

CHAPTER 8

Revenue Management and Capacity Analysis

Two topics with special relevance for revenue management are *capacity analysis*, especially the capacity model developed by Computer Aided Manufacturing-International (CAM-I), and the *theory of constraints* (TOC), as set forth by Eli Goldratt in *The Goal* and subsequent publications. This chapter discusses capacity analysis; the TOC is presented in Chapter 9.

Considerations of capacity are central to revenue management, which is about generating additional revenue (selling unused capacity) in a profitable way.

Background: Capacity Management

Concern regarding the analysis, costing, and management of capacity has been a long-standing issue in accounting, finance, and management. McNair and Vangermeersch provide a historical summary of 12 major capacity management concepts, ranging from the early 20th-century work of Henry Gantt to the theories and techniques of the late 20th century.¹ One pervasive issue involves how to address the cost of capacity not currently utilized in production: Should the cost be identified separately or should the cost be incorporated into product costs and borne by current production, even though the excess capacity does not contribute to current production? This issue has been discussed for the better part of a century, and will not be addressed here.

Another prevalent theme focuses on management techniques for the efficient use of capacity. Since about 1980, several capacity-related management techniques have emerged on the scene.² Material requirement planning (MRP) focuses on coordinating material acquisition, production scheduling, and process control for more efficient use of manufacturing

capacity. Just-in-time (JIT) production tends to focus on small-cell manufacturing, with techniques designed to minimize waiting, material or product movement, and inventories. The TOC emphasizes the identification and management of bottlenecks (constraints) in the production process. The capacity utilization bottleneck efficiency system (CUBES) extended TOC by developing an 11-factor model of capacity utilization. Finally, the CAM-I model emphasized the strategic use of capacity. Readers interested in further details on these topics are encouraged to consult McNair and Vangermeersch.³

McNair and Vangermeersch consider capacity management at three levels.⁴ At the operational or short-term level, they summarize seven relevant practices, none of which involve revenue issues. At the tactical or intermediate-term level, they cite 12 common elements of the various capacity management models; again, none mentions revenue. Only at the strategic or long-term level do revenue issues seem to enter the picture. Four of their seven core features mention value creation, market strategy, and customer and market requirements. Indeed, they state that, from a long-term perspective, “capacity is redefined as the value-creating capability of the firm and is tied only loosely to the underlying costs and resources that create this value.”⁵

Despite the extensive capacity literature over a long time period, the predominant themes remain regarding how to deal with the cost of unutilized capacity and how to utilize capacity in the most production-efficient way. Both themes have limited connection to revenue management. However, two of the previously cited techniques do have relevance to revenue management. The CAM-I model, discussed in this chapter, takes a strategic look at capacity utilization, including the question of how much is truly revenue producing. This analysis serves as a foundation for considering how to generate additional revenues from one’s capacity by changing strategies or policies. The TOC model, discussed in the next chapter, explicitly incorporates throughput (net revenue) as the leading metric for making capacity decisions.

Capacity Analysis

As mentioned earlier, revenue management is about generating additional revenue by selling unused capacity in a profitable way. Thus, it is essential

to know what one's capacity is, and how it is currently deployed. In the early applications of revenue management, relevant capacity was obvious: the number of seats on a flight, the number of rooms in a hotel, the number of autos at a rental agency, and so forth. But as revenue management expanded to more sophisticated levels, a better analysis and understanding of capacity was needed.

Much of the traditional capacity literature is concerned with overhead costing: how to spread the cost of capacity, including unused capacity, to products. Such considerations have little to no value from a revenue management perspective, since mere allocations of cost do nothing to generate revenues or influence real profits. Indeed, such allocations can prove harmful to revenue management if the allocated costs adversely influence price setting.

CAM-I—a group made up of large industrial companies, consultants, and others—developed a useful model showing how capacity is used.⁶ Their model begins by analyzing how capacity is currently being used. The four main components of capacity are physical, personnel, processes, and supply:

- Physical capacity—buildings, equipment, and technology—is generally available 24/7.
- Personnel capacity is present to the extent management decides to provide it. Workers can be taken off the job and sent home; machines cannot undergo the same.
- Processes refer to all the activities involved in the provision of goods and services to customers; processes are an element of capacity in terms of how much business an organization can *handle*.
- Supply capacity (purchases) is the ability to acquire the goods and services needed to operate. Supply capacity is harder to analyze, requiring an assessment of whether needed goods and services can reliably be acquired in the quantities, locations, and time frames needed.

The CAM-I Model

As designed, the CAM-I capacity model focuses on physical capacity, though it can be modified to address other dimensions of capacity as well.

It begins with a notion of *rated capacity*, which is usually a 24/7/365 availability of physical resources. Time is the initial means of measurement. The rated capacity is then subdivided as follows:⁷

1. *Productive capacity*: capacity in use and providing salable goods and services—that is, revenue generating.
2. *Nonproductive capacity*: capacity in use but not providing salable goods or services.
3. *Idle capacity*: not currently in use.

We consider each of these categories, beginning with idle capacity.

Idle Capacity

Capacity may be idle for various reasons. It may be *off limits*—that is, its use is prohibited by law, regulation, contract, physical limitations, or management decision. There may be certain hours of the day, or days of the week, when the business does not operate. Bars in some areas have opening and closing times set by law. A store in a shopping mall typically can operate only during hours when the mall itself is open. A golf course cannot function during nondaylight hours (unless the course is lighted) or during northern winters. Management is probably the prime mover in deciding to put capacity off limits by setting business hours, including deciding to be closed on certain days, not to work a third shift, and the like. Thus, some off-limit capacity may be mandatory, whereas others may be discretionary.

Capacity may be idle because it is deemed *nonmarketable*; that is, management believes that there is little or no demand to justify its use. There may not be enough product demand to justify a second or third shift, and so management leaves the plant idle during those times. A retail store may find too little demand during overnight hours to remain open 24 hours a day. Capacity may also be idle even though it is *potentially marketable*, but management chooses not to exploit the opportunity. A restaurant could be open for breakfast and lunch, but management chooses to operate a dinner-only facility. A company might be able to increase its marketing effort, thus creating more product demand to justify more

production time, but it has not done so. Idle-marketable capacity suggests unexploited—though not necessarily profitable—revenue opportunities.

Nonproductive Capacity

Capacity is nonproductive when it is in use but not producing salable goods and services. In a manufacturing environment, nonproductive may mean that the production facility is down for repair or maintenance, or that setup work is being performed. Production of defective goods also constitutes a nonproductive use of capacity. Often a major component of nonproductive use of capacity occurs when the business is open and staffed—the capacity is in use—but it is not fully productive because of a lack of customers. The restaurant with empty tables at dinnertime, the hotel with vacant rooms, and the airline with empty seats on a flight all demonstrate this type of nonproductive capacity, which may be called *stand-by capacity*. The physical facilities were designed to accommodate a given number of customers, but at some times, not enough customers are present.

Nonproductive time does not imply unnecessary time—it simply means non-revenue-generating time. Thus, for an airline, maintenance, loading and unloading, waiting for a connecting flight to arrive, and waiting to take off are necessary activities, but they do not generate revenue. Time spent in these activities means time not spent in moving passengers from place to place. Although nonproductive time can often be managed, it typically cannot be entirely eliminated.

Productive Capacity

Capacity is productive when it generates revenue by producing salable goods and services. Having capacity in productive use is a desirable state, though incomplete. The capacity model is about the *utilization* of capacity but it says nothing about profitability. The goal of revenue management is to increase capacity utilization *and* be profitable.

The CAM-I model also includes as productive the capacity time spent on *product development*, such as running prototypes, and time spent on *process development*, such as integrating new equipment or techniques into

production. Although these are not immediately revenue producing, they are deemed to contribute to future revenues by developing tomorrow's products and processes. The principle is stated as "the productive use of capacity results in tangible changes in the product or service that are of value to the customer."⁸ Alternatively, one could classify these activities within the nonproductive-use-of-capacity category.

Some activities are difficult to classify, such as inspection and testing. Where each product is different, or where product failure would be catastrophic, as with elevator cables, aircraft, or military equipment, testing becomes an integral part of production and hence a productive use of capacity. Where production is more standardized or where failure of an individual unit has minor consequences, inspection and testing could be included as a nonproductive, albeit still necessary, use of capacity.⁹

Example

Suppose a restaurant is open for dinner only, six days a week. Service hours are from 5:00 to 10:00 p.m., but the restaurant is staffed from 3:00 to 11:00 p.m. to allow for setup, initial food preparation, and cleaning. The physical capacity is available 168 hours per week (24 hours \times 7 days). The productive capacity is at most 30 hours per week (5 hours \times 6 days), depending on how full the restaurant is. The nonproductive time is at least 18 hours per week (the 3 hours daily of preparation and cleanup), plus any unutilized time during open hours. There remains 120 hours of idle time per week.

Suppose that the restaurant could serve 120 dinners each evening, given normal service durations. In a typical week, on average, 90 dinners are served daily, or 75 percent of maximum. The weekly capacity analysis is shown in Table 8.1.

Using the Capacity Model to Enhance Revenues

The analysis of physical capacity utilization is a helpful tool for revenue management, by focusing attention on how the physical resources are used. But as pointed out earlier, the goal is not just increased utilization, but *profitable* utilization. Analyzing how much of a business's physical

Table 8.1 Analysis of physical capacity

Productive time (30 open hours \times 75% utilization)		22.5 hours
Nonproductive time: stand-by capacity—restaurant is open and staffed but has unfilled space (30 hours \times 25%)	7.5 hours	
Nonproductive time: preparation and cleanup—restaurant is staffed but is not serving customers.	18 hours	25.5 hours
Idle capacity—restaurant is not in use		120 hours
Total time		168 hours

Note: The physical facilities are in productive use about 13 percent of the available time, in nonproductive use about 15 percent of the available time, and idle about 71 percent of the available time.

capacity is idle or nonproductive can point to revenue enhancement opportunities.

Some businesses enhance revenues by expanding the use of only a portion of their physical resources. Many restaurants offer take-out or catering service, utilizing food-preparation capacity but not impacting dining room capacity. To the extent that the kitchen can handle more than the in-house customers, this approach is a good way to expand capacity utilization (by reducing nonproductive kitchen capacity) and enhance revenue. Similarly, many retailers offer catalog or online sales, further utilizing their inventory and distribution capacity beyond their retail store operations. This expansion enables the company to serve a new class of customers who are not close to a retail outlet, or who choose not to go to a physical site.

Analyzing how physical capacity is currently utilized—how much is idle and why, and how much is nonproductive and why—is a useful step to finding creative ways to enhance revenues without expanding one's investment in physical resources.

Issues in Measuring Physical Capacity Utilization

Early applications of revenue management were found primarily in industries that could easily measure utilization of physical capacity. An airline had a given number of seats on its flights, a hotel had a given number of rooms, and a restaurant had a reasonably given service capacity. Golf courses, theaters, cruise ships, rental car companies, and freight

companies all have fairly well-defined notions of their service capacity and how much of it is being utilized. Manufacturing companies often have some idea of their maximum output capability, given their machines and process times, though varying product mix complicates the measure. Professional service firms, such as accountants and lawyers, would think more of the service capacity of their staff (discussed later) than of their physical resources. For some business types, however, the analysis of physical capacity is more challenging. How do we measure the utilization of the physical capacity of a retail store?

Other Dimensions of Capacity

The CAM-I capacity model focuses on physical capacity, which is what the term *capacity* means to most people. Physical capacity is typically a major investment, is not easily or quickly modified, and represents a large fixed cost to most businesses. Considering how a company would increase the utilization of physical capacity for greater revenue and profit necessitates thinking about other dimensions of capacity as well. To make physical capacity operational typically requires personnel, purchases, and processes.

Personnel

Personnel are almost always necessary to turn physical capacity into revenue. Aircraft cannot generate revenues without pilots, flight attendants, ground crew, and others. What differentiates personnel from physical assets is that personnel staffing is discretionary and often is capable of short-term modification. Although the physical facilities are in place 24/7/365, management decides how many personnel are in place at any given time. Thus, there is typically little notion of idle personnel capacity, in the sense that physical capacity can be idle. But there may be considerable nonproductive personnel capacity, especially of a stand-by nature—the business is open and staffed to serve customers, who may not materialize in the numbers expected. The CAM-I framework can be used to analyze the extent to which personnel capacity is productive or nonproductive.

Returning to the restaurant example earlier, assume that there are 18 employees—manager, cooks, other kitchen help, servers, clean-up personnel—all working from 3:00 to 11:00 p.m. The 144 daily hours of personnel capacity are analyzed in Table 8.2.

Table 8.2 Analysis of personnel capacity (per day)

Productive time (5 open hours \times 18 staff \times 75% utilization)		67.5 hours
Nonproductive time: stand-by capacity—restaurant is open and staffed but has unfilled space (5 hours \times 18 \times 25%)	22.5 hours	
Nonproductive time: preparation and cleanup—restaurant is staffed but is not serving customers (3 hours \times 18)	54 hours	76.5 hours
Idle capacity—restaurant is not in use (no staff on duty)		0 hours
Total time		144 hours per day

Note: There is no idle capacity for personnel because the restaurant is not staffed at other times.

For some businesses, personnel capacity is far more important than physical capacity in determining revenue generation. Professional service firms, especially, sell the time of their professional staff rather than the utilization of their physical resources.

Purchases

Beyond physical facilities and personnel, businesses require materials, supplies, and external services to generate revenue. Thus, purchases become an additional consideration. A dependable supply of such items—in the locations, quantities, and times needed—is critical to revenue generation. Some companies, such as Walmart, have extensive internal supply and distribution networks; others depend on a variety of external, independent suppliers.

Processes

Finally, revenue generation depends on having sufficient processes in place to make the physical capacity, personnel, and purchases operational. Adequate information systems are an important process for many businesses; airlines and hotels depend on sophisticated reservation systems, which often allow price modifications to help fully utilize physical capacity.

The processes by which output is generated also impact capacity. For example, a restaurant's physical capacity depends on the size of its kitchen and dining area. Its personnel capacity depends on the number and capabilities of its food preparation and service personnel. The purchases dimension of its capacity reflects its ability to have a steady and reliable source of food and service products. But we cannot fully measure the restaurant's capacity without knowing something about its processes—is this restaurant a fast-food outlet, a buffet operation, casual dining, or fine dining? A fast-food restaurant has a greater customer capacity than a fine-dining restaurant, due to shorter preparation, service, and seating times—though it may not necessarily produce more revenue.

Capacity Is a Multidimensional Concept

The previous example demonstrates that capacity is multidimensional. Physical capacity is the most constraining, because it is not easily changed in the short term. However, understanding how physical capacity is used—to what extent is it idle or nonproductive—is essential to revenue management. Converting some idle or nonproductive time to productive use may be a profitable way to enhance revenues without additional capital investment.

Physical capacity also may not be a single measure. Hotels have standard rooms and suites; an aircraft may have first-class and main-cabin seats. An airline may have different types of aircraft, and can decide which type to use on a given route, therefore affecting the capacity of that flight. A restaurant may have greater food preparation (kitchen) capacity than service (dining room) capacity, enabling it to consider adding take-out or catering services. The capacity of a manufacturing plant may depend on the mix of products being manufactured. Despite these complications, an analysis of how physical capacity is used is an important aspect of revenue management.

Processes may be the next most constraining feature of capacity, as they too are usually not easily changed. A business establishes and becomes known for the types of goods and services it provides—low cost

or premium, minimal or high service, and other aspects of the business model. As noted earlier, processes impact the utilization of capacity and potential revenue generation.

Personnel and purchases are the most flexible dimensions of capacity. They also have considerable impact on revenue generation and profitability. Inadequate staffing or an inadequate supply of materials may lead to customers being turned away, or being unhappy with the quality of the goods or services provided. As mentioned earlier, Circuit City, a large consumer electronics chain, decided to lay off all its highest-paid floor personnel, in a misguided attempt to reduce costs and increase profitability. The results were disastrous from a revenue perspective. The remaining salespeople were young and inexperienced, and were unable to offer the technical information and advice customers needed. Customers were dissatisfied and took their business elsewhere, and the chain soon filed for bankruptcy. On the other hand, excessive staffing and an oversupply of materials add costs without generating revenue, and thus impair profitability. Making the right decisions on staffing and supply is critical to overall capacity management.

Applying the CAM-I Model in Revenue Management

Capacity analysis is important to revenue management. Begin by applying the CAM-I model to physical capacity. How much of the time is capacity idle or nonproductive, and why? Can some of this idle or nonproductive time be converted to productive revenue-generating and profitable use?¹⁰

How does the business model—the processes for delivering goods and services—impact capacity? Are changes to these processes needed? And are the supporting processes, such as the information systems, adequate to support revenue growth?

Are personnel and supply reasonably aligned with capacity utilization—not too much, not too little? If some idle or nonproductive capacity can be made productive, are adequate personnel and supply sources available to service it?

There are numerous examples of companies employing their underutilized capacity to enhance their revenue generation, listed as follows:¹¹

- Many supermarkets are open 24 hours. At one time, overnight hours were used solely for nonproductive maintenance and restocking tasks. The building was in use and had some staff. By adding some additional staffing (cashiers and a manager), sales could be made during these hours.
- Some fast-food establishments have instituted 24-hour service at their drive-through window. This service generates revenue with reduced staffing (no inside cleanup needed) and without compromising the safety and security of employees working overnight.
- Different parts of one's physical facilities may have different capacities. For example, a restaurant's kitchen may have sufficient space and personnel to prepare more meals than needed to serve dine-in patrons, given the seating capacity of the dining room and the pace of service. Many restaurants have increased utilization of their kitchen capacity and enhanced their revenue generation by offering take-out or catering service.
- Disney World adopted its FAST-PASS® system to reduce the waiting times for its attractions. Customers viewed waiting times as nonproductive because waiting reduced their enjoyment and might even discourage repeat visits. Disney also concluded that waiting time reduced customers' time to patronize other revenue-generating facilities, such as gift shops and eating establishments.
- Southwest Airlines attempts to achieve quick gate turn-arounds; the time the aircraft spends at the gate is not revenue producing. By achieving quicker turns, an aircraft may be able to complete an additional flight each day.

Even though capacity considerations can be very complex in many business environments, it is difficult to effectively manage revenues without a good understanding of one's capacity and how it is being used. As a result of this analysis, new revenue opportunities may be uncovered.