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Time Required by Veterinarian to Perform Veterinary Acts in Routine: A Regression Analysis

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Abstract: Increased size of veterinary practices and the arrival corporate practices modifies the veterinary landscape in many countries. This enables economies of scale for drugs or pet food purchases, overall improving the profitability. Working time per act is a key driver of profitability for firms with high human resources such as veterinary practices. The time spent by veterinarians to perform veterinary acts in routine is yet currently poorly described. Using regression analysis, we analyze the working time of different veterinary acts in veterinary practices. The time required for each veterinary act in mixed practices has been determined using multivariable regression model. A dataset of 714,413 observations from a 3 year-period (2015-2017) was extracted from the accounting software's of French veterinary mixed practices. The number of worked days per veterinarian and per month, and the number of acts per veterinarian and per month were analyzed for different acts in companion animal and farm producing animals. We found that the average time required for a farm producing animals' consultation, herd-monitoring, surgery and companion animal consultation was 46 (95%CI = 39-55), 177 (95%CI = 159-190), 97 (95%CI = 77-116) and 29 (95%CI = 19-36) minutes, respectively, based on an average 9h day working duration.

Key words: veterinary practices; profitability; regression; consultation; surgery; herd monitoring
JEL codes: M2, M54

1. Introduction

In western countries, veterinary healthcare consists of a growing economic sector, combining elements from human healthcare systems and from the agricultural sector. Indeed, veterinarians provide healthcare to farms and companion animals, but an important specificity lies in the fact that (i) health insurance is not well adopted, and therefore animal owners have to pay for veterinary services, and (ii) in the case of animal agriculture, healthcare supply can be considered as a necessary input to reach economic objectives (Lhermie et al., 2017). While business models in human healthcare are relatively well described, partly due to the involvement of public insurance, the

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economic model of veterinary practices remains poorly qualified. Scarcity of available data for firm managers is an obstacle to make rational decision. A prominent component of economic profitability of veterinary activity consists of the time required to perform routine acts. In France as in several countries worldwide, veterinarians perform a set of acts, such as consulting, radiology, surgery, which are relatively high time consuming-activities, and they also deliver drugs and pet food.

In a recent publication, we calculated the average profitability through the net margin rate (ratio of profit over revenue) by comparing inputs and outputs (Minviel et al., 2019). Optimal resource allocation should require short and long-term projection of the practice' business model, based on the marginal profitability of each activity given a context, and not the average one. The calculation of the marginal profitability is yet limited by time required for each activity, and there is a high inconsistency observed in the field or when asking field actors. Time required for each activity is recognized as a key factor limiting prediction in agriculture (Dorward A., 2013) and more broadly in biology (Belage et al., 2019). The situation is all the more complex that veterinarians performed a high range of activities in a high diversity of contexts. Factors influencing the time required for veterinary activities are the nature of the act, the species, the context (on farm/at home intervention) and the way it is invoiced (per act, all-inclusive…).

In human healthcare, the contribution margin (CM) has already been used to assess profitability of a given service or department (Macario et al., 2001). Because CM is not related to time required for a given procedure, it has been substituted by the contribution margin per hour (CMH) defined as the reimbursement for a procedure minus variable costs divided by the average calculated length of the surgical procedure (Macario A., 2006). The CMH is a tool that hospital administrators can use to cover fixed costs and still have sufficient funds remaining for society's common good (Dexter et al., 2002). The profitability of human healthcare has also been analyzed by applying comparative and descriptive statistics — evaluating the sales, variable costs of treatment and the fixed costs- (Dakin et al., 2015), as well as structure indicators — the financial values which have the greatest influence on the situation of the health care entity (Gabrusewicz, 2014). These indicators estimate the share of the selected costs within the total costs and identify the costs of crucial importance and their change with time. Other approaches are cost/volume analysis where the profitability of additional volume is equated with the marginal revenue minus the marginal cost associated with the volume change (Horngren. 1972). This brief overview of indicators used in human medicine for economic approach of cares and hospital management clearly highlight the needs for the veterinary sector and show how time required for interventions is a key information for business management.

In order to improve the profitability assessment of veterinary acts, the present study aims at estimating the working time required to perform veterinary acts and at identifying the origin of the variation.

2. Material and Method

2.1 Data Collection and Mining

The data were collected for the period 2015-2017 from veterinary management and accounting software. All the invoices emitted by the veterinary practice were compiled. Four veterinary general mixed practices (mainly companion animals (CA)) and food producing animals (FPA)) were enrolled in the study. The practices were composed of 5 to 12 associate veterinarians and employed veterinarians as well as nurses and assistants. The annual revenue was on average 1,197,056€ for acts and the average share for CA and FPA was 43% and 56%,

respectively.

The invoices recorded the different activities (medical acts, sales and delivery of drugs) and only medical acts are used here. Sales and drug delivery were not considered to take extra time for vets, or to be done by nurses or veterinary assistants. All the decisions for activities to be kept in the dataset and their potential merging were based on time required for them. For instance, travelling time to reach farms were gathered with the FPA consultation; veterinarians invoice rural visits, including travel expenses. Anesthesia were considered within the surgery act. To standardize the records of the invoices that content different labels across veterinary practices or even within practices, 22 sub-categories of acts (Table 1) has been created.

The original database was composed of 714,413 observations for the 3-year period. The sales of drugs and the administration of drugs in addition to medical acts were discarded (294,745 observations), leading to consider only medical acts. Three criteria of exclusion were applied. First, medical acts that could not be attached to any subcategory for lack of information on the sectors (CA or FPA) or on type of act were excluded (87,294 observations discarded). Second, sub-categories of acts for which fewer than 25 procedures have been identified over the 3-year period were excluded (154,112 observations). Third, the anesthetics performed in FPA medicine (16.3%) were excluded, and only those performed for companion animals (83.7%), were kept. Our final dataset included 215,398 observations and 22 sub-categories.

Sub-categories have been grouped into categories. First, similar sub-categories into FPA and equine activities have been grouped because the share for equine was low (8%) and the same act was expected to be equally time-consuming in these two sectors. All categories considered similarly time-consuming according to author's experience, were grouped as indicated in Table 1.

Finally, four categories were proposed. The group FPA consultation represents the farm producing animals' consultation category refers to individual medicine for a specific problem. The CA group consultation gather all individual medical care and diagnosis performed to companion animals, for a single animal. Surgery corresponds to surgical procedures requiring anesthesia. Herd monitoring corresponds to the general monitoring of the herd, including concomitant examination of several animals or diseases risk factor evaluation. The records of acts reported in the invoices contained different labels across veterinary practices or even within practices. we standardized into 22 sub-categories, the grouped into the 4 classes variable category.

Table 1 Grouping of the 22 Sub-categories Into 4 Categories

Category	FPA consultation	CA consultation	Herd monitoring	CA surgery
Sub-categories	Equine consultation Rural consultation Equine X-rays Rural displacement Small rural acts Small equine acts Rural prophylaxis[1] Rural vaccination Rural identification Rural on-call intervention Equine on-call intervention	Companion consultation Small companion acts Companion vaccination Companion identification Companion prophylaxis Companion X-rays Companion on-call intervention	Companion herd monitoring Rural herd monitoring Equine herd monitoring	Companion anesthesia and surgery

[1]: corresponds to the blood sampling of the animals for the control of the diseases, in this study only prophylaxis costing less than 100€ was included.

2.2 Calculation of Working Time From the Invoice Dates

The number of days worked during each of the 36 months by each veterinarian was calculated. For each practitioner, we considered that a day with an invoice made was a day worked. To validate this assumption, the monthly number of days worked, based on invoice editing (the veterinarian is working if an invoice is done) was compared for 3 veterinary practices with the yearly number of days worked, based on veterinarians' schedules (Table 2). Both calculation methods include on-call interventions.

The difference between the number of days worked per year calculated and declared by the veterinary practices was low and the method proposed to evaluate the working days of vets was therefore considered as correct. The monthly number of days worked was modified to exclude the on-call activities (Sundays and bank holidays), since they were expected to represent a high source of variability in the workload (43,568 observations discarded). The on call activities performed during the lunch break or week nights were kept in the dataset, since they are on average proportional to the daily workflow for each individual, and they might be some difference in the opening hours of the offices. As a result, the number of on-call days on weekends and bank holidays was removed from the number of days worked per year, the sub-categories (Rural/companion/equine) on-call intervention were removed too.

Table 2 Average Number of Days Declared and Calculated for Each Year of Three Veterinary Practices

	Year	Average declared working time (days/year)	Calculated average working time (days/year)
Veterinary Practice # 1	2015	213	188
	2016	186	182
	2017	216	175
Veterinary Practice # 2	2015	209	197
	2016	216	187
	2017	215	187
Veterinary Practice # 3	2015	200	142
	2016	197	140
	2017	239	195

The final dataset gathered the total number of days worked and the total number of activities carried out per category and subcategory, for each month and veterinarian. It contained 171,830 observations built on a structured query language (SQL).

2.3 Multivariable linear regression model

Data analysed with R software (R Core Team, 2019). A linear regression model was used to analyze the relationship between the dependent variable Y (the number of days worked per month) and several independent variables X (number of activities per month, for each activity or sub activity group):

$$Y= \beta 0 + \beta 1X1 + \beta 2X2+\ldots. + \beta nXn+ \varepsilon$$

This model allows to estimate the coefficients β, i.e., the time required to perform each activity for a veterinary practitioner and to determine the related 95% confidence intervals (CI). A stepwise descending regression was applied first and all interactions were tested for significant variables. Alternatively, all subcategories were considered instead of the 4 categories.

3. Results

3.1 Descriptive Statistics

The number of acts calculated per category is shown in Table 3. The summary statistics of the sample of veterinary practices over the three years (2015-2017) (Table 4) shows that, within 16 days worked in average per month, a veterinarian can perform 3 herd monitoring, 45 FPA consultations, 70 CA consultations and 15 CA surgeries. Results also shows the diversity of the activities between veterinarians (min and max values), and the average activities per month as indicated above does not represent real activities of veterinarians, since most of them do not have the same share of the activities.

Table 3 Number of Acts Performed in Each Veterinary Practice

	Veterinary practice	herd monitoring	FPA consultation	CA consultation	CA surgery	Total
3 year period	1	980	8,138	6,928	3,532	19,578
	2	1,584	14,029	30,537	8,334	54,484
	3	474	21,507	41,415	5,209	68,605
	4	1,140	14,433	11,240	2,349	29,163
	All	4,178	58,108	90,120	19,424	171,830
2015	1	243	1,819	1,976	1,256	5,294
	2	695	5,784	10,618	3,123	20,220
	3	196	8,348	12,033	1,387	21,964
	4	295	5,341	3,736	712	10,084
	All	1,429	21,292	28,363	6,478	57,562
2016	1	900	1,876	2,283	1,478	6,537
	2	714	4,529	9,929	2,826	17,998
	3	634	7,472	15,361	1,566	25,033
	4	891	4,622	3,848	833	10,194
	All	3,139	18,499	31,421	6,703	59,762
2017	1	476	4,443	2,169	790	7,878
	2	375	3,716	8,990	2,385	15,466
	3	141	5,645	13,846	2,245	21,877
	4	454	4,471	3,556	804	9,285
	All	1,446	18,275	28,561	6,224	54,506

Table 4 Summary Statistics on Veterinary Practice Acts for the Whole Period 2015-2017

	Mean	SD	Min.	Max.
Worked time (average number of days worked/month)	16.28	4.89	1	27
Herd monitoring (average number/month)	3.21	5.47	0	54
FPA consultations (average number/month)	44.91	42.36	0	488
CA consultations (average number/month)	69.49	64.16	0	369
CA surgeries (average number/month)	15.01	17.26	0	148

SD: standard deviation

3.2 Results of the fixed-effect linear regression model

The results of the final multivariate regression show that average cattle herd monitoring, FPA consultation, CA consultation and CA surgery take on average 0.328, 0.085, 0.054, 0.179 days worked per month, respectively

(Table 5). The model explains 69% of the total variability.

Table 5 Results of the Linear Model Without Random Effect

	Estimate	Std. Error	P-value
FPA consultation	0.0859	0.006	<2e-16 ***
CA consultation	0.0546	0.005	<2e-16 ***
CA surgery	0.1793	0.018	<2e-16 ***
Herd monitoring	0.3286	0.054	<2e-16 ***

Interactions between activities are significant and showed an estimate of -0.0025 for CA consultation * CA surgery, and -0.0043 for FPA consultation * herd monitoring without any change in the order of magnitude for the other coefficients.

Including the sub-categories instead of categories led to inconsistent results, with difficulties of estimation for some of the subcategories. The situation was linked to the high variation within the distribution of the subcategories for each veterinarian (Table 1), leading to consider categories only in the final regression.

4. Discussion

Assuming that veterinarians worked 9 hours per day in average, the results of the fixed-effect linear regression model (Table 5) show that FPA consultation, CA consultation, CA surgery, and cattle herd monitoring required on average 46 (95%CI = 39-55), 29 (95%CI = 19-36), 97 (95%CI = 77-116) and 177 (95%CI = 159-190) minutes, respectively. For 8 hours of work per day, they are 41 (95%CI = 34-50), 26 (95%CI = 21-32), 86 (95%CI = 68-100) and 157 (95%CI = 147-187) minutes, respectively. For 10 hours per day, they are 51 (95%CI = 43-60), 33 (95%CI = 26-40), 107 (95%CI = 85-129) and 197 (95%CI = 163-220) minutes respectively. The model with interactions CA consultation * CA surgery and FPA consultation * Herd monitoring shows that the coupling of two medical acts would take less time for the veterinarian than if they were carried out separately, but the effect size is so small that this has very low practical significance: based on a 9 hours of work per day, a vet performing a CA consultation and a CA surgery would save 1.35 minutes.

The difference in the FPA and CA consultation time is also in accordance with the nature of the activity. In our model, the time required for visiting the farm is included in the FPA consultation time, explaining a longer time compared to CA consultations performed at the veterinary practice. Importantly, the present results only refer to time required for activities and should not be directly interpreted as profitability indicators of activities, even by comparing to the price of the services, since the resources required for each activity is very different. They for instance include travel expenses, vehicles and depreciation of equipment for FPA consultations and herd monitoring and building cost and nurses or assistant salaries for CA consultations.

The methodology used here as well as our findings may help to improve the performances and the management of business models of veterinary practices. The duration of carrying out human medical acts has for instance been shown to be a key factor of the hospital financial equilibrium (Langenbrunner J. C. et al., 2009). The cost-effectiveness of an activity is mainly determined by an optimization of its fixed costs (Rosenstein, 1999; Macario A., 2006). Personnel costs represent the major contributor to fixed costs and go in parallel to the duration of the procedures. In the veterinary sector, human resource represents the first indirect expenses, and the procedure used for allocating their related costs could have a large impact on the profitability of the activities (Minviel et al., 2019). Veterinarians may maintain their level of profit by increasing the revenues of medical acts

and a rational optimization of time. Time required for activities is all the more important to evaluate the marginal profitability of each activity given a context that permit approach and tools for resource allocation and long or short term projection of firm trajectory. The results of the present study (i.e., parameters estimated of the duration of veterinary acts) can therefore be used to calibrate a mathematical programming model in order to link a time base to a sum of money in the form of added value.

In this study, we used regression modelling to identify relationships between time devoted to activities and the total monthly workload of veterinarians. The use of the billing information for this purpose is an original approach and valorization of existing data. Thanks to this approach, the present conclusion relies on a large exhaustive dataset of 4 vet offices, 108 veterinary months (3 years) and up to 25 detailed activities. The estimation of the working time was based on the assumption that working time of a practitioner is the time of presence within his/her practice, as given by the practice calendar. This assumption was validated in three practices. Because of the liberal characteristics of the work for main veterinarians, there might be slight difference within the practice calendar and the effective work load. A declarative method, i.e., using data directly provided by the veterinary practices from surveys may also be used alternatively. Another way to address the question of working time per activity would have been to perform surveys. There is yet no evidence that such an approach would have provided better precision of the information compared to the present method.

5. Conclusions

The results of the present work show that FPA consultation, CA consultation, CA surgery, and cattle herd monitoring required on average 46, 29, 97 and 177 minutes, respectively, assuming that veterinarians worked 9 hours per day in average. The present results may help decision making for the veterinary firm management, for instance to determine if it is profitable to hire more employees or to identify sources for improving profitability. The results of the present study (i.e., parameters estimated of the duration of veterinary acts) may be used for mathematical programming models.

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