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The Inter – Relationship Between Profitability and Growth in Iranian Market

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KEYWORDS

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Firm growth,
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ABSTRACT

Owing to the attractiveness of developing economies, which seems engaging for investors, studying cardinal features of financial market of these economies seems important and necessary. The present study examines the relationship between firm's profitability and growth in Iranian manufacturing industry consisting of Tehran Stock Market listed between manufacturing firms. For the purpose of the study, firms' annual data during2005-2014 period constituted the sample of the paper. In order to understand the direction of causality between firm growth and profitability, system GMM (Generalized Method of Moments) is employed to estimate growth and profit regressions. The results obtained indicate that there is a positive bilateral relationship between profitability and growth in the case of Iranian manufacturing firms. Also, the empirical analysis finds that the positive impact of current profit (growth) on current growth (profit) is stronger than the impact of the prior's year..

1. Introduction

The high competitiveness of today's economical environment, added to effects of globalization, means that industries must find ways to satisfy their customers [1]. In so doing, the extent to which a firm achieves profit and growth is an indicative factor according to traditional theories. Organizational theorists believe that profit and growth are firms' two competing targets. Although pursuing both objectives simultaneously is difficult, managers opt for either profit or growth, but not both. Thus, an interaction occurs between growth and profitability. The relationship between growth and profitability has been a striking and controversial issue in finance due to inconsistent results reported in empirical findings [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. While previous studies have provided evidence from advanced and developed countries, this paper investigates data from a developing's. In so doing, the researchers investigate the data of Iranian listed manufacturing firms to fathom whether the relationship between profit and growth is

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contingent upon economic development. Developing economies are acquiring engaging positions since the complexities of the present financial markets have caused international companies and investors having a tendency towards developing financial markets to earn more profitability and growth. The attractiveness of the developing markets is in the profit and growth levels that developed markets do not offer to investors [14].

The proposition that growth and profit affect each other is suggested by some related theories, but it still seems equivocal. In developing economies whose financial markets are not well-developed enough, both profit and retained earnings are considered as two important sources of finance for expansion as the firms must permanently control the situation to make appropriate investment decisions [15]. In order for profitable growth to be achieved, firms either focus on profit or growth since it is difficult to achieve these very two objectives concurrently [12]. Furthermore, developing growth has been a key benchmark of firms' success, and sales growth has become one of the most common objectives for business managers [11]. Therefore, there is an interplay between profit and growth that empirical analysis determines its direction.

In this context, the researchers try to shed light on the relationship between growth and profitability; in other words, the aim of this study is to seek answers for these very questions: Is profitability a corollary of growth? Or firms grow due to profitability and reinvesting the profits? Therefore, this paper uses a panel data on 72 Iranian listed manufacturing firms over the span 2005-2014. Profit and growth rates are observed annually for this period, and several control variables, such as firm's size, debt ratio, and financial leverage, are considered. We estimate growth and profit regressions by using system-GMM [16]. This paper provides contribution to the literature because this is the first study that investigates the profit-growth relationship amongst Iranian firms while uses controlling variables as well.

The paper proceeds as follows. Section 2 reviews the literature germane to our study. In section 3, the regression model and estimation method are presented. This is followed in section 4 by empirical results. Section 5 concludes the paper.

2. Literature Review

Theories, such as First Mover Advantages (FMAs) [17], network externalities [18], experience effects [19], and scale economies [20], suggest that profitability arises from growth or establishing a stronger market position either via lowering costs.

Several, but not many, studies have been conducted in empirical realm specifically in advanced countries. For instance, Robson and Bennett [21] observed a positive profitability-growth and profitability-number of employee's relationships in small and medium-sized British firms although only the growth case is considered statistically significant. Cox et al. [22] indicated the presence of a positive relation between sales growth rate and profit growth rate. In conformity with antecedent studies Cowling [23] indicates that profit-growth relationship is dynamic in British firms. Coad [7] reported that the growth impact on consequent financial performance is larger in French firms, whilst profitability is of a positive and statistically significant effect on growth. Investigating a sample of Italian manufacturing firms, Bottazzi et al. [24] observed that the correlation between profitability ratio and firm growth is positive, but scarcely significant; however, Coad et al. [25] showed that growth has a positive impact on profitability, but reciprocal relationship is not approved. Perényi and Yukhanaev [26] reported a positive relationship between past profitability and firm current growth rate. On the other hand, some studies have demonstrated that growth does not lead towards profitability [27, 28] and firm's profit generation slows down because of swift growth [29]. Besides, a study by Davidsson et al. [10] contended that profit-focused firms are in better situation to reach profitable growth in comparison with growth-focused-firms.

However, a consistent positive growth-profit relationship is not found in empirical studies. Some studies report no relation between the growth and profitability [27]; for instance, Gschwandtner [30] argued that there is not a statistically significant relationship between firm growth and profitability in American companies. Likewise, Bottazi et al. [24] proved that there is not a remarkable relationship between growth trend and profitability. Furthermore, by using a dynamic panel model, Shehzad et al. [31] found that growth and profitability are independent.

On the other hand, some studies have demonstrated that growth does not lead towards profitability [27, 28, 32] and firm's profit generation slows down because of rapid growth [29]. A study by Davidsson et al. [10] suggested that profit-focused firms are in better condition to reach profitable growth in the future that in comparison with growth-focused-firms.

Markman and Gartner [27] studied profit-growth relationship via sales as well as employment growth as indicators of firm growth and found a negative interplay between firm growth and profitability.

Also, Jang and Park [12] provided evidence on the dynamic relationship between profit and firm growth. They found that the prior year's profit influences the growth rate of the current year positively. Although, the current and prior year's growth rates have a negative effect on the current year's profit, their findings evince that in the restaurant industry, profit begets growth, but growth has a detrimental impact on profit. Delmar et al. [33] recognized positively bilateral relationships between growth and profit. Lee [34] used dynamic panel data regressions by applying fixed effects and GMM methods to evaluate the relationship between growth and profitability in Korea, and found that profit affects growth negatively, but growth affects profit positively. Federico and Capelleras [35] examined Spanish manufacturing firms during the period 1996–2010, and declared that the effect of profit on growth is not significant. Yu et al. [36] showed the profit-growth relationship is mediated via investment. Firm's contemporaneous and lagged profits display positive and significant effect on investment spike and investment activity leading to higher growth. Based on the system generalized method of moments Model, Yoo and Kim [37] found that a profitability-driven management strategy limits firm's growth.

Insert Table 1

Table 1 presents the results and denouement of the most seminal empirical studies, showing that the empirical results consist of a motely group of findings. As seen above, both theoretical and empirical approaches are paradoxical in finding the direction of profit-growth relationship in firms of different financial markets. To be in line with the literature, this paper explores this objective in Iranian manufacturing firms.

3. Research Methodology and Model

Many researchers have compared different time series models together in order to determine the more efficiency in financial markets [38]. For the purpose of this study, trying to figure out the relationship between growth and profitability, a two-step system GMM [16] is employed. In this section, research methodology, model, data, and variables are presented.

3-1. Research Methodology

Dynamic panel data estimation becomes more suitable where unobservable factors affect both the dependent and the explanatory variables, and also some explanatory variables are strongly related to the past values of the dependent variable [39]. This is the matter in regressions of growth on profit, and vice versa. Blundell and Bond [16] suggested the dynamic panel data model employed in the equations of present study; by the way, the developed version of GMM estimator was also recognized as system-GMM (sys-GMM) derived from a system's estimation of two simultaneous equations: in first differences (with lagged levels as instruments) and in levels (with lagged first differences as instruments). The two-step sys-GMM uses a consistent appraisal of the weighting matrix taking the residuals from the one-step estimate when heteroscedasticity and serial correlation exist [40]. However, the two-step GMM runs estimations of the standard errors that tend to be downward biased.

A weakness of GMM estimations may be too many instrument problems, although there are diverse methods to lessen instrument variable number. Using only certain lags, rather than all available lags for instruments (limited lags), is the first method. The second, collapsing, is to compound instruments by adding them to smaller sets. A dynamic way is to benefit from the two techniques together [41]. There are several reasons to justify the preference of dynamic sys-GMM panel model. Firstly, static panel estimation ignores dynamics and leads to estimation bias [42, 43]. The meaning of omitted dynamics implies that such models are misspecified as passing over the impacts of lagged dependent variable on dependent variable [43]. Secondly, the correlation of independent variable with the error term occurring in regression model can be solved easier by dint of dynamic panel data models in comparison with the static models.

3-2. Model

To depict the specification of the dynamic panel growth and profit models, the following equations are specified:

$$GR_{i,t} = \alpha_1 + \beta\alpha_2 GR_{i,t-1} + \alpha_3 PR_{i,t} + \eta_{1\mathrm{i}} + \nu_{1i}; \quad i = 1,2,\dots,n.\ t = 1,2,\dots,T. \qquad (1)$$

$$GR_{i,t} = \alpha_1 + \beta\alpha_2 GR_{i,t-1} + \alpha_3 PR_{i,t} + \alpha_4 PR_{i,t-1} + \eta_{1i} + \nu_{1i}; \quad i = 1,2,\dots,n.\ t = 1,2,\dots,T. \qquad (2)$$

$$PR_{i,t} = \beta_1 + \beta_2 PR_{i,t-1} + \beta_3 GR_{i,t} + \eta_{2i} + \nu_{2i}; \quad i = 1,2,\dots,n.\ t = 1,2,\dots,T. \quad (3)$$

$$PR_{i,t} = \beta_1 + \beta_2 PR_{i,t-1} + \beta_3 GR_{i,t} + \beta_4 GR_{t-1} + \eta_{2i} + \nu_{2i}; \quad i = 1,2,\dots,n.\ t = 1,2,\dots,T. \quad (4)$$

Where i represents the firms (i = 1, …, 72) and t indicates the time span (t = 2004 ,…, 2010). η_{1i} and η_{2i} indicate firm-specific effects; ν_{1i} and ν_{2i} are random error terms. To constitute additional related control variables, size, debt ratio, and financial leverage are considered, but the coefficients of these control variables are not estimated in the regressions, only used as exogenous instrumental variables.

3-3. Data and Variables

The data are extracted from balance sheets and annual financial statements of 72 manufacturing firms listed in Tehran Stock Market over the period 2004-2010. In this paper, sales growth, believed to be closely related to the profitability, is used as a measure of firm growth. Net sales growth is an obvious prospect for a variable that would designate a firm's profitability due to giving a more accurate image of the real sales engendered by the firm. Model's variables and their computational methods are presented in table 2.

Insert Table 2

Descriptive statistics of the main and control variables are presented in table 3. Accordingly, the results show that growth rate is greater than profit rate for manufacturing firms listed in Tehran Stock Market. It means these firms have a high growth rate, but profit rate is slower. The average size indicates that these firms are relatively large.

Insert Table 3

4. Empirical Results

Before model estimation and as a preliminary step, we use scatter plots to provide a visual representation of the underlying relationships between growth rate and prior year's profit rate or between profit rate and prior year's growth rate. In table 4, these relationships, as scatter plots, are displayed.

Insert Table 4

The first row of Table 4 displays $GR_{(t)}$, $GR_{(t-1)}$, and prior year's profit rate. The second row of Table 2 represents $PR_{(t)}$, $PR_{(t-1)}$, and prior year's growth rates. It is obvious, based on the plots, for profit rate in times *t* and *t-1*, the current and prior year's profit rates have positive correlation. All other plots have a cloud shape and implicate no relationship but $GR_{(t)}$ and $GR_{(t-1)}$ that almost have a little positive correlation. Clearly, these scatter plots show that whether or not there is a relationship between variables but no information about directions of effects will be given by them.

To find the directions of causalities, Eq (1), Eq (2), Eq (3), and (4) are estimated by using sys-GMM estimators, and the results are presented in tables 5 and table 6.

Insert Table 5

According to results presented in Table 5, there is a statistically significant relationship between growth and profit. Likewise, a positive relationship exists between the present growth and the growth of prior year. The regression of Eq (1) denotes that growth persists and the current profit bolsters the current growth. The impact of the current profit on current growth (1.2) is more apparent than that of prior year's growth (0.5); however, both are statistically significant. It means high profitability gives rise to high level of growth for firms. In dynamic regression equations, the lagged dependent variable is included into the model in order to control the endogeneity problem or better still the correlation of independent variable with the error term. Using the lagged profit added to the model and regressing Eq (2), it is revealed that the current profit and prior year's profits have a positive effect on firms' growth, but prior year's profit impact is not significant (t-value, 0.57), meaning that Iranian market is intensely volatile as well as making an allusion to pickaxe society of Katouzian [44]. On the other hand, prior year's growth does have a fairly strong positive impact on the current growth (0.54) and statistically significant (t-value, 16.39) for the manufactory firms of Tehran Stock Market. The results convey that high profits of a particular year tend to have higher growth rates next year. Moreover, the Sargan test and the test for second-order autocorrelation of the residuals, AR (2), were performed to assess model specification and instruments validity, and approve the robustness of findings.

The results of the profit regression, Eq (3) and Eq (4), are presented in Table 6. According to the result of Eq (3), prior year's profit is of a positive and significant (t-value, 3.53) impact on current profit. Besides, the current growth influences the current profit positively and significantly. All regressions engender statistically significant and positive coefficient estimates of the prior year's profit and growth terms. That is to say, high growth leads to high profits. Although the result of Eq (4) conveys that prior year's growth has a very little and insignificant impact on the current profit, the impact of the current growth is more obvious than the prior's.

Comparing the regression result of profit with that of growth, for manufactory firms of Tehran Stock Market, the authors fathom that the impact of the current profit on the current growth, and vice versa, is much stronger than prior year's effect. It may happen due to the volatility of a developing economy affected by environmental factors. Furthermore, the results demonstrate that lagged growth affects the current year's profit positively, but it is not statistically significant; furthermore, there is a relatively strong positive relationship between lagged profit and the current growth.

Insert Table 6

5. Conclusion

This study investigates the relationships between firm's profitability and growth in Iranian manufacturing industry consisting of Tehran Stock Market listed manufacturing firms covering 2005-2014. In order to fathom the direction of the causality between firm's growth and profitability, Dynamic Panel Data estimation methods are employed to estimate profit and growth regressions.

The empirical analysis corroborates the direct relationship between the current growth and current profit; what is more, findings indicate a positive relationship between prior year's profit with current growth rate and also a positive inter-relationship between prior year's growth and the current profit exists. The findings from the profit regressions show that firm growth affects the profit positively. The positive effect of growth on profit is consistent with the findings recently reported by other researchers from different financial market and contradicts the theories in Industrial Organization suggesting a negative relationship.

The present study finds a bilateral positive relationship between growth and profitability. Be that as it may, limitations of this context may lie in the dataset used in this analysis which is not sufficient enough to generalize these results over the all Iranian manufacturing sector. Moreover, using LAD regression could be useful to check the robustness of the results. Also, the findings in this study indicate a need for further research to explore the moderating role of different variables on the relationship between profit and growth.

Reference

[1] Mahmodi J, Minaee MH. *Using System Dynamics to Model Rod Bar Supply Chain in Iranian Market*, International Journal of Industrial Engineering, Vol. 21, (2010), pp. 129-135.

[2] Aaker DA, Day GS. *The perils of high‐growth markets*, Strategic Management Journal, Vol. 7, (1986), pp. 409-421.

[3] Kaldor N. *Causes of the slow rate of economic growth of the United Kingdom: an inaugural lecture*, Cambridge University Press, (1966).

[4] Mueller DC. *A life cycle theory of the firm. The Journal of Industrial Economics,* (1972), pp. 199-219.

[5] Mueller DC. *The persistence of profits above the norm. Economica,* Vol. 44, (1977), pp. 369-380.

[6] Goddard J, McMillan D, Wilson JO. *Do firm sizes and profit rates converge? Evidence on Gibrat's Law and the persistence of profits in the long run,* Applied Economics, Vol. 38, (2006), pp. 267-278.

[7] Coad A. *Testing the principle of 'growth of the fitter': the relationship between profits and firm growth,* Structural Change and economic dynamics, Vol. 18, (2007), pp. 370-386.

[8] Coad A. The growth of firms: A survey of theories and empirical evidence. Edward Elgar Publishing; (2009).

[9] Brännback M, Carsrud A, Renko M, Östermark R, Aaltonen J, Kiviluoto N. *Growth and profitability in small privately held biotech firms: Preliminary findings,* New biotechnology. Vol. 25, (2009), pp. 369-376.

[10] Davidsson P, Steffens P, Fitzsimmons J. *Growing profitable or growing from profits: Putting the horse in front of the cart?,* Journal of Business Venturing. Vol. 24, (2009), pp. 388-406.

[11] Steffens P, Davidsson P, Fitzsimmons J. *Performance configurations over time: Implications for growth‐and profit‐oriented strategies,* Entrepreneurship Theory and Practice. Vol. 33, (2009), pp. 125-148.

[12] Jang SS, Park K. *Inter-relationship between firm growth and profitability*, International Journal of Hospitality Management, Vol. 30, (2011), pp.1027-1035.

[13] Soininen J, Martikainen M, Puumalainen K, Kyläheiko K. *Entrepreneurial orientation: Growth and profitability of Finnish small- and medium-sized enterprises*, International Journal of Production Economics, Vol. 140, (2012), pp. 614-621.

[14] Izquierdo JD. *Analysis of the relationship business growth and profitability in Brazil*, Tourism & Management Studies, Vol. 11, (2015), pp. 182-188.

[15] Farajian MA, Mohammadi S. *Mining the banking customer behavior using clustering and association rules methods*, International Journal of Industrial Engineering, Vol. 21, (2010), pp. 239-245.

[16] Blundell R, Bond S. *Initial conditions and moment restrictions in dynamic panel data models*, Journal of econometrics. Vol. 87, (1998), pp. 115-143.

[17] Lieberman MB, Montgomery DB. *First-mover advantages*, Strategic management journal, Vol. 9, (1988), pp. 41-58.

[18] Katz ML, Shapiro C. *Network externalities, competition, and compatibility*, The American economic review, Vol. 75, (1985), pp. 424-440.

[19] Stern CW, Stalk G, editors. Perspectives on strategy: from the Boston Consulting Group. J. Wiley; (1998).

[20] Besanko D, Doraszelski U. *Capacity dynamics and endogenous asymmetries in firm size*, RAND Journal of Economics, (2004), pp. 23-49.

[21] Robson PJ, Bennett RJ. *SME growth: The relationship with business advice and external collaboration*, Small business economics, Vol. 15, (2000), pp. 193-208.

[22] Cox H, Mowatt S, Prevezer M. *The firm in the information age: organizational responses to technological change in the processed foods sector*, Industrial and Corporate Change. Vol. 11, (2002), pp. 135-158.

[23] Cowling M. *The growth–profit nexus*, Small Business Economics, Vol. 22, (2004), pp. 1-9.

[24] Bottazzi L, Da Rin M, Hellmann T. *Who are the active investors?: Evidence from venture capital*, Journal of Financial Economics, Vol. 30, pp. 488-512.

[25] Bottazzi G, Coad A, Jacoby N, Secchi A. *Corporate growth and industrial dynamics: Evidence from French manufacturing*, Applied Economics, Vol. 43, (2011), pp. 103-116.

[26] Perényi Á, Yukhanaev A. *Testing relationships between firm size and perceptions of growth and profitability: An investigation into the practices of Australian ICT SMEs*, Journal of Management & Organization, (2016), pp. 1-22.

[27] Markman GD, Gartner WB. *Is Extraordinary Growth Profitable? A Study of Inc. 500 High‐Growth Companies*, Entrepreneurship theory and practice, Vol. 27, (2002), pp. 65-75.

[28] Chathoth PK, Olsen MD. *Does corporate growth really matter in the restaurant industry?*, International Journal of Hospitality Management, Vol. 26, (2007), pp. 66-80.

[29] Aaker DA, Day GS. *The perils of high‐growth markets*, Strategic Management Journal, Vol. 7, (1986), pp. 409-421.

[30] Gschwandtner A. *Profit persistence in the 'very'long run: Evidence from survivors and exiters*, Applied Economics, Vol. 37, (2005), pp. 793-806.

[31] Shehzad CT, De Haan J, Scholtens B. *The relationship between size, growth and profitability of commercial banks*, Applied Economics, Vol. 13, (2013), pp. 1751-1765.

[32] Reid GC. *Early life-cycle behaviour of micro-firms in Scotland*, Small Business Economics, Vol. 7, (1995), pp. 89-95.

[33] Delmar F, McKelvie A, Wennberg K. *Untangling the relationships among growth, profitability and survival in new firms*, Technovation. Vol. 33, (2013), pp. 276-291.

[34] Lee S. *The relationship between growth and profit: evidence from firm-level panel data*,

Structural Change and Economic Dynamics, Vol. 28, (2014), pp. 1-11.

[35] Federico JS, Capelleras JL. *The heterogeneous dynamics between growth and profits: the case of young firms*, Small Business Economics, Vol. 44, (2015), pp. 231-253.

[36] Yu X, Dosi G, Grazzi M, Lei J. Inside the Virtuous Cycle between Productivity, Profitability, Investment and Corporate Growth: An Anatomy of China Industrialization. Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy, (2015).

[37] Yoo S, Kim J. *The Dynamic Relationship between Growth and Profitability under Long-Term Recession: The Case of Korean Construction Companies,* Sustainability, Vol. 7, (2015), pp. 15982-15998.

[38] Esfahanipour A, Davari-Ardakani H. *A hybrid Multi Criteria Approach for Performance Evaluation: The Case of a Holding Company,* International Journal of Industrial Engineering, Vol. 26, (2015), pp. 287-309.

[39] ÇOBAN S. *The interaction between firm growth and profitability: Evidence from Turkish (listed) manufacturing firms*, Bilgi Ekonomisi ve Yönetimi Dergisi, Vol. 9, (2014), pp. 73-82.

[40] Davidson R, MacKinnon JG. Econometric theory and methods. New York: Oxford University Press; (2004).

[41] Roodman D. *A note on the theme of too many instruments*, Oxford Bulletin of Economics and statistics, Vol. 71, (2009), pp. 135-158.

[42] Baum CF. An introduction to modern econometrics using Stata. Stata press, (2006).

[43] Bond SR. *Dynamic panel data models: a guide to micro data methods and practice*, Portuguese economic journal, Vol. 1, (2002), pp. 141-162.

[44] Katouzian H. *The short-term society: a study in the problems of long-term political and economic development in Iran*, Middle Eastern Studies, Vol. 40, (2004), pp. 1-22.

Tab. 1. Recent seminal studies of growth and profit

	Regional Scope	Period	Method	Growth on profit	Profit on growth
Cowling [23]	UK	91–93	OLS 2SLS	Positive	Positive
Goddard et al. [6]	EU	92–98	OLS GMM	Neutral	Positive
Coad [7]	France	96–04	OLS GMM	Positive	Neutral
Coad [8]	France	96–04	LAD(VAR)	Positive	Neutral
Coad et al. [25]	Italy	89–97	LAD(VAR)	Positive	Neutral
Jang and Park [12]	US	78–07	GMM	Negative	Positive
Lee [34]	South Korea	97-12	Fixed effects GMM LAD(VAR)	Positive	Negative
Coban [39]	Turkey	99-08	GMM	Positive	Positive

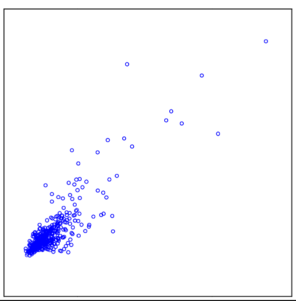
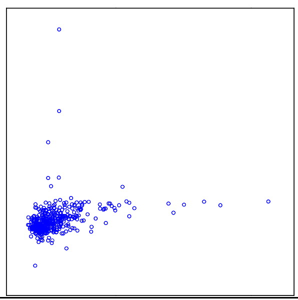
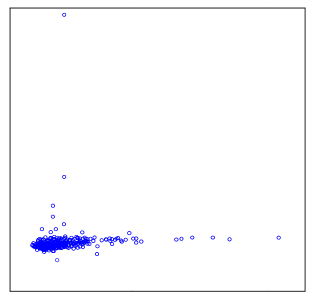
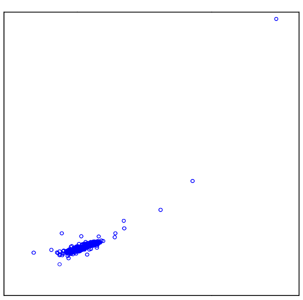
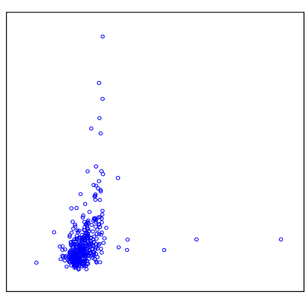
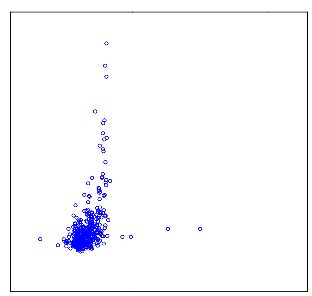
Tab. 2. The variables and their computational methods of the sys-GMM Model

Main variables	Computational method of the variables
Growth Rate	Book to market value-Shareholders' equity+(Stock $price_{(t)}$*Stock $quantity_{(t)}$) / Book-to-market value
Profit Rate	Gross operating $profit_{(t)}$ / $Sales_{(t)}$
Control variables	**Computational method of the variables**
Leverage	(Short term debt + Long term debt) / Equity
Debt Ratio	Total liabilities / Total assets
Size	Stock $price_{(t)}$*Stock $quantity_{(t)}$

Tab. 3. The descriptive statistics of main and control variables

Variables	GR	PR	Leverage	Size	Debt
Mean	0.5863	0.3166	2.3819	0.6045	62.8035
Std. Dev.	1.0024	0.5664	3.6065	0.2345	18.4569
Obs.	496	504	496	497	504

Tab. 4. The scatter plots of growth and profit rates using one year lag

Y Axis: $GR_{(t-1)}$ X Axis: $GR_{(t)}$	Y Axis: $PR_{(t)}$ X Axis: $GR_{(t)}$	Y Axis: $PR_{(t-1)}$ X Axis: $GR_{(t)}$
		
Y axis: $PR_{(t-1)}$ X Axis: $PR_{(t)}$	Y Axis: $GR_{(t)}$ X Axis: $PR_{(t)}$	Y Axis: $GR_{(t-1)}$ X Axis: $PR_{(t)}$
		

Tab. 5. Two-step sys-GMM estimation results of growth regressions

Dependent variable: GR	Eq (1)		Eq (2)	
	Coefficient	t-statistic	Coefficient	t-statistic
$GR_{(t-1)}$	0.5745	21.4027	0.5457^{***}	16.3913
$PR_{(t)}$	1.2064^{***}	2.6353	1.0261^{**}	1.9391

$PR_{(t-1)}$	_____	_____	0. 3608	0.5750
AR(1)	0.0004		0.0004	
AR(2)	0.5822		0.7414	
Sargan	0.097		0. 058	
Instruments	15		15	
Observation	573		573	

NOTE: Year dummies are included for all regressions, but not reported here in order to save space. GMM type variables are GR(t-1) and PRt and their lags range is set from two to five in all models.
*Significance levels at 5% level.
**Significance levels at 1% level.
*** Significance levels at 0.1% level.

Tab. 6. Two-step sys-GMM estimation results of profit regressions

Dependent variable: PR	Eq (3)		Eq (4)	
	Coefficient	t-statistic	Coefficient	t-statistic
$PR_{(t-1)}$	0.2409^{***}	3.5324	0.1516	2.1351
$GR_{(t)}$	0.1196^{**}	2.7733	0.0917^{**}	1.9580
$GR_{(t-1)}$	_____	_____	0.0266^{*}	0.6031
AR(1)	0.0052		0.0045	
AR(2)	0.3079		0.3530	
Sargan	0.256		0.222	
Instruments	15		15	
Observation	573		573	

NOTE: Year dummies are included for all regressions, but not reported here in order to save space. GMM type variables are GR(t-1) and PRt and their lags range is set from two to five in all models.
*Significance levels at 5% level.
**Significance levels at 1% level.
*** Significance levels at 0.1% level.

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Developing a Method for Order Allocation to Suppliers in Green Supply Chain

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KEYWORDS

Supplier selection,
Order allocation,
Green supply chain,
MOLP

ABSTRACT

Due to increased competition in the services and manufacturing, many companies are trying to lower price and offer good quality products to the market. In this paper, the multi-criteria decision-making techniques to evaluate and select the best supplier from among the existing suppliers are applied. First, hierarchical structure for selecting suppliers of raw materials is used, and the analytic hierarchy process to obtain the relative importance of quantitative and qualitative criteria related to the green supply chain is applied. Then, a fuzzy TOPSIS technique ranked the suppliers for each raw material according to the relevant criteria. Finally, regarding the weight of suppliers and demand of raw material and resource constraints by a multi-objective mathematical model, optimum order is determined. The objectives are to minimize the total cost, maximize the amount of purchases from desirable suppliers, and minimize raw materials required which are not provided. The proposed method is performed in a real case study of Food Company, and the relevant results are expressed.

1. Introduction

In a competitive environment, supplier selection is one of the most important issues that manufacturing companies face it. The cost of supplying raw materials in some industries includes the major portion of a product's final cost, and selection of a suitable supplier can significantly reduce it (Ghodsypour and O’Brien, 1998). Supply chain is a set of methods which is used to integrate suppliers, manufacturers, warehouses, and stores. Therefore, necessary products will be produced in a certain time and place with specified quantities and will be delivered to the customers in order to minimize the total cost of the chain and satisfy the buyer's needs in high-quality service. According to governmental legislation and increased awareness of people about protecting the environment, companies cannot ignore environmental issues for maintaining their competitive advantage and staying in the globalization trend. Increasing environmental concerns means considering the fact that the environmental pollution issue along with industrial development in supply chain management activities is important, leading to the emerging concept of green supply chain

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management (Hsu and Hu 2009). Srivastava defined green supply chain as follows: “considering environmental issues in supply chain management including product designing, selection and materials sourcing, production process, delivery of the final product to the customer and product management after consumption and expiration of its shelf-life”. Supplier selection is one of the most important activities that its results represent a big picture of good quality, organization performance, and supply chain (Chen et al. 2006). Therefore, the organizations should apply environmental management to all of the life cycles of their products to ensure the improving environmental performance of the supply chain. Green supply chain management is an integrator of supply chain management with environmental requirements in all steps of product designing, selection and materials supply, production, processes of distribution and transfer, delivery to the customer. In addition, after consumption, it is considered as recovery management of reuse for maximizing efficiency of energy consumption and its source for improving performance of the entire supply chain. In fact, green supply chain includes the processes of raw materials supply, production, logistics management, distribution, and service (Junior et al. 2014). You can refer to a reviewed paper (Govandin et al. 2015) to review the previous researchers about supplier selection in a green supply chain.

An appropriate supplier selection leads to reducing operating costs, increasing productivity and product quality, improving competition in the market, and satisfying customer's demands faster (Abdollahi et al, 2015). Supplier selection and evaluation are an issue of multi-criteria decision-making (MCDM) including quantitative and qualitative factors such as total cost, delivery time, the satisfaction level of the customer which is broken into two related issues: 1- Which supplier should be selected? 2- How much/many selected sources should be purchased? According to Weber and Current's statement (1993), these two cases of decision-making are called supplier selection.

Since the 1950s, supplier selection issue was introduced into scientific literature as a research issue coinciding with the emergence of linear programming and before propounding concepts relevant to supply chain in the business space (Aissaoui et al. 2007). Dickson (1966) conducted a study to identify and prioritize criteria used in supplier’s evaluation. The obtained result specified 23 criteria that were often used in the evaluation by the firms and the most important criteria such as quality, delivery time, producer validity, facilities, manufacturing capacity, and price. Most of the studies conducted in this domain have considered the supplier selection issue as a multi-criteria issue and have focused on various quantitative and qualitative criteria, so that the necessity of using multi-criteria decision-making criteria is discovered. Due to multi-criteria’s nature of supplier selection issue, analytic hierarchy process (AHP) technique was suggested which has determined weight coefficients of criteria and suppliers score based on pairwise comparisons. This technique has been applied by many researchers up to now, like Barbarsoglu et al. 1997.

2. Green Supplier Selection

Green supply chain management focuses on encouraging suppliers to improve their environmental performance and providing this green supplier for supply chain management, which is considered as an important factor in decision making for purchase (Kannan et al. 2013). Many researchers have done studies about evaluating indicators of green suppliers to get familiar with environmental criteria. Noci (1997) applied AHP to design a green supplier rating system. Sarkis (1998) categorized business method of the environment into five major components: planning for the environment (green planning), life cycle analysis, comprehensive environmental quality management, green supply chain, and certificate related to the environment such as ISO 14000. Handfield et al. (2002) worked on Delphi method in order to collect viewpoints of environmental experts in different companies based on AHP. Sarkis (2003) used ANP (analytic network process) to develop a six dimensions strategic decision framework in green supply chain management. Hsu and Hu (2009) proposed new criteria for supplier selection with hazardous substances management including green purchasing, green materials coding and recording, capability of green design, a list of hazardous substances, management of hazardous substances, legal-compliance competency, and environmental management system. Lee (2009) applied quality, technology, pollution control, environmental management, green products, and competencies for green supplier selection in the high-tech industry. Bai and Sarkis (2010) used grey system and rough set method to integrate sustainability into supplier selection and summarized environmental criteria as pollution control, pollution prevention, environmental management system, resource consumption, and pollution production. Awasthi et a1. (2010) proposed a fuzzy multi-criteria approach to evaluate environmental performance for green supplier selection which applied available clean materials, environmental effects, green image, environmental costs, green products, environmental management and green management process. Yeh and Chuang (2011) developed two multi-objective genetic algorithms for green partner selection which included four objectives, e.g., cost, time, product quality, and green score evaluation. They offered green image of renewal products, green design, green supply chain management, pollution treatment cost, and evaluation criteria of environmental performance. Govindan et al. (2013) proposed a fuzzy multi-criteria approach for measuring sustainability of a supplier and considering pollution production, consumable resource and available resource, compatibility with environment, and environmental management system as environmental criteria. Trapp and Sarkis (2016) developed an optimization model which considers the supplier selection, supplier development, and its sustainability. They believed that decision-making for the supplier selection is difficult in the supply chain of the organization. Because the integration of sustainability issue in the chain causes more complexity in decision making, it should be done well to improve the total performance of the supply chain. Also, sustainability criteria may be variable. In the developing countries, the customers do not want to pay more for the compatible products with the environment (Gandhi et al. 2016). According to the relevant literature, there is a wide range of work with focus on the green supplier selection (Akman 2015 and Kannan et al. 2015). Aknan (2015) ignored social dimension in decision-making of the supplier selection.

In the past, the life cycle of product included some processes from design to consumption. Now, due to environmental management approach, it includes processes of preparing raw materials, design, production, recycle, reuse and formation of a closed ring from materials circulation for reducing resource consumption and environmental harmful effects. Green supply chain includes processes of raw materials supply, production, logistics management, distribution, services, and recycle (Strivasta, 2007). Importance and advantages of green supply chain management do not limit the decrease of hazardous and poisonous substance consumption or decrease of harmful pollutants. Principles of green supply chain management can be utilized for all parts of an organization and their effects can spread on all tangible and intangible domains. Companies should accept green approach and compatibility with green supply chain management because of ten reasons as follows:

- Resource sustainability
- Cost reduction
- Efficiency
- Attainment of competitive advantage
- Compatibility with rules
- Risk reduction
- Gaining brand reputation
- Refund
- Assurance staff
- Morals

In some papers, evaluated green production variables are as follows:

- Utilization of compatible raw materials with environment
- Elimination of harmful raw materials for environment
- Accuracy in compatible criteria with environment
- Accuracy in compatible design with environment
- Optimization of processes for waste reduction
- Utilization of clean technologies for saving water and energy consumption and reducing pollutants
- Raw materials recycling in production stage
- Utilization of principles of comprehensive quality management

3. The Proposed Integrated Approach

According to the Spiegler et a1. (2012), there have been many literature reviews about flexibility in supply chain since recent years, but there are a few models which show the performance of supply chain flexibility or evaluate the impact of different strategies for giving flexibility in the supply chain (Torabi et al. 2015). In this article, an integrated approach is proposed for green supplier evaluation. Figure 1 shows the framework of the proposed method.

At first, AHP is used for measuring weights of supplier selection criteria. Then, fuzzy TOPSIS technique is used to rank suppliers of raw materials. After, a multi-objective linear programming (MOLP) model, order allocation of each raw material to the suppliers is done regarding demand and resource constraints. According to the relevant literature, there are just a few papers which have been developed and have mixed some methods among green and economic supplier selection criteria regarding resource allocation methods for multi-objective supplier selection problem in green supplier chain.

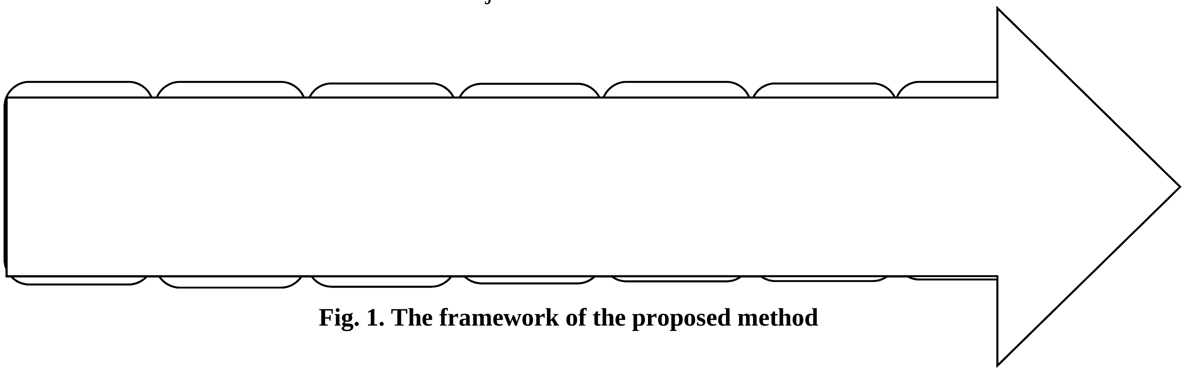

Fig. 1. The framework of the proposed method

3-1. Analytic Hierarchy Process

Multi-criteria decision-making techniques can evaluate different options with regard to various criteria which do not have the same units. It is an important advantage over the traditional methods that all the criteria should turn into the same unit from them. An important advantage of the other MCDM techniques is that they can analyze and evaluate qualitative and qualitative criteria simultaneously. One of the most efficient decision techniques is AHP that were proposed by Tomas Al-Saati (1980) for the first time. Dweiri et al. (2016) proposed ranking of forecasting model for production planning in the supply chain. This model is based on the AHP from multi-criteria decision making. It is useful in many industries and easy life application. One of the strongest features of the AHP is that it can generate numerical priority through the subjective knowledge. This method is very applicable in evaluating supplier’s weights in terms of various factors based on the pairwise comparison matrix. The problem is divided into two hierarchies (main criteria and sub-criteria). The main criteria are price, quality, on-time delivery, service were identified based on literature review. These criteria have been ranked based on the expert’s opinions. Implementation of AHP in decision-making includes four phases: 1-making hierarchy; 2- doing pair-wise comparison; 3- calculation of weights; 4- system compatibility. This method is one of the most famous methods of decision making. For more details, refer to the relevant sources about this domain.

3-2. Fuzzy Set Theory

In the real world, ambiguous and inexact information involves evaluation and prioritization of the options. Therefore, fuzzy set theory is used in the evaluation of different options for reflecting unreliability and ambiguities related to the feeling and understanding of decision-maker (DM). Fuzzy set theory was developed by Zadeh (1965) and used to formulate some problems with inadequate and inexact information related to different criteria in the real-world decision-making. Koumar et al. (2006) used an ideal fuzzy programming method to solve a multi-objective vendor selection problem by minimizing total cost, total rejected cost, delivery delay time, buyer's demand constraint, sellers capacity, seller ration flexibility, value of items purchasing, and budget allocation to the individual sellers. In addition, Amid et al. (2006) utilized a fuzzy model for supplier selection problem to resolve ambiguous input parameters in determination of the weight of quantitative and qualitative by finding different sources and constraint capacities. Ozgen et al. (2008) proposed integration of fuzzy set theory and multi-objective linear programming to model uncertainty in supplier evaluation and order allocation. Crispim and Souza (2009) developed a process to help the decision-makers to identify company’s criteria and to reach goals and needs of each project. They continued their procedure to find a multi-objective function which is considered as a good approximation from TOPSIS for ranking virtual alternatives of the company. Using previous similar cases, Faez et al. (2009) proposed a reasoning approach based on the sample for solving seller selection problem. They resolved ambiguity of some selection criteria by fuzzy set theory and formulated a programming model of complex integer number regarding seller selection and order allocation simultaneously. For more details about fuzzy set theory in supplier selection problem, refer to the following studies: (Moghaddam 2015, Junior 2014, Amid et al., 2011, Ozkok and Tiryaki, 2011; Wu 2010, Yucel and Guneri 2011).

3-3. The Fuzzy TOPSIS Method for Ranking Suppliers

TOPSIS is one of the classical methods for solving MCDM problem, originally proposed by Hwang and Yoon (1981). Shih et al. (2007) described this method in more details. TOPSIS is a simple computation process, systematic procedure, and a sound logic representing the rationale of human choice. This set includes an unlimited range of criteria and alternative performance. There is an explicit trade-off between options in this set. Furthermore, pairwise comparisons required by methods such as AHP are avoided (Shih et al. 2007; Wang and Chang, 2007; Govindan et al. 2013). The TOPSIS method finds the distance between PIS and NIS at the same time by defining relative closeness to the ideal solution. Finally, the ideal solution closest to the PIS and farthest to the NIS is obtained. Steps of TOPSIS solution are as follows (Hwang and Yoon, 1981; Chen et al. 2006):

Step 1: The normalized fuzzy decision matrix $\left(\tilde{R}\right)$ can be obtained as:

$$\tilde{R}=\left[\tilde{r}_{ij}\right]_{m\times n}$$

$$\tilde{r}_{ij}=\left(\frac{a_{ij}}{c_j^*},\frac{b_{ij}}{c_j^*},\frac{c_{ij}}{c_j^*}\right),\ j\in B \tag{1}$$

$$c_j^* = Max_i\, c_{ij},\ j\in B$$

$$\tilde{r}_{ij}=\left(\frac{a_{ij}}{c_j^*},\frac{b_{ij}}{c_j^*},\frac{c_{ij}}{c_j^*}\right),\ j\in C \tag{2}$$

$$a_j^- = Min_i\, a_{ij},\ j\in C$$

where B and C are the sets of benefit and cost criteria, respectively.

Step 2: Regarding the weights of different criteria, weighted fuzzy decision matrix is obtained by multiplying the coefficient of each criterion importance with fuzzy normalized matrix:

$$V=\left[\tilde{v}_{ij}\right]_{m\times n} \quad i=1,2,\ldots,m;\ j=1,2,\ldots,n$$
$$\tilde{v}_{ij}=\tilde{r}_{ij}\cdot\tilde{w}_j \tag{3}$$

where $\tilde{w}_j$ is coefficient of criterion importance, c_j.

Step 3: The positive ideal solution (PIS, A^*) and negative ideal solution (NIS, A^-) are defined as:

$$A^*=\left\{\tilde{v}_1^*,\tilde{v}_2^*,\ldots,\tilde{v}_n^*\right\}$$
$$A^-=\left\{\tilde{v}_1^-,\tilde{v}_2^-,\ldots,\tilde{v}_n^-\right\} \tag{4}$$

Step 4: The distance of each alternative from PIS and NIS is calculated as:

$$d_i^*=\sum_{j=1}^{n} d\left(\tilde{v}_{ij},\tilde{v}_j^*\right),\ i=1,2,\ldots,m \tag{5}$$

$$d_i^-=\sum_{j=1}^{n} d\left(\tilde{v}_{ij},\tilde{v}_j^-\right),\ i=1,2,\ldots,m \tag{6}$$

Step 5: The closeness coefficient (CC_i) is calculated as:

$$CC_i=\frac{d_i^-}{d_i^*+d_i^-}, \tag{7}$$
$$i=1,2,\ldots,m$$

Step 6: The ranking of alternatives: They are ranked according to the descending order of calculated closeness coefficients CC_i.

3-4. Mathematical Model for Supplier Selection Problem

In this section, a MOLP model is proposed for order allocation to the suppliers. The objective function of MOLP includes a set of objectives which should be optimized simultaneously. The aim of MOLP is to find the best solution among the most efficient points (Wang and Yang, 2009). Wodhwa and Ravindran (2007) developed the supplier selection problem as a multi-objective programming problem, in which there are three objective functions. Here, we determine optimum order by a multi-objective mathematical model regarding the weight of suppliers, demand for raw materials, and resource constraints. The objectives are minimizing the total cost, maximizing amount of purchase from desirable suppliers, and minimizing required raw materials that are not provided. The following notations are used in order to formulate this model:

Raw materials $r=1,2,3,\ldots,R$

Suppliers s = 1,2,3, …… , S

Parameters:

p_{rs}: Price of purchasing the rth raw materials from the sth supplier

o_{rs}: Cost of ordering the rth raw materials to the sth supplier

t_s: Cost of transporting the rth raw materials

d_s: Distance from the sth supplier from company.

h_r: Cost of holding the rth raw materials

W_{rs}: The weight of the sth supplier for rth raw materials supply
q_{rs}: The average defect of the rth raw materials from the sth supplier
Q_r: Maximum acceptable defect from the rth raw materials.
D_r: Demand of the rth raw materials
c_{rs}: Maximum capacity of the sth supplier for the rth raw materials supply
c'_{rs}: Minimum acceptable order of the rth raw materials for the sth supplier

Decision variables:
X_{rs}: Amount of purchasing the rth raw materials from the sth supplier
Y_{rs}: is one, if the rth raw materials are supplied from supplier *s*. Otherwise, it is zero.
L_r: The amount of rth raw materials that are not supplied.

Objective functions:
The first objective function minimizes the total costs of purchasing, ordering, transportation, and holding. The second objective function maximizes the purchasing from qualified suppliers. The third objective function minimizes the amount of demand, those raw materials that are not supplied.

$$MinTCP = \sum_r \sum_s p_{rs} X_{rs} + \sum_r \sum_s o_{rs} X_{rs} + \sum_r \sum_s t_r$$

$$MaxTVP = \sum_r \sum_s W_{rs} X_{rs}$$

$$MinL = \sum_r L_r$$

Constraints:

$$\sum_s q_{rs} X_{rs} \le Q_r D_r \qquad \forall r \qquad (8)$$

$$\sum_s X_{rs} = D_r - l_r \qquad \forall r \qquad (9)$$

$$X_{rs} \le c_{rs} \qquad \forall r, s \qquad (10)$$

$$X_{rs} \ge c'_{rs} Y_{rs} \qquad \forall r, s \qquad (11)$$

$$X_{rs} \ge 0 \qquad \forall s \qquad (12)$$

$$Y_{rs} \in \{0,1\} \qquad \forall r, s \qquad (13)$$

Constraint (8) ensures that overage number of defect of raw materials cannot be higher than the maximum acceptable defect of demand. Constraint (9) is a balance constraint for each raw material. In this constraint, the number of orders of the rth raw materials from each supplier should be equal to demanded quantity of the rth raw materials minus quantity of the rth raw materials that would not be provided. Constraint (10) controls the maximum capacity of each supplier to provide any type of raw material. Constraint (11) states that the order quantity of raw materials from a supplier cannot be less than the minimum acceptable. (The order quantity of the rth raw materials from the sth supplier should be more than the minimum capacity of the sth supplier to be economical). Constraints (12) and (13) show kinds of decision variables.

3-5. Goal Programming for Decision-Making

Many of the real-life concepts are designed into a single objective linear programming model. Researchers are more and more aware of the presence of multi-criteria in real-world problems of decisions and management (Tamiz et al. 1998). The goal programming (GP), first formulated by Charnes and Cooper (1961), is a tool for solving multi-objective decision-making problems, achieving a set of compromise solutions. The main idea of GP is to introduce auxiliary variables, called deviations, which work not as 'decision makers' but as 'facilitators' to formulate the model. These deviations present the distance between aspiration levels of goals and the realized solutions. Two kinds of deviations are excited, under-achievement of the goal, shown by negative deviation (d^-) and over-achievement of the goal, shown by positive deviation (d^+). GP consists of two sets of constraints: system constraints and goal constraints. System constraints are formulated following the linear programming concepts, while goal constraints are auxiliary constraints, which determine the best possible solution with respect to a set of desired goals. In this study, weighted linear programming model with multi-objective function can be formulated as follows:

$$MinZ = \sum_{i=1}^{m} (w_i^+ . d_i^+ + w_i^- . d_i^-)$$

Subject to

$$\sum_{i=1}^{m} a_{ij} . x_j - d_i^+ + d_i^- = g_i ; \; j = 1,2,...,n$$

$$x_j \ge 0; \; j = 1,2,...,r$$

$$x_j \in z; \; j = r+1, r+2,...,n$$

$$d_i^+, d_i^- \ge 0; i = 1,2,...,m$$

where Z is an optional set of hard constraints in linear programming. In this model, function Z is the weighted sum of deviation variables, and W_i^-

and W_i^+ are negative and positive weights, respectively, related to the ith goal. In addition, d_i^+ and d_i^- represent the positive and negative deviations from the ith objective value, respectively, and g_i is the ith goal value.

4. A Case Study

This paper aims to provide a clear image from the structure of purchasing manager's activities and supply of raw materials by the proposed method and through supplier selection and evaluation of food raw materials in Green Service Food Company in Shahrekord city in Iran. Sunil Luthra et al (2016) focused on the initiative of green practice for the complicated decision making; the supplier selection has been done for obtaining economic, environmental, and social benefits. In addition, the proposed framework of this study improves the complex selection of an alternative to extend the products and the green process regarding the other criterion of the company, which is the profit, so that it can remain in the competitive climate. We identify and evaluate the criteria for green supplier selection in this study. Then, we recognize the relative importance of weights in the green supplier selection and evaluate the green supply chain. The proposed model has been validated using real data in the food industry of green service Food Company in Shahrekord. This research encouraged innovation in creating a hierarchy for the supplier selection and order allocation to a favorite supplier. A summary of activities and contracts of green service company in Shahrekord has been registered in Cheharmahal and Bakhtiyari province in 2002. It has concluded 28 contracts with the public organizations for providing some services such as preparing, cooking, distributing, and supplying manpower. The following contracts from the respectable employers have been applied successfully.

A list of effective criteria in evaluation and selection of green suppliers in the company has been considered. Finally, nine major criteria were identified after interviewing with experts of raw materials selection and experts of food industries. These criteria are as follows: price, quality, transportation cost, fulfillment of the order, distance, environmental compatibility, defect, flexibility, technology, and timely delivery. There are different suppliers for each food raw material. Totally, there are 28 suppliers for 9 food raw materials in this study. The name of food raw materials are: 1) meat, 2) chicken, 3) schnitzel, 4) rice, 5) fish, 6) tomato paste, 7) lemon juice, 8) tomato, and 9) yoghurt.

4-1. Hierarchical System for MADM

The steps of the proposed method for the first raw material have been explained. These steps have been considered for other raw materials. The steps of the proposed method are as follows:

Step 1: construction hierarchical tree

Five alternatives were studied for selection of an appropriate supplier of the first raw material in a food company. Moreover, five criteria have been considered for selection of an appropriate alternative: c1: price, c2: transport cost, c3: flexibility, c4: technology, c5: quality. The hierarchical structure is shown in Figure 2.

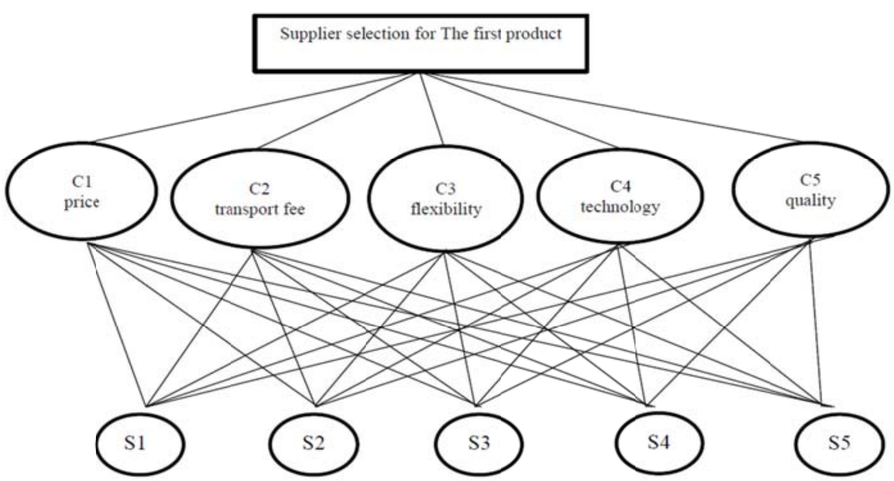

Fig. 2.The hierarchical structure of the AHP

Step 2: Pairwise comparisons At first, the pairwise comparison matrix has been constructed to determine an appropriate criterion by AHP. You can see this matrix in Table 1. Consider that indicator n (X_j) has been compared in relation to decision-making purpose in a MADM by DM as pairwise. The following scaled sections have been obtained from its comparisons.

Tab. 1. The pairwise comparison of each criterion for the meat

	C1	C2	C3	C4	C5
C1	1	5	9	7	6
C2	0.2	1	7	5	1
C3	0.111	0.142	1	3	2
C4	0.142	0.2	0.333	1	3
C5	0.166	1	0.5	0.333	1

Step 3: obtaining weights from decision matrix
The weight vector should be obtained for each pairwise comparison matrix to determine the score of each alternative. Row set method was used in this case study. Table 2 shows criteria weights for the first raw material. In the row sum method, elements sum of each row would be written in one vector, and this vector would be normalized (i.e., all the elements are divided into the largest element of each vector).

Tab. 2. Determination of the weights of criteria

	W1	W2	W3	W4	W5
W1	0.498869	0	0	0	0
W2	0	0.252998	00	0	0
W3	0	0.111408	0	0	
W4	0	0	0	0.083293	0
W5	0	0	0	0	0.053432

4.2. Using fuzzy TOPSIS for evaluating suppliers
Due to the subjective uncertainty of managers, fuzzy numbers are used to determine the best supplier. The linguistic variables for rating alternative are shown in Table 3. The fuzzy information is expressed in Table 4 based on these linguistic variables. Table 5 shows normalized fuzzy decision matrix. All the calculations have been done using Ms Excel. In this step, weighted normalized decision matrix can be obtained through Equation 3 (Table 6).

Tab. 3. Linguistic variables for rating criteria

Fuzzy numbers	Linguistic variable
(0,0,1)	(VL)Very low
(0,1,3)	low (L)
(1,3,5)	Medium low (ML)
(3,5,7)	medium (M)
(5,7,9)	Medium high (MH)
(7,9,10)	(H) High
(9,10,10)	Very high (VH)

Tab. 4. Ratings of the suppliers by DMs under various criteria linguistic variable for rating of criteria for meat

suppliers	price	transport fee	flexibility	technology	quality
S1	(1,3,5)	(9,10,10)	(0,0,1)	(0,0,1)	(0,0,1)
S2	(7,9,10)	(7,9,10)	(9,10,10)	(9,10,10)	(9,10,10)
S3	(5,7,9)	(9,10,10)	(5,7,9)	(0,1,3)	(0,1,3)
S4	(3,5,7)	(5,7,9)	(3,5,7)	(3,5,7)	(5,7,9)
S5	(9,10,10)	(7,9,10)	(0,1,3)	(5,7,9)	(5,7,9)

Tab. 5. Fuzzy normalized ratings criteria

Suppliers	price	transport fee	flexibility	technology	quality
S1	(0.2, 0.33, 1)	(0.5, 0.5, 0.55)	(0, 0, 0.1)	(0, 0, 0.1)	(0, 0, 0.1)
S2	(0.1, 0.11, 0.14)	(0.5, 0.55, 0.77)	(0.9, 1, 1)	(0.9, 1, 1)	(0.9, 1, 1)
S3	(0.11, 0.14, 0.2)	(0.5, 0.5, 0.55)	(0.5, 0.7, 0.9)	(0, 0.1, 0.3)	(0, 0.1, 0.3)
S4	(0.14, 0.2, 0.33)	(0.55, 0.714, 1)	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.5, 0.7, 0.9)
S5	(0.1, 0.1,0.11)	(0.5, 0.55, 0.71)	(0, 0.1, 0.3)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)

Tab. 6. Fuzzy weighted normalized ratings

Suppliers	v_1	v_2	v_3	v_4	v_5
s1	(0.18, 0.33, 1)	(0.35,0.45, 0.55)	(0,0, 0.07)	(0, 0, 0.09)	(0,0, 0.1)
s2	(0.09,0.111, 0.142)	(0.35,0.495, 0.77)	(0.27,0.5, 0.7)	(0.45, 0.7, 0.9)	(0.63, 0.9, 1)
s3	(0.0999,0.142, 0.2)	(0.35, 0.45, 0.55)	(0.15, 0.35, 0.63)	(0, 0.07, 0.27)	(0, 0.09, 0.3)
s4	(0.1278, 0.2, 0.33)	(0.385, 0.6426, 1)	(0.09, 0.25, 0.49)	(0.15, 0.35, 0.63)	(0.35, 0.63, 0.9)
s5	(0.09, 0.1, 0.111)	(0.35,0.495, 0.71)	(0, 0.05, 0.21)	(0.25, 0.49, 0.81)	(0.35,0.63, 0.9)

We can calculate the fuzzy PIS and the fuzzy NIS by Equations 3-7. Table 7 shows the distance of each alternative suppliers from the positive ideal and negative ideal solutions $\left(S_1^-, S_1^+\right)$. Finally, closeness coefficients of the alternatives are determined through Equation 7, and similar calculation has been done for other alternatives.

CC1=0.182986907 CC2=0.523831845 CC3=0.218226254 CC4=0.427944857 CC5=0.354111808

Tab. 7. The *PIS* and the *NIS*

supplier	$d(S_k^+)$	$d(S_k^-)$
S1	3.683712	0.825043
S2	2.158753	2.37484
S3	3.46224	0.966458
S4	2.644803	1.978533
S5	2.905796	1.593119

Tab. 8. Supplier evaluation

Preferred order of the suppliers	Raw material
$S_2 > S_4 > S_5 > S_3 > S_1$	Meat
$S_7 > S_8 > S_6$	Chicken
$S_{10} > S_9 > S_7 > S_8$	Schnitzel
$S_{12} > S_{11} > S_{13}$	Rice
$S_{14} > S_{15} > S_{16}$	Fish
$S_{19} > S_{17} > S_{18}$	Tomato paste
$S_{20} > S_{21} > S_{22}$	Lemon juice
$S_{23} > S_{24} > S_{25}$	Tomato
$S_{26} > S_{28} > S_{27}$	Yoghurt

4-4. MOLP Model for Order Allocation

After prioritization of suppliers and calculation of supplier importance in raw materials, the proposed mathematical model has been solved by goal programming method and Lingo software. The proposed model will turn into the following model to solve the multi-objective model by goal programming method:

$$min\,Z = W_1(d_1^{+} + d_1^{-}) + W_2(d_2^{+} + d_2^{-}) + W_3(d_3^{+} + d_3^{-})$$

$$s.t:$$

$$TC - d_1^{+} + d_1^{+} = g_1$$

$$TV - d_2^{+} + d_2^{+} = g_2$$

$$L - d_3^{+} + d_3^{+} = g_3$$

$$d_1^{+}, d_1^{-}, d_2^{+}, d_2^{-}, d_3^{+}, d_3^{-} \geq 0$$

$$and(4)to(10)$$

In the case study, we have: $W_1 = W_2 = W_3$, $g_1 = 20000000000, g_2 = 421065, g_3 = 0$. By solving the mathematical model, the optimal order allocation to each supplier of any raw materials was specified, and the best solution was determined for order allocation. In the optimal solution, the objective function values are 25801550000, 4117365, and 0, respectively. The value of unmet demand is zero regarding the optimal solution, but cost and value of purchasing from desirable suppliers have a deviation from the goals. Table 9 shows the value of purchasing raw materials from each supplier.

5. Conclusion

One of the important competitive factors in the organizations is supply chain management which includes different activities. In the initial steps, supplier selection process is very important, which its goal is a selection of the best supplier. In this article, supplier selection problem has been considered with several suppliers and raw materials. The proposed integrated method is composed of analytic hierarchy process, fuzzy TOPSIS, and integer programming model. Supplier selection criteria were obtained after interviewing with industry experts. These criteria were different about the selection of each type of raw material. This model was applied in Green Service Food Company to evaluate the proposed model and its results were expressed. This study is an integrated approach to green supplier selection and order allocation problem in order to improve initiatives of green supply chain management.

Tab. 9. The order allocation of raw material from the suppliers

Supplier	Meat	Chicken	Schnitzel	Rice	Fish	Tomato paste	Lemon juice	Tomato	Yoghurt
s2	5184000								
s3	9764000								
s5	7500000								
s7		2392200	1696500						
s8		6951900	1992700						
s9			2550000						
s10			4040000						
s11				1519900					
s14					5819000				
s15					1122000				
s16					9000000				
s17						4500000			
s18						6290000			
s19						7680000			
s20							9270000		
s22							1350000		
s24								1880200	
s25								3000000	
s26									2370340
s28									1064930

References

[1] Abdollahi, M., Arvan, M., Razmi, J., An integrated approach for supplier portfolio selection: Lean or agile? Expert Systems with Applications, Vol. 42, No. (1), (2015), pp. 679-690.

[2] Akman, G., Evaluating suppliers to include green supplier development programs via fuzzy c-means and VIKOR methods. Computers & Industrial Engineering, Vol. 86, (2015), pp. 69-82.

[3] Amid, A., Ghodsypour, S. H., O'Brien, C. A fuzzy multi objective linear model for supplier selection in a supply chain. International Journal of Production Economics, Vol. 104, (2006), pp. 394–407.

[4] Amid, A., Ghodsypour, S. H., O'Brien, C. A weighted max–min model for fuzzy multi-objective supplier selection in a supply chain. International Journal of Production Economics, Vol. 131, (2011), pp. 139–145.

[5] Awasthi, A., Chauhan, S.S., Goyal, S.K., A fuzzy multi criteria approach for evaluating environmental performance of suppliers. International Journal of Production Economics, Vol. 126, (2010), pp. 370-378.

[6] Bai, C., Sarkis, J, (2010). Integrating sustainability into supplier selection with grey system and rough set methodologies. International Journal of Production Economics, Vol. 124, No. (1), pp. 252-264.

[7] Barbarsoglu, G., yazgae, T., An application of the analytic hierarchy process to the supplier selection problem. Production and Inventory Management journal, Vol. 38, (1997), pp. 14-21

[8] C. Chen, C. Lin, S. Huang, A fuzzy approach for supplier evaluation and selection for supply chain management. International Journal of Production Economics, Vol. 102, No. (2), (2006), pp. 289-301.

[9] Crispim, J. A., Sousa, J. P. d., Partner selection in virtual enterprises: a multi-criteria decision support approach. International Journal of Production Research, Vol. 47, (2009), pp. 4791–4812.

[10] Dickson, G.W., An analysis of vendor selection system and decisions. Journal of Purchasing, Vol. 2/1, (1966.), pp. 5-17.

[11] Dweiri, K., Kumar, S., Ahmed Khan, S., Jain, V., Designing an integrated AHP based decision support system for supplier selection in automotive industry, Expert Systems with Applications, Vol. 62, (2016), pp. 273-283.

[12] Kannan, D., Khodaverdi, R., Olfat, L., Jafarian, A., Diabat, A., Integrated fuzzy multi criteria decision making method and multi objective programming approach for supplier selection and order allocation in a green supplychain, Journal of Cleaner Production Vol. 47, (2013), pp. 355-367.

[13] Faez, F., Ghodsypour, S. H., O'Brien, C. Vendor selection and order allocation using an integrated fuzzy case-based reasoning and mathematical programming model International Journal of Production Economics, Vol. 121, (2009), pp. 395–408.

[14] Junior, F.R.L, Osiro, L., Carpinetti, L.C.R., A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection" Applied Soft Computing, Vol. 21, (2014), pp. 194–209.

[15] Gandhi, S., Mangla, S. K., Kumar, P., Kumar, D., A combined approach using AHP and DEMATEL for evaluating success factors in implementation of green supply chain management in

Indian manufacturing industries. International Journal of Logistics Research and Applications, (2016), pp. 1-25.

[16] Ghodsypour, S.H., O'Brien, C.O, "A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming". International Journal of Production Economics,Vol. 56-57, No. (1-3), (1998),pp. 199-2.

[17] Govindan, K., Rajendran, S., Sarkis, J., Murugesan, P "Multi criteria decision making approaches for green supplier evaluation and selection: a literature review", Journal of Cleaner Production, Vol. 98, No. (1), (2015), pp. 66-83.

[18] Govindan, K., Khodaverdi, R., Jafarian, A., A Fuzzy Multi criteria approach for measuring sustainability performance of a Supplier based on triple bottom line approach. Journal of Cleaner Production Vol. 47, (2013), pp. 345-354.

[19] Handfield, R., Walton, S., Sroufe, R., Melnyk, S., Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process. European Journal of Operational Research, Vol. 141, (2002), pp. 70-87.

[20] Hsu, C.W., Hu, A.H., Applying hazardous substance management to supplier selection using analytic network process. Journal of Cleaner Production. Vol. 17, No. (2), (2009), pp. 255-264.

[21] Hwang, C.L., Yoon, K., Multiple Attribute Decision Making. Springer-Verlag, Berlin (1981).

[22] Kannan, D., Govindan, K., Rajendran, S., Fuzzy axiomatic design approach based green supplier selection: a case study from Singapore. Journal of Cleaner Production, V ol. 96, (2015), pp. 194-208.

[23] Lee, A.H.I., A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks. Expert Systems with Applications Vol. 36, No. (2), (2009), pp. 2879-2893.

[24] Luthra, S., Govindan, K., Kannan, D., Mangla, S.K., Garg C.P., An integrated framework for sustainable supplier selection and evaluation in supply chains, Journal of Cleaner Production, Vol. 140, No. (3), (2016), pp. 1686-1698.

[25] Moghaddam, K.S., Fuzzy Multi-Objective Model for Supplier Selection and Order Allocation in Reverse Logistics Systems under Supply and Demand Uncertainty. Expert Systems with Applications, (2015), pp. 6237-6254.

[26] Aissaoui, N., Haouari, M., Hassini, E., Supplier selection and order lot sizing modeling: A review. Computers & Operations Research, Vol. 34, (2007), pp. 3516-3540.

[27] Noci, G., Designing green vendor rating systems for the assessment of a supplier's environmental performance. European Journal of Purchasing and Supply Management, Vol. 3, No. (2), (1997), pp. 103-114.

[28] Ozgen, D., Onut, S., Gulsun, B., Tuzkaya, U. F., Tuzkaya, G., A two-phase possibilistic linear programming methodology for multi-objective supplier evaluation and order allocation problems. Information Sciences, Vol. 178, (2008), pp. 485–500.

[29] Ozkok, B. A., Tiryaki, F., A compensatory fuzzy approach to multi-objective linear supplier selection problem with multiple-item. Expert Systems with Applications, Vol. 38, (2011), pp. 11363–11368.

[30] Torabi, S.A., Baghersad, Mansouri, M.S.A., Resilient supplier selection and

order allocation underoperational and disruption risks, Transportation Research Part E, Vol. 79, (2015), pp. 22–48.

[31] Sarkis, J, Evaluating environmentally conscious business practices. European Journal of Operational Research, Vol. 107, No. (1), (1998), pp. 159-174.

[32] Sarkis, J, A strategic decision framework for green supply chain management. Journal of Cleaner Production, Vol. 11, No. (4), (2003), pp. 397-409.

[33] Strivasta, S.K., Green supply chain management: A state of the art literature review, International Journal of management Reviews, Vol. 9, No. (1), (2007), pp. 53-80.

[34] Spiegler, V.L.M., Naim, M.M., Wikner, J., A control engineering approach to the assessment of supply chain resilience. International Journal of Production Research, Vol. 50, No. (21), (2012), pp. 6162– 6187.

[35] Shih, H.Sh., Shyur, H.J., Lee, E.S., An extension of TOPSIS for group decision making. Journal of Mathematical and Computer Modeling, Vol. 45, (2007), pp. 801-813.

[36] Tamiz, M., Jones, D.F., El-Darzi E., A review of goal programming and its applications, Annals of Operations Research, Vol. 58, (1993), pp. 39-53.

[37] Trapp, A. C., & Sarkis, J. Identifying robust portfolios of suppliers: a sustainability selection and development perspective. Journal of Cleaner Production, Vol. 112, (2016), pp. 2088-2100.

[38] Wang, T.C., Chang, T.H., Application of TOPSIS in evaluating initial training aircraft under a fuzzy environment. Journal of Expert Systems with Applications, Vol. 33, (2007), pp. 870-880.

[39] Wang, T.Y., Yang, Y.H A fuzzy model for supplier selection in quantity discount environments. Expert Systems with Applications, Vol. 36, (2009), pp. 12179-12187.

[40] Wu, D. D., Zhang, Y., Wu, D., Olson, D. L., Fuzzy multi-objective programming for supplier selection and risk modeling: A possibility approach. European Journal of Operational Research, Vol. 200, (2010), pp. 774–787.

[41] Weber, C., Current, J., A multi-objective approach to vendor selection. European Journal of Operational Research, Vol. 68, (1993), pp. 173–184.

[42] Yucel, A., Guneri, A. F., A weighted additive fuzzy programming approach for multicriteria supplier selection. Expert Systems with Applications, Vol. 38, (2011), pp. 6281–6286.

[43] Yeh, W.C., Chuang, M.C., Using multi objective genetic algorithm for partner selection in green supply chain problems. Expert Systems with Applications, Vol. 38, (2011), pp. 4244-4253.

[44] Zadeh, L. A. Fuzzy Sets. Information and Control, Vol. 8, (1965), pp. 338–353.

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