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ABSTRACT

This paper identifies important performance measurements for the operation of CRM units in the call center industry, and then uses Data Envelopment Analysis (DEA) to compare the performances of a selected set of call centers. The results provide several managerial insights that will assist CRM managers in effective decision making, especially in the areas of increasing efficiencies and improving customer service. Overall, this paper contributes towards managing resources and processes that would aid in the acquisition and support of information technology within a firm.

INTRODUCTION

Although Customer Relationship Management, popularly referred to as CRM, has been around for almost over a decade, there is little or no consensus about the exact depth and breadth of the CRM concept across a wide array of enterprises. Often time, it is left to the discretion of the managers to define the customer relationship management function to best suit their customer facing interfaces. However, a generic definition outlines the seamless integration of technology and marketing strategy to effectively manage and improve the relationship with existing and potential customers to meet the evolving business objectives.

CRM units are used by companies in all aspects of services including financial, healthcare, airlines, recreation, and manufacturing. For instance, IBM's CRM offerings include strategy and change-consulting, system integration, enterprise application implementation for partners such as Siebel, SAP, Peoplesoft, Genesys and Avaya, business reengineering and process redesign, as well as speech recognition and Interactive Voice Response (IVR) (Kelsey, 2002). The early application of CRM was offered as a solution to redefine customer relationships using computer-based tools. However, CRM has evolved both in its functionality and adoption in more recent years. According to a recent Forrester Research estimate, the total CRM market – including applications, infrastructure and services – is likely to grow from $42.8 billion in 2002 to $73.8 billion in 2007 (Prahalad, Krishnan, & Mithas, 2002). But, today's CRM is a dramatically slimmed-down version of the original – it lost its swagger, its acne, and much of the baby fat (Greenberg, 2002). CRM is still expensive and still little cloudy of its benefits; but when it works, it yields great results and remains worthy of the risk of investment. With the IT budget squeeze in recent years, the need to demonstrate the connection between IT spending and business results has become even more critical.

Customer satisfaction remains a major objective in CRM operations. Higher customer satisfaction facilitates building and cultivating customer loyalty that results in the ability of a company to retain its existing customers and increase the value of these customers via cross-sell and up-sell (Karbowiak, 2002). Having an IT staff that understands the business and its customers' needs is one key to improving customer satisfaction (Chabrow, 2002). Investing in skilled IT personnel who understand the clients and the business process is probably more beneficial

than investing on pure technology. The human factor is very important in implementing an IT system. If the product is too cumbersome to use, employees will quickly find ways to work around it, defeating the very purpose of its implementation. With most IT issues, there is, as the Gartner Group puts it, the Hype Cycle (Fernandes, 2002). The CRM glitter has passed by, and realty has set in. It is time now to aim for operational efficiency.

CURRENT LITERATURE

Klenke (1995) identifies call center managers as "matchmakers" who decide which agent can best meet a particular caller's needs, using a skill-based routing system. Bordoloi (2004) offers a quantitative model for determining an optimal recruitment policy amidst vibrant turnover rates in knowledge-intensive call centers. Madariaga (2004) offers a comparative study between CRM's in USA and Spain. McManus and Snyder (2003) discuss the role of Electronic Performance Support System (EPSS) in the Knowledge Management context. On the other hand, there are strategy related discussions on CRM. Wallace and Eagleson (2000) offer a "sacrificial HR strategy" that reflects the deliberate, frequent replacement of agents in order to provide enthusiastic, motivated customer service at low cost. Lea (2005) offers a case study on leveraging information technology to gain competitive advantage in General Electrics consumer products.

There exist some pioneering research papers that suggest selected performance measurement parameters for call center operations. Gans, Koole and Mandelbaum (2002) conduct an extensive review of the status of research in telephone call centers in the form of a tutorial. Anton (2000) offers a managerial survey of historical tracking of contact center operations over the years. Several benchmark research projects have been conducted at Purdue University's Center for Customer-Driven Quality. In a more focused research, Koole and Mandelbaum (2002) use queuing models to capture the operational characteristics of call center management under a central socio-technical environment. Gans and Zhou (2003) offer a model to maximize the throughput for low-priority traffic, such as email, subject to service-level constraints. Hall and Porteus (2000) offer a model for service quality that connects operations, human resources and marketing decisions. Jitpaiboon and Kalaian (2005) offer a hierarchical linear model to analyze the effect of top management's support on information system performance. Addo, Chow and Haddad (2004) develop a balanced scorecard system to assess IT performance within the context of overall corporate strategy and financial performance. Chan (2007) offers a predictive analytic model for value chain management that deals with probable circumstances in the future.

There also exists a stream of literature that evaluates performances of ERP systems. Ifinedo (2007) compares the prioritization of ERP system effectiveness with a focus on IT professionals and business managers. Wu, Hsieh, Shin and Wu (2005) offer a methodology for evaluating data and output misfits in commercial off-the-shelf ERP systems.

None of the above research, however, conducts an analysis to evaluate CRM performance. The variety of objectives that exist in the current literature, makes it important for us to take a closer look at the tradeoff between the various inputs such as labor cost, training, turnover rate, etc on performance measures such as productivity, efficiency, and customer satisfaction.

In this paper, with the help of data from existing CRM units, we apply a quantitative method, namely Data Envelopment Analysis (DEA), to compare the performance of a selected set of CRM units for call center operations. DEA is not new to measure performances of IT processes. Bandopadhyay and Kumar (2007) use DEA to evaluate order fulfillment process options of B2C portals. For our study, working with a company which provides "knowledge management" solutions to call centers, we developed a model to provide some insights into how one might evaluate the performance of various CRM units, given that each unit uses different levels of inputs leading to various levels of performance. The result of this analysis leads to several managerial insights that will assist CRM managers in effective decision-making.

The rest of this paper is organized as follows. In next section, we present our research objectives and model. The following section develops the DEA model for evaluating the CRM units. Then we present numerical results and managerial insights. Finally, the last section is devoted to future research directions and conclusions.

RESEARCH OBJECTIVES

We aim at achieving two primary objectives in our model formulation and analysis:

1) Given data collected from a representative set of CRM units (using call centers as a platform), identify performance parameters and inputs/outputs for CRM operations.
2) Conduct a detailed study using Data Envelopment Analysis (DEA) on selected performance parameters of CRM operations to offer managerial insights – this will provide depth to our research in assisting CRM managers in decision making.

The theoretical underpinnings of our research are established based on our attempts to meet the above objectives. The data that we collected facilitate us to model the situation using Data Envelopment Analysis (DEA) and the subsequent sensitivity analysis would provide the necessary managerial insights to CRM managers to help in decision making on issues such as degree of IT investment and ideal size of labor force.

While we looked at several measures, given that each of these surveyed companies listed either "increased efficiency" or "improved customer satisfaction" as one of its top three priorities for call center operations, we decided to focus on two objectives: productivity (average calls handled per hour) and First Call Resolution (FCR) rate. We estimated that productivity is a more useful measurement than resource utilization, even though we see the benefits of both. While productivity is a measure of efficiency of a CRM unit, FCR (the percentage of customers whose needs are met in one attempt) is a measure of customer satisfaction. On the input side, considering what the top management at these units deemed important for this study, we choose three measures – the average fully burdened cost of a call center agent, the average turn over rate, and the average number of days required for training.

We surveyed a total of 47 CRM units and collected data on organization, size, human resource expenses, efficiency, training, overhead, and financial measures. These organizations represented various industries such as Information Technology, Financial Services, Health Care, Telecom, and Energy. Finally, each company surveyed was actively using a CRM package within their call center operations.

Of the 47 units surveyed, we were able to use data collected from 21 units, as some units were unable to provide us with the needed information.

DATA ENVELOPMENT ANALYSIS (DEA) MODEL

We apply Data Envelope Analysis (DEA) to determine the relative efficiencies for the call centers selected, the results of which can be used to determine the efficient frontier within the set of call centers. For a given call center, the operational efficiency can be evaluated by taking ratios of different inputs and outputs. The concept of benchmark comes in handy when comparing one system to another. The relative standing of similar call centers on the scale of a joint efficiency index guides a management team to improve overall productivity of the center, despite some in-built inefficiencies. Based on the "CCR" approach to Data Envelopment Analysis, (Charnes, Cooper & Rhodes, 1978) For CRM unit i, let:

O_{1i} = Productivity measure for unit i
O_{2i} = FCR measure for unit i
I_{1i} = Average fully burdened cost of an agent at unit i
I_{2i} = Average turn over rate at unit i
I_{3i} = Average days of training at unit i

Then, given the 2 outputs and 3 inputs, the DEA problem of a multi-unit situation is set up as follows:

Problem P1:

Max $E_i = (u_1O_{1i}+u_2O_{2i})/(v_1I_{1i}+v_2I_{2i}+V_3I_{3i})$

Subject to:

E_i <=1 for all i = 1, 2, .. N
$u_i \geq 0$, $v_j \geq 0$ *where i = 1 and 2 and j = 1,2, and 3*

Where,
E_i = Efficiency score of unit i
u_1 and u_2 = Coefficients for outputs
v_1, v_2, and v_3 = Coefficients for inputs

Setting the denominator in the objective function to be equal to one, Problem *P1*, becomes:

Problem P2:

Max $E_i = u_1O_{1i}+u_2O_{2i}$

Subject to:

$(v_1I_{1i}+v_2I_{2i}+v_3I_{3i}) = 1$
$(u_1O_{1i}+u_2O_{2i}) - (v_1I_{1i}+v_2I_{2i}+v_3I_{3i}) \leq 0$ for all i = 1,2,…,N
$u_i \geq 0$, $v_j \geq 0$ *where i = 1 and 2 and j = 1,2, and 3*

Based on empirical findings and the experience of DEA practitioners (Fitzsimmons, 2006), the minimum number of service units (K) needed for a problem situation with N number of inputs and M number of outputs is given by the relationship: K ≥ 2*(N+M). For the three-input, two-output situation in this study , the minimum number of units needed will be 2*(2+3) = 10. Table 1 shows twenty-one CRM units with their corresponding productivity and FCR measures along with their Average Training Days per Agent, Average Turn Over Rate per Agent, and Average Annual Cost per Agent. For example, Unit 9 has a measure of high productivity and FCR, however it also has a relatively high labor cost measure. Similarly, unit 41 may not have very high output measures, but then it does so with relatively modest levels of labor cost and a low turn over rate. From a cursory glance at the table, it is impossible to judge whether or not the lower cost of labor is benefiting the CRM unit in generating a higher level of productivity or increased FCR with a desirable reduction in the turnover rate.

Table 1: Data for twenty one CRM units used in our analysis.

CRM Unit	Productivity	FCR	Training	TO Rate	Cost
1	3.48	20.00%	31.45	58.92%	$ 47,420.65
2	6.64	60.00%	25.56	13.52%	$ 26,481.48
3	4.00	65.00%	30.00	10.00%	$ 75,000.00
4	5.88	60.00%	25.00	25.00%	$ 48,400.00
6	1.50	74.00%	15.00	7.00%	$ 49,400.00
9	3.78	70.00%	116.44	16.72%	$ 56,892.66
15	25.00	90.00%	30.00	1.00%	$ 61,997.42
16	8.77	75.00%	28.50	47.50%	$ 43,225.00
17	17.14	75.00%	10.00	50.00%	$ 28,000.00
19	9.52	48.00%	25.00	5.00%	$ 51,995.84
21	24.04	12.00%	168.78	10.06%	$ 72,101.96
22	5.45	60.00%	180.00	2.00%	$ 54,000.00

31	8.57	63.00%	28.00	17.00%	$ 34,700.00
34	7.29	60.00%	25.00	10.00%	$ 35,384.62
35	5.83	79.00%	17.88	9.36%	$ 52,151.00
37	3.05	85.00%	14.39	22.54%	$ 43,703.33
38	4.17	54.00%	34.14	10.00%	$ 71,379.31
39	18.88	35.00%	13.56	5.78%	$ 63,555.56
41	7.10	60.00%	25.27	14.38%	$ 35,000.00
45	4.45	71.80%	5.00	10.29%	$ 41,302.86
47	9.44	40.00%	63.67	7.04%	$ 45,874.69

NUMERICAL RESULTS AND MANAGERIAL INSIGHTS

Problem *P2* can be solved as a linear program for each unit i in order to find its efficiency score, E_i. The efficiency measures E_i are true indicators of the relative standing of each unit on the scale of 0 to 100%. The results of solving problem *P2* are shown in Table 2 for each of the service units.

Table 2: Efficiency Scores for Service Units.

	Output	Inputs				
CRM Unit	Productivity	FCR	Training	TO Rate	Cost	Efficiency Score
1	3.48	20.00%	31.45	58.92%	$ 47,420.65	16.85%
2	6.64	60.00%	25.56	13.52%	$ 26,481.48	100.00%
3	4.00	65.00%	30.00	10.00%	$ 75,000.00	53.76%
4	5.88	60.00%	25.00	25.00%	$ 48,400.00	60.06%
6	1.50	74.00%	15.00	7.00%	$ 49,400.00	93.11%
9	3.78	70.00%	116.44	16.72%	$ 56,892.66	64.45%
15	25.00	90.00%	30.00	1.00%	$ 61,997.42	100.00%
16	8.77	75.00%	28.50	47.50%	$ 43,225.00	70.97%
17	17.14	75.00%	10.00	50.00%	$ 28,000.00	100.00%
19	9.52	48.00%	25.00	5.00%	$ 51,995.84	58.79%
21	24.04	12.00%	168.78	10.06%	$ 72,101.96	79.79%
22	5.45	60.00%	180.00	2.00%	$ 54,000.00	74.77%
31	8.57	63.00%	28.00	17.00%	$ 34,700.00	85.30%
34	7.29	60.00%	25.00	10.00%	$ 35,384.62	89.98%
35	5.83	79.00%	17.88	9.36%	$ 52,151.00	90.63%
37	3.05	85.00%	14.39	22.54%	$ 43,703.33	98.33%
38	4.17	54.00%	34.14	10.00%	$ 71,379.31	46.27%
39	18.88	35.00%	13.56	5.78%	$ 63,555.56	100.00%
41	7.10	60.00%	25.27	14.38%	$ 35,000.00	83.20%
45	4.45	71.80%	5.00	10.29%	$ 41,302.86	100.00%
47	9.44	40.00%	63.67	7.04%	$ 45,874.69	53.62%

From Table 2, Units 2, 15, 17, 39, and 45 appear to be the most efficient units, with a relative efficiency score of 100% for each. The other units fall in between the efficiency scores of a low of 16.85% (unit 1) and 98.33% (unit

37) indicating their corresponding operating inefficiency in managing labor costs, turn over and training. In the next section, we discuss how these degrees of inefficiency can be interpreted and how they help in managerial decision-making.

Given the relative efficiency scores of each CRM unit, we can calculate the combination of inputs and outputs measures, which will make each of the inefficient CRM units efficient. Using shadow prices generated by the linear programming solution (for a more detailed explanation, see Appendix), we calculate the values that would make each of the corresponding units efficient. This is listed in Table 3.

Table 3: Measures for Efficiency Rating of 100%.

CRM Unit	Productivity	FCR	Training	TO Rate	Cost
1	3.66	20.00%	4.92	9.93%	$ 7,991.23
2	6.64	60.00%	25.56	13.52%	$ 26,481.48
3	11.77	65.00%	16.13	5.38%	$ 40,318.48
4	6.42	60.00%	15.02	15.02%	$ 29,069.60
6	11.49	74.00%	13.97	6.52%	$ 45,997.59
9	11.64	70.00%	27.66	10.78%	$ 36,665.58
15	25.00	90.00%	30.00	1.00%	$ 61,997.42
16	12.75	75.00%	20.23	33.71%	$ 30,678.54
17	17.14	75.00%	10.00	50.00%	$ 28,000.00
19	10.63	48.00%	14.70	2.94%	$ 30,570.35
21	24.04	88.44%	27.33	8.03%	$ 57,528.94
22	16.02	60.00%	20.36	1.50%	$ 40,374.07
31	8.57	63.00%	23.88	14.50%	$ 29,598.07
34	9.78	60.00%	22.50	9.00%	$ 31,839.46
35	11.30	79.00%	16.20	8.48%	$ 47,265.76
37	8.90	85.00%	14.15	22.17%	$ 42,972.57
38	10.47	54.00%	15.80	4.63%	$ 33,026.05
39	18.88	35.00%	13.56	5.78%	$ 63,555.56
41	7.10	60.00%	21.02	11.96%	$ 29,118.89
45	4.45	71.80%	5.00	10.29%	$ 41,302.86
47	9.44	40.00%	13.80	3.77%	$ 24,595.90

Interpreting the results of Table 3, if one wants to make Unit 1 move to the efficient frontier, a combination of all of the following must happen: its Productivity must rise from 3.48 to 3.66, Average Training Days would need to fall from 31.45 to 4.92 days, The TO Rate must go from 58.92% to 9.93% and finally the Average Labor Cost must be reduced from $47,420.65 to $7991.23. Clearly a lot must happen in order to move Unit 1 to an efficiency score of 100% (One must also note that, to begin with, it had the lowest score of 16.85%).

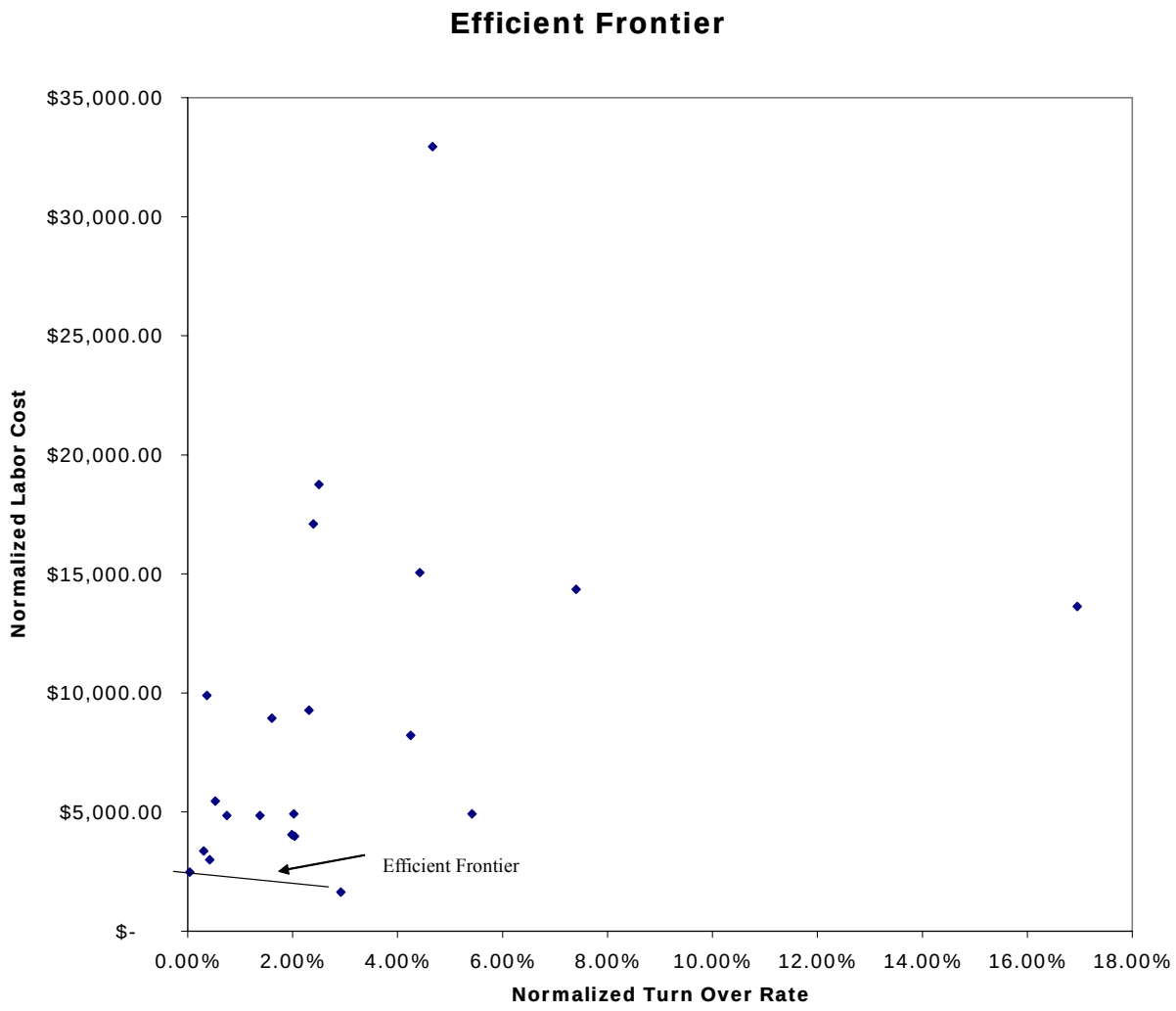
In order to explain some of the additional managerial insights derived from the DEA analysis, we considered a subset of the above 3-input, 2-output situation, and did more extensive analysis of our results. Consider only the case of one output measure (Productivity) and two input measures (TO Rate and Labor Cost). For this case, using DEA, we arrive at the efficiency scores shown in Table 4 (note that there are only two efficient units, Unit 15 and Unit 17):

Table 4: Efficiency Scores For Productivity, TO Rate, and Labor Cost.

CRM Unit	Productivity	TO Rate	Cost	Efficiency Score
1	3.48	58.92%	$ 47,420.65	13.38%
2	6.64	13.52%	$ 26,481.48	54.31%
3	4.00	10.00%	$ 75,000.00	12.79%
4	5.88	25.00%	$ 48,400.00	26.29%
6	1.50	7.00%	$ 49,400.00	7.26%
9	3.78	16.72%	$ 56,892.66	15.23%
15	25.00	1.00%	$ 61,997.42	100.00%
16	8.77	47.50%	$ 43,225.00	38.21%
17	17.14	50.00%	$ 28,000.00	100.00%
19	9.52	5.00%	$ 51,995.84	44.38%
21	24.04	10.06%	$ 72,101.96	79.79%
22	5.45	2.00%	$ 54,000.00	24.90%
31	8.57	17.00%	$ 34,700.00	53.79%
34	7.29	10.00%	$ 35,384.62	47.39%
35	5.83	9.36%	$ 52,151.00	26.44%
37	3.05	22.54%	$ 43,703.33	15.07%
38	4.17	10.00%	$ 71,379.31	13.99%
39	18.88	5.78%	$ 63,555.56	72.09%
41	7.10	14.38%	$ 35,000.00	45.12%
45	4.45	10.29%	$ 41,302.86	25.01%
47	9.44	7.04%	$ 45,874.69	49.07%

Additionally, the analysis results in an Efficient Frontier (Figure 1). Note the efficient frontier will be a straight line connecting the points depicting CRM units 15 and 17. The distance of the inefficient units from the efficient frontier indicates the degree of inefficiency for the corresponding CRM unit (the closer one is to the efficient frontier line, the higher the efficiency).

Figure 1: Efficient Frontier for 2-input, 1-ouput situation.



With the selected inputs as TO Rate (I_1), and Average Labor Cost (I_2), and the selected output as Productivity (O_1) by the CRM unit, we identified three major questions for the inefficient CRM units:

1) For a given TO Rate and a given Labor Cost, how much would the productivity have to increase for the CRM unit to be efficient?
2) For a given level of Productivity and TO Rate, how much would the Labor Cost have to decrease for the CRM unit to be efficient?
3) Finally, for a given level of Productivity and Labor Cost, how much would the TO Rate have to decrease for the CRM unit efficient?

For each of the above questions, we set the constraint equations for the DEA formulations accordingly as follows such that the necessary margin of inefficiency shows up for the CRM units that are not on the efficient frontier:

1) $(v_1I_1 + v_2I_2)/u_1 \geq O_1$
2) $(u_1O_1 - v_2I_2)/v_1 \leq I_1$
3) $(u_1O_1 - v_1I_1)/v_2 \leq I_2$

For the first case, we get the results shown in Table 5. This indicates that, for Unit 1 for example, for a given TO Rate of 58.92% and a given labor cost of $47,420.65, the current productivity of 3.48 calls per hour needs to increase to 25.99 calls per hour to be efficient (Again, note that Units 15 and 17 are currently efficient).

Table 5: Productivity Needed to be Efficient (For a given Labor Cost and TO Rate).

	Given		Variable	
CRM Unit	TO Rate	Labor Cost	Current Productivity	Productivity Needed To be Efficient
1	58.92%	$ 47,420.65	3.48	25.99
2	13.52%	$ 26,481.48	6.64	12.22
3	10.00%	$ 75,000.00	4.00	31.28
4	25.00%	$ 48,400.00	5.88	22.38
6	7.00%	$ 49,400.00	1.50	20.65
9	16.72%	$ 56,892.66	3.78	24.81
15	1.00%	$ 61,997.42	25.00	25.00
16	47.50%	$ 43,225.00	8.77	22.96
17	50.00%	$ 28,000.00	17.14	17.14
19	5.00%	$ 51,995.84	9.52	21.46
21	10.06%	$ 72,101.96	24.04	30.13
22	2.00%	$ 54,000.00	5.45	21.91
31	17.00%	$ 34,700.00	8.57	15.93
34	10.00%	$ 35,384.62	7.29	15.38
35	9.36%	$ 52,151.00	5.83	22.04
37	22.54%	$ 43,703.33	3.05	20.20
38	10.00%	$ 71,379.31	4.17	29.83
39	5.78%	$ 63,555.56	18.88	26.19
41	14.38%	$ 35,000.00	7.10	15.75
45	10.29%	$ 41,302.86	4.45	17.79
47	7.04%	$ 45,874.69	9.44	19.24

For the second case, we get the results shown in Table 6. This indicates that, for Unit 2 for example, for a given TO Rate of 58.92% and a given Productivity level of 6.64 calls per hour, the current Labor Cost of $ 26,481.48 needs to be reduced to $12,564.52 to be efficient (Also note that it is not feasible to reduce the Labor Cost of Unit 1 in order to make it efficient as the required cost is negative).

Table 6: Labor Cost Needed to be Efficient (For a Given Level of Productivity and TO Rate).

	Given		Variable	
CRM Unit	Productivity	TO Rate	Current Labor Cost	Labor Cost Needed To be Efficient
1	3.48	58.92%	$ 47,420.65	$ (8,676.35)
2	6.64	13.52%	$ 26,481.48	$ 12,564.52
3	4.00	10.00%	$ 75,000.00	$ 7,023.75
4	5.88	25.00%	$ 48,400.00	$ 7,300.00
6	1.50	7.00%	$ 49,400.00	$ 1,677.59
9	3.78	16.72%	$ 56,892.66	$ 4,495.72
15	25.00	1.00%	$ 61,997.42	$ 61,997.42
16	8.77	47.50%	$ 43,225.00	$ 7,878.94
17	17.14	50.00%	$ 28,000.00	$ 28,000.00

19	9.52	5.00%	$ 51,995.84	$ 22,259.93
21	24.04	10.06%	$ 72,101.96	$ 56,930.48
22	5.45	2.00%	$ 54,000.00	$ 13,001.84
31	8.57	17.00%	$ 34,700.00	$ 16,354.00
34	7.29	10.00%	$ 35,384.62	$ 15,220.29
35	5.83	9.36%	$ 52,151.00	$ 11,764.07
37	3.05	22.54%	$ 43,703.33	$ 954.31
38	4.17	10.00%	$ 71,379.31	$ 7,453.95
39	18.88	5.78%	$ 63,555.56	$ 45,343.37
41	7.10	14.38%	$ 35,000.00	$ 13,469.20
45	4.45	10.29%	$ 41,302.86	$ 8,058.77
47	9.44	7.04%	$ 45,874.69	$ 21,457.71

Finally, for the third case we get the shown in Table 7. Notice that none of the inefficient units can be made efficient by reducing the TO rate (for the given level of productivity and Labor Cost) as all values are negative, implying that the reduction has to exceed the feasible limits (absolute best turnover rate of 0%) This means that for the given situation, the other input, namely the labor cost, dominates the results to such an extent that even a 0% turnover rate in the inefficient units will not make them efficient.

Table 7: TO Rate Needed to be Efficient (For a Given Level of Productivity and Labor Cost).

	Given		Variable	
CRM Unit	Productivity	Labor Cost	Current TO Rate	TO Rate Needed To be Efficient
1	3.48	$ 47,420.65	58.92%	-131.72%
2	6.64	$ 26,481.48	13.52%	-33.78%
3	4.00	$ 75,000.00	10.00%	-221.02%
4	5.88	$ 48,400.00	25.00%	-114.68%
6	1.50	$ 49,400.00	7.00%	-155.18%
9	3.78	$ 56,892.66	16.72%	-161.35%
15	25.00	$ 61,997.42	1.00%	1.00%
16	8.77	$ 43,225.00	47.50%	-72.62%
17	17.14	$ 28,000.00	50.00%	50.00%
19	9.52	$ 51,995.84	5.00%	-96.06%
21	24.04	$ 72,101.96	10.06%	-41.50%
22	5.45	$ 54,000.00	2.00%	-137.33%
31	8.57	$ 34,700.00	17.00%	-45.35%
34	7.29	$ 35,384.62	10.00%	-58.53%
35	5.83	$ 52,151.00	9.36%	-127.89%
37	3.05	$ 43,703.33	22.54%	-122.74%
38	4.17	$ 71,379.31	10.00%	-207.25%
39	18.88	$ 63,555.56	5.78%	-56.12%
41	7.10	$ 35,000.00	14.38%	-58.80%
45	4.45	$ 41,302.86	10.29%	-102.69%
47	9.44	$ 45,874.69	7.04%	-75.94%

This clearly shows the tradeoff that exists between different input factors for a CRM unit. Without a measurement system such as the one developed in this paper, it will be very difficult for the CRM unit to compare the benefits from changes in dissimilar inputs such as TO Rates, Training, and Labor Costs.

CONCLUSIONS AND F UTURE RESEARCH

In this paper, we offer a methodology to evaluate and compare CRM units given dissimilar inputs and output measurements. The results help us determine the efficiency front of the chosen set of CRM units and provide a measure on extent of inefficiencies for the units that are not on the efficient frontier. An extension of the DEA results along with the sensitivity analysis provides several managerial insights that will help CRM managers in decision-making on issues such as degree of IT investment and the ideal size of labor force.

Our future research will focus on developing a more comprehensive set of measurements that will attempt to seek out the most relevant of all these inputs and outputs that will apply generally to most CRM units. We are focusing currently in CRM units for call centers of different types. This will involve looking at measures that are focused on several areas: financial, customer satisfaction, internal processes, and human resources.

With sufficiently large set of data, we believe that our DEA model will give more valuable insights to the CRM units under study as to what improvements are possible to make and by how much. The complexity of the quantitative analysis increases drastically with the inclusion of more inputs and outputs. Therefore, the wisdom of selecting the appropriate number of inputs and outputs lies in arriving at a balance between degree of mathematical complexity and usefulness of the results.

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