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# Links and Levels: Minimizing Problems in Cross-Functional Research Using the Principles of Data Modeling

**Diane H. Parente,** Pennsylvania State University - Erie

Sustainable competitive advantage in an organization arises from distinctive competencies that reside deep within the organization. Capabilities, or the way things work together, are intangible sources of distinctive competencies that are not easily imitated. Cross-functional capabilities within an organization are perfect candidates for such distinctive competencies because they are both hard to observe and difficult to imitate.

Operations is a function that interfaces with most other areas within the organization. Therefore, it is easy to conceptualize much of the interest in cross-functional research having operations as one side of a dyad or triad. For example, the manufacturing-marketing interface has been an area of academic research for over 30 years (Lawrence & Lorsch, 1967). Although much of the work on the manufacturing and marketing interface was precipitated by marketing (e.g., Jaworski & Kohli, 1993; Kahn, 1996; Kahn, 1997; Kahn & Mentzer, 1994; Kahn & Mentzer, 1998; Kohli & Jaworski, 1990; Reukert & Walker, 1987), the recent increase in Operations Management survey research (Amundson, 1998; Malhotra & Grover, 1998; Scudder & Hill, 1998) has opened the door for significantly more cross-functional research centered on POM.

However, while the importance of cross-functional capabilities is recognized in industry, cross-functional design is less common in POM research. In fact, cross-functional research carries such unique problems and challenges that we may wonder if these complications have stunted the advancement of research in this area.

One of the challenges is that of the *multiple informant design* of research projects. In this design, there may be a dyad, triad, or even a network of respondents of interest as well as multiple constructs of interest.

Multiple informant methodology has been used in a number of different areas (Anderson, 1985; Krannich & Humphrey, 1986; Romney, Weller, & Batchelder, 1986). Marketers and organizational behavioralists have used this research design, and, while patterns of research also emerge in psychology, sociology, and anthropology, in particular, the use of multiple informant techniques in most fields is limited. Methodologically, issues of informant accuracy (Bernard, Killworth, Kronenfeld, & Sailer, 1984) and measurement (Kumar & Dillon, 1990; Kumar, Stern, & Anderson, 1993; Phillips, 1981) are topics commanding past interest. However, a search of the literature doesn't give us any tips as to how to manage multiple informant data collection or analysis.

What is the difference between the more commonly used single and the less-used multiple informant design? The answer may lie in the difference between a "flat file" and a "database." A *flat file* is a term used in information systems that refers to a one-dimensional set of data elements that all describe a single unit. A *database* is a shared collection of files and associations between the files. A more complex and robust answer is demanded by a cross-functional design.

An example of one way to approach the challenges of multiple informant issues is data modeling. Using these principles

**Diane H. Parente**

*is an assistant professor at Pennsylvania State Erie. Her PhD is from the State University of New York at Buffalo. She is a second-career academic with industry experience in a variety of functional and cross-functional positions including operations, MIS, marketing, logistics, international management, and strategic management. Her research interests include cross-functional strategy and business simulations. Her teaching interests are in strategic management, operations, and international business. She has published in* IJOPM, Journal of Healthcare Management, *and* Simulations & Gaming Across Disciplines and Cultures.

**email: dhp3@psu.edu.**

allows a straightforward design of the data collection and analysis to enable us to analyze the data in a variety of ways. Further, data modeling clarifies the spider web of data in a dyadic design and lays a foundation for triad and network research design, thus allowing a more robust analysis. This paper begins with a short discussion of data modeling followed by an example of its use in a multiple informant design.

## Data Modeling

A *data model* is a map for organizational data that includes entities and relationships that are important to the business. Managing information is important in an organization for cost-effective development and operation of information systems. Poorly implemented systems frequently result from a lack of efficient data management. Developing an understanding of the relationships between data is critical in managing the data resource. Similar statements can be made concerning academic research—particularly survey research.

A database is created by first identifying and illustrating the business associations or relationships that exist between the various data components. This may be called the conceptual design, or abstract representation of the data. Typically, an entity-relationship diagram is used in this stage to enumerate the relationships between components as 1 to 1, 1 to many, or many to many.

Design of the physical model follows in which the designer pays attention to several key aspects of the process. These include identifying the characteristics of the entity that distinguishes it from another. The second aspect is that of naming conventions. Meaningful and unique names must be given to each data element. If naming is not done appropriately, confusion may result in both common usage as well as in the data analysis. Naming conventions, or templates, are often developed at this stage.

## Example in the Manufacturing–Marketing Context

Much of the prior work in the manufacturing–marketing interface has been done comparing the two functions on a broad basis (Jaworski & Kohli, 1993; Kahn, 1997; Konijnendijk, 1993; Narver & Slater, 1990; Powers, Sterling, & Wolter, 1988; Prabhaker, 1995; Rho, Hahm, & Yu, 1994). Lawrence and Lorsch (1967) compare salespeople to manufacturing managers, and Kahn and Metzer (1994) discuss norms that distinguish manufacturing and marketing people. Knowledge of both sales and production highlights the importance of specific pairings of marketing and manufacturing managers. These dyads create different dynamics of the relationship which could lead to different outcomes. Therefore, linking specific manufacturing survey responses to specific marketing survey responses is one issue of cross-functional research.

Further, in an industrial setting, both manufacturing and marketing individuals can be involved in multiple dyads. For example, each manufacturing manager may provide products to multiple salespeople, while each salesperson may sell multiple products that are each produced by different manufacturing managers. Once the logical assumption is made that the dyad of one specific salesperson and production person will be different from another, it becomes necessary to keep track of and analyze dyads that have common members.

Evaluation of the interaction between sales and production at the product level mandates a statement of the relationships that exist in the population of the study. For example, in one of our recent studies, multiple respondents were surveyed on the various constructs in the model. The constructs of interest were represented in this research by the unique combination of a customer who buys a specific product, the salesperson who sells the product to that customer, and the production manager who manufactures the product (see Exhibit 1).

The data were gathered through surveys from each of the three actors. Further, a structured interview gathered various descriptive data about each company including market information, production control structure, and both inter- and intra-organizational structures. The data were gathered through structured interviews with the company management. Although the design allowed for the ability to segment and analyze the data on various bases, the mechanics of managing the data without confusion quickly became an issue.

Thus, another complication of cross-functional research was identified. A more complex linking mechanism was necessary to distinguish between responses of salesperson #1 concerning production person A, versus those concerning production person B.

The next problem emerged as the dyad became a triad when customers were included to form the third leg. Since a customer may purchase multiple products—each with a different production manager—it may be necessary to aggregate and disaggregate triads with common elements.

In other words, it was necessary in our study to be able to distinguish specific dyads and relate them to specific customers' responses. While our original interest was in the sales and production interface, the richness in the study came from including the customer as the third leg in the analysis. As a result, we had complex sets of data, related by various common elements and relationships.

| Relationship | Number in Relationship |
|---|---|
| Salesperson : Customer | 1 : many |
| Customer : Salesperson | 1 : 1 |
| Product : Customer | 1 : many |
| Customer : Product | 1 : many |
| Salesperson : Product | 1 : many |
| Product : Salesperson | 1 : many |

***Exhibit 1:*** *Constructs of interest.*

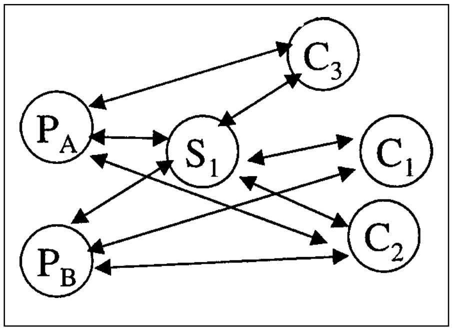


***Figure 1:*** *Data related by various common elements.*

In Figure 1, Salesperson 1 has three customers ($C_1$, $C_2$, and $C_3$) and sells two products ($P_A$ and $P_B$). Product A is purchased by two customers ($C_2$ and $C_3$), while Product B is purchased by two customers ($C_1$ and $C_2$).

Additionally, certain aspects of $S_1P_A$ occur at the dyad level, while other aspects of the relationship may be specific to individual customers. This example suggested that not only did we have links between elements to manage, but also that the levels of analysis were an issue to be managed. After understanding the full complexity of the data in the study, we knew we needed a design that would simplify our data and streamline the analysis. In the next section, these issues are developed, followed by an enumeration of the steps in the process that was designed.

## Issues of Data Management

The issues of data management may be classified in cross-functional research as *input-related, processing related,* and *output-related.*

**Input-related Issues**

- Coding data elements from multiple sources.
- Maintaining integrity of original research sources.
- Designing questionnaire to minimize respondent boredom.

**Processing-related Issues**

- Merging multiple data sources for each data point.
- Transforming and analyzing data elements easily.

**Output-related Issues**

- Interpreting results easily.

A stepwise procedure is presented that addresses the input, processing, and analysis issues of cross-functional design. In our research, we used constructs and items from prior research. The process presented here can be modified for use with new constructs or items. Output-related issues will be handled indirectly through addressing input and process-related issues. Such output issues are, therefore, extraneous to the main subject of this paper. The steps in the process to manage cross-functional data are summarized below:

1. Establish a construct database in which each construct is given a number.
2. Code questionnaires with a section identifier in which the first position references the source of the data and the second position references the participant about whom the data is requested.
3. Code items on each questionnaire. Field names for each item begin with the section identifier, followed by the construct code number, and are completed with an alpha item identifier. The alpha identifier uniquely denotes the specific survey question.
4. Identify data point codes that uniquely identify each point of interest. Include this identifying number on each of the questionnaires and labels for the envelopes.
5. Establish the *empty* database of respondents prior to distributing the questionnaires.
6. Issue questionnaires, obtain responses, enter results, and analyze.

While poor initial planning in a cross-functional, multiple informant design would be disastrous, good initial design can be expected to minimize the difficulties encountered later in a research project. Inefficiencies in data gathering, coding, and questionnaire design could not only cost a researcher significant analysis time, but, perhaps, invalidate results entirely.

## Input-Related Issues

Input-related issues comprise the bulk of the discussion and planning for the extensive data management. This is also characterized as the data collection and is defined as the management of the data during the collection stage of the process. By way of definition, a *data element* is a field or item for analysis such as sales revenue or inventory items. A *data point* is a group of data elements that refer to a specific situation.

The first step was to establish a *construct* database that included a construct identifier. Therefore, each set of questions from earlier empirical studies was tagged with a name. As the questionnaires were constructed, modifying items from the original research, the construct code number was "carried" along with each item in *hidden text.* In this way, questions could be re-ordered or otherwise changed while preserving the original source.

The next step involved coding each data point for easy processing. Since each data point was a triad of the customer who purchased a specific product, the salesperson who sold the product and the production manager who produced the specific product, it was essential to create a structure that allowed each respondent to be quickly identified with the appropriate participating company and the product, customer, salesperson situation with which each was associated.

The following system describes the identification of each data point. A unique, one-digit identifying code was used for each participating company. For example, all codes for sales, production, and customer respondents for Company C begin with "3". Each product for the company was coded, as was each salesperson. The customer was given a code number that also began with "3" but was unique to the specific customer. Therefore, the customer questionnaire was personalized for each product data point in which the customer was included. A data point number might be 301-322-311 where *301* is the number assigned to a specific customer (ABC Corp.); *322* is the product number for, say, bolts produced at Company 3's plant in Memphis; and *311* is the salesperson identifier for Joe Smith. Likewise, if Joe Smith

| Identifier | Source of Data | Subject of Data | Construct Code | Item Identifier | Level of Interest |
|---|---|---|---|---|---|
| Characteristics | C / S / P | C / S / P | Numeric | Alpha | |
| For example: | C | S | 57 | A | Dyad |
| | S | CP | 57 | A | Triad |
| | P | SC | 57 | A | Triad |

***Table 1:*** *Date element coding scheme.*

sold screws from Company 3's plant in Nashville (product number 361) to ABC Corp., the identifying number for the data point would be 301-361-311.

In addition, a label with the appropriate nine-digit identifying number of each point was placed on the first page of the questionnaire and on the back flap of the return envelope. Completed questionnaires were not separated from return envelopes since the labels provided an easy reference for the researcher.

Initially, the questionnaire consisted of identifying "Product A" or "Product B". However, it was felt that one reference early in the questionnaire would not be sufficient to minimize error. Therefore, customization of each customer questionnaire included specifically naming each product and salesperson combination. While the time for questionnaire preparation for all respondents was increased dramatically, the time saved in processing was significant. Confusion was minimized for the customer, resulting in higher response rates and fewer errors.

In addition, each salesperson and production manager was a participant in multiple data points because the level of inquiry was a customer-product-salesperson combination. Once again, originally the questionnaires were not customized. However, it was quickly recognized that internal confusion could be avoided by customizing sales and production questionnaires. Each salesperson responded in the survey to questions involving each of their customer-product situations. Likewise, each production manager responded in his / her survey to questions concerning the customer / salesperson situation in which he / she was a participant. Therefore, ***every questionnaire*** used in this research was customized.

## Processing Related Issues

Once each of the input-related issues was handled by the coding structure given above, the processing issues became manageable. Both the merging of four data sources and the ease of computation and transformation of data elements were facilitated through the naming scheme for data elements.

While this may seem to be a trivial matter, the naming scheme developed allowed the researcher to confidently do analyses with limited consultation to a code book. Once again, the time saved by this design was substantial. The Coding Scheme is shown in Table 1 and consists of an example of item codes.

The first example illustrates a field name "CS57A". The source of the element is the customer questionnaire; the subject is the salesperson who is assigned to the customer; the construct under inquiry is "57," which was customer orientation, and it is the first item of the scale used. Since this construct is also surveyed from both the sales and the production perspective, there are corresponding data elements. By way of explanation, "SCP57A" relates to the first item of construct 57 of information provided from the salesperson about a specific customer and product combination. Likewise, "PSC57A" is the data element that is the first item of construct 57 of information provided from the production manager about a specific sales and customer combination. Thus, analysis for the cross-functional design is facilitated through the naming conventions used. Each element on each questionnaire was coded using the scheme in Table 1, enabling an unexpected ease of analysis.

Merging of records from the three surveys and the structured interview was accomplished through Excel and SPSS translation. The use of the three-field identifier for data points (customer, salesperson, and production manager identifier) was the match for the combination of data from the four sources. Although the effect of the design was to create four relational databases, in our analysis all item responses from the three surveys, as well as the categorical responses from the company-structured interview questionnaire, were ultimately encompassed in one record for each data point.

Transformation and analysis were accomplished through identification of the items contained in each construct through the construct numbering scheme. While reliability and validity analysis eliminated specific items, the remaining components of each item were readily identified.

## Output-Related Issues

Interpreting results easily is an output-related issue that also was handled through the coding structure. The coding scheme allowed for both the source and the computation method to be easily identified. Employing the methodology above minimized the potential output-related issues. Data integrity for addition of companies was also preserved through the data management techniques.

## Summary

While cross-functional research is clearly a priority area of management study, the task of data management in the multiple informant design is not made easier by published articles of past successes or failures. It was with this in mind that the stepwise procedure was developed. Data modeling, as expressed by the stepwise procedure outlined above, may be used generically in the future for cross-functional researchers to make the issues of data management less intimidating.

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*Holly S. Lewis*
*Pennsylvania State University*
*303 Business Administration Building*
*University Park, PA 16802*
*(814) 863-3797*
*fax: (814) 863-2381*
*email: hsl2@psu.edu*


***The head table at the awards luncheon at the DSI International Meeting in Athens: Bob Markland, Lee Krajewski, Carol Latta, Joyce Elam, Steve Zanakis, Georgios Doukidis, Takis Miliotis, Dimitris Despotis, and Kostas Zopounidis. For information on the highly successful Athens meeting, see pages 24-26.***