

Service operations in DMV (division of motor vehicles) offices of the USA - a comparative study

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Abstract:

Purpose: Division of motor vehicle (DMV) offices serve a wide swath of Americans in all states and can therefore serve as excellent vehicles to study the quality of public services in the country. However, relatively little attention has been devoted in the academic literature to studying operations in DMV offices, especially as it relates to service quality and productivity. In an attempt to address the same, this paper aims to present the results of a study of DMV offices across the USA through a nationwide survey about vehicle titling and registration services, that received response from 31 of the 50 states and District of Columbia.

Design/methodology/approach: The authors use a mixed methods approach – a sequential unequal weight mixed methods approach starting with a quantitative analysis of DMV operational data followed by a qualitative case study approach. The primary data collected for this study were with a nationwide survey of the highest DMV office in each state, conducted through the American Association of Motor Vehicle Administrators. Out of the 50 states, 31 states and District of Columbia responded to the survey. In addition to descriptive statistical analysis performed to glean nationwide findings, Data Envelopment Analysis was used to determine efficiency of operations. Finally, extensive in-person interviews with senior managers of DMV offices in Ohio and Indiana were conducted to get more in-depth information for case studies and identification of best practices. **Findings:** States exhibit significant variations in labor and capital productivity and based on Data Envelopment Analysis, Texas and Minnesota DMVs are the most efficient in terms of using their labor and capital inputs to maximize the number of transactional services rendered. The authors also find that while operational performance of vehicle titling and registration services is monitored by most DMV offices across the nation, assessment of customer satisfaction received much less attention. Among the states that do well on both are Indiana and Ohio; the case studies presented based on interviews with their officials that also identify best practices. **Research limitations/implications:** This research was limited to the USA as are its findings. Additionally, it focuses only on vehicle titling and registration at DMV offices because that represents the bulk of services performed by a DMV

and the output is standard across all states. Nonetheless, a future study should be extended to other DMV services. **Practical implications:** Given the finding that assessment of customer satisfaction is not widely practiced in DMV offices, DMV officials should address this by putting appropriate systems in place. Additionally, practitioners and state officials can use the findings of this study to develop best practices for their operations and also determine the most appropriate ways to structure the provision of those services that result in enhanced efficiencies and customer satisfaction. **Social implications:** DMV services are among the most widely used services offered by the government in the USA and the overall size and scope of services provided by them across the country is immense. Thus, any improvements in productivity and service quality has significant implications in terms of improving public satisfaction with government services. **Originality/value:** To the best of our knowledge, this represents the first nationwide comparative study of DMV offices in the USA that focuses on service quality and analyzes productivity across the states. Additionally, the case study provided at the end of the paper identifies best practices from two states that have received national recognition for service quality which could be adopted by all DMV offices across the USA. The findings also conform/strengthen numerous hypotheses espoused in existing models and theories from service operations literature by providing evidence in their favor.

Keywords: Service quality | Service productivity | Labor productivity | Production and operations management | Capital productivity | DEA analysis | DMV offices

Article:

1. Introduction

Service operations management is a relatively new and emerging discipline within the larger area of operations management (Heineke and Davis, 2007) that has come into prominence, as economies have moved from products to services (Oliva and Kallenberg, 2003). Well-known texts in this discipline include, in chronological order, Sasser *et al.* (1978); Murdick *et al.* (1990); Stevenson and Sum (2002); Johnston *et al.* (2012) and Fitzsimmons and Fitzsimmons (2013). Concomitant with the introductions of these books is the portfolio of scholarly articles in this area – Collier (1983); Kellogg and Nie (1995) and Roth and Menor (2003), are a few examples of well-cited papers in this field. As stated in Ellram and Cooper (2014, pg. 13), research in the field should provide greater “depth and breadth of insight” and similar to other fields, researchers in service operations management must use consistent terminology, value replication studies and increase the level of rigor in those studies. We attempt to contribute to the same by reporting on the findings of a study that includes a nationwide survey, selected interviews, descriptive analyses and efficiency frontier analyses so as to provide in-depth insights on a commonly provided service activity – the titling and registration of vehicles.

Public/government-owned and -administered organizations/agencies provide a significant share of services in the USA to the populace (Christensen and Lægheid, 2005; Fountain, 2001; West, 2004), and hence, there are several studies related to customer service quality for public agencies. Developing a model of public service quality and customer satisfaction, Rhee and Rha (2009) posited a service value chain that drives satisfaction or dissatisfaction of customers, comprising four main quality dimension of public service: design quality, process quality,

outcome quality and relationship quality (Rha and Rhee, 2007; Rhee and Rha, 2009). Design quality concerns how well a public policy or service is developed at policy making or service design stages. Process quality concerns how customers perceive quality during a service process (Grönroos, 2000). Outcome quality concerns how customers perceive the quality of what is left after a service process is finished (Grönroos, 2000). Relationship quality refers to the depth and climate of the relationship between parties in the service delivery process. These dimensions lend themselves to Chung's (2001) triad classification of services provided by local governments: social welfare services, social utilities services and industrial and economic services. Social welfare services (social safety networks, labor, child care, health care, etc.) are common foci of quality research, as are social utilities services (transportation, housing, education, water and sewage, etc.) because both are focused on transactions or exchanges of service. Industrial and economic services, on the other hand, are less commonly found in quality research because they focus on the making of policies and regulations.

Among the most widely used services offered by the government are those related to the services provided by DMV (division of motor vehicle) offices. While DMV offices in the USA are administered by individual states rather than the federal government, their overall size and scope of services across the country are underscored by several facts. Together, they oversee titling and registration for over 253 million cars and trucks, 12.5 million registered boats and manage driver's licenses for over 214 million licensed drivers. It is estimated that approximately 33 million residents of the USA use DMV services each year. Owing perhaps to the scope of operations, as well as regulatory differences between states, there are wide differences in how DMV offices are administered in each of the states. From an organizational standpoint, while 78 per cent of all DMV offices in the USA are housed within the state Department of Transportation, the remaining offer various DMV-related services through the Department of Revenue and in a small minority of cases, through the Department of Secretary of State (Martin *et al.*, 2014). In addition to standard services such as vehicle registration and titling and issuance of driver's licenses, state DMV offices vary in other service offerings, such as voter registration (e.g. NC), mobile home registration (e.g. Florida) and issuance of hunting and fishing licenses (e.g. Indiana). By virtue of this immense scope and diversity, DMV offices can serve as an excellent platform to perform studies about service operations and quality in the USA, especially as it relates to those offered by public agencies. While the diversity of services across the states may make inter-state comparisons challenging, this difficulty can be overcome by focusing on a standard service such as vehicle titling and registration that is relatively uniform across all DMVs and also represents one of the most important portions of their overall workload. Nonetheless, research done for this paper indicates that there are relatively few academic studies performed on this subject, despite several available in the practitioner literature.

Perhaps the most well-known academic work on service operations in DMVs is that of Karwan and Markland (2006). As noted therein, public agencies face an inherent trade-off between providing broader services to residents and being cost efficient. The need to broaden the reach of services provided often results in an over-emphasis in dispersed facilities for government agencies (White, 1979). Also, in sharp contrast to the for-profit sector, government agencies such as DMVs emphasize effectiveness and equity over efficiency. Notwithstanding the definition of success, one of their central tenets is that success in service delivery is best achieved by implementing service operations concepts in tandem with information technology in

governmental operations; something also emphasized in Muthaiyah and Kerschberg (2008), who completed a study on how to improve online governmental services. Using a service design framework, Karwan and Markland suggest that.

Service design in these agencies would then require a separate accounting of the front and back offices and then an integrated look at how these could be simultaneously improved via enhancements to technology.

They also make several recommendations related to personnel, training, data integrity, service automation, etc. Finally, it is interesting to note that extending Chung's (2001) classification scheme referenced before, process and outcome quality would be the most salient features of public service quality to customers of state motor vehicle departments. Customers of DMVs directly receive the core benefits of a public service. They mainly experience the encounter process and the final outcome of the public service. Hence, they are naturally sensitive to the process quality during a service encounter and see great import in both process and outcome quality.

Practitioner literature indicates that some states have commissioned studies on customer service in their DMV offices and strategies to improve them. One example is that of Kane and Foltz (2011), which describes such an effort undertaken by the Idaho Transportation Department, through a telephone survey. The results of the survey pointed to several ways to improve DMV services, such as expanding hours of operation, hiring more staff, better promoting online services and providing better information. In that study, many residents reported not using online services simply because they were unaware that they existed; nonetheless, in an interesting twist, the authors also concluded based on the data that increased awareness of online services did not necessarily result in an increased adoption of the same. Kane and Foltz conclude their study by making several recommendations about improvement of services, especially through the use of automation and the internet. More recently, North Carolina's DMV has undertaken several significant projects in an attempt to understand and improve customer service. Research by Martin *et al.* (2014) focused entirely on license plate agencies (LPA), which are private contractors employed by the North Carolina's DMV to offer vehicle titling and registration services. Their study focused primarily on understanding the regulatory and operational environment across all LPA offices in North Carolina.

Drawing upon some of the work done in Martin *et al.* (2014), the essential contribution of this paper is to add to the above referenced literature on DMVs based on a comprehensive survey of DMV offices in all 50 states in the continental USA and the District of Columbia. This survey, which to the best of our knowledge is the first nationwide academic study of DMV offices, was focused on identifying important organizational features of DMV offices in each state and eliciting operational and customer satisfaction measurement practices as related to vehicle titling and registration services. Our primary conclusions are that significant differences exist among various states with regard to labor and capital productivity measures of their vehicle titling and registration operations and the efficiency with which state DMV offices convert their labor and capital inputs into outputs. Further analysis using data envelopment analysis (DEA) reveals that Texas and Minnesota are the most efficient in terms of utilizing their labor and capital inputs to maximize the number of transactional services rendered. In particular, Texas (TX) stands out as a

state whose DMV offices have also been nationally recognized for service quality in addition to being found efficient in our study. We also find that most states (69 per cent) have systems in place to monitor operational performance of vehicle titling and registration operations. However, the same cannot be said of monitoring customer satisfaction with these services; presently, the vast majority (over 80 per cent) of states lack an institutionalized system to measure or manage customer satisfaction (e.g. through established benchmarks). Among the exceptions are Indiana and Ohio – both have been nationally recognized by the American Association of Motor Vehicle Administrators (AAMVA) for their service quality. Therefore, the paper ends with an interview-based case study on these two states that identifies their best practices and identifies how they substantiate existing similar results in the management literature. For example, missing from all the studies quoted above is one whose focus is on the need for balance between accessibility and efficiency, especially as they relate to the location of DMV offices (White, 1979). Our study fills some of this gap by presenting evidence from the state of Ohio on the beneficial effects of co-location of DMV departmental offices.

The remaining paper is structured as follows. Section 2 describes how the survey was conducted and the data compiled while Section 3 focuses on the results obtained through a quantitative analysis of the data. The first set of results pertains to overall descriptive statistics from the national survey and the second portion of this quantitative analysis performs DEA to determine DMV offices that are the most efficient in using their capital and labor inputs. Section 4 highlights the main points from Indiana and Ohio, in which focused interviews were conducted and Section 5 concludes the study, highlighting the main results, as well as best practices identified from the interviews described in Section 4.

2. Research methodology and survey data collection

As mentioned above, DMV offices in the USA provide a wide variety of services that are administered in varying manners across the country. Nonetheless, vehicle titling and registration are common services across all DMV offices, regardless of state, and produce a standard output, namely, authorization of licensed vehicles to operate within that state. Indeed, these services represent the major operations of any DMV office. For example, in North Carolina, these services represent about 60 per cent of the total number of interactions between the DMV and the general population (Martin *et al.*, 2014). This makes vehicle titling and registration a suitable platform to evaluate state-level DMV protocols across DMV offices.

With the above in mind, this paper looks to compare service operations across DMV offices in the USA by focusing on the vehicle titling and registration service. The overarching objective of the study was to seek answers to research questions such as the following:

RQ1. How productive are DMV offices with regards to capital and labor and how do these figures vary across the different states in the USA?

RQ2. Which states in the USA are more efficient than others at converting capital and labor into output?

RQ3. What types of measures are used by DMV offices to monitor operational performance?

RQ4. How do DMV offices across the various states in the USA monitor customer satisfaction?

RQ5. What are some best practices across the DMV offices in the USA with regard to operational processes and procedures and customer service?

In an effort to answer these questions, the study used both survey methodology and face-to-face interviews with selected senior DMV managers across two different states in the USA. While most of the information needed to answer *RQ1-4* were collected based on the survey data, answers to question 5 above was primarily informed through extensive interviews. To begin with, a survey questionnaire was developed in consultation with senior managers from North Carolina DMV and the AAMVA – the primary national association of state motor vehicle administration officials in the USA. Initial versions of the survey were pilot tested on senior managers from North Carolina DMV for clarity and readiness with which required data could be obtained and necessary changes were made to the same. Appendix 1 represents the final version of the survey questionnaire and as evident therein, the questions focused on collecting quality management practices, as well as operational and transactional information pertinent to answering the research questions listed above. Thereafter, data were collected between 2014 and 2015 by emailing the questionnaire under the aegis of AAMVA to all of its members in 49 states (excluding North Carolina, since that state's information was collected separately) and the District of Columbia. The e-mail from AAMVA specifically requested survey completion by a senior administrative official in each state DMV headquarters and multiple email reminders were sent during the data collection period. DMV administrators in 31 states completed the survey. Administrators in five additional states started the survey but left some questions unanswered. No response was received from DMV administrators in the remaining jurisdictions. Therefore, the survey had an overall response rate of 62 per cent, which lends credibility to the conclusions drawn from the data collected.

In addition to the above survey, the research team also conducted extensive in-person interviews with senior managers of DMV offices in Ohio and Indiana including in-depth information about their processes and quality control procedures to better understand DMV operations. These states were chosen based on prior quality achievements, as both have been recognized by AAMVA for service quality. Further, while Ohio uses private contractors to offer vehicle titling and registration services, Indiana (IN) does not, providing insight into operations at two very different kinds of DMV offices that nonetheless have been recognized for service quality.

3. Survey results

This section contains the analysis of the quantitative data from the survey. As the data collected are too extensive to be comprehensively reported in this paper, we focus instead on presenting

the results obtained from analyzing the data.¹ The first set of results, captured in Table I, presents overall descriptive statistics gleaned from the survey, related to labor and capital productivity, measurement of operational performance and how customer satisfaction is monitored across the different DMVs. The second set of results, presented in Table II, is based on an in-depth DEA to determine states whose DMV offices are the most efficient in terms of transforming capital and labor inputs into outputs (measured by the annual number of transactions performed). An important aspect of DEA (discussed shortly in some detail) is that it provides a flexible form of efficiency ranking for DMVs, as it is not *a priori* prejudiced in terms of either labor productivity or capital efficiency. This is a valuable feature, as it is quite plausible that some DMVs might choose to substitute sophisticated capital equipment and systems for labor.

Table I. Service operations, performance and quality measurement in DMV offices: overall summary statistics

Statistic	Notes
Whether services are provided in-house or outsourced	66% of states offer service in house within the DMV's; remaining 34% outsourced to private contractors
Annual number of vehicle titling and registration transactions	Max: California (33.7 million transactions). Min: South Dakota (175,500 transactions) Median: 3.5 million transactions
Total number of DMV employees devoted to vehicle titling and registration	Max: California (4,855 employees) Min: South Dakota (40 employees) Median: 281 employees
Total annual expenditures related to vehicle titling and registration services	Max: California (\$464m) Min: Mississippi (\$2.19m) Median: \$20.2m
Median labor productivity	11,309.52 transactions/employee
Median capital productivity	\$5.72 per vehicle titling/registration transaction
Percentage of states where DMV offices measure operational performance with regards to vehicle titling and registration services	69%
Percentage of states where DMV offices measure customer satisfaction with regards to vehicle titling and registration services	48%
Percentage of states where DMV offices have an institutionalized system to measure customer satisfaction	36% of 48% = 17.28%
Percentage of states where DMV offices have established benchmarks/metrics with regards to customer satisfaction for vehicle titling and registration services	16% of 48% = 7.68%

As for organizational resources and productivity, the analysis examined the following state-level DMV data: total number of employees engaged in providing vehicle titling and registration services, annual number of vehicle titling and registration transactions processed and annual expenditures related to vehicle titling and registration services in the state. An overall conclusion based on this data is that these vary tremendously across states depending on how vehicle titling and registration services are offered, as evidenced by the fact that the coefficient of variation for

¹ This data may be accessed from the Martin *et al.* (2014) report available at following website of North Carolina Department of Transportation <https://connect.ncdot.gov/projects/planning/Lists/RNASrchProj/DispForm.aspx?ID=910&RootFolder=%2A>

the total number of employees engaged in providing vehicle titling and registration services across the different states in the USA is 166 per cent and the corresponding measure for the annual expenditures is 204 per cent. At the high end, DMV offices in states such as California and New York employ 4,855 and 1,712 employees, spend \$464m and \$41m, respectively, in processing 33.7 million and 6 million transactions annually in each of these two states. At the low end, states such as South Dakota and Mississippi employ 40 and 50 people, spend \$2.6m and \$2.19m, respectively, in processing 175,500 and 414,000 transactions annually in each of these two states. Probing further, correlational studies between the above variables indicated only a weak positive correlation between the annual number of vehicle titling and registration transactions and number of employees (4.1 per cent) or annual expenditures (5.1 per cent). Under the reasonable assumption that DMV employees across the different states are not vastly different in terms of their skills and given the fact that the final output (a registered/renewed vehicle license) is a standard product, this points to the possibility of different levels of efficiencies among the DMVs across the states in using the capital and labor inputs. This is supported by the DEA analysis conducted later in this section. In this context, it is interesting to note parallel observations regarding productivity noted for university-based technology transfer offices in Siegel *et al.* (2003).

Table II. Results of data envelopment (DEA) analyses

State	DMU	BCCI Rank	BCCO Rank	CCRI Rank	CCRO Rank	BCCI Score	BCCOS core	CCRI Score	CCRO Score
California	1	1	1	10	10	1	1	6.17E-02	6.17E-02
Colorado	2	11	8	8	8	0.1054275	0.2580925	8.95E-02	8.95E-02
Connecticut	3	12	13	13	13	0.100098	8.59E-02	4.96E-02	4.96E-02
Florida	4	1	1	4	4	1	1	0.4534773	0.45347732
Louisiana	5	7	12	7	7	0.2417121	0.10030031	0.1000956	0.10009565
Michigan	6	8	7	6	6	0.1717995	0.3683306	0.1530168	0.15301678
Minnesota	7	1	1	1	1	1	1	1	1
Mississippi	8	1	1	3	3	1	1	0.9140631	0.91406314
New Mexico	9	9	14	11	11	0.1426538	7.23E-02	5.74E-02	5.74E-02
New York	10	14	9	14	14	4.33E-02	0.19998611	4.28E-02	4.28E-02
Oklahoma	11	10	11	9	9	0.1182906	0.11584036	7.69E-02	7.69E-02
South Dakota	12	1	1	5	5	1	1	0.4418907	0.44189069
Texas	13	1	1	1	1	1	1	1	1
Utah	14	13	10	12	12	7.02E-02	0.16302683	5.73E-02	5.73E-02

Notes: Correlation b/w BCCI and BCCO Score: 0.979; correlation b/w BCCI and CCRI Score: 0.772; correlation b/w CCRI and CCRO Score: 1.000; correlation b/w BCCO and CCRO Score: 0.772

Next, two measures of productivity were computed – *Labor Productivity* (as measured by annual number of transactions processed per employee) and *Capital Productivity* (as measured by dollars spent by DMV per transaction). Similar variances as above were also observed for both of these measures across the different DMV offices: the coefficient of variations for these two measures were 136 per cent for labor productivity and 147 per cent for capital productivity. To develop national benchmarks, the medians were computed and the survey results indicated that the median national annual labor productivity is 11,309.52 transactions per employee per year²

² To keep comparisons meaningful, only states that use in-house state employees to perform vehicle titling and registration were used in computing labor productivity. The minority of states that have outsourced this activity to private contractors were excluded.

and also that the median national capital productivity of DMV offices across the USA is \$5.72 per vehicle titling/registration transaction.

The next set of overall descriptive measures gleaned from the national survey are related to operational performance measurement across DMV offices. With regard to the same, it was observed that across the USA, 69 per cent of DMV offices have processes and procedures in place to measure the performance of vehicle titling and registration services and the two most common performance measures used are:

- wait times of customers (60 per cent of states measure this); and
- error rates of customer transactions (52 per cent of states measure this).

The literature on service operations management strongly emphasizes the importance of measuring and improving customer satisfaction by organizations (Fitzsimmons and Fitzsimmons, 2013; Johnston *et al.*, 2012). Hence, we next focus on what DMV offices across the states have done with regards to the same. Our data indicated that at a basic level, DMV offices in every state ensure that when customers complain regarding vehicle titling and registration services, these are handled by designated staff. However, for most states that is all the DMV offices have implemented by way of improving customer satisfaction. Nationally, only 48 per cent of DMV offices directly measure customer satisfaction (at any level at all) with vehicle titling and registration services. Even of the states that measure customer satisfaction, only 36 per cent have an institutionalized system (e.g. a regularly administered survey or requiring reporting it in the contracts issued to external contractors) in place. Further, of the states that measure customer satisfaction, only 16 per cent have established published benchmarks/metrics that are used as a part of the evaluation system, with Indiana and Florida being two standout examples. For example, IN uses 10 min of wait time as a benchmark for the performance of an office and Florida is the only state where not only is customer satisfaction and office performance measured but, in addition, these results are also made publicly available (<http://services.flhsmv.gov/performance/dashboard/>). Thus, the overall conclusion from the national survey is that a sustained and systematic focus on measurement of customer satisfaction and implementing a continuous improvement system based on the same has not been institutionalized across the vast majority of DMV offices in the country. The above descriptive statistics are summarized in Table I.

Recall from the productivity analysis presented above points to the fact that states vary widely in terms of how efficiently they convert labor and capital inputs into the standard output (annual number of vehicle titles and registrations produced). Therefore, the next portion of our analysis focuses on estimating the relative efficiency of states in transforming inputs (capital and labor) into output as it relates to vehicle titling and registration transactions. While the two productivity estimates above (labor and capital productivity) provide an overall estimate of their median values across the USA, what follows is thus a deeper analysis of productivity at the individual state level. We begin with the observation from the literature on productivity analysis that studies investigating organizational efficiency typically use techniques such as regression analysis or ratio analysis. Both of these approaches are limited, however. Regression analysis, a parametric approach, is limited by focusing on mean effects across the sample observations and on only one output (i.e. one dependent variable) per analysis. Ratio analysis, on the other hand, can only

investigate inputs and outputs in total relative to each other, with no opportunity to vary the weights to optimize the resulting ratio. As discussed below, the technique known as DEA is not subject to either of these shortcomings.

DEA – a non-parametric approach – has grown dramatically in a number of academic and practical settings (Cook and Seiford, 2009) in large part because it is able to investigate multiple inputs and outputs simultaneously for each decision making unit (DMU) (i.e. DMV offices of each state in our instance). DEA identifies an “efficient frontier” for the DMUs in the sample of states. This efficient frontier is a piecewise linear surface that provides an envelope region by connecting the most efficient DMUs (these are identified by selecting the combination of weights on inputs and/or outputs that provides an optimal ratio of the combination for each DMU). It is thus possible to calculate inefficiency scores for the non-frontier DMUs, by calculating the distance of each DMU from the efficient frontier (Coelli *et al.*, 2005; Cook and Seiford, 2009). As noted above, DEA is flexible in terms of selecting the combination of outputs or inputs that makes the DMU appear most efficient (i.e. presents it in the most favorable efficiency light) – thus, it implicitly considers the possibility of substitution of labor productivity and capital productivity. This is important as in our sample of DMVs, the correlation between labor productivity and capital productivity is -0.62 , indicating a significant substitution of labor and capital by the DMV offices in the effort to achieve productive operations.

A wide variety of DEA models have been developed and used in the performance measurement literature (Coelli *et al.*, 2005; Cook and Seiford, 2009). Of these, the constant returns to scale (CRS) and variable returns to scale (VRS) models are among the most widely used. The CRS model, developed by Charnes *et al.* (1978), assumes that an increase in the input(s) will lead to a proportionate increase in the output(s), while the VRS model, introduced and popularized by Banker *et al.* (1984) assumes (this is referred to as the BCC model), in contrast, that an increase in the input(s) may result in either an increase or a decrease in the output(s). It is important to note that the CRS model does not take into account the scale effect, but the VRS model can accommodate the scale effect in its analysis (Banker *et al.*, 1984; Charnes *et al.*, 1978). In our analyses, we use the CRS approach (i.e. the CCR model), as a proportional transformation of inputs into outputs is reasonable to assume in the case of DMVs. However, to accommodate the possibility that the DEA scores may be impacted by large variances in key contextual variables such as size and capital and labor resource endowments across states we also use a VRS model using the BCC model.

DEA models can also be either input-oriented or output-oriented. An input-oriented DEA model attempts to minimize the inputs necessary to generate a given level of outputs, while an output-oriented model aims to maximize the level of outputs given the level of inputs. Putting it another way, in contrast to the output approach, the input approach is consistent with the view that DMUs have more control over inputs utilized and transforming them to outputs. It is important to note that the selection of input or output orientation typically has little effect on the efficiency score obtained from the DEA analysis (Coelli and Perelman, 1999). However, we use both approaches in our estimations, to ascertain that this is indeed true for our sample and analyses.

The output measure used in the present study is the number of transactions generated per employee per state DMV. Inputs are the number of employees and the actual dollar expenditures

(unscaled) per state. To ensure a meaningful analysis, only data from those states that had provided complete information on these inputs and outputs in the survey were analyzed; this reduced the number of states included in our DEA analysis to 14. The results are shown in Table II. All four models estimated (i.e. the input, and separately, output formulations of the CCR and BCC models) show that Texas and Minnesota are the most efficient in terms of transforming labor and capital inputs into output. Another state – Mississippi – is noteworthy, in that it ranks 1 for BCC (VRS model) and just below 1 in CCR (CRS model).

While there is no guaranteed relationship between service quality and efficiency in using capital and labor, it is interesting to note that DMVs in Texas have managed to do well on both. In addition to ranking high on efficiency in our DEA analysis, TX DMV has also won numerous awards for service quality from AAMVA. For example, in 2005, TX won the *Chair's Award of Excellence and Achievement* from AAMVA for vehicle titling and registration services and more recently, in 2016, TX was awarded the *Trailblazer Award* for service and security based on excellence in, among other areas, “innovative use of technology, customer convenience and improvement through efficiencies”.

4. Case studies: Ohio and Indiana

To better understand operational processes within DMV offices in the USA, detailed in-depth interviews were conducted on-site with senior DMV staff, including top state officials, in two states: Ohio and Indiana. These two states were chosen because they have been nationally recognized by AAMVA for service quality and while Indiana offers vehicle titling and registration through in-house employees, Ohio (OH) does the same through private contractors, thus lending credence to the hypothesis that high service quality may be achieved using either “business model” in DMV. Presented below are salient observations from these interviews particularly as they pertain to best practices³. Each interview lasted between 3-5 h and interviewees responded to both structured and unstructured questions – see Appendix 2 for the same. Two senior managers (Commissioner of Indiana Bureau of Motor Vehicles [BMV] and Director of Vehicle Programs Policy & Programs) were interviewed in Indiana and 11 were interviewed in Ohio (ranging from Registrar of Ohio BMV to Chief of Records and Research). The interviews’ notes were transcribed into a MS-Word document and subsequently audited by the interviewees for validity and correctness. Because most of the questions were highly structured, no special software was needed to code the data obtained from the interviews. We present our findings below and also discuss how these relate to existing results in the academic literature.

4.1 Ohio

In Ohio, the Registrar is the highest-ranking leader of the BMV, a division of the Ohio Department of Public Safety. Vehicle titling and registration services are handled by different service providers in Ohio. Vehicle titling is processed by the Clerk of Court in a given county, an

³ Five DMV officials from a third state, Missouri, were also interviewed since that state has recently embarked on a quality initiative to improve vehicle titling and registration processes, some of which is modelled after Ohio. However, that is not included in the paper, as it did not alter the findings substantially and Missouri’s efforts are still in progress.

elected position. Vehicle registration is handled by private contractors, referred to as Deputy Registrars. The state is served by nearly 200 Deputy Registrars, with a handful of dual authority Clerks of Court and Deputy Registrars, authorized to handle both vehicle titling and registration. Most dual authority designations serve Ohio's rural counties, as by law, each of Ohio's 88 counties must have at least one Deputy Registrar office. A "one-stop shop" approach is also found in Ohio's co-location strategy, with more than 40 Deputy Registrars and Clerk of Court co-located under one roof, and another nearly 40 "super offices" where all services offered by BMV are available at one location. Private contractors renting facilities from the state at state-approved rates permits this structure.

The state's largest Deputy Registrar offices handle in excess of 150,000 transactions each year. To maintain high levels of customer service Deputy Registrar offices are required to maintain at least limited Saturday hours. In addition, the Deputy Registrar must live within one hour driving distance of the office and spend at least 20 hours per week in the office. Customer wait times are monitored through independently submitted comment cards. Deputy Registrar offices are overseen by BMV field representatives, who make regular site visits.

A rigorous and continuous performance review process is based on operational performance, on-site visits, customer comment cards and secret shopper surveys. From this, a semi-annual CPA (Continuous Process Assessment) score is calculated for each Deputy Registrar, who may comment or rebut the score. Once the CPA scores are finalized, they are ranked and shared with Deputy Registrars. The CPA score becomes an important determinant of contract renewal for every Deputy Registrar, with 85 per cent of Deputy Registrars earning contract renewal and some holding contracts with Ohio BMV for more than 30 years.

The contract award process selects Deputy Registrars through an open competitive bidding process that begins with a public RFP in January and ends with contract awards by June. Contracts run for five years. Bidders are given extensive information including revenue potential of a given site and detailed information on the evaluation system used in assessing bids. Urban areas such as Cleveland, Columbus and Cincinnati have as many as a dozen bids, while rural areas may attract at most one bidder. Rules prohibit a bidder from bidding on more than six separate offices. Each bidder must affirm an ethics statement that acknowledges, among other things, neither the bidder nor an immediate family member has contributed more than \$100 to any political party nor will they. Non-profit organizations such as Chambers of Commerce may bid. BMV evaluation of bids is extensive and includes not only review of operational and personnel plans, but also reference checks and site visits. For existing Deputy Registrar offices, the CPA scores earned over the life of the prior contract are also taken into consideration. From this, BMV staff collectively finalize preliminary evaluation scores and publish these scores with their rationale so that each bidder can see individual scores, as well as those of competitors. Bidders may submit comments, which BMV staff review before producing final scores, and serve as the basis for final recommendations to the Registrar, which are also shared with the bidders. The Registrar awards the contracts. The process is authentic, transparent and rigorous.

Approximately, 20 per cent of BMV transactions, including vehicle registrations, are conducted online. Incentivizing Deputy Registrars to install self-service terminals in their offices to save on personnel costs has been explored. Equipment expenses in Deputy Registrar offices is paid for

by Ohio BMV. More than a decade ago BMV developed a proprietary information system for vehicle registrations that is used by Deputy Registrars. Communication between Deputy Registrars, IT staff, and end users is efficient and strong. Moreover, open channels of communication with Deputy Registrars extends throughout the system. BMV conducts all evaluations of Deputy Registrars with transparency and opportunities for rebuttal and feedback. Senior BMV staff routinely hold roundtables with Deputy Registrars and the Ohio BMV Registrar visits Deputy Registrar offices throughout the state.

4.2 Indiana

In contrast to Ohio, motor vehicle services in the state of Indiana are exclusively offered by state employees working for the BMV. BMV is led by a Commissioner who reports directly to the Governor, an organizational structure that enables the Commissioner to swiftly effect changes within the bureau.

Each of the more than 130 BMV branch offices is held to standards of performance and customer service as measured by wait times, error rates and employee productivity (number of error-free transactions performed annually). These measurements are monitored in real time by the headquarters in Indianapolis and that, in turn, is enabled by system programming that generates a scorecard for each branch office. Real-time data allow BMV to monitor wait times and intervene quickly when an office experiences extended customer delays. SharePoint platform-based resources are made available to all employees to review regulations and procedures to minimize follow up inquiries by customers to the BMV help desk. Centralization of complex titling transactions (for example, those involving liens or special inquiries) at the main office in Indianapolis has made titling and registrations routine and efficient at branch offices. Fulfillment of license plates is also centralized to minimize branch office inventory costs. Shipping of license plates to the vehicle owner is handled by the vendor after the order is placed by BMV. “One Call, One Resolution” offers one-stop shop service, permitting customers to call one central number at BMV to resolve questions or complaints. Independently administered quarterly surveys of BMV customers provide critical feedback on branch office services, with customer wait times the single greatest predictor of customer satisfaction.

Upwards of 50 per cent of transactions by BMV customers are completed online, with the cost of online transactions running approximately one-sixth of the cost of the same transaction completed in person. Further, registration renewal reminders sent via e-mail rather than USPS generate substantial savings. Information technology is further leveraged with customer service kiosks for customers who perform their transactions in cash.

The above in-depth interviews conducted with high-ranking officials in Ohio and Indiana allow two immediate recommendations for DMV offices across the USA that are interested in improving service operations.

- Where contractors are used, as in Ohio, establishing an effective partnership between DMV and contractors is crucial.
- Regardless of whether services are performed in-house (Indiana) or outsourced (Ohio), DMVs should adopt an operational framework that is grounded in the principles of

continuous improvement that involves measurement of operational performance and establishing benchmarks.

During the interviews, the research team also asked DMV officials in each state to identify what they considered a “best practice” within their state in comparison to other DMV offices in other states. A summary of some of these salient practices reported by DMVs in the states are as follows:

- *One-stop shop co-locations*: This is a best practice followed in Ohio. Given the wide variety of services offered by DMV, it is not uncommon to find that customers have to go to different offices to get the different services. For example, in North Carolina, driving licenses are issued in offices that are geographically separated from those that perform vehicle titling and registration. This occurs despite the inconvenience, increased travel time and loss of social interaction that diverse service locations have on service consumers as documented in Moseley *et al.* (2004). To address these problems, Ohio practices agglomerating various services under one roof (even if some of them are outsourced to private contractors such as Deputy Registrars) and has introduced nearly 40 “super offices” where all services offered by BMV are available at one location.

It is interesting to note that locations and co-locations of public agencies and the advantages/disadvantages of the same have been studied widely in the previous literature. As mentioned in the introduction section, Karwan and Markland (2006) have clearly enunciated the inherent trade-off that all public agencies face between providing broader services to residents and being cost efficient. The need to broaden the reach of services provided often results in an over-emphasis in dispersed facilities for government agencies (White, 1979). The agglomeration of service facilities in Ohio attempts to address this over-emphasis noted in the literature. Furthermore, as Kahn and McDonough (1997) have noted, although this might have been done with the intent of improving the performance and interdepartmental integration of the various departmental units, the expectation is it will also contribute to customer satisfaction.

- *Transparent contract award processes*: This is another best practice from Ohio, which has been copied by other states that use private contractors such as Missouri. As described above, Ohio has put into practice a highly transparent and open contract bidding and award process where all bidders are aware of the rules and the status of their applications throughout the process, including a rationale for those whose bids are rejected. Moreover, the process also allows for feedback by the bidders.

The literature on public sector management provides ample evidence of the importance of transparency in contract award processes – Kinsey (2004), Rege (2001) and Smith (2008). The detrimental impact of opaque contract award processes on organizational performance of public agencies is well documented whether it be in Bangladesh (Mahmood, 2010), Latin America (Boehm and Olaya, 2006) or Nigeria (Olusegun *et al.*, 2011). Thus, it can be stated that the contract award process adopted by Ohio DMV has contributed to its overall operational success.

- *Institutionalized performance review process*: This is a best practice from both Indiana and Ohio. Indiana offers DMV services, including vehicle titling and registration, through in-house state employees. To maintain a high level of customer satisfaction, every one of its branch offices is held to standards of operational performance (monitored in real time), and customer service and customers at every branch office are routinely surveyed to measure the level of satisfaction; such feedback is then used to improve service. By contrast, Ohio uses the semi-annual CPA (Continuous Process Improvement Assessment) process to achieve the same with its private contractors. Reviewing the academic literature, we note that this best practice is consonant with prior documented findings. Robust performance review processes have been linked to strategic competitiveness, including customer service excellence, in myriad studies (Beatty *et al.*, 2003; Becker and Gerhart, 1996; Rousseau and Wade-Benzoni, 1994). It is thus well-documented that institutionalized performance review practices contribute to enhanced customer service outcomes.
- *Strong IT systems support*: The institutionalized performance review process mentioned in Indiana above requires an effective information technology system that seamlessly connects all 130 branch offices with the headquarters in Indianapolis and permits real-time monitoring of operational performance indicators. Equally importantly, this homegrown IT system developed by BMV is also user-friendly enough that upwards of 50 per cent of customer transactions with regards to vehicle titling and registration are conducted online, thereby reducing overall operational costs. As a contrast, these percentages are usually in the low teens for DMV's in other states such as Missouri (less than 10 per cent) and North Carolina (13 per cent) and approximately 20 per cent for Ohio. We note that Kane and Foltz (2011) observed similar challenges in Idaho. Managers from Indiana's BMV believe this has been made possible because of substantial investments by the government in developing a strong in-house information technology system that is also maintained and updated continuously by dedicated in-house employees. Both BMV officials interviewed were unanimous in their belief that absent this substantial investment in IT, the service quality levels achieved would not have been possible. It should also be mentioned here that although not a part of our case study, DMV offices in Texas, ranked first in the prior DEA study for efficiency, and the winner of several AAMVA awards for service quality, has also benefited greatly from its technology investment, as evidenced by their most recent 2016 AAMVA Trailblazer Award mentioned before in this paper. That provides further evidence of how DMV offices may benefit from investments in strong IT systems.

The importance of strong IT systems in improving organizational performance that has been noted above is well-documented in the academic literature, including in the case of DMV (Karwan and Markland, 2006) or other government agencies (Muthaiyah and Kerschberg, 2008). Going further, Davenport and Short (1990) suggest that IT provides organizations with the opportunity to change their processes so as to achieve organizational goals, and Brynjolfsson and Hitt (2000) show that IT not only leads to the improvements in product and service features but also results in increases in intangible benefits such as timeliness, convenience, accessibility. The success demonstrated by

Indiana BMV in leveraging IT to reduce costs and improve customer service provide further evidence of the importance of strong IT systems.

- The findings also demonstrate the importance of information technology in facilitating processes within governmental institutions, The interaction of information technology and the standardization of processes have the potential to improve accessibility, efficiencies and enhance customer satisfaction at those institutions (Fan, 2013).

5. Conclusions and future research

This paper attempts to partially address the gap in the academic literature on service operations management in DMV offices across the USA. This survey, which, to the best of our knowledge, is the first nationwide academic study of DMV offices in the USA, was focused on identifying important organizational features of DMV offices in each state and eliciting operational and customer satisfaction measurement practices as related to vehicle titling and registration services. The salient findings of the paper are as follows:

- Significant differences exist among the states with regard to labor and capital productivity measures of their vehicle titling and registration operations and the efficiency with which they convert these two inputs into the standard output of annual number of vehicle titles and registrations.
- A DEA-based efficiency analysis showed that Texas and Minnesota are the most efficient in terms of using their labor and capital inputs to maximize the number of transactional services rendered. In particular, Texas stands out as a state whose DMV offices have also been nationally recognized for service quality in addition to being found efficient in our study.
- Operational performance of vehicle titling and registration is monitored by the vast majority (69 per cent) of the states with wait times and error rates being the two most commonly used indicators of operational performance. Our analysis affirms the Rhee and Rha (2009) framework of a service value chain, with emphasis on customer perceptions of quality during the process, as well as outcome quality. Moreover, with wait times and error rates the most commonly measured DMV quality metrics, the results upheld Chung's (2001) thesis that customers value both process and outcome quality in a public service context.
- Presently, the vast majority (over 80 per cent) of states lack an institutionalized system to measure or manage customer satisfaction.

The paper also contains short descriptive case studies based on interviews with senior management of DMV offices in Indiana and Ohio that identifies their best practices. It is also shown that the identified best practices are consonant with results from the published academic literature on organizational performance. Further, these findings also demonstrate the importance of information technology in facilitating processes within governmental institutions, the interaction of information technology and the standardization of processes have the potential to improve accessibility, efficiencies and enhance customer satisfaction at those institutions (Fan, 2013).

The findings presented in this study have implications for both practitioners and researchers in the USA and abroad. Practitioners and state officials in the USA can use the findings of this study to develop best practices for their operations and also determine the most appropriate ways to structure the provision of those services that result in enhanced efficiencies and customer satisfaction. However, while this paper identifies some best practices with regard to vehicle titling and registration services, others evident in the practitioner literature should also be investigated. For example, in Ghana, a developing country where such services have traditionally involved “middlemen” between the Driver Vehicle and Licensing Authority and end-customers, a recent program was rolled out in 2016 where the agency takes vehicle and licensing and registration renewal to the “doorstep of organizations and drivers” (Myjoyonline.com, 2016), eliminating the services of the “middlemen”. This redesigned process has enabled the agency to increase its revenues significantly while improving customer satisfaction. Thus, whereas our findings suggest that co-location represents a best practice in improving efficiency, convenience and quality, other designs should be investigated such as eliminating outsourcing of vehicle titling and registration services (practiced across several states in the USA) as done in Ghana or facilitating online registration and renewal as done by Indiana BMW.

For academics, future research on the subject could be along one of various different strands. Given the evidence provided here about the possible impact of varying levels of complexity of processes and procedures across the different states on their respective labor and capital productivities, further in-depth study is needed on comparing the vehicle titling and registration processes involved in the different states and deducing their differences. Another immediate extension is to study other important processes besides vehicle titling and registration at DMV offices that are also common across all states – perhaps issuance and maintenance of driver’s licenses and compare the empirical results with regard to productivity to the ones obtained in our study. Also relevant from an application standpoint would be a survey of senior staff across all DMV offices that is focused entirely on their customer service quality management plans, as that was identified as a shortcoming for most DMVs in the USA. Such a study ought to focus on operational practices that the staff believe are both feasible and necessary for improvement of service quality within their respective offices. A compilation of the results would serve not only as a contribution to the current literature on service quality management but also be a guide for other DMV offices across the USA.

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Appendix 1. Survey questionnaire

Survey of the US DMV Offices on Operational Practices and Transactional Data for Vehicle Registration and Titling Services:

1. In what US state do you work?
2. What is the highest-level organizational department in your state that oversees motor vehicle titling/registration services? Please check all that apply.
 - Department of Motor Vehicles.
 - Department of Transportation.
 - Department of Public Safety.
 - Department of Revenue.
 - Department of Secretary of State.
 - Other State Department (please specify).
 - Other County, City, or Local Government Agency(ies) (please specify).
 - Other Privately-owned Contracted Agency(ies) (please specify).
 - Other Type of Agency(ies) (please specify).
3. For the organization(s) you listed in Question 2, if possible please provide the following details specific to motor vehicle Titling/Registration services in your state:
 - Total Number of Employees engaged in providing Titling/Registration services.
 - Total Annual Revenues of the organization(s) related to Titling/Registration services.
 - Total Annual Expenditures of the organization(s) related to Titling/Registration services.

If your state uses a privately-owned Contracted Agency(ies) to provide motor vehicle Titling/Registration services, please provide as many of the following details as possible.
4. Total number of motor vehicle Titling/Registration contractors currently operating in your state?
5. Total number of motor vehicle Titling/Registration transactions processed annually by the contractor(s)?
6. How is the contractor compensated for completed transactions? Please choose all that apply.
 - Flat rate per transaction.

- Fixed fee plus escalating cost basis.
- Percentage of gross revenue.
- Other compensation method(s) (please specify).

7. Does your state measure the performance of its motor vehicle Titling/Registration contractor(s)?

If you answered YES to Question 7, please describe how your state measures:

- Service (transaction completion) times.
- Transaction error rates.
- Customer satisfaction.
- Other performance measures (please specify).

8. Please describe how Customer Complaints about your state's motor vehicle Titling/Registration contractor(s) are handled.

9. How many different types of contract agreements does your state use for motor vehicle Titling/Registration contractors? Please choose all that apply.

- Term-limited contract with automatic renewal.
- Term-limited contract without automatic renewal.
- Perpetually renewing annual contract.
- Other contract type(s) (please specify).

10. Please describe how a contract is awarded to a motor vehicle Titling/Registration contractor (e.g., competitive bid process, other process or criteria).

11. May we obtain a sample of your contract document(s) to review for our research project?

If you answered YES to Question 11, please provide contact information to request the sample contract document.

12. Does your state have a Standard Operating Procedure Manual for motor vehicle Titling/Registration contractors?

If you answered YES to Question 12, may we obtain a sample of your manual to review for our research project?

If YES, please provide contact information to request the sample manual.

If your state does not use a privately-owned Contracted Agency(ies) to provide motor vehicle Titling/Registration services, please provide the following details.

13. Total number of motor vehicle Titling/Registration transactions processed annually by your state?

14. Does your state measure the performance of its motor vehicle Titling/Registration services?

If you answered YES to Question 14, please describe how your state measures:

- Service (transaction completion) times.
- Transaction error rates.
- Customer satisfaction.
- Other performance measures (please specify).

15. Please describe how Customer Complaints about your state's motor vehicle Titling/Registration services are handled.

Appendix 2. Questions/discussion topics for DMV interviews

1. Process used by customers to do vehicle registration and titling. Where and how is technology used?

2. What is the extent to which external contractors are involved? If so, how are they compensated?
3. Quality assurance procedures used by your DMV office to ensure (a) error-free transactions (b) good customer service (wait times, transaction times etc.) to citizens.
4. Customer satisfaction – is it measured? If so, how? And how are results used?
5. Distinctive features of your vehicle registration and titling services that you would consider “best practice”.
6. Other comments and observations about your DMV operations, especially as it relates to vehicle titling and registration services and service quality management.