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Robert Stroufe  
*Boston College*

Frank L. Montabon  
*Iowa State University, montabon@iastate.edu*

Steven A. Melnyk  
*Michigan State University*

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## **Abstract**

This paper examines the role played by environmental issues in manufacturing planning. Using exploratory field research, this study highlights case studies of eight manufacturing companies. Initial findings suggest that environmental issues should be addressed at strategic and tactical levels of the firm such as aggregate planning and master production scheduling.

## **Keywords**

Environmentally Responsible Manufacturing, Materials Management, Production Planning, Qualitative Data, Shop Floor Scheduling

## **Disciplines**

Operations and Supply Chain Management | Sustainability

# INTEGRATION OF ENVIRONMENTAL MANAGEMENT INTO MANUFACTURING PLANNING

Robert Sroufe, Boston College, Wallace E. Carroll School of Management, Fulton Hall, 140 Commonwealth Ave., Chestnut Hills, MA 02167-0433, sroufe@bc.edu, (617) 552-0469

Frank Montabon, Iowa State University, 300 Carver Hall, Ames, IA 50011, montabon@iastate.edu, (515) 294-1208

Steven A. Melnyk, Michigan State University, Eli Broad Graduate School of Management, Department of Marketing and Supply Chain Management, N370 NBC, East Lansing, MI 48824, melnyk@msu.edu, (517) 353-6381

## ABSTRACT

This paper examines the role played by environmental issues in manufacturing planning. Using exploratory field research, this study highlights case studies of eight manufacturing companies. Initial findings suggest that environmental issues should be addressed at strategic and tactical levels of the firm such as aggregate planning and master production scheduling.

Keywords: Environmentally Responsible Manufacturing; Materials Management; Production Planning; Qualitative Data; Shop Floor Scheduling

## INTRODUCTION

Production plans guide the firm's transformation of raw materials into outputs. Unfortunately, not all of the outputs are value-added products that can be sold to customers. Some units must be scrapped or reworked. Other outputs from the production processes may be various forms of pollution or waste. Usually manufacturing planning connotes the production of saleable units. In practice though, the firm realizes that there will be different types of waste produced as well. This paper will look into issues of manufacturing planning to see how planning processes may be able to help or hinder environmental management.

Orders express organizational intentions. Initially, an order represents a concept or idea of some particular finished goods. Shop-floor control assigns resources and schedules work to determine how workers transform the abstract order into a completed product. Along the way, the order can result in one of four forms. An *acceptable* order moves routinely through the system to fulfill customer expectations for the due date, quality, cost and quantity. A *rework* order, or some portion of an order that becomes rework, requires special handling or extra processing to meet customer needs. These extra steps often correct problems with initial processing. Rework represents a temporary order to bring products up to usual standards.

*Salvaging* is an order or part of an order that the OM system cannot complete according to initial intentions, but for which the system can still find some use. Since the salvage order does not

fulfill the demand that generated the initial order, the system often processes a replacement order as well.

*Scrap* is any part of an order that the system cannot process into a usable product. The system must dispose of such an order in some way. Despite its lack of value to the firm's own process, scrap may be very valuable to someone else. Depending on the industry and type and form of material involved, the firm may have many regulations pertaining to the disposal of the scrap.

Of these four forms of orders, only acceptable orders are value-added from the customer perspective. The other three forms indicate problems within the OM system. They attract the attention of process control activities such as just-in-time manufacturing and total quality management. Ideally, all orders released are acceptable. However, even for those orders that are acceptable, in many cases some amount of scrap or waste will be created. Thus, firms not only need their planning and control systems to allow them to complete acceptable orders, but also to track and manage the amount of waste created.

This paper investigates how firms are using their manufacturing planning systems to accomplish environmental management tasks. This is done through a series of case studies. In particular, this paper looks to answer three questions with regard to the use of manufacturing planning systems for environmental management:

- Is it feasible to include environmental management in all levels of manufacturing planning?
- Are firms able to include environmental concerns in different levels of the firm?
- At what level of manufacturing planning do firms find environmental impacts?

## **LITERATURE REVIEW**

Firms have a wide variety of environmental management practices available to them to help manage and control their environmental impacts. These practices can be associated with the strategic, tactical and operational planning levels of the firm [26]. In a similar way, manufacturing planning is usually described as consisting of aggregate production planning, materials requirements planning and shop floor control.

A major set of activities that take place within the firm consists of planning, scheduling, and execution. The three terms describe the three major activities needed to go from broad based plans which reflect corporate objectives to focused operational planning and ultimately to the detailed execution of these plans to either on the shop floor, or within suppliers. This set of activities consistently tries to balance demand against capacity. The demand comes not only from customers, but also includes information capacity and environmental capacity. This latter capacity includes storage facilities for waste and limits on emissions. This balance between demand and capacity is maintained by either changing the demand or altering capacity [7].

When taken together, the planning, scheduling, and execution system exhibits certain important traits. First, this system is very cross-functional in nature. Areas such as marketing, finance, top management, purchasing, production and inventory control, logistics, quality assurance, human resource management, facility management and manufacturing engineering are involved. Also involved are areas external to the firm such as the customers, government, stockholder and

suppliers. Second, the movement of plans through this process is moderated by transition check points. These points exist to ensure that the plans generated in the preceding stages are both acceptable and feasible. Third, the planning, scheduling and execution process emphasizes aggregation by time period.

## **METHODOLOGY**

Since the focus of this research is exploratory in nature, qualitative data collection methods are used to develop an understanding of important issues and variables. The method followed was similar to the grounded theory development methodology suggested by Glaser and Strauss [8], Miles and Huberman [21], and Yin [28].

In instances where a well developed set of theories regarding a particular branch of knowledge does not exist, Eisenhardt [6] and McCutcheon and Meredith [18] suggest that theory-building can best be done through case study research. Comparative literature reviews of research on environmental management strategies confirm that environmental management is at an early stage of development [12] [14] [22] [2] [5] within the domain of operations management. In this stage of theory building, a key objective is to characterize the different types of environmental practices used in manufacturing.

There are some pitfalls to case study analysis, including lack of simplicity or narrow and idiosyncratic theories [6]. A primary disadvantage of the case research approach is the difficulty in drawing deterministic inferences, and there are limitations in terms of the external validity of the study. These limitations are often addressed by using large samples, or using “before” and “after” quasi-experimental designs [4]. While causality can never be shown in case studies, analysis of data collected from multiple sites can help support the development of theory and the generalizability of results.

The researchers participating in this project relied primarily on the methods of qualitative data analysis developed by Miles and Huberman [21], which consists of anticipatory conceptual model development and simultaneous data collection, reduction, display, and conclusions testing. After the above steps were taken, the authors went back to the literature to look for similar frameworks upon which to build. Multiple research sites were used in order to provide a broader taxonomy of practices with regard to manufacturing planning issues.

### **The Sample**

Each of the firms selected was chosen to represent a wide spectrum of environmental management. The objective of this sampling approach was to construct a sample of firms that would be diverse enough to capture the variance of environmental management attributes across firms and products that may be overlooked in a single industry or product sample.

Several industries were chosen for this study. Single industry studies do not provide a strong basis for achieving generalizability. External validity is more easily achieved in cross-industry studies. However, for the industries selected, the types of environmental issues and range of planning programs used must offer sufficient variability for study.

After the initial screening, which also assessed the willingness of the company to participate, eight firms were again contacted and site visits arranged. A total of sixteen interviews were performed at eight companies. The interviews were conducted with several managers at each site. These managers came from such functional areas as Corporate Quality Services, Supervisor/Planning Group, Plant Planner, Global Director of Development, Environmental Science and Assessment, New Product Group, and Design Engineering.

### **The Interview Protocol**

The interview protocol, included in Appendix A, was developed based on the researchers' general understanding of environmental management issues facing industry today. The protocol was pre-tested at two manufacturing facilities and then used for the eight firms included in this study. Minor changes were made to the protocol after the pre-test. Interviews were conducted in the respondent's facilities, and discussions focused on the consideration of environmental management as an important part of the planning process, the factors affecting environmental management, tools used, metrics, and perceived environmental management opportunities.

To avoid responses exhibiting social desirability, different managers were questioned at the two different sessions. The same structured interview protocol was used at all of the site visits. After each visit the protocol was reviewed, and/or updated to accommodate new lessons learned. This constant updating of the protocol after each visit is the foundation of grounded theory development [8]. When the sessions involved multiple respondents, all comments or views of the managers were recorded separately. Subsequent coding of the notes would highlight any differing views of the managers.

## **RESULTS AND DISCUSSION**

While firms have a wide variety of environmental management practices available to them to help manage and control their environmental impact, here we focus on environmentally responsible manufacturing and manufacturing planning practices. In this section we provide brief summaries of the observations made at the eight firms. The firms have been kept anonymous at their request.

### **Themes**

Some common themes emerged from this series of case studies. First, many firms remarked that they did not believe it was the job of the manufacturing planning systems to be concerned with environmental issues. Two primary reasons emerged for this. First, many of the firms in this study believe that environmental issues were more properly handled in the product design and process design processes. This is in line with the idea that most of the costs of production are committed in the design stage [1]. What this overlooks is the perception of environmental problems. Most managers go to extremes when identifying environmental problems. Overlooked problems still involve rework salvaging, and scrap. Given a different mind-set, the production managers interviewed can see the relationships between waste and the environment, but have yet to make this relationship a reality within the planning process.

The second reason for the firms' lack of integration of environmental concerns into manufacturing planning appeared to be a lack of motivation to do so. Firms did not feel a "push" from the market to adjust their manufacturing planning. For many firms, such a "push" in the form of environmental regulations was also lacking. Here again is seen the opportunity to bring about more awareness of the relationships between planning, environmental impacts, and the resulting types of orders, i.e. acceptable, rework, salvage, or scrap. For those firms wanting to take a proactive approach to understanding processes and planning, a better understanding of the hidden environmental relationships within planning becomes essential.

Yet, all of the firms involved in the study noted that they did need to keep track of rework, salvage, scrap, waste and/or pollution. Varying degrees of success in tracking these outputs were noted by the researchers. So while some of the firms were perhaps not as concerned about environmental issues in manufacturing planning, all of the firms exhibited confidence that their manufacturing control systems allowed them to track various forms of waste. Upon further review of processes and documentation, the researchers found that while there were some existing informal and formal systems that captured output metrics, these metrics did not have strong visible relationships to performance or to other traits of the planning process such as cross functional visibility, or inclusion in planning checkpoints. Alternatively, output metrics, much the same as planning information, was aggregated by period, but this was typically done post-hoc.

Interestingly, the experience of Firm 8 may be a harbinger of things to come. This firm definitely had a "push" to integrate environmental issues into manufacturing planning in the form of new government regulations. As it is unlikely that environmental regulations are going to decrease, more firms may find themselves in Firm 8's situation. In essence, the new regulations became a constraint on their manufacturing planning. Their response was a classic example of manufacturing planning – they shifted production to other facilities. Other firms caught in this type of situation may not have that luxury.

## CONCLUSIONS

Upon review of the qualitative data, the evidence suggests that environmental issues do play a role in manufacturing planning. Much the same as other planning traits, environmental information should have cross functional visibility, be reviewed during transition checkpoints, and be included in information that is aggregated by time period. The extent of this inclusion becomes a key question. One of our research questions asked if it is feasible to include environmental management in all levels of manufacturing planning. Our interviews with these firms indicate that it clearly is at some levels. Environmental concerns can and in some cases have to be viewed as another constraint when devising production plans. Further, it is clear that the planning systems, such as MRP, can be used to track the creation of rework, salvage, scrap or waste, some forms of which can be considered pollution [20].

However, it appears at this time that firms are not actively including environmental constraints in their production planning process at the shop floor level. Thus, the information from the field studies suggests that firms are able to include environmental concerns in different levels of the firm, but do not see an imperative need to do so at the shop floor level. Instead, as perceived by the managers interviewed, these environmental issues and constraints should be addressed at

higher levels of the firm. Even in those cases where firms identified environmental issues in their manufacturing plans, the primary response was to shift production to sites that had available capacity.

So where is the real impact of including environmental constraints into manufacturing planning? Currently, most of the impact appears to take place at a strategic level, if done correctly. When some firms devise their aggregate production plans, they are taking into account environmental concerns. Some firms are clearly worried about environmental constraints during product design. Many of the firms in this study discussed with us the idea that if they can identify environmental issues when the product is being designed, this can mitigate potential environmental issues when the manufacturing planning is done.

Limitations to this study are those normally associated with qualitative case studies, such as small sample size. As discussed in the methodology section, the literature on conducting qualitative studies guided the research plan. Despite these limitations, we find there are real opportunities for more integration of environmental practices in planning and a better understanding of processes at all levels of the firm.

The primary contribution of this study is identifying the idea that the integration of environmental concerns early in the planning process should alleviate problems at lower levels of planning and execution. While it is feasible to integrate environmental issues at all levels of planning, more impact is found if this integration is done as early as possible in the planning process. Additionally, environmental planning does span aggregate planning, the master production schedule and the shop floor. If environmental issues are not addressed until the shop floor, then firms are creating a liability that is not reconcilable until a problem is discovered.

For those firms who consider environmental practices a constraint or cost of doing business, slow incremental change may be the only way to impact manufacturing planning. For those firms who are more innovative and proactive in their approach to environmental management, change can take place at many levels of the planning process to ensure that environmental management impacts processes and products early in strategic and tactical phases of the business planning model. Future research should address relationships between environmental issues and manufacturing planning. Specific research questions include the need to better understand at what level of the firm is it best to include environmental practices in planning, or what type of situations cause firms to use shop floor scheduling for environmental management. Previous research has demonstrated the ability of MRP systems to be modified so that environmental waste data is more visible. Future researchers may want to identify the best situations that call for the use of such systems. Additionally, models based on exemplary environmental firms and frameworks need to be developed to guide practitioners and researchers in the integration of environmental constraints and planning. Alternatively, there needs to be work done regarding the use of environmental performance metrics at different stages of manufacturing planning. This study and the resulting insights environmental practices and planning theory are a step toward addressing this important and overlooked research issue.

Full paper available upon request from Frank Montabon.