European Journal of Business and Social Sciences, Vol. 2, No.4 , pp 09-24, **JULY 2013.** **P.P. 09 - 24**
URL: *http://www.ejbss.com/recent.aspx*
ISSN: 2235 -767X

VIEWING PROJECT LAUNCHES INTO KNIGHTIAN UNCERTAINTY: ILLUSTRATED BY THE HOSPICE & PALLIATIVE CARE TRIAGE INITIATIVE

Edward J. Lusk, PhD, CPA
(Corresponding Author)

Professor of Accounting
The State University of New York (SUNY) at Plattsburgh
School of Business and Economics: Plattsburgh, NY, USA
luskej@plattsburgh.edu

Term Visiting Scholar 2013-2014
Leuphana Universität
Lüneburg, Germany
mgunkel@inkubator.leuphana.de

Emeritus, Department of Statistics
The Wharton School, University of Pennsylvania, Philadelphia, PA, USA
lusk@wharton.upenn.edu
Tel: +01.518.564.4190
Fax: +01.518.564.3183

Nellie Selander, BA, MUP
Consultant: New York University College of Nursing, New York, NY, USA
RWJ:IOM 80/20Project
nms337@nyu.edu

&

Michael Halperin, PhD
Director Lippincott Library of the Wharton School, University of Pennsylvania, Philadelphia, PA, 19014, USA
halperin@wharton.upenn.edu Tel: +01.215.898.9434

ABSTRACT

The United States is in the midst of grave fiscal conditions. In addition to overall economic instability—i.e., The "Fiscal Cliff, the cost of health care in the U.S. has exploded over the past half-century. There is a particular concern, given the aging baby boomer population, in that escalating end-of-life health care costs will soon overwhelm the health care delivery system [HCDS]. In 2012 in the May/June issue of Nursing Economic$, Kovner, Lusk, and Selander posited the general mission and basic strategic considerations for addressing the impending cost crisis called the KLS-Action Plan the focus of which is to lower end-of-life health care costs through the tandem coordinated use of Hospice and Palliative care. In 2013, Lusk, Selander and Halperin discussed the economic and political imperatives in play as they are likely to impact the sustainability of the KLS-Action Plan. In this related paper, using pilot test information we will illustrate a Decision Support System [DSS] programmed in Excel™ using open-access VBA®-code that can be used by health planners to test out that sustainability. In addition, we have used Knightian Uncertainty to develop the final introspective output of the DSS.The KLS-Action Plan DSS is available at no cost from the corresponding author and we waive all intellectual property rights to its use.

Key Words: *What-If Analysis; Likely Worst and Likely Most Optimistic Case Recalibrations, DSS, Sustainability*

1. Introduction

In *Our Changing Journey to the End*, Lusk, Selander, and Halperin (2013) evaluated the Hospice & Palliative Care Triage Model of Kovner, Lusk, and Selander (2012) (KLS-Action Plan), which introduces a plan to avert the catastrophic effect of the enormous costs currently devoted to caring for people in the last few months of their lives, combined with the aging baby boomer generation by swapping patients from expensive, acute care settings at the end of life to less expensive hospice and palliative care settings. Lusk, Selander, and Halperin (2013) note the following caveat to the immediate implementation or launch of the KLS-Action Plan:

> *In outlining the KLS-plan we have calculated that if in a hypothetical environment we could make a straightforward swap between hospital beds and hospice beds, substantial savings could be made. Such a swap is not realizable and the measurements necessarily are crude - - -. Nevertheless on a macro scale there is no question that medical care in the hospital is more expensive than care in the home or a nursing home.*

This caveat is the point of departure of our study. In this paper we will detail the functionality of a Decision Support System (DSS) that provides interactive decision maker support for conducting the necessary *What-if* analyses to evaluate not only the wisdom of launching the KLS-Action Plan, but also addresses the sustainability of achieving the plan in the planning horizon. The illustration of the DSS *is the subject of this paper*. The DSS is programmed in Excel™ using the open-VBA® code. The DSS is available from the corresponding author at no charge and there are no restrictions on the use of this intellectual property.

In the following pages, we will:

1.) Discuss the general context of the KLS-Action Plan, which is essentially a triage model, moving patients from expensive, acute care hospital environments to less expensive, but effective Hospice and/or Palliative care settings;
2.) Argue that the specification of the information needed to parameterize the DSS and so address the inherent planning issues needed to evaluate the feasibility of the KLS-Action Plan best fit in the Knightian framework of Measured Uncertainty (Knight, 1921) rather than probability profiling;
3.) Rationalize the need to consider What-If analysis as integral to better understanding the critical aspects of major macro-project launches such as the KLS-Action Plan;
4.) Develop a Normative Comprehensive What-If analysis for the DSS that is based upon the following elements:
    - (i) The Knightian concept of Measured Uncertainty extended to the creation of an interval context for the outputs of the DSS,
    - (ii) A Likely Worst Case and Likely Most Optimistic Best Case Analyses to measure the Range of Knightian Uncertainty,
    - (iii) The Empirical Rule to calibrate the Knightian decision-making intervals.
5.) Discuss and illustrate a VBA-Excel™ DSS that will aid health care delivery system (HCDS) planners in evaluating programmatic changes needed in how health care is delivered in the U.S. as it relates to launching the KLS-Action Plan.

2. The KLS-Action Plan: An Overview

In a Special Edition of *Nursing Economic$*, Kovner, Lusk, and Selander offered the eight-point KLS-Action Plan to reduce end-of-life health care costs in the U.S (2012). The KLS-Action Plan, derived from a synthesis of six articles contributed by experts in nursing and health care economics, offers two principal suggestions: 1) increase the percentage of American adults with advance directives, and 2) develop a triage model that moves more patients, when appropriate and in accordance with patients' advance directives, into hospice and/or palliative care treatment plans at the end-of-life.

In addition to being politically ambitious because it broaches the sensitive subject of end-of-life health care decisions, the KLS-Action Plan will also require significant investment on the part of governments and policy professionals in order to ensure its success as a worthy and fully developed health care policy. In their article, Kovner, Lusk, and Selander address the logic of the investment in the KLS-Action Plan:

> We fully recognize that the complicated systemic-dynamic change necessary to achieve our action plan will require pilot testing, re-design refinements, further pilot testing, a full-scale launch, and then monitoring and evaluation. We propose this action plan because at some point systemic change will happen; we want these change efforts to be pro-active – driven by design rather than re-active – not spawned by panic. (181)

Our research goal in this paper is to not to *per se* assess the feasibility of implementing a particular version of the KLS-Action Plan, but rather, to offer a DSS tool that may be a valuable modeling framework for health planners to investigate future configurations of the HCDS and to assess the possible impact of the KLS-Action Plan. Ultimately, our focus is to offer a modeling tool with What-If capabilities configured in the Knightian world of measured uncertainty. To illustrate this DSS we will use pilot test information, based on the implementation of the KLS-Action Plan. Hopefully this modeling tool will find currency in the macro-planning context and will eventually motivate changes in the HCDS, moving toward a system like that outlined in the KLS-Action Plan. Our analysis will also be sensitive to the temporal nature of implementing the KLS-Action Plan, showing sensitivity for the costs and benefits associated with significant HCDS changes. We will develop a "time to payback" ratio the investments needed to effectively launch and maintain the KLS-Action Plan or, alternatively, a plan like it, using standard present value computations to provide a context for our economic feasibility analysis results.

3. Exploring the Economic Feasibility of the KLS Action Plan Using a DSS

As the focus of this paper is to illustrate a DSS modeling tool, let us first underscore the critical importance of having invested the resources necessary to integrating a DSS into the macro planning process. The principal advantage of the powerful computing world is that it facilitates the creation of Decision Support Systems. A DSS provides an informational aid to the decision maker. DSSs are varied and run the gamut from simple data links that provide summaries of data streams connected to Excel™ or Word™ display platforms via General User Interfaces (GUI), to integrated interactive networked GUIs that generate expert systems information for decision makers.

A decision-making enhancement often integrated in DSS functionality is the simple idea of *What-If* analyses. A What-If analysis, in the DSS context, is the interactive re-parameterization of a DSS from which the DSS informational output is re-calibrated to refine the decision maker's understanding of the process under examination; it serves as a useful tool for decision makers to converge the range of possible acceptable predicted event outcomes to a feasible and desirable solution set. Such information is essential to evaluate the merits of sustainability and argue for it.

DSSs and related What-If analyses are not new concepts, individually; however their use *in combination* is just now achieving currency in application. Consider now a few projects that document uses of integrated DSSs in generating scenarios for sustainability that enables valuable projects and initiatives to continue. These projects, as reported in the literature, argue for the need of using integrated DSSs as a forum of interaction to address sustainability issues. They also demonstrate that one of the critical aspects of sustainability is projecting realistic scenarios that enrich the decision possibility space. The creation of such scenarios, of course, is no guarantee of longevity or sustainability over the planning horizon, but we believe that such scenarios enhance the likelihood of sustaining the launched project.

In this regard Bohner (2006) makes specific mention of selecting a "set of evaluation methods" to obtain a more complete simulation of urban dynamics effected via DSS modeling. In our paper we have selected the Knightian concept of measured uncertainty to form a decision variable set and, also, the DSS is programmed to encourage the use of What-If analysis. We will elaborate on these important aspects subsequently. Related and consistent support for a DSS as the holistic participative support montage is found in Maia and Schumann (2007) and Koh and colleagues (2013).

Consider now the subject of this paper, which is the creation of a Normative Comprehensive What-If DSS. In the following pages we will offer specific information that will illustrate the functionality of the DSS. This information will be drawn from informational sources that we recommend. Other decision makers and health planners may, of course, have other sources and so other parameter-setting information. The ability to use various sources is a positive feature of the DSS decision-making context.

4. Normative Comprehensive What-If DSS Model

In this section, we will present the five stages of information needed to form the model and then illustrate these stages with an example using specific, sourced information. For ease of identification, all the information and variables that are required to be inputted into the DSS will be noted in *italics* and all final output or calculated information will be noted in **bold**. For each of the sections, we will also make the same calculations that are programmed in the Excel DSS workbook. We will provide this "completed" illustrated DSS upon request.

4.1 DSS Section 1: Estimation of the Possible Number of Triage Swaps from Hospital to Hospice

In this section of the DSS, the decision maker will specify the *Decision Making Domain* and the *Duration of the Planning Horizon*, and gather source information to satisfy the following input fields: *Expected Number of Deaths in the Baseline Year*, *The Number of these Deaths likely to Occur in Hospitals*, and *Percent of Hospice Triage Swaps*. This information is then used to calculate the **Expected Number of Annual Triage Swaps to Hospic**e, meaning: the number of patients a HCDS planner could count on being able to move from an intervention-intensive, acute care setting to a hospice or palliative care setting.

For the purposes of illustrating Section 1 of the DSS, we used the following calculations and data sources. According to the National Hospice and Palliative Care Organization (2012), the number of deaths in the U.S. in 2010 was reported as *2,452,000*. Further, using information provided by Benson and Aldrich (2012), in 2007, *36 percent of deaths* occurred in a hospital setting. We assume this percentage is the same for 2010. Given this information, the estimated number of hospital deaths in 2010 was **882,720** (36 percent of 2,452,000). We also assume that this is the number of patients that can potentially move from hospital to hospice care at the end-of-life. Assuming that the number of Swaps from the acute care hospital environment to Hospice Care were to be *25%*, then the number of individuals that could be triaged from Hospital to Hospice would be **220,680** [882,720 × 25%]. Remember, these are sources that we chose; you, the decision maker, can use other sources, more applicable to your planning horizon and decision-making context.

4.2 DSS Section 2: Cost Differential between Acute Hospital Care and Hospice Care

This section of the DSS seeks to derive the cost differential for moving patients from hospital settings at the end-of-life to a hospice or palliative care setting, be it in a facility or in the home. To determine this cost differential, we had to first ascertain the *total terminal costs of patients* in various health care settings. For the purposes of this illustration, we chose data on North Carolina and used it to extrapolate information on the U.S., as a whole. According to Abernathy and colleagues (2011), the total terminal costs of patients in various health care settings in North Caroline, in which the patient died, is presented in Table 1. Once we had established these figures, we then calculated the *relative health care costs per capita* in North Carolina as compared to the U.S. average. As reported by the Kaiser Family Foundation (2012), in 2008, in-patient hospital expenses in the U.S. averaged $1,782; in North Carolina it was $1,515 (Abernathy, Kassner, Whitten, Bull, & Taylor, 2011).

Using this information, we formed an estimate of the *average cost of hospice deaths* in North Carolina by combining Hospice and Home Health Agency categories in Table 1; we found that in 2008, the average cost of hospice deaths was $19,529.50 (($19,249.00 + $19,810.00)/2). To calculate the *estimate for hospital deaths*, we combine the hospital and Skilled Nursing Facility categories, even though nursing facilities typically have more of a palliative focus than traditional hospital settings; this mix will, of course, be biased toward finding a smaller swap differential—i.e., conservative relative to our perspective. This mixed estimate was $29,059.00 (($25,842+ $30,603 + $30,732)/3). Then we adjusted these values using the *ratio of U.S. per cap expenditures to North Carolina expenditures*: $1,782/$1,515. This ratio calculation is entered in the DSS directly as: *1.176*. This yielded the following 2008 estimates, which can also be found in Table 1:

R1 Hospital: **$34,173.38** and Hospice: **$22,966.69**

Where $34,173.38 = $29,059.00 × (1.176)

As these are the 2008 projections of total cost per patient for those who died, they need to *be adjusted to 2012 levels*, as this is the base line year that we have selected for our analysis. In adjusting them to 2012 values, we decided to use annual compounding as opposed to continuous compounding. This is consistent with the way that percentage increases are reported by most government sources and so this information is readily available. The rate that we will use for projecting the 2008 values is 5.1 percent -- i.e., annual growth compounded at 5.1 percent per year, which we gathered from the Kaiser Family Foundation (2012). The formula for this is:

EQ1 $\text{Projected Year} = \text{Base} \times (1 + 5.1\text{ percent})^n$

Where, *n* is the difference between the year of the information and 2012, the year of the projection. This is the Excel Formula: *-FV*. Using EQ1 for the values in R1, we arrive at the following projections:

R2 **Hospital: $41,696.42** and **Hospice: $28,022.65**

Where: $\$41{,}696.42 = \$34{,}173.38 \times (1+ 5.1\text{ percent})^{(2012-2008)}$

This then allows us to calculate the savings from swapping a hospital death for a hospice death:

R3 Gross Swap Savings:

$13,673.77 = (**$41,696.42 – $28,022.65**)

As you can see from Relation 3, swapping a hospital death for a hospice death results in a gross savings of $13,676 per patient.

4.3 DSS Section 3: Cost of Construction and Conversion

Relation 3 (R3) above depicts the expected gross annual savings from swapping a hospital death for a hospice death; it is the case that if at this stage there is reason to believe that savings is not in the offing then the DM will have to re-form the parameter set as the underlying contingency is that the swap will create savings. However, nothing comes without a cost. Therefore, in this section of the DSS, we address the following question: What is the resource commitment needed to effect these gross per-patient annual savings?

Calculating the cost of swapping requires estimating the cost of construction of hospice and palliative care facilities, as well as the cost of renovating a home to accommodate hospice or palliative care. Using a Florida state agency report and a Washington state home health care facility proposal we found that in Florida, Washington, and Oregon there were two estimates of average per hospice bed construction: $241,000 (Florida Agency for Health Care Administration) and $236,000 (State of Washington Department of Health, 2012). The DSS takes the average and also reports the median should the decision maker wish to compensate for outliers that may skew the cost estimate. The average is: $238,500 [($241,000 + $236,000)/2]. Here we use the proposed costs of actual construction projects, rather than historical costs. We have chosen these proposed costs, as we want to use currently accepted and funded construction projects as examples of cost projections. In addition to creating new hospice beds, we also explored the costs associated with renovating a home to accommodate hospice care. We found the conversion costs associated with this to be $101,000 per residential conversion (Green House Project, 2012). Ultimately, the cost of caring for patients in a hospice or palliative care setting will require a mixture of the two costs outlined above.

Additionally, the DSS asks the decision maker if these estimates are representative of the regional average likely over the planning horizon. The decision maker enters a factor for the regional calibration. Proactively speaking, this factor is a calibration and usually is in the range [0.75 to 1.25]. The decision maker enters this and the cost estimates are recalibrated to reflect the regional context. For example, if the decision maker feels that the estimates are taken from a data source that is in a region where the cost are relatively low relative to the projected context, the decision maker may choose to use a factor of 1.10 to increase the estimates. In the DSS, we have assumed that the cost estimates are reasonable reelections of the likely future costs and so we used 1.0 as the factor.

To summarize Section 3, the DSS provides the following estimates:

New Construction: $238,500 [[($241,000 + $236,000)/2] × 1.0]

Residential conversion $101,000 [$101,000 × 1.0]

4.4 DSS Section 4: Percentage Utilization and Construction/Conversion Time Frame

A pivotal aspect of calculating the resource commitment of moving people at the end of life from hospital to hospice care settings is evaluating whether or not the hospice system can absorb, without capital construction, patient transfers from hospital settings to hospice or palliative care settings. Here, we are making an assumption that in every system there is slack. We assume that the average hospice system is operating at 90 percent productive capacity and so there is a possibility to swap 10 percent of current end-of-life hospital patients to hospice and palliative care settings without capital expansion. Further, most conservatively, we assume that the triage will place an individual in the particular care setting for a full year. The baseline we will use for the triage analyses is moving 25 percent of the patients who die in hospitals or 220,680 (882,720 × 25 percent). The next question then is where are individuals likely to die? Answering this will give an indication of the cost of providing for the expected number of patients that must be triaged.

Consider now the estimates in Table 2, which are based on statistics from the 2010 edition of the Centers for Disease Control’s report on the health of the nation (National Center for Health Statistics, 2011). These are the latest available statistics, which we have used to calculate the percent utilization of the slack in the hospice care delivery system.

Table 2 indicates that the current hospice system could absorb 60,349 additional or incremental patients; this number is the 10 percent slack in the existing system explained in the previous paragraph. The sum of the differences between Column 2 and Column 3 is presented in parentheses in Column 3 of Table 1. Multiplied by the total number of hospice patients, the number of new patients that can be *absorbed into the current hospice system* is *60,349* [5.86% × 1,029,840]. This means that the health care delivery system needs to grow to provide new facilities and/or encourage individuals to utilize hospice care in their own homes for *160,331* [220,680 – 60,349] hospital patients that cannot be absorbed by the slack in the hospice care delivery system. This information is entered in the DSS by the decision maker.

Above, we formally suggested a protocol for making this computation; however, as there are many ways that the decision maker can arrive at the number of *absorbed-hospice-patients* and, therefore, the *non-absorbed-hospice-patients*. We decided to omit this as a modular calculation in the DSS, as the decision maker may have sources of this information or may simply wish to enter a judgment value in the DSS.

Ultimately, the cost of caring for non-absorbed-hospice-patients will require a mixture of the two construction costs outlined in Section 3. Specifically, as hospice care is provided in private residences 41.1 percent of the time, then 58.9 percent (1− 41.1 percent) of non-absorbed-hospice-patients will receive care in newly constructed facilities rather than in their homes. Therefore, the number of patients placed in each type of hospice care environment, as calculated by the DSS, is as follows:

Residential: 65,897 (41.1 percent × 160,331)

New Construction: 94,435 (58.9 percent × 160,331)

The total mixed cost calculated by the DSS then is: **$29,178,237,863**;

calculated as: [(0.441 × 160,331 × $101,000) + (.589 × 160,331 × $238,500)]

4.5 DSS Section 5: Cost Savings from Hospice Triage

In this section we compare the swap savings of $13,677 that we originally calculated to the construction and conversion costs for the 25 percent of hospital patients that we believe can be, realistically, transitioned from hospital to hospice care settings at the end-of-life. This requires developing a plan for construction and conversion, and a corresponding time frame. Here we advise that such a major systems change cannot happen overnight, while maintaining high quality patient care; we are, after all, taking about people's lives. We propose a 10-year time frame for executing the 25 percent swap of hospital patients to hospice care at the end-of-life.

We selected 10 years as the time frame because it is what the Institutes of Medicine (IOM) used when advocating for reconfiguring the nursing education system – a process designed to help increase the capacity of the health care delivery system, while improving the quality of patient care (see Kovner, Lee, Lusk, Catigbak, & Selander, 2013). Specifically, the IOM committee on *The Future of Nursing* proposed, among seven other recommendations, to increase the proportion of nurses with a baccalaureate degree to 80 percent over ten years (80/20 Initiative) (IOM, 2011). As a point of information, these skilled nursing costs are NOT part of our cost calculations, as the cost of nursing and, in fact, all the medical costs are part of the relative cost of the two systems. Our only intention is to estimate the cost of the swap with the coincident availability of the personnel likely needed if the swap is affected.

4.6 Proposed Construction and Conversion Time Line

Although an ambitious timeline, we assume that construction and conversion will start in the first year of the planning horizon and that 50 percent of the needed capacity will be available by the beginning of Year 2. Further, in the second year the remaining 50 percent will be completed. Recalling that 60,349 patients will be absorbed each year, the savings, assuming conservatively that there is only one triage deployment per year, are estimated and presented in Table 3.

Year 3 is the stasis year at an annual savings of $3,017,527,564. As one can see in Table 3, in year two, 50 percent of the new hospice beds will be created. This will permit a swap of 50 percent of the 80,166 ((220,680 − 60,349) × 50 percent) hospice patients not already absorbed by the slack in the hospice and palliative care delivery system, for each of which the gross savings is $13, 673.77, or $1,921,362,955 total. Using the calculations above, after a little more than ten years, which is our planning time frame, the U.S. health care delivery system will have saved: $26,886,781,809 the Total Gross Swap Savings as calculated by the DSS: from Table 3 as (Year 1 + Year 2 + (8 × $3,017,527,564)).

The DSS then calculates the <u>key</u> <u>performance</u> <u>statistic</u>, the ratio of Expenditure Needed to Affect the Swap [and so create the savings] <u>to</u> the Swap Savings.[1] Specifically this ratio is called the **B**reak-**E**ven in **S**ustainability **T**ime [BEST]. In this case, the BEST ratio is:

BEST = 1.09 [$29,178,237,863 / $26,886,781,809]

The meaning of the BEST ratio is:

1. If the BEST ratio = 1, the time to Breakeven is the Planning Horizon suggesting temporal Sustainability at the balance point.
2. If the BEST ratio > 1, the time to Breakeven is longer than the Planning Horizon suggesting temporal Sustainability may not be achievable
3. If the BEST ratio < 1, the time to Breakeven is shorter than the Planning Horizon suggesting a likelihood of temporal Sustainability

The five sections outlined above are the first computational functionality cycle of the DSS; we used actual values from a pre-test of the DSS as the illustration presented above. That is to say that the above information is the exact information that one will find in the DSS. However, once the DM arrives at the Initial BEST, then it is time to consider entering the What-If phase as programmed in the DSS which is examined in detail following.

5. The What-If Re-parameterization Section of the DSS

At this point in the analysis the DM has formed the initial BEST ratio. Logically, if the BEST ratio is greater than 1.0 or even close to 1.0—indicating a possible problem with sustainability—the DM may want to test other possible reasonable parameters to develop a robust rendering of the DSS inferential signals. This, then, would lead to another BEST ratio based upon a recalibration of the DSS parameters so as to provide an enriched context for evaluating the temporal sustainability of the KLS-Action Plan within the planning horizon defined by the IOM's recommendations (IOM, 2011). In this case, this DSS recalibration is the second computational cycle of the DSS and is highly recommended. Following we detail the What-If protocol.

5. 1 What-If protocol: Recommended Stages to Developing the Recalibration of the BEST Ratio and the Requisite Knightian Interval Information

In the first two steps we outline below, the decision maker can generate a second valuation for the BEST ratio. Then we will delve into the creation of interval information that is needed to make inferential sense of the two BEST ratio point estimates. Consider now the two steps needed to generate the second BEST ratio point estimates.

1.) *Identification of the DSS Impact Variables* The essential decision that now needs to be made is to identify the two or three *impact variables* that are: (i) part of the DSS parameter set, and (ii) likely to impact in an important way the metric of evaluation. Recall that the metric of evaluation that we have been using and recommend is the BEST ratio.
2.) *The Re-parameterization of the BEST Ratio* The next step is to form, from collected re-parameterization information that pertain to the impact variables, the re-parameterization of the BEST ratio. Then, there will be two versions of the BEST ratio: The *Initial* [$BEST_I$] and the *Re-parameterization* [$BEST_{RP}$].

As these are point measures—i.e., each is a single measured output value—they are of little practical value in the decision making process. It is for this reason that we have programmed an interval calculation into the DSS. Consider now the technical development of this interval information; then we will offer a Decision Making Taxonomy.

5.2 Knightian Decision Making Intervals: The Inferential Context for the DSS

In 1921, Frank Knight published the definitive treatise on risk and uncertainty; it is still the standard. He makes the simple distinction between risk and uncertainty. According to his view:

> Uncertainty must be taken in a sense radically distinct from the familiar notion of Risk, from which it has never been properly separated. The term "risk," as loosely used in everyday speech and in economic discussion, really covers two things which, functionally at least, in their causal relations to the phenomena of economic organization, are categorically different. The nature of this confusion will be dealt with at length in chapter VII, but the essence of it may be stated in a few words at this point. The essential fact is that "risk" means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomenon depending on which of the two is really present and operating. There are other ambiguities in the term "risk" as well, which will be pointed out; but this is the most important. It will appear that a measurable uncertainty, or "risk" proper, as we shall use the term, is so far different from an unmeasurable one that it is not in effect an uncertainty at all. We shall accordingly restrict the term "uncertainty" to cases of the non-quantitative type. It is this "true" uncertainty, and not risk, as has been argued, which forms the basis of a valid theory of profit and accounts for the divergence between actual and theoretical competition. (p. 26)

Thusly, Knight characterizes uncertainty into two nuanced classes:

1. *Measured Uncertainty*—for a particular variable even though there is some measured or measurable incertitude nevertheless the decision maker has an opinion as to a specific value that may defended experientially. Simply put the DM is comfortable in specifying a value for the DSS variable in question. For example, such a variable is the likely cost of residential hospice in the near future. However, the DM does not have sufficient observations to form a probability density function that permits risk modeling of the variable merely a reasoned and defensible opinion as to the likely values of the variable in question.
2. *Unknowable or Un-measurable Uncertainty* – This is uncertainly where according to Knight the decision maker has no confidence because of lack of training or experiential proficiency in fixing any values to the variable. In this context NO valuation can be given to this variable and so it cannot be used in the DSS.

As suggested by Guennif (2002) and demonstrated by Chow and Sarin (2002), this Knightian view of uncertainty may be contrasted with probability risk where there are probabilities estimated for the variables in question. For this reason, where variables:

1. have been identified by the decision as important in the decision making context,
2. the decision maker <u>does</u> have the confidence to render a judgmental opinion in fixing valuation, but
3. for which there is <u>no</u> historical frequency profile so that probabilistic or risk projections cannot be anchored on a frequency profile, then

we will characterize these variables as *Knightian Uncertain*.

Given this argument, all of the variables in the KLS-Action Plan DSS are Knightian Uncertain. This is another way of indicating that the variables that are *Unknowable or Un-measurable Uncertainty* are not part of the variable set for the DSS. Therefore, the *Initial* [$BEST_I$] and the *Re-parameterization* [$BEST_{RP}$] are Knightian uncertain.

The next step is to form a decision-making interval around these Knightian uncertain BEST ratios that is consistent with the measured uncertainty that characterizes the nature of the decision maker's judgmental non-risk formation of the variables. In constructing these intervals, we will use *The Empirical Rule* [ER] first offered by De Moivre (1667-1754); see Hald (1998) for the underlying profile presentation of the ER.

In order to create the variation needed to form a decision making interval around the measured Knightian BEST ratios we will use *Range Information* generated under two assumptions:

1. The Likely Worst [LW] Case that could prevail over the planning horizon for the Knightian Impact Variables identified by the DM, and
2. The Likely Most Optimistic [LMO] Case that could prevail over the planning horizon for the Knightian Impact Variables identified by the DM.

The LW case is obtained by having the decision maker estimate the value of the selected impact variables using the LW case lens as the estimation context individually for each impact variable. Also this will be done for the Likely Most Optimistic (LMO) characterization of the impact variables.

5.3 The Knightian Interval and Decision Making Taxonomy

Assume that the decision maker using the DSS has now generated the following information:[2]

[$BEST_I$] = 1.09

[$BEST_{RP}$] = 1.27

[$BEST_{LW}$] = 1.42

[$BEST_{LMO}$] = .95

Using the BEST ratio expectations developed by the DSS to wit: [$BEST_I$] and the subsequent re-parameterization [$BEST_{RP}$], we suggest a 95% Empirical Rule interval. Given the de Moivre calibration for the 95% interval has the range of four standard deviations about the BEST central tendency—i.e., $\pm 2 \times$ Sd of the ER is the spanning range of the ER. Therefore, as we now have the range: [$BEST_{LMO} - BEST_{LW}$] then the estimate of the Sd will be:

Sd= ($BEST_{LMO} - BEST_{LW}$)]/4

Therefore the 95% Knightian ER interval which is $\pm 2 \times$ Sd of the ER the center of which will be one of the BEST ratios will be form as:

The Lower Value of the Knightian interval:

$BEST_i$ – [2* [($BEST_{LMO} - BEST_{LW}$)]/4)]

The Upper Value of the Knightian interval then is:

$BEST_i$ + [2* [($BEST_{LMO} - BEST_{LW}$)]/4)]

Where; ($BEST_{LMO} - BEST_{LW}$)/4 is the estimate of the standard deviation at the 95% marker for the ER—i.e., spanning range divided by four.

Specifically, for the information that we have developed above, we find the following:

The Lower Value of the Knightian intervals is:

$BEST_I$ – [2* [($BEST_{LMO} - BEST_{LW}$)]/4)]

$BEST_{RP}$ – [2* [($BEST_{LMO} - BEST_{LW}$)]/4)]

Or[Here using the exact values form the DSS]

1.09 – [2* (1.42 – 0.95)/4)] = 0.850

1.27 – [2*(1.42 – 0.95)/4)] = 1.034

The Upper Value of the Knightian intervals is:

$$1.09 + [2^* (1.42 – 0.95)/4)] = 1.320$$

$$1.27 + [2^*(1.42 – 0.95)/4)] = 1.504$$

Finally, the DSS forms the decision-making tableau for the two measures of the BEST ratio and their Knightian context of broken down in Table 4. Given that we now have the Point estimates and the Interval context, we now need a taxonomy to guide the decision maker in drawing the needed inferences. The Knightian context that we propose as our decision maker taxonomy follows on the *Min* and *Max* operators that are used to fix choice options in typically non-probabilistic decision-making problems. Here we follow basically the same decision logic as presented in Bird, Yeung, and Woolley (2012).

5.4 The Knightian Boundary Context for the Decision Taxonomy as Programmed in the DSS

Given that we have two intervals for $BEST_I$ and $BEST_{RP,}$ ratios, we offer the following exhaustive set of partitions, which are consistent with the conceptual boundaries implied by Rakow (2010):

I. *Condition I: Likely Sustainability*. If the *max* of the Upper Interval values among all the BEST ratios is ≤ 1.0, then the project is likely to be sustainable in the time horizon. Recognize this as a *max*[*max*] criteria, which is the *least accommodating* or *most demanding* test for *Condition I: Likely Sustainability*.

II. *Condition II: Unlikely Sustainability*. If the *min* of the Lower Intervals among all the BEST ratios is > 1.0, then then the project is not likely to be sustainable in the time horizon. Recognize this as a *min*[*min*] criteria, which is the *least accommodating* or *most demanding* test for *Condition II: Unlikely Sustainability*.

III. *Condition III: Unmeasured Uncertainty*. If Conditions I and II fail, and only one of the following conditions occurs, then we note this result as truly uncertain or un-measurable in a Knightian context—i.e., there is no way to rationalize an action given the parameter set used in the analysis. These OR conditions are:

  Only the *max* of the Interval Values for all the BEST ratios is ≥ 1.0 OR only the *min* of the Intervals Values for all the BEST ratios is ≤ 1.0

  When this occurs, we note this as a Discordant Analytic experience. In this case the recommendation is that the decision maker reconsiders all the relationals and their logical linkages to identify if there are relationships that lack logical time functional consequences. Recognize that this as the *most accommodating* or *least demanding* test for lack of true Knightian uncertainty as it represents the highest level of dissonances relative to the binary location pattern.

IV. *Condition IV The Straddle Scenario*. In this instance, which completes the arrangement possibilities, occurs *if* the *max* of the Lower interval values ≤ 1.0 AND the *min* of the Upper interval values is ≥ 1.0. Therefore, in this case each of the BEST ratios has the two lower boundaries positioned ≤ 1.0 and has the two upper boundaries positioned ≥ 1.0 — i.e., straddling 1.0. Or, the max of one Interval ≤ 1.0 AND the min of the other interval ≥ 1.0 in which case the Intervals are uniquely partitioned relative to 1.0 and in that sense straddle 1.0. When condition IV is signaled by the DSS, it indicates that there is not sufficient information to make an assessment of sustainability. In this case we recommend that the decision maker reengage the process that was used to generate all of the variables used in the DSS. Experience suggests that when *Conditions I*, *II*, and *III* fail the DSS was not populated with discriminating or decision independent variables, as the variety of outcomes was not sufficiently different to make a judgment. *Condition IV* is the very valuable signal that the decision problem was sufficiently well formed to locate it the Knightian decision context relative to sustainability.

In our illustrative case, developed using pilot test information, *Condition III*: Uncertainty obtains as:
Condition I fails [as *max[max]*[1.320; 1.504]→ 1.504 ***is not*** ≤ 1.0, and
Condition II fails [as *min[min]*[0.850; 1.034]→ 0.850 ***is not*** > 1.0, and
Condition III obtains as: The second OR condition where only *min* of the all the Interval Values [0.850; 1.034 : 1.320; 1.504;] → 0.850 ≤ 1.0 is true so Condition III is founded.

In this case then, *Condition III* is signaled by the DSS and so characterizes the likely event expectation. This suggests that the decision problem, as expressed through the variable set used in the setting up the DSS for the KLS-Action Plan, is not configured in a way so as to provide unambiguous decision making information regarding sustainability in a Knightain context. This suggests that the decision maker may wish to consult with others in order to re-form the variable relationals. In this case, perhaps the configuration used by the decision maker was not realistic or currently valid to create reliable sustainability information.

6. Summary

The Knightian taxonomy is suggested as a means of recognizing various conditions of analytic inquiry related to the output of the DSS. Using the concept of measured uncertainly we can arrive at four states;

1. Likely Sustainability: *Condition I*
2. Unlikely Sustainability: *Condition II*
3. *Condition III.* An indication that the variables in the DSS are not logically organized or, possibly, are not correctly scripted and that the decision maker would benefit from re-configuring the variable relationals and linkages.
4. *Condition IV.* An indication that the decision maker who populated the DSS did not use a sufficient rich or independent variable set to nuance the decision space, so the analysis is not specific due to the lack of sensitivity.

In these last two cases, following on the recommendations of Finch and Dinnie (2001), the decision maker may wish to invite more stakeholders into the decision-making context and so re-populate the DSS with other more independent variable sets. The idea of extending the DSS population to related stakeholders is also suggested by Thorburn, Jakku, Webster, and Everingham (2011) in a report on the use of DSSs as a means of distributing relevant decision making information among the decision making community.

The authors welcome possible collaborations in the use of the DSS and as indicted above are happy to share without restrictions the DSS-KLS version that we used in the pilot test.

Tables

Table 1. *Location of Death and Total per Patient Cost in North Carolina and the U.S., 2008*
Source: Abernathy et al., 2011, p. e5.

Location of Death	Total Terminal Cost per Patient in North Carolina	Total Terminal Cost per Patient in the U.S.
Hospice	*$19,249*	**$22,966.69**
Home Health Agency	*$19,810*	
Skilled Nursing Facility	*$25,842*	**$34,173.38**
Hospital	*$30,603*	
Multiple Settings	*$30,732*	

Table 2. *Location of Death and Expansion Potential*
Source: National Center for Health Statistics, 2011, p. 6.

Residence at death	Percent patients dying in setting, 2010	Percent expansion into 10 percent slack (Percent change)
Private Residence	41.1%	*N/A*
Nursing Home	18.0%	19.80% (1.8%)
Residential Facility	7.3%	8.03% (0.73%)
Hospice Inpatient Facility	21.9%	24.09% (2.19%)
Acute Care Hospital	11.4%	12.54% (1.14%)
Total Hospice Patients	1,029,840	60,349 (5.86%)

Table 3. *Cost Savings Associated with Swap Made by the DSS*

	Year 1	Year 2	Year 3
Savings	$825,198,346	$1,921,362,955	$3,017,527,564
Calculation	60,349 × $13,673.77	((220,680 – 60,349) × $13,673.77) × 50% + $825,198,346	((220,680 – 60,349) × $13,673.77) × 100% + $825,198,346

Table 4. Final DSS Knightian Markers and their Respective Inferential Intervals

Scenarios	**Decision Maker Evaluation Interval**
$BEST_I = 1.09$	0.850 to 1.320
$BEST_{RP} = 1.27$	1.034 to 1.504

References

1. Abernathy, A. P., Kassner, C. T., Whitten, E., Bull, J., & Taylor, D. H. (2011). Death Service Ratio: A Measure of Hospice Utilization and Cost Impact. *Journal of Pain and Symptom Management, 41*, e5-e6. doi:10.1016/j.jpainsymman.2011.03.004.
2. Benson, W. F., & Aldrich, N. (2012). Advance Care Planning: Ensuring Your Wishes Are Known and Honored If You Are Unable to Speak for Yourself. Centers for Disease Control and Prevention. Available at http://www.cdc.gov/aging/pdf/advanced-care-planning-critical-issue-brief.pdf.
3. Bohner, C. (2006). Decision-support systems for sustainable urban planning. *International Journal of Environmental Technology and Management, 6*, 193-205. doi: 10.1504/IJETM.2006.008261
4. Bird, R., & Yeung, D. (2012). How Do Investors React under Uncertainty? *Pacific-Basin Finance Journal, 20*. 310-327.
5. National Center for Health Statistics. (2011). Health, United States, 2010: With Special Focus on Death and Dying. Available at http://www.cdc.gov/nchs/data/hus/hus10.pdf.
6. State of Washington Department of Health. (2012). Evaluation Dated April 23, 2012, For the Certificate of Need Application Submitted by Community Home Health and Hospice Proposing to Establish a Hospice Care Center in Clark County. Available at http://www.doh.wa.gov/Portals/1/Documents/2300/12-14eval.pdf.
7. Chow, C. C., & Sarin, R. K. (2002). Known, Unknown, and Unknowable Uncertainties. *Theory and Decision, 52*, 127-138.
8. Finch, J. H., Dinnie, N. (2001) Capturing Knightian advantages of large business organisations through group decision-making processes. *International Journal of the Economics of Business, 8*, 379-403.
9. Florida Agency for Health Care Administration. State Agency Action Report on Application for Certification of Need. CON #9690 & 9691. Available at http://www.fdhc.state.fl.us/MCHQ/CON_FA/Batching/decisions/docs/2003-04/9690-91.pdf.
10. Green House Project. (2012). Home Economics: The Business Case for The Green House Model. Available at http://thegreenhouseproject.org/doc/21/business-case-full-web.pdf.
11. Guennif, S. (2002). From Knowledge to Individual Action: Confidence, the Hidden Face of Uncertainty: A Rereading of the Works of Knight and Keynes. *Mind & Society, 3*, 13-28.
12. Hald A. (1998). *History of Mathematical Statistics from 1750 to 1930*. New York: Wiley and Sons.
13. Institute of Medicine (IOM). (2011). *The Future of Nursing: Leading Change, Advancing Health*. Washington, D.C.: The National Academies Press. Available at http://www.thefutureofnursing.org/sites/default/files/Future%20of%20Nursing%20Report_0.pdf.
14. Kaiser Family Foundation. (Accessed November 17, 2012). State Health Facts. Available at http://www.statehealthfacts.org/index.jsp.
15. Knight, F. H. (1921). *Risk, Uncertainty, and Profit*. Boston, Massachusetts: Hart, Schaffner & Marx; Houghton Mifflin Co. Available at http://www.econlib.org/LIBRARY/Knight/knRUP.html.
16. Koh, S.C., Genovese, A., Acquaye, A.A., Barratt,P., Rana, N., Kuylenstierna, J., & Gibbs, D. (2013). Decarbonizing product supply chains: design and development of an integrated evidence-based decision support system - the supply chain environmental analysis tool. *International Journal of Production Research, 51*, 2092-2109. doi: 10.1080/00207543.2012.705042
17. Kovner, C., Chuo-Hsuan, L., Lusk, E. J., Katigbak, C., & Selander, N. (2013). Sustainability of the IOM 80/20 Nursing Initiative as Viewed Through a Decision Support System Supporting What-If Benchmarking Capabilities, *J. Sustainability and Management, 3*, (In press).
18. Kovner, C., Lusk, E. J., & Selander, N. Affordable Death in the United States: An Action Plan Based on Lessons Learned from the Nursing Economic$ Special Issue. *Nursing Economic$, 30*, 179-184.

19. Lusk, E. J., Selander, N., & Halperin, M. (2013). Advance Directives and Hospice Care: Cost Savers at the End. In C. Staudt (Ed.), *Our Changing Journeys to the End: Reshaping Death, Dying, and Grief in America*. Santa Barbara, California: ABC-CILO Publisher.
20. Maia, R., & Schumann, A. H. (2007). DSS Application to the Development of Water Management Strategies in Ribeiras do Algarve River Basin. *Water Resource Management, 21*, 897–907. doi: 10.1007/s11269-006-9106-3
21. National Hospice and Palliative Care Organization. (2012). *Facts and Figures: Hospice Care in America*. Available at www.nhpco.org/sites/default/files/public/Statistics_Research/2012_Facts_Figures.pdf.
22. Rakow, T. (2010). Risk, Uncertainty and Prophet: The Psychological Insights of Frank H. Knight. *Judgment and Decision Making*, *5*, 458-466.
23. Thorburn, P.J., Jakku, E., Webster, A.J., & Y. L. Everingham. (2011). Agricultural decision support systems facilitating co-learning: a case study on environmental impacts of sugarcane production. *International Journal of Agricultural Sustainability, 9,* 322–333. doi:10.1080/14735903
24. U.S. Department of Health and Human Services. Centers for Medicaid and Medicare Services. (Accessed on March 24, 2013). Hospice. Available at http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/Hospice/index.html.

Notes

[1] In this scenario we are assuming that the discounted cash outflows which happen in years 1, 2 and 3 and swap saving inflows which happen over 10 years have present value discounting factors so that the present values will balance out. In this case then one can use the 2012 baseline values and their projections. This is reasonable and also conservative as Medicare reimbursement is on a cost basis as so if the construction were financed using variable long term debt as is likely to be the case the costs would be recouped irrespective of the CPI variations. More simply put: The time to payback under cost reimbursement is reasonably the same for discounted or non-discounted time values in particular given the very low likely discount factor. To show that this is the case consider using the NPV *F(x)* in Excel the NPV for the Savings for the following parameter settings:

$NPV_{Savings}$*(52WeeksT-Bill Rate(20June13),* $NPV_{Construction}$, 825393273,1921816817, 3018240360,---,3018240360*)*

The $NPV_{Savings}$ is less than the one year stasis value. In fact, if we add less than 90 percent of the stasis value as an 11th year the $NPV_{Savings}$ is positive! Further, if one increases the NPV discount factor of the construction costs by 25 percent then the $NPV_{Savings} > 0$. All of this argues that even under the most conservative rendering of the relative comparisons we arrive at a payback of around 10 Years.

[2] The valuation for computing the alternative Best ratio used in the pilot were: *The Hospital/Hospice Differential* [$12,434]; *The Hospital/Hospice Slack Variable: Number of Patients Absorbed* [44,276]; and *The Weighted Average of The Cost of Construction & Conversion* [$173,701]. In this case the DSS produces a second BEST ratio: $BEST_{RP} = 1.27$.As for the Interval information, we have selected three impact variables: *The Hospital/Hospice Differential*; *The Hospital/Hospice Slack Variable: Number of Patients Absorbed*, and *The Weighted Average of The Cost of Construction & Conversion*. In the pilot phase we selected the following for the LW and the LMO parameters: LW[$12,920, 40,999, $198,222] and LMO:[$14,009, 63,298, $167,298] leading to a $BEST_{LW} = 1.42$. and $BEST_{LMO} = 0.95$. As this is programmed in the DSS we have not presented a detailed set of computations in the paper.