AN APPLICATION STUDY TO CREATE A MOBILE-BASED COST CALCULATION SOFTWARE REGARDING WOVEN FABRIC MANUFACTURING IN SMALL-SCALE TEXTILE BUSINESSES

KÜÇÜK BOY TEKSTİL İŞLETMELERİNDE KUMAŞ ÜRETİMİ İLE İLGİLİ MOBİL TABANLI BİR MALİYET HESAPLAMA PROGRAMININ OLUŞTURULMASINA YÖNELİK UYGULAMA ÇALIŞMASI

Serkan ÖZDEMİR[1], **Erkan YEŞİL**[2], **Emine UTKUN**[3]

[1]*Pamukkale University, Buldan Vocational Training School, Program of Accounting and Tax Implications, Denizli, Turkey*
[2]*Pamukkale University, Buldan Vocational Training School, Denizli, Turkey*
[3]*Pamukkale University, Buldan Vocational Training School,* Program of Fashion Design*, Denizli, Turkey*

ABSTRACT

Small-scale weaving businesses that make production in a highly competitive environment in textile industry need to properly calculate the unit cost of the products, which they produce or trade, in order to survive under the market conditions. But as most of the small enterprises in the industry have a workshop-type manufacturing structure on order basis, the cost calculation processes are usually carried out based on professional experiences without a specific method. The main factors that affect the unit cost of fabrics which are woven in enterprises that work on order basis are weaving preparation, raw material, labour, energy and amortization costs. Besides these main cost elements, the incalculable hidden cost factors and the cost factors of yarn waste, product waste and shrinkage ratio must be included in the unit cost calculation. The calculations involving all these elements do not seem possible to be made by the business owners in a continuous, correct and rapid way based on the professional experiences. In this study, software to calculate the unit cost of the products that are manufactured by small weaving enterprises was created and run in a sample application. The interface of this calculation software was created in ASP.NET programming language by using Microsoft Visual Studio 2013 application development software. The design of the application is in the level to be viewed in both mobile operating systems and Windows environment.

Keywords: Unit cost, calculation software, weaving, small enterprises, mobile operating system.

ÖZET

Tekstil sektöründe yüksek rekabet ortamında üretim yapan küçük dokuma işletmelerinin piyasa şartlarında varlığını sürdürebilmesi için üretmiş olduğu veya ticaretini sürdürdüğü ürününün birim maliyetini doğru hesaplayabilmesi gerekir. Fakat sektördeki küçük işletmelerin çoğunluğunun atölye tarzı ve siparişe dayalı bir üretim yapısına sahip olmasından dolayı maliyet hesaplama işlemleri genelde belli bir yönteme dayandırılmadan, mesleki tecrübelere dayalı olarak gerçekleştirilmektedir. Sipariş esaslı çalışan işletmelerde dokunan kumaşların birim maliyetine etki eden temel unsurlar dokuma hazırlık, hammadde, işçilik, enerji ve amortisman maliyetleridir. Bu temel maliyet unsurlarının dışında iplik firelerinin, ürün firelerinin, çekme oranlarının ve hesaplanamayan görünmez maliyet unsurlarının da birim maliyet hesaplamasına dahil edilmesi gerekmektedir. Tüm bu unsurların dahil edildiği hesaplamaların işletme sahipleri tarafından mesleki tecrübelere dayalı olarak sürekli, doğru ve hızlı bir biçimde yapılması mümkün görülmemektedir. Bu çalışmada küçük dokuma işletmelerinin üretmiş oldukları ürünlerinin birim maliyetini hesaplayacak bir program hazırlanmış ve bir örnek uygulamada çalıştırılmıştır. Bu hesaplayıcı programın arayüzü, Microsoft Visual Studio 2013 uygulama geliştirme yazılımı kullanılarak ASP.NET programlama dilinde hazırlanmıştır. Uygulamanın tasarımı hem mobil işletim sistemlerinde hem de Windows ortamında görüntülenebilecek düzeydedir.

Anahtar Kelimeler: Birim maliyet, hesaplama programı, dokuma, küçük işletmeler, mobil işletim sistemi.

Corresponding Author: Emine Utkun, eutkun@pau.edu.tr

1. INTRODUCTION

The key foundation philosophy of businesses is to make profit by producing and selling goods and services. In the industries where free competition is dominant, the selling prices of manufactured goods are set at the point where supply and demand cross under the market conditions although they are determined by the enterprises. Therefore, the most important activity to be performed so that the enterprises can make a profit in the desired level is to calculate the cost in the most correct way and to build an efficient cost control system. Thus, it will be possible to have the lowest manufacturing costs by continuously checking the manufacturing costs (1).

Weaving industry, which is one of the most important sub-branches of textile industry, is a manufacturing industry where there is a high level of competition in the world market today. The fact that the unit prices of the fabrics, which are woven especially in the countries such as China, India and Brazil where the labour and energy costs are relatively low, are low and their output is high complicates the competitiveness of the other countries in this industry (2).

Enterprises need methods for efficiently calculating their manufacturing costs and for a consistent cost control in order that they can compete and can be permanent in weaving industry. The medium-size and big enterprises in the industry usually have the cost calculation programs and the trained personnel to use the methods of efficiently calculating the manufacturing costs within their existing organizational structures. But as most of the small enterprises in the industry have a workshop-type manufacturing structure on order basis, the cost calculation processes are usually carried out based on professional experiences without a specific method. Error probability is quite high in cost calculations which are made without any specific method and software. In this industry where there is a high level of competition, such cost calculation errors may cause the small enterprises to encounter financial difficulties in a short time (2).

Various studies on the subject are summarized as follows.

In their study, Bulgun and Başer (2000) created a packaged software in order to support the clothing businesses during the design and order acceptance process. Thanks to this software, businesses can archive the production and design parameters that they have in their computers, and in case of a new product design and production, they can quickly create the data of the new product by utilizing the data of the previously-manufactured similar patterns. Within the study, they worked on trousers as the sample item. Thanks to the created database, the data such as unit sewing time, unit quantity and unit cost of the requested product can be easily provided (3).

In the study, Vuruşkan (2005) developed a computer program aimed to systematically conduct the estimated cost calculation stage that can be considered as the beginning of work flow for knit clothing businesses. The estimated cost module, which was prepared within the scope of study, works to define the products and to calculate the unit costs during the product development and order acceptance process (4).

In the study, Türker (2006) was developed a computer aided design program for the construction of woven fabrics. The program was based on visual basic programming language (5).

In the study, Erdoğan at al. (2007) were emphasized that the importance of the product cost. They were explained about transportation method, and made an application study for determination of the production planning and production cost. Transporation method was used in production and serving sectors (6).

In the study, Bal (2007) analyzed the polyester, viscose and elastane companion woven fabrics, examined the values obtained from the analysis, and focused on calculating the product values and yarn consumption of new fabrics with reference to a known fabric type and planning the business requirements thanks to these values. At the end of the study, a computer program that includes all these subjects was developed (7).

In their study, Yeşilpınar et al. (2009) developed a computer program that can calculate the fabric consumption amount of ready-to-wear businesses. They worked on jeans as sample. The developed software can quickly calculate the fabric expenses of new patterns by utilizing the previous cloth spreading plans and the stored production data (8).

In the study, Ak (2009) developed a software that can calculate the fabric expenses of different t-shirt patterns. In the research, the data of a large-scale clothing business that makes production on customer basis was utilized. The technical drawings, size table, cutting plan and order details of different t-shirt patterns were obtained from the enterprise. In addition to these, 3-D clothing patterns were included in the software in order to analyze the view in complex patterns more easily. The purpose of the software is to contribute to the quick calculation of fabric expenses during order acceptance for a similar pattern (9).

In their study, Değirmenci and Çelik (2013) designed a computer program that helps calculate the unit costs of knitted fabrics. Within the study, the production and unit cost works which were calculated with the help of the formulas were turned into the interface. If required, the software can only be used for production calculation (10).

Antemie at al. (2013) developed an algorithm that calculates the total material in use from the design phase to the end of the production phase of a textile product. In the study, the quantity of the material to be used for each surface of the product was separately calculated taking the parameters of each surface into consideration (11).

Three different Android-based and iOS-based mobile applications were encountered in textile and clothing industry. These applications can be accessed from mobile markets.

The screenshot of the Android-based mobile application named as Textile Costing Calculator, which can calculate the cost of a fabric manufactured by using one or multiple yarns, is shown in Figure 1 (12). The screenshot of the Android-based mobile application named as Textile Yarn

Calculator, which makes calculations for the yarn with its weight, length and layer parameters, is shown in Figure 2 (13).

In the mobile application named as Tektextil, which was developed for iOS-based systems, there are a glossary of textile terms along with the converters for fabric manufacturing and a section where the news from the textile world are shared (Figure 3) (14).

The main factors that affect the unit cost of fabrics which are woven in small enterprises that work on order basis are weaving preparation, raw material, labour, energy and amortization costs. Besides these main cost elements, the incalculable hidden cost factors and the cost factors of yarn waste, product waste and shrinkage ratio must be included in the unit cost calculation. The calculations involving all these elements do not seem possible to be made by the business owners in a continuous, correct and rapid way based on the professional experiences.

The objective of the study is to develop a cost software to calculate the unit cost of the fabrics, which are usually woven in workshop-type small enterprises that work on order basis, in an easy, correct way and to be viewed in mobile operating systems and Windows environment. The developed software was run by using it in the unit cost calculation of a sample item. Another objective of our study is to create awareness in the industry regarding the importance of correct and rapid calculation of unit costs in small-scale weaving businesses via a computer program.

2. MATERIALS AND METHOD

In this study, the interface of this software to calculate the unit cost of the products manufactured by small-scale weaving enterprises was created in ASP.NET programming language by using Microsoft Visual Studio 2013 application development software. The design of the application is in the level to be viewed in both mobile operating systems and Windows environment.

The developed software was designed to calculate the unit costs of small-scale weaving enterprises that make production on order basis and that weave raw fabric. The unit costs which are calculated by running the software are in United States Dollar (USD) currency.

The cost calculation method, which constitutes the infrastructure of the unit cost calculation software, was taken from the study named as "A Study on the Calculation Method for the Determination of the Unit Costs of Fabrics Woven in Semi-Automatic Looms in Small Enterprises" by Utkun and Özdemir (2015) (2).

The basic abbreviations, which are used in the cost calculation method in the related study, and their explanations are given as follows:
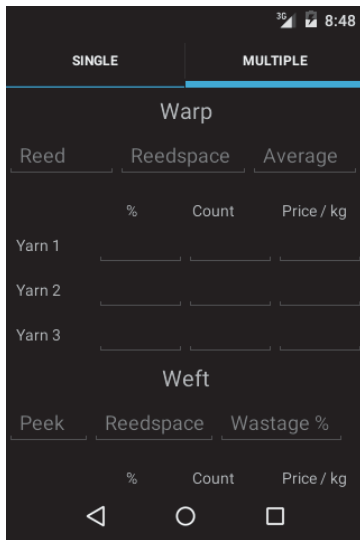

Figure 1. Textile Costing Calculator

Figure 2. Textile Yarn Calculator

Figure 3. TekTextil

C	= Cost		**R**	= Rate
CT	= Count		**S**	= Speed
D	= Density		**SA**	= Shrinkage Amount
E	= Expenses		**T**	= Time
EF	= Efficiency		**ThN**	= Number of Thread
EL	= Economic Life		**TN**	= Number of Teeth
L	= Length		**W**	= Width
P	= Price		**WL**	= Warp Length
Q	= Quantity		**WW**	**=** Warp Width

As in the other enterprises in weaving companies, the expenses occurring during the manufacturing process of the product must be determined firstly in order to determine the unit costs. As it is seen in equation **[1]**, Total Production Cost (C_{TP}) can obtain by adding Raw Material Cost (**C_{RM}**), Direct Labour Cost (C_L) and General Production Expenses (Overhead Cost) (E_{GP}).

$$C_{TP} (\$) = C_{RM} + C_L + E_{GP}$$

[1]

In weaving enterprises, as in the other enterprises, first of all, the expenses occurring during the manufacturing process of the product must be determined in order to determine the unit costs. As it is seen in equation **[2]**, first of all, Total Production Cost (C_{TP}) are divided into Production Quantity (Q_P) in calculation of Total Unit Cost (C_{TU}) of the fabrics woven in semi-automatic looms in small-scale enterprises. Other Costs Rate (R_{OC}) in a definite rate and Wastage Rate of Product (R_{WP}), which may vary from product to product, are added to the unit cost and C_{TU} figure is obtained (2).

The most important problem in the calculation of unit costs in small- scale weaving enterprises is that the required cost calculation data cannot be obtained in detail. Therefore, at the end of the one-on-one meetings with the industry representatives, it was confirmed that other costs rate as 10% must be added to the total unit cost. Other costs rate include "Incalculable Micro Costs", "Indirect Labour Costs", "Invisible Costs", "Unexpected Costs" and "Possible Calculation Deficits-Errors" (2).

$$C_{TU}(\$) = \left[\left(\frac{C_{TP}(\$)}{Q_P(\text{Piece})} \right) \times 1 + R_{OC} \right] \times 1 + R_{WP}$$

[2]

C_{TU} = Total Unit Cost, C_{RM} = Raw Material Cost, E_{GP} = General Production Expenses, Q_P = Production Quantity, R_{OC} = Other Costs Rate, R_{WP} = Wastage Rate of Product

Calculation of Raw Material Cost

Raw material cost is one of the main element in a product cost. If it is a woven fabric, raw materials are yarns (10). Raw Material Cost (C_{RM}) can calculate as it is seen in equation **[3]**. Yarn cost can obtain by adding Weft Yarn Cost (C_{WtY}) and Warp Yarn Cost (C_{WY}).

$$C_{RM} (\$) = C_{WtY} + C_{WY}$$

[3]

C_{RM} = Raw Material Cost, C_{WtY} = Weft Yarn Cost, C_{WY} = Warp Yarn Cost

a) Weft Yarn Cost

As it is seen in equation **[4]**, first of all, the weft yarn quantity to be used for the ordered product is specified as kg. in calculation of Weft Yarn Cost (C_{WtY}). The total weft yarn cost as per order is calculated by multiplying the specified quantity with the yarn price (2).

$$C_{WtY} = \left[\left(\frac{L_{UF} \times D_{Wt} \times W_C}{CT_{WtY}} \times 1 + R_{WY} \right) \times Q_P \right] \times \left(\frac{P_Y}{1000} \right)$$

[4]

C_{WtY} ($\$$) = Weft Yarn Cost, L_{UF} (m) = Unit Fabric Length, D_{Wt} (in 1 cm) = Weft Density, W_C (cm) = Comb Width, CT_{WtY} (Nm) = Weft Yarn Count, R_{WY} = Wastage Rate of Yarn, Q_P (Piece) = Production Quantity, P_Y ($\$$/Kg) = Yarn Price

b) Warp Yarn Cost

As it is seen in equation **[5]**, first of all, the warp yarn quantity to be used for the ordered product is specified as kg. in calculation of Warp Yarn Cost (C_{WY}). The total warp yarn cost as per order is calculated by multiplying the specified quantity with the yarn price (2).

$$C_{WY} = \left[\left(\frac{L_{UW} \times (TN_C \times Th_{NH} \times WW_{FH} + TN_C \times Th_{NF} \times WW_{FF})}{CT_{WY} \times (1 - SA_W)} \times 1 + R_{WY} \right) \times Q_P \right] \times \left(\frac{P_Y}{1000} \right)$$

[5]

C_{WY} ($\$$) = Warp Yarn Cost, L_{UW} (m) = Unit Warp Length, TN_C (in 1 cm) = Number of Teeth on the Comb in One cm, Th_{NH} (in one teeth) = Number of Thread in One Teeth in Hem, WW_{FH} (cm) = Warp Width of Fabric Hem, Th_{NF} (in one teeth) = Number of Thread in One Teeth in Floor, WW_{FF} (cm) = Warp Width of Fabric Floor, CT_{WY} (Nm) = Warp Yarn Count, SA_W (%) = Shrinkage Amount of Product in Warp Direction, R_{WY} = Wastage Rate of Yarn, Q_P (Piece) = Production Quantity, P_Y ($\$$/Kg) = Yarn Price.

Calculation of Direct Labour Cost

In the formula to be used in calculation of the labour cost in small- scale weaving enterprises, first of all, the monthly working hours required for the related order are calculated, and then, the obtained result is multiplied with the monthly labour cost of one worker. In calculation of the labour cost, the social security deductions of the employer must be added to the cost in addition to the gross pay. As there is a workshop-type manufacturing in small- scale weaving enterprises, the calculated labour cost is "Direct Labour Cost". As "Indirect Labour Cost" was very low and incalculable in the total labour cost, it was not included in the calculation. The impact of the indirect labour cost on the manufacturing cost is included in "Other Costs" (2).

As it is seen in equation **[6]**, first of all, the time to be spent for manufacturing the ordered product is specified in minutes in calculation of the labour cost. The coefficient, which is determined by dividing the specified figure into 10.800 minutes that is the normal monthly working hours of a worker, is multiplied with Monthly Labour Cost of One Worker (C_{ML}), so the total Direct Labour Cost (C_L) as per order is calculated (2).

$$C_L = \frac{\left(\dfrac{L_{UF} \times D_{Wt}}{S_M \times E_{MP}}\right) \times Q_P}{T_{WM}^{\;*}} \times C_{ML}$$

[6]

C_L (\$) = Labour Cost, L_{UF} (cm) = Unit Fabric Length, D_{Wt} (in 1 cm) = Weft Density, S_M (Turnover/Minute) = Machine Speed, E_{MP} = Production Efficiency, Q_P (Piece) Production Quantity, T_{WM} (Minute/Month) = Normal Monthly Working Minutes of a Worker, C_{ML} (\$) = Monthly Labour Cost of One Worker

Normal Monthly Working Hours of a Worker (WH_N):

4 Weeks x 45 Hours = 180 Hours x 60 Minutes = **10.800 Minutes/Month**

Calculation of General Production Expenses (Overhead Cost)

As it is seen in equation **[7]**, General Production Expenses(Overhead Cost) (E_{GP}) in the small- scale weaving enterprises running on a per order basis are determined by adding up the calculated Weaving Preparation Cost (C_{WP}), Energy Cost (C_E) and Amortization Cost (C_A).

$$E_{GP}\ (\$) = C_{WP} + C_E + C_A$$

[7]

E_{GP} = General Production Expenses, C_{WP} = Weaving Preparation Cost, C_E = Energy (Electricity) Cost, C_A = Amortization Cost

a) Weaving Preparation Cost

Weaving preparation process consists of four main titles as "Warp preparation", "Drawing-in", "Combing" and "Knotting". As it is seen in equation **[8]**, order-based Weaving Preparation Cost (C_{WP}) is calculated by adding up Warp Cost (C_W), Drawing-in Cost (C_D), Combing Cost (C_C) and Knotting Cost (C_K). All of these costs are determined by multiplying the time to be spent for the process with the labour cost (2).

$$C_{WP}(\$) = C_W + C_D + C_C + C_K$$

[8]

C_{WP} = Weaving Preparation Cost, C_W = Warp Cost, C_D = Drawing in Cost, C_C = Combing Cost, C_K = Knotting Cost

C_{WP} = Weaving Preparation Cost, T_W (Hour) = Warp Time, C_{WL} (\$/Hour) = Warp Labour Cost, T_D (Hour) = Drawing in Time, C_{DL} (\$/Hour) = Drawing in Labour Cost, T_C (Hour) = Combing Time, C_{CL} (\$/Hour) = Combing Labour Cost, T_K (Hour) = Knotting Time, C_{KL} (\$/Hour) = Knotting Labour Cost

$$C_{WP}\ (\$) = [(T_W \times C_{WL}) + (T_D \times C_{DL}) + (T_C \times C_{CL}) + (T_K \times C_{KL})]$$

[8]

b) Energy Cost

In the formula to be used in calculation of the energy cost in small- scale weaving enterprises, first of all, the monthly working hours required for the related order are calculated and then, the obtained result is multiplied with the monthly average energy cost of one machine. As the proportion of the energy cost to the total cost is very low in the manufacturing in semi- automatic looms, the monthly energy cost of the looms was not calculated in detail in the study and an average cost figure was taken into consideration. This situation constitutes another constraint of the study (2).

As it is seen in equation **[9]**, first of all, the time to be spent for manufacturing the ordered product is specified in minutes in calculation of the energy cost. The coefficient, which is determined by dividing the specified figure into 10.800 minutes that is the normal monthly working hours of a worker, is multiplied with Monthly Energy Cost of One Machine (C_{MF}), so the total Energy Cost (C_F) as per order is calculated (2).

C_E (\$) = Energy Cost, L_{UF} (cm) = Unit Fabric Length, D_{Wt} (in 1 cm) = Weft Density, S_M (Turnover/Minute) = Machine Speed, E_{MP} =Production Efficiency, Q_P (Piece) = Production Quantity, T_{WM} (Minute/Month) = Normal Monthly Working Minutes of a Worker, C_{ME} (\$) = Monthly Energy Cost of One Machine

c) Amortization Cost

In the formula to be used in calculation of the amortization cost in small- scale enterprises, first of all, the monthly working hours required for the related order are calculated and then, the obtained result is multiplied with the monthly amortization cost of one semi-automatic weaving loom. The monthly amortization cost of a weaving loom is calculated by dividing the unit cost of the loom into the economic life of the machine and then dividing the obtained figure into 12 (2).

As it is seen in equation **[10]**, first of all, the time to be spent for manufacturing the ordered product is specified in minutes in calculation of the amortization cost. The coefficient, which is determined by dividing the specified figure into 10.800 minutes that is the normal monthly working hours of a worker, is multiplied with monthly amortization cost of one machine which is calculated via another equation, so the total Amortization Cost (C_A) as per order is calculated (2).

C_A (\$) = Amortization Cost, L_{UF} (cm) = Unit Fabric Length, D_{Wt} (in 1 cm) = Weft Density, S_M (Turnover/Minute) = Machine Speed, E_{MP} = Production Efficiency, Q_P (Piece) = Production Quantity, T_{WM} (Minute/Month) = Normal Monthly Working Minutes of a Worker, C_{UL} (\$) = Unit Cost of Semi-Automatic Loom, EL_M (Year) = Economic Life of Machine

$$C_E = \frac{\left(\frac{L_{UF} \times D_{Wt}}{S_M \times E_{MP}}\right) \times Q_P}{T_{WM} *} \times C_{ME}$$

[9]

$$C_A = \frac{\left(\frac{L_{UF} \times D_{Wt}}{S_M \times E_{MP}}\right) \times Q_P}{T_{WM} *} \times \frac{\frac{C_{UL}}{EL_M}}{12}$$

[10]

Note: In order to increase the ease of use of the developed cost calculation software, a study was conducted to reduce the data amount to be entered in the interface by the users. The following data were fixed in the calculation software due to their standard or almost standard structures.

Machine Production Efficiency (E_{MP}) = 0,80 (80%)

Normal Monthly Working Minutes of a Worker (T_{WM}) = 10.800 (Minute/Month)

Other Costs Rate (R_{OC}) = 1,10 (10%)

Wastage Rate of Product (R_{WP}) = 1,02 (2%)

The summary of the cost calculation method, the details of which are given above, is explained in Table 1.

When determining the data that need to be entered in order to run the cost calculation software, these data were especially selected in a way that all the shareholders in the industry can know, understand and easily identify for the product, the cost of which is calculated.

The program was designed via Microsoft Visual Studio 2013 application development software. The application calculates the unit cost according to the entered values. This calculation is based on the method which is presented in Table 1. A part of the design coding of the interface was conducted as in Figure 4.

3. RESULTS AND DISCUSSION

The interface of the unit cost calculation software was designed in button box view in order to simplify the mobile use. When the users access the program on **http://anket.erkanyesil.com/**, they see the screenshot in Figure 5. The interface data entries are conducted in three steps. In the first step, "Cost of Raw Material", in the second step, "Cost of Direct Labour" and in the third step, "Cost of General Production "data are entered in the program. The software was designed not to make calculation before entering all the data and to notify the user. The data that does not affect the unit cost and that needs to be left blank must be entered as "0".

Figure 4. A Screenshot of the Design Section of the Application Created by Using ASP.NET Programming Language

Figure 5. Splash Screen of Unit Cost Calculation Software

Table 1. Unit Cost Calculation Method

		Formula
Yarn Cost	Weft Yarn Cost	$C_{WtY}(\$) = \left[\left(\dfrac{L_{UF}(m)\times D_{Wt}(\text{in 1 cm})\times W_C(cm)}{CT_{WtY}(Nm)} \times 1 + R_{WY}\right)\times Q_P(\text{Piece})\right]\times\left(\dfrac{P_Y(\$/Kg)}{1000}\right)$
	Warp Yarn Cost	$C_{WY}(\$) = \left[\left(\dfrac{L_{UW}(m)\times(TN_C(\text{in 1 cm})\times Th_{NH}(\text{in one teeth})\times WW_{FH}(cm) + TN_C\times Th_{NF}(\text{in one teeth})\times WW_{FF}(cm))}{CT_{WY}(Nm)\times(1-SA_W(\%))}\times1 + R_{WY}\right)\times Q_P(\text{Piece})\right]\times\left(\dfrac{P_Y(\$/Kg)}{1000}\right)$
Raw Material Cost		$C_{RM}(\$) = C_{WtY} + C_{WY}$
Direct Labour Cost		$C_L(\$) = \left[\dfrac{\left(\dfrac{L_{UF}(cm)\times D_{Wt}(\text{in 1 cm})}{S_M(\text{Turnover/Minute})\times E_{MP}(\%)}\right)\times Q_P(\text{Piece})}{T_{WM}(\text{Minute/Month})*}\right]\times C_{ML}(\$)$
	Weaving Preparation Cost	$C_{WP}(\$) = [(T_W(\text{Hour})\times C_{WL}(\$/\text{Hour})) + (T_D(\text{Hour})\times C_{DL}(\$/\text{Hour})) + (T_C(\text{Hour})\times C_{CL}(\$/\text{Hour})) + (T_K(\text{Hour})\times C_{KL}(\$/\text{Hour}))]$
	Energy Cost	$C_E(\$) = \left[\dfrac{\left(\dfrac{L_{UF}(cm)\times D_{Wt}(\text{in 1 cm})}{S_M(\text{Turnover/Minute})\times E_{MP}(\%)}\right)\times Q_P(\text{Piece})}{T_{WM}(\text{Minute/Month})*}\right]\times C_{ME}(\$)$
	Amortization Cost	$C_A(\$) = \left[\dfrac{\left(\dfrac{L_{UF}(cm)\times D_{Wt}(\text{in 1 cm})}{S_M(\text{Turnover/Minute})\times E_{MP}(\%)}\right)\times Q_P(\text{Piece})}{T_{WM}(\text{Minute/Month})*}\right]\times\left[\dfrac{\left(\dfrac{C_{UL}(\$)}{EL_M(\text{Year})}\right)}{12}\right]$
General Production Expenses (Overhead Cost)		$E_{GP}(\$) = C_{WP} + C_E + C_A$
TOTAL PRODUCTION COST		$C_{TP}(\$) = C_{RM} + C_L + E_{GP}$
TOTAL UNIT COST		$C_{TU}(\$) = \left[\left(\dfrac{C_{TP}(\$)}{Q_P(\text{Piece})}\right)\times 1 + R_{OC}\right]\times 1 + R_{WP}$

Source: Utkun ve Özdemir, 2015 (2)

In order to calculate the "Cost of Raw Material", the 16 different data in the screenshot in Figure 6 must be entered in the required units in the software.

In the software, "Nm" numbering system is used in yarn count data entry to calculate the weft and warp yarn costs. When the calculation is made for different fibers and counts, the link on the right of the box for data entry must be used to access and the "Yarn Count Converter "must be used.

Figure 6. Data Input Screen of Raw Material Cost

In order to calculate the "Cost of Direct Labour", the one data in the screenshot in Figure 7 must be entered in the required units in the software.

Figure 7. Data Input Screen of Direct Labour Cost

In order to calculate the "Cost of General Production (Overhead Cost)", the 12 different data in the screenshot in Figure 8 must be entered in the required units in the software.

Figure 8. Data Input Screen of General Production Cost

The developed calculation software was used to calculate the unit cost of "Peshtemal" item which was woven in a small weaving enterprise and the production data of which was taken from the Limited Buldan Weavers' Association No: 1. Cost data of the sample item is as in Table 2.

The sample item cost data in Table 2 was entered in the program interface as in Figure 9. The program that works when pressing on the "Calculate" button calculated the unit cost of "Peshtemal" as $6,76. The program can also calculate the share of four main cost factors within the calculated unit cost. In the sample application, the program calculated the "Cost of Raw Material "as $3,73; the "Cost of Direct Labour "as $2,24; the "Cost of General Production "as $0,79. If required, users can access different product unit costs by changing some cost parameters and recalculating them.
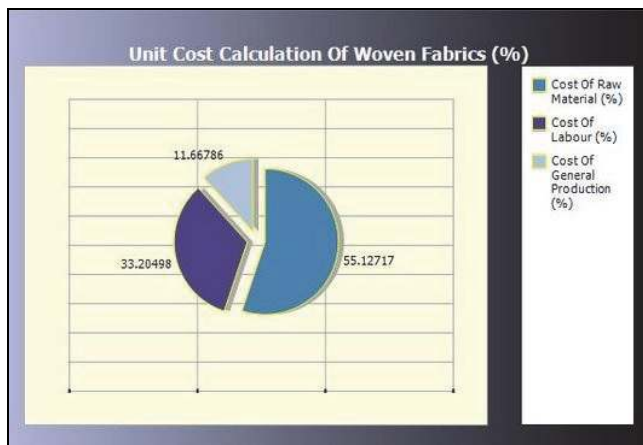

Figure 9. Unit Cost Calculation Screen of Sample Item (Peshtemal)

Table 2. Unit Cost Data of Sample Item (Peshtemal)

Cost of Raw Material	
Fabric length (**L$_{UF}$**) (m)	1.8
Weft density in 1 cm (**D$_{Wt}$**)	16
Comb width (**W$_C$**) (cm)	105
Unit Warp Length (**L$_{UW}$**) (m)	2.2
Number of Teeth on the Comb in One cm (**TN$_C$**)	8
Number of Thread in One Teeth in Hem (**Th$_{NH}$**)	4
Warp Width of Fabric Hem (**WW$_{FH}$**) (cm)	2
Warp Yarn Price –Cotton (Nm 30/2)(**P$_Y$**)($/Kg)	6
Wastage Rate of Yarn (**R$_{WY}$**) (%)	10
Production quantity (**Q$_P$**) (Piece)	1000
Weft Yarn Price –Cotton (Nm 20/2)(**P$_Y$**) ($/Kg)	5
Weft yarn count (**W$_C$**) (100% Cotton) (Nm 20/2)	10
Warp Width of Fabric Floor (**WW$_{FF}$**) (cm)	103
Warp yarn count (**CT$_{WY}$**) (Nm 30/2)	15
Number of Thread in One Teeth in Floor (**Th$_{NF}$**)	2
Shrinkage Amount of Product in Warp Side (**SA$_W$**) (%)	0
Cost of Direct Labour	
Monthly Labour Cost of One Worker (**C$_{ML}$**)($)	600
Cost of General Production (Overhead Cost)	
Warp Time (**T$_W$**)	2.5
Drawing in Time (**T$_D$**)	4
Combing Time (**T$_C$**)	0.5
Knotting Time (**T$_K$**)	5
Machine Speed (**S$_M$**) (turnover/minute)	100
Monthly Energy Cost of One Machine(**C$_{ME}$**) ($)	75
Warp Labour Hourly Rate (**C$_{WL}$**)	15
Drawing in Labour Hourly Rate (**C$_{DL}$**)	20
Combing Labour Hourly Rate (**C$_{CL}$**)	15
Knotting Labour Hourly Rate (**C$_{KL}$**)	10
Unit Cost of Semi-Automatic Loom (**C$_{UL}$**)($)	5000
Economic Life of Machine (**EL$_M$**) (year)	5

Source: Limited Buldan Weavers' Association No: 1 (15)

Figure 10. Unit Cost Elements (%) of Sample Item (Peshtemal)

Another significant feature of the created cost calculation software is that users can calculate the share of four main cost factors within the unit cost as percentage. The percentage ratio of the four main cost factors within the unit cost calculated by the program is calculated when pressing on the "Click to view chart "button on the bottom of the screen. The provided screenshot is as in Figure 10. In the sample application, the program calculated the "Cost of Raw Material "as 55,1%; the "Cost of Direct Labour "as 33,2%; the "Cost of General Production "as 11,7%.

4. CONCLUSIONS

The traditional company owners reach a conclusion without considering all the data that need to be processed when determining the cost of a product and without processing them systematically. Even in some enterprises, the company owners conduct costing based on only their professional experiences. The cost calculation method developed within the scope of the study eliminates such disadvantages and enables the small enterprises to calculate their costs with standard data. Thereby, wrong managerial resolutions that may arise regarding the product costing are minimized. Another advantage of this method compared to the traditional methods is the ease of use and distribution with the popularity of mobile data processing systems.

Enterprises are the establishments which are profit-driven in all their operations and which are founded to produce and sell goods and services. There are two basic methods to maximize the profit in enterprises. The first one is to increase the selling prices, and the second one is to reduce the costs. Considering that there is a highly competitive environment for the enterprises manufacturing in weaving industry and that the selling prices are formed under the market conditions, it does not seem much possible to maximize the profit by raising the selling prices. It is possible to maximize the profit only through the remaining second method, which is to reduce the costs. The main condition for the enterprises to reduce their costs provided that they keep the production quality stable is to have correct cost calculation methods that provide proper and rapid results.

In most of the big textile companies, the costs can be efficiently calculated via computer programs and the other calculation methods. But as most of the small enterprises in the industry have a workshop-type manufacturing structure on order basis, the cost calculation processes are usually carried out based on professional experiences without a specific method. This situation complicates the cost control and profit maximization in small weaving plants.

In our study, awareness was created regarding the importance of correct and rapid calculation of unit costs in small-scale weaving businesses via a computer program.

At the end of the study, a cost software to calculate the unit cost of the fabrics, which are usually woven in workshop-type small enterprises that work on order basis, in an easy, correct way and to be viewed in mobile operating systems and Windows environment was developed.

The most important advantage of the software is that it was developed in the structure to be viewed in mobile operating systems. Thanks to this feature, business owners can rapidly fulfill their instant need to calculate the unit costs via smart phones and internet connection without any restriction on location. This situation will gain significant advantages to

small-scale weaving enterprises in their marketing activities compared to their competitors.

It is planned to gain a corporate aspect to the software and to make it be widely used in mobile environment with the help of the financial support to be supplied in the advanced stages of the study and with the help of different properties to be assigned to the unit cost calculation software which has been developed as a draft version.

REFERENCES

1. Kaplan E., Koç E., 2006, Tekstil İşletmelerinde Maliyet Hesaplamaları-Dokuma Kumaş Maliyeti, *Çukurova University Journal of the Faculty of Architecture*, 21(2), p: 45-61.
2. Utkun E., Özdemir S., 2015, A Study on the Calculation Method for the Determination of the Unit Costs of Fabrics Woven in Semi-Automatic Looms in Small Enterprises, *Industria Textila*, 66 (4), p. 211-219.
3. Bulgun E.Y., Başer G., 2000, Development of a Computer Aided Garment Design Program, *Dokuz Eylül University Journal of Engineering Faculty of Science and Engineering*, 2(2), p. 113-122.
4. Vuruşkan A., 2005, Development a Software About Calculating the Production Parameters in Knitted Garment Plants, *Dokuz Eylül University, Department of Textile Engineering*, Master Thesis, Turkey.
5. Türker E., 2006, Dokuma Kumaş Yapılarının Bilgisayarda Tasarımı, Tekstil ve Konfeksiyon, 2, p. 110-117.
6. Erdoğan M.Ç., Şen A., Yücel Ö., 2007, Konfeksiyon Üretiminde Ulaştırma Modeli Yardımıyla Birim Maliyetlerin Belirlenmesi, *Tekstil ve Konfeksiyon*, 2, p. 132-139.
7. Bal Ö., 2007, A Computer Package Programme Designed for Weaving Calculations and Planning of the PES/CV Blended Woven Fabrics, *Çukurova University, Department of Textile Engineering,* Master Thesis, Turkey.
8. Yeşilpınar S., Aytaç V., Khalilov F., Bozkurt L., 2009, Development of software that calculates the fabric consumption of garments in clothing factories, *The Journal of The Textile Institute*, 100 (7), p. 626-632.
9. Ak D., 2009, Development of Software That Calculates the Fabric Consumption of Various T-Shirt Models, *Dokuz Eylül University, Department of Textile Engineering*, Master Thesis, Turkey.
10. Değirmenci Z., Çelik N., 2013, Devoloping a Software to Calculate the Unit Cost of the Double-Fleece Knitted Fabric, *Journal of Textiles and Engineer*, 20(92), p: 49-58.
11. Antemie, A., Harnagea, F. Popp, A. and Bruniaux, P., 2013, Developing original software designed to estimate consumption norms for textile products, using the method based on the sum of all rests, Industria Textila, 64(5), p. 285–292..
12. https://play.google.com/store/apps/details?id=com.sidharth.textilecostingcalculator.
13. https://play.google.com/store/apps/details?id=com.FataFat.TextileCalculator.
14. https://itunes.apple.com/nz/app/tektextil/id648366696?mt=8.
15. Limited Buldan Weavers' Association No: 1.