Hands-on Planning and Control: Improving Supplier, Customer, and Internal Production-Logistics Planning Systems

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ABSTRACT (003-0443)

The supply chain perspective has changed production planning and control from a top-down, intra-company process to one in which horizontal flows of information—between companies and their downstream customers, between companies and their upstream suppliers, and even within areas of the same company—drive planning, control, and ultimately, effective execution. In response to this shift, we implemented company-sponsored projects within an MBA-level planning and control course to give students the opportunity to map, evaluate, and propose improvements to such horizontal information flows in a real-world setting. In these projects, students assessed the accuracy, timeliness, reliability, form, and completeness of information flows and quantified the benefits of their recommendations to close the gaps between current flows and ideal flows. In this paper, we describe the methodology we used to structure course projects and manage team interactions with companies and other teams, and we share illustrative results from projects carried out in the Fall 2004 semester.

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1 Evolution of Planning and Control

The classic view of planning and control (P&C), focused almost exclusively on intra-firm activities, is perhaps best encapsulated in the framework for manufacturing planning and control (MPC) presented in Vollmann, Berry, Whybark, and Jacobs (2005—hereafter referred to as VBWJ). Their framework is reproduced in Figure 1. Since the 1990s, however, a new perspective—that of supply chain management (SCM)—has been developing and is now widely espoused by practitioners and academics alike as the dominant perspective driving effective planning. The SCM perspective spans not only the P&C functions within a given firm, but also across dyadic-partners in the supply chain and, to the extent possible, even across the entire chain. In the 2005 edition of their text, VBWJ reflect this now-dominant SCM perspective and offer some valuable discussion on how MPC systems can and should link across dyads in the supply chain.

As VBWJ imply, however, dyadic relationships in supply chains are nothing new. They are, of course, as old as commerce itself. What is new, and continuing to be refined and improved, however, is how those dyadic relationships are managed, particularly as regards the planning and execution activities that form the basis of modern commerce. The old approach, in the words of VBWJ, was “up-down-and-over,” whereby the two firms’ MPC systems were linked as the downstream firm fed its procurement information to the upstream firm, which in turn fed this information into its Demand Management and Master Scheduling processes. “Up-down-over” would thereby trickle its way up the supply chain, perhaps taking several months to percolate changes at the farthest downstream echelon in the chain up to echelon farthest upstream. The flow of the “up-down-and-over” process is clearly seen in Figure 2, reproduced from VBWJ.

As supply chains continue to evolve and become more adept in responding to the dynamics of the marketplace, “up-down-and-over” has clearly become inadequate for rapidly incorporating new information about demand and supply and rapidly executing to meet new requirements and/or adjust to new constraints. As operations management practitioners and academics now recognize broadly, the old top-down perspective for MPC, while fully sufficient for medium- to long-range resource planning activities, must be supplemented by rapid horizontal flows of information. Such flows link dyadic
partners in the supply chain at the lowest levels in their MPC systems, the level of manufacturing (“shop floor”) execution, as implied by the low-level link in Figure 2.

In a related paper, Bozarth and Warsing (2005) overlay the VBWJ framework on a broader map of SC planning and execution processes derived from the Supply Chain Operations Reference (SCOR) model (http://www.supply-chain.org/slides/SCOR5.0OverviewBooklet.pdf). This broad framework of Bozarth and Warsing for supply chain planning and execution is shown in Figure 3.

2 Projects

In the Fall 2004 academic semester, the authors implemented team-based semester projects as part of the course requirements for BUS 572, Planning and Control Systems, a required course for MBA students pursuing the Supply Chain Management concentration at NC State University. The projects were sponsored by corporate partners of NC State’s Supply Chain Resource Consortium (SCRC), and the objective of each project was the same: to map, evaluate, and propose improvements to a particular P&C-related, horizontal information flow in an actual company.

Three project sponsors participated, representing industrial equipment manufacturing and pharmaceutical manufacturing and distribution. To preserve the anonymity of the sponsors and protect confidential company information, we refer to the projects as Project 1, Project 2, and Project 3. From the class enrollment of 34 students, a total of nine student teams were formed, with three teams assigned as a “team cohort” to each project. In addition, each team identified a team leader so that the three team leaders in each cohort could serve as a project management team to coordinate project tasks and ensure that project time and resources were devoted to completing them. We discuss project management activities in greater depth in Section 3.

Figure 4 maps the three semester projects against the SC planning and control framework presented in Figure 3. From this figure, one can see that the three projects span the MPC framework of VBWJ very nicely. Projects 1 and 3 dealt with inter-firm planning issues, but on different sides—upstream versus downstream—of the firms’ respective dyadic relationships. Project 2 dealt with intra-firm control of inventory flows.
Project 1 focused on the firm’s communication of medium-range planning information to its suppliers. Suppliers that had recently experienced difficulty meeting a surge in demand were selected to participate in mapping the flows of planning information between them and the project sponsor. The two suppliers chosen for the project represented an interesting contrast: One supplier, after failing to meet the project sponsor’s demand surge, had recently installed an ERP system and significantly improved its sales and operations planning processes; in contrast, the other supplier essentially continued to ignore medium-range planning communication from the customer firm and relied exclusively on its admittedly well-developed, Kanban-based vendor-managed inventory replenishment system for all “planning” information.

Project 2 focused on the firm’s need to remove buffer inventories from within the production facility in order to accommodate a planned installation of new production capacity. The systems and processes linking the company’s master scheduling activities with its inventory planning and production execution systems represented a very wide diversity of approaches, from push-driven MRP for some components to sophisticated, Kanban-based pull systems that sent replenishment signals to external suppliers.

Project 3 focused on the firm’s collaborative planning, forecasting, and replenishment (CPFR) process with three of its major customers. One of those customers represented what the company felt was the state-of-the-art in collaborative forecasting processes, and the company’s hope was to identify common procedures that would improve the CPFR process in place with the other two customers.

3 Project Management

The methodology the students followed in completing the projects consisted of applying three basic tools of analysis:

- *Structured interviews and data sharing with company personnel*—Initial rounds of these interviews were performed with significant faculty guidance and intervention. Data collection and analysis activities became more independent on the part of the students as the semester progressed.

- *Information flow maps*—In order to protect the anonymity of project sponsors, examples of detailed maps cannot be shown in this paper. We have, however,
reproduced in Figure 5 an interesting set of “current” and “proposed” maps of the physical flows from Project 2. Part of the support for the proposed condensing of flows came from information flow mapping that detailed the many arrows in the “current” situation, in addition to the application of some important theoretical principles presented in Section 4.

- **Information flow profiles**—This tool is presented and discussed in more detail in Bozarth and Warsing (2005). Here, its basic purpose was to allow students to identify gaps between current and “ideal” information flows. Students then used those profiles as base from which to quantify the costs and benefits of closing gaps. An example from Project 3 is shown in Figure 6.

To keep the projects on track, we used two primary tools. The first was a document of understanding (DOU), established at the outset of each project by the course instructors and personnel from the project sponsor. A generic example, based on Project 3, is provided in the Appendix. After being agreed to by the instructors and the sponsor company, the DOU was provided to all students working on the project. In addition, the professors established a clear set of project milestones, which are laid out in Table 1. These project management tools also formed the basis for the professor roles throughout the semester: scope definition, scope monitoring, and milestone reviews.

### 4 Content Lessons

**Project 1**

*Principle:* A well-integrated, inter-firm planning and control system requires both “low-level” links that integrate the firms’ execution systems and “high-level” links that integrate the firms’ planning systems.

*Corollary 1:* Without closed-loop communication from customer to supplier, planning that a customer thinks is occurring based on its data transmissions to the supplier may actually not be occurring.

*Corollary 2:* A careful information profiling analysis may reveal that what were assumed to be tightly integrated electronic linkages to communicate planning data could actually be inadequately sequenced data feeds that are being supplemented by informal, ad-hoc human communication.
Corollary 3: A well-executed replenishment system that is actively managed by significant inter-firm personal communication can actually mask underlying errors in inventory system parameters or even a complete absence of medium- to long-term planning.

**Project 2**

*Principle:* An execution system is only as good as the business process that updates its parameters. Moreover, this business process can be better understood through the use of information profiling analysis.

*Principle:* The administrative costs of updating execution system parameters are unavoidable. It’s “pay me now, or pay me later,” where “now” could imply sophisticated information technology with large front-end set-up costs and “later” could imply the ongoing expense of human-driven administration.

*Corollary:* Attempting to optimize a complex production-inventory system on a part number-by-part number basis in order to minimize the total costs of holding and transporting inventory may fail to incorporate the costs of complexity in managing and maintaining the system—i.e., the “hidden factory” costs (Miller and Vollmann 1985).

*Principle:* In a given operating system, you cannot escape Little’s Law ($I = R \times T$). If constraints on inventory ($I$) are tightened, either the production rate ($R$—i.e., the rate at which inventory is transformed by the system) must decrease (a potentially undesirable effect) or the throughput time ($T$—i.e., the time that inventory spends in the system) must decrease.

*Corollary:* Decreasing $T$ can clearly be achieved by increasing the frequency with which the inventory in the system is replenished. This obviously increases replenishment costs as it simultaneously decreases inventory holding costs and satisfies constraints on $I$.

**Project 3**

*Principle:* According to Galbraith (1973), companies can accommodate uncertainty either via better information or additional resources, such as inventory.

*Corollary:* Improved information exchange can have a measurable impact on resource requirements. As this project showed, it is critical to understand the effects of forecast accuracy, timeliness, and detail on the amount of inventory required to maintain target customer service levels. Moreover, it is generally inefficient to impose similar
levels of uncertainty reduction and customer service on all items in the system (along the lines of “ABC” management of inventories).

5 Pedagogical Lessons

In terms of pedagogical lessons, the biggest one is, “Try as you might to avoid it in defining the project, scope creep will occur.” Still, it is interesting to consider whether it is better to allow students to identify and address scope creep on their own or whether the instructor would be better off intercepting scope creep and helping the teams address it immediately. The answer probably is, “It depends on how much time and/or resources you have.” Regarding the timing of course topics and project needs, however, it is probably relevant to consider whether we were simply fortunate in being able to identify relevant projects that integrated very well with the course material. (We would prefer to think that we—meaning the authors and the SCRC staff at NC State, in particular Mr. Steve Edwards—were just good.)

Another important issue that rose to the fore during the semester was sorting out theory, “real-world” complications, and (just plain…) poor practice. Perhaps the larger issue is whether managers are ever as good as they say they are, or whether they have a real understanding of the kinds of principles that we are trying to teach our management students. By incorporating interactions with practicing managers in the education process, faculty member must wrestle with the question of why the decisions of practicing managers rarely mesh with the normative prescriptions of academic theory. This should set the stage for a powerful research agenda that is relevant and that seeks to reconcile theory and practice.

In our view, there is real value in flow mapping and profiling for performing the “sorting” implied above—theory versus a reality that challenges that theory versus poorly implemented, or just plain ignored, theory. As qualitative as the profile is in its current state, at least it forces students to step back and try to make an objective assessment of whether the planning process and the embedded information flows are adequate to achieve the company’s goals.

Beyond all this is what we consider to be the “holy grail” of academics: building strong, mutually reinforcing connections between teaching and research. An important
issue along these lines is whether management academics are doing enough to simultaneously invigorate management education and expose graduate students to emerging issues by involving them in the research process. In a program like NC State’s, where there are no Ph.D. students, it seems that our choice is either to ignore the capabilities of MBA students in helping to advance the state of research in the field or treat them truly as graduate students by exposing them to, and tapping their skills and knowledge to help develop, leading-edge ideas. In this sense, it is relevant to think about different types of projects that can “ebb and flow” along with the supply of, demand for, and appropriate fit of hands-on, external-engagement-type projects versus secondary-research-type projects.

6 Research Considerations

We believe the project scoping and implementation process proposed above injects a sufficient amount of flexibility into the course and project planning process so that it can still effectively advance the faculty member’s research stream, as represented in Figure 7. In this figure, the “fat” arrow is essentially self-explanatory: A faculty member’s research agenda is dynamic and develops over time. The “skinny” arrows that feed into and out of the “semester project” boxes warrant some discussion. In a perfect world (for the faculty member, at least), semester projects would be completely consistent with the course instructor’s research agenda. In our minds, this is part of the holy grail of academia mentioned above—bringing cutting-edge concepts into the classroom and truly integrating the practice of teaching with the practice of research.

For the projects to be external-engagement-type projects, however, this requires some means of identifying practicing managers that are wrestling with the very same concepts in practice that the faculty member is wrestling with in theory. There is clearly more to this “into-the-bottom-box” arrow than the diagram indicates. Some negotiation of terms must transpire that attempts to reconcile what the project sponsor might really want the students to do and what the instructor views as (a) relevant for the students to do in the context of the course and (b) consistent with the instructor’s interests and areas of expertise. As with any efficient negotiation process, there must be give-and-take on both sides, with the practicing manager agreeing to deliverables that are still consistent with
the spirit of the issue he/she is grappling with and the instructor augmenting his/her course syllabus and research agenda to be more consistent with what practicing managers consider relevant. Additional augmentation of the faculty member’s research stream occurs at the close of each semester, represented by the “skinny” arrow feeding from the course projects back into the research stream. Again, the great value of this process is that it requires faculty to be tapped into practice as they develop and test theories.

It is important to distinguish this practice-interactive research process from the one-way flow of research to practice (“We invent; You use”) that typifies much of the hard sciences and most sub-disciplines of engineering. This is consistent with, and motivated by, the thinking of management “guru” Peter F. Drucker (see http://www.gurustore.org/uk/conteudos/drucker4.asp), who points out that management is more a practice than a science—more akin to medicine than to, say, chemical engineering. As in medicine, the study of management is replete with complex systems that respond in ways that are still mysterious to us even though many of the underlying principles are well understood by academics.

Finally—and this might be more of a “perfect world” statement than the current state of the art being practiced at NC State actually reflects—each set of semester projects should form a longitudinal path that positively influences the definition of course projects in future semesters.

References

Bozarth, C. C. and D. P. Warsing (2005), *A conceptual model of supply chain information flows: Case studies, propositions, and directions for future research*, North Carolina State University working paper, Raleigh, NC.

Galbraith, Jay R. (1973), *Designing Complex Organizations*, Addison-Wesley, Reading, MA.


Enterprise resource planning (ERP) system

Resource planning

Sales and operations planning

Demand management

Master production scheduling

Front end

Detailed capacity planning

Detailed material planning

Material and capacity planning

Engine

Supplier systems

Shop-floor systems

Back end

Enterprise resource planning (ERP) system

Figure 1—MPC framework from VBWJ

Supplier

Master scheduling

Forecasting

Purchasing

MRP

Stocks

Manufacturing

Customer

Master scheduling

Forecasting

Purchasing

MRP

Stocks

Manufacturing

Figure 2—“Up-down-over” linkage from VBWJ
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**Figure 3**—A broad perspective on supply chain planning and control

**Figure 4**—Mapping Fall 2004 semester projects onto framework for SC planning and control
Current Physical Flows

Proposed Physical Flows

Figure 5—Physical flow maps from Project 2
Retailer information flows

![Graph showing retailer information flows with dimensions from Poor to Excellent for Accuracy, Timeliness, Completeness, and Form & Detail.]

Figure 6—Information flow profiles from Project 3

Research Stream

![Diagram showing the semester project definition process over time.]

Figure 7—The semester project definition process
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<td>Follow-up mapping meeting (if necessary)</td>
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Table 1—Sample project milestones from Fall 2004 semester
Appendix

Sample Student Team Project and Scope Definition
BUS 572—Planning and Control Systems
Sponsor: XYZ Company, Your Town, NC

Situation
In the spring of 2005, XYZ Company will complete a rearrangement of the production lines in its Your Town, NC facility. This physical rearrangement of the production space will require XYZ to do away with its line-side stocking (LSS) locations, physical areas where components currently are staged to supply the production lines. Therefore, any product flows that currently require LSS space in the XYZ facility will need to be redesigned in early 2005 such that they no longer require this staging space. XYZ has identified 14 distinct flow paths that cover all materials that support the current production process; nine of those 14 flow paths currently involve LSS areas.

Project Scope
Three teams of NCSU MBA students will be assigned to work with XYZ, specifically with Joe Smith, Materials Management Supervisor. Each team will be assigned a subset of the part numbers (P/Ns) on one of the nine flow paths that involve LSS areas. Each project team will perform the following tasks:
1) Within the team’s assigned subset of P/Ns, identify distinct groups of P/Ns with common physical flows and information triggers (e.g., MRP “push” into LSS area, kanban-based “pull” into LSS area).
2) For each distinct physical-info flow identified in (1), build a detailed map of the current information flow corresponding to the physical flow. This will be used later in identifying the necessary changes to the information flows (steps 3 and 4 below).
3) Redesign the current physical flows to eliminate LSS inventory in the production facility and design perfect information flows to support this (per the information flow profile presented in class).
4) Identify the gaps between the current information flows and the required future flows, quantify the net benefit—in concrete balance sheet (e.g., inventory) or income statement (e.g., freight cost) terms—of closing these gaps, and propose an implementation plan to close the gaps.

Project Deliverables
Each team will generate two documents that will be shared with XYZ Company:
1) A set of verified (i.e., “signed-off” by XYZ personnel) current information flows that clearly identify the component group to which they apply.
2) A final report that describes the team’s analysis and clearly identifies and quantifies the net benefit of closing the gaps between “as-is” and “perfect” information flows and implementing “non-LSS” physical flows.
Benefits to Project Sponsor
The primary benefit to the project sponsor will be a template for analyzing information flows that can be extended to all components used in production at XYZ. The project team interactions with XYZ will be structured so that each team’s analysis is reasonably consistent and similarly useful to XYZ, in terms of XYZ’s ability to quickly implement the recommendations generated by the projects.

Roles and Responsibilities
- **XYZ Company** will:
  - Host a single project introduction meeting with representatives of all NCSU MBA student teams involved in this project.
  - Make key personnel available for on-site meeting(s) to map current information flows (projected 2 to 3 hours in total, preferably in a single session with representatives from all student teams).
  - Provide data required to design new (i.e., “non-LSS”) physical and information flows, as identified by the student teams and faculty advisors.

- **NCSU MBA teams** will be responsible for:
  - Setting up interviews with key personnel at XYZ.
  - Maintaining the confidentiality of any information shared with them by XYZ.
  - Responding in a timely fashion to questions or concerns raised by XYZ.
  - Making effective use of the time allocated to them by XYZ personnel and, therefore, minimizing the time and effort required by those individuals.

- **NCSU faculty advisors** will clarify and reinforce the ground rules for team communication with the sponsor company and provide additional guidance to the teams as required.

Time Frame
Project reports will be completed by November 30, 2004.

For Additional Information
- Primary NCSU contact: Prof. Don Warsing, tel: 919-515-6954, e-mail: don_warsing@ncsu.edu.
- Additional information about NC State University’s College of Management may be found at [http://www.mgt.ncsu.edu/index.html](http://www.mgt.ncsu.edu/index.html).
- Additional information about the NC State University’s Supply Chain Resource Consortium may be found at [http://scrc.ncsu.edu/](http://scrc.ncsu.edu/).
- Additional information about the NC State University MBA Program may be found at [http://mba.ncsu.edu/](http://mba.ncsu.edu/).
- Additional information about BUS 572, Planning and Control Systems, may be found at [http://courses.ncsu.edu/bus572/lec/001/](http://courses.ncsu.edu/bus572/lec/001/).