A Mathematical Model for White-Collar and Student Cognitive Turnover

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Abstract

This paper and subsequent presentation present a framework for measuring Cognitive Turnover. Cognitive turnover (CT) is a combination of the turnover thought process and the results of burnout. In essence it occurs when key employees show up for work and seem to go through the motions. In the educational arena it occurs when students show up for classes and go through the motions. This phenomenon is becoming an important issue for organizations. As a result of Cognitive Turnover organizations experience increased costs associated with health insurance, disability claims, lost productivity and retention. The mathematical model presented here will be beneficial for organizations in identifying these workers or students prior to the onset of behavior which impacts the bottom line.

Introduction

In the business community it has become critical that companies know how productive their knowledge workers are. One productivity issue is employees who show up for work and seem to go through the motions, but have mentally "quit" their jobs, often as a precursor to physically leaving. Similarly, in the education arena cognitive turnover is evident prior to students changing majors. In many cases students suffering CT become discouraged, lose interest in the subject, experience a drop in their grade and either change their major or leave the institution. This drawn out quitting process is termed "Cognitive Turnover (CT)" This research focuses on measuring knowledge workers and how they deal with challenges that may cause them to mentally depart from their jobs before they physically leave.

Recent estimates state that stress-related problems and mental illness (including depression) are costing businesses $150 billion annually in health insurance and disability claims, lost productivity, and other expenses. The costs associated with employee loss of productivity can be grouped into three categories—direct costs, indirect costs and indirect opportunity costs. Direct costs are those incurred as a result of stress and disability claims, worker's compensation claims, increased medical costs, and lawsuits, including wrongful discharge. Indirect costs include poor quality, high turnover, absenteeism, poor customer relationships, or even sabotage. Finally, indirect "opportunity" costs encompass lowered employee commitment, such as a lack of discretionary effort, commitments outside the job, time spent talking about the problem rather than working, and loss of creativity.[1]

Mental health experts estimated that up to 15 percent of executives and managers were suffering from depression or critical levels of stress that would eventually affect job performance. The most recent estimate is that stress-related problems and mental illness is costing business $150 billion annually in health insurance and disability claims, lost productivity, and other expenses.[1]

To adequately address the problem the phenomenon of CT must be measured robustly. Traditional models of burnout and aspects of turnovers have been tested, for the most part, on personnel after the events have happened. This research created a methodology that can be used in a proactive manner to identify troubled populations.

Literature Review

Cognitive Turnover Background

Cognitive turnover (CT) is a combination of the turnover thought process and the results of burnout which affects white collar workers. It is important that we define the items that make up the background of cognitive turnover. The next sections will define white collar workers, turnover, and burnout.

White-Collar workers

The white collar worker is usually distinguished from the blue collar worker, as personnel whose core task is normally thinking, while the blue collar worker's core task is usually doing. The white collar worker can be categorized as a knowledge worker. Students in technical majors like engineering, science and mathematics can also be considered as a knowledge worker. The term knowledge worker was first coined by Dr. Peter Drucker in the 1960s as any work that requires mental power rather than physical power[2]. Further defined as work that involves analyzing information and applying specialized expertise to solve problems, generate ideas, teach others, or create new products and services[3]. It is difficult to define knowledge work in more detail because knowledge work is invisible-it is hidden away in the head of the knowledge worker[2]. Because of the difficulty to measure white-collar workers production, this research provides a method of measuring their production.

Turnover

Turnover is defined as voluntary cessation of membership in an organization by an individual who receives monetary compensation for participating in that organization[4]. Turnover has cognitive indicators that predict eventual departure. The conditions indicated prior to cessation, can be utilized to describe an aspect of cognitive turnover. This definition emphasizes voluntary behavior because prevailing turnover models primarily seek to explain what motivates employees to withdraw from the workplace. This notation excludes individuals who work without payment, such as volunteers, students, and members of unions or fraternities.

Burnout

Burnout is the mental dissonance from organizational pressure[5]. It occurs when people, attempting to cope with complex situations that burgeon more rapidly than do the skill and attitudes that permits successful coping[5]. Some researchers associate burnout and low productivity. In this research, the gap between the pre-turnover employee who has thoughts of leaving the company along with burnout symptoms, and the potential loss of productivity for companies has been bridged.

Statistical Evaluation of Cognitive Turnover Control System (SECtCS)

The methodology developed for measuring Cognitive Turnover is called Statistical Evaluation of Cognitive Turnover Control System, or SECtCS. This methodology was created by Jones during his dissertation work[6]. The SECtCS methodology utilizes Statistical Process Control (SPC) in evaluating Cognitive Turnover. The idea that statistics may be important in assuring the quality of products and processes goes back to the advent of mass production.

Statistical quality assurance includes mainly three techniques, quality control, establishment of tolerance limits and acceptance sampling. The word quality, when used technically, refers to some measurable property of a product, process or in our case a condition.

In order to assure quality, a process has to have variability that does not fluctuate greatly between products or process. Quality is defined in this research as respondents not having a CT measurement beyond what is considered normal. When the variability present in a process is confined to chance variation, the process is in a state of statistical control. This state is usually attained by finding and eliminating the problem that is creating the variation, called assignable variation. Most processes often have this variation, and the most common method for detecting serious deviations is by using control charts. There is a differentiation between control charts for measurements and control charts for attributes, depending on whether the observations with which the researcher are concerned are measurements that count data. This research is a control chart for measurement[7].

The SECtCS methodology is to be implemented in six phases, Phase 1 – analyze, Phase 2 – model and score, Phase 3- chart and evaluate, Phase 4 – intervention, Phase 5 – chart and re-measure, Phase 6 – Publish and disseminate. We describe the phases which identify and measure cognitive turnover in detail below, phases 1-3.

Phase 1 (SECtCS Analyze)

The objective of Phase 1 is to develop a specific test instrument by collecting data on burnout, fatigue and motivation using a questionnaire. The questionnaire developed uses a summated rated scale methodology. The summated rating scale is one of the most frequently used tools in the social sciences. Its invention is attributed to Rensis Likert, who described this technique for the assessment of attitudes. These scales are widely used across the social sciences to measure attitudes and description of people's lives. The questionnaire has been developed and undergoing additional testing to insure reliability and validity.

Phase 2 (SECtCS modeler)

The objective of Phase 2 is to analyze the data collected and incorporate it into a mathematical model suitable for measuring CT at the organization. This analysis takes place via scoring of the instrument and interpretation of results. In this initial study a multiple linear regression was performed.

Phase 3 (SECtCS evaluator-i)

The objective of Phase 3 is collect data from the modeler for the statistical measurement of individuals with respect to the organization (SECtCS evaluator-i). "Evaluator-i" is the initial SPC chart determined for the respondent, department, or organization; it will be used as the baseline to measure the future results against. Using the CT index determined from the SECtCS modeler, we will use statistical process control charts to evaluate the results. The typical SPC chart is designed to monitor a stable manufacturing or service process, where the measured parameter is expected to remain relatively constant. Evaluator-i charts are very similar to a typical SPC chart, yet they have some adjustments. They are similar with respect to the central line, the UCL, and LCL lines, zone calculations, axes normalization, and the pattern-analysis rules. The first modification would be to change the use of the historical data to calculate the central line, the UCL and LCL lines, and the zones.

In a typical SPC chart, historical data may be based on a set of sample measurements from a single production process. Each individual measurement is a sample measurements in a sample set taken immediately after the other in order to capture the process performance at a specific point in time. The historical data is then utilized to calculate chart components. In the development SECtCS SPC charts, we use for our historical parameter data on "n" number of respondents, the different "Cognitive Turnover" mean scores for similar professionals. This approach is related to the chart of individuals for manufacturing processes[8].

Second, the parameter values plotted on the y-axis. SPC charts plot actual measurement values. Each point on the chart is intended to reflect the current state of the system. This approach allows for instantaneously detecting of changes in the normally stable process. Because it has been noted in our research that the length of time that an individual stays at a company keeps them from leaving because of benefits and pension investment the propensity for "cognitive turnover" to increase over time may distort findings.

In this research the charts for individuals is utilized as opposed too more traditional charting techniques. Examples in which individual charts for individuals, otherwise known as xcharts, are used include accounting data, such as shipments, orders, absences, and accidents; production records of temperatures, humidity, voltages, or pressure; and the results of physical or chemical analyses.

The main advantage for control charts for individuals is that specifications can be drawn on the chart and compared directly with the control limits[3]. In practice these individual measurements allow process standard deviations to be estimated and three-sigma control limits used[3]. Because of this fact charts for individual measurements are also used to help shop personnel, who often misunderstand charts for averages, better understand quality charts[9].

Cognitive Turnover (CT) scores are charted on an individual event as opposed to the averages of the CT scores for the individual, because this was more appropriate when measuring Cognitive Turnover (CT). With this type of chart, the sample size for process control is 1 as opposed to the traditional sample size of 5 to 6. The main differences between the control charts for individuals and the traditional x-bar control charts are that the control chart for individuals tracks independent variables.

Chart Component Calculations

The test population and sample group were identified earlier from the SECtCS analyzer. Since we are testing to identify respondents who have excessive CT trauma, we will utilize a chart that was derived from a normal group. This allows the identification of excessive CT to be identified by the SECtCS control chart.

The questionnaire variable data for the non-CT respondents was utilized to calculate the central line, UCL, and LCL lines, and the zone boundaries. A chart of individuals approach is utilized here.

Results

In previous research, a representative sample of 51 white-collar workers were identified and measured for cognitive turnover and there information was utilized for creating the control charts. Then a representative group of 10 white-collar worker respondent's CT indices were measured on individual Statistical Process Control Charts and tracked utilizing the SECtCS CT. Results were that the respondents which the model identified as CT and when charted over a 12 week period validated they showed out of control run patterns and had cognitive turnover. Also, respondents who were non-CT's did not show out of control run patters. This research focused on white-collar workers who were utilized as knowledge workers and project managers. One limitation is that jobs were loosely designed and did not use specific methods and procedures but required specific background or training in order to be considered engineers[10]. Another limitation of the theory is that more respondents need to be studied for further validation of the model. This is currently being addressed via additional studies being conducted with engineering students who are considering changing their majors out of engineering.

Conclusion

In conclusion the SECtCS modeler can be utilized to identify and measure unproductive knowledge worker behavior. After using the SECtCS modeler respondents then should be tracked on a SECtCS Control Chart or Statistical Process Control Chart that will indicate if there are institutional problems or individual despondency. Also, tough decisions may have to be made. If a department is showing an extreme amount of CT there should be some intervention taken by the organization. Further extremely high scores of CT should be monitored for personnel because it may indicate some possibility of sabotage for the company and nervous breakdown or other physical impairments for the employee. Further, this methodology can be used to identify "at risk" students who are considering changing majors out of the science and engineering.

The contribution to the body of knowledge for this research is the SECtCS methodology. The Statistical Evaluation of Cognitive Turnover System (SECtCS) is a noninvasive repeatable methodology that includes the usage of a reliable and valid questionnaire that can be scored and placed in a predictive model. The SECtCS methodology can potentially go into any organization and indicate what independent variables are relevant for that organization and then score the employees who work there. The true benefit is that after the personnel are scored, the scores can be utilized to determine if a department, group, project, or organization as a whole has an out of control Cognitive Turnover group. This methodology becomes even more robust when measuring and comparing groups of similar workers like teams. Upon identification some type of intervention can take place for these knowledge workers or teams and will allow the company to make their personnel more profitable or cut their losses on personnel or departments that are not providing the productivity that is necessary for the group, project, or organization to remain profitable from this team. Further this methodology will add to the engineering management curriculum a technique for educators to teach engineering management students how to measure and manage white collar workers and other knowledge worker populations.

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