, its conversion into corn ethanol goes back only about a millennium. It is first known to have

been distilled into a drink about AD 1200. Its use as a fuel is considerably more recent, and received serious impetus from the Energy Tax Act of 1978 created ethanol tax credits in an effort to decrease the nation's vulnerability to oil shortages and to raise the price of corn, which had been depressed by agricultural subsidies. Since that time, the use of corn ethanol as a fuel has grown almost exponentially due largely to the irrational concern about global warming. Other grains, such as rye, have also been used to produce ethanol, but corn remains the principal source of ethanol production.

Although corn ethanol production has grown to be a large industry in North America and Europe, its use as a fuel has raised some serious questions. The most obvious question has to do with the issue of supply and demand. As more corn is consumed in the production of ethanol, there have also been price increases to consumer products, such as cereal, corn cooking oil and milk. Increased ethanol consumption has also caused a significant increase in the of price beef. In an article entitled**, "*How Biofuels Could Starve the Poor*," Runge and Senauer (2007)** point out that the growth in the corn ethanol has meant that a larger and larger share of corn production is being used to feed the huge mills that produce ethanol. At that time, according to some estimates, that ethanol plants would consume up to half of U.S. domestic corn supplies within a few years. Doornbosch and Steenblik (2007) echo this concern. They point out that the concern to decrease greenhouse gas emissions might lead to food shortages and biodiversity damages resulting from competition for the same resources.

This injury to the consumer is further compounded by the fact that ethanol production is highly subsidized by the government. The Food and Agricultural policy Institute of Missouri University-Columbia (2009) reports that as of 2010 the subsidy provided to ethanol production was $0.12 per liter. This injury was further compounded by the fact that a tariff of $0.14 per liter was levied upon imported ethanol. Auld (2008) writes that such subsidies in Canada have raised the cost of food to consumers by $400M. He further points out that any carbon dioxide reduction came at a cost of $368 per ton.

In summary, even if the benefits of ethanol used as fuel were as advertised, its use comes at a serious cost to society, and may have serious long-term implications for food availability. It is further to be observed that ethanol could probably not be produced at a profit without government subsidies and tariff protection. Thus, even if the benefits to ethanol were as advertised, its cost and long-term food implications would be enough to call into question its use as a fuel.

However, the advertised benefits have become increasingly questionable. As early as 1991, Pimentel (1991) wrote that approximately 72% more energy was required to produce a gallon of ethanol than the energy available in a gallon. Another issue raised by Doornbosch and Steenblik (2007) concerns ethanol production capability. They point out that, as of that time, production technology was insufficient to make ethanol attractive as a gasoline substitute. They also go on to point out that "… current benefits from ethanol are minimal and challengeable." Koplow (2006) echoes this concern. He points out that the governments have rarely subjected the claims of ethanol to critical examination, and have before rushing into "investment." Koplow goes on to point out that the trade-offs between ethanol production and reduced greenhouse gas emissions are unattractive.

Proponents for ethanol production have attempted to blunt these criticisms. It has been claimed that substantial improvements have been made in production processes, so that ethanol has now become cost effective to use. For example, Mueller (2008), in responding to the need for updated data, wrote that ethanol

produced in 2008 required 28% less energy than that produced in 2001. Shapouri, et al (2008) echoed this view, and went so far as to say that such production improvements had made it possible to derive 2.3 BTUs of output energy for each BTU of input energy expended in ethanol production.

Other proponents of ethanol have attempted to justify its use through pointing to innovations such as using the by-products of ethanol for livestock feed (Kim, et al, 2008); also Ham, et al, (1994). Rosenstater and Muthukumarappan (2006) advance similar justifications for corn-based ethanol. Other writers deal with improved modeling techniques (Kwiatkowski, et al, 2006; Heungjo, et al, 2011). Gallaghera, et al (2006), estimate that capital costs for ethanol increase more rapidly for ethanol than for a typical processing enterprise. This paper also points out that construction costs for an ethanol production plant are highly variable. Thus, computing the real cost of ethanol production is problematical at best.

Farrell, et al, (2006) conclude that the carbon-dioxide emissions from ethanol are similar to those of gasoline. This conclusion is Pimentel and Patzek (2007) who conclude that the negative environmental effects of ethanol production have been largely overlooked, and that unrealistically low costs have been attributed to ethanol production. Lipman and Delucchi 2002) add that this uncertainty also extends to the emissions from ethanol use. They point out that in addition to carbon-dioxide, methane and nitrous oxide are emitted from ethanol combustion, and that the latter two emissions are difficult to measure.

3. Methodology

For this initial analysis, the methodology has been that of surveying a representative number of writers on the subject of ethanol production to determine why they arrive at different conclusions on such issues as the energy fraction of ethanol, the amount of carbon dioxide released into the atmosphere during the life-cycle production of ethanol, and the comparative costs of ethanol production. In order to arrive at sound estimates of these quantities, it was essential to identify all of the steps involved in producing ethanol. This has been possible through several papers, the most thorough of which was done by Shapouri, et al (2008), and is shown below in **Figure 2**.

Processing Power Configuration	Natural Gas & Purchased electricity		Biomass Power, Replace 50% w/Corn Stover	Biomass power, Replace 100%
	ASPEN DDG credit	Survey DDG credit	of Natural Gas (NG)	of NG & elec w/ Corn Stover
	in BTU / gallon			
Corn Production	9,811	9,811	9,811	9,811
Corn Transport	1,430	1,430	1,430	1,430
Ethanol Conversion	40,019 [1]	40,019	26,767 [4,2]	2,135 [2]
Ethanol Distribution	1,470	1,470	1,470	1,470
Farm Machinery	1,055 [5]	1,055	1,055	1,055
Total Energy Used	53,785	53,785	40,533	15,901
Byproduct Credit	20,409 [3]	12,936	12,936	12,936
Energy Used, Net of Byproduct Credit	33,375	4,0849	27,597	2,965
Ethanol Energy Produced	76,300	7,6300	76,300	76,300
Energy Ratio, w/o Byproduct Credit	1.42	1.42		
Energy Ratio, w/ Byproduct Credit	2.29	1.87	2.76	25.73

Figure 2: Summary of life-cycle ethanol production costs

More information remains to be gathered, but once this has been completed it will be necessary to resolve the discrepancies among the conclusions. This can only be done by comparing the various approaches to calculation such quantities as energy fraction. It is evident that those making the calculations are making different assumptions, and including, or perhaps excluding, different things. Once these assumptions are understood, it will be possible to repeat the calculations for the energy fraction using realistic assumptions, and to compare these with the energy fraction for gasoline. It will

also then be possible to do sensitivity analysis upon the various parameters involved.

Finally, examination of the methods of calculation, and rationalization of the assumptions, will also allow accurate estimates of the carbon dioxide emissions for the life-cycle production of ethanol as compared with gasoline. Again, it will be possible to perform sensitivity analysis on the results to determine the stability of the conclusions. This will also make possible accurate estimates of the production cost to the consumer as compared with gasoline. These extensions of the present paper will be published in subsequent papers.

4. Conclusions

It is evident from the foregoing literature evaluation that there are wide discrepancies in the conclusions of the various authors who have written upon the subject of ethanol production. The authors differ widely as to the life-cycle carbon dioxide emissions from the production of ethanol. They also differ widely upon the life-cycle cost of the production of ethanol. It is evident that their analyses are based upon different computational methods, and/or upon different assumptions. Researchers who work from similar assumptions, and who use the same computational methods do not come to different conclusions. Thus, the assumptions of the various writers, and their computational methods, must be analyzed and rationalized before any durable conclusions can be drawn about any of the important issues concerning ethanol production and use.

While the above issues can only be resolved by future study and analysis, one of the conclusions reached by Shapouri, et al (2008) can be criticized at this point. In this paper, the authors conclude that the energy ratio, what the current paper refers to as the energy fraction, is between 1.9 and 2.3 for ethanol produced in a dry-grind plant. In the conclusions on page 6, they even express the wistful thought that this energy ratio might rise as high as 2.8. If true, this would mean that every BTU of energy expended in the production of ethanol would result in 1.9 to 2.3 BTUs of usable energy from the ethanol so produced. Now this claim is absurd upon its face, for it violates *the second law of thermodynamics*. If true, it would mean that for each unit of energy consumed in ethanol production, it would be possible to produce 2 units (or more) of energy for use. Thus, after a short while it would be possible to produce enough ethanol both to operate the production facility, and to sell to consumers. This would mean that the ethanol production facility would be more than 100% efficient: If the energy fraction were 2, it would mean that the ethanol production cycle would be 200% efficient! Such a facility would become entirely self-sufficient, and would eventually not require any exterior source of energy to produce and sell ethanol. The absurdity of this conclusion underscores the need to examine the assumptions of researchers and their methods of calculation.

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Safety and Human Factors Perspectives in Flight Training

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Abstract

An on-site assessment of an overseas flight academy was performed to evaluate safety and human factors aspects of the current state of operations. Observation sessions and interviews were conducted with air traffic control, maintenance, flight instructors, students, ground instructors, scheduling, and management personnel. The findings of the assessment are discussed along with suggested recommendations for optimizing operations of the flight academy. The main concern of the researchers is that the current structure of the organization along with current processes has the flight academy performing a portion of their operations with only one-line of defense. Therefore, many of the recommendations suggested by the researchers is to be proactive in implementation of multiple lines of defense within the flight academy operations to positively impact the safety culture not only from a reactive standpoint but also proactive approach towards safety. The recommendations consist of immediate recommendations that the researchers suggest be made within 0-3 months and long-term recommendations that will take greater than three-months to implement. Future research is also addressed.

1. Introduction

An on-site assessment of a flight academy overseas was performed to evaluate safety and human factors aspects of the current state of operations. Observation sessions and interviews were conducted with air traffic control, maintenance, flight instructors, students, ground instructors, scheduling, and management personnel. The main concern of the researchers is that the current structure of the organization along with current processes has the flight academy performing a portion of their operations with only one-line of defense. Therefore, many of the recommendations suggested by the researchers is to be proactive in implementation of multiple lines of defense within the flight academy operations to positively impact the safety culture not only from a reactive standpoint but also proactive approach towards safety. The recommendations consist of immediate recommendations that the researchers suggest be made within 0-3 months and long-term recommendations that will take greater than three-months to implement. Future research is also addressed.

2. Literature Review

Flight academy operations are similar to healthcare operations in that both are complex and not easily understood making it a challenge to model and analyze due the human factor

involved in decision-making, information processing and carrying out tasks (Carstens, Rodriguez, & Wood 2014; Mehrjerdi, 2013). The healthcare field relies on process management to enhance the patient-flow processes which is also important in aviation as the goals are of safety and efficiency of flight students as a key factor in success (Rohner 2012; Chen & Cheng 2012).

Task Analysis method is used to identify and document the flow of operations in any environment and is of importance tool used to identify bottlenecks in processes in treating patients on the sickness to wellness continuum. Task analysis is invaluable as it investigates processes such as transition times when new staff arrives to relieve the existing staff. A study performed by Chircu, Gogan, Boss and Baxter (2013) suggest that during shift transition times, 40 percent of medication errors, 20 percent of which cause harm, occur from staff miscommunication in healthcare operations. A different study performed by the same authors, Gogan, Baxter, Boss and Chircu (2013) discusses how process management analysis such as evaluation of tasks result in radical improvements for healthcare processes.

The human error of causation model also referred to as the "Swiss Cheese or Error Trajectory Model" suggests that there are always gaps (holes) in every defense protocol (cheese slices) so multiple lines of defense should be in existence for organizations' processes so that all of the gaps don't line up creating a path for a safety incident to occur (Reason, 1990). The potential errors that get identified by researchers are any factors that contribute to potential errors, factors that reduce the likelihood of error, potential consequences of errors, risk assessment of errors, and recommendations to reduce errors and/or mitigate error effects (Chandler, 2002).

Dhillon (2003) identified steps that are important to follow when assessing an organization to see where errors can occur. These consist of (a) defining the system and its related parts, (b) developing appropriate ground rules such as the limits of operational and environmental stresses, definitions of what constitutes failure of system components, etc., (c) describing in detail the system, (d) identifying all possible failure modes and their associated effects, (e) developing critical items list comprised of statement of failure mode, criticality classification and the FMEA worksheet number page to refer to for additional information and (f) documenting the analysis such as system failure modes and their effects.

An example of an aviation task that is prone to errors is scheduling flight students for their flight training (Jacobs, 2014). There are many restrictions that arise to include unknown events such as weather constraints or maintenance delays with aircraft. Many other restrictions were identified by Jacobs (2014) that studied specifically flight training operations at Training Air Wing-Two (TW-2) which is built manually each day by squadron scheduling officers (SKEDSOs). The additional restrictions include instructor and student available periods of time, instructor crew day limits, instructor event limits, student event limits, students scheduled no more than six consecutive days, night events, student solo and instructor crosswind limits. The purpose of Jacobs' (2014) study was to assess whether the building of an optimum daily flight schedule can be automated to include time-critical changes being made on a completed schedule giving the SKEDSO a greater amount of time to determine the best substitute events for both students and

instructors to optimize flight training operations.

3. Methodology

The focus of the study was to conduct a human factors and safety assessment of an overseas flight academy operations. Observation sessions and interviews were conducted with air traffic control, maintenance, flight instructors, students, ground instructors, scheduling, and management personnel. The observations and interviews conducted were with the purpose of understanding the tasks and potential errors involved with training flight students.

Once the observation sessions and interviews took place, the researchers were able to piece together the current tasks and therefore a task analysis was performed. Within different tasks, bottlenecks and potential errors were identified. Recommendations were identified that could be implemented in the short-term, three-months of less, or long-term, over three-months to enhance operations by enhancing safety and human performance resulting in more efficient operations while enhancing the overall safety culture. The recommendations were identified through examination of how errors can be eliminated in current operations or as a minimum resulting in mitigating error effects.

4. Results

This section displays the findings from the observation sessions and interviews conducted of air traffic control, maintenance, flight instructors, students, ground instructors, scheduling, and management personnel.

Air Traffic Control observation and interviews resulted in learning that their operations include a nonradar environment, multiple planes are in training at the same time, aircraft from different organizations utilize the practice fields, multiple touch and go flight training occurs at the same time and different languages are spoken by students, pilots and ATC. Controllers all had familiarity with the emergent ATC procedure consisting of pressing the red alarm button and calling fire and other numbers.

Maintenance observation and interviews resulted in learning the shift times for operations and the type of maintenance and performance data that is logged and tracked. Technicians were not all consistently familiar with the voluntary safety reporting system nor does regulation require their participation. There is a lack of a post flight inspection by either pilots or technicians at times. Inspection due dates and times are updated daily using a manual process but pilots are not presented this information. Potential safety issue, one-layer of safety defense in place to prevent dispatch of an aircraft that is due for maintenance or inspection.

The flight instructors' observation and interviews resulting in learning that instructors are consistently assigned different planes and students. Instructors and students reportedly do not use the minimum equipment list (MEL). Instructors do not consistently record concerns in the logbook. Forms for reporting safety are not consistently being utilized by instructors or students. Crew flight training, aircraft maintenance and student and instructor assignments needs stronger link. Maintenance reports are not consistently kept in the binder for instructors to review. Formal procedures are missing such as post-flight checks.

The observations and interviews of students resulted in several findings. With ground instruction, students would prefer to have a

better understanding of sensors and gyros providing opportunity for increased computer-based training (CBT). Landing jets is a weakness for them providing an opportunity to add a mandated fixed training device 10-hour course to better prepare students. Situational awareness of jets is a weakness. Students find jets to be more complex than the training planes.

The observation and interviews for ground instructors resulted in learning about challenges experienced. These included instructors challenged by very rigorous training demands in a short period of time. Also, logistically not all management is located in the same facility.

Observations and interviews of scheduling operations resulted in learning that it is currently a manual process. Automation would be beneficial. The current process involves three functions. The first function is flight crew scheduling consisting of the name, hours and specific flights for instructor s & students. The second function is aircraft planning which is identifying when aircraft maintenance is due. The third function is flight planning. Since reports are produced the night before and printed, there is potential for inaccurate data regarding availability of aircraft the next day resulting in bottlenecks caused from planes becoming unavailable for flight training with limited notice.

The observation and interviews of management also resulted in many findings. Multiple employees lack the required authorization for personnel to make decisions to perform their job more efficiently. This results in personnel being required to email a minimum of one manager for various approvals resulting in time delays.

5. Discussion

The immediate recommendations that the researchers suggest consist of recommendations to be made within the short-term, 0-3 months, and long-term recommendations that will take greater than three-months to implement. The concern of the team is that the current structure of the organization has a portion of their processes operating with only one-line of defense. The human error of causation model suggests that there are always gaps (holes) in every defense protocol (cheese slices) so multiple lines of defense should be in existence so that all of the gaps don't line up creating space for a safety incident to occur (Reason, 1990). Therefore, many of the recommendations suggested by the researchers is to be proactive in implementation of multiple lines of defense within the flight academy to positively impact the safety culture not only from a reactive standpoint but also proactive approach towards safety. Proactive approaches to safety minimize the occurrence of multiple failures lining up to result in a mishap. These recommendations were identified after reviewing data collected from the on-site visit.

The short-term recommendations (0-3 months) consist of the following:

1. Provide clear and frequent communications on restructuring/re-organization to employees to increase morale, reduce stress, and increase safety margins.
2. Require that all employees, staff, and pilots are trained and educated on how and when to use the voluntary safety reporting system to enhance safety.
3. Establish a post-flight inspection procedure for aircraft turn-around to ensure there are no discrepancies from the previous flight to enhance safety.
4. Standardize processes to leave maintenance history in the logbook so that

flight instructors can review the maintenance history of aircraft.

5. Until there is scheduling technology, the scheduling of flight instructors and students can be simplified through assigning students to a specific instructor during their flight training for the same times each week. This would also result in instructors being assigned the same aircraft or type of aircraft. Hiring of a temporary staff person to assist with the large amount of scheduling work tasks. Technology is needed to lighten the current workload and to assist with real-time data enabling the scheduling of flight training to be optimized.

6. Enforce English to be used by all instructors and ATC personnel to provide for better communication and enhanced safety. This includes meetings, briefings and emails to standardize communication practices for flight instructors, students, etc.

7. Provide those capable with greater authority to eliminate unnecessary bottlenecks within the operation. It is not necessary for all personnel to email a minimum of one manager before being granted permission to make decisions as it results in time delays to get approvals for decisions that could instead be made by the lower-level employee.

8. Complete, at a minimum, annual emergency preparedness drills on-site at the airport.

The long-term recommendations (greater than 3 months) are listed below:

1. Establish an assistant safety manager position, which is located on-site at the flight school. This person would be responsible for sorting only safety reports to: 1) provide timely feedback to employees, staff, and pilots (at least monthly), 2) promote the safety program and safety culture at the flight school, and 3) complete training as necessary to employees, staff, and pilots on the use of and value of the safety reporting program. The overall safety culture needs to move from a reactive to a proactive approach, which can successfully be accomplished using a top-down management approach. Therefore, those reporting potential safety hazards need to be rewarded for their commitment to safety to enhance the organization's safety culture.

2. Consider use of electronic dispatching software that incorporates maintenance tracking information to provide backup to the manual tracking system. Technology for scheduling instructors and student flight training sessions and aircraft maintenance is needed over manual scheduling. ATC would also benefit from use of radar to track aircraft, as manually tracking aircraft in the practice fields can be unsafe.

3. To better prepare students with learning how to land jets, situational awareness with jets and jet automation, the development of a fixed training device 10-hour course for students addressing these issues would be beneficial. Furthermore, assessing the curriculum to add critical thinking skills and identifying measures for evaluating critical thinking skills would also better prepare students to become commercial pilots. Learning material by rote is often necessary, but in order for the information to generalize to other situations, critical thinking skills are necessary to anticipate unexpected events.

6. Conclusion

As a result of numerous interviews and observation sessions with air traffic control, maintenance, flight instructors, students, ground instructors, scheduling, and

management personnel, recommendations were put forth to enhance the current training program that optimizes safety and human performance. Both short and long-term recommendations were included as a result of the data the team gathered during our on-site.

In short, these recommendations emphasized seven primary areas needing attention: 1) Increased communications among all departments; 2) Increased feedback of potential safety issues with greater participation in a voluntary safety reporting system and more diligent use of maintenance history records; 3) Increased logistical support, particularly in the area of scheduling, to include more automated technology; 4) Provide lower level personnel with greater authority to eliminate unnecessary decision-making bottlenecks; 5) Moving from a reactive to proactive safety culture; this can be better served by establishing an assistant safety manager position; and 6) Enhanced training to include situational awareness with jets and jet automation, and curriculum modifications to include the development of critical thinking skills.

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Validation of a Conceptual Framework for Federal Government Marketing

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Abstract

The federal government market, which exceeds $500 billion per year in products and services, has been largely ignored by the research literature community. The complexities related to its size, breadth of services involved, intense competition, and regulatory challenges would seem to make it an attractive area of study and business practice that has yet to be approached in a disciplined manner. In recognizing this research gap, the authors previously conducted an analysis of the dynamic contribution of existing government systems data elements to identify their possible use in the developing federal government marketing plans. The study resulted in development of a conceptual framework that has the potential of serving as a guide to the future research and practice. The framework can serve to illustrate the application of existing government systems data to develop the key elements of government marketing plan for the various market segments of the government. This study expands on the previous research study and consists of a thematic empirical validation and action research project of the conceptual framework that tests the framework by applying it to a modified case study related to an existing segment of the government market – specifically consulting. This study results in identifying the usefulness of the information provided by existing government systems that has important implications for business practice and market research. The study also resulted in the identifying areas of weakness in the government systems data for businesses competing for a share of government market segments.

1. Introduction

A search of articles in the Journal of Public Procurement and other sources reveals many articles that discuss procurement policy and processes from a government perspective. In addition, a review of research literature yields a significant number of articles that discuss the importance of market planning and strategy in business. However, research literature is essentially silent concerning the marketing planning and strategy of business organizations that market their products and services to the federal government (Thai, 2001). The subject of business marketing to the government sector has been covered basically by trade journals and magazines (Thai). With a market size of $500 billion annually, complexity of government bureaucracy, six hundred thousand registered competitors for federal contracts, complex regulatory requirements, and challenging proposal processes involved; business government marketing is a field that would appear to be ripe for academic study (Amtower, 2011; Bradt, 2010; Santo, 2001; Slavens, 2007; "USASpending.gov", 2015). To address this research gap, the authors conducted two previous research studies in which they developed and refined a conceptual framework

that was designed for use in developing marketing plans from existing government information systems that can serve as a guide to future research and business marketing strategy (Shehane, 2013; Shehane, & Sherman, 2014). This study is designed to validate the previous framework by applying the framework to an active marketing sector of the federal government. The frameworks validation is expected to identify the frameworks usefulness, lessons learned, and possible strengths and weaknesses in the framework when applied to a business practice situation.

2. Market research and planning

Market research and planning are critical to developing both the strategic and tactical means of approaching a new marketing segment, such as the federal government. Marketing plans should contain the following strategic elements: market opportunity identification, target market areas, and market value determination (Kotler, & Keller, 2012). Marketing plans should also contain the following tactical elements: product features definition, product promotion approach, product merchandizing approach, product pricing, sales channels definition, and support services available to customers (Kotler, & Keller).

3. Government information systems

The following government systems were identified in previous studies that could be used to provide the data needed to develop government marketing plans (Shehane, 2013; Shehane, & Sherman, 2014).

3.1. Federal Procurement Forecasts (FPF)

Annual forecasts of contracting opportunities are provided by government agencies. There is no single web site for the forecasts, but Acquisition Central is a good starting place to find each agency's individual sites ("Acquisition Central", 2014).

3.2. Government Functions and Services (GFS)

A list of all government agencies and contact information that is located at USA.gov ("USA.gov", 2014).

3.3. FedBizOpps (FBO)

This system provides a listing and detailed description of government business opportunities for amounts of $25,000 and above ("FedBizOps", (2014).

3.4. USASpending.Gov

The system provides a searchable list of historical information on awarded government contracts of $25,000 and up ("USASpending.gov", 2015).

3.5. GSA schedules and queries

This a two part system that gives a searchable list of existing GSA Schedule Contracts with the government that contains a description of the products provided, prices of the products, terms of service, company descriptions, and company marketing materials. GSA also provides an online system that reports on the amount of sales for GSA Contracts ("GSA eLibray", 2014; "GSA Sales Query", 2015; Parvey, & Alston, 2010)

3.6. Federal Procurement Data System – Next Generation (FPDS-NG)

This system provides a flexible reporting and query capability on detailed contract awards of contract awards of $3,000 and above ("FPDS-NG", 2014).

4. Framework

Previous research by the authors resulted in the Conceptual Systems/Market Plan Framework presented in Table 1. The framework was designed for use in guiding research and business practice concerning the development of government marketing plans by using data from government information systems (Shehane, 2013; Shehane, & Sherman,

2014). The framework shows the expected relationship between government information systems and the marketing elements they can feed with useful data. The data provided for each marketing element was described in the author's previous research, but no test of the framework was conducted to validate the process for assimilating the data into a coherent marketing plan under real-life conditions.

5. Methodology

The framework was first empirically tested by using it to assist three existing companies to assess their capability to compete in the federal government market. As part of this test, government marketing plans were developed using the framework. These test cases provided the authors the opportunity to experiment with and refine the process and order of assembling the data from the government information systems, to encounter the challenges of data inadequacies, to identify weaknesses and strengths, and to obtain feedback from company executives which became part of an action research project. The experience and findings were noted in a log that was used to analyze the case and develop the findings and results. The log recorded the following information for each case: order and steps involved in using the framework, elements of the final marketing plans that were developed, acceptance or rejection of the plan by management, lessons learned, usefulness of the framework in satisfying company needs, degree of efficiency and effectiveness of systems data. However, due to confidentiality agreements, the specific results of the test cases cannot be cited. This study, however, will use a modified case study to present the results and findings from the test cases to avoid any violations of confidentiality. Facts, numbers, and identifiable information have been removed from the test cases to create the modified case study. The modified case will serve as a basis for assessing the usefulness of the framework and as a guide to management practice and future research in federal government marketing.

6. Case description

The modified case study involved the following basic characteristics:

- Small business class – 6 million annual sales in non-government markets
- Core business is consulting
- No government granted set aside advantages such as HUBzone, women owned, disabled veteran, etc.
- Staff of approximately 40 consultants
- New to the government market.
- Two consultants with government experience.
- Skillsets – general management consulting, financial consulting
- Ability to recruit skills for special needs

7. Application of the framework

7.1. Strategic elements

Management and marketing officials wanted to assess the overall strategic elements of a marketing approach first in order to determine the degree that the company might fit the market, the services that are the best match for the market, and the overall potential of the market for the company. The strategic elements of a marketing plan consists of identifying market opportunities, target market, customers, and the potential value of the markets.

7.1.1. ***Order of analysis:*** The first lesson learned from using the framework to meet management's needs was that the order of using the various systems and data items in the systems was important. The proper order to proceed was very much related to the requirements of developing a coherent marketing plan and the organization's needs. The study found that the first step needed was to identify the market opportunities portion of the marketing plan which involved identifying the market areas and potential services that best matched the organizations existing capabilities. This identification of market area and services involved the following:

7.1.2. ***Core product/services:*** The first step in developing the marketing plan involved an assessment of the core business services the organization had to offer. The core services were developed from careful study of an inventory of past projects that the company had participated in and an inventory of the skill sets that the consulting staff represented.

7.1.3. ***Market opportunities:*** These core services and skillsets were then first compared with the GSA Schedules to identify potential market opportunities that fit best to the company offering. Based on this analysis, the consulting company was found to best match Schedule 874-1 consulting services and Schedule 520-13 financial management services service areas in the federal government market place. The GSA Schedules were very detailed in their descriptions of services so the matching of commercial service terms to government service terms was not difficult and the determination of the compatibility of services proceeded efficiently. This analysis indicated several things: best market area for competing, best service choices, and also which GSA Schedule Contract areas that the consulting company should consider for developing and pursuing. However, as previously noted in the framework development, this information was not helpful in identifying target markets since it did not identify the customer base to whom the services were sold.

The next step involved identifying non-GSA market opportunities and services to see how they might best fit the consulting company's capabilities. The USASpending, and FBO systems were used to perform this task and provided query reports by service type that either validated the GSA opportunities or expanded the number of services to consider. The FPF system provided future marketing forecasts but was of no use in identifying market opportunities due to the difficulty in finding sites and the lack of specifics in the forecasts.

7.1.4. ***Target markets:*** Next, the FPDS-NG system was used to identify target markets. The USASpending and FBO had already been used simultaneously to identify the target markets during the market opportunities analysis to avoid duplication of effort that would have been expended for reviewing the systems twice (market opportunities and target markets). In addition, the FPDS-NG, USASpending, and FBO systems were all used to identify contracts that had been awarded or issued under cross-referenced GSA Schedule numbers in order to identify the GSA target market that was not available in the GSA Schedule and Query analysis. The use of the USASpending, and FPDS-NG, and FBO systems was useful and efficient in filtering information by product and service code. The service code could easily be matched to the existing consulting company's services. However, the data proved to be cumbersome to delineate since contracts were listed individually and so compilation of data was time consuming. However, the ability to delineate by service code, by agency serviced, and by state location proved helpful in identifying the target market customer base. The description of task and detailed contract information provided by FBO was difficult to categorize and summarize because it was so voluminous and peppered with government terminology for services provided. However, FBO proved helpful in identifying target markets and initial agency contacts when using combination searches on service and product codes (NAIC, PSC, FSC) and agency, office, state, or ZIP searches. The FPF and GFS systems were only used to gather more information on the agencies identified by the FBO, USASpending, and FPDS-NG reviews since the FPF and GFS proved to be cumbersome for searches due to their loosely organized sites.

7.1.5. ***Market potential:*** Market potential value was identified by two systems. The GSA Sales Query Reports easily provided current and past sales totals for GSA Schedule Contracts by market area, specific service, and fiscal year.

The USASpending system provided totals by agency, service code, fiscal year, and location. These two systems were both effective and efficient in their reporting of the needed information due to their advanced filtering capability. The FPF system provided future marketing projections by location and agency that proved to be of little use to the consulting company due to the difficulty in finding sites and the lack of specifics and lack of commitment represented by the forecasts. This system might prove to be useful to companies already heavily involved in government business with existing sales channels that they wish to monitor for long range projects.

7.2. Tactical elements analysis

Management and marketing officials wanted to assess the tactical elements next since they would usually be assessed after strategic decisions of overall direction had been made. The tactical elements of a marketing plan typically consist of product features, product promotion, merchandizing, product/service pricing, sales channels, and service support.

7.2.1. *Product/service pricing:* It was discovered that it was more efficient to go ahead and analyze the GSA Schedules for product/service pricing rather than backtracking later to conduct the analysis. In addition, as part of management's initial decision to pursue or not pursue a federal government market sector, management was concerned as to whether their pricing was competitive enough for the market. Therefore, management wanted an upfront assessment as to how much their pricing might have to change to be competitive. Even though pricing was classified as a tactical issue in the original framework, it became obvious that pricing information was also a key part of the initial strategic assessment since it had such an impact on determining whether the company could be profitable in the government market. The GSA Schedules proved to be ideal for identifying the pricing for consulting positions. The schedules typically provided a list of prices for various consulting job titles and levels of experiences. One of difficulties encountered with the GSA Schedule pricing information was that it was difficult to determine where competition's job titles were actually equivalent to the consulting company's job titles. Fortunately, some of the schedules also provided detailed descriptions of each job title and level within job titles which enabled some cross-matching between the company's job titles with the competitions job titles. However, the matching job title pricing information still encountered problems where competitors offered more job titles and levels than the consulting company under study or the competition offered some job titles and levels not available in the consulting company. This resulted in the researchers having to use their judgment to decide on matching prices. In addition, the researchers found that they had to utilize management and their expertise to determine equivalent pricing decisions. The use of the USASpending and FPDS-NG systems proved useless and very laborious in identifying any relevant service/product pricing. The previous framework studies indicated that these two systems may not be ideal since they only provided overall pricing for the entire transaction rather than details such as job title pricing. This proved to be true when applying the framework. In addition, the previous study had surmised that the data from these systems might be cross-matched to reported GSA contract numbers for comparison. However, this proved to be not only laborious, but useless since the transaction award pricing was not detailed enough to tie it to the job title level.

7.2.2. Product features: The product features element of the marketing plan was analyzed next – first using the GSA Schedule and Query Reports. The GSA Schedule proved to be very useful in identifying product features by using the filtering features of both of the GSA systems. Both GSA systems provide reporting down to the Special Item Number (SIN) level –

which describes the service category being provided. This enabled the researchers and management to identify and agree with the service categories and elements that could be provided in the government marketing effort and which ones best matched their current consulting talent pool. Management agreed that the SIN 1 consulting services offered in the 874 GSA Schedule Contracts and SIN 13 in the 520 GSA Schedule Contracts better matched their core capabilities and contained the service/product features desired by the government market. The search options of the FBO proved useful, especially the use of Product Service Code (PCS) and North American Industrial Classification System (NAICS) which both permitted the researchers to filter results by service category and function. For example, the market area of 871-1 consulting services identified in the previous GSA analysis was cross referenced to PCS R499 and NAICS R499 management consulting services in the FBO. However in practice, the review of search results in FBO proved to be laborious to review, inconsistent, and error prone in matching services with exactness. There were several reasons for these problems. Firstly, as expected in previous studies, the FBO displays entire procurement packages that are voluminous (sometimes hundreds of pages), filled with government language, and containing requirements that may include the same PCS/NAICS but involve extraneous requirements not matching the particular service area. In addition, many examples were found of procurements that were wrongly identified to a NAICS or PCS classification due to government clerical errors when entered into the database. As a result, the interpretation of the FBO searches involved a joint review by the researchers and management to sort out mismatches and categorize the specific services represented in the procurement packages that matched the desired NAICS/PCS. Management was also used to identify those portions of the procurement packages that were not matches to the service area that might require the recruitment of specialized skills not existing in the company's existing staff. For example, NAIC 54611 contained specific services that fell under it that could include such things as strategy consulting, executive coaching, policy development, expert witness, etc. that would require a specific set of consulting competencies that had to be identified to develop a full product/service plan.

7.2.3. Service support: The analysis of the service support elements of the market plan was conducted at the same time as the product features analyses since these elements were contained in the product/service features searches in the same GSA and FBO searches. It was found that in practice, the identification of service support elements were just an extension of the product/service feature search and resulted in the same findings as noted in the product/service analysis section above.

7.2.4. Product promotion and merchandizing: The product promotion and merchandizing approach analyses were conducted in concert with the Product Features analysis since they used the same systems and focused on the same product information sections in the GSA and FBO reports. The GSA Schedules contained examples of competitor product promotion and merchandizing approaches that was easily found, documented, and categorized for managements review and acceptance for inclusion in the marketing plan. In addition to the basic descriptive information found, the GSA Query Reports showed annual sales data for competitors that enabled management to assess the success that each competitors approaches were having in the government market. The sales data, along with information on competitor approaches, enabled the researches to rank some approaches in order of success when they were unique to certain competing companies. The FBO also provided the capabilities to determine and assess product promotion and merchandizing, but in a different manner than the GSA systems. A

unique capability within FBO, is the ability it provided the researchers to test how well the consulting company's existing services promotion and merchandizing abilities matched government requirements. This was accomplished by submitting proposals for the consulting company to "sources sought" requests which are used by the government to assess a company's capabilities to satisfy future requirements that the government is considering. The use of "sources sought" requests resulted in feedback opportunities from the government, the opportunity to promote the company's service without committing resources, the opportunity to influence the scope and details of future requirement, and the opportunity to open a dialog with government procurement officials. The FBO was also used to register for different procurements to assess the viability of teaming with competitors in common market areas of interest. The feedback and interchange with competitors was very helpful in further defining promotion and merchandizing potential. The details within the FBO procurement instruments were also useful for identifying government merchandizing preferences such as packaging, display approach, service design, etc. However, the voluminous nature of the procurement documents, government oriented terminology, and specialized government requirements required the use of the small consulting staff that had previous government experience to analyzing the information provided by FBO. This proved to be problematic for the consulting company since the government experienced staff had to be pulled from other projects to assist with analyzing the procurement documents. Set-aside searches were not used since the consulting companies under study had no disadvantages recognized by the government.

7.2.5. Sales channels: Sales channel data was documented during the FBO and USASpending reviews. Both systems enabled filtering on agencies, offices, state, zip, etc. which was helpful in compiling a list of avenues for selling services. USASpending was also useful in identifying the amount of sales produced by each filtering category that proved helpful in finding sales channel matches with consulting staff and office locations. There were no difficulties encountered with using these systems for this use. The FPF and GFS systems were used to gather more information on the agencies identified in the FBO and USASpending reviews since both systems proved to be cumbersome for searches due to their loosely organized sites.

8. Findings

Table 2 shows the resulting Validated Systems/Market Plan Framework after testing the use of federal procurement systems. A summary of the findings pertaining to the tests of the framework are as follows:

The results obtained from using the framework was accepted by company management and their marketing executives.

Those systems identified in Table 2 as useful by a "U" designation were found to be useful and efficient. Those identified as of limited use were by an "L" and were found to be only useful in providing more detailed information to support the findings of the systems designated as useful.

The order of use for the framework was not addressed in previous studies, and was affected by management preferences and by the decision to efficiently utilize system results.

Product pricing was initially considered to be a strategic element of marketing, but this element was addressed in the early stages of framework use in order avoid duplication of effort in using the GSA reports. Pricing was also considered part of management's strategic decision-making since it was a key determiner of company competition and profitability.

The filters and cross-referencing capability of FPDS-NG, USASpending, and FBO were found to be useful for determining both GSA and Non-GSA target markets.

The FPF and GFS systems were found to only be moderately useful for gathering more supportive and descriptive information on agencies for marketing purposes.

The GSA reports, as expected, proved to be useful for identifying product/service pricing and for cross-matching this data to existing job titles within the consulting company. However, management personnel had to be used to determine equivalent pricing in complex job title situations.

USASpending and FPDS systems proved to be laborious and useless for pricing analysis.

FBO proved to be laborious, inconsistent, and error prone for product features searches. As a result, management had to be used to interpret and correct the results.

The unique capability of FBO to test their capabilities against government requirements using the "sources sought" and "teaming interest" features was helpful in assessing practical federal market potential for the consulting company.

The voluminous and complex nature of the procurement documents in FBO resulted in researchers having to use specialized management and consulting personnel to analyze the data.

9. Conclusions and Future Research

Overall, the conceptual framework worked to guide the research effort and assisted in identifying modifications needed to develop the final validated framework. The weakest area encountered when using the conceptual framework was when company management and personnel had to be used to interpret product feature codes in FBO, sort through voluminous and complex procurement document in the FBO, and interpret complex job title differences in the GSA system. As could be expected, these weaknesses indicate the need for company in-house personnel with both an understanding of company functions and government expertise to fully make use of the framework.

The new validated framework provides a much improved guide for additional research into various government markets and a guide for management practice. Future studies are planned to test the framework in other federal government market fields to assess its generalizability. In addition, the framework is expected to be used to study the fairness of government procurements and how government policy and information sources might be improved to encourage competition.

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11. Tables

Table 1. Conceptual Systems/Market Plan Framework

Market Element	Systems ----------						
	GSA	FBO	USA Spend	FPDS -NG	FPF	GFS	Internal Company
Market Opportunities	X	X	X		X		
Product Pricing	X		X	X			
Target Market		X	X	X	X	X	
Market Potential	X		X		X		
Product Features	X	X					
Service Support	X	X					
Product Promotion	X	X					
Merchandizing	X	X					
Sales Channels		X	X		X	X	

Table 2. Validated Systems/Market Plan Framework

Order of Development-Market Element	Systems ----------						
	GSA	FBO	USA Spend	FPDS -NG	FPF	GFS	Internal Company
1- Core Business Services							U
2- Market Opportunities	U	U	U				
2- Product Pricing	U						
3- Target Market		U	U	U	L	L	
4- Market Potential	U		U	U	L		
5- Product Features	U	U					
5- Service Support	U	U					
6- Product Promotion	U	U					
6- Merchandizing	U	U					
7- Sales Channels		U	U		L	L	

Xilinx FPGA Design Tools: From ISE to Vivado and EDK

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Abstract

Xilinx Integrated Software Environment (ISE) is software system for synthesis and analysis of HDL designs on Xilinx FPGA chips. Vivado is the next generation replacement for the ISE tool, which has faster implementation, better design density and verification. Embedded Development Kit (EDK) is a set of tools to develop embedded systems on a FPGA chip, it includes a Xilinx Platform Studio (XPS) which design the hardware platform and a Software Development Kit (SDK) to create firmware and applications using C programming language.

1. FPGA chips

Field Programmable Gate Array (FPGA) technology has started a new revolution in electrical and computer engineering education. With FPGA chips and proper implementation software package, we can implement complicated designs in digital logic and computer architecture courses.

For example, in a digital logic courses, we can design complicated traffic light controllers, VGA controllers, a simple video game console, UART/PS2 interfaces, and finite state machine controlled data path to implement a math algorithm. (Haskell & Hanna, 2012). For computer design courses, simple soft processors can be designed from scratch and tested on a FPGA chip. (Patt & Patel, 2004). A complete embedded computer system with processor, BUS, I/O and memory can also be implemented on one chip. (Chu, 2008).

2. ISE suite

Xilinx Integrated Software Environment (ISE) is software system for synthesis and analysis of HDL designs on Xilinx FPGA chips. Simple designs can use schematic entry method. More complicated designs need to use VHDL or Verilog programming language. Pre-existing hardware modules called Intellectual Properties (IPs) can be used, so the design can be finished quicker and better.

3. Vivado suite

The Vivado Design Suite is the next generation replacement for ISE. It delivers a SoC-strength, IP-centric and system-centric, next generation development environment that has been built from the ground up to address the productivity bottlenecks in system-level integration and implementation.

The Vivado Design suite provides accelerated implementation, integration, and verification. It provides 4X faster implementation, 20% better design density and up to 3X speed grade performance advantage and 35% less power. It also provides C-based IP generation, model-based DSP design integration, block-based IP integration and integrated design environment for design and simulation.

4. EDK package

Embedded system and system-on-a-chip (SoC) are common FPGA applications. Many commercial IP cores are available to be purchased. For example, the most popular ARM Cortex processors are used on 90% of all smart phones and digital TVs.

There are many soft processor cores available for free. Xilinx EDK is one of them. The EDK package includes a hardware development tool called XPS, and a software/firmware development tool called SDK.

XPS (Xilinx Platform Studio) include a free 32-bit soft processor called MicroBlaze, plus a complete set of BUS, I/Os, and Memory. The XPS has a base system builder wizard which can help to create a working embedded system with single or dual MicroBlaze processor within minutes. XPS also includes other intelligent design wizards to quickly configure the embedded system architecture, buses, memory and peripherals.

After the hardware platform is designed by XPS, SDK can be used to create software. The SDK (Software Development Kit) includes a GNU C/C++ compiler and debugger for application development. The final executable code can be standalone, or associated with a real-time or embedded OS. This package supports real-time operating system Xilkernel from Xilinx or open source embedded operating system Linux.

5. Implementations

ISE suite is used extensively for various projects. Figure 1 shows the screen shot of ISE, and a Nexys 3 prototyping board using Spartan 6 FPGA chip from Xilinx. The project is a Pong game console, the game console uses a standard VGA display, and can be played with push buttons on the Nexys 3 board.

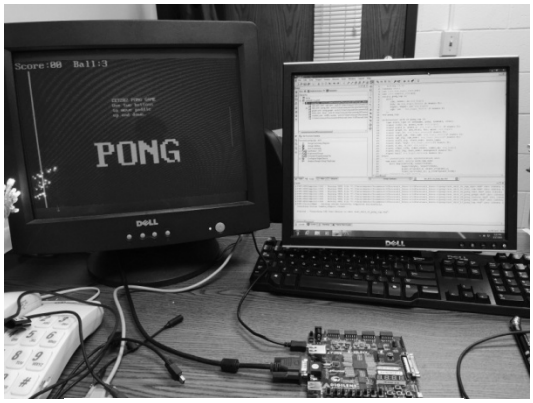

Figure 1. ISE suite and Nexys 3 FPGA prototyping board

Vivado support new 7 series FPGA chips from Xilinx. Figure 2 shows the screen shot of Vivado and a Basys 3 prototyping board using the latest Artix 7 FPGA chip. We are still experimenting with the new system, and it will gradually replace the ISE/Nexys3 setup, with better performance.

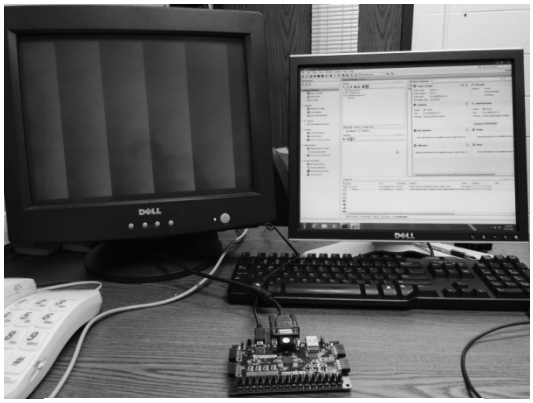

Figure 2. Vivado suite and Basys 3 FPGA prototyping board

XPS is used to quickly design an embedded hardware platform. Figure 3 is an example of an embedded system with dual MicroBlaze soft processor, AXI bus with two GPIO, and RS232 UART; four LMB memory bus which connect the 16KB and 8KB memory to the two processor. All the modules are provided as pre-existing IPs, and if needed, more circuit modules can be

added for analog, arithmetic, USB, Ethernet, DMA, and video applications.

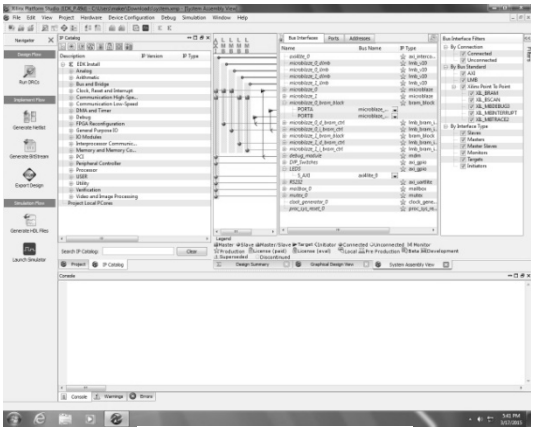

Figure 3. XPS screen shot

SDK will develop the firmware/software for the newly finished embedded system. SDK can be initiated either from within XPS, or independently. Figure 4 shows an example hello.c program, it can be compiled as a standalone .elf file, and then loaded to the memory of the embedded system. When the program executes, the ASCII code “hello, world” will be transmitted through RS232 serial interface. If a computer running a terminal program is connected to the embedded system with RS232, then “hello, world” will be displayed on the terminal.

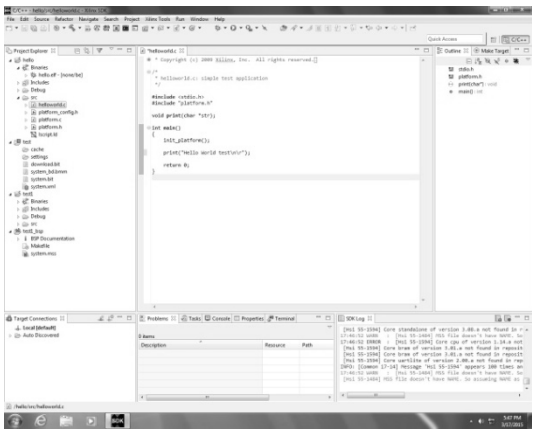

Figure 4. SDK screen shot

6. Summary

FPGA technology is a true revolution, it is an excellent tool for teaching, prototyping or small volume production of digital circuit and embedded systems. ISE, Vivado and EDK from Xilinx provide a complete solution for hardware and software design, simulation and implementation. All these packages are used in various courses and lab projects for better understanding of the course materials. The students will have hands on design experiences and master skills that are highly sought after, and its future is bright.

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