Examining efficiency and performance trade-offs in the Australian airline industry

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Abstract

We test the theory of efficiency and performance trade-offs for airline firms. Data from 2004-2014 were analyzed for evidence pertaining to performance based trade-offs and their subsequent effects on market success. To test our hypotheses on airline efficiency and performance trade-offs, we employed a data envelopment analysis methodology where two significant groups of airline players were identified: High Efficiency and Low Efficiency. Results support our hypotheses that trade-offs are present in airlines with high efficiency and consistent with the theory of performance frontiers. Additionally there are differences in efficiency depending on airline group and this subsequently affects their market success.

Keywords: Trade-offs, Data envelopment analysis (DEA), Efficiency, Airlines

Introduction

Operations capabilities are critical to the well-being of any company with the general agreement that cost, quality, delivery and flexibility are some of the capabilities that can improve the competitive position of a company in the marketplace (Hayes and Wheelwright, 1984; Hill, 1995; Sarmiento et al., 2010; Voss, 1995). These four capabilities are the fundamental categories across which manufacturers often need to make choices because of the limited resources available to them (Skinner, 1969). Consequently, leading to numerous conceptual and empirical studies on capabilities and performance based on operations strategy frameworks such as trade-offs (Boyer and Lewis, 2002; Corbett and van Wassenhove, 1993; Da Silveira and Slack, 2001; Pagell et al., 2000; Rosenzweig and Easton, 2010; Schroeder et al., 1996; Singh et al., 2014; Skinner, 1969) and more recently the theory of performance frontiers (TPF) (Schmenner and Swink, 1998; Vastag, 2000). However, much of these studies have revolved around the manufacturing sector and similar investigations for the service sector remain scarce (Roth and Van Der Velde, 1991).

The trade-off model is the most established when it comes to operations strategy and understanding the relationship between competitive priorities. This notion was first posited by Skinner (1969) who proposed that companies must make choices regarding which competitive priorities should receive the greatest investment of time and resources. The propositions of the trade-off theory remain to intrigue authors and more recently authors have tried to explain and seek some sort of resolution of this phenomenon by employing the TPF. The TPF assumes that a firm's position on the frontier can be useful in explaining whether trade-offs will arise. The performance frontier is "defined by the maximum performance that can be achieved by a manufacturing unit given a set of operating choices" (Schmenner and Swink, 1998, p. 108) and comprises a structural asset frontier and an infrastructural operating frontier. The TPF assumes that firms that operate on the asset frontier will be subject to trade-offs and those that are below will have the capacity to make simultaneous improvements. The trade-off theory assumes that no single plant can provide superior performance in all dimensions simultaneously and therefore this will be especially true if plants are operating on their asset frontier (Vastag, 2000). Studies that have made empirical attempts in examining trade-offs from the TPF perspective in a manufacturing setting include that of Swink et al. (2006) and Cai and Yang (2014). Studies that have been carried out in a service-based setting include that of Lapré and Scudder (2004) and Nand et al. (2013).

In light of the above arguments, we develop and test the theory of efficiency and performance trade-offs in a service setting (airline firms) demonstrating a new approach to understanding performance trade-offs by using the DEA methodology. The theory of PF allows us to merge the divergent perspectives of performance trade-offs in literature and the novel approach used enables us to carry out a more holistic assessment than what prior research provided allowing for more in-depth insights into firms practices i.e., understanding whether firms trade-off or accumulate capabilities. This study is distinctive as it examines efficiency and performance trade-offs in a pure service setting and explicitly looks at measuring frontiers using longitudinal data (objective data) with a DEA technique. This study clarifies the assumptions stated by the TPF in a more rigorous way and validates differences to the manufacturing setting. The remainder of this paper is organised as follows. Section 2 draws upon the literature to develop theory and related hypotheses. Section 3 details the data collection and methodology employed to investigate support for the hypotheses. Section 4 presents the analysis and results. Section 5 and 6 presents a discussion of limitations and implications of the findings and future research directions.

Backround

Hypotheses Development

Based on the TPF, we assume that trade-offs will be demonstrated by firms that are situated on the frontier. The theory states that the performance frontier can be constructed using dimensions of manufacturing performance. These include having inputs and outputs such as cost, product, range, quality etc. To enable a comprehensive examination of performance trade-offs, Rosenzweig and Easton's (2010) suggestions can be taken into account. Their suggestions are: research designs must (1) take into account the manufacturer's position relative to a performance frontier; (2) recognize that the improvement paths of manufacturers near the frontier should be different from that of manufacturers with slack; and (3) determine if manufacturers positioned on or near the frontier do indeed experience trade-offs over time.

In our study, we examine all Australian airlines with respect to their efficiency and performance trade-offs. From an efficiency perspective, this means that airline operators can be distinguished into groups and that there are efficiency differences among these airline groups. This leads us to our first five hypotheses:

Performance Trade-offs in Airline Groups
H1: The distribution of efficiency is different across airline groups

By creating efficiency groups, the TPF can be further invoked. With this view, we can assume that different airline operators can be grouped based on their levels of efficiency. Therefore at a conceptual level, we can conclude that airline operators will operate either on or below the frontier. The frontier represents 'maximum efficiency' of airlines. Hence, in the language of microeconomics, we can say that those airlines that were better performers are more efficient players and can be classed under "High Efficiency". Those that are less efficient can be classed under "Low Efficiency" as there is still available capacity or slack for them to close the gap. Therefore, we can assume that there are two important groups of players or airline operators (High and Low Efficiency). The foregoing logic would then suggest that those airlines in the "High Efficiency" group would be likely to experience tradeoffs to a higher extent than those that are in the "Low Efficiency" group. This leads us to our second and third hypothesis:

H2: Performance trade-offs are evident in high efficiency airline groups
H3: Performance trade-offs are not clearly evident in low efficiency airline groups

In considering the implications of H2 and H3, it is important to note whether trade-offs explain performance differences across airline groups. We assume that there are airlines that demonstrate efficiency and those that are lesser in comparison. Therefore, it would mean that each of these groups of airline operators would be occupying different positions along the performance frontier. Their positions on the frontier represent their unique combinations of capabilities, skills, management techniques, purchased inputs with respect to performance (Porter, 1996). So we can agree that the positions occupied by these airlines actually represent different modes of efficiency. Therefore, it is likely that airline operators that pursue efficiency despite their different modes would still perform well when it comes to overall market success. Given their combination of inputs and resources to create maximum performance, we would expect that they would produce similar levels of market success. Hence, it would then be reasonable to assume that those airlines that have positions below the frontier would experience lesser levels of market success. Ideally, those airlines that operate on the frontier at an efficient level should be rewarded for their performance and value created (Swink et al., 2006). This discussion leads to our next two hypotheses:

H4: There is no significant difference in market success across high efficiency airline groups which pursue different modes of efficiency.
H5: Efficient airline groups (High Efficiency) have superior financial and market performance than inefficient airline groups (Low Efficiency).

Methodology

Airline efficiency via DEA

In order to evaluate capability trade-offs and efficiency, we utilized DEA, considering multiple performance outcomes. In this context, DEA can be employed to create an efficiency metric that captures performance relative to the "best" airlines in the sample. This efficiency metric can serve as a proxy for an airline firm's position relative to the performance frontier. In assessing airline efficiencies, we employed the variable returns to scale model as suggested by Banker et al. (1984).

3.3 Measures

Our dataset consisted of all firms in the airline industry over the period of 2004-2014. Our dataset captures the complete population of major Australian airlines. Over the sample period, firms either entered (i.e., Jetstar and Virgin Australia) or exited via acquisition (i.e., Tiger Airways and Skywest Airlines). Therefore, our data are presented as an unbalanced panel set. Our primary data sources were annual reports and Company360 database, which contain various financial and operational data. These sources were supplemented by the Australian Bureau of Infrastructure, Transport and Regional Economics (BITRE) for additional operational data, such as on-time performance as a measure of delivery performance and sectors scheduled as a measure of flexibility performance.

Cost represents the amount of expenditure incurred by a company in manufacturing and delivering a particular product (Sum et al., 2012). To measure cost, we used the cost per available seat kilometres (C/ASK). For service quality and reliability, we observed the number of flights not cancelled for the respective years. For a measure of delivery, we utilised airline on-time arrival percentages. To capture flexibility or responsiveness, the airlines ability in best utilisation of their fleet over the sectors flown was calculated. In addition, financial measures such as revenue (EBITDA) values were included for analysis. Finally to measure competition in the industry, market share was calculated (determined through the number of passengers carried by the respective airlines).

Analysis and results

Use of DEA to form efficiency groups

We defined airline performance elements related to service quality, delivery performance and flexibility measures as outputs. Hence, a total of three operational efficiency scores were treated as outputs in the DEA evaluations. Cost served as the input measure to the DEA model. A high score of close to or at least one indicates efficient airlines while those closer to zero meant that were airlines less efficient. This conceptualization employs an operational efficiency view of resources, in which cost is the input in the model, while the service quality, delivery performance and flexibility measures are outputs. We implemented the DEA evaluations with the BCC model in identifying the airline groups. With one input and three outputs, the sample of projects being evaluated using DEA must be significantly greater than 14 (the product of inputs and outputs) for effective discrimination (Boussofiane et al., 1991). Each of the DEA evaluations that we performed met this requirement effectively. Hence, we have four major airline players, Qantas, Virgin Australia, Regional Express and Skywest. This makes it possible for us to test our first hypothesis:

H1: The distribution of efficiency is different across airline groups

To statistically test for the efficiency differences among airline operators, a follow-up analysis was done using the Kruksal-Wallis test. This test tells us overall whether the airlines groups are indeed different. In order to understand the overall effect, pairwise comparisons were checked. The results of the pairwise tests are presented in Table 2 below.

Table 2 Pairwise comparisons for airline groups

Pairs	Test Statistic	Std.Error	Std. Test	Sig.	Adj.Sig
REX- Skywest	-1.111	5.514	-0.202	0.840	1.000
REX-Virgin Australia	20.182	6.231	3.858	0.000	0.001
REX-Qantas	22.818	6.231	4.362	0.000	0.000
Skywest-Virgin Australia	19.071	5.514	3.459	0.001	0.003
Skywest-Qantas	21.707	5.514	3.937	0.000	0.000
Virgin Australia-Qantas	2.636	5.231	0.504	0.614	1.000

As shown in Table 2, we reject the null hypothesis for the CCR scores and based on the pairwise differences, we have: Group 1- High Efficiency comprising Qantas and Virgin Australia and Group 2- Low Efficiency comprising Regional Express and Skywest. This lends statistical support to our earlier discussions and H1 is supported. From the pairwise comparisons, wherever values fall below the criterion of 0.05, this suggests that significant differences are present on efficiency. In this instance, there is a significant difference among the two groups High Efficiency: Qantas and Virgin Australia and Low Efficiency: Regional Express and Skywest.

4.2 Performance trade-offs in airline groups

Now that efficiency groups have been identified, it is possible for us to run further tests to examine whether trade-offs are present among the two efficiency groups. Based on our earlier discussions, we are interested in understanding how efficient airline groups might be positioned on the performance frontier and how this might differ for those (low efficiency group) positioned elsewhere on the overall performance space. This leads us to test our second hypothesis:

H2: Performance trade-offs are evident in high efficiency airline groups

To investigate this question, we performed independent t-tests, which allows for the comparison of means of two entities. In this instance, we have determined that the high efficiency group is made up of two players: 1 = Qantas; 2 = Virgin

Table 3: Group statistics and independent samples t-tests for high efficiency airlines

					t-test for Equality of Means		
	N	Mean	Std.dev	Std.Error Mean	df	Sig.(2 tailed)	Mean Diff
Cost (cents/10 seat km)							
1	11	6.642	1.94	0.585	20	0.413	-0.576
2	11	7.218	1.21	0.365			
Quality (% flights not cancelled)							
1	11	98.682	0.49	0.148	20	0.597	0.115
2	11	98.566	0.517	0.156			
Delivery (% flights on-time delivery)							
1	11	82.755	3.547	1.069	20	1.000	0.000
2	11	82.755	3.975	1.199			
Flexibility (sectors flown per 0.1 aircraft)							
1	11	1146.31	123.045	37.099	20	0.006	-456.886
2	11	1603.19	472.766	142.544			
Revenue (000)s							
1	11	14474245	1490192	449310	20	0.000	11673609.909

2	11	2800636	995273	300086			
EBITDA margin percentage							
1	11	1.278	11.952	3.604	20	0.552	-3.266
2	11	4.545	13.314	4.014			
Market share							
1	11	0.6636	0.0262	0.008	20	0.000	0.316
2	11	0.3473	0.0825	0.025			

Based on the above results (Table 3), while Flexibility is the only one that is significant, i.e., Virgin Australia has a higher flexibility (M= 1603.2, S.E=142.5) than Qantas (M= 1146.3, S.E=37.1). This difference, -456.9 was significant at $p<0.05$. Qantas, on the other hand, seems to be focusing on low cost (M= 6.642, S.E=0.585). Both airlines are effective with respect to service quality and delivery performance. We can therefore say that in the high efficiency group, Qantas and Virgin Australia differed on one dimension each (flexibility and low cost) and this suggests that performance trade-offs are manifest among efficient players. This lends support for H2. Next, based on our logic of the TPF, it is reasonable to assume that those airlines that are not as efficient in comparison to efficient ones and are positioned below the performance frontier will not demonstrate clear trade-offs as seen with efficient airlines. This leads us to the next hypothesis:

H3: Performance trade-offs are not clearly evident in low efficiency airline groups

Similar to the earlier hypothesis (H2), we performed independent t-tests, which allows for the comparison of means of two entities in the low efficiency group. The low efficiency group is made up of two players: 3 = Rex; 4= Skywest

Table 4: Group statistics and independent samples t-tests for low efficiency airlines

					t-test for Equality of Means		
	N	**Mean**	**Std.dev**	**Std.Error Mean**	**df**	**Sig.(2 tailed)**	**Mean Diff**
Cost (cents/10 seat km)							
3	11	22.809	4.154	1.252	18	0.075	4.100
4	9	18.709	5.544	1.848			
Quality (% flights not cancelled)							
3	11	99.546	0.327	0.099	18	0.047	0.745
4	9	98.8	1.109	0.370			
Delivery (% flights on-time delivery)							
3	11	83.218	3.965	1.195	18	0.786	-0.537
4	9	83.756	4.758	1.586			
Flexibility (sectors flown per 0.1 aircraft)							
3	11	1838.7	380.809	114.818	18	0.000	855.955
4	9	982.748	286.638	95.546			
Revenue (000)s							
3	11	216359	52912	15953.6	18	0.005	82569.4
4	9	133789	61823.5	20607.8			
EBITDA margin percentage							

3	11	7.496	3.967	1.196	18	0.000	7.863
4	9	-0.367	3.863	1.288			
Market share							
3	11	0.049	0.010	0.003	18	0.000	0.039
4	9	0.010	0.005	0.002			

Based on the above results, Regional Express is superior to Skywest with respect to quality (M=99.5, S.E=0.10, $p<0.05$) and Flexibility (M=1838.7, S.E=114.8, $p<0.05$). The other two factors, cost and delivery are not statistically significant. Therefore, results indicate that in low efficiency airlines trade-offs were not present and distinguishable. There are no trade-offs evident in this low efficiency groups and Regional Express dominates Skywest and is also shown to be as an all rounder performer. This is evident from the EBITDA values (M=7.4964, S.E=1.19, $p<0.05$). This supports our hypothesis H3.

4.3 Analysis of market success differences across the airline groups

Next, given the two distinct groups, it is important to understand whether there are any significant differences between them in market success. The first test is to understand whether the group of efficient airlines (High Efficiency) who are manifesting trade-offs are in fact experiencing differences when it comes to their market success. Although, the two airlines Qantas and Virgin Australia are equal in terms of being situated on the performance frontier, they have pursued different modes of efficiency to arrive at that position. So as shown by the earlier results, Virgin Australia has traded-off on flexibility and Qantas has traded-off on cost. Whether pursuing different modes of efficiency results in market success differences is of interest. This leads us to test the next hypothesis:

H4: There is no significant difference in market success across high efficient airline groups which pursue different modes of efficiency.

From our earlier t-test results (Table 3), specifically, the EBITDA margin percentage across the two groups (Qantas and Virgin Australia) is insignificant. This means that there are no differences with respect to the modes of efficiency pursued. This suggests that there are different strategies in play and that the focus is different for each airline operator (flexibility and low cost). Regardless of this trade-off and focus, market success measured through EBITDA remains insignificant hence supporting our hypothesis (H4). Our next hypothesis is a further testing of the TPF in the overall context of the service industry. Now that we have identified two groups (High Efficiency and Low Efficiency) and have carried out the necessary tests to check for the existence of trade-offs, we want to know if efficient performers are indeed superior in terms of their overall financial and market performance. This leads us to our next hypothesis:

H5: Efficient airline groups have superior financial and market performance than inefficient airline groups

To investigate this next question, another set of independent t-tests were performed, which allows for the comparison of means of the two airline groups and its entities: 1 = High Efficiency: Qantas and Virgin; 2 = Low Efficiency: Rex and Skywest

Table 5 Pairwise comparisons for high and low efficiency airline groups

	N	Mean	Std.dev	Std.Error Mean	t-test for Equality of Means		
					df	Sig.(2 tailed)	Mean Diff
Revenue (000)s							
1	22	8637440.50	6100799.459	1300694.815	40	0.000	8458238.200
2	20	179202.30	69706.763	15586.906			
EBITDA margin percentage							
1	22	2.911	12.459	2.656	40	0.731	-1.047
2	20	3.958	5.538	1.238			
Market share							
1	22	.506	0.173	0.037	40	0.000	0.474
2	20	.032	0.022	0.005			

Based on our results (see Table 5), we can observe that revenue and market share is significant, i.e., Qantas and Virgin Australia are better than Regional Express and Skywest (p<0.05), but EBITDA is not significant (p>0.05). This means that H5 is somewhat supported with the high efficiency group demonstrating a better financial and market outlook than the low efficiency groups. High efficiency airlines dominate and are better performers on revenue and market share.

5. Discussion and Conclusion

Our analysis of the data yielded interesting results, which have important theoretical and managerial implications. Hypothesis 1 was supported by our data, suggesting that based on efficiency arguments, there are different airline groups. In our study, we saw that airline operators were found to be either high efficiency or low efficiency players. Qantas and Virgin airlines fell into the high efficiency group and Skywest and Regional Express were in the low efficiency group. Based on this finding, we were able to then check for the presence of trade-offs in the groups.

Hypothesis 2 and Hypothesis 3 suggests that airlines are subject to trade-offs depending on their position on the performance frontier. Qantas and Virgin Australia were neatly positioned on the performance frontier and manifested trade-offs with one of their capabilities, flexibility and cost. Regional Express and Skywest were located below the performance frontier and thus as low efficiency players, there were no cases of trade-offs evident. The demonstration of trade-offs as a result of being positioned on the performance frontier is similar to the results of authors Lapré and Scudder (2004) , Nand et al. (2014) and Swink et al. (2006). Hypothesis 4 sheds light on whether different modes of efficiency affect market success. The high efficiency group is of interest and demonstrated that despite different areas of focus, market success measured through their EBITDA margins were not different. This result suggests that once on the frontier, airlines can still continue to be rewarded and enjoy significant levels of performance regardless of their modes of pursuit. This result is also in line with Swink et al. (2006). Finally, Hypothesis 5 confirmed that there is support that being a high efficiency player and being subject to trade-offs there are more gains to be received in comparison to those that are not as efficient. The above finding on the presence of trade-offs and performance is supported by Pagell et al. (2000), who state that trade-offs are necessary and can be sustainable.

The findings overall indicate that there is a significant difference among high and low efficiency operators. With more efficient players, there are signs that they are generally performing well in most capabilities except one. These airline operators practice trade-offs for one of their capabilities as they move along the frontier. The TPF assumptions is clearly established (Schmenner and Swink, 1998; Vastag, 2000). When comparing the two groups, high efficiency group are the better performers. This holds important implications for managers alike who can make critical decisions with respect to the level of time and resources spent on select capabilities without having to worry about its impact on overall business performance.

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