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Investigation of Effect of Labour and Road Infrastructure on Fermented Dairy Production Capacity in Upstream Fermented Dairy Supply Chain

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ABSTRACT

Scope of the study focuses on fermented dairy products because, they constitute very large and important part of human diet. These products are very healthy because, they have some health benefits. 2731 fermented dairy processors in 227 sub-sectors in 48 cities have been investigated to determine the effect of the length of roads, the number of white-collar and blue-collar employees on fermented dairy production capacity. To do that, Generalized Linear Model has been utilized. Consequently, results state that the number of blue-collar employees has a positive effect on fermented dairy production capacity at 0.001 significance while the number of white-collar employees does not have a significant effect on the fermented dairy production capacity. On the other hand length of road has a positive effect on the fermented dairy production capacity at 0.10 significance level.

Keywords: Fermented dairy products supply chain, Labour, Road infrastructure, Fermented dairy production capacity

1. Introduction

Fermented dairy products are focused on in the study because of their crucial effects for human health. The most common produced fermented dairy products in Turkey are cheese, Kashar cheese, yogurt, kumis kefir and butter milk (Akın & Cevger 2019). However dairy processors which produce 13 different fermented products are included in the study. Cultured dairy products are a fruit of a promising technology. Most companies produce dairy proteins such as casein and whey by fermentation of certain microorganisms or the use of bioreactors (Krampe & Fridman 2022). Fermented dairy products are derived from fermentation process of milk. Fermentation is a cheap, common process in food- beverage sectors (Dos Reis et al. 2017). The fermentation process is done by utilizing suitable as well as harmless microorganisms.

Main types of fermented dairy products are cheese, yogurt, fermented milk, butter milk, kumis, kefir (García et al.2020). Fermented dairy products constitute very large and important part of human diet. These products are very healthy because they have some health benefits for human body.

Fermented dairy products have immunological, anti-carcinogenic, immunomodulatory, anti-allergens, antioxidant, hypocholesterolemic, bone and hypotensive effects on human body (Shafiee & Sharifi 2017). These effects are very crucial for humans to stay healthy. Because of these health benefits for human body scope of the study focuses only on fermented dairy products.

There are 81 cities in Turkey however, 48 cities constitute the scope of the study because of database in Turkey lacks proper data in fermented dairy products. Actors of the whole fermented dairy supply chain are given in Figure 1. Consequently, all actors of fermented dairy supply chain deserve attention in the related dairy supply chain studies. But due to time as well as monetary constraint. Because, empirical findings show processors of dairy food products add the highest value compared to all the other members operating in the milk processing supply chain (Nahar et al. 2022) the study only focuses on milk processors operating in Turkey.

The important issue in dairy supply chain is transport infrastructure and condition of roads. Babu et al. (2015) conducted a study in India. The authors conducted swot analysis in Indian dairy supply chain. According to the study, poor transport infrastructure in dairy supply chain was found to be one of the greatest challenges in dairy business. Consequently, in this study impact of main roads on fermented dairy production capacity is investigated.

Leonardo et al. (2015) emphasizes that the most important reason of inefficiency in farm production is quality of labour. According to Janssen (2013), the source of inefficiency in food production is lack of reliable workforce. Additionally, Fassio et al. (2006) states that dairy production should be organized in a more rationalized manner, the production activity will need more professional workforce.

In any case, labour productivity is one the of most important components in global dairy production (Střeleček et al. 2007).

Consequently, the purpose of the study is to investigate the impact of labour and road infrastructure on production capacity in upstream fermented dairy supply chain. In this context, variables related to labour and road infrastructure are independent variables while production capacity is considered as a dependent variable in the model in which GLM has been deployed to investigate the effect of labour and road infrastructure on production capacity.

This study has some uniqueness in the literature, to the best of our knowledge, the study is the first ever study investigating effect of labour and road infrastructure on the production capacity in fermented dairy products also it is the first ever study in related literature that has the purpose of investigating the effect of different workforce categories (skilled, unskilled workforce) on production of fermented dairy products.

The other uniqueness of this study is to take human resource (white-collar, blue-collar employees) and logistics (length of road) into consideration as variables in the study.

The study starts with explaining the importance of workforce in food especially in dairy production. After that, snapshot of milk supply chain is provided, health benefits of fermented dairy products are mentioned, importance of logistics infrastructure for fermented dairy products is explained, related literature review is given, model of the of the study is outlined finally, the study is concluded with conclusion remarks also caveats in the study.

2. Importance of Workforce in Food and Dairy Production

Food sector is regarded as a low-tech sector just as other traditional sectors. Production of dairy products in food sector employs higher percentage of labour like other low-tech manufacturing sector as opposed to high-tech or middle-tech manufacturing sectors (Sargent & Matthews 2008) that is why, both blue-collar and white-collar employees working in fermented dairy processors are addressed in the study.

Eurostat (2017) categorizes subsectors of manufacturing sector into high-tech, high-middle-high tech, middle-low tech and low- tech sector based on their technological intensity. Low technologically intensive sectors are regarded as labour intensive sectors in which labour is used predominately in manufacturing processes (Liu et al. 2014). Food sector is also regarded as a low-tech sector just as other traditional sectors. Production of dairy products in food sector employs higher percentage of labour like other low-tech manufacturing sector as opposed to high-tech or middle-tech manufacturing sector (Sargent & Matthews 2008). Most part of labour requirement in food and dairy production is met by family members (Ojo 2004; Nmadu et al. 2015; Kumari et al. 2020) despite this, cost of labour is about 35% of all other associated costs in food and dairy production (Albarrân-Portillo et al. 2015) especially, in some specialty food production areas for example in vine production in U.S. Labour cost makes up 60% of total costs. Labour shortage is the greatest impediment in production (Rutledge & Mêrel 2022).

Although, fermented dairy products which constitute the focus of the study are categorized in low-tech production sector these products require some specialized processes to prepare or produce. This means that fermented dairy products sector requires more professional namely skilled workforce compared to other traditional food production sectors.

3. Importance of Logistics Infrastructure for Fermented Dairy Products in Turkey

Figure 1 elucidates the milk processing supply chain. The milk processing supply chain consists of all the relevant members beginning from the input supplier to final customers (Dani 2015).

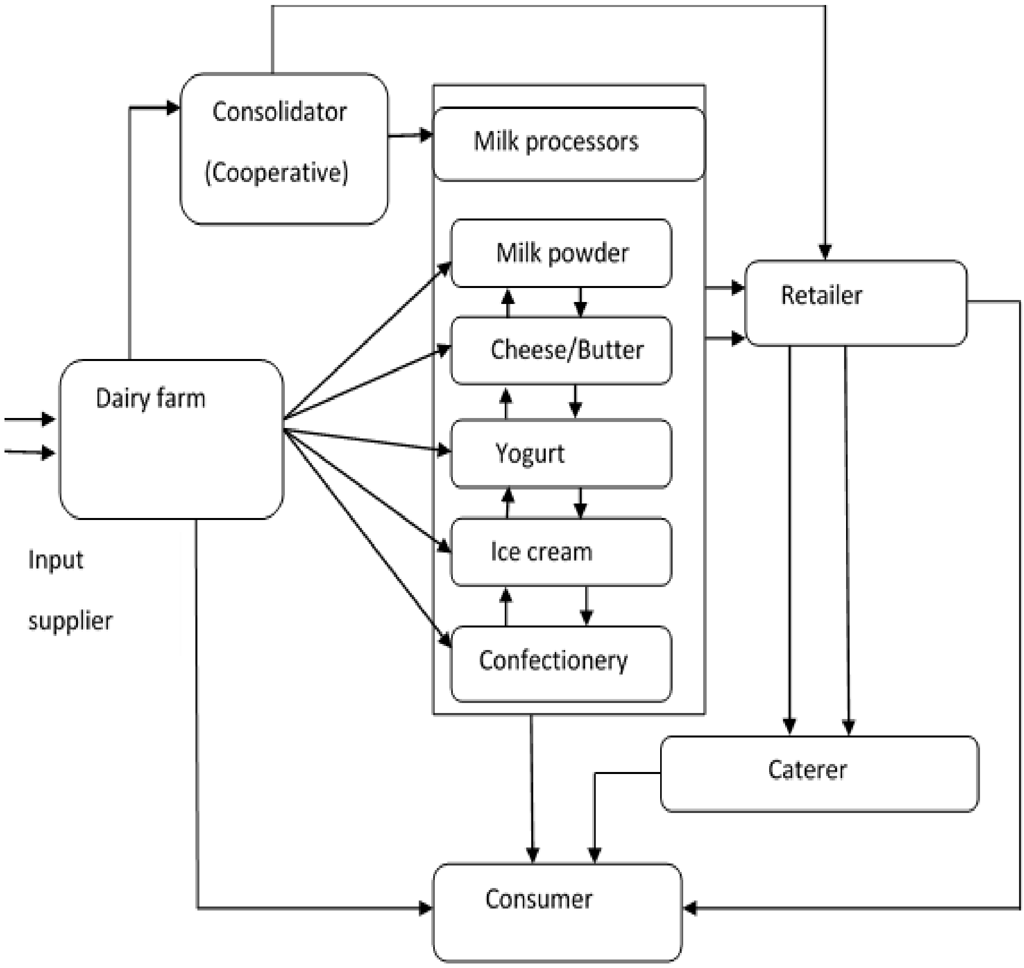

Figure 1- Anatomy of a Milk Processing Supply Chain. Source: Dani, S. (2015). Food supply chain management and logistics: From farm to fork. London: Kogan Page Publishers, p. 13.

All the members of the milk processing supply chain add value to the milk on its journey of becoming a final product throughout the whole supply chain. However, empirical findings show that processors of dairy food products add the highest value compared to all the other members operating in the milk processing supply chain (Nahar et al. 2022). That is why, the study only focuses on milk processors operating in Turkey.

The most common produced fermented dairy products in Turkey are cheese, Kashar cheese, yogurt, kumis kefir and butter milk (Akın & Cevger 2019).

Daily milk requirement is determined by planned production quantity in Turkey. Raw milk should be used within 48 hours. That is why, raw milk is transported to milk factory for the next day production. Raw milk should be stored in a cool condition both in the phases of milk collecting and dairy production. Cold chain in logistics activities of dairy product is very vital. The other process is in dairy production is heating raw milk for a sterilization process (Malliaroudaki et al. 2022). After this procedure dairy products are not yet ready for distribution after production because, all products are kept in quarantine for a while. If they are fit to meet standards in terms of hygiene, taste, texture and packaging etc. they are prepared for distribution otherwise, they are discarded (Smit 2003). Dairy products are transferred to distribution centres after going through the quarantine process.

Transport costs of dairy products are high because, they are carried by reefer trucks or vehicles which have cooling systems. Consequently, it is crucial to utilize full capacity of these vehicles. Retailers have a higher level of stocks in many other sectors. However, retailers in dairy products supply chain have relatively lower level of stocks. Because they buy frequently but smaller quantity of dairy products to provide fresh dairy products (Kiambi et al. 2020).

The whole supply chain activities of fermented dairy products explained above can also be summarized in Figure 2 (Malliaroudaki et al. 2022). As seen in Figure 2, milk is transferred to the dairy plant after initial production of raw milk on the farm. In dairy plant milk will be under certain processes to produce end- products.

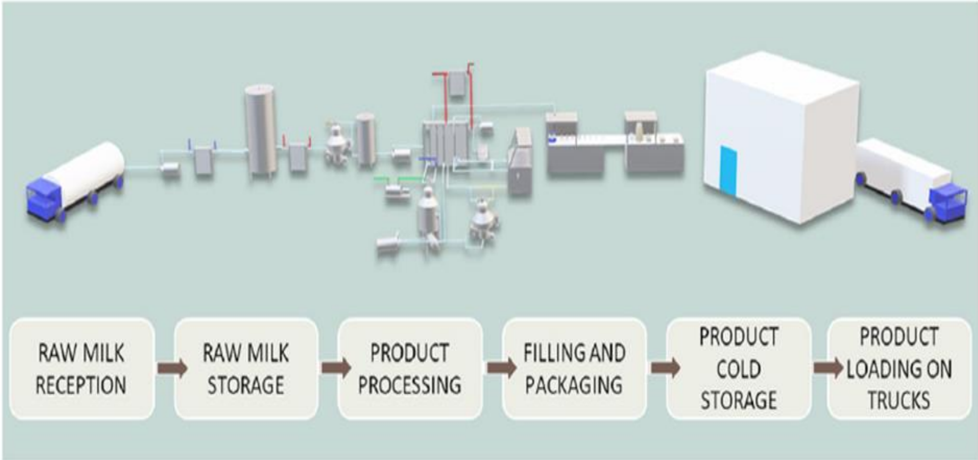

Figure 2- Dairy Production activities taking place in a dairy supply chain for producing fresh dairy products and fermented dairy products including milk, cream, butter, cheese and powdered products. Source: Malliaroudaki et al. (2022) Energy management for a net zero dairy supply chain under climate change. Trends in Food Science & Technology

4. Literature Review

Transport infrastructure is important issue in dairy supply chain because, quality of milk transportation plays an important role (Martinelli et al. 2022). According to the study done by Martinellli et al. (2022) in Brazil by collecting data from 347 dairy farmers, quality of milk transport is one of competitive indicators that effects farmers' competitiveness in the dairy supply chain. In the study condition of main roads as well as secondary roads were chosen as sub-indicators in quality of milk transport in the study.

There are some studies investigating effect of labour on agri-food value chain sustainability, one of them was done by Malanski et al. (2022) which suggests that improving employment as well as working conditions may promote agri-food value chain sustainability. There are also some studies investigating labour productivity in agriculture. For example, according to the result of the study done by Cortignani et al. (2020) suggests that use of temporary labour leads to instability because workers in farmlands are employed only in some, generally short, period of the production cycle. Some studies investigate labour productivity in dairy production. According to one of them done by Sarvana & Padrian (2013) it was concluded that additional workforce decreased labour productivity. However, Hussain et al. (2010) determined that a 1% increase in labour hours increased milk production by 2,15%. Consequently, according to this study, number of blue-collar employees has a positive effect on fermented dairy production capacity at 0.001 significance while the number of white-collar employees does not have a significant effect on the fermented dairy production capacity. In a recent study, Garcia-Covarrubias et al. (2024) have found that additional labour in Ireland has a positive impact on dairy production on farms, particularly amplifying these effects on small and medium-sized farms.

According to some studies done by Tse et al. (2018); Silvi et al. (2021) although food and dairy production are deemed to be low-tech, changing as well as improving new technologies have greater impact on food and dairy production. This will lead to a decrease in labour requirement however increase efficiency. However, Du et al. (2022) reached a conclusion that only a small fraction of farms utilizing milking machineries or robots in milk production process employed less workers after robotic technology. On the other hand, Bewley et al. (2001) reached a conclusion that integration of technology into dairy production increased labour productivity. Frick et al. (2019) determined that innovation activities in food production increased labour production more than in high-tech sectors. Moreover, an increase in population as a result, an increase in demand lead to more increase in employment and production in food production sector compared to other sectors (Tereszczuk & Marczak 2018; Grodach & Martin 2020).

5. Dataset and Model

Dataset related to labour employed in dairy processors and fermented dairy production capacity was obtained from the Union of Chambers and Commodity Exchanges of Turkey (TOBB) where there was a data with regard to production of 13 different fermented dairy products. Additionally, the data related to length of roads (in Km) in 48 cities were obtained from General Directorate for Highways. In this context, information on the production capacity of 2731 dairy processors doing business in 48 cities in Turkey and providing a capacity report was utilized. Because data used in the study consisted of total dairy production capacity as well as qualified and unqualified labour per city, dataset was formed including 227 sub-sectors in 48 cities. Consequently, the dataset used in the study includes the information of total fermented dairy production capacity, the number of employees including engineers, managerial personnel, foremen, technicians, workers working in the fermented dairy production process as well as total length of roads in 48 cities. 5 different labour groups i.e., engineers, managerial personnel, foremen, technicians as well as workers are broken into two different groups i.e., skilled-educated labour as well as unskilled-uneducated labour as suggested by Acemoğlu (1998); Goldin & Katz (1998) based on "skill biased technical change". This approach suggests that technological change increases efficiency of skilled labour and demand in skill labour however it has an opposite effect for unskilled labour. As mentioned before, production of fermented dairy products that is considered in food sector is in low-tech production process as well as it is labour intensive. However, a need for some specific knowledge in fermenting process lately, increase in technology in food production render skilled labour as important as ever before. White-collar signifies engineers as well as managerial personnel while blue-collar signifies technicians, foremen as well as workers in the study. Here, white-collar symbolizes well-educated employees blue-collar symbolizes uneducated workers as well as foremen, technicians who need some special education and knowledge. Based on the scope of the study explained above roadmap of the study can be formed as in Figure 3.

GLM has been utilized to find out the effect of the length of roads, the number of white-collar as well as blue-collar employees on fermented dairy production capacity. Table 1 provides the necessary information on dependent and independent variables.

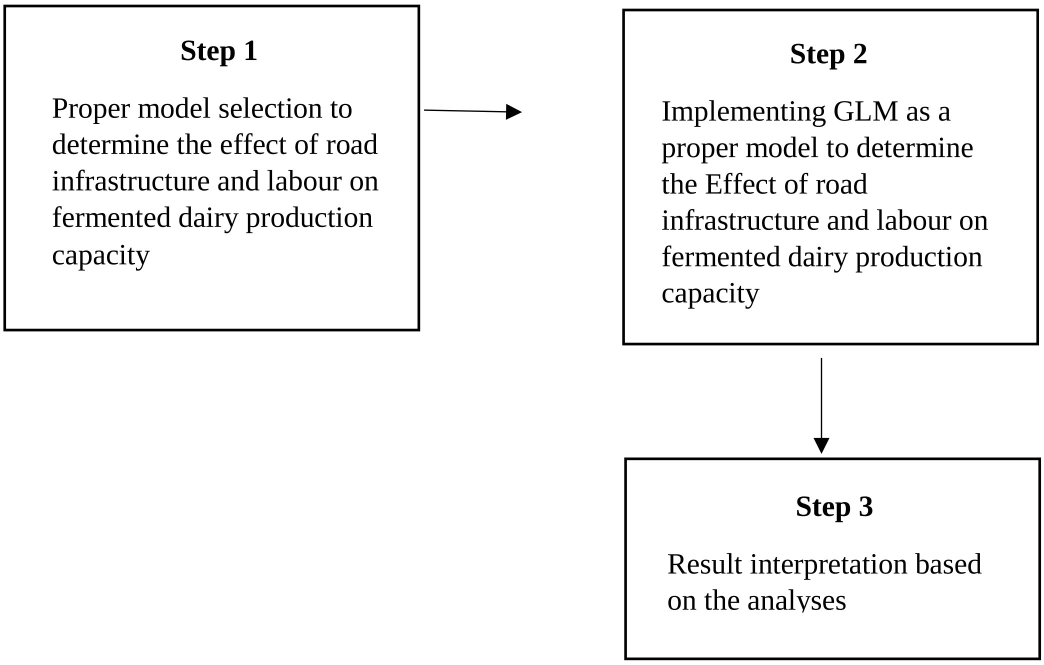

Figure 3- Roadmap of the Study

Table 1- Descriptive Statistics related to Dependent and Independent Variables. Source: Own calculations based on Turkish Union of Chambers and Exchange Commodities and General Directorate of Highways (2022)

Variable	*N*	*Mean*	*Standard Deviation*	*Median*	*Skewness*	*Kurtosis*
Production Capacity (dependent variable)	227	1.16+07	2.66+07	3735520	6.467988	59.17881
White-collar Labor	227	91.22907	155.1436	38	5.617148	51.20763
Blue-collar Labor	227	534.2775	751.7396	260	4.08083	30.66947
Total Road	227	445.2731	330.3021	353	2.222786	8.642645

Values of skewness, kurtosis of production capacity, positive difference between its median and mean state that distribution is not a normal distribution. Dependent variable i.e., production capacity as well as figure of distribution of residuals based on conventional linear regression model is obtained through histogram which are shown in Figure 4.

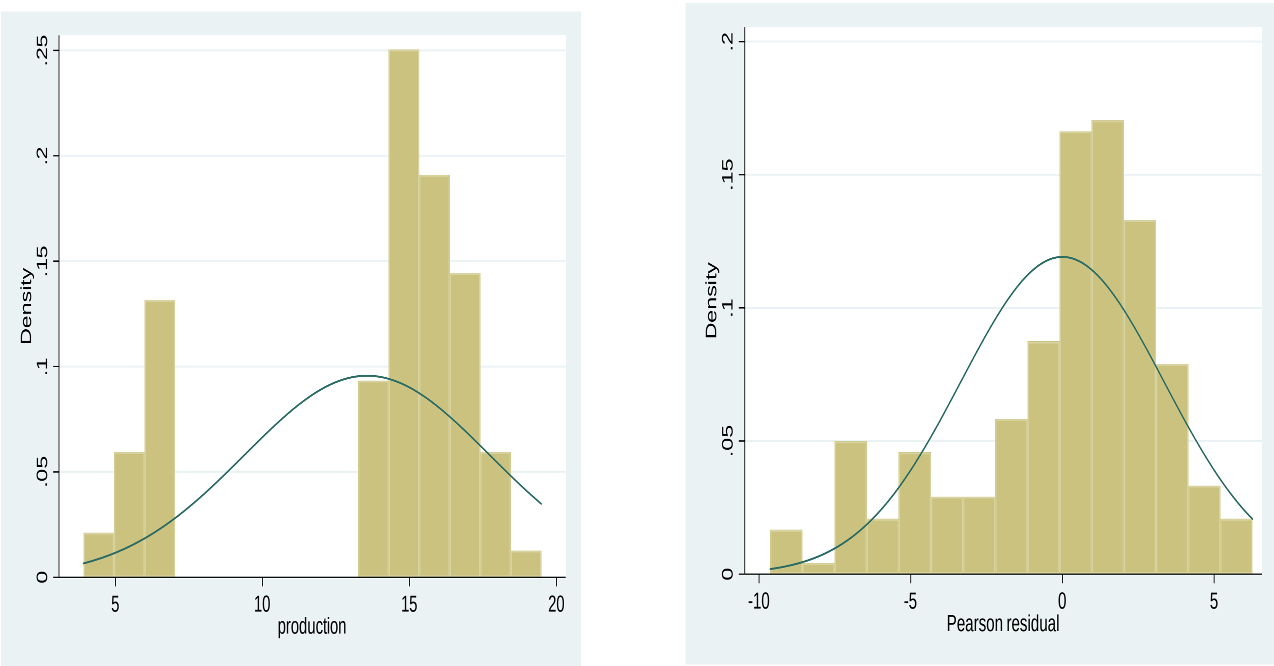

Figure 4- Production Capacity and Histogram of Distribution of Residuals. Source: Own calculations based on Turkish Union of Chambers and Exchange Commodities and General Directorate of Highways

As seen in Figure 4, distribution of production capacity is too left-skewed. This distribution is a contradiction to basic assumption of conventional linear regression model. Consequently, Generalized Linear Models are utilized instead. Generalized Linear Models developed by Nelder & Wedderburn (1972) consist of response variables (dependent variable) as well as non-normal (conditional) distributions through transformation termed as link function.

Generalized Linear Models provides flexibility for two important assumptions of conventional Linear Regression (normality and heteroscedasticity). General Linear Models can be formulated easily by choosing a proper response (probability) distribution and a link function. In this sense, Generalized Linear Models (GLM) provide social scientists with a simplified as well as flexible approach for constructing a statistical model (Wu 2005).

Generalized Linear Model can be defined as;

$$f(y) = c(y, \emptyset)exp\left\{\frac{y\theta - a(\theta)}{\emptyset}\right\},\ g(\mu) = X\beta \tag{1.3}$$

for exponential distributions based on probability density function.

In Equation (1.3) $g\,(\mu)$, indicates transformation of mean that represents predicted value of the dependent variable. In this context, GLMs consist of three basic components (Lindsey 2000):

1) *Coincidental Component or "Error Construct":* Y (i 1……….n) μ_i are independent coincidental variables with mean. They share the same distribution with a constant scale parameter from an exponential distribution family.

2) *Linear Component:* This represents linear systematic component. It is indicated by $n = X\beta$

3) *Link Function:* It is the last component of GLM. It fulfils a predictor link function in relation between Mean of i^{th} sample and its linearity. It is indicated by $n = g_i\,(\mu_i)$.

Priority in constructing GLMs is to determine a proper kind of exponential distribution for a dependent variable as well as determine a proper link function for the determined distribution. When $g(\mu) = \theta$, g is termed as canonical link function. There could be different distributions and link functions based on the structure of a dependent variable.

Gamma and inverse normal distributions are frequently used because of the structure of a positive continuous data corresponding to the dependent variable of the study. Unit and log functions are preferred for link function in general (Fox 2015). Akaike (AIC) and Basian (BIC) information criterions can be used to determine the most proper model for the dataset. This information criterion allows to compare interwoven models to un-nested models. The models might vary by linear predictor, link functions and distribution of response variables (Anderson et al. 2010). The other method of model comparing is coefficient significance which is obtained by including a variable which is equal to square of linear predictor in the model to predict a dependent variable. If coefficient is significant, it is assumed that there is lack of goodness of fit in the model (Hardin & Hilbe 2007). Consequently, in the study different model predictions are carried out with different link functions for gamma and gaussian distributions. Obtained information criterion as well as information of the coefficient related to square of the dependent variable are exhibited in Table 2.

Table 2- Model Comparison Criterion

Distribution-Link Function	*AIC*	*BIC*	*Square Variable Model*		
			HAT	*HATSQUARE*	*CONS*
Gaussian-identity	**5.285774**	1324.362	2.559229***	**-.0579095***	-10.13846*
Gaussian-log	5.309716	1385.767	70.92451**	-10.97332*	-96.22754**
Gamma-identity	7.210662	**-1187.00**	2.34645***	-.0531617**	-8.117995*
Gamma-log	7.2129	-1186.50	59.36268**	-9.081588*	-78.90173**

***, **, and ***: significant at 1%, 5% and 10% respectively.** Source: Own calculations based on Turkish Union of Chambers and Exchange Commodities and General Directorate of Highways

As can be seen in Table 2, the most suitable model distribution is gaussian (inverse normal) while most suitable link function is unit according to both information criterion as well as square variable models. Furthermore, Pearsan residuals suggested by McCullogh & Nelder (1989) are also reviewed in order to examine measures of goodness of fit in GLMs. According to this view, the most important indicator which shows that the model is properly constructed is the fact that distribution of residuals approaches to normal distribution.

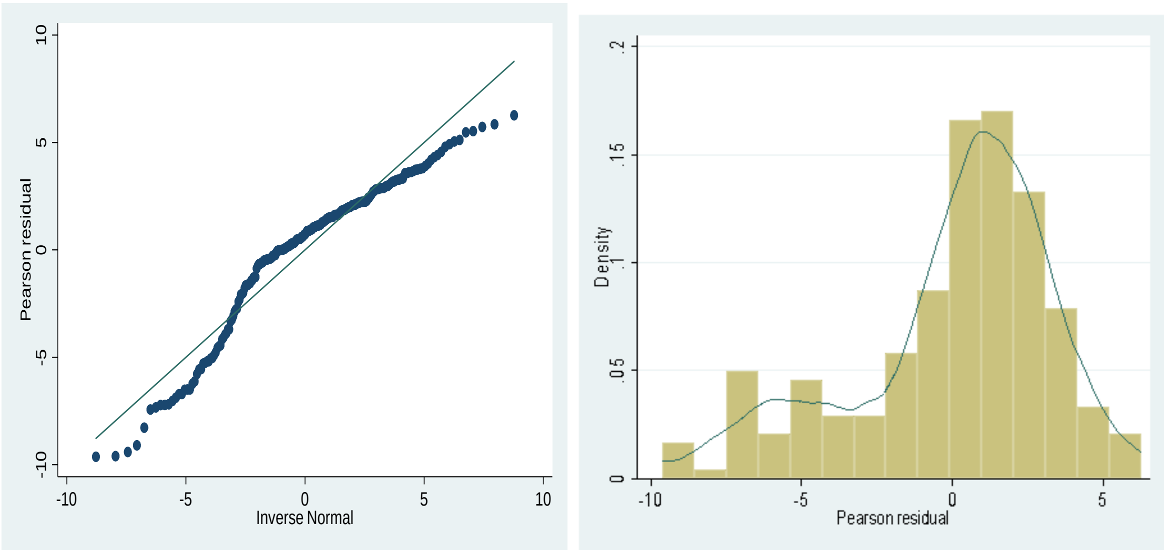

Figure 5- Gaussian distributed Unit Link Function Generalized Linear Model Pearson Residuals. Source: Own calculations based on Turkish Union of Chambers and Exchange Commodities and General Directorate of Highways

It is apparent that distribution has approached to normal distribution when Figure 5 is compared to Figure 4. This provides important evidence that model is constructed properly.

In the result of examining of all these statistics as well as histogram it is concluded that model will be predicted. Unit link function and gaussian (inverse normal) will be utilized for GLM. The results are exhibited in Table 3.

Table 3- Gaussian distributed Unit Link Function Generalized Linear Model Results

Namber of obs.=227	Residual df=223
Scale parameter=11.3638	(1/df) Deviance =11.3638
1/df pearson=11.3638	Deviance= 2534.126332
Pearson = 2534.126332	AIC= 5.2857
Log pseudolikelihood = -595.9352984	
Variance function: V(u) = 1	
Link function: g(u) = u	
Dependent Variable: Production capacity Variables	Coefficient
the number of Blue- Collar Employees	1.819683*** (0.6003369)
the number of White- Collar Employees	0.1529437 (0.1529437)
Length of Total Roads (km) in cities	0.548256* (3203659)
Constant	-0.3486598 (2.208456)

(i) *, **, and * significant at 1%, 5% and 10% respectively. (ii) The values in bracket are with standard error. (iii) Inverse normal distribution and unit link function are utilized in model prediction.** Source: Own calculations based on Turkish Union of Chambers and Exchange Commodities and General Directorate of Highways

As seen in Table 3, the number of blue-collar employees has a positive effect on fermented dairy production capacity at 0.001 significance while the number of white-collar employees does not have a significant effect on the fermented dairy production capacity on the other hand length of road (in km) in cities where fermented dairy products are produced has a positive effect on the fermented dairy production capacity at 0.10 significance level.

6. Conclusions

According to the results of the study, a unit increase in the number of blue-collar employees leads to 1.82-unit increase in fermented dairy production capacity. This justifies the idea of Liu et al. (2014) which states that labour has a prominent effect on production processes in food production. This result in the study also supports the result of the study done by Hussain et al. (2010) and Garcia-Covarrubias et al. (2024). On the other hand, this result in the study contradicts the idea suggested by Saravana et al. (2013) which is claimed that additional labour in dairy production might decrease efficiency.

Although the data as well as model in the study do not provide information about technology used in fermented dairy production, some interpretation can be made for fermented dairy production which is considered among low-tech sectors. First of all, the result of study related to white-collar employees having no significant impact on fermented dairy production capacity contradicts hypothesis of skill biased technical change. This may stem from two probable situations. First, milk processors located in Turkey that constitute scope of the study might have low level of technology in their fermented dairy production. This might cause white-collar employees to participate in managerial or sale activities rather than production processes.

Secondly, diversity of blue-collar in the sector might cause this. As mentioned before, blue-collar employees consist of foremen, workers as well as technicians. In most cases, foremen and technicians can be required to have a certain level of education. These employees might be deemed as qualified employees. This is in line with mentioned hypothesis as well as the results reached by Bewley et al. (2001) and Frick et al. (2019).

The results related to white as well as blue collar has been interpreted based on two approaches mentioned before in the study. However, a potential future study which includes level of technology use as well as aspects of human capital in firms producing fermented dairy products might reach more comprehensive also clearer conclusions.

The other result of the study is that one-unit increase in length of roads (in km) in cities where fermented dairy production is taking place results in 0.5-unit increase in fermented dairy production capacity. This is an expected result which is line with the related literature. For example, according to Subburaj et al. (2015) the important issue in dairy supply chain is transport infrastructure and condition of roads. According to the study poor transport infrastructure in dairy supply chain was found to be one of the greatest challenges in dairy business. In their study Kiambi et al. (2020) reached similar results. According to the study, one of the biggest challenges faced by large dairy processors was poor roads and public infrastructure. Authors suggested that this might led to risk of milk spoilage. Consequently, when related literature taken into consideration, the result of this study which emphasizes the effect of roads on fermented production capacity is rightfully sound.

Transport cost, energy use, water use, warehousing cost and inventory carrying cost in the fermented products supple chain dairy are also important issues. For example, Malliaroudaki et al. (2022) emphasized energy use in dairy production. They suggested some mitigation strategies for energy use. Talukder et al. (2021) listed inventory carrying cost warehousing cost, distribution cost finally water consumption as probable indicators of lean, agile and sustainable supply chains in dairy business. Especially, cold chain in logistics activities of dairy product is very vital because, raw milk should be stored in a cool condition both in the phases of milk collecting and dairy production (Martinelli et al.2022). Without a proper cold chain milk will certainly spoil. There are some studies done by Tostivint et al. (2017); Kiambi et al. (2020); Subburaj et al. (2015) which emphasize the importance of cold chain in dairy supply chain. As mentioned above although cold chain, transport cost, energy use, water use, warehousing cost, inventory carrying cost are important dependent variables they are not included in the study because, database in Turkey lacks proper information of these important components in the dairy supply chain. Consequently, in the future if proper data is reached consisting of information on these aspects the dairy supply chain in Turkey the effect of these elements on fermented dairy production capacity can also be investigated.

Conflicts of Interest: The authors declare no conflict of interest.
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Data Availability: Data utilized in this study available at:
https://www.kgm.gov.tr/Sayfalar/KGM/SiteTr/Istatistikler/DevletveIlYolEnvanteri.aspx
https://sanayi.tobb.org.tr/
Ethics Approval: Not applicable to this paper.

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