In recent years, a large number of companies in the construction industry, aiming to increase their levels of internal performance, have adhered to and improved management tools. Among the initiatives undertaken are the implementations of production planning and control (PPC) and inventory management. This paper analyzes the PPC practices of companies in the construction industry in general and in residential construction in particular. This analysis is based on an empirical study of three companies—two mid-sized and one large one—operating in the state of Rio de Janeiro. The study conducts interviews with managers from planning and from supply and finds that managers try to apply PPC models, even in far-from-ideal scenarios, to ensure that inventories meet the defined planning steps so as to reduce waste and increase productivity.

Keywords: production planning and control, demand planning, inventory control, building construction
1 Introduction

Brazilian companies find themselves facing fierce competition in global markets. As they try to expand their global business, they must continue to meet customer needs and improve their service. Companies face unrelenting pressure to achieve three objectives—to lower their inventories, to come up with quicker solutions, and to reduce transaction costs. Regarding PPC systems, companies must learn to integrate and respond to customer needs (Vollmann et al, 2006; Lustosa et al, 2008).

Construction companies have responded to the competition by seeking a greater role in their internal processes, aiming to eliminate waste materials and to cut down on manpower, two factors that directly impact project costs and delivery times. Given this response, what might serve as an excellent tool in aiding the performance of variables and constraints present is production planning and control (PPC), a system already widely used in the manufacturing industry. Indeed, one of the main problems with construction lack of planning on the part of companies, according to Formoso et al (1999) and Bernardes (2001).

Such a finding suggests that defects in this process are among the main causes for the sector’s low productivity, high losses, and poor product quality. This study analyzes, then, the construction industry’s PPC practices; through a multiple case study, it examines business practices and compares them with the theoretical foundations of PPC. Such a study, it is hoped, will contribute to harmonizing practice with theory.

2 Planning and Control of Production in Construction

The literature offers numerous definitions of planning. However, that given by Formoso (1991) is one of the few that considers an inherent part of the planning process to be control. Hence, it is the one most aligned with the goals of this study. Formoso (1991) defined planning as “the process of decision making that involves setting goals and procedures necessary to achieve them, and when followed by an effective control.”

2.1 Dimensions of planning

We can represent process planning and production control through two basic dimensions—the horizontal and the vertical. The first refers to the stages of planning and production control. The second refers to the linkage of these steps with the different management levels of an organization (Laufer & Tucker, 1987). Laufer and Tucker (1987) divide the horizontal dimension of the planning process into five stages: 1) planning of the planning process, the step that covers the standards and procedures to be adopted in the implementation of the planning process; 2) gathering information, essential to the quality of planning and control is the providing information to all those responsible for making decisions; 3) preparation of plans, where the work plan is laid out and ends up getting more attention from planners; 4) information dissemination, where the information generated by developing such plans must be disseminated to all stakeholders, including the designers, sub-contractors, material suppliers, and the various parts of the company; and 5) evaluation of the planning process, the goal of which is to provide continuous process improvement, both for the project itself and for future endeavors.

As for the vertical dimension, Lustosa and colleagues (2008) highlighted that PPC acts in a coordinated manner in applying productive resources, allowing a company to carry out the plans generated at the strategic, tactical, and operational levels. According to the authors, long-term strategic policies are set at the strategic level, including, for example, the capacity of a plant. Serving as a transition to the tactical level is the designing of aggregate production planning. This sets forth the composite of specific production strategies. At the tactical level, medium-term plans for production are established, resulting in a master production plan (MPP). At the operational level, inventories are
managed, production orders sequenced, purchase orders issued and released, and monitoring and control are carried out. At this level short-term plans are prepared as a result of Materials Requirement Planning (MRP).

Santos (2009) pointed out that planning could be divided into three hierarchical levels. In the planning horizon, uncertainties and the plan’s degree of detail are considered (this is the tactical planning). The time horizon includes the levels of long- and medium-term planning, and the operational horizon consists of short-term planning.

2.2 Systematic review of PPC systems by Bernardes (2001)

Bernardes (2001) developed a systematic evaluation of PPC systems in construction companies, considering 14 key practices for implementing and managing successful models that had previously been presented. These 14 practices, in summary form, are given below:

1) standardization of PPC – in order to reduce the variability in flow activities and conversion (Koskela, 1992)

2) hierarchy of planning – to reduce the uncertainty of the production environment, minimizing rework production plans

3) analysis and qualitative evaluation processes – to increase the overall performance of production (Shingo, 1996)

4) analysis of physical flows – to eliminate or reduce, in an uncertain environment, losses in the production system

5) analysis of restrictions – increases the reliability of operations at the construction site, improving the effectiveness of planning

6) use of visual devices – designed to enable identification rapidly and deviations of the patterns existing in process (Koskela, 1992)

7) formalization of short-term planning – facilitates production and controls assignment of goals to work teams

8) detailed specification of tasks – poorly detailed specification of tasks can cause the execution of activities to be incompatible with requirements, resulting in rework and probable interference in subsequent tasks

9) task scheduling reserves – having interference in the flow of work at construction site, it is possible to move teams to other affected services

10) participative decision making – involves employees with the issues affecting the company, improving the overall performance of the processes, as well as reducing the incidence of interference between rework and production teams

11) using PPC and identifying problems – should occur jointly to reduce variability in planning process

12) use of system performance indicators – use of performance measurement and evaluation processes can improve the quality of information available for decision making

13) implementation of corrective actions from the causes of problems – to reduce variability of PPC

14) hold meetings to disseminate information – making participants clearly informed about what should be done
This study aims to analyze models as well as planning and production control (PPC) practices of civil construction companies. In doing so, it adopted the descriptive research method. The analyses were made, after all, based on such evidence collected that would describe the relevant points found in the current models practiced by those companies surveyed. The research employed both a qualitative and quantitative approach, within a multiple case study. The researchers, seeking further clarification, interacted with the respondents by interviewing them or sending them a structured questionnaire.

The sample selection was defined by the market segments to which the companies belonged. We selected three companies active in residential construction. These companies were selected to answer a four-part questionnaire consisting of 52 questions. The first section was meant to identify the construction companies and their main characteristics and relationships. The second section aimed to identify whether they used tools of production management systems to implement demand forecasting and inventory control. The third section focused on the planning process and production control. Here we used the model carried out in 2001 by PPC NORIE/UFRGS for Bernardes. This was to assess whether the company had effectively carried out the planning of the tactical and operational levels. The fourth section was intended to assess the PPC-related practices adopted by the company. Evaluating PPC after the deployment step was based on the work of Bernardes (2001). For its realization, we used a set of 14 practices proposed by the author and considered essential to the successful implementation of the PPC model (Krawczyk, 2003). Finally, at the request of some respondents to preserve strategic information from their fellow competitors, companies were identified as “A,” “B,” and “C.”

3 Data analysis and discussion of results

3.1 Characterization of companies

Company “A,” is large (900 employees) and operates in high quality real estate ventures for all social classes across Brazil. Companies “B” and “C,” with 120 and 160 employees each, are medium-sized and operate in southeastern Brazil, constructing residential and commercial properties.

3.2 Demand Forecasting and Inventory Control

The supply management, through efficient techniques of demand forecasting and the strict control of inventory, has a number of objectives. These include the planning of inventory, the amount of material entering and leaving, the time of such inflows and outflows, the period between such movements, and the points where materials are applied. For a project to succeed, the three main flows (materials, information, and financial) must be aligned.

- Company A

A system of hierarchical planning and control is in place, i.e., with well-defined long-, medium-, and short-term horizons. As for the long term, the supply area does the programming of resources that have long acquisition cycles (lifts, frames, etc.). The company makes a supply schedule as part of the planned execution of the work. As for the medium term (defined as less than 30 days), the resources covered by this period have a cycle of reprogramming and delivery. As for the short term, it is characterized by the immediate need for information or resupply, motivated by some factor not previously considered. Suppliers are selected based on an assessment of production capacity as well as technical, commercial, and legal quality, meeting the demands of supply according to the consumption curve and predetermined delivery time.

From there, it is a matter of mapping out all inputs consumed and of the stages of work for when suppliers should deliver inputs to the jobsite. Once that is done, an operational plan identifies the location of both the warehouse and the deposits at the jobsite. To minimize costs and maximize operations at the jobsite, the equipment needs are studied.
in detail. At the time of procurement planning, the function of articulating and making ends meet is up to the supply area; it is this area that must also understand the capabilities and limitations of each job, making the necessary adjustments to better serve that job. Utilizing the management integration software SAP/R3, the company coordinates the interaction between the supply area, the team’s work, and other strategic areas.

- **Company B**

After defining the overall planning of the work and with the board’s approval, the supply area starts a major mobilization from its suppliers. These vendors are chosen according to the suitability of their prices, within the estimated values of the project. Deliveries of supplies are made in large quantities, and the engineer’s job is to coordinate all their movement and storage; the engineer reports, when necessary, on low supplies of necessary spare stock. In the case of lifts, due to the reduced number of suppliers and lead-time, the same board negotiates strategic acquisitions, closing lots with manufacturers, aiming to ensure delivery and lower prices. This company makes no use of the integrated management system and therefore employs a specialist who follows the needs of all areas involved regarding the job, linking up with the areas of planning and supply.

- **Company C**

The programming schedule of supplies, set early in the project, is ordered hierarchically. In long-term planning, with a focus on strategy, the tool Balance Line is used to define and scale “Master Line” works for a period of usually 2.5 years. This step analyzes Time Vectors and Cash Flow. In medium-term planning, the focus is on tactical activities and detailed in a month-long horizon. At this stage the company is able to see what restrictions are present and tries to schedule the tasks that follow a set of procedures. Short-term planning is operational and considers, based on an analysis of previous weeks, each stratified week of the medium term as well as the demand forecasts for the following week. This stage is a way to signal the need for materials to be supplied, minimizing large amounts of stock taking up space at the construction site as well as the waste associated with it.

### 4 Evaluation of Good Practices in a PPC Empirical Study

To assess these companies’ implementation of PPC, the research team, in addition to the analysis of the responses obtained in the first three phases of the interview, also administered a set of 18 questions concerning Bernardes’ (2001) 14 practices to achieve successful implementation. For each practice, one or more questions were given to obtain one of three responses: not applied, partially applied, or fully applied. The responses collected can help us calculate an Index of Best Practices in Planning and Production Control (IBP PPC) based on a percentage of the sum of the practices applied in relation to all practices, that is:

\[
IBPPC = \frac{\sum \text{practices evaluation}}{14}
\]

A weight of 0 was assigned to an indicator for practices not applied, a weight of 0.5 for practices partially applied, and a weight of 1 for practices fully applied. Table 01 shows the results of the IBP PPC obtained for each company, A, B, and C.

**Table 01 - Evaluation of best practices for planning and control of production in companies A, B and C**

<table>
<thead>
<tr>
<th>Practice</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Answer</td>
<td>Weight</td>
<td>Answer</td>
</tr>
<tr>
<td>1. Standardization of PPC</td>
<td>1.0</td>
<td>3</td>
<td>0.0</td>
</tr>
</tbody>
</table>
2. Hierarchy of planning 1.0 3 0.0 1 1.0 3
3. Qualitative evaluation processes 0.5 2 0.5 2 0.5 2
4. Analysis of physical flows 1.0 3 0.5 2 0.5 2
5. Analysis of constraints 1.0 3 0.5 2 1.0 3
6. Use of visual devices 0.5 2 0.0 1 1.0 3
7. Formalizing the short-term planning 0.5 2 0.0 1 0.5 2
8. Detailed specification of tasks 1.0 3 0.5 2 1.0 3
9. Scheduling of reserve tasks 1.0 3 0.5 2 0.5 2
10. Corporate decision making 0.5 2 0.5 2 1.0 3
11. Use of PPC and identification of problem causes 1.0 3 0.0 1 1.0 3
12. Use of system performance indicators 0.5 2 0.5 2 1.0 3
13. Corrective actions to problem causes 1.0 3 1.0 3 1.0 3
14. Meetings held to disseminate information 1.0 3 0.5 2 1.0 3

82.1% 35.7% 85.7%

Legend: 1-NA (weight 0.0), 2-applied partially (weight 0.5), 3-fully applied (weight 1.0)

In a way, it is understandable that companies A and C presented high values for their indicators. After all, both companies had already established a planning model and disseminated it at all levels of their organizations. However, Company B, despite not following the hierarchical model of planning, implemented some of the practices analyzed; when it comes to PPC, however, the company carried out many fewer than expected for a medium-sized company.

5 Conclusions

As seen in the cases of Companies A and C studied, a culture of proper planning can help reduce costs and meet deadlines defined in a project. One of the critical success factors is the hierarchy of planning. It permits greater detailing of the process, providing for quicker removal of restrictions.

Another highlight is supply management having a focus on reducing inventory levels. This leads to reducing waste and increasing productivity. Despite these positive assessments, components were found that obstructed improvement to planning; these included the following: high costs of computerizing construction sites, difficulty of operationalizing the software as well as it being ill-suited to the reality of building construction, and shortages of trained professionals in the planning area—often forcing the company to resort to outside consulting.

What accounts for a company’s resistance to adopting the principles laid out here? A few reasons might include the industry’s excessive bureaucracy, the belief that the planning instruments fail to meet the simplest way a company works, and the notion that anything so sophisticated represents an unnecessary cost. However, as the building industry gets more and more competitive, companies will increasingly find it necessary to adapt to the need of improving the processes of planning and construction control.

References