Article

Examining Strategy Improvements in Hospitals: Linking Trade-Offs to Performance Frontiers

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Abstract

The notion of trade-offs has long been recognized by operations management scholars as a necessary constraint to operations strategy. The increasing importance of this concept is reflected in numerous scholarly works, all seeking an understanding on how firms compete with their limited set of resources. A large majority of the past studies have primarily focused on the empirical validation of trade-offs mainly in manufacturing, with few that have visualized trade-offs as a result of performance frontiers in service sectors. In this article, using longitudinal data, we test and validate trade-offs in a public healthcare service-based setting through a performance frontier lens. Our analyses show that better performing hospitals on the basis of quality and cost-efficiency are those that are closer to their performance frontiers and exhibit a cost trade-off. Those that are situated further away demonstrate a trend for quality and cost improvements. However, despite the positions on the frontier, quality always seemed to be the prerequisite dimension for all hospitals. We believe this reaffirms the logic surrounding the sand cone model, albeit in old industry not known for quality.

Keywords

Improvements, hospitals, longitudinal data, trade-offs, performance frontiers

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Introduction

The notion of trade-offs is central to the founding works of manufacturing strategy (Skinner, 1969) and continues to intrigue scholars (Egbunike et al., 2018; Wurzer & Reiner, 2018). The traditional view of manufacturing strategy asserts that firms seeking superior performance would have to prioritize their competitive objectives and resources (Boyer & Lewis, 2002). That is, focusing on a narrow set of objectives over a broader set objectives in a technically constrained operating environment was seen as a more lasting improvement (Da Silveira & Slack, 2001; Skinner, 1974). Skinner argues that firms cannot excel at everything and that trade-off choices had to be made.

Much of the research dedicated to this argument has been focused on the empirical validation of this concept. For instance, several studies have examined trade-offs among competitive priorities cost-efficiency, quality, delivery and flexibility in various manufacturing settings (Boyer & Lewis, 2002; Filippini, 1997; Qamar et al., 2019; Safizadeh et al., 2000; Vargas-Berrones et al., 2019). Whilst there was some support for the trade-off argument, it still was not convincing for some researchers. For example, Schonberger (1986) questioned the merit of trade-offs on the basis of the successes of the Japanese firms that were able to perform well in many areas simultaneously. This view was supported by authors such as Collins and Schmenner (1993), Corbett and Van Wassenhove (1993) and Hill (1988). A more recent view has been that trade-offs are not only real but dynamic as well (Skinner, 1992), and it could also be contingent on a company's approach to the development of performance dimensions (Ferdows & De Meyer, 1990; Slack, 1991). The unification and resolution of the two views has culminated into the integrated model based on the theory of performance frontiers. The theory proposes that resource trade-offs are more likely for companies moving towards their asset frontiers (Schmenner & Swink, 1998; Vastag, 2000).

The research presented in this article, therefore, examines whether firm's position relative to their performance frontiers really does result in trade-offs and whether a slight movement away from the frontiers signal simultaneous improvements. This article examines trade-offs between cost-efficiency and quality dimensions of public hospitals based on their performance frontiers. The next sections outline the evolving views on trade-offs followed by a set of hypotheses. We then describe our data and analysis and conclude with results and some implications for future research.

Relevant Literature

There are three prominent streams of literature surrounding trade-offs. Trade-offs were first discussed and explored in the early 1870s and 1880s, following Skinner's (1969) seminal works whereby trade-offs were viewed as constraints to competitiveness. Skinner posited that firms needed to make choices and set priorities based on their manufacturing structure and infrastructure (Hayes &

Schmenner, 1978). Superior performance and competitive advantage meant that firms would have to lower their performance in another by giving up one or two priorities, for example, lowering unit cost and improving levels of quality at the expense of delivery and reliability. This view of appropriately positioning competitive objectives, and consequently designing a suitable manufacturing system, was also supported by Miller (1983), Hayes and Wheelwright (1984) and Banks and Wheelwright (1979). Constraints influenced manufacturing decisions requiring firms to choose and be good at one or two objectives at any point in time.

The second stream of literature came about in the late 1880s and early 1890s and questioned the notion of trade-offs. Hall and Nakane (1990), Hall (1987), Jaikumar (1986) and Womack et al. (1990) refuted the notion of trade-offs, following the successes of Japanese manufacturers who demonstrated that by focusing on quality as a prerequisite, improvements on all other dimensions were possible. Schonberger (1986), the leading representative of the World Class Manufacturing School, advocated that it was possible for companies to improve in multiple areas simultaneously, suggesting that trade-offs do not exist. He asserted that companies can continuously improve their competitive dimensions and not trade them off against each other. Authors such as Hill (1988) and Corbett and Van Wassenhove (1993). Ferdows and De Meyer (1990) lend further support to this view through their sand cone model, an analogy they use to describe cumulative capabilities. That is, for firms to be competitive, a sequence in which competitive objectives should be achieved needs to be followed. This sequence required that quality be the prerequisite dimension; and once a desirable base of quality has been established, only then can firms proceed onto building dimensions delivery, flexibility and cost (Ehie & Schoenherr, 2020; Rosenzweig & Easton, 2010).

By the late 1990s, the consensus was that trade-offs are real but they are also dynamic (Skinner, 1992)—contingent on a company's approach to development of its competitive dimensions (Ferdows & De Meyer, 1990), that certain trade-offs could be overcome in the long run (Slack, 1991), with changes in manufacturing technologies and methods (Clark, 1996; New, 1992) and enhanced operations capabilities and repositioning (Hayes & Pisano, 1994, 1996). These arguments resulted in a series of conceptual and empirical papers seeking to validate trade-offs in various manufacturing settings such as Noble (1995), Mapes et al. (1997), Da Silveira and Slack (2001), Boyer and Lewis (2002) and Fynes et al. (2005). Table 1 provides a list of various exemplar studies to date that have attempted to empirically validate the operations strategy models.

There have been mixed results from these studies with some supporting trade-offs, insinuating that trade-offs were contingent on manufacturing and organizational aspects, while others supported improvements along multiple dimensions with quality as the base. In addition, given that trade-offs were originally proposed from a traditional manufacturing setting, majority studies done to date on this area have been done on manufacturing. Service-based studies remain scarce and include that of Lapré and Scudder (2004), Talluri et al. (2013) and Ashwini Nand et al. (2013) pertaining to a transportation context. The inconclusive results led to a third stream of literature which sought for a reconciliation between the two debates: trade-offs versus accumulation via the integrated model.

Table 1. Summary on Exemplar Studies Supporting Operations Strategy Models

Operations Strategy Model Supported	Authors
Trade-off model	Mapes et al. (1997); Safizadeh et al. (2000); Pagell et al. (2000); Da Silveira and Slack (2001); Boyer and Lewis (2002); Squire et al. (2006); Kim and Park (2013); Sarmiento et al. (2018); Qamar et al. (2019); Vargas-Berrones et al. (2019); Hutton and Eldridge (2019)
Cumulative capabilities (including sand cone model)	Ferdows and De Meyer (1990); Roth and Miller (1992); Noble (1995); Morita and Flynn (1997); Corbett and Whybark (2001); Corbett and Clay Claridge (2002); Flynn and Flynn (2004); Größler and Grübner (2006); Rosenzweig and Easton (2010); Avella et al. (2011); Sum et al. (2012); Bortolotti et al. (2015); Boon-Itt and Wong (2016); Tamayo-Torres et al. (2017); Scarpin and Brito (2018); Ehie and Schoenherr (2020)
Integrated model (theory of performance frontiers)	Lapré and Scudder (2004)*; Swink et al. (2006); Ashwini Nand et al. (2013)*; Talluri et al. (2013)*; Cai and Yang (2014)

Source: The authors.
Note: * Marks the few studies that have been predominantly situated in a service setting.

By the early 21st century, there was general agreement that improvements along multiple dimensions were possible, however trade-offs could not be entirely eliminated, hence leading to the integrated model grounded on Schmenner and Swink (1998) and Vastag's (2000) theory of performance frontiers. Schmenner and Swink describe a performance frontier "by the maximum performance that can be achieved by a manufacturing unit given a set of operating choices" (p. 108). The frontier is, therefore, made up of an asset frontier (structural) which reflects the investments undertaken by the company and an operating frontier (infrastructural) which reflects the actions possible, given a set of available assets. The location of a firm on the performance frontier explained the likelihood of trade-offs and accumulation occurring. For instance, firms that are closer to their asset frontiers would more likely experience trade-offs, while those further away would experience improvements. The operating frontier, however, could potentially change or move in an outward direction of the performance space, given improvement and betterment initiatives (Amoako-Gyampah & Meredith, 2007). This last stream has received some attention by scholars Lapré and Scudder (2004), Swink et al. (2006), Ashwini Nand et al. (2013) and Cai and Yang (2014) who have explored whether trade-offs are present from the perspective of the theory of performance frontiers. In one way, or another, these papers studied associations of trade-offs to asset frontiers.

Despite these recent developments, there is still an unclear understanding as to how frontiers work and how improvements occur, particularly in service industries, as they move along various points on the frontier (Wurzer & Reiner, 2018). Whether capabilities in service industries develop differently to that of a manufacturing setting demands research attention. Based on this uncertainty and following on from Lapre and Scudder's (2004) works, we examine how the emergency departments (EDs) of public hospitals in Australia are linked to the performance frontier. Similar to Lapre and Scudder's study, we also develop measures for cost-efficiency and quality and calculate a performance frontier, in particular suited to a healthcare setting. Based on these measures, we test whether improvements are evident among these two dimensions. We also examine if location close to or away from the performance frontier impacts their quality–cost-efficiency trade-off.

Therefore, based on Schmenner and Swink's (1998) theory of performance frontiers and leveraging off the ideas of strategic resourcing and competitive positioning (Hayes & Pisano, 1996; Porter, 1996), we develop the following hypotheses.

H_{1a}: Hospitals closer to their performance frontiers (i.e., operating at higher utilization levels) will not exhibit simultaneous improvements on both cost-efficiency and quality dimensions.

Leveraging off the sand cone thinking:

H_{1b}: Hospitals that are further away from their performance frontiers have latitude to build their capability and selectively dedicate their resource competencies.

H_2: We expect improvements on quality at the expense of cost-efficiency, before high performing hospitals reach a position superior on the basis of both quality and cost-efficiency dimensions.

Data and Method

Sample Profile

The selected hospitals were the largest located in the metropolitan areas of Australia's largest cities, each having 500 or more beds. The advantage of looking at large hospitals is that they typically have a functional and busy ED and tend to report more thoroughly on their general performance in comparison to smaller hospitals. Each of the EDs had a significant number of patients passing through each day making them relatively busy and pressed to achieve a government-imposed performance expectation of treatment in under 4 hours. It is enormously difficult to study hospitals in any jurisdiction. They are places where life and death decisions are made, where very sophisticated and expensive equipment are utilized, data systems have low priority, the level of staff credentialization is very high, and which in combination has created an environment for limited transparency, high costs and questionable quality. The Australian government has made several attempts at motivating state government health departments to be more transparent with performance monitoring by setting up key performance criteria and tying these to funding models. One of these agencies is the Health Performance Authority (now known as the Australian Institute of Health and Welfare [AIHW]), which was set up under the Council of Australian governments to collect information from hospitals in a systematic process and structure. This mandate also stipulated that the data was to be collated and made freely available to the people of Australia, if for no other reason than to enable better decisions on their healthcare needs. A secondary motivation was to enable voters to gain an appreciation of whether public funding was being appropriately operationalized. The data repository set up to implement this mandate was the MyHospitals website.

A convenience sample of the 17 largest public hospitals, representative of the five mainland states, were selected. Secondary data on each of these hospitals were collected for a six-year period (2011–2016) from a variety of sources, for example, MyHospitals, annual reports, and relevant websites. The objective data that was collected for each of these hospitals were based on appropriate operational measures pertaining to cost-efficiency (Cost per National Weighted Activity Unit [NWAU]), quality performance (Staphylococcus aureus bloodstream infections), and utilization measures such as patient numbers and ED treatment performance. These are currently the best available proxy performance measures in the Australian healthcare industry, and they also serve the study's need.

Sample Relevance and Importance of Measures

The motivation for this study was to examine the presence of trade-offs in hospitals as they approach their performance frontiers. Although the data collection for this study is up to 2016, it still enabled us to carry out a thorough examination of this research question. The six-year period of data in its present form is illustrative of an archival study (that is, using data from a time period from the past) and enables the study of trade-offs on 17 of the largest public hospitals operating in Australia. Cost-efficiency and quality are commonly accepted as generic operational capabilities in both service and manufacturing sector (see, for example, Ashwini Nand et al., 2013; Ehie & Schoenherr, 2020). As for a measure of performance frontier, efficiency and utilization measures have been used in previous studies (see, for example, Lapré & Scudder, 2004; Talluri et al., 2013). A number of healthcare studies have also been conducted which focused on hospitals that have employed these operational and efficiency measures (see, for example, Butler et al., 1996; Chang et al., 2011; Ho & Huang, 2020; Matthias & Brown, 2016; van Ineveld et al., 2016) albeit from different research purposes.

Measures

Service Quality. Service quality has been traditionally defined in terms of consumer (dis)satisfaction (Garvin, 1987) and it is, hence, subjective in nature. However, rather than consumer (dis)satisfaction or consumer complaints filed, we define it as a service or procedural outcome/error commonly measured as an infection rate in hospitals. This is the rate of healthcare-associated Staphylococcus aureus (S. aureus) bloodstream (SAB) infections recorded in hospitals over the course of a year. In large hospitals, this can vary from 5,000 to 20,000 occurrences per annum. This is an important measure of the quality and safety of hospital care with the general aim of having as few occurrences as possible according to AIHW 2015–2016 annual reports.

Cost-Efficiency. The National Health Reform Act 2011 established the Independent Hospital Pricing Authority (IHPA) as part of the National Health Reform agenda. The key purpose of IHPA is to promote improved efficiency in, and access to, public hospital services through the setting of the National Efficient Price (NEP) and National Efficient Cost (NEC) for public hospital services. The National Hospital Cost Data Collection (NHCDC) is the annual collection of public hospital cost data and is the primary data collection used to inform the NEP and NEC. The measure for unit cost in the hospital industry is cost per service/procedure. In Australia, this is the Cost per NWAU, which is a measure used by most governments to manage their largest public hospitals, focusing on acute admitted patients (excluding ED and property, plant and equipment costs). It includes the costs, types of patients and activity as defined by the NEP Determination for each respective year (as per AIHW 2015–2016 annual reports). For example, in the financial year 2015–2016 collection:

- 334 hospitals participated;
- Expenditure increased by 7.5%;
- costed activity increased by 4%;
- the average NWAU of an admitted acute separation was $5,194; and
- the average length of stay for a patient was 2.59 days.

Utilization. As noted above, public hospitals in Australia (and internationally) have a paucity of valid and reliable utilization metrics collected and reported to the public on an annual basis. Utilization in hospitals is a complex and difficult measure to calculate reliably both within a hospital and more importantly across hospital campuses. The most prominent government instituted performance criteria that all public hospitals are required to meet is the time of treatment of the patients in an ED. For our study, we use the percentage of patients treated on time in EDs across hospitals to assess how close hospitals are to their performance frontiers. We believe this is an appropriate and internationally recognized measure of total resource utilization at the front end of a hospital, which in turn dictates the overall performance of the hospital campus.

Method

Using cost-efficiency and quality measures, we were able to construct performance improvement paths for each of the hospital cases. The evolutions of cost-efficiency and quality positions were plotted. Next, based on our logic and calculations, we were able to create ED utilization plots which served as surrogates for performance frontiers: hospitals with higher ED utilization indicating that hospitals are closer to their performance frontiers, and if this is the case, then we would expect to see some initial trade-offs (H_{1a}). Performance frontiers are typically considered to be investments that would show as fixed assets on a corporate balance sheet (Schmenner & Swink, 1998). For instance, in Lapre´ and Scudder's (2004) study, the number of aircraft has been used to represent the asset frontier, and utilization of the seats in these aircraft was the surrogate for closeness to an asset frontier. Those hospitals that are situated further away from the performance frontier would possibly demonstrate some level of improvement (H_{1b}). Based on the sand cone logic, we would then expect to see that while improvements are underway, there may be a sequence demonstrated in our cases: quality being established at the expense of cost-efficiency, before high performing hospitals reach a position superior on the basis of both quality and cost-efficiency dimensions (H_2).

In addition to the analysis of performance improvement path plots described above, we also conduct a multivariate analysis to test whether trade-offs are more likely to occur for hospitals operating closer to their performance frontiers (H_1). For this, we use SPSS Linear Regression modelling with data transformation (Hair et al., 1998).

In general, we follow Lapre´ and Scudder's (2004) modelling for quality/cost-efficiency calculations:

Let $C_{i,t}$ denote cost per NWAU (cost) for hospital *i* in year *t*.
Let $Q_{i,t}$ denote patient infection incidence for hospital *i* in year *t*.
Cost and quality improvements are denoted by:
$\Delta C_{i,t} = C_{i,t} - C_{i,t-1}$ and
$\Delta Q_{i,t} = Q_{i,t} - Q_{i,t-1}$.

For every hospital-year observation (*i,t*), we determine the following:

- whether both cost-efficiency and quality improved ($\Delta C_{i,t} < 0$ and $\Delta Q_{i,t} < 0$);
- whether a trade-off occurred ($\Delta C_{i,t} \times \Delta Q_{i,t} < 0$); or
- whether both cost and quality worsened ($\Delta C_{i,t} > 0$ and $\Delta Q_{i,t} > 0$).

As we are interested in simultaneous improvements vs. trade-offs, we omit all hospital-year observations for which both cost-efficiency and quality worsened. For the remaining observations, we define for hospital *i* from year $t - 1$ to *t*:

$TO_{it} = 2$, if a trade-off occurred,
$TO_{it} = 1$, if simultaneous improvement occurred.

In terms of distance to the asset (performance) frontier, we again follow Lapre´ and Scudder's (2004) modelling approach:

Let HU_{it} be the hospital utilization for hospital *i* in year *t*. For each hospital subgroup, we define the highest hospital utilization observed up to year *t* as follows:

$Max\ \mathrm{HU}_t = max_{\ j,s \le t}\ \{\mathrm{HU}_{js}\}$, and
the lowest hospital utilization observed up to year t as follows:
$Min\ \mathrm{HU}_t = min_{\ j,s \le t}\ \{\mathrm{HU}_{js}\}$.
We define distance to the performance frontier as:

$$\mathrm{DPF}_{it} = \frac{Max\ \mathrm{HU}_t - \mathrm{HU}_{it}}{Max\ \mathrm{HU}_t - Min\ \mathrm{HU}_t}. \tag{1}$$

Lapre´ and Scudder's (2004) modelling used binary logistic regression to estimate (binary) dependent variable (TO_{it}) over their 10-year time window. However, we found out that this was not appropriate over the shorter 5-year time window we have in this study (i.e., 2011–2012 to 2015–2016) and the less precise proxy for hospital utilization (i.e., percentage of patients treated on time in EDs). In our study, we have performed Linear Regression modelling with transformation for each of the subgroups, using the following formulation to determine the distance to performance frontier (DPF):

$$\mathrm{DPF}_{it} = \alpha + \beta_1\, \Delta \mathrm{C}_{it} + \beta_2\, \Delta\, \mathrm{Q}_{it} + \beta_3\, [\mathrm{TO}_{it} = 2] \tag{2}$$

The advantage of using regression to estimate distance to asset frontier is that coefficients are easily interpreted. A negative estimate for β in Equation 2 would imply that the probability of a trade-off is higher for a lower distance to the asset frontier. In other words, closer to the asset frontier, trade-offs would be more likely to occur.

Results

Given the limited number of hospitals with available data, and the small 5-year (2011–2012 to 2015–2016) analysis window compared to previous studies (Lapre & Scudder, 2004), we have configured the performance improvement paths for the 17 major metropolitan hospitals, arranged in groups according to their frontier/quality/cost-efficiency performance (see Table 2).

Group-1 was, thus, formulated by only those hospitals that showed improvements on both quality and cost (a reduction) over the time period. Group-2 was formulated by only those hospitals that showed improvements on quality, but an increase in cost over the time period. And in a similar fashion, Group-3 was formulated by only those hospitals that showed reductions in quality and an increase in cost over the time period. Surprisingly, to us Group-1 (the highest improvement group) was also the closest to the performance frontier, suggesting that quality and cost may be important factors in enabling these hospitals to achieve the government's stipulated ED treatment targets.

We, thus, believe this formulation is both a contrast to Lapre and Scudder (2004) and appropriate to the Australian (and international) public healthcare hospital context in which the measurement, reporting, and governance of quality and cost is a very new phenomenon.

Table 2. Hospital Groups

Hospital Group	n	Average ΔQ_{it} (rate)	Average ΔC_{it} ($)	Average DPF
Group-1: Closer to frontier	6	2,280	134.3	110.8
Group-2: Intermediate frontier	7	1,500	–59.5	126.8
Group-3: Furthest from frontier	4	–1,280	–44.8	160.0

Source: The authors.

Performance Improvement Paths

The Figures 1–3 show the performance improvement paths for the 17 major metropolitan hospitals of each of the groups. Note that the scales differ for each hospital to accommodate differing performance profiles.

Figure 1 is a representation of the six hospitals that are seen as being the closest to the asset frontier. From Figure 1, at a first glance, we see the non-linear nature of the quality/cost-efficiency curves. From the plot, we also see that generally this group of hospitals are seemingly better and improving on both dimensions, albeit in a non-linear seemingly haphazard relationship.

Figure 2 represents those hospitals at an intermediate distance to the frontier. In this group, we see aspiring hospitals that have managed to reach an intermediate level and not necessarily situated closer to or on the frontier with respect to Group-1 hospitals. However, they are in a position whereby trade-offs between cost and quality are moderately noticeable.

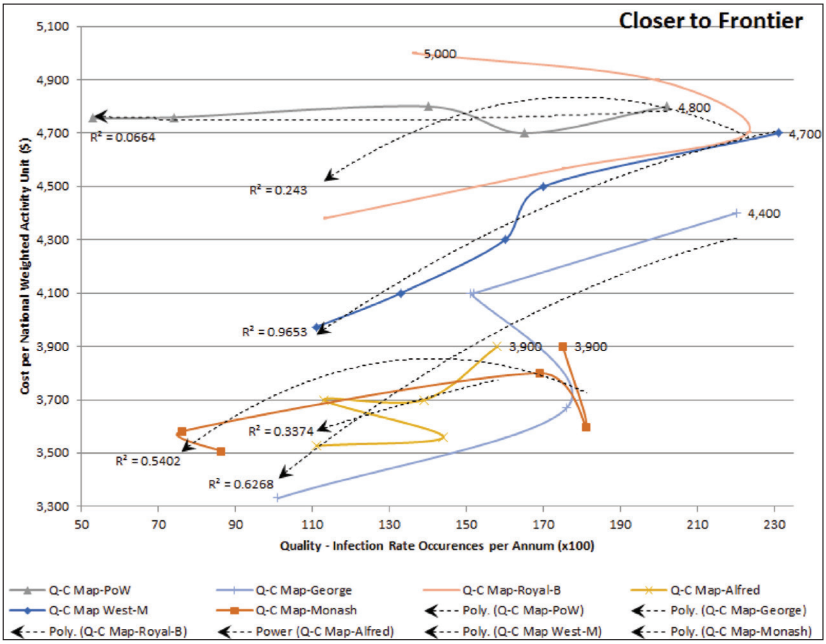

Figure 1. Group-1: Hospitals Closer to Frontier with +Q+C Curves

Source: The authors.

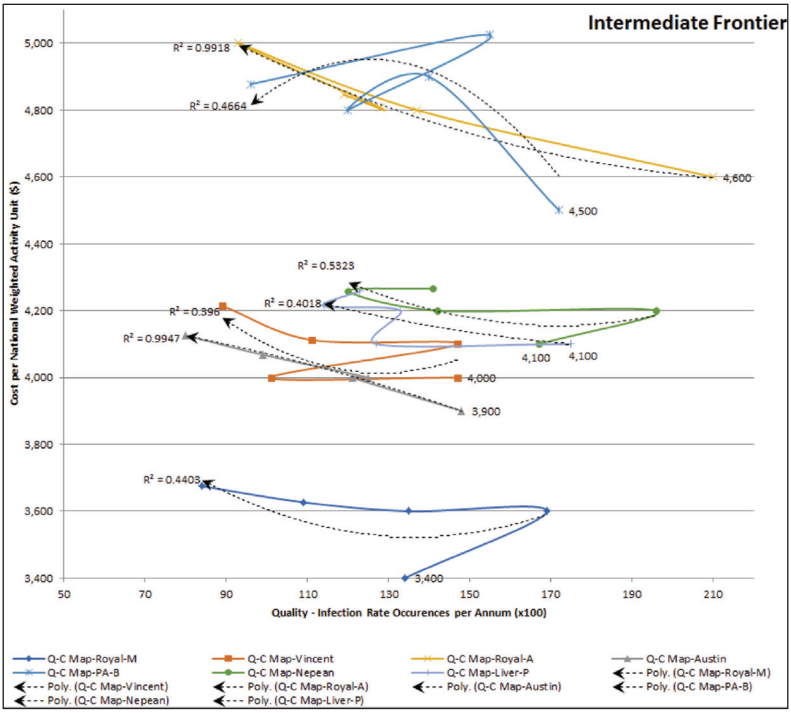

Figure 2. Group-2: Hospitals with an Intermediate Frontier and +Q–C Curves

Source: The authors.

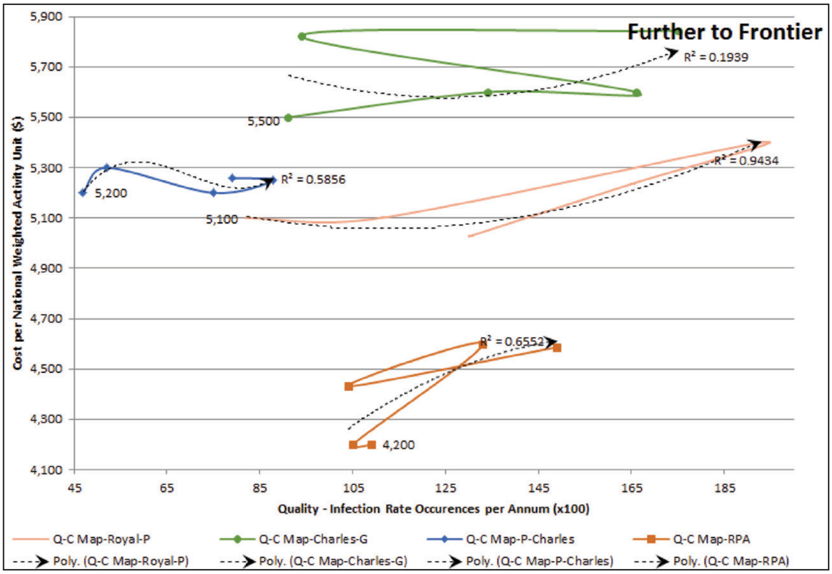

Figure 3. Group-3: Hospitals Furthest from Frontier and –Q–C Curves

Source: The authors.

Figure 3 represents those hospitals which are furthest from the frontier. The hospitals in this group are demonstrating threshold worsening levels of quality (though well within the minimum SAB mandated rates) as well as decreasing cost-efficiency.

Regression Analysis

Table 3 reports the regression estimates of (Equation 2) for Group-1, the set of hospitals that were seen to be the closest to the frontier. The estimate for β, the coefficient for both TOPF = 1 and cost, is negative and significant ($\beta_i = -0.224$ and -0.351, $p < .05$). TOPF = trade-off or improvements seen with hospitals with regards to their performance frontier. So, the closer a hospital is to the performance frontier, higher is the probability of a quality and cost interaction being used to drive the cost lower from year $t - 1$ to t.

From these results, we assert that these hospitals have been able to dedicate time and resources to develop stable levels of quality which enable them to progressively build on cost-efficiency which have enabled trade-offs to gradually disappear. These would be considered the better performers, or as seen from the plots above. Also, we can see from the estimated means plots (see Figure 4) that the hospitals in this group have continuously strived and essentially obtained above the threshold levels of quality which give them a unique cost position.

Table 3. Group-1: Hospitals Closest to the Performance Frontier

Group-1	Coefficient β_i	Std Error	Significance
Intercept	0.919	0.114	0.001
TOPF = 1 ($\Delta C_{i,t} < 0$ and $\Delta Q_{i,t} < 0$)	–0.224	0.093	0.025
TOPF = 2 ($\Delta C_{i,t} \times \Delta Q_{i,t} < 0$)	0		
Cost (transformed)	–0.351	0.0154	0.033
Quality			NS
$n = 24$			
$R^2 = 25.2\%$			

Source: The authors.

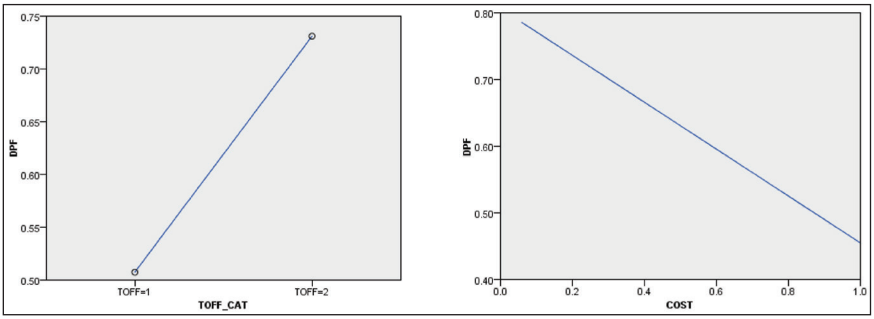

Figure 4. Group-1: Estimated Means

Source: The authors.

Table 4. Group-2: Hospitals Intermediate Frontier Distance

Group-1	Coefficient β_i	Std Error	Significance
Intercept	0.248	0.106	0.030
TOPF = 1 ($\Delta C_{i,t} < 0$ and $\Delta Q_{i,t} < 0$)	0.484	0.179	0.014
TOPF = 2 ($\Delta C_{i,t} \times \Delta Q_{i,t} < 0$)	0		
Cost (transformed)	0.390	0.196	0.06
Quality			NS
n = 23			
R^2 = 22.1%			

Source: The authors.

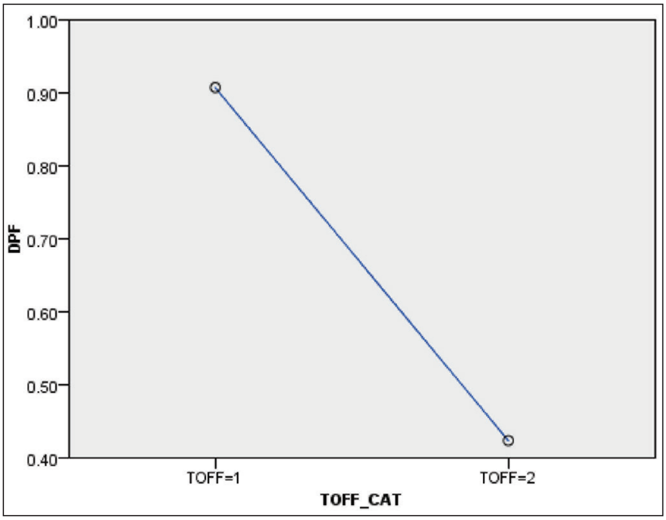

Figure 5. Group-2: Estimated Means

Source: The authors.

This lends support to H_2. That is where hospitals eventually demonstrate a position superior on cost-efficiency after efforts to develop significant resources of quality at the expense of cost-efficiency.

Table 4 reports the regression estimates of (Equation 2) for Group-2, the set of hospitals that were seen to be at an intermediate distance to the frontier. Based on the regression results and estimated means plots (see Figure 5), it is interesting to note that both quality and cost improvement variables are not significant, and that only TOPF = 1 is positive and significant ($\beta_i = 0.484$, $p < .05$). We assert that Group-2 shows evidence of initial trade-offs occurring with cost-efficiency as they approach their asset frontiers.

This lends support to H_{1b}. That is, hospitals that are not yet operating at higher utilization levels, will not exhibit simultaneous improvements on both cost-efficiency and quality dimensions, have latitude to build their capability.

Finally, Group-3 which is the furthest from the frontier does not produce any significant results. We assert that this group of hospitals despite meeting the minimum mandated quality thresholds are perhaps struggling to dedicate resources to the improvement and understanding of quality–cost interaction at an operational level. This could be due to a number of contextual and funding factors which are not evident in the data. This lends some support to H_{1b} suggesting that hospitals that are further away from their performance frontiers have latitude to build their capability.

Discussion

Our analysis of the data yielded some interesting results, and these have some important theoretical and managerial implications. Our data supported H_{1a} and H_{1b}, suggesting that hospital's distance to their performance frontiers does influence their cost-efficiency/quality performance dimensions. We see that Group-2 (intermediate) hospitals are more inclined to be depicting trade-offs in this case with their cost-efficiency dimension. This is generally in agreement with Lapre and Scudder's (2004) results as well as others (see, Swink et al., 2006; Talluri et al., 2013). Alternatively, those hospitals that are situated close to their performance frontier are in a position to be better engaged in multiple improvements, with a focus on cost.

It is important to note that in a hospital setting, there are certain mandated requirements. In our study, quality was measured through SAB rates and a value below 2.0 is considered acceptable for hospitals. This also suggests that the threshold levels are in play (Hill, 1988). The sand cone logic is also relevant whereby for firms to be successful, quality dimension as a prerequisite must be built and reinforced over time (Ferdows & De Meyer, 1990). Our final hypothesis provides some answers and explanation regarding the theory of performance frontiers. Performance frontiers demonstrate a firm's actions that are made possible as a result of their various decisions and investments. The theory posits that firms strive towards their asset frontiers and nearing the frontier would eventually begin to result in initial trade-offs. For those firms that still remained significantly away from their frontiers, multiple improvements would be possible (Hayes & Pisano, 1996; Schmenner & Swink, 1998). We were able to create performance improvement plots for hospitals on cost-efficiency–quality dimensions based on our distance to asset frontier calculations. We saw that there was a group of hospitals that came in as being the closest to the frontier. Our analysis of the hospitals in this group shows that the hospitals that eventually ended up in a superior position on both dimensions had to improve quality initially which enabled them to grow and progress on the cost-efficiency dimension.

From a managerial perspective, our results show that trade-offs do occur and is probably more necessary for companies in intensely situated industries, such as healthcare. Hospitals at all levels (furthest to closest) were expected to maintain the threshold levels of quality as a start and then work towards other dimensions. Hospitals, particularly those that are in an intermediate position, are likely to be exhibiting trade-offs. For managers, this stage is a transitionary stage, and it signals that making initial trade-offs by focusing on higher levels of quality promise a competitive and superior position in the future. It is also reasonable to assume that attaining this superior level of quality is possible only over time, and for that reason having patience is important. The study also provides some guidance to managers on the competitive dimensions that must be concentrated on allowing them to make sensible decisions when it comes to their limited set of resources (Losa et al., 2020).

Conclusion

Our study attempts to seek explanations for trade-offs from the performance frontier perspective in a service setting using longitudinal data. We can conclude from our results that hospitals having an intermediate position exhibit initial trade-off and those furthest remain in a strong position to continuously engage in improvements however being mindful of quality. Hospitals that were positioned closest to the frontier from the rest were able to progress in a sustainable superior manner along both dimensions; however, this may have required significant efforts in the initial years to build and develop quality.

Our results suggest that the theory of performance frontiers is relevant (Schmenner & Swink, 1998) even if there are difficulties in measuring and identifying a firm's asset frontier (Ashwini Nand et al., 2013; Lapré & Scudder, 2004). We have tried our best to operationalize and measure the asset frontier as best as we could. We have also extended our work in the service setting similar to Lapré and Scudder (2004), guided by their motivation and call for more validation of trade-offs along the lines of performance frontiers. The Australian hospital setting can also be described as a dynamic and progressive one where hospitals need to be competitive. Hospitals and their EDs are engaged in providing the best of care to patients with limited resources and having to outperform others. This requires that they make wise decisions pertaining to their resources, time, and investments undertaken. This signals that trade-offs or choices are important in such competitive and progressive industries and affect competitive positioning (Sarmiento et al., 2018; Schmenner & Swink, 1998; Thürer et al., 2017).

Finally, we had several limitations relating to the measures that we used to represent cost-efficiency, quality dimensions, and performance frontiers. Whilst some of these measures are acceptable proxies, others like the manner in which we calculated our asset frontiers may be questionable. We have tried our best to logically explain hospital utilization as a measure of their asset frontier based on the original assumptions of authors such as Schmenner and Swink (1998), Vastag (2000) and Clark (1996).

We believe that this study has in some way clarified some of the discussions surrounding trade-offs and achieving improvements in a service-based public sector health environment. Future researchers can advance this by including multiple measures of competitive dimensions over a longer period of time which will enable more robust analyses techniques such as parametric and non-parametric tests (Chen & Iqbal Ali, 2002; Jacobs, 2001; Narasimhan & Schoenherr, 2013;

Wanke et al., 2019). Also, the theory of performance frontiers continues to intrigue scholars and has potential to offer explanations on trade-offs, and this area requires research to continue working in various settings. Researchers through their efforts can further add to the knowledge on performance frontiers and ways in best capturing and measuring the frontier in various industry sectors.

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References

Amoako-Gyampah, K., & Meredith, J. R. (2007). Examining cumulative capabilities in a developing economy. *International Journal of Operations and Production Management*, *27*(9), 928–950. https://doi.org/10.1108/01443570710775801

Ashwini Nand, A., Singh, P. J., & Power, D. (2013). Testing an integrated model of operations capabilities: An empirical study of Australian Airlines. *International Journal of Operations and Production Management*, *33*(7), 887–911. https://doi.org/10.1108/IJOPM-12-2011-0484

Avella, L., Vazquez-Bustelo, D., & Fernandez, E. (2011). Cumulative manufacturing capabilities: An extended model and new empirical evidence. *International Journal of Production Research*, *49*(3), 707–729. https://doi.org/10.1080/00207540903460224

Banks, R. L., & Wheelwright, S. C. (1979). Operations VS strategy-trading tomorrow for today. *Harvard Business Review*, *57*(3), 112–120.

Boon-Itt, S., & Wong, C. Y. (2016). Empirical investigation of alternate cumulative capability models: A multi-method approach. *Production Planning and Control*, *27*(4), 299–311. https://doi.org/10.1080/09537287.2015.1124299

Bortolotti, T., Danese, P., Flynn, B. B., & Romano, P. (2015). Leveraging fitness and lean bundles to build the cumulative performance sand cone model. *International Journal of Production Economics*, *162*, 227–241. https://doi.org/10.1016/j.ijpe.2014.09.014

Boyer, K. K., & Lewis, M. W. (2002). Competitive priorities: Investigating the need for trade-offs in operations strategy. *Production and Operations Management*, *11*(1), 9–20. https://doi.org/10.1111/j.1937-5956.2002.tb00181.x

Butler, T. W., Leong, G. K., & Everett, L. N. (1996). The operations management role in hospital strategic planning. *Journal of Operations Management*, *14*(2), 137–156. https://doi.org/10.1016/0272-6963(95)00041-0

Cai, S., & Yang, Z. (2014). On the relationship between business environment and competitive priorities: The role of performance frontiers. *International Journal of Production Economics*, *151*, 131–145. https://doi.org/10.1016/j.ijpe.2014.02.005

Chang, S. J., Hsiao, H. C., Huang, L. H., & Chang, H. (2011). Taiwan quality indicator project and hospital productivity growth. *Omega*, *39*(1), 14–22. https://doi.org/10.1016/j.omega.2010.01.006

Chen, Y., & Iqbal Ali, A. I. (2002). Output–input ratio analysis and DEA frontier. *European Journal of Operational Research*, *142*(3), 476–479. https://doi.org/10.1016/S0377-2217(01)00318-6

Clark, K. B. (1996). Competing through manufacturing and the new manufacturing paradigm: Is manufacturing strategy passé? *Production and Operations Management*, *5*(1), 42–58. https://doi.org/10.1111/j.1937-5956.1996.tb00384.x
Collins, R. S., & Schmenner, R. (1993). Achieving rigid flexibility: Factory Focus for the 1990s. *European Management Journal*, *11*(4), 443–447.
Corbett, L. M., & Claridge, G. S. (2002). Key manufacturing capability elements and business performance. *International Journal of Production Research*, *40*(1), 109–131. https://doi.org/10.1080/00207540110073091
Corbett, L. M., & Clay Whybark, D. C. (2001). Searching for the sandcone in the GMRG data. *International Journal of Operations and Production Management*, *21*(7), 965–980. https://doi.org/10.1108/01443570110393441
Corbett, C., & Van Wassenhove, L. (1993). Trade-offs? What trade-offs? Competence and competitiveness in manufacturing strategy. *California Management Review*, *35*(4), 107–122. https://doi.org/10.2307/41166757
Da Silveira, G., & Slack, N. (2001). Exploring the trade-off concept. *International Journal of Operations and Production Management*, *21*(7), 949–964. https://doi.org/10.1108/01443570110393432
Egbunike, O., Purvis, L., & Naim, M. M. (2018). A systematic review of research into the management of manufacturing capabilities. *Production Planning and Control*, *29*(16), 1349–1366. https://doi.org/10.1080/09537287.2018.1535147
Ehie, I. C., & Schoenherr, T. (2020). Revisiting the cumulative capability model (CCM) among manufacturing firms in developing countries. *Production Planning and Control*, *32*(9), 715–729.
Ferdows, K., & De Meyer, A. (1990). Lasting improvements in manufacturing performance: In search of a new theory. *Journal of Operations Management*, *9*(2), 168–184. https://doi.org/10.1016/0272-6963(90)90094-T
Filippini, R. (1997). Operations management research: Some reflections on evolution, models and empirical studies in OM. *International Journal of Operations and Production Management*, *17*(7), 655–670. https://doi.org/10.1108/01443579710175583
Flynn, B. B., & Flynn, E. J. (2004). An exploratory study of the nature of cumulative capabilities. *Journal of Operations Management*, *22*(5), 439–457. https://doi.org/10.1016/j.jom.2004.03.002
Fynes, B., Voss, C., & De Búrca, S. (2005). The impact of supply chain relationship dynamics on manufacturing performance. *International Journal of Operations and Production Management*, *25*(1), 6–19. https://doi.org/10.1108/01443570510572213
Garvin, D. (1987). Competing on the eight dimensions of quality. *Harvard Business Review*, November-December Issue, 101–109.
Größler, A., & Grübner, A. (2006). An empirical model of the relationships between manufacturing capabilities. *International Journal of Operations and Production Management*, *26*(5), 458–485. https://doi.org/10.1108/01443570610659865
Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (1998). *Multivariate data analysis*. Prentice Hall.
Hall, R. W. (1987). *Attaining manufacturing excellence*. McGraw-Hill.
Hall, R. W., & Nakane, J. (1990). *Flexibility—Manufacturing Battlefield of the 90s: A Report on Attaining Manufacturing Flexibility in Japan and the United States*. Association for Manufacturing Excellence.
Hayes, R. H., & Pisano, G. P. (1994). Beyond world-class: The new manufacturing strategy. *Harvard Business Review*, *72*(1), 77–86.
Hayes, R. H., & Pisano, G. P. (1996). Manufacturing strategy: At the intersection of two paradigm shifts. *Production and Operations Management*, *5*(1), 25–41. https://doi.org/10.1111/j.1937-5956.1996.tb00383.x

Hayes, R. H., & Schmenner, R. W. (1978). How should you organize manufacturing. *Harvard Business Review*, *56*(1), 105–118.

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring our competitive edge: Competing through manufacturing*. John Wiley & Sons.

Hill, C. W. L. (1988). Differentiation versus low cost or differentiation and low cost: A contingency framework. *Academy of Management Review*, *13*(3), 401–412. https://doi.org/10.5465/amr.1988.4306957

Ho, F. N., & Huang, C.-W. (2020). The interdependencies of marketing capabilities and operations efficiency in hospitals. *Journal of Business Research*, *113*, 337–347. https://doi.org/10.1016/j.jbusres.2019.09.037

Hutton, S., & Eldridge, S. (2019). Improving productivity through strategic alignment of competitive capabilities. *International Journal of Productivity and Performance Management*, *68*(3), 644–668. https://doi.org/10.1108/IJPPM-11-2017-0277

Jacobs, R. (2001). Alternative methods to examine hospital efficiency: Data envelopment analysis and stochastic frontier analysis. *Health Care Management Science*, *4*(2), 103–115. https://doi.org/10.1023/a:1011453526849

Jaikumar, R. (1986). Postindustrial manufacturing. *Harvard Business Review*, *64*(6), 69–76.

Kim, B., & Park, C. (2013). Firms' integrating efforts to mitigate the tradeoff between controllability and flexibility. *International Journal of Production Research*, *51*(4), 1258–1278. https://doi.org/10.1080/00207543.2012.698319

Lapré, M. A., & Scudder, G. D. (2004). Performance improvement paths in the US airline industry: Linking trade-offs to asset frontiers. *Production and Operations Management*, *13*(2), 123–134.

Losa, E. T., Arjomandi, A., Hervé Dakpo, K. H., & Bloomfield, J. (2020). Efficiency comparison of airline groups in Annex 1 and non-Annex 1 countries: A dynamic network DEA approach. *Transport Policy*, *99*, 163–174. https://doi.org/10.1016/j.tranpol.2020.08.013

Mapes, J., New, C. & Szwejczewski, M. (1997). Performance trade-offs in manufacturing plants. *International Journal of Operations & Production Management, 17*(10), 1020–1033.

Matthias, O., & Brown, S. (2016). Implementing operations strategy through Lean processes within health care: The example of NHS in the UK. *International Journal of Operations and Production Management*, *36*(11), 1435–1457. https://doi.org/10.1108/IJOPM-04-2015-0194

Miller, S. S. (1983). Make your plant managers job manageable. *Harvard Business Review*, *61*(1), 68–74.

Morita, M., & Flynn, E. J. (1997). The linkage among management systems, practices and behaviour in successful manufacturing strategy. *International Journal of Operations and Production Management*, *17*(10), 967–993. https://doi.org/10.1108/01443579710176933

Narasimhan, R., & Schoenherr, T. (2013). Revisiting the progression of competitive capabilities: Results from a repeated cross-sectional investigation. *International Journal of Production Research*, *51*(22), 6631–6650. https://doi.org/10.1080/00207543.2013.825739

New, C. (1992). World-class manufacturing versus strategic trade-offs. *International Journal of Operations and Production Management*, *12*(4), 19–31. https://doi.org/10.1108/EUM0000000001298

Noble, M. A. (1995). Manufacturing strategy: Testing the cumulative model in a multiple country context. *Decision Sciences*, *26*(5), 693–721. https://doi.org/10.1111/j.1540-5915.1995.tb01446.x

Pagell, M., Melnyk, S., & Handfield, R. (2000). Do trade-offs exist in operations strategy? Insights from the stamping die industry. *Business Horizons*, *43*(3), 69–77. https://doi.org/10.1016/S0007-6813(00)89203-4

Porter, M. E. (1996). What is strategy. *Harvard Business Review*, *74*(6) *61–78*.

Qamar, A., Hall, M. A., Chicksand, D., & Collinson, S. (2019). Quality and flexibility performance trade-offs between lean and agile manufacturing firms in the automotive industry. *Production Planning and Control*, *31*(9), 723–738.

Rosenzweig, E. D., & Easton, G. S. (2010). Tradeoffs in manufacturing? A meta-analysis and critique of the literature. *Production and Operations Management*, *19*(2), 127–141. https://doi.org/10.1111/j.1937-5956.2009.01072.x

Roth, A. V., & Miller, J. G. (1992). Success factors in manufacturing. *Business Horizons*, *35*(4), 73–81. https://doi.org/10.1016/S0007-6813(05)80165-X

Safizadeh, M. H., Ritzman, L. P., & Mallick, D. (2000). Revisiting alternative theoretical paradigms in manufacturing strategy. *Production and Operations Management*, *9*(2), 111–126. https://doi.org/10.1111/j.1937-5956.2000.tb00328.x

Sarmiento, R., Whelan, G., & Thürer, M. (2018). A note on 'Beyond the trade-off and cumulative capabilities models: Alternative models of operations strategy'. *International Journal of Production Research*, *56*(12), 4368–4375. https://doi.org/10.1080/00207543.2018.1428773

Scarpin, M. R. S., & Brito, L. A. L. (2018). Operational capabilities in an emerging country: Quality and the cost trade-off effect. *International Journal of Quality and Reliability Management*, *35*(8), 1617–1638. https://doi.org/10.1108/IJQRM-04-2017-0061

Schmenner, R. W., & Swink, M. L. (1998). On theory in operations management. *Journal of Operations Management*, *17*(1), 97–113. https://doi.org/10.1016/S0272-6963(98)00028-X

Schonberger, R. (1986). The vital elements of world-class manufacturing. *International Management*, *41*(5), 76–78.

Skinner, W. (1969). Manufacturing-missing link in corporate strategy. *Harvard Business Review, 47*(3)*,* 136–145.

Skinner, W. (1974). The focused factory. *Harvard Business Review, 52*(3)*,*114–121.

Skinner, W. (1992). *Missing the links in manufacturing strategy. Manufacturing strategy: Process and content,* 13–25. Chapman and Hall.

Slack, N. (1991). *The manufacturing advantage: Achieving competitive manufacturing operations*. Mercury Books.

Squire, B., Brown, S., Readman, J., & Bessant, J. (2006). The impact of mass customisation on manufacturing trade-offs. *Production and Operations Management*, *15*(1), 10–21. https://doi.org/10.1111/j.1937-5956.2006.tb00032.x

Sum, C. C., Singh, P. J., & Heng, H. Y. (2012). An examination of the cumulative capabilities model in selected Asia-Pacific countries. *Production Planning and Control*, *23*(10–11), 735–753. https://doi.org/10.1080/09537287.2011.642135

Swink, M., Talluri, S., & Pandejpong, T. (2006). Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs. *Journal of Operations Management*, *24*(5), 542–562. https://doi.org/10.1016/j.jom.2005.09.004

Talluri, S., Kim, M. K., & Schoenherr, T. (2013). The relationship between operating efficiency and service quality: Are they compatible? *International Journal of Production Research*, *51*(8), 2548–2567. https://doi.org/10.1080/00207543.2012.737946

Tamayo-Torres, J., Roehrich, J. K., & Lewis, M. A. (2017). Ambidexterity, performance and environmental dynamism. *International Journal of Operations and Production Management*, *37*(3), 282–299. https://doi.org/10.1108/IJOPM-06-2015-0378

Thürer, M., Stevenson, M., Sarmiento, R., & Gianiodis, P. (2017). On strategic trade-offs: Does the principle of energy conservation explain the trade-offs law? *Management Research Review*, *40*(11), 1163–1174. https://doi.org/10.1108/MRR-09-2016-0214

Van Ineveld, M., van Oostrum, J., Vermeulen, R., Steenhoek, A., & van de Klundert, J. (2016). Productivity and quality of Dutch hospitals during system reform. *Health Care Management Science*, *19*(3), 279–290. https://doi.org/10.1007/s10729-015-9321-7

Vargas-Berrones, K. X., Sarmiento, R., & Whelan, G. (2019). Can you have your cake and eat it? Investigating trade-offs in the implementation of green initiatives. *Production Planning and Control*, 1–16.

Vastag, G. (2000). The theory of performance frontiers. *Journal of Operations Management*, *18*(3), 353–360. https://doi.org/10.1016/S0272-6963(99)00024-8

Wanke, P., Azad, M. A. K., & Correa, H. (2019). Mergers and acquisitions strategic fit in Middle Eastern banking: An NDEA approach. *International Journal of Services and Operations Management*, *33*(1), 1–25. https://doi.org/10.1504/IJSOM.2019.099652

Womack, J. P., Jones, D. T., & Roos, D. (1990). *Machine that changed the world*. Simon & Schuster.

Wurzer, T., & Reiner, G. (2018). Evaluating the impact of modular product design on flexibility performance and cost performance with delivery performance as a moderator. *International Journal of Operations and Production Management*, *38*(10), 1987–2008. https://doi.org/10.1108/IJOPM-03-2017-0152