# Social Production Factors in Supply Chain Cooperations

**Laura Koppers [1], Stephan Zelewski [2], Matthias Klumpp [3]**

[1] Key Account Management Public Institutions, 3M Deutschland GmbH,
Carl-Schurz-Straße 1, D-41453 Neuss, Germany
lkoppers@mmm.com
[2] Institute for Production and Industrial Information Management, University of Duisburg-Essen,
Universitätsstraße 9, D-45141 Essen, Germany
stephan.zelewski@pim.uni-due.de
[3] Competence Center Logistics, FOM University of Applied Sciences Essen,
Sigsfeldstraße 5, D-45141 Essen, Germany
matthias.klumpp@fom.de

**Abstract**

Supply chain management concepts largely rely on cooperation. Therefore the economic success of companies within supply chain cooperations depends on the ability and capacity of these companies to build up and nourish cooperation relations. This capacity with its 'social factor inputs' as e.g. trust, experience and motivation can be modelled as a destinctive production factor as it is scalable and relevant for the production output as well as economic value indicators respectively. The described research concept tries to identify this interdependance between social factors and production output in supply chains with a case study research as well as a data envelopment analysis. The results show that supply chains seek a diversity of social competencies and social factor levels in order to optimize their overall economic success. Given this fact, there is on the other hand no evidence, that supply chains require a minimum level of social competences. Next to this, the research brought up the assumption, that it is more difficult for international supply chains to use social factors as an input due to their specific conditions. If this is to be true, advantages of global supply chains would have to be reconsidered.

*Keywords:* Social Production Factors, Supply Chain Management, Supply Chain Cooperations, Social Factors in Cooperations

## 1. Introduction

Companies within a supply chain usually try to optimize their cooperation with instruments described in *Supply Chain Management (SCM)* concepts [5, 24, 49, 50, 68]. For example companies in the textile industry use web portals and extranets to integrate information between companies and in the chemical industry inter-company integrated planning projects are carried out [43]. But besides these instuments and the specific situation and market factors influencing the quality and productivity of supply chain cooperations there are *social factors* as shown in figure 1 within these company cooperations in a supply chain [27, 50].

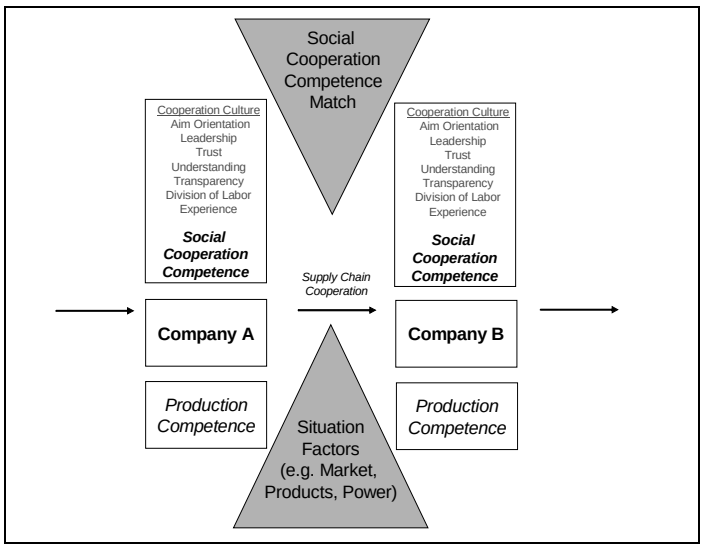


*Figure 1. Supply chain cooperation model.*

The encompassed scientific problem is the *efficient steering of production capacities in supply chain cooperations* [11, 17, 65]. The main suggestion of this approach is that besides existing rational models of using cooperation instruments in order to *improve cooperative information and planning* there is also a social production factor constituted out of the individual social cooperation competencies of the involved companies (chapter 2). The following research hypotheses are derived from the cooperation model above and will be tested in the suggested research: (i) Cooperating companies do not only have complementary production competencies but also *complementary social cooperation competencies*, therefore successful supply chains seek *diverse* not similar social competencies. (ii) Cooperating companies need a *minimum* level of *social cooperation competencies* in order to be able to work together in a supply chain. (iii) Companies in a supply chain cooperation need as much *social cooperation competencies* as possible, therefore successful supply chains seek *similar and high levels of social competencies* in the involved companies. The *scientific method* applied is *action research* with case studies in nine different cases of supply chain cooperations (chapter 3) as *qualitative* research combined with a *data envelopment analysis* calculating a *quantitative* test for the impact of social cooperation competencies on supply chain productivity (chapter 4). The expected scientific result is a suggestion for a *new production paradigm in supply chains* modelling social cooperation competencies as a production factor.

## 2. Concepts of Social Production Factors

The economic base for a discussion of a productive role of *social factors* as e.g. trust or cooperation can be found in the transaction cost theory as e.g. shown by ARROW [6]. In this context social factors are able to *reduce transaction costs* and therefore the overal production costs for companies. Though social factors as trust have a multitude of influencing factors rooted in psychological, sociological and economic areas and are hard to describe or calculate an *increasing number* of behaviour models have been presented in order to gain an understanding in this area; see e.g. [25, 30, 33, 34, 39, 46, 54, 57]. In many business and management contexts such as in SMEs social factors and values are considered to be important for long-term success [3, 67]. In specific areas such as the finance sector, cooperations are discussed (as 'co-opetition') and have been proven necessary when looking back at the business year 2007 [2]. Influences on *cooperation in supply chains* are determined by three characteristics as shown below in figure 2.

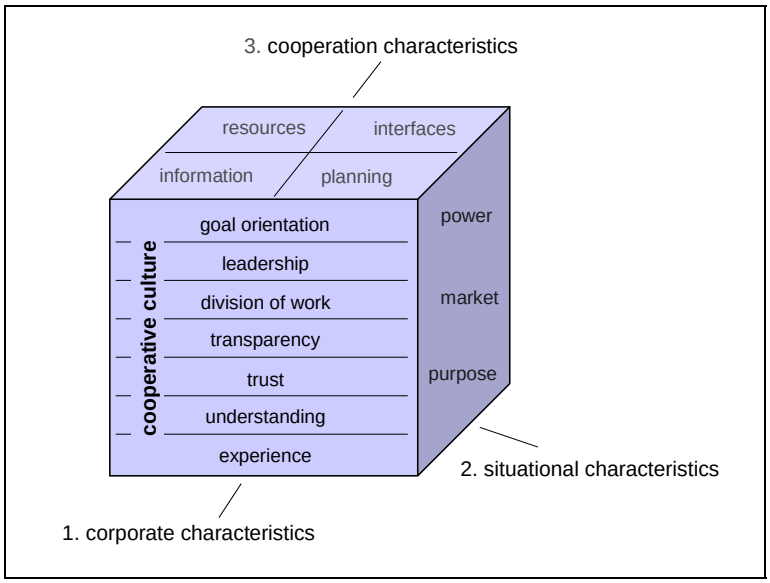


*Figure 2. Influences on cooperation. [43], p. 173.*

Social *corporate characteristics* shape a firm's cooperative culture, which itself influences strongly the success of cooperations of firms [48]. The corporate *characteristics* can be defined for each firm. Situational characteristics of cooperation contain cooperation purpose, market situation and balance of power [27, 58]. In dependence of character and complexity, cooperation may entail the objectives of sharing information, planning, interfaces or even resources. A combination of one, two, three or all four operative objectives is possible.
The success of cooperations depends on the cooperative culture within a firm. Cooperative culture can be defined as the *specific set of ability, willingness and awareness of a firm* and its employees to work in collaboration with other firms to offer customer-oriented solutions [48]. Interdependence between cooperation ability and cooperation willingness can be assumed as it may also be the case with cooperation willingness and cooperation awareness [42].

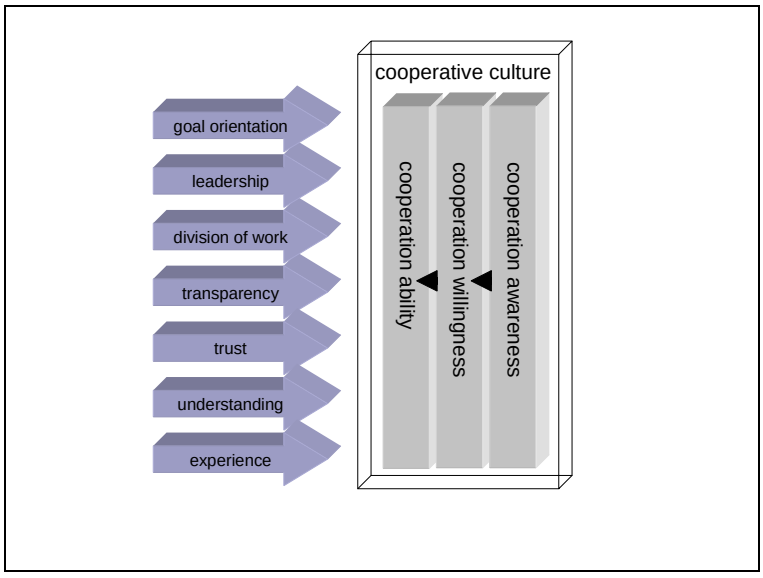


*Figure 3. Influencing factors of cooperative culture in firms. [48], p. 75.*

Cooperative culture in a company (to be seen as an independent production factor) is influenced by the seven factors shown above:

- Goal orientation means, that cooperation partners strive and pursuit common cooperation goals.
- Appropriate leadership arrangements put the employees in the position to collaborate with the cooperation partners, e.g. encouragement of teamwork.
- Division of labour resulting in workload reduction for each cooperation partner.
- If partners have access to cooperation-related information without loss, delay or distortion, transparency exists [35].
- A corporate culture based on trust enables the employees to trust external cooperation partners [10, 48].
- A shared understanding for the business and current situation of the cooperation partner advances the success of cooperation. The knowledge of the cooperation partners business' allows the partner to analyse their strengths and weaknesses and coordinate them accordingly [48, 50].
- Experienced benefits and issues within cooperation can be taken into early consideration of cooperation planning.

Furthermore besides these factors there are also hints from preceding research that companies in supply chains use their cooperation culture or the cooperation competence of external partner companies (substitution strategy) as important factor enhancing their productivity [43].

## 3. Case Study Research in Supply Chains

As a precursor and explorative qualitative method in the field of social factors in supply chains a *case study questionnaire* with eleven questions was developed and sent to 20 companies in a widespread distribution of different fields of economic activity in order to provide a general *representativeness*. The companies have been chosen according to personal contacts of the authors, a similar research method is described in detail in [43]. The addressed and also answered *supply chain cases* are described in table 1 in order to provide a general information about the cases and therefore the background of the following research results. Besides two header questions (identification of companies and supply chains) the results of six *quantitative questions* in the case questionnaires were used for the subsequent data envelopment analysis whereas the three *qualitative questions* are discussed below.

| Industries / Supply Chains | Questionnaire | Feedback Date | Feedback | Case No | Supply Chain |
|---|---|---|---|---|---|
| Textile | 19.12.2007 | 07.01.2008 | 1 Quest. | Nr. 01 | SC 01 |
| Chemical (Machines) | 19.12.2007 | 07.01.2008 | 1 Quest. | Nr. 02 | SC 02 |
| Chemical (Materials) | 19.12.2007 | 19.12.2007 | 3 Quest. | Nr. 03, 04, 05 | SC 03 |
| Electronics | 19.12.2007 | 20.12.2007 | 1 Quest. | Nr. 06 | SC 04 |
| Fast Food | 15.12.2007 | 08.01.2008 | 3 Quest. | Nr. 07, 08, 09 | SC 05 |
| Metal Working | 15.12.2007 | 08.01.2008 | 3 Quest. | Nr. 10, 11, 12 | SC 06 |
| Construction | 18.12.2007 | 06.01.2008 | 1 Quest. | Nr. 13 | SC 07 |
| Energy (Materials) | 18.12.2007 | 20.12.2007 | 1 Quest. | Nr. 14 | SC 08 |
| Health Care | 14.12.2007 | 06.01.2008 | 1 Quest. | Nr. 15 | SC 09 |
| Aviation | 14.12.2007 | - | | | |
| Textile | 14.12.2007 | - | | | |
| Forwarding | 15.12.2007 | - | | | |
| Steel | 15.12.2007 | - | | | |
| Furniture | 18.12.2007 | - | | | |
| Construction Supply | 18.12.2007 | - | | | |
| Steel | 19.12.2007 | - | | | |
| Automotive | 19.12.2007 | - | | | |
| Energy | 19.12.2007 | - | | | |
| Food | 08.01.2008 | - | | | |
| Textile | 08.01.2008 | - | | | |

*Table 1. Research cases in supply chains.*

The following table 2 shows the responses of companies (Nr. 1 to 15) in the adressed supply chains 01 to 09 for the qualitative questions regarding management examples for ‘trust and harmony’ (C2), ‘cooperation and cooperation behaviour’ (D2) and ‘soft factors in general’ (E2). Based on the original responses the following research results can be determined:

- Trust is gained trough positive experience, e.g. reliability or consistency, and needs therefore time, which means that established supply chains are more successful than newly established ones.
- Supply chain cooperations need pragmatism and flexibility: It is important to find the balance between standardized processes and officialdom.

- The lack of answers concerning question 'cooperation' (D2) may be explained by the *middle* specificity level (between 'trust' and 'soft factors'); this may also indicate that more research with extended support information could be necessary.

| No. | SC | Industry | Supply Chain | (C2) By which examples trust and harmony are created in the supply chain? | (D2) Which examples support cooperation or cooperative behaviour in the supply chain? | (E2) By which examples such 'soft factors' are possibly supported and fostered? |
|---|---|---|---|---|---|---|
| 1 | 1 | textile | producer | controls, reliablity | inidivudal adapted systems | supplier / customer visits, workshops, individual designed offers |
| 2 | 2 | chemical (machines) | producer | - | - | - |
| 3 | 3 | chemical (materials) | supplier | strategic planning, pragmatism, flexibility, consistency, goal-orientation | supply chain planning systems, close supplier / customer relationships, IT-solutions e.g.VMI | supply chain workshops: emphasize common dependence, experience sharing, identify room for improvement |
| 4 | 3 | chemical (materials) | supplier | realtime informationen | - | supplier / customer visits, supply chain meetings |
| 5 | 3 | chemical (materials) | supplier | open communication, clear assignments, project integration, feedback | access to IT-sytems and tools | common trade fairs, company / customer events |
| 6 | 4 | electronics | producer | - | - | - |
| 7 | 5 | fast food | supplier | constistency, reliability, pragmatism, openness, flexibility, "family-thinking" | - | common agenda |
| 8 | 5 | fast food | wholesaler | punctuality, quality, reliability | - | trust, openness |
| 9 | 5 | fast food | retailer | punctuality, quality, reliability, service | - | punctuality, reliability, trust |
| 10 | 6 | metal working | producer | - | - | - |
| 11 | 6 | metal working | wholesaler | - | - | - |
| 12 | 6 | metal working | retailer | - | - | - |
| 13 | 7 | construction | producer | single sourcing, incentives, openness, faimess, pragmatism, customer orientation, customization, regular meetings | individual advertencies, mutual understanding, goal orientation, flexibility, problem solution competency | feedback, customer events |
| 14 | 8 | energy (materials) | supplier | regular meetings, open communication | project meetings | - |
| 15 | 9 | health care | producer | multi-sourcing, transparency, long-term customer relationships | - | management by objectives, project- and teamwork trainings |

*Table 2. Qualitative case study results.*

## 4. Data Envelopment Analysis for Social Production Factors

The method of data envelopment analysis (DEA) is an important and widely used tool to calculate the efficiency by individual input-output-comparisons of decision making units (DMU) – which are destinctive companies in supply chains for this research study. This efficiency can be assumed as economic productivity. The knowledge of specific production functions as input-output-transformation laws are not necessary ('black box') as they are in general not obtainable for operative companies or supply chains. Moreover there is no fixed weighting distribution as an input parameter necessary but the DEA algorithm is calculating these weighting factors individually for each DMU in order to allow different 'tracks to efficiency'. Therefore there is little leeway for an external 'fiddling' with weighting criteria in order to influence productivity results and DEA is seen as a quite 'objective' method; for general method amendmends see [13, 15, 16, 19, 20, 22, 23, 31, 40, 59, 62, 70]. As the DEA method does not require weighting factors it is often used in areas with assumed but not known weighting factors and so-called 'social' factors. Although these 'social' factors as e.g. input factors are traditionally still 'hard' quantitative facts with cardinal input or output scales

(meaning in essence 'not monetary' factors). For example the two areas of health care and education services where DEA analysis and results are widely used and published; see in university education e.g. [1, 4, 7, 31, 32, 37, 44, 53, 64] and for the health care sector e.g. [12, 21, 26, 28, 38, 45, 69].
In contradiction to this traditional use here social factors really are determining *social dimensions* as described in chapter 2. Hereby DEA is used to identify those companies within the *research cases* with efficient combinations of social (input) factors on the one hand and economic success data as output factors on the other hand. As these companies are working within supply chains social factors are recognized as cooperation factors and cooperation competencies within these companies. Further on the research concept aims at a qualitative comparison of characteristics of efficient units (versus inefficient units) in the DEA. As a result there may be some proof for the introduced research hypotheses from chapter 1. A comparable concept of ‚soft' input factors as cooperation competencies can be found in the context of 'resource-based view' models with non-quantitative factors. Moreover these factors cannot be observed or even measured in cardinal scale indicators but are only available as 'opinion expression' of 'on-the-job experts' within the companies (building a subjective indicator of cooperation competences within the companies). In a first literature comparison this evaluation concept is similar to macroeconomic 'wellbeing indices' as described by MURIAS/MARTINEZ/DE MIGUEL with a DEA method and socio-economic indicators for Spain [55]. But on a closer look it can be recognized that even this analysis is based on 'hard' data consisting out of per-capita-income, income distribution inqueality ('Gini coefficient') and the unemployment rate. For another comparison there are some single DEA concepts in the area of human resource management in a resource-based model by LUCHT and KRUSZYNSKI [47, 52]. Both concepts use completely different indicators and models compared to this presented research study on cooperation in supply chains.
On the other hand DEA was used in some research models for supply chains describing e.g. suppliers' selection by efficiency standards; see [14, 29, 41, 51, 56, 61, 66]. Only one publication by REINER/HOFMANN [61] is describing efficiency aspects within supply chains. All models are using 'hard' quantitative data as e.g. price reductions by suppliers, quality requirements, delivery punctuality or stock turnover rates, extensively described by CEBI/ COBAN/GOZLU [14]. Only circumferential cooperation competence (described as „potential capability of working in cooperation") and communication competence ("communication skills") are analysed which can be seen as a precursor to this study as they are only marginally used in the published model and are in fact output indicators of suppliers' efficiency instead of input parameters. The highest similarity towards the presented DEA model can be found in PETERS [59], describing the efficient use of resources in order to build trust and cooperative relationships between actors in value-added partnerships between companies. Trust is similarly used as a 'soft' factor, but differing from this research study it is used as an output factor and therefore the research question is deviating from this model. In extension of this concept the described DEA model is calculating the efficient use and impact of social input factors as trust and cooperation in order to reach economic outputs as quantitative and qualitative success indicators.
Two distinctions regarding the possible DEA model variations are discussed in detail, for general decision criteria see [36]: First DEA can be basically used as input-oriented or output-oriented model. In an *input-orientation* the assumption has to hold true that companies are faced with *fixed* outputs and try to *minimize* their input resources – this is obviously *not* true as supply chain management in general is very much a concept to increase outputs as customer orientation, competetion advantages or economic values within a supply chain [63]. Therefore the output-oriented model with the assumption of (short-term) fixed input factors as e.g. cooperation competence is used in this DEA calculation in order to maximize output indicators (economic success). This is connected to basic management experience and the concept

of a resource-based view. These inputs as resources (trust, cooperation) are changing only on a long-term base triggered by *investments* (increase) or even *unlearning effects* (decrease). Second a modus for assumed *returns to scale* has to be identified depicting the actual production context: Based on practical management experience and heuristic assumptions a model with *constant* returns to scale is generally used as CCR model [15, 62]. This model will be used here as the condition of a company's ability to *scale its size* according to external requirements (calculated by amounts of total inputs and total outputs) can be assumed to hold true and in this way a comparison to other research findings is possible. An alternative could be the so called BCC model with *variable* returns to scale, see [8, 9]. This model is usually required to calculate ordinal scale data as e.g. dichotomous data ('0', '1') or marks ('1' to '6') with a 'closed' (ordinal) scale meaning that an ('endless') increase of inputs and outputs is technically *not* possible due to the used scale (contrary to the assumption of the CCR model). A comparison of DEA results with both models could describe differences in efficiency modelling resulting from this question of returns to scale assumptions.

| Unit | Score | Actual C1 | Actual D1 | Actual E1 | Actual F | Actual G | Actual H |
|---|---|---|---|---|---|---|---|
| | | Input | Input | Input | Output | Output | Output |
| | | *'Trust and Harmony'* | *'Cooperation, Cooperative Behaviour'* | *'Soft Factors in General'* | Turnover Increase 2006/2005 | Achievement of Quanti-tative Object. | Achievement of Qualitative Object. (Mark) |
| Nr. 01 | 67,19 | 22,00 | 25,00 | 32,33 | 120,00 | 90,00 | 1,00 |
| Nr. 02 | 100,00 | 13,67 | 9,67 | 19,00 | 110,00 | 80,00 | 1,00 |
| Nr. 03 | 75,63 | 25,00 | 25,67 | 28,67 | 111,77 | 103,83 | 1,00 |
| Nr. 04 | 81,34 | 25,67 | 18,00 | 36,00 | 111,77 | 100,00 | 2,00 |
| Nr. 05 | 100,00 | 28,67 | 18,00 | 36,00 | 115,00 | 100,00 | 3,00 |
| Nr. 06 | 100,00 | 22,00 | 28,67 | 19,00 | 136,00 | 109,00 | 2,00 |
| Nr. 07 | 100,00 | 25,00 | 25,00 | 28,67 | 100,00 | 110,00 | 3,00 |
| Nr. 08 | 91,58 | 32,33 | 25,00 | 36,00 | 110,00 | 115,00 | 3,00 |
| Nr. 09 | 98,62 | 25,00 | 25,00 | 36,00 | 107,00 | 110,00 | 3,00 |
| Nr. 10 | 71,15 | 22,00 | 25,00 | 36,00 | 102,00 | 92,00 | 2,00 |
| Nr. 11 | 99,70 | 16,00 | 19,00 | 32,33 | 114,00 | 114,00 | 2,00 |
| Nr. 12 | 100,00 | 16,00 | 16,00 | 32,33 | 116,00 | 116,00 | 2,00 |
| Nr. 13 | 100,00 | 19,00 | 25,00 | 22,00 | 120,00 | 103,83 | 2,50 |
| Nr. 14 | 100,00 | 11,33 | 13,67 | 25,67 | 100,00 | 103,83 | 1,00 |
| Nr. 15 | 99,88 | 22,00 | 19,67 | 23,33 | 103,00 | 110,00 | 1,00 |
| ***Average*** | | | | | *111,77* | *103,83* | *1,97* |

*Table 3. Overall quantitative DEA results (CCR model, constant returns to scale).*

The results for the data envelopment analysis are calculated with values sorted by rank (highest value meaning highest input or output), the presented analysis was calculated with the software ‚Frontier Analyst®', version 4.0.10, of Banxia Holdings Ltd.
Table 3 above shows the overall results for the *efficient units* 02, 05, 06, 07, 12, 13 and 14. Interestingly all these efficient units belong to *different* supply chains (SC 02, 03, 04, 05, 06, 07, 08 leaving only SC 01 and SC 09 *without* a single efficient unit) – giving way to the assumption that within a single supply chain there is a *distinction in terms of social factor levels or economic success* between the companies. On the other hand the units 01, 03 and 10 are the least efficient – which enhances the assumption of strong efficiency differences within one supply chain for the examples SC 03 and SC 06 even more as they are composed out of one efficient and one inefficient unit each (and also one unit with a 'middle' efficiency). These assumptions seem to *verify* the research thesis (i) about supply chains seeking 'diversity' in social competencies but also *falsify* research thesis (ii) about minimum levels of social

factors (as e.g. the least efficient units would not be 'tolerated' in the supply chain). Research hypothesis (iii) about a maximisation of social competencies can be suported slightly as e.g. SC 05 (DMU Nr. 07, 08 and 09) has quite efficient DMUs and also an above-average output concerning the indicators G (average 103,83) and H (average 1,97).
From the analysis of efficient and inefficient DMU another assumption can be obtained: Combined with background information about the described cases it seems possible that *geography* may play an important role in the efficiency regarding social factors. The majority of efficient DMUs are SMEs with *local* supplier networks and relations within Germany or the EU – whereas the inefficient DMUs Nr 01, 03 and 10 are 'global players' in textiles, chemicals and metal working retailing with widespread *global* supplier networks. Therefore these companies may be in a way 'handicapped' in building social factors as trust and cooperation within their supply chains due to distances and language as well as cultural differences.

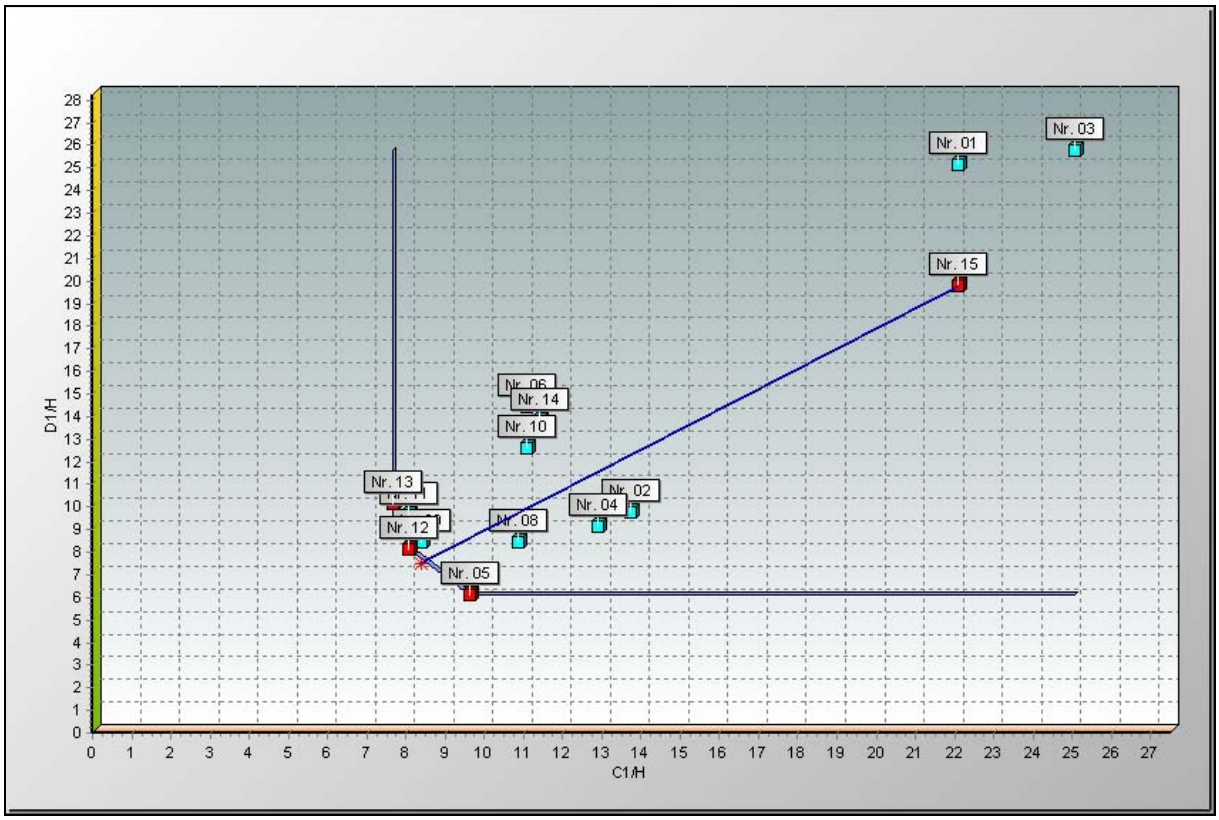


*Figure 4. DEA results for two inputs (C1, D1) and one output (H). CCR model.*

Figures 4 (above) and figure 5 (below) show the DEA graphs illustrating the distances of inefficient DMUs towards the efficient unit on the 'efficiency frontier', in the first case in a model with the inputs C1 (trust), D1 (cooperation) and the output H (qualitative objectives), in the second case with the inputs D1 (cooperation), E1 (soft factors) and the output H (qualitative objectives). Both figures underpin the basic result of a *'three-divide'* among the DMUs with a leading efficient group, a second group with middle to high efficiencies and a third group of quite inefficient DMUs. This is also supporting research thesis (i) about a 'healthy mixture' or a sort of *complementary structure* in social factors.

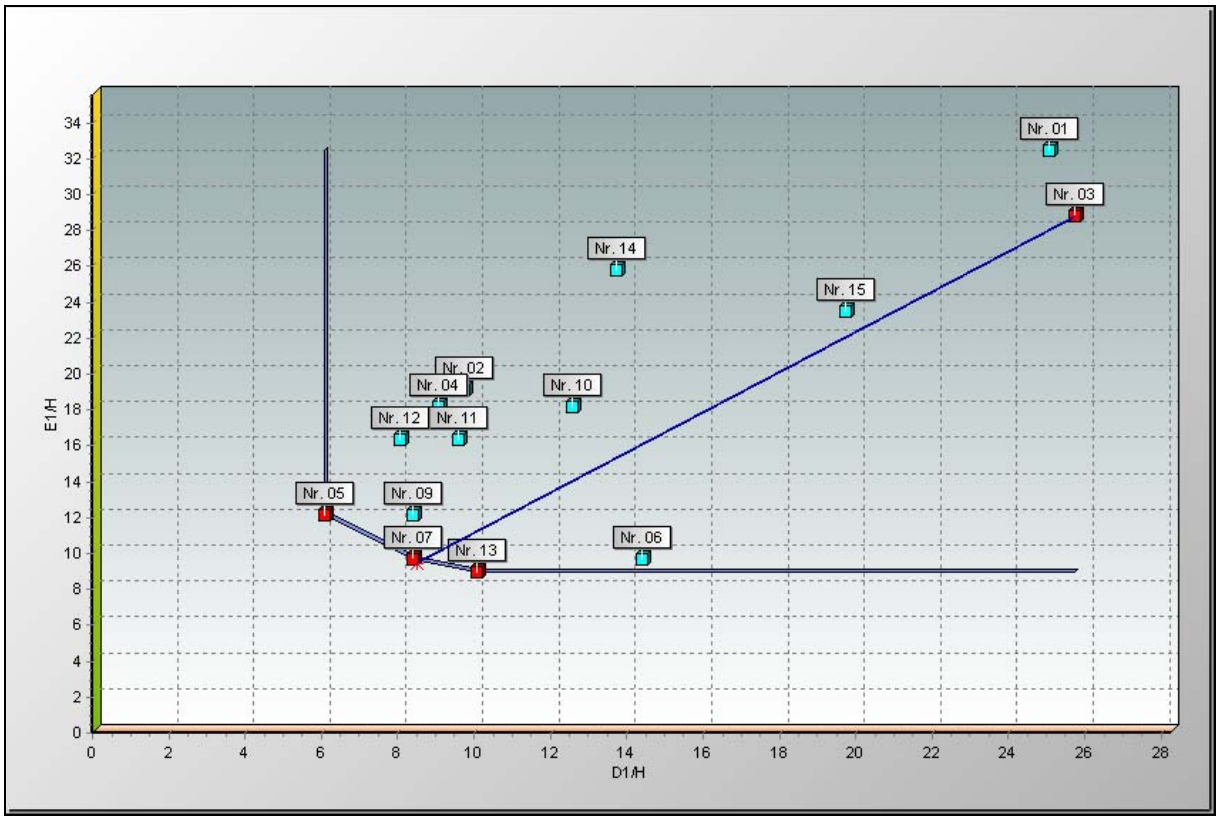


*Figure 5. DEA results for two inputs (D1, E1) and one output (H). CCR model.*

All results are to be presented under *severe restrictions* due to the special nature of the research environment and also the used scales and data in the efficiency model:
(a) The number of required DMU data sets (for $n_{in}$ inputs und $n_{out}$ outputs) is usually due to model restrictions required as $n_{Ob}$ with: $n_{Ob} \geq \max \{ n_{in} \bullet n_{out}, 3 \bullet (n_{in}+n_{out}) \}$; see [19]. As here only three inputs and three outputs are presented the required number of DMUs would be at least 18. Therefore only a maximim of 4 indicators is used in a DEA calculation.
(b) The calculated resources can not be interpreted as *direct* 'resources' but as *indirect* 'indicator replacements' building on a likelihood between actual resource investments and reported marks by the interviewed persons in the companies; see [60].
(c) The DEA model is using ‚qualitative' data with an *ordinal* scaling whereas originally a DEA calculation would *ratio* data (which are not obtainable for this research question); as exemplified in other DEA models, see [14, 59]. Theoretically a mathematical transformation should be possible but up to now there is no corresponding software algorithm accessible for this model, see [18].
(d) So far, there is no clear distinction between traditional production factors (‚resources') and a social factor which is built (or at least influenced) by these resources whereas both areas act as input factors for a company's (respectively a supply chains) productive output (economic success) and efficiency. Therefore for future modelling a *two-step approach* could be useful: First efficiency could be calculated in assembling the social factors in the way of traditional resource investments, see [59]. In a second step the DEA model could be used to determine the efficiency of using these social factors (as input) for the resulting economic output and success of a company (or a supply chain). The *second step* of such an elaborated research concept was presented here.

## 5. Conclusions

The described research efforts have contributed jointly in a qualitative and a quantitative analysis to the following concluding remarks:

- Research thesis (i) is *verified* stating that supply chains seek a diversity of social competencies and social factor levels and are able to optimize their overall economic success by this strategy.
- Whereas there is no evidence for research thesis (ii) stating that supply chains require a minimum level of social competences.
- Research thesis (iii) stating an optimization by increasing social input factors is slightly verified in the basis of an *individual case* comparison.
- This leads to the interesting assumption that a social production factor (or at least the resulting *impact* in the form of an increasing supply chain productivity and economic success) may be *highly transferable between companies* within a supply chain. This may be a unique characteristic of social factors as with traditional production factors transferability of productivity impact is not assumed but economic output or success of one production factor is bound to the production unit using it ('non-transferable impact').
- A new assumption did arise during the research connecting the productivity impact of social factors with the *geographic extension* of supply chains and cooperations: International supply chains seem to be less efficient in the use of social factors as e.g. regional supply chains. This could be a point of interest for further research as increasing doubt about productivity advantages of global supply chains may be voiced also from other research contributions. On the other hand this may motivate especially international companies and supply chains to study and enhance their social cooperation factors.

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