Factors Influencing the lead time of chicken transportation

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Abstract. The paper's purpose is to analyze thirteen variables behind the inappropriate lead time of chicken transportation and determine the factors affecting this distribution. Data, using the snowball sampling method, included 264 questionnaires collected from chicken truck drivers. First, we use the principal component analysis (PCA) to identify the factors contributing to the longest delivery time. We find through PCA that all the variables analyzed take part significantly in the transport time. The most important factors were Connectivity, Resources, Verification & Frisking, Road, and Planning. Improving these factors will optimize the lead time of transport, consequently; improving profitability and animal welfare and quality. The findings are useful to production companies of any fresh products looking to improve their delivery time and increase more benefits.

1 Introduction

According to the Moroccan agricultural ministry, the poultry sector is one of the most dynamic activities in the country, with an average growth rate during the last four decades of around 7.7% of poultry production, and 3.5% of egg production. In 2019, the production of poultry meat was 625,000 tons, and 6.1 billion eggs for consumption, these products are consumed by the entire population.

Depending on the inter-professional federation of the poultry sector of Morocco (FISA), the marketing and transportation of chicken in Morocco have a lack of strict regulations that follow a primitive system. More than 85% of the chickens are sold alive by small retailers who buy either from the wholesale market or directly from farms depending on the region. The Moroccan consumer, therefore, prefers to buy the animal still alive and generally gives it to an adjacent slaughterhouse for the slaughtering service - plucking.

Meanwhile, the developed countries know a remarkable evolution in the last decades, in poultry transportation, such as the United States, Canada, and the European Union. Morocco still has various difficulties in this field. Indeed, the process of chicken transport from loading, transferring, to discharging to the final customer suffers from several constraints, e.g. inappropriate catching, over packaging, old truck, and poor transport conditions.

In fact, birds lived until their maturity in industrial or even traditional henhouses with invariable environmental conditions. Then they are suddenly exposed to different changes like being handled, caught, and withdrawal of food and water. They experience stimulators that may be new, such as motion with vibration, speed, noise as driving behavior, cancelling of

food and water, bad weather conditions, lack of hygiene in cages [1-3], overcrowding, temperature extremes [4], long distance and duration of delivery [5].

The consequences of these factors can vary between physical, psychological injuries, behavioural changes, and even broilers mortality [6-7]. On the other hand, they contribute to fewer incomes to the stakeholders.

Many papers are focused to study the effect of these factors mentioned before on the animal welfare, quality and mortality during transportation. However, few researchers are conducted in the field of transportation lead time factors.

The aim of the survey is to identify variables behind inappropriate transportation lead time of poultry products concerning chicken, and factors associated with this process of distribution from farms to the wholesale markets. Such knowledge may be helpful to indicate measures to be taken to reduce the transportation lead time in the food supply chain. Therefore, the quality, cost, and delivery time of the product could be satisfactory.

2 Data

The study was conducted in Rabat, which is a Moroccan city where chicken's production and consumption are significant compared to the country, especially in the summer season. Up to now, there is no such research work available on poultry transportation in Morocco. For collecting the data used in the analysis, a survey with appropriate questions was essential.

According to the consultation with poultry experts, a questionnaire was drawn up using closed questions to obtain the desired quantifiable data. Participants should choose only one of the answers given on a 5-point Likert

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scale ranging from 1 (not significant) to 5 (very significant).

Then, the sample of interviewees was defined directly in the field. It was offered to people who are mainly related to chicken transport. They are responsible for the delivery of these perishable products to markets. As there is no list of transporters, the snowball sampling method was used to identify the respondents. This method usually starts with a few people who have the desired characteristics and use those people to identify others with the same ones [8].

The distributed questionnaire includes socio-demographic data such as age, educational level, experience in transportation, and the type of job held by the interviewer. From the selected state, Table 1 presents these characteristics expressed by percentage. It shows that the major age category of chicken transporters was between 35-49 years, with a percentage of 56%; 58% of the interviewers went to primary school, and only 22% of them were at secondary school. In terms of experience in transportation, only 4% of chicken transporters have more than 20 years of experience, 26% with experience between 15-20 years, 42% for the 10-15 years' category, and 8% less than 5 years of experience. Regarding the nature of employment, 68% of the interviewers are individual external truck drivers, 26% are farm drivers, and only 6% are managers on registered farms or individual owners of their small farms. This is satisfied: truck drivers are the most concerned by this study since they are the most experienced in the field, and know the operational problems that transportation encounters.

The study focuses on a total of thirteen variables. They were the fruit of the investigation carried out.

Three hundred questionnaires were distributed, but only 264 participants completed all the questionnaire responses, with a response rate of 88%. Therefore, the number is sufficient for factor analysis: a recommended sample size to variables ratio would be 20:1, which means 20 cases per variable [9]. The list of variables of chicken's transport that is covered in this paper is presented in Appendix A.

3 Research methods

3.1 Principal Component Analysis

To extract the reasons behind the inappropriate transportation time in the poultry supply chain regarding chicken; data analysis was performed using the principal component analysis method (PCA). It is used when the analysis is based on a large number of observed variables such as that of this study, and wish to reduce this number to a smaller one of variables, called "principal components" that will account for most of the variance of the variables without losing the information contained [10].

The objective of PCA is to reduce the information into a smaller set of components by examining the matrix of item correlations. When the intercorrelation is high, items are assumed to be measuring the same latent component [11].

In other words, this technique produces orthonormal eigenvectors and eigenvectors as well as a non-negative square root of eigenvalues called singular values. The diagonal singular values are ordered in descending order. The largest eigenvalue corresponding to the largest eigenvector is the first principal component. The first principal component explains most of the variance

Table 1. Socio-demographic data's characteristics of respondents.

	Categories		Percentage	Total number
Interviewers	Age	20-34	30%	79
		35-49	56%	148
		50 and more	14%	37
		Total	100%	264
	Education	No education	15%	40
		Primary school	58%	153
		Secondary school	22%	58
		University studies	5%	13
		Total	100%	264
	Experience	0-5 years	8%	21
		5-10 years	20%	53
		10-15 years	42%	111
		15-20 years	26%	69
		More than 20 years	4%	10
		Total	100%	264
	Type of job	Farm drivers	26%	68
		Manager/ Owner	6%	16
		Individual truck drivers	68%	180
		Total	100%	264

in the dataset. The second principal component and subsequent principal components follow the same order [12].

Let A be a real $m \times n$ matrix where $m \geq n$:

$$A = U \Sigma V^T \quad (1)$$

The matrix U consists of orthonormal eigenvectors associated with the largest eigenvalue of AA^T , and the matrix V consists of the orthonormal eigenvectors of $A^T A$. The diagonal elements of Σ are the non-negative square roots of the eigenvalues of $A^T A$, and they are called singular values. Where:

$$\Sigma = \text{diag}(\sigma_1, \dots, \sigma_n) \text{ and } \sigma_1 \geq \sigma_2 \geq \dots \geq \sigma_n > 0$$

For more details, [12].

In this paper, we use IBM SPSS: Statistical Package for the Social Sciences - Version 26, and the statistical processing was performed using the varimax method. However, before initiating the principal component analysis, it is necessary to measure the reliability of the variables using the Pearson correlation to test whether the dataset has the appropriate correlations to contribute to the extraction of the factors [13].

For this test, we use Coefficient α that is a measure index of the internal consistency between the variables. It varies between 0 and 1 and is considered "acceptable" from 0.7. The closer the alpha value is to 1, the more homogeneous the set of elements [14]. The result is presented in Table 2. Next, we conduct the Kaiser-Meyer-Olkin criterion, which is a processor that determines the appropriate number of principal components to represent the variance and the correlation between the variables. The KMO index varies between 0 and 1 and is considered "acceptable" from 0.6 [15]. The result is presented in Table 3. For the last test, a Bartlett's test of Sphericity is performed to examine the correlation between the variables. If the correlation matrix "Eq. (2)" is not identical to the identity matrix, the factor analysis is appropriate to the dataset [13]. The result is also presented in Table 3.

Let a dataset that has n observations and, for each observation i ($i = 1, \dots, n$) values corresponding to each one of the k metric variables X . The correlation matrix ρ is defined as follows.

$$\rho = \begin{pmatrix} 1 & \rho_{12} & \dots & \rho_{1k} \\ \rho_{21} & 1 & \dots & \rho_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{k1} & \rho_{k2} & \dots & 1 \end{pmatrix} \quad (2)$$

$$\rho_{jj'} = \frac{\sum_{i=1}^n (x_{ji} - \bar{x}_j) \times (x_{j'i} - \bar{x}_{j'})}{\sqrt{\sum_{i=1}^n (x_{ji} - \bar{x}_j)^2} \times \sqrt{\sum_{i=1}^n (x_{j'i} - \bar{x}_{j'})^2}} \quad (3)$$

Where $\bar{x}_j$ and $\bar{x}_{j'}$ represent the means of variables X_j and $X_{j'}$, respectively. For more, see [13].

3.2 Determination of Principal Components

There are too many procedures to determine the exact number of principal components representing the factors

related to the chicken delivery time; the most commonly used is the eigenvalue-one criterion, also known as the Kaiser criterion. It is based on the selection of components with eigenvalues equal to or greater than one [15]. Components with eigenvalues less than one are considered insignificant and are not retained [10]. The result is presented in Table 4. For further analysis, a second test is used to confirm the results of the first criterion. It's the Scree test, which is a decreasing curve determining the significant factors through the identification of the breakpoint at which the scree begins, and retained only the components appearing before the break [16], (Figure 1).

3.3 Varimax rotation method

After extracting the principal components, the most popular rotation method, which is known as Varimax, was used. It is an orthogonal rotation; whose aim is to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix. The result of the method allows identifying each variable with a single factor (principal component) [17], (Table 5).

4 Research results

4.1 Reliability analysis

The principal component analysis assumes the set of variables to be homogeneous. We use Cronbach's Alpha (Coefficient α) to examine the correlation of the data. According to the SPSS results (Table 2), the Cronbach alpha is 0.865 greater than 0.7, so that the data set meets the homogeneity of these elements. Next, we find the KMO measure of the sampling adequacy value to be 0.76. Since the value obtained is superior to 0.6, The KMO test indicates the adequacy of the factor (Table 3). The Bartlett's test of Sphericity indicates that the correlation matrix is different from the identity one: the approximate Chi-Square value of 2801,26 and a p-value of 0. This result confirms that the correlation between the variables is significantly different from an identity matrix (Table 3).

Table 2. Cronbach's Test.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Variables
0,865	0,872	13

Table 3. KMO and Bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,769
Bartlett's Test of Sphericity	Approx. Chi-Square	2801,26
	Df.	78
	Sig.	0,000

The three indices are judged acceptable and indicate that the factor analysis is appropriate in this case, and support the relevance of the principal component analysis used in this study.

4.2 Principal Component Analysis

Depending on the result of the Kaiser criterion presented below (Table 4), the first five principal components have initial eigenvalues superior to one; meanwhile, the remaining components have eigenvalues less than one and considered insignificant. Therefore, there are five factors (principal components) affecting lead time in chicken transportation.

The scree plot shows several breaks from component 1 to 5, then the large breakpoint appears after the fifth component, allowing the line to start flattening. The components which follow this breakpoint and which constitute a semi-straight line are assumed to be trivial and not significant, as shown in Figure 1.

Fig. 1. Scree Plot.

The Kaiser criterion and the scree test are in agreement; there are five principal components (Factors) affecting transportation lead time in the chicken supply chain: they account for 85,3% of the variation across the sample. The PC1 to PC5 can be used to represent the 13 variables without losing the information contained.

After determining the exact number of principal components, the varimax method is used to link each variable with its factor and interpret the result of the study. The rotated matrix is presented in Table 5.

Table 5. Varimax Rotation Method.

Variables	Component				
	1	2	3	4	5
X ₁	0,945	-	-	-	-
X ₂	0,836	-	-	-	-
X ₃	0,795	-	-	-	-
X ₄	0,695	-	-	-	-
X ₅	0,684	-	-	-	-
X ₆	-	0,761	-	-	-
X ₇	-	0,679	-	-	-
X ₈	-	0,676	-	-	-
X ₉	-	-	0,927	-	-
X ₁₀	-	-	0,778	-	-
X ₁₁	-	-	-	0,929	-
X ₁₂	-	-	-	0,807	-
X ₁₃	-	-	-	-	0,978

By analysing the varimax-rotated component matrix of the PCA (Table 5), the loading plot of each variable allows us to clear up the correlations between the principal components and variables. First, we find that X₁ (0.945), X₂ (0.836), X₃ (0.795), X₄ (0.695) and X₅ (0.684) show high correlation with the first factor (PC1, with 31.056 % of Variance); the variables X₆ (0.761), X₇ (0.679) and X₈ (0.676) load to PC2 (17.475% of Variance); X₉ (0.927) and X₁₀ (0.778) are related to PC3 (14.614% of Variance); X₁₁ (0.929) and X₁₂ (0.807) are correlated to PC4 (13.529% of Variance); and finally,

Table 4. Kaiser Criterion.

Component	Initial Eigen values			Rotation Sums of Squared Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative%
1	5,740	44,156	44,156	4,037	31,056	31,056
2	1,759	13,532	57,688	2,272	17,475	48,531
3	1,565	12,040	69,728	1,900	14,614	63,145
4	1,021	7,858	77,586	1,759	13,529	76,674
5	1,004	7,725	85,311	1,123	8,637	85,311
6	0,652	5,017	90,328			
7	0,308	2,373	92,701			
8	0,280	2,157	94,858			
9	0,238	1,827	96,685			
10	0,175	1,344	98,030			
11	0,116	0,889	98,919			
12	0,094	0,726	99,645			
13	0,046	0,355	100,000			

PC5 (8.637% of Variance) has the last variable X_{13} (0.978). This is as shown in Table 6.

Table 6. Grouping factors with its corresponding variables.

Principal Component	Factor Name	Weight	Corresponding Variables
1	Connectivity	31,056 %	X_1, X_2, X_3, X_4, X_5
2	Resources	17,475 %	X_6, X_7, X_8
3	Verification & Frisking	14,614 %	X_9, X_{10}
4	Roads	13,529 %	X_{11}, X_{12}
5	Planning	8,637 %	X_{13}

The result can be interpreted that the lead time of chicken transportation may be affected by several factors. They are characterized by different rankings depending on the variance of each one.

5 Discussion of the results

The findings from this study show that several factors are affecting the delivery time of chicken transportation. The results imply that Morocco needs to handle these elements in orderly. According to the study, the first principal component, which loads bad road connectivity, bad driving condition, lack of communication between drivers, lack of organization structuring the field of chicken drivers, and long-distance between farm and wholesale, is the leading factor that can be called “Connectivity”. It may be due to the unavailability of information. Indeed, the drivers are independents and have no structure framing them with no source of information that can allow them to plan the best route, best start, and even avoid poor road conditions (e.g. rain, accidents, traffic jams, dust storms...), despite the richness of the area and the proximity of the farms.

On the one hand, the various vehicles used by the drivers are generally old with a lifespan between 8 and 15 years, which increases the percentage of dysfunction, and breakdowns of these resources, therefore truck stops. On the other hand, the ignorance of the drivers about the fragility/time/quality of the product, and careless driving (speed, non-compliance with the road code, lack of sleep, fatigue...), are a significant reason reacting to the lead time. They constitute the second principal component that we named “Resources”.

For the third factor, termed “Verification & Frisking”, the study shows that the truck drivers interviewed confirmed the continuous stops of their vehicles during the chicken delivery journey by the Moroccan police authorities. The police often order the stopping of these trucks to check the weight, the type of goods, the papers, the speed, and other criteria, which is why the lead time becomes very high compared to the distance travelled. The passage of the toll stations, which can encourage the delay, is little frequented.

The findings confirm that PC4 called “Roads” has less influence on lead time. In fact, the transport sector in Morocco has evolved a lot in recent years. According to the respondents of the questionnaire, the roads have become more and more suitable. Traffic jams are an important criterion. However, chicken truck drivers generally deliver overnight (between midnight and 4 a.m.), which avoid rush hours and allows a short delivery time.

In the end, the more well-planned and respected the departure time and duration, the more likely it is to have the availability of transport vehicles, better lead time, and better product quality when the destination arrives. These elements establish the last factor (PC5) named “Planning”.

6 Conclusion

In conclusion, the road transport of chicken used in Morocco has evolved a lot in recent years. However, this model still has problems affecting the lead time during the delivery of these goods.

The principal component analysis was used to analyze the primary data collected from the drivers directly involved in the transportation of chickens and extract the principal components affecting the lead time. The PCA method yielded five principal components, with 85,311% of the total variance in the thirteen variables analyzed. The results show that all these variables contribute significantly to the delivery time of chicken transport.

By using the varimax method, the study defined five important factors behind inappropriate transportation lead time in the chicken supply chain: Connectivity, Resources, Verification & Frisking, Roads, and Planning. Indeed, to improve lead time, it is necessary to act mainly on the first factors having the most significant impact on delivery. Hence the interest of future research.

This study is carried out in the Moroccan capital region. It can be performed in another area, on other food products, and confirm other factors using different methodologies.

Appendix A

X_1	Bad road connectivity
X_2	Poor driving conditions
X_3	Lack of communication between drivers
X_4	lack of organization structuring the field of chicken drivers
X_5	Long distance between farm and wholesale market
X_6	Unsuitable vehicles
X_7	Inappropriate driving behavior
X_8	Not Awareness of the importance of time and quality of transportation
X_9	Police verification and frisking
X_{10}	Frequent toll booths
X_{11}	Traffic James
X_{12}	Inappropriate route

X ₁₃	Poor departure planning and Non-punctual availability of transport vehicles
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