Structural Modelling and Consumer-Driven Decisions: a New Synthesis to Put Content Into the Structure

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Abstract— ***This paper presents a new way to understand relations between variables. The paper combines two methods, structural equation modelling and experimental design of ideas. The objective is to first reveal relations between variables through the structural modelling (i.e., what the system is or does), and then identify in a deeper fashion the relation between two variables that structural model reveals to be linked together. The paper thus synthesizes two well-investigated areas into a new combination, mixing high tech (structural modelling) with high touch (experimental design of ideas). The paper outlines the approach using electronic health records as an illustrative example.***

I. Introduction – Structural Modelling and Bare-Boned Relations Between Variables

STRUCTURAL equation modelling (SEM) enables research to answer a set of correlated research questions by means of a single, systematic and comprehensive analysis. This is done by modelling the relations among multiple dependent and independent constructs in a simultaneous rather than a sequential fashion. Simultaneity in analysis differs profoundly from most linear and thus sequential approaches, namely the regression-based approaches such as analysis of variance, linear regression, and the like.

Structural equation modelling and regression techniques such as LISREL and partial least squares (PLS) and (AMOS) are second generation data analysis techniques that can be used to test the extent to which the structure of the relations among variables is correct. The literature behind structural equation modelling is well worked out, and now available on many personal computers, as a statistical package (e.g., Anderson & Gerbing, 1988)

The literature using structural models focuses primarily on the interrelations between variables. For example, with a structural model one can create a coherent 'structure' that allows one to test specific hypothesis. For example, in some of the work presented by the senior author (HB) on the adoption of electronic health records (EHR). one of the hypotheses is that Individual Organisational Characteristics will have shared correlation matrix impact on the usefulness of EHR (electronic health care records). To exemplify this approach consider the structure in Figure 1. Structural equation modeling will use the correlations to identify these general relations. Looking at the statement of the hypothesis we see only a relation between variables. We have no idea from the representation of the model, or from the mathematics of SEM how an independent variable can be changed to produce a desired change in the dependent variable. That is the SEM approach is content-free, and only looks for structure.

Hypothesis to be tested by structural modeling: Individual Characteristics, Individual Organizational Characteristics, General Attitudes and Usefulness of EHR will have shared correlation matrix impact on AIU- EHR

AIU-EHR: The actual individual usage of EHR. It is defined as the average time each EHR function is used per week by the specific personnel in charge if the EHR system is used.

Individual characteristics: It is defined as the cognitive structure of every department manager (CS)

Attitudes: It is defined as The General Attitudes of each manager (GA)
General Attitudes to EHR (GA)

Individual Organizational : It is defined as the years spent by a manager in an organisation (Yrs)

Usefulness of EHR: It is defined as attitudes towards contribution. (AC)
Attitudes to EHR Contribution (AC)

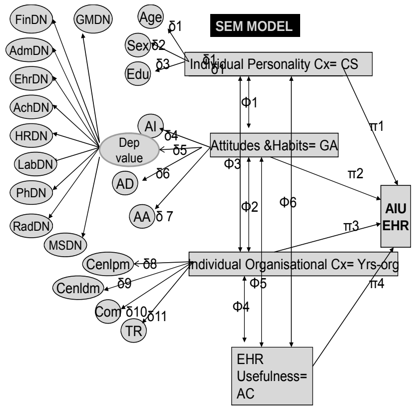

Figure 1: An example of different variables related to each other by structural Equation modeling, and the graph of this model. Note that SEM looks only at structure, not at content within the structure

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2. Adding Content to Structure or "High Touch" to "High Tech"

Despite the ability of structural modeling to explicate and confirm compound relations among variables, the models miss the richness of content that might be added by a professional, albeit perhaps in descriptive fashion. We know that variables behave in a way to suggest relations, and that the correlation matrix may suggest intervening variables that can be hypothesized to 'make relations work out'. What we miss, however, are words and phrases that give some type of vitality and 'realness' to the nodes on the structural model. That is, looking at Figure 1 (the structural model) we see that certain variables are related to each other, yet we don't really sense any of the descriptive richness that provides more meaning to the model. Of course, using many different Likert scales to generate a single variable in Figure 1 could add some of the meaning. The researcher would have to abstract the meaning from the anchor points on Likert scales and the scores on these scales.

Let's move in a different direction, going beyond the bare-bones structural model shown in Figure 1. Let's assume that the model is correct. Let's now flesh out the model. The question is how. The rest of this note deals with an approach based in experimental psychology (stimulus-response) and in statistical design of experiments (so-called conjoint analysis).

Our basic goal in this part of the paper is to identify richer language for each variable in the model, so that the structure we develop has more meaning that simply showing the existence of relations. We illustrate the approach by looking closely at two variables that are connected in Figure 1. These are attitudes and habits as one variable versus the perceived usefulness of EHR as the other variable. How can we flesh out relation of these variables to each other in a way that lets the researcher create desired changes in the dependent variable by systematically varying the content of the independent variable?

3. Thinking in the Mode of Stimulus-Response (S-R) and Experimental Causation

Let us focus on the perceived interest in EHR as driven by two sets of variables – the respondent's attitudes and habits on the one end, and the perceived usefulness of EHR on the other. We know that attitudes and usefulness are related to each other, but we really need to have a more profound sense of how they interact to drive a response such as interest in HER (see Anderson, 1970). Notice that we are moving here from establishing the existence of co-varying aspects to understanding what drives the professional's mind. We move from the sociological and statistical approach of establishing structure to the psychological approach of establishing content or simply what specifically can one say to drive the response..

To understand the mind we move from the world of correlations between variables to the world of experimentation and causation. Rather than using the research to establish that there exists a structure, we are going to use experimental design to establish part of the structure (Moskowitz, German & Saguy, 2005). The outcome will be a causative model. That is, we will be able to plug in some variables and estimate the response to those variables. We will plug in statements about attitude toward medical care, and attitudes towards EHR and come out with a prediction of 'how well this describes today's health care reality'. Our experimentation will thus add another dimension to structural model – filling in the deeper structure of the mind at each of the nodal points.

The 'how' in the S-R approach is straightforward. We I create different elements to describe the current state EHR from the point of view of description of what EHR is/does, and statements about how professionals respond to EHR. These are our independent variables. We want to learn whether a medical professional or a consumer, reading these elements combined into vignettes (independent variable) will be excited about EHR or just indifferent to it (dependent variable). This response is our dependent variable. Note that in the typical SEM model there is only a linkage and a correlation. Conventional SEM modelling does not drive the relation further, beyond description, to structural causality and engineering control. Hence the synthesis here.

4. Steps in the "High Touch" – How Information About EHR Might Cause Interest in It

Our experiment to 'flesh out' the structural model uses experimental design of ideas (Box, Hunter & Hunter, 1978), also known as conjoint measurement (Luce & Tukey; Moskowitz, Porretta & Silcher, 2005; Wittink, Vriens & Burhenne, 1994). Our goal here is to understand how the specific elements of 'attitude' and response to EHR drive the response of 'How do you feel about EHR based upon what you just read?'. Even if the respondents cannot rationally deal with individual items as describing health care reality, they can intuitively respond to combinations of elements. These elements, in turn, interact with each other to drive the response, and from regression analysis we will see what elements are most critical.

Step 1 – Create a matrix of ideas to flesh out the specific variables. The ideas are simple, stand-alone phrases. They will be later combined into vignettes or test concepts. Table 1 shows the four silos (A-D) and the three elements in each silo. These phrases add texture and dimensionality to the variables of attitudes and responses to EHR.

Code	Element	Utility
	Additive constant	**26**
	Silo A - EHR from the viewpoint of the health provider	
A1	EHR makes the health care job easier	6
A2	EHR. makes hospital services more efficient	9
A3	HER Increases the quality of care given to patients	8
	Silo B - Outcomes of EHR from an economic view:	
B1	EHR makes hospital administration cost efficient	5
B2	EHR makes patient care quality and cost efficient	6
B3	EHR solves many problems..but will create many new ones	-4
	Silo C- Attitudes: Resistance vs acceptance of EHR:	
C1	Studies suggest that in quite a number of cases physicians still resist EHR	-3
C2	Studies reveal that older physicians tend to resist EHR than younger physicians	2
C3	Studies suggest that EHR is accepted more readily by those with more education	4
	Silo D - how the industry perceives EHR:	
D1	EHR will be accepted when the industry and the market are ready… trend reports suggest this will be fairly soon	7
D2	EHR will be accepted when the government recommends it	6
D3	EHR will be accepted when the hospital or organization decision makers finally agree to it	5

TABLE 1 – LIST OF SILOS AND ELEMENTS, AS WELL AS DATA FROM A SMALL PANEL OF RESPONDENTS WHO PARTICIPATED. DATA FOR ILLUSTRATIVE PURPOSES ONLY.

Step 2 – Invite people to participate, and introduce the project. Figure 2 shows an example of the introduction or orientation page.

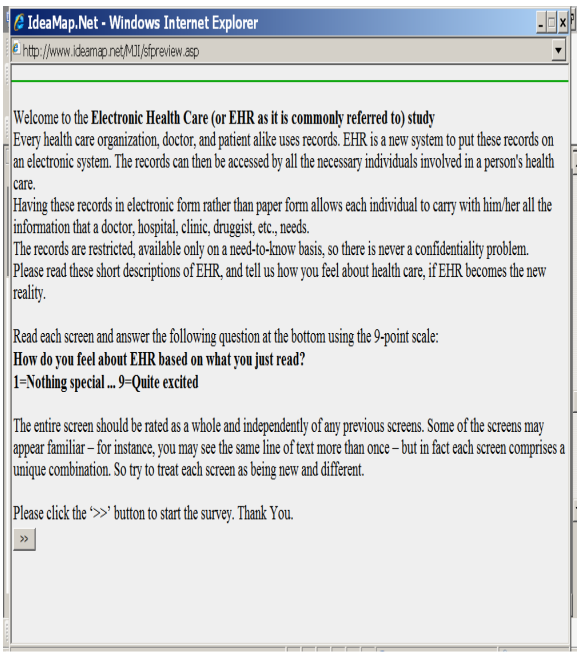

Figure 2: Orientation Page

Step 3 - Mix and. match these elements into small, easy to read combinations (test concepts or vignettes). These represent small communication pieces about the state of the medical profession, with specific focus on EHR. Figure 3 shows an example of a test combination. Present different combinations of these vignettes to respondents, get ratings. This step is done entirely by computer, which does all the relevant mixing/matching to create the vignettes, presents the stimuli, acquires the data and does immediate data processing. The combinations are created by experimental design, allowing for regression modelling (e.g., ordinary least squares).

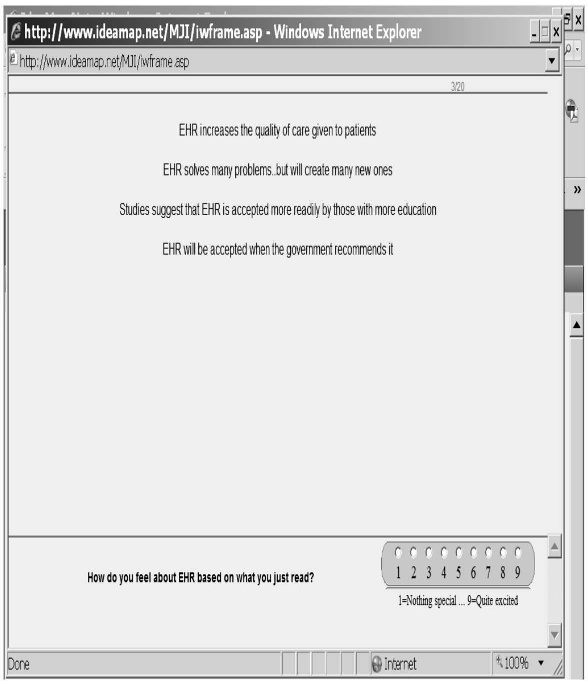

Figure 3: Example of a test concept and the rating scale

Step 4 – Using ordinary least-squares regression analysis, relate the presence/absence of the elements to the rating (How do you feel a bout EHR based on what your just read?). Create this model for each respondent. It is here that the content is added. The original SEM had suggest a relation between information and response of professionals. Now we know a more precise relation between specific information and the magnitude of the response.

Step 5 – Use the results of the model to show how each individual element describes the health care reality. We see a demonstration of this database in Table 1 above, on the right hand column. The additive constant shows the proportion of respondents who are excited by HER, either basically (additive constant), or as a function of the message.

In this case we have an additive constant of 26, meaning that 26% of the respondents are basically interested in what EHR has to provide, even without any elements.

There are many positive elements that add to this excitement. One element in particular adds an additional 9%. This element is EHR .makes hospital services more efficient. Some elements, however, diminish excitement. Here is one element that reduces excitement so that 4% fewer respondents are excited, i.e., a negative utility: EHR solves many problems..but will create many new ones.

Step 6 – The utility values can be added to the constant to come up with an expected percent of the respondents who would be excited by EHR. The sums (constant + up to 4 elements, one per silo) have ratio properties. That is, a sum of 56 represents 56% of the respondents, which is twice as much as a sum of 28.

5. *Discussion*

Traditional structural modelling, like traditional regression analysis, uncovers a set of relations that we might consider to be ‘bare bones’. We know what variables relate to each other from Figure 1, but in reality we have no sense of what these variables are about, or how strongly they relate to each other. In a sense Figure 1 shows the architecture, but without content.

We are looking at the architectural plan in Figure 1. This paper shows how that plan can be used by the interior designer, to add vibrancy and life to the plan. Carrying the metaphor a bit further, we can say that structural modelling provides the general architectural plan, but the infinite variety within that plan can better be done by studies using experimental design of ideas (see Moskowitz & Gofman, 2007).

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