Indian Journal of Science and Technology, *Vol 9(46), DOI: 10.17485/ijst/2016/v9i46/107395, December 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

The Structure of Supplier Network and Firm's Performance: The Case of Korean Manufacturing Industries

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Abstract

Objectives: The purpose of this paper is to investigate the relationship between the structure of supplier network and firm's performance in Korean manufacturing industries. **Methods/Statistical Analysis**: The standard method of network analysis as well as the regressionanalysis wasapplied to a unique dataset that contains information on buyer and supplier linkages for more than 20,000 incorporated manufacturing firms. **Findings**: Firstly, the characteristics of the network structure is different for industries; both hierarchy and openness are relatively high in metal and metal products, both are relatively low in textile and apparel, hierarchy is high but openness is low in automobile and electronic devices, hierarchy is low but openness is high in food and beverage. Secondly, both the productivity, measured by total factor productivity, and the profitability, measured by the operating income to sales, of the firms involved in the supplier network are higher than those of the firms not involved, and increase sequentially as the order numbers of tier of the firm increase in supply chain. Thirdly, the sales concentration ratio, representing for the openness of the network, has a significant positive effect on the productivity, and no significant effect on the operating income to sales. **Improvements/Applications**: One of the most important policy implications is that regulations against the inter-firm transaction should take different forms according to the transactional characteristics of the industries.

Keywords: Hierarchy, Openness, Productivity, Profitability, Supplier Network

1. Introduction

It is well-known that Korean big business firms have led the economic growth in the late industrialization. As a result, the hub & spoke type supplier networks, in which big business firms take the hub positions, have been developed in most of Korean manufacturing industries. In these industries the leading big business firms supply final goods and services, and the intermediate goods and materials are supplied by subcontracting firms. Most of the first-tier subcontracting firms are usually big sized firms, but the second and the rest tier are small and medium sized ones in these supplier networks.

The purpose of this research is to clarify empirically both the hierarchical characteristics and the degree of the openness of this inter-firm supplier network in Korean manufacturing industries, and to examine the effect of these characteristics on the managerial performances of the firms. Most of the empirical studies[1-3], which had analyzed the customer-supplier relationships, focused only on the relationships between the big business firms and their first-tier suppliers. They did deal with neither the relationships among the second and the rest tier firms, nor its impact on the managerial performances. This is partly because there is no data including the hierarchical network among the firms.

In this study, we used the information of the year 2011 in the data base provided by Korean Enterprise Data Inc. and the Auditory Reports of Corporation (2011) publicly revealed by Financial Supervisory Service. The DB of the Korean Enterprise Data Inc. includes both the amount

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and the partner of sales of the 23,839 firms, which is essential for the analysis of the buyer-supplier network. Among them,1,071firms of which some financial information cannot be identified in the data of the Financial Supervisory Service are deleted from the sample. The final number of firms is used as a sample in the analysis is 22,768firms.

In analyzing the buyer-supplier network in 9 two-digit Korean manufacturing industries, the standard methodology of social network analysis was adopted. The characteristics of a network, in which a firm engaged in the transactional relationship, was represented by two indicators; one is the hierarchical degree, measured by the order number of the tier of that firm from the leading big firms, namely, flagship company, in the hierarchical supply chain, the other is the degree of openness of the transactions of that firm, measured by the sales concentration. We also take multiple regression analysis in order to examine if these two characteristics of supplier network have an effect on both the productivity and the profitability of the firm.

We found the following three empirical results. Firstly, the characteristics of network structure is different by industries; both hierarchy and openness are relatively high in metal & metal products, both are relatively low in textile & apparel, hierarchy is high but openness is low in automobile and electronic devices, hierarchy is low but openness is high in food & beverage. Secondly, both the productivity, measured by total factor productivity, and the profitability, measured by the operating income to sales, of the firms involved in the supplier network are higher than those of the firms not involved, and increase sequentially as the order numbers of tier of the firm increase in supply chain. Thirdly, the sales concentration ratio, representing for the openness of the network, has a significant positive effect on the productivity, and no significant effect on the operating income to sales

2. The Structure of Supplier Network: Hierarchy and Openness

2.1 Hierarchy of the Network

The characteristics of a buyer-supplier network can be represented by two dimensions: hierarchy and openness. In the dimension of hierarchy, the starting point is the 'flagship company', which produces final goods and is at the highest level in the supply chain of an industry. They did not have sales transactions but only buying transactions in their own industries. Starting from this flagship company, we can identify first-tier subcontractors, which supply their products to the flagship company, and second-tier subcontractors, which supply to the firms of the first level, and third-tier subcontractors, which supply to the firms of the second-tier subcontractors, etc[4].

According to the method of[5], we define the 'absolute position' of a firm in the hierarchical supply chain by the minimum distance of the whole transactions, which is necessary for the products of that firm to arrive at the flagship company. All firms that supply goods or services to the flagship company are designatedas first-tier suppliers. All firms that supply their products to any of the first-tier firms are designated as the second-tier suppliers and so forth. In this way, 240 flagship companies can be identified in 9two-digit industries, and calculated the absolute position of all firms in the sample. The results are summarized in the Figure 1 and 2.

In Figure1 we presented how the 240 flagship companies are distributed by 9 two-digit manufacturing industries and also how they are divided between affiliates and non-affiliates of Korean big business groups. There are some differences in the number of flagship companies by the industries. It is more than fifty in such industries as textile and apparel and food and beverage, the entry

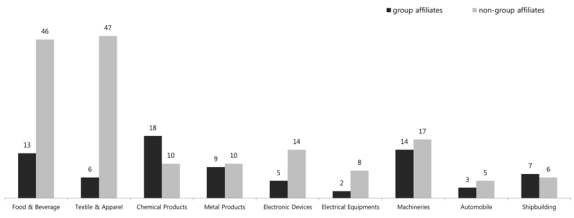

Figure 1. Number of flagship companies in 9 Two-digit manufacturing industries.

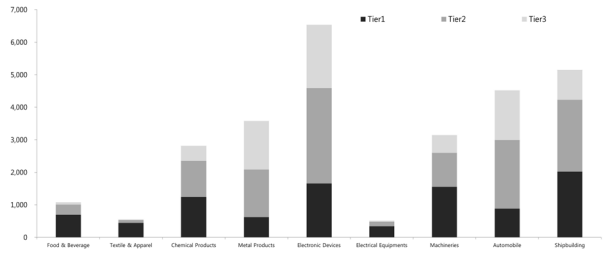

Figure 2. Number of suppliers by tier in 9 Two-digit manufacturing industries.

barrier into which is known to be relatively low. On the other hand it is less than ten in such industry as automobile, the entry barrier into which is known to be relatively high. It can be noted that the ratio of the affiliates of big business groups among the flagship companies is also different by industries. It is very low in such industries as textile and apparel, food and beverage, electrical equipment and electronic devices, but relatively high in such industry as chemical products.

Figure 2 displays the number of each type firms from the first-tier to third-tier by 9 two-digit industries. As can be seen in the figure, the number of firms, involve din the supplier network, is relatively large in the assembly and processing industries such as electronics, shipbuilding, and automobiles. On the other hand the number is relatively small in the electric appliances industry and in the light and consumer's product industries such as textile and apparel and food and beverage.

2.2 Openness of the Network

If the transactional relationship of a firm is open, that firm keeps transactions with many firms. But if it is closed, the firm keeps transactions with very few firms and its sales highly depend upon them. So the openness of a supplier network can be measured by the sales concentration ratio of a firm involved in the supplier network. Furthermore the sales concentration ratio (SCR) of a firm can be measured by the following Hirschman-Herfindahlindex[6].

$$SCR = \sum_i S_i^2 \qquad (1)$$

In equation (1), S_i represents the share of the amount of sales to firm i in total sales of the firm, and the index increases as the sales of the firm concentrates to a few firms ($0 \leq \mathbf{SCR} \leq 1$). Therefore the structure of supplier network could be said to become more closed as SCR increases, and more open as SCR decreases.

Figure 3 represents average values of SCR by 9two-digit manufacturing industries. It can be identified that the degree of openness of the industry such as food & beverage, in which the affiliate companies of the Korean big business groups do not take an active role as a flagship company, is relatively high. But on the other hand, the degree of openness of the industries such as shipbuilding and automobile in which the affiliate companies of the Korean big business groups take a remarkable position as a flagship company is relatively low.

Now in Figure 4 the characteristics of the supplier network of the 9 2-digit manufacturing industries are represented by the two indices: average order of the tier and reciprocal of the average value of SCR of all the firms except the flagship company in an industry. Here we can see that the network is more hierarchical in such as automobile and ship building industries in which the core firms of the Korean big business groups provide final goods. On the other hand it is relatively less hierarchical in light and consumer products industries, in which non-affiliates of the Korean big business groups take a great share as flagship companies.

It also can be identified that the network is more hierarchical in such industries as electronic devices, automobile and metal, the production process of which is technologically divisible or its product is module-type, on the other hand it is less hierarchical in such industries as textile and apparel, food and beverage, and electrical equipment, the production process of which is technologically indivisible. The degree of the openness of a network is higher in such industry as food and beverage, the market structure of which is competitive and in which the core firms of the big business groups do not participate as flagship companies. On the other hand it is lower in such

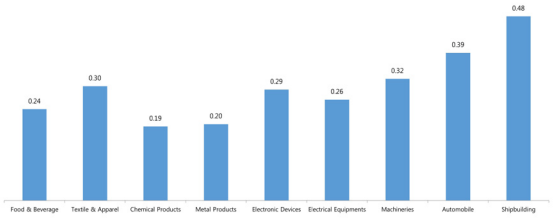

Figure 3. Average value of sales concentration ratio (SCR) by 9 Two-digit manufacturing industries.

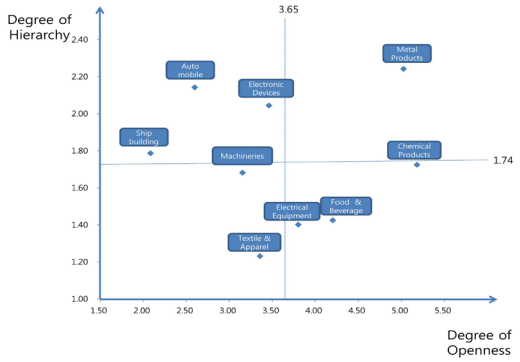

Figure 4. Hierarchy and openness of the supplier networks by 9 Two-digit manufacturing industries

industries as shipbuilding and automobile, its market is highly oligopolistic and the core firms of big business groups take an active role as flagship companies in the market.

3. The Effect of Network Structure on the Productivity and the Profitability of Firms

3.1 Productivity of Firms

The hierarchical position of a firm in the supplier network will have an influence on the productivity of firms. The productivity of the flagship company will be the highest, and the productivity of the firms involved in the network will be the next highest, and the productivity of the independent firms not connected to any supplier network will be the lowest. Among the firms involved in the same supplier network, a firm's productivity will increase as the hierarchical tier of the firm decreases. One of the reasons is that the buying firm wants to select more efficient firm as its transaction partner. So the firms involved in the supplier network are more efficient than the firms not connected to supplier network. Further more a firm of the first (second) tier in the transactional hierarchy is more efficient than a firm of the second (third) tier, since the firms involved in the network want to transact with the firms in a higher hierarchical tier.

Another reason is related with the stability of the firm's sales partner. As sales partners of a firm become more stable, so the demand also becomes more stable. The stability of demand for a firm's product makes the environment for investment better, and more investment makes the firm more productive. Furthermore stable relationships with sales partner enable a firm to invest into relationship-specific assets and skills, which can raise its productivity[7, 8,9]. It is generally accepted that the firms involved in the supplier network have more stable relationships with their sales partner than those of the firms not involved, and that the firms in the higher hierarchical tier have more stable relationships with their transaction partner than those of the lower tier in the hierarchical network. So the firms involved in the supplier network are more productive than the firms not involved, and a firm in the first (second) tier in hierarchical network is more productive than a firm in the second (third) tier.

How does the sales concentration of a firm, which measures the openness of the supplier network, have an effect on its productivity? When sales concentration of a firm becomes higher, it is more probable that the stability of its sales relationship increases. This means that a firm of more sales-concentrated has better incentive to invest both general and relationship-specific investment as mentioned above. Therefore it can be said that a firm of more sales-concentrated becomes more productive than less sales-concentrated firm.

We examined the above hypotheses on the effect of the characteristics of networks upon total factor productivity (TFP) by multiple regression analysis, and used the equation (2).

$$TFP_i = \beta_0 + \beta_1 Z_i + \sum_k \beta_{2k} NET_{ik} + \varepsilon_i \qquad (2)$$

This equation means that a firm's Total Factor Productivity(TFP) depends upon the firm's internal competency(Z), and the firm's position in the supplier network (NET). In estimating total factor productivity (TFP), we measured labor(L), capital(K), and output (Y) by number of employment, total amount of asset, value-added. We selected firm's age(lnYR) ,export ratio(XR),big firm dummy (BIG) and medium firm dummy (MED)as variables of the internal competency (Z). As a variable tore present the characteristics of the supplier network, in which a firm is involved (NET), we used sales concentration ratio(SCR) and subcontracting sales to total sales of a firm (SUBR) as well as various dummy variables representing a firms position in the supplier network such as flagship company (FS), firm whether or not connected tonetwork (SUB), and the order number of the tier in the supplier network(Tier1, Tier2, Tier3). In addition, industry dummies (ID) are also used as control variables. The OLS regression results are summarized in Table 1.

The explanatory power of all the regression equations is not so high, but all the equations are significant at 0.01 level. In equation (1), the estimated coefficient of FS and SUB is both positive at the significance level of 0.01, and the coefficient of FS is larger than that of SUB. This implies that the productivity of flagship companies is the highest, and the firms connected to the flagship company through supply chain are more productive than the firms not connected. In equation (2), in which SUBR, measured by the share of subcontracting in total sales, is used as an explanatory variable instead of SUB, the estimated coefficient of SUBR is also positive in the significant level of 0.01.

In regression equation (3) and (4),in addition to the variable SUBR, all the variables FS, Tier1, Tier2, and Tier3that represent a firm's hierarchical position in the

Table 1. Network positin and productivity

	(1)	(2)	(3)	(4)
lnYR	0.002 (1.09)	0.002 (1.62)	– 0.002 (0.93)	– 0.003 (1.31)
BIG	0.063 (6.72)***	0.063 (6.86)***	0.061 (6.50)***	0.070 (7.48)***
MED	0.013 (2.79)***	0.014 (3.00)***	0.011 (2.37)**	0.008 (1.64)
XR	0.022 (2.14)***	0.019 (1.81)*	0.026 (2.50)**	0.032 (3.15)***
SUB	0.017 (4.32)***			
SUBR		0.021 (4.87)***	0 .011 (2.33)**	
SCR				0.043 (6.33)***
FS	0.073 (3.66)***	0.080 (4.02)***	0.088 (4.42)***	0.092 (4.44)***
Tier1 Tier2 Tier3			0.018 (4.20)*** 0.019 (3.95)*** 0.013 (1.78)*	0.019 (4.62)*** 0.019 (4.11)*** 0.013 (1.84)*
Const	– 0.142 (16.03)***	– 0.141 (16.18)***	– 0.139 (15.85)***	– 0.124 (13.22)***
Adj. R^2	0.023	0.023	0.024	0.028
F-VALUE	19.40***	19.58***	18.51***	16.88***
OBS	22,768	22,768	22,768	17,773

Notes: The Numbers in the parentheses are t –values and industry dummies are used. ***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% levels respectively.

supplier network, have positive and statistically significant coefficients. Furthermore the coefficient of FS is the largest among all the variables representing the hierarchical positions of firms, and both coefficients of Tier1 & Tier2 are larger than that of Tier3. This result can be interpreted that productivity of a firm will increase as the hierarchical tier of the firm decreases, even though the coefficient of Tier2 is slightly larger than or equal to that of Tier1. Moreover in equation (4) the coefficient of SCR is also positive at the significance level of 0.01. This means the productivity of the more sales concentrated firm is higher than that of the less concentrated firm. These results support all the hypotheses, which we established about the effect of the characteristics of supplier network on the productivity.

3.2. Profitability of firms

It can be identified from the above regression analysis that a firm gains the benefit of productive efficiency from connecting tointer-firm supplier networks. This efficiency is quasi-rents, which is originated from the relationship-specific investment of suppliers[6,10,11]. But how will these quasi-rents be distributed among the firms involved in the supplier network? The bargaining power in transaction will play an important role in the process of the distribution of these quasi-rents. It goes without saying that the bargaining power of the flagship company is the greatest, and it decreases as the hierarchical position of a firm goes down from the first to lower tier.

If much of the quasi-rents, originated from the cooperative supplier network, transfer from the lower level of the hierarchy to the higher one, the greatest part of them will be distributed into the flagship company, and the next greatest part goes into the first-tier supplier, and the next is the second-tier and then the third and the rest-tier. As a result, the operating income of the firm connected to the supplier network, especially the firmof the lower level in the hierarchical network, willnot always bemore than that of the firm not connected to the network. But if the transfer of the quasi-rents does not occur, the size of the operating income of a firm will be independent of its position in the hierarchical network.

We examined empirically if the transfer of quasi-rents occurs by multiple regression analysis, and used the equation (3).

$$\pi_i = \gamma_0 + lnZ_i + \sum_k \gamma_{ak} NET_{ik} + \epsilon_i \qquad (3)$$

A firm's profitability(π) depends upon internal competency (Z) such as technological and marketing capability as well as the network characteristics (NET). As the dependent variable representing for a firm's profitability(π), we selected the operating income to sales of a firm. Technological capability is measured by the

log-transformation of the value-added per labor ($\frac{\ln Y}{L}$) and marketing capability is measured by the log-transformation of the advertising expenditure(lnPR). In addition, log-transformation of the sales (lnQ), and log-transformation of the firm's age(lnYR), big firm dummy (BIG), medium firm dummy (MED), export ratio(XR) are added as proxy variables for internal competency. Besides, industry dummies (ID) are also added as control variables.

As variables representing for a firm's hierarchical position in the supplier network, we use the same dummy variables as the former regression analysis for the productivity; the share of subcontracting in total sales(SUBR), firms connected to the supplier network(SUB), flagship company(FS), and the order number of the tier in the supplier network(Tier1, Tier2, Tier3). Sales concentration ratio (SCR) is also used as an explanatory variable. But the expected sign of this variable is inconclusive. On the one hand it will have a positive effect, because the amount of the quasi-rents arising from the relationship-specific investment increases as sales concentration ratio increases. On the other hand it will have a negative effect, because the bargaining power decreases as sales concentration increases. The total effect of this variable will be positive if the former positive effect is larger than the latter negative effect, and negative *vice versa*.

The OLS regression results are summarized in Table 2. Adjusted R^2 of all the regression equations are not so high but statistically significant at 0.01 level. In equation (1), the coefficient of the variable FS is positive in the significant level of 0.01. Andthat of the variable SUB is negative in the significant level of 0.01. This result shows that most of the quasi-rents, created from the relationship-specific investment of the subcontracting firms connected to the supplier network, are distributed to the flagship company due to its overwhelming bargaining power. This can be also confirmed in the results of the equation (2), (3) and (4), the coefficient of the variable SUBR is negative and significant at 0.1level, and the coefficient of the variable SCR is positive but insignificant in equation (4).

In equation (3) and (4), the variable of a firm's order number in the hierarchical network, Tier1, Tier2, and Tier3 are included instead of SUB, in order to examine if the amount of the quasi-rents distributed to the firms will become different according to its hierarchical position in the supplier network. The coefficients of the variables, FS

Table 2. Network position and profitability

	(1)	(2)	(3)	(4)
lnQ	– 0.012 (33.57)***	– 0.012 (33.91)***	– 0.012 (33.76)***	– 0.013 (31.06)***
ln(Y/L)	0.024 (42.56)***	0.024 (42.91)***	0.024 (42.53)***	0.024 (36.92)***
lnYR	0.005 (9.64)***	0.005 (9.33)***	0.005 (9.02)***	0.005 (8.31)***
lnPR	0.001 (6.18)***	0.001 (6.03)***	0.001 (5.95)***	0.001 (5.62)***
BIG	0.026 (11.05)***	0.026 (11.15)***	0.026 (11.13)***	0.029 (11.42)***
MED	0.017 (13.67)***	0.017 (13.69)***	0.017 (13.56)***	0.016 (13.14)***
XR	– 0.002 (0.91)	– 0.002 (0.95)	– 0.001 (0.63)	– 0.001 (0.39)
SUB	– 0.003 (3.04)***			
SUBR		– 0.001 (1.20)	– 0.002 (1.88)*	
SCR				0.002 (1.11)
FS	0.031 (7.75)***	0.031 (7.62)***	0.032 (7.87)***	0.038 (8.03)***
Tier1 Tier2 Tier3			0.002 (2.21)** 0.001 (1.20) – 0.002 (0.98)	0.003 (3.35)*** 0.002 (2.46)** – 0.000 (0.07)
Const	0.133 (26.19)***	0.133 (26.24)***	0.136 (26.17)***	0.143 (23.96)***
Adj. R^2	0.125	0.125	0.125	0.125
F-VALUE	95.27***	94.98***	87.08***	68.12***
OBS	21,068	21,068	21,068	16,438

Notes: The Numbers in the parentheses are t –values and industry dummies are used.***, **, and * indicate that the coefficient estimate is significant at the 1%, 5%, and 10% levels respectively.

and Tier 1are all positive. The coefficient of Tier 2 is also positive in equation (4) but insignificant in equation (3). On the other hand, the coefficient of Tier3 is negative and insignificant in both equation (3) and (4). Moreover, the value of coefficient of the variable FS is the largest, and much larger than those of the variables Tier1, Tier2, and Tier3. It can be identified again from these results that most of the quasi-rents are distributed into the flagship companies. It is also interesting to note that the values of the coefficients of the variables, Tier1, Tier2, and Tier3 are in sequential order, i.e. Tier1 > Tier2 > Tier3. It implies that the bargaining power against the distribution of the quasi-rents decreases as the distance of a firm from the flagship company in the supplier network increases.

4. Conclusion

The DB of the Korean Enterprise Data Inc. includes both the amount and the partner of sales of the 23,839 firms, which is essential for the analysis of the buyer-supplier network. Based on this DB, it is clarified that the structure of supplier network among the Korean manufacturing-firms is different by industries. It was also identified that firm's position in the supplier network has an impact on both the productivity and profitability. Especially it was found that a firm can get the benefits of increasing productivity from participating in the supplier network, but most of these benefits are attributed to the flagship company due to its overwhelming bargaining power. In other words, the profitability of the firms in the supplier network decreases sequentially as the order number of tier of the firm due to the unequal bargaining power among the firms in the network.

One of the most important policy implications is that regulations against the inter-firm transaction should take different forms according to the network structure of industries. The general form of regulations against an unfair trade may be pertinent and effective in the industries, where inter-firm transactions are not repetitive. In these industries, the amount of the quasi-rentsto be created is not so large, because the firm in the supplier network does not have an incentive to invest in relationship-specific assets. The possibility that the sequential transfer of the quasi-rent takes place is also low, because bargaining power is not unequal among the firms involved in the supplier network.

But in some industries, the transactional structure and relationship of which is characterized as multi-level hierarchical and repetitive, both the absolute size of the quasi-rents, created from the supplier network, and the possibility of the transfer of the quasi-rents from lower-tier firms to higher-tier firms and flagship companies are great. In these industries, general forms of regulations, such as regulating a breach or a unilateral change of a contract, are not sufficient. Some different kinds of regulations should be necessary in order to increase the long-run efficiency.

The most common mechanism of the transfer of the quasi-rents is that the buying firm takes advantage of the information, acquired in the repetitive transaction, on the supplier's technology and cost price. So it is difficult to mitigate the unequal distribution of the quasi-rentsonly with the traditional regulations against the unfair trading. In these cases it is necessary for the fairness of the transaction to reform the institution itself toward enhancing the weakened bargaining power of supplier; for example to regulate the buyer's requiring the seller's information of technology and cost, or to permit the sellers to bargain collectively. Moreover considering the asymmetry in the sense that buying firm participates in the distribution of the seller's income, but seller does not participate in the distribution of buyer's income, it is desirably recommended to introduce a kind of 'profit sharing' program in which the quasi-rents should be divided according to the pre-determined rules among the firms involved in the supplier network.

5. Acknowledgment

This work was supported by a Research Grant of Pukyong National University(year 2015). The main idea of this work was based upon the author's previous research[6].

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