Competitiveness and finance of supply chains: Considerations on optimisation

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ABSTRACT

The financial aspect of supply chain (SC) management is a somewhat neglected research area, while earlier papers showed that it has a strong link to competitiveness. Our main contribution to literature is to analyse the competitiveness effects of SC financial management decisions under perfect information and cooperation among SC members the absence of which may distort empirical findings. Our simulation-based research shows that even in case of perfect foresight seasonality decreases the profitability and the ability to grow while increasing the capital need. But, we also conclude that cooperation of SC members may reduce this additional capital need while enhancing the profitability and the growth, thus leading to higher competitiveness. This cooperation may be achieved through regulating payment terms or introducing special fees to be paid by the SC members to the dominating company of the SC. Thus, an economic policy aiming at providing cheap capital to firms at a lower level of SC or increasing their added value at the costs of other SC levels may decrease the competitiveness of the SC in whole.

INTRODUCTION

When analysing supply chains (SCs), usually the management of flow of (1) goods and services, (2) rights, (3) information and knowledge (technology), and (4) financial resources are listed as critical issues (Pfohl – Gomm, 2009). This article focuses on this later point.
Based on an extensive survey of Indian firms, More and Basu (2013) highlight that the most critical challenge is the lack of shared vision among SC members (SCMs). The unpredictability of cash flows resulting from delayed financial transactions, poor automatization of financial processes, and weak knowledge of SC finance tools are among the fundamental problems. They call for more collaboration among SCMs to increase the financial stability of the SC. However, what would be the SC like if this cooperation were perfect? In this article, we focus on possible optimisation of the payment process, assuming no information barriers among the SCMs.

LITERATURE REVIEW

Recently various papers focused on SCs, particularly on the competitiveness of them and the new methods to solve finance issues. Still not too many articles examined how competitiveness and financing of SCs are connected.

Competitiveness of supply chains

The term of supply chain management appeared in the literature in the 1980's. Since then, many papers proved that the efficient management of SCs increases the competitiveness of the individual SCMs and so the total of the SC (Marcuta and Marcuta, 2013).
At the same time, measuring SC competitiveness could be very complicated. It is usually measured by the sum of production costs, quality offered and flexibility of the network. Marwah et al. (2014) emphasise that both increased efficiency of SCMs and the improvement of SC activities themselves may lead to improved competitiveness.
Based on case studies on Indian automotive component manufacturers, Joshi et al. (2013) even identified 24 factors of competitiveness within eight groups (cost, flexibility, quality, delivery, buyer-supplier relationship, technology, environmental factors, and customer demand).
Instead of focusing on such influencing (input) factors, we may estimate competitiveness from the output side by measuring the growth of sales, export or employment, in addition to achieved profitability and capital efficiency (business performance) of the SCMs. As for UK Oil and Gas industry Yusuf et al. (2014) found three SC agility factors with high correlation to the business performance: "cooperating to compete" (long-term partnership, reward based on team performance etc.), "mastering change and uncertainty" (rapid decision making, proactive response to changes etc.) and "leveraging the impact of people and information" (information accessibility, team spirit etc.).
Hult et al. (2007) underline that in SCs culture of competitiveness and knowledge development have a positive association with performance. They highlight that during turbulent times the link to knowledge development becomes stronger, while culture of competitiveness seems to lose its effects.

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Finance for supply chains

Literature on SC finance usually takes one of two perspectives: papers either focus on products of financial institutions to cope with accounts payable and receivable issues or concentrate on the whole of the SC and the reduction of the working capital need (inventories included) and sometimes also on financing invested assets (Gelsomino et al., 2016).

Still, both of these research directions are far from being complete. Pfohl and Gomm (2009) underline that contrary to flow of goods and information only limited research was done in the field of financing supply chains. Even in those, the cost of capital stayed mostly neglected. Those are the amount of capital needed, the cost of that capital and the flow of cash achieved by employing the given capital that determine the value of the given company. Therefore, it is not only by individual inventory, process, and cash management but also by collaboration and synchronisation among supply chain members and optimisation of funding costs that we may enhance value creation. Based on this logic, we should not only minimise the capital need of the SC, but extraordinary efforts should be made to achieve that the highest amount of capital need emerges at the SCM facing the lowest cost of financing. Of course, when optimising, we also have to consider the duration of that financing need. To be able to do so, Pfohl and Gomm (2009) underline the importance of the information flow among SCMs.

Cavenaghi (2013) highlight that this information is needed not only by SCMs but also by the banks providing financing to them as no matter which member of the SC they finance at the end of the day the financial institutions take the payment risk of the final customer. The management of these new complex and integrated systems call for new risk management tools instead of the standard methods (Chun-Lian, 2016).

Based on case studies, Liebl et al. (2016) emphasise the vast opportunity reverse factoring may offer in supply chain financing. In those cases, buyers seek the help of financial institutions to be able to pay suppliers early to reduce the risk of shocks a bankruptcy at earlier SC levels may generate. This tool is more often used by buyers with a weaker bargaining power as they seem to focus on strengthening of the relationship to key suppliers with a flawless track record.

Based a theoretical optimisation model, Wuttke et al. (2016) showed that introducing SC finance program (where thanks to the main buyer suppliers receive financing on their account receivable at preferred term in exchange for accepting longer payment terms) is a dynamic process where timing is an essential factor. They conclude that the immediate introduction of such a system is not always beneficial for the buyer. It seems that high procurement volume and long initial payment terms both promote the introduction. Extending deadlines under SC financing, which may limit the number of suppliers, is only advantages buyers with lower financing cost, high procurement volume and long initial payment term.

Focusing on the management practices, based on a sample of 110 Malaysian electronics manufacturer, Sundram et al. (2011) identified six dimensions having a significant effect on the SC performance. Like Basu (2013), they found that agreed (1) vision and goals (i.e. a kind of central coordination) are the most critical factor, but also (2) strategic supplier partnership, (3) information sharing, (4) information quality, (5) postponement strategy and (6) risk and reward sharing play a statistically significant role.

Finance of supply chains and competitiveness

The performance of an SCM is strongly linked to that of the SC. Using a Romanian sample, Gyula (2013) showed that the financial, marketing and innovation performance of the SC have a positive and statistically significant impact on the overall organisational performance.

Filbeck et al. (2016) proved for US automotive manufacturers that supply chain disruptions do not only affect negatively the share price of the company being hit but also those of the competitors. This link was particularly strong in bear markets, but not present for Japanese carmakers.

Pino et al. (2010) modelled a SC in a multi-agent system to show that even in case of a flat final demand a vast variation could emerge in the demand lower level SCMs face, called the ‘‘bullwhip effect’’. They conclude that this variation caused by the separate management of the SCMs can be dramatically reduced using MASs methodology. That is why our simulation built on perfect information assumes no such distortions. They underline that removing fluctuations from demand reduces the capital need of SCMs.

MODEL DESCRIPTION

Our model focuses on the financial management issues of an SC. We examine how different financial parameters influence the competitiveness (measured by the ability to grow) of the SC, and how perfect cooperation would transform financing and payment terms to maximise shareholder value (total cash flow achieved).

The SC in our model has three levels: A sells to final customer (market), B is the main supplier of A and the main buyer of C that purchases raw material at a price of 10 per unit. A, B, and C could each be considered as a single company, or a representative merged firm for the given level in the SC. Only A has sales outside of the SC. We assume perfect foresight regarding the demand level. Each level needs one period (month) to produce its final product from the product purchased from its supplier. Thus, in any given period A produces the required quantity in line with the market demand (D_t), but places an order with company B equal to (D_{t+1}). B produces this amount but places an order with C equal to D_{t+2}. So, C manufactures at time t the amount needed at time t+2.

When manufacturing, the firms have to pay immediately for wages (any cost not related to SCMs they purchase from), but they pay for the SC products P days later. Payment terms may not be the same for different SCMs.

As manufacturing needs one period, suppliers need to deliver at the start of the period, thus if P=0 payment to suppliers is due at the beginning of the period.
At the end of the period, all SCMs deliver their products to their buyers but collect the income only R days later. (R may be different for all players.) Due to the set-up of the SC, $P_A=R_B$ and $P_B=R_C$.
Two measures control profitability of the SCMs. Added value (AV) of their product is added to the price of their supplier to calculate their selling price. But a given percentage of AV (Wage%) has to be spent on wages and other costs due immediately.
The simulation starts with setting up manufacturing capacities: we assume that to perform production for each of the SCMs 1 unit/piece invested asset is needed. We have to purchase the machines by the start of the actual manufacturing period, so the payment for the machines takes place a period earlier. If production increases, the additional investment is deducted from the accumulated cash. (Equation 3 and 12.) Initial capacity setup takes place for all companies at the period -2 and that investment is considered as part of the initial capital need.
As a next step, the cash flow of each period is calculated, and the result is added to the opening cash balance. To evade bankruptcy, each of the SCMs has to hold a certain amount of cash at the start of the simulation, representing their working capital (WC) need. This WC (together with the machines) is financed at a cost, though. Cost of capital (CoC, e.g. interest payment or dividend required) may be different for each of the firms. The cash balance is decreased at the end of each period by the starting amount of capital (covering WC and initial machines) times CoC.
This calculation method assumes that firms need to hold a WC enough for to survive the total simulation period right from the start (capital may not enter or leave the company, e.g. there is no dividend payment). There is no loss of capacity due to the usage of the machines and during the simulation period neither the price of the products or the machines changes.
The simulation covers 30 periods, where the first period is the one in which A first sells its products, implying that manufacturing at C starts in period -2. To measure the competitiveness of the SC, we calculate the individual and total amount of start-up capital required to survive simulation period, total additional cash amount generated by the end of the simulation (as a measure of profitability), and maximum growth the SC may survive using a certain amount of capital.
SC is facing a final market demand for the product of A that is calculated based on equation 1 and 2.

$$D_t = D_0 * \prod_{i=1}^{t}(1+g_i) * (1+s) \quad (1)$$

$$s = a * sin(c * (t-1)) \quad (2)$$

D stands for the amount of demand, t indicates time (starting from 1), g shows the growth rate of the period, s for the seasonality trend. Constants a and c describe the form and size of seasonality effect and their value were chosen to be 25 percent and 101 respectively. $D_0*(1+g_1)$ equals to 100 in all cases.
The cash flow of any period is calculated using formula 3 and is added to the initial cash amount.

$$CF_t = Income_t - Wages_t - Mat_t - Inv_t \quad (3)$$

where

$$Income_t = \\ = (x * Q_{t-int(\frac{R}{30})-1} + (1-x)Q_{t-int(\frac{R}{30})}) * SPrice \quad (4)$$

$$x = \frac{R}{30} - int\left(\frac{R}{30}\right) \quad (5)$$

$$Q_{A,t} = D_t \quad Q_{B,t} = D_{t-1} \quad Q_{C,t} = D_{t-2} \quad (6)$$

$$Sprice_A = Sprice_B + AV_A$$
$$Sprice_B = Sprice_C + AV_B$$
$$Sprice_C = Sprice_{Raw} + AV_C \quad (7)$$

$$Wages_t = Q_t * Wages\%_t \quad (8)$$

$$Mat_t = \\ = (y * Q_{t-int(\frac{P}{30})-1} + (1-y)Q_{t-int(\frac{P}{30})}) * PPrice \quad (9)$$

$$y = \frac{P}{30} - int\left(\frac{P}{30}\right) \quad (10)$$

$$Pprice_A = Sprice_B$$
$$Pprice_B = Sprice_C$$
$$Pprice_C = Sprice_{Raw} \quad (11)$$

$$Inv_t = max(0, (Q_{t+1} - Q_t) * 1) \quad (12)$$

The initial cash is determined by iteration that aims to find the minimum amount enough to have all of the end of period cash balances (from the period -2 to 30) above 0.

SIMULATION RESULTS

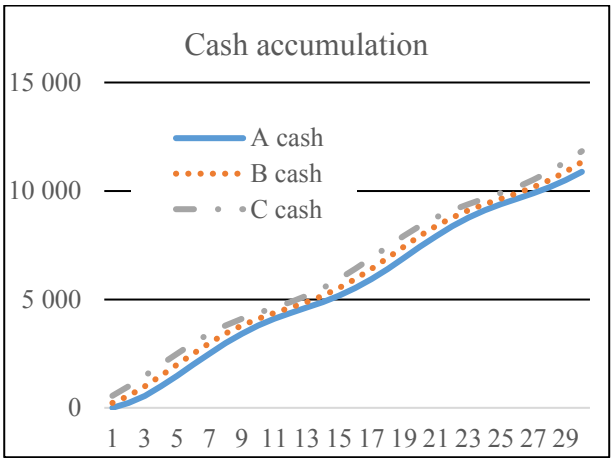
First, to have a reference point, we run the simulation with the parameters in Table 1. We picked 30 days (1 period) as a payment term for all participants. As procurement takes place at the start of the period and the sale happens at the end of it, this means that there is a financing gap of 1 period for all players. Demand was flat at 100 pieces for all the periods.

Table 1: Base scenario

Firm	A	B	C
Payment days	30	30	30
Added value	10	10	10
Wage (% AV)	60%	60%	60%
Cost of capital	1%	1%	1%

Our result shows that the SC needs altogether 4899 units of initial capital to set up, but due to the stable operating cash flow of 400 for all SCMs in each period at the end of period 30, there will be 29633 extra cash accumulated. Both investment need and cash profit are distributed equally among the firms. To be able to grow by 1 percent monthly (12.7 percent yearly), this system needs 30 units (0.6 percent) of additional capital. Thus, accumulated cash rose to 33660.

When adding the seasonality effect to the non-growing market demand, the capital need rises to 5244, while cash accumulated decreased by 2.8 percent to 28807. (This increase is in line with the results of Pino et al. (2010).) When adding 1 percent growth, capital need climbs to 5278, while accumulated cash reaches 32426. This means that in case of growth the seasonality boosted investment by 7 percent while reducing profit by 3.7 percent. Hence, our model supports well the empirical experience that fluctuations in demand may raise capital need, slow growth, and cut back on the profitability of the supply chains (More – Basu, 2013) even in case of perfect foresight.



Figures 1: Base case with seasonality

While the base scenario investigated a SC where members were identical, usually we find huge differences among SCMs. We examined two further cases. (1) SC build on smaller firms and controlled by a big multinational and a (2) distribution channel where the huge producer sells its localised products first to regional and then to local retailers. In the first case, added value content and market power of the firms increases along the SC, while in the second case the opposite is likely.

Table 2 shows the parameters of the scenario describing the manufacturing SC of a large multinational company (e.g. a global car manufacturer). We assumed that both A and B could achieve longer payment terms than their receivable turnover days, but C still has to pay for the raw materials after 30 days. (The market pays to A in 30 days.) Note that the total added value and cost is the same as in the base case.

Table 2: Manufacturing SC of a large multinational company

Firm	A	B	C
Payment days	45	60	30
Added value	15	10	5
Wage (% AV)	60%	60%	60%
Cost of capital	0.5%	1.0%	1.5%

The total start-up capital need of this SC is 6242 (27.4 percent more than the base case) 43 percent of which is needed in company C characterised by the highest cost of capital and lowest profitability (only 40% of its 5 added value remains with the company). When seasonality added, the minimum capital requirement climbs by further 10 percent to 6780. (The growth is similar for all SMCs.) The total of accumulated cash by the end of the last period reaches 27523, 59 percent of which remains with firm A investing only 30 percent of the total capital. Only 5 percent of the return was realised by company C who was the top investor. This finding is again in line with empirical results: the companies at the bottom of the SC complain about weak profitability and high investment need.

Would this SC be more competitive if payment terms remained the same as in the base case? The answer is positive with no doubt. Total capital need when seasonality included is 5226 (24 percent less), while total extra cash accumulated climbs by 3.3 percent to 28422. Capital need is more fairly distributed (A: 39.1%, B: 33.5%, C: 27.5%) just like accumulated cash (A: 52.1%, B: 33.7%, C: 14.1%). The only problem is that this results in A receiving 8.7 percent less of cash, while B faces a decrease of 3.1 percent so that C could get 187.8 percent more. It is clear to see that by coordination both A and B could keep its old profit by receiving compensation from C that would then end up with a 64.4 percent growth.

When adding 1 percent growth, the capital need of the coordinated system (same payment terms) is 23.4 percent less, while cash accumulated is 3.3 percent more. It seems that in case of a strict capital constraint reducing the burden on the SCM with the highest financing cost by offering more advantageous payment terms would be for the benefit of the whole SC and also all the individual SCMs. These findings are in line with Bassu (2013) and Pfohl and Gomm (2009). It seems that it is in the interest of the most powerful SCM not to use its position on extending its payment terms instead to convince the other SCMs to take part in an overall cooperation system.

At the same time, there is another significant conclusion. Many countries support local firms to be a member of multinational SCs expecting a general improvement in the performance of the economy. But, easing on capital constraints by state subsidies lessens the pressure for cooperation and thus reduces the competitiveness of the given firm and SC too.

Another common goal of countries hosting mostly firms joining global SCs at a lower level is to enhance the added value content of the local companies. Let us examine, how relocating some of the high added value functions would modify the competitiveness of the SC. If added value of C would amount to 15, while that of A is cut to 5 in the no-cooperation case (without growth and seasonality) capital need grew by 10 percent, while final cash raised only by 1 percent. When focusing on firm C alone, it will see its capital need to be increased by more than 46 percent (as higher AV implies more wage to pay asking for more WC), while its final cash amount will grow by more than 483 percent.

This result means that by achieving the relocation competitiveness (capital efficiency) of the whole SC decreases while that of C increases radically. Because now a more significant part of the total SC capital need is financed at a country with a higher cost of capital and C improves at the expense of B and A, in the long run, all SCMs will be in a worse position. So, moving more AV to earlier level if SC located in less favourable countries is not realistic if the decision is to be made by A dominating the SC and it is not even advantageous for C in the long run.

Our third scenario describes a retail chain. In this case, C is dominant with the highest AV and best financing position. It is by offering advantageous payment term to its buyers (very often own subsidiaries) that financing is provided to A and B operating with a higher cost of capital due to their smaller size and less advantageous location (e.g. riskier countries). Critical parameters are summed up in Table 3.

Table 3: Retail SC of a large multinational company

Firm	A	B	C
Payment days	60	60	30
Added value	5	10	15
Wage (% AV)	60%	60%	60%
Cost of capital	1,5%	1,0%	0,5%

This SC needs a total capital of 7468 and accumulates a total of 29607 cash. This structure transfers profit from C to A. A invests 18.2 percent of total capital but receives 24.8 percent of the cash, while C invests 51.4 percent and gets 45.9 percent only. (B has a share of almost 30 percent in both cases.) This allocation could be particularly advantageous if all SCMs belong to the same group and A faces a lower corporate tax rate.

If 1 percent growth is added, the capital need grows by 0.9 percent, while total final cash increases by 13.7 percent. Interestingly, capital need at B climbs by 1.2 percent, while that of A and C only by 0.8 percent. Adding seasonality to the base case causes similar distortions. Total initial capital need grows by 9.4 percent, but while this increase is 8.7 percent for A and 8 for C, B suffers a boost of 12.3 percent. This result calls attention to the fact that the growth and the fluctuation of demand may put very different burdens to SCMs even if no structural change occurs within the SC.

To reduce investment need at C, we may try to balance the return distribution back towards that of the investment. A way for this could be C to charge some fee to A (e.g. for the brand, marketing, know-how, licence fee). For to reflect this transfer from A to C, the manufacturing cost expressed in percentage of AV (Wage) should be modified. To evade distortion, we should keep the total of these costs across the SC constant. Given the original AV and Wage values, these expenses amounted to 18 (60%*5+60%*10+60%*15). For example, assuming a compensation per piece of 1.5, we have to modify Wage ratio of A up to 90 percent, and that of C down to 50 percent in our model.

When doing so, SC will need (without growth or seasonality) 2 percent less capital and produce 0.9 percent more total cash. In other words, this step improves the financial competitiveness of the SC. Under the new rules, A loses 62.3 percent of its original final cash balance, while C receives 35.7 additional cash. This restructuring leaves B is entirely unaffected, what is the main difference in this model between charging a fee and modifying payment terms. Therefore, the fees to be paid by the SCMs to the controlling entity are tools to fine tune the system, that is, they offer a method to force cooperation on SCMs. This new structure including fee payment performs better not only in case of growth, but also in case of seasonality, and when controlling for both of them. (Capital need diminished by 2 percent, total final cash increased by 1.1-1.5 percent.) This outcome is in line with Hult et al. (2007) promoting cooperation in turbulent times and Sundram et al. (2011) addressing fair risk and reward sharing as one of the SC success factors. Our finding implies that in case we assume a rational control over the SC by the dominant player national authorities may decrease the competitiveness of the SC if questioning the rightfulness and limiting the amount of such fees (see transfer pricing regulations).

Table 4 summarises our findings in details. Base scenarios refer to the primary assumptions related to the three major cases (identical firms, SC of a large multinational company and retail chain with a dominant actor). Relative changes are calculated to the base scenarios within each case.

Table 4: Summary of scenarios and results

Case	Scenario	Parameters*					Relative changes to Base scenarios			
							Flat demand		+1% growth in demand	
		Payable turnover days	Added value	Wage ratio	Cost of capital	Seaso-nality	Initial capital	Cash accu-mulated	Initial capital	Cash accu-mulated
Case 1: Identical firms	Base scen.	30-30-30	10-10-10	60%-60%-60%	1%-1%-1%	No	-	-	-	-
	Scenario 1					Yes	7%	-3%	6%	-4%
Case 2: Production chain	Base scen.	45-60-30	15-10-5	60%-60%-60%	0.5%-1%-1.5%	No	-	-	-	-
	Scenario 1					Yes	9%	-4%	9%	-5%
	Scenario 2	30-30-30				No	-22%	2%	-22%	2%
	Scenario 3					Yes	-16%	-1%	-16%	-2%
	Scenario 4	45-60-30	5-10-15			No	10%	1%	10%	2%
Case 3: Retail chain	Base scen.	60-60-30	5-10-15	60%-60%-60%	1.5%-1%-0.5%	No	-	-	-	-
	Scenario 1					Yes	9%	-4%	9%	-5%
	Scenario 2			90%-60%-50%		No	-2%	1%	-2%	1%
	Scenario 3					Yes	7%	-3%	7%	-4%

*Listed parameter values refer to Firm A - Firm B - Firm C in the given order.

MAJOR FINDINGS AND CONCLUSION

Our simulations have confirmed that fluctuations in demand cause fall back in growth, profitability and an increase in the capital need even in case of perfect information, so it is not only the uncertainty about the future affecting performance and competitiveness adversely.

We also showed that cooperation among SCMs might allow for reducing the total investment need while boosting the profitability and the ability to grow, in other words, improves the competitiveness. At the same time, we concluded that easing the capital constraint by state subsidies may hurt the competitiveness of the SC dominated by a big company by reducing the motivation for cooperation.

Our results also imply that relocating more of the added value generation of the SC to firms with weak bargaining power (high working capital need) and a high cost of capital decreases the competitiveness of the SC. Thus, for a long-term advantage, economic policy should also focus on improving macro conditions and payment terms beside of raising added value content of the local firms.

We also showed that growth of the SC might ask for very different additional investment from SCMs even if none of the structural variables changes. At the same time, fees paid by SCMs to the controlling company may offer a tool to enforce cooperation among independent firms. Using them wisely may help to optimise the performance of the SC and boost its competitiveness. In such cases, too conservative national transfer pricing systems may weaken the SC competitiveness.

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