

Hospitality, Big Data, and Restaurateurs: Does Simulation Have a Seat at the Table?

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ABSTRACT

Big data is a proven asset within the hospitality industry – where might modeling and simulation further increase the value of data housed in hospitality data systems? Many industries find insights from big data and act on them to realize benefits. The hospitality industry uses data to focus marketing campaigns, enhance customer experience, optimize internal operations, and increase operating profits. This paper provides an overview of how hospitality sectors are using big data in a high stakes business. Restaurants represent a large sector of the hospitality industry. Restaurateurs manage operations ranging from multi-kitchen, four-star hotels to locally-owned restaurants. Trends in the restaurant sector show increased use of technologies to manage those operations. Mindful of the technologies restaurateurs use, this paper provides a look at big data within the context of these technologies and how predictive analytics is a leading capability for analyzing information. It highlights challenges restaurateurs faced in becoming data centric and viewing the switching costs as an investment. As data-centric organizations mature, shifting from predictive analytics to prescriptive analytics is a natural step. Modeling and simulation is a powerful approach to push beyond prediction and provide restaurateurs with insights they can act upon. Like big data, modeling and simulation solutions will need to overcome challenges before restaurateurs adopt them. This paper closes with three overarching questions to begin the conversation with restaurateurs and stimulate ways in which simulation professionals may provide answers.

Keywords: big data, hospitality industry, restaurant sector, data science, data maturity model, customer intimacy, social media, cloud-based services, predictive analytics, prescriptive analytics, restaurant technology stack

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SETTING THE CONTEXT: WHO MAKES UP THE HOSPITALITY INDUSTRY? WHAT IS BIG DATA?

This paper pulls a thread of commonality between two large industries: hospitality and big data. Data science is the common element between them that aids decision making and provides insights to improve operational outcomes. Overall, this paper aims to build upon this commonality and identify areas where modeling and simulation may be able to assist the restaurant sector. Admittedly, this paper is a thought piece – it is intended as such. The secondary aim is to stimulate dialogue among industry professionals from one industry who may not be aware of the others' challenges and solutions. Setting the stage for future conversation starts by introducing the industries to one another.

The Hospitality Industry is Broad and Serves Nearly Everyone

Any reader who has stayed in a hotel for business, taken a vacation journey to a far-off land, or eaten in a restaurant is a guest of the hospitality industry. The essential characteristics of this industry are easy enough to wrap one's mind around because they are tangible, accessible, and touch nearly everyone's lives. Additional details on the hospitality industry appear later in this paper. However, it is worth noting why this industry is a key focus of this paper. That reason lies in *uncertainty*. Until the earlier part of this decade, outside of academic research the hospitality industry had been uncertain of the role data could play in serving its customers. In contrast, industries such as banking, telecommunications, and marketing have exploited the use of data for decades by using systems like customer relationship management software (Mohammed & bin Rashid, 2012). As Joseph Sirosh aptly noted in his keynote at the Strata+Hadoop Conference, "every company is a data company" (2015). This is no less true for hospitality, and the literature indicates that leaders within the hospitality industry have adapted to using big data as well (Hayes, Ninemeier, and Miller, 2016; Riehle, 2017; Song & Liu, 2017; Stabineraug, 2017). Within the last five years, the hospitality industry has begun to use big data to improve operations, increase profits, and enhance customer relationships.

Big Data Has Established Itself as a Competitive Advantage

Like the hospitality industry, most people have had an experience with big data. Examples would include customers taking the recommendations offered by Google, Apple, Facebook, or Amazon. Big data is conceptually less tangible or relatable to most consumers; but like hospitality, it touches nearly everyone's lives. Big data refers to very large repositories of data, but that is not its only characteristic. Kitchin and McArdle (2016) note the term *Big Data* first appeared in a 1998 presentation given by John Mashey, then the Chief Scientist at Silicon Graphics. Later in 2001, Doug Laney articulated three commonly referenced characteristics of big data, the "3V's":

- **Volume:** there is an enormous amount of data. An IDC study found data is doubling every three years and by 2025 there will be 163 zettabytes (163 trillion gigabytes) of data in the datasphere (Reinsel, Gantz, & Rydning, 2017).

- **Velocity:** systems create data in real-time. The Internet of Things, content marketing, and smartphones drive a continuous stream of data that results in a need for continuous analysis to gain competitive advantages.
- **Variety:** data arrives in multiple forms. Decades ago, structured databases held the bulk of business data. Today, the richness of data from social media and streaming data exists in unstructured formats.

Big data is impacting many industries beyond its early adopters from retail, logistics, and technology (Song & Liu, 2017). Technologists have produced tools and techniques to work with big data within the hospitality industry. Today, data science professionals can channel data from Twitter along with data about online dining sites and combine that with weather data to glean insights about how the weather may impact guest arrivals (Eshelman-Haynes, Gendron, Hall, & Hall, 2016). The “3V’s” exist in the DNA of hospitality industry data. Fortunately, technologies used within that industry often provide utilities that are readily accessible and developed specifically for leveraging big data.

PROBLEM SOLVING: HOSPITALITY PROFESSIONALS USE BIG DATA TO ENHANCE BRAND

Professionals within the hospitality industry are expert problem solvers. Catering to the needs of a widely varied clientele poses many a problem in customizing a solution to each of their needs. Combine that with the precision timing involved in receiving a group for a major event or getting all the meals out at the proper temperature even when there are dozens or thousands of guests expecting their meals at the same time. The business of hospitality is inherently about solving problems. The advent of big data affords hospitality professionals a means to help solve problems without causing additional problems from using that information.

Hospitality: Providing New Experiences, Creating Customer Intimacy, and Anticipating Customer Needs

Guests are continually looking for new experiences, and they are making their decisions on the perceived value of their experience. One might say, *To the brand with the greatest value goes the guest*. Price is one factor in perceived value, but it also includes quality and customer intimacy. The Wharton School of Business at the University of Pennsylvania promoted the concept of **customer intimacy**. Libert, Wind, Fenley and Corso (2015) describe how this concept works within a business context:

They make a strong effort to understand the unique characteristics and preferences of each customer and use the insights that they gain to serve the customer better. Further, they see each customer as a complete personality with needs around different facets such as work, play, socializing and self. They serve these needs wholly – and this, in turn, encourages more sharing and openness from their customers (para. 5).

Here is the concept of customer intimacy in summarized form – “changing your relationship with your customers means changing the way you interact with them” (Libert, et al., 2015, para. 14). This may require changes to the underlying business model through initiatives and technology which allow customers to co-create in lasting, mutual, and self-reinforcing relationships. Unfortunately, nearly 80% of businesses are not willing to make changes at the business model level (Libert, et al., 2015). Technology is changing the environment for most businesses, including those in hospitality. Hayes, Ninemeier, and Miller (2016) note that data allows hospitality professionals to “learn more about guests' needs and then use this information for marketing and advertising purposes as well as to better serve current guests” (p. 23). They highlight four ways the hotel sector is using data and cloud-based technologies (see Table 1).

Table 1. The Use of Data and Cloud Technologies in Hospitality (Hayes, Ninemeier, & Miller, 2016)

Ways to Leverage Data and the Cloud	In Practice...
Managing room-rate practices	Data provides insights to customize the guest experience while matching demand levels with room rates.
Using social media technology for sales and marketing	Successful use of social media can increase interaction with guests and potential guests by informing them about nearby activities or food and beverage specials. Hospitality professionals can better connect with guests to increase value and attend to problems before they learn about them in comment cards at checkout.
Reducing time to make operating decisions	Data can provide insights on how long it takes to accomplish routine operations (e.g., cleaning rooms) and how many people it takes to prepare for an event. These insights are based on historical data.
Implementing cloud-based services	Migration to the cloud increases each year and it enables powerful and user-friendly systems: <ul style="list-style-type: none"> • guest management systems • sales and marketing tools • loyalty and reward program management Overall, cloud-based services reduce the load on staff members and allow hospitality professionals to focus on guests and provide them the best possible experience.

As noted earlier in this section, creation of customer intimacy is a vision proposed for businesses. Consider Google, Apple, Facebook, and Amazon. They use data to anticipate consumer needs and cater to them. This results in increased brand loyalty and customer satisfaction. Hospitality deals with guests on a relatively large scale as well, and the essence of its business is satisfaction. The volume of guest data available provides hospitality professionals the opportunity to find hidden insights and connect with guests on a more individualized level. Song and Liu (2017) point out that advertising can go only so far without the proper information and targeting. Hospitality is a fast-paced industry that requires equally fast analysis. It is imperative that guests' needs are satisfied to maintain their loyalty. Big data applications will help interface classic hospitality functions like call centers, loyalty programs, and accommodation preferences with online reviews, booking histories, and social media content (Song & Liu, 2017).

Restaurants: Managing Operations, Marketing, and Delighting Guests

In 2017, expected annual sales in the restaurant sector was \$799 billion across more than 1 million locations. However, this represents flattened growth that is likely to remain below two percent per year through the near future. The use of technology is one of the growing trends to counter stalled sales growth (Riehle, 2017). Stabineraug notes “a 2016 National Restaurant Association survey reported that four out of five restaurateurs believed that business would improve if they embraced technology, and a third worried that they were lagging in those efforts” (2017, para. 6). Oracle, a technology vendor in the restaurant sector, offers their assessment of technology trends (see Table 2).

Table 2. Technology Trends in the Restaurant Sector (Oracle, n.d.)

Technology Area	Trend
Cloud technology	Food and beverage operators are migrating towards the cloud to reap benefits of paying only for technologies needed, centralizing information technology (IT) to save money, and remaining innovative by quickly taking advantage of new features available on cloud-based systems.
Data security	Security has become extremely important in the digital age. Any breach of data opens the possibility of damaging food and beverage brands.
Data analytics	Restaurateurs aware of big data are considering how to use the large amounts of data available to them. Successful operations “will be those who can access the right data in the right formats to identify ways of cutting costs and maximizing revenues.”
Mobility	Today’s mobile technology has changed the way restaurants deliver their service and restaurateurs must adapt to meet changes in guest expectations.
Restaurant loyalty	“The millennial generation expects a frictionless guest experience that is personalized without them knowing it. Loyalty programs offer a great insight into guest behavior and preferences, allowing you to deliver better service and increase revenues.”
Omni channel	Guests want options when paying for food and drink. Restaurateurs should consider third-party payment systems available to them and their guests to meet expectations.
Customer engagement	Food and beverage operators can find competitive advantages by remaining engaged in innovative and unique ways provided through technology.

All told, the restaurant sector is big business that accounted for 13% of consumer spending in 2015 (Riehle, 2017). The restaurant business faces continued flat growth, but technology appears to offer numerous ways of increasing profits and brand loyalty. In many cases, the differentiator could be big data and restaurateurs’ attitudes and actions to adopt it in their operations.

BIG DATA AND THE RESTAURANT TECHNOLOGY STACK

Present-day analytic techniques are more dependent on the technology stack than in previous decades. Statistical analysis in the past used data sets loaded from data warehouses, such as Microsoft SQL Server or Oracle, into statistical computing software, such as R, Python, SAS, or SPSS. Analysis may have taken weeks and months, but this was an acceptable timeline. Modern analytics works on much shorter timelines and relies on other technologies to meet business demands. Analytic techniques are increasingly running on cloud-based technologies like Amazon Web Services clusters and making use of distributed computing with Hadoop and Spark. Streaming analytics relies on these technology stacks to perform in-time analysis of consumer sentiment, customer check-in locations, and emerging short-term trends. The restaurant sector has long used point of sale systems as a technology stack to run its operations. Analytic functionality now exists in that stack.

Point of Sale (POS) Systems Hold Important Restaurant Data

A POS system is a technology architecture that is essential to restaurant operations composed of hardware, software, and cloud services. The hardware elements are commonplace, like the one shown in Figure 1, as well as wireless tablets and mobile devices. According to Oracle (n.d.), a vendor of restaurant POS systems, they are essential for operators wishing to provide exceptional customer experience, controlling costs, and increasing profits. They indicate a trend away from on-premises POS to cloud-based services, which provide advantages made available by cloud technology:

- Enhanced guest experiences from rewards and loyalty programs
- Reduced IT complexity and costs
- More secure systems
- Faster innovation



Figure 1. Restaurant POS (<https://pos.toasttab.com>)

POS Systems Are A Gateway for Providing Decision Science Support to Restaurants

To a decision science or simulation professional, awareness of the underlying restaurant sector IT is critical to delivering the solutions demanded by the business problems. Cavusoglu (2015) investigated technology applications based on responses from 136 of 500 randomly selected restaurant technology managers subscribing to *Hospitality Technology Magazine*. Among these, roughly 60% perform their technology role as a secondary function. Collectively, these managers made decisions and held beliefs that impacted over 67,000 U.S. restaurant units (locations) under their responsibility. Restaurant units included in the study belonged to one of four category types: a) quick service; b) casual or family; c) fine-dining; and d) other types. Overall, the study results capture the IT decisions and preferences of 136 restaurant technology managers – data worthy of consideration by decision science and simulation professionals. The study conducted by Cavusoglu looked at four research questions:

1. What are the main drivers for IT investments in restaurants?
2. What are the main drivers for restaurants' IT efforts?
3. What is the top challenge facing restaurants' technology departments?
4. What are the point of sale (POS) Front of House (FOH) technology features used in restaurants?

Technological Homogeneity Largely Exists Among Different Restaurant Unit Categories

A key finding of the Cavusoglu (2015) study indicates that there is little difference in respondent responses among quick service versus fine-dining restaurant units. The study also found little difference in responses when asked from a business leadership (restaurateur) versus a technology leadership (IT) focus. For decision science and simulation professionals, this implies that although market segments may appear very different when considering the fare on guests' plates, the market is more homogeneous when considering technological solutions running in a POS system technology stack. Some study results are especially relevant to the discussion of analytics and simulation in the restaurant sector:

- Technology budgets among restaurants are increasing – beating other investments for constrained resources
- POS systems continue to make up the largest component of technology spending in restaurants

- Spending on mobile technologies continues to rise with growth potential (even if this represents only nine percent of total spending)
- Five top drivers and the top three challenges influencing restaurant technology initiatives:
 - Drivers – “Business efficiency, Enhanced guest service, Employee productivity, Security/compliance (PCI and payments), and Cost-saving measures”
 - Challenges – “Insufficient IT budgets to keep pace with needed investments, The technology itself is insufficient to meet our needs, and Guests expect greater technology than we can keep pace with” (Cavusoglu, 2015, p. 86)
- Top five and bottom five used POS technology features point to underutilized tools that could bring benefits in the areas of cost savings and productivity increases:
 - Top Five – “Accounting/Financial software, Enterprise reporting, Inventory management software, Kitchen printers, and Company intranet”
 - Bottom Five – “Labor screening and recruitment tools, Real-time web-based reporting, Kitchen management, Customer relationship management system, and Mobile device for manager use” (Cavusoglu, 2015, p. 87)
- Twenty five percent of restaurant clientele state technology is important to their deciding on where to eat
- The highest ranked emerging technologies that restaurant managers plan to implement:
 - Bill pay via customers’ mobile phone
 - Social media activity integrated into POS and/or customer relationship manager platform
 - “POS Integration into online ordering, Barcode scanners, Digital signage, and Take-out/Delivery system” (Cavusoglu, 2015, p. 87)
- Restaurant managers favorably view mobile POS devices to help serve guests more quickly and increase overall guest satisfaction

The study results provide reasonably good market research for simulation systems providers. The findings highlight areas of interest among restaurateurs, underutilized tools, likely sources of funding, and insights about the market. Despite the vast differences among types of restaurants, the commonalities in technology needs can help simplify product and service development for the market. Big data can make a difference as the costs of platforms decrease and employees become more comfortable with what data can provide them (Song & Liu, 2017).

DATA MATURITY MODEL PROVIDES CLUES ABOUT THE NEXT STEPS

He who asks a question is a fool for five minutes; he who does not ask a question remains a fool forever.

Chinese proverb

Exploring the Data Maturity Model

The Data Maturity Model (DMM) is a framework that aids analytic organizations in assessing their experience and organizational development in matters relating to data analysis. In 1991, Carnegie Mellon University released the Software Capability Maturity Model describing best practices in software development. That model codified a standard for software process maturity levels ranging from ad hoc to optimal. By 2000, the organization refined the original model into a unifying framework called the Capability Maturity Model Integration (CMMI) that continues as a standard for software enterprise process maturity levels (Software Engineering Institute, 2009). A similar framework for data maturity has emerged to support businesses and organizations which increasingly rely on data-centric decision making. In 2015, Booz Allen published the Data Science Maturity Model. Like the CMMI, it provides a framework to describe organizational maturity in delivering data science solutions. It is composed of five levels (Collect, Describe, Discover, Predict, and Advise) as shown in Figure 2.

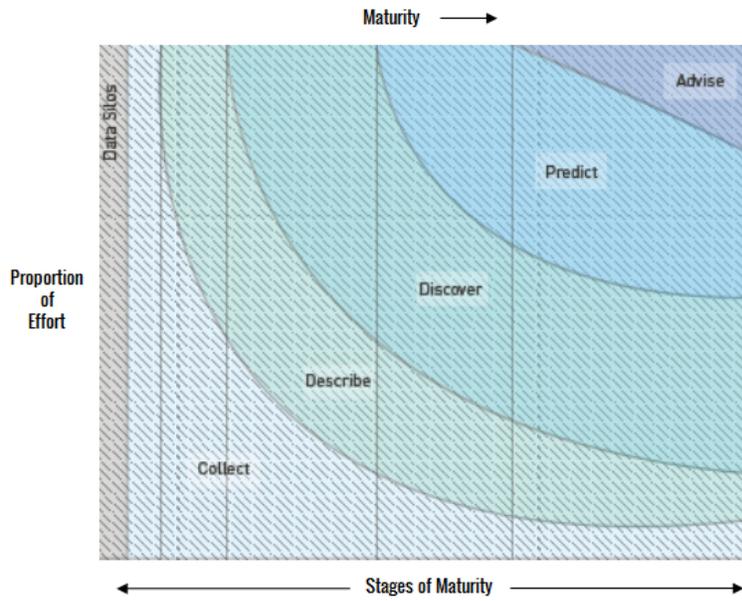


Figure 2. The Data Science Maturity Model (Booz Allen Hamilton, 2015)

As an organization increases in data maturity, it incorporates more levels into problem solving and developing data products. For example, organizations in the early stages of maturity spend most of their effort collecting and describing data. As maturity increases beyond the second stage, the remaining three levels (Discover, Predict, and Advise) begin to complement Collect and Describe. Maturity does not eliminate the need for any of the earlier stages; they are additive. What changes is the proportion of effort that mature organizations place on the various levels. Each stage offers different impacts and insights. Table 3 describes each of the five levels of data science maturity, with an example of each level.

Table 3. The Level of Data Science Maturity (Booz Allen Hamilton, 2015)

Level	Description	Example
Collect	Collects internal or external datasets	Gather sales records and corresponding weather data.
Describe	Enhances or refines raw data; leverages basic analytic functions such as counts	How are my customers distributed with respect to location, namely zip code?
Discover	Identifies hidden relationships or patterns	Are there groups within my regular customers with similar purchase patterns?
Predict	Utilizes past observations to predict future observations	Can we predict which products certain customer groups are more likely to purchase?
Advise	Defines possible decisions; optimizes those decisions; advises on the option with the best outcome	Target specific groups for certain products to maximize revenue.

Restaurants Lay in the Middle of the Data Maturity Model with Room to Advance

Considering the description of the restaurant sector earlier in this paper, one could place that segment somewhere near the middle of the maturity stages in Figure 2. There is evidence of using ‘Collect, Describe, and Discover’ as well as ‘Predict’ in running restaurant operations. Web-based analytic tools (akin to Google Analytics) are available in POS systems. These types of tools help restaurateurs understand customers, learn who their regular guests are, and spot

trends based on various factors like time of day or day of week. Meanwhile, some restaurant managers with longer vision and larger budgets have acted on cues from marketing and use predictive analytic techniques to anticipate what types of guests will visit or what types of promotions may attract guests. But running a restaurant is not a game. It is not the equivalent of guessing the winner of this week's big game and checking up on that guess come Monday. No; managers must make decisions that commit resources, and they must make them in the present. They must prescribe solutions to their problems and rise to the 'Advise' level of maturity. Gartner is a world leader in information technology research and advisory services. Their Information Technology Glossary defines **Prescriptive Analytics** as "a form of advanced analytics which examines data or content to answer the question 'What should be done?' or 'What can we do to make _____ happen?'" (Gartner, 2018, para. 1). It includes techniques such as graph analysis, simulation, complex event processing, neural networks, recommendation engines, heuristics, and machine learning.

Restaurant managers have shown an increasing trust in technology and its underlying analytic power, as demonstrated by increasing purchases of technology – specifically cloud-based POS systems. This attitude among restaurateurs provides the opportunity for data science and simulation professionals to present business cases using more predictive and prescriptive analytic approaches. Although there may be differing opinions among any individual restaurateur regarding the value of data and how they justify the ROI on such an investment (Stabineraug, 2017), on the aggregate the trends show an overall positive inclination for technology-based solutions to restaurant business problems. Modeling and simulation has the tools to help make the next step towards increased data maturity and provide a catalyst to shift into prescriptive analytics. For instance, Chick-fil-A uses simulation results to address questions about restaurant queuing (Abouhneidi, 2014) as well as real-estate location and site layout (Glover, Hodges, & Tiger, 2017; Wong, 2016). These analyses *prescribe* solutions to enhance operations at Chick-fil-A. The authors would argue that simulation has even more to offer:

- Produce **affordable** and **scalable** Java based simulations that can serve as applets for POS systems
- Expand the **perspectives** of restaurant managers by sharing other dimensions of simulation like risk management, sensitivity analysis, and Monte Carlo techniques (Field, McKnew, & Kiessler, 1997)
- Explore the **restaurant problem space** for solutions that may be unique or best served by simulation

SO, DOES SIMULATION HAVE A SEAT AT THE TABLE?

You don't think your way into a new kind of living. You live your way into a new kind of thinking.

Henri Nouwen

Thus far, this paper has looked at the hospitality and big data industries, summarized characteristics of these businesses and technologies, and shared trends emerging in the restaurant sector. Restaurateurs are using POS systems to tap into big data insights. Those systems do not currently use simulation solutions. This section poses three overarching questions along with discussion intended to foster conversations between simulation professionals and restaurateurs.

How can simulation provide value-added solutions to the business needs of restaurateurs?

Consider...

- Simulation is a diverse capability useful in a broad range of domains
- Good modeling and simulation starts with asking the right question
- Team composition should fit the commercial space it serves and may need some change in its membership

Recall how simulation has solved past problems. A professional does not simply throw an old model at a new problem. Rather, they consider what the management question may be – even when the client may have trouble articulating one. The art of the question is challenging for both the person asking and the person asked. Learning to ask questions

and discern the essence of the matter is a learned skill. It requires one to transcend thinking about models and data, open new doors, and discover the clients' essential management question (Gendron, 2016). Meanwhile, it is not uncommon for clients to have difficulties articulating their management questions. This is where a good coach with strong questioning skills adds great value to the overall solution process. This coach (strategist) is one of four archetypes that is useful in assembling a team for engaging with a new industry. The **strategist** helps to determine the best way to deliver value in the simulation. They work closely with the **designer** who will develop the model and visualizations the client will use. The **tester** and **engineer** strive to continually improve the simulation product using structures and data flows that function within POS systems (Gendron, Mortimer, Crane, & Haynes, 2018).

What are the key benefits that simulation can offer to the restaurant sector?

Consider...

- Simulation provides a prescriptive capability and “emergent behavior” not found in predictive methods alone
- Simulation provides a “what if” capability that is more insightful than traditional predictive analytics alone

As noted in the discussion about data maturity, predictive analytics are important – but there is more. The business of restaurateurs is not a game. Successful restaurateurs will not merely make guesses about the guests they expect to see or the meals they may order. Rather, they will take action based on insights from predictions. Even better is using tools that prescribe actions to business problems. This is a great benefit offered by simulation. However, a key challenge will be to incorporate simulation as a technology solution within the price point of a point of sale system.

How can simulation professionals effectively relate and interact within a different industry culture?

Consider...

- Commercial clients will buy value-added technology, but not necessarily get involved in its development
- Minimum viable products result from engaging with potential customers and listening to their needs
- Clients you speak with likely know much more about the restaurant domain than the technology
- POS systems and cloud-based architectures are the current standard for restaurant technology solutions

Most simulation professionals have worked in industries outside of hospitality. Culture is a powerful if not invisible force. Consider it when preparing for interactions with new clients. For instance, if former clients paid for and were involved in the development of a simulation, that is not likely the case in developing simulations for hospitality. They need *off-the-shelf* solutions. This requires a *lean startup* mentality and developing minimum viable products (MVPs) – the smallest solution that is sellable to a buyer so that users can learn and provide feedback. Key to a successful MVP rollout is engagement with customers. Yet, restaurateurs will know considerably more about the restaurant domain than technology. This challenge is one for the simulation professional to surmount. Take time to learn about existing technology preferences in the restaurant sector. Look at the problem and answer the business question from multiple perspectives which fit inside that infrastructure – without secretly hoping to bend their industry to fit yours. Establish interactions that make simulations relatable to restaurateurs. Bridge the cultures. Provide solutions.

Take great care that it does not confuse your mind. And the signs which you have learned here will not look at all as you expect them to look, when you meet them there.

C. S. Lewis, *The Chronicles of Narnia*

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