Negotiation Engineering: Why Quantitative Thinking Can Also be Useful in Negotiations

Prof. Michael Ambühl, Dr. sc. techn. ETH, Swiss Federal Institute of Technology (ETH)

Nora Meier, Master of Public Administration / B.A. Political Science, Swiss Federal Institute of Technology (ETH)

Although often complex, negotiations are based on practical problems that can be solved using specialized, ad hoc methods. Based on Negotiation Engineering: A Quantitative Problem-Solving Approach to Negotiation (2017), we examine the approach to Negotiation Engineering developed by the authors therein. Negotiation Engineering is a problem-solving approach to difficult negotiations, inspired by the established solution-oriented discipline of engineering. It is based on the reduction of problems into their most formal structures and the heuristic application of quantitative problem-solving methods. Mathematical language in negotiations can help increase logical accuracy in negotiation analysis and apply various existing mathematical methods to reach a negotiation agreement. We demonstrate the practicability and usefulness of this approach using two case studies in which Negotiation Engineering was applied to reach negotiation agreements. While both case studies stem from the field of international diplomacy, Negotiation Engineering could be useful in contributing to solving a wide variety of problems in different fields and contexts. As such, it could be particularly beneficial for professionals with a technical training and a background in natural science, who could transfer and apply their skills more effectively.

1. Introduction

Solving negotiation problems is often a complex and challenging process. Particularly in the context of more elaborate negotiations (e.g., intergovernmental negotiations), it is important to find viable mechanisms to address these issues. Such mechanisms must on the one hand, be sufficiently sophisticated and on the other hand, sufficiently practical to be applicable to real-world problems.

There has been extensive progress in negotiation research in recent decades (such as in the areas of applied game theory, negotiation analysis, decision theory, behavioral sciences) by using a variety of advanced methods. Nevertheless, it remains a constant challenge to put the findings and techniques into practice. This is especially the case with quantitative methods, which often encounter difficulties in practice, even though they could complement and contribute to solving complex problems. Existing quantitative approaches focus mainly on the general analysis of negotiations (Raiffa, 2007) whereas solution-oriented concepts often limit themselves to the use of qualitative methods (Fisher and Ury, 1981).

While established quantitative analysis-oriented, as well as qualitative solution-oriented approaches exist, Langenegger and Ambühl (2017) identified the need for a quantitative solution-oriented concept. In Negotiation Engineering: A Quantitative Problem-Solving Approach to Negotiation (2017), they introduced such a practice-oriented approach (Negotiation Engineering) to enable the harnessing of the benefits of quantitative methods in finding a solution for real-world negotiation problems.

In this paper, we examine Negotiation Engineering – previously developed by Langenegger and Ambühl (2017) – as an approach that could be useful in contributing to solving a wide variety of problems in different fields and contexts, not only in international diplomacy. As such, we argue that Negotiation Engineering could be particularly beneficial for professionals with a technical training

and a background in natural science, who could transfer and apply their skills more effectively. In doing so, this present paper is based on the above referenced paper.[1]

We first provide the reader with an introduction to the concept of Negotiation Engineering, including its definition, classification and basic elements. We then exemplify the approach using two cases, which are based on the experience of one of the authors (M. Ambühl). Finally, before concluding, we discuss the strengths, weaknesses, and limitations of Negotiation Engineering.

2. Concept of Negotiation Engineering

«Negotiation Engineering» combines the two concepts of (i) «negotiation» and (ii) «engineering»:

According to the Cambridge Dictionary (2021), negotiation is «[a] formal discussion between people who are trying to reach an agreement.» The core of a negotiation lies thus in the parties' efforts to agree on the issues at hand. In contrast, engineering – as «the study of using scientific principles to design and build machines, structures and other things […]» – focuses on finding a viable solution to a problem within the given constraints (Cambridge Dictionary, 2021).

Throughout the solution-finding process, engineering uses mathematical language, which allows for complex issues and dependencies to be formalized and subsequently better understood. Naturally, mathematical language also enables the application of existing mathematical tools. To that end, breaking down problems into smaller sub-problems can help achieve such formalization and ultimately improve or even resolve the problem.

In line with the above definition, the engineering method seeks to better a «poorly understood or uncertain situation within the available resources» (Koen, 1985). This strategy of seeking to ameliorate or solve a given problem is the use of heuristics.

Heuristics does not strive to find the solution but rather an adequate, though often imperfect, solution to a problem (Polya, 1957).[2] In doing so, it looks to any means that reduce the time needed to solve a problem, such as rule of thumb or general simplification and includes learning, discovering and trial-and-error processes (Feigenbaum and Feldmann, 1963). As such, heuristics – when applied – is iterative in its nature and can lead to a multitude of possible solutions.

Finding the optimal solution, however, requires valuation and weighting. Consequently, engineering cannot always be entirely objective and value free. Rather, it is influenced by the social perception of the problem(s) trying to be solved.

2.1. Definition and Differences from Existing Methods

2.1.1. Definition

We define Negotiation Engineering as a solution-oriented approach to negotiation problems that uses quantitative methods in a heuristic way to find an adequate solution. Thereby, we particularly draw on the decomposition and formalization of the negotiation problem and the heuristic application of mathematical methods[3] to facilitate the process of reaching an agreement.

2.1.2. Differences from Existing Methods

A variety of practice methodologies can address negotiation problems.[4] We distinguish these by (i) their methodical orientation and (ii) by the focus on their objectives.[5]

The orientation – referring to the methods used in practice – can range from qualitative to quantitative while the objective can be found on a continuum of «analysis-oriented» (ex post) to «solution-oriented» (ex ante). We classify the concept of Negotiation Engineering as «quantitative» and «solution-oriented» (see graph below).

With its focus on the application of situation-specific instruments and tools and its emphasis on the heuristic utilization of quantitative methods to increase logical accuracy and help structure the negotiation, Negotiation Engineering sets itself apart from other methodologies. Negotiation Engineering also differs from other approaches in that it puts the problem at the center and not the description and discussion of the latter.

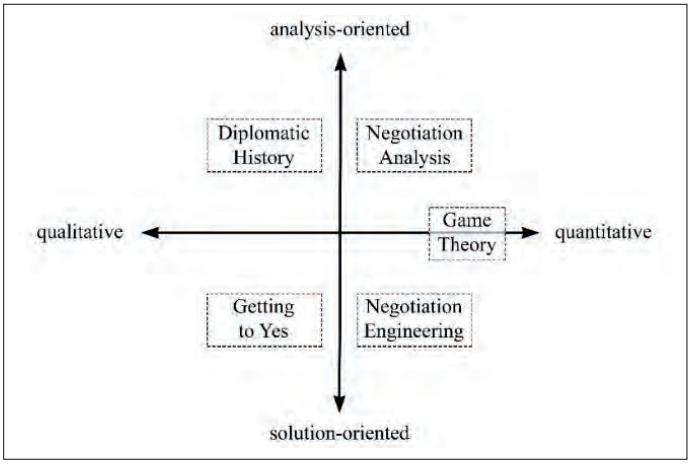


Figure 1: Classification according to orientation and objective of methodology.

2.2. Basic Elements

Based on the above definition, we identified four elements, which form the basis of the Negotiation Engineering concept:

2.2.1. Decomposition

By decomposing a problem, the latter is broken down into its underlying sub- and sub-sub problems. We argue that reducing a problem's complexity in such a way is fundamental to their approach as it not only allows key problems to be identified but also assists in singling out the structure and relationship between the issues at hand.

[1] As one of the original authors (M. Ambühl) is also author of this paper, it is refrained from making any further references to this source in the text.

[2] On the contrary to exact science.

[3] This includes classical methods, such as game theory as well as more recent ideas around principled algorithmic distribution of resources or responsibilities (Grech et. al., 2020).

[4] For instance, diplomatic history, «Getting to Yes» (Fisher and Ury, 1981), negotiation analysis (Raiffa, 2007) and game theory (von Neumann and Morgenstern, 1944).

[5] Langenegger and Ambühl (2017) limited the number of distinguishing criteria to two. While they did consider additional criteria, those were deemed as not fully independent as well as related to the other two.

2.2.2. Formalization

To further break down the problem to its most formal structure and in order to reveal its core construction, each sub-problem, which is decisive for the finding of the solution is then translated and restated into formal mathematical language.

2.2.3. Mathematical Method

Once a sub-problem is expressed in mathematical language (and thus formalized), a variety of mathematical tools, for instance in the area of game theory, can then be applied in order to further analyze the sub-problem based on objective and measurable criteria.

2.2.4. Heuristics

These mathematical tools are applied in a heuristic way, meaning that experience-based techniques, learning and discovery promote a solution that is «good enough for the given set of goals» (Langenegger and Ambühl, 2017). The process of finding a solution is iterative, often undergoing several rounds. As stated above, for all real-world problems – both in the negotiation as well as in the solutions process – multiple reasonable solutions do exist. Therefore, it is important to evaluate the different options based on their merits and to select the solution that best meets the requirements.

3. Cases

The following section illustrates the application of Negotiation Engineering in two specific negotiation situations (cases) to allow for a better understanding of the method and its elements. Even though both cases originate from the field of international diplomacy, the intention is to demonstrate that the method can be applied in other areas as well. Both cases are based on the personal experience of one of the authors (M. Ambühl).[6]

3.1. Case 1: Land Transport Agreement between Switzerland and the European Union

3.1.1. Background

In 1993, Switzerland and the European Union (EU) agreed to start negotiations on a package of bilateral agreements[7] in seven areas (later called Bilateral I): free movement of people, air traffic, road traffic, agriculture, technical trade barriers, public procurement, and science. One year later, in early 1994, the Swiss electorate voted on a federal initiative («Alpeninitiative») regarding the protection of the alpine regions from transit road traffic (Swiss Federal Council, 1999).[8]

With the adoption of the «Alpeninitiative» and of the subsequent new constitutional article (Art. 84 BV) however, Switzerland violated provisions of the transit treaty with the EU (in force since January 1993). This led to the negotiations around the Land Transport Agreement being blocked, which in turn stalled the negotiations on the overall package of the bilateral agreements as the EU insisted on negotiating the entire package of all seven areas in parallel. The blockage of the Land Transport Agreement thus obtained a central role in the negotiations of the Bilateral I.

The two positions of Switzerland and the EU seemed incompatible. Switzerland on the one hand, was obliged to fulfill its constitutional mandate by ensuring that transalpine goods traffic from border to border was carried out by rail (and not on the road) (Art. 84 BV) – a

Figure 2: Land transport. Source: Flickr

provision which de facto only affected foreign traffic and therefore violated the prohibition of non-discrimination. The EU on the other hand, demanded the elimination of the 28-ton weight limit on trucks as well as non-discriminatory treatment of transports.

3.1.2. Negotiation and Results

In a first step towards finding a solution, Switzerland proposed interpreting the new constitutional article (Art. 84 BV) not literally, but according to sense and spirit. This allowed (i) for a reduction of the overall volume of all traffic categories (transit, bilateral and national), which in turn contributed to protecting the alpine region from transit traffic and (ii) for a non-discriminatory treatment of EU transports.

The second step was to regulate the demand through market-based instruments in order to reduce goods traffic on the roads. In this context, Switzerland proposed three approaches: (i) a «tariffication»[9] of the weight limit – a proposal which was rejected by the EU as being too academic; (ii) an internalization of the external costs – a concept which was equally not accepted by the EU as it was (and still is) politically not ripe and (iii) a pragmatic Negotiation Engineering method to determine tariff. The EU agreed to this third approach.

In applying this Negotiation Engineering approach, the tariff was first split into three categories according to ecological criteria.[10] In terms of the determination of the tariffs, the parties then agreed

[6] Michael Ambühl was a member of the Swiss negotiation team in case 1 and the facilitator in case 2.

[7] As a non-EU member, Switzerland's relations with its most important partner – the EU – are governed by bilateral agreements. This bilateral relationship is an alternative to an EU-membership, which could be of interest to other states. Inspired by the Swiss method (not the model), the British model could be developed further, namely, to negotiate one agreement at a time when there is a common interest.

[8] The package of the Bilateral I was signed in 1999 and approved in a popular referendum in 2000. This package was later followed by a second package (Bilateral II), which was signed in 2004. For a couple of years now, Switzerland and the EU have been negotiating a framework agreement (institutional agreement), with the intention of integrating all institutional questions of this so-called bilateral way into one agreement. For the time being (March 21, 2021) negotiations are ongoing.

[9] Tariffication: Transformation of quotas into tariffs, often applied in trade negotiations, where e.g., a quota on tomato imports is transformed into an import tariff.

[10] Instead of one price that was dependent on weight and distance.

on a weighted average, depending on the composition of the total truck fleet. This measure ensured that the tariffs would stay the same on average, even when vehicles were to become cleaner in the future.

The calculation of this weighted average is a linear optimization problem in which the weighted average is G, the highest tariff is not above the threshold P, and the tariff split is maximized, but not more than 15% of the average.

$$\max_{x,y,z}(x - z)\ s.t.$$
$$\alpha \cdot x + \beta \cdot y + \gamma \cdot z = G$$
$$x \leq P$$
$$0 \leq x - y \leq 0.15 \cdot G$$
$$0 \leq y - z \leq 0.15 \cdot G$$
$$x, y, z \geq 0$$

where χ, γ, and z are the tariffs for the three truck categories, and α, β, and γ are the shares of the corresponding truck categories.

This mechanism allowed for a mutually acceptable agreement: the 28-ton weight limit for trucks was abandoned without a significant increase of the transport volume and without discrimination of foreign traffic. The Land Transport Agreement between Switzerland and the European Union was signed in 1999 and adopted by the Swiss electorate in 2000.[11] Since then, the numbers of vehicle trips in Switzerland have continuously decreased:

	2000	2011	2012	2013	2014	2015	2016	2017	2018
France	1527	1341	1259	1212	1220	1253	1279	1362	1409
Switzerland	1404	1220	1151	1049	1033	1010	975	954	941
Gotthard	1187	898	843	766	758	730	701	698	677
Austria	1653	1980	2058	2028	2112	2160	2315	2453	2602
Alpine Arc	**4584**	**4541**	**4468**	**4289**	**4365**	**4423**	**4569**	**4769**	**4952**

Table 1: Number of heavy goods vehicle trips, in 1000s. Data includes trucks, freight trains (on road) and semi-trailer trucks with a permissible total weight of more than 3.5 tons. Numbers during Corona pandemic are not included. Source: Federal Office of Transport (2020) and European Commission (2020).

3.1.3. Analysis

Applying the Negotiation Engineering approach allowed the parties to come to an agreement on this matter and to make progress in the overall negotiation package (Bilateral I). In particular, the decomposition of the problem into a single key issue (defining the tariffs) and the subsequent iterative process of defining the solutions, along with the implementation of the mathematical tool (linear optimization), led to a compromise.

The difficult negotiations lasted four years. Progress was made only when the parties agreed to an abstract, algebraic formulation of the underlying problem. As soon as the problem was decomposed into an algebraic formula, the only remaining question was the determination of the specific values – an issue that consequently then became easier to solve.

3.2. Case 2: Facilitating Nuclear Talks between Iran and P5+1

3.2.1. Background

After discovering Iran's uranium enrichment program in 2003, concerns about its possible non-peaceful purpose were raised. Three years later, in 2006, a dialogue between Iran and the P5+1 was initiated in order to (i) ensure Iran's right to enriching nuclear fuel for civil purposes according to the Treaty on the Non-Proliferation of Nuclear Weapons and to (ii) prevent Iran from developing nuclear weapons.

The situation throughout the dialogue was tense, in particular between the United States and Iran, two states that share a problematic past and until today, maintain no diplomatic relations. Accordingly, it was difficult to agree on preconditions: one side demanded the end of all nuclear program-related activities and the other side requested an enrichment guarantee. The U.S.' demand for a regime change and Iran's perpetuation of unacceptable views of historical events further contributed to a charged rhetoric.

It was in this context, that the Swiss Foreign Ministry offered its support for a restart of the negotiations, in consultation with key actors, in particular the Secretary General of the International Atomic Energy Agency (IAEA), Mohamed ElBaradei.[12] As a neutral state that is neither a member of the EU nor NATO and has no colonial past, Switzerland saw an opportunity to contribute by not only providing a platform for the dialogue, but also by introducing new ideas.

3.2.2. Negotiation and Results

Accordingly, in 2007, one year after the start of the dialogue, in a non-paper[13] to the two parties Switzerland suggested to restart the negotiations. This non-paper included both diplomatic-procedural as well as thematic proposals. The former consisted of (i) confidence-building measures (P5+1 will not table any new sanctions, and Iran will not develop any new nuclear enrichment-related activities; the so-called «freeze for freeze» concept), (ii) guiding principles for the negotiations, and (iii) a phased approach for the talks.

The thematic proposal on the other hand, consisted of two sets of formulas. The first set of formulas concerned the construction of centrifuges and created a mechanism for negotiating the exact number of centrifuges and their development over time. In doing so, the formula defined the number of centrifuges at a given time as the number of existing centrifuges one time-period before (for example, two months) plus a rate of increase. This rate of increase was defined as the average number of centrifuges constructed in the time before the mechanism would come into place, multiplied by a factor β. This coefficient was crucial for the development of the future number. It could be between 0 and 1 and defined if the number of centrifuges stayed the same (β=0) or if it increased at

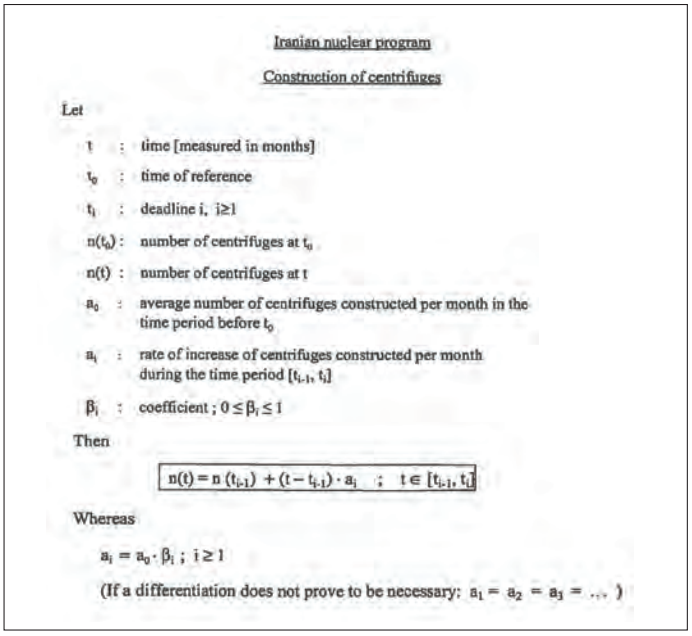
[11] It was not until June 1, 2002 when the agreement entered into force as part of the Bilateral I (Swiss Federal Department of Foreign Affairs, accessed on March 2, 2021).

[12] Switzerland has represented U.S. interests in Iran as a protective power since 1980, when diplomatic relations between the U.S. and Iran were broken off (Swiss Federal Department of Foreign Affairs, accessed on March 10, 2021).

[13] A non-paper is an informal negotiation text for discussion among delegations. It has no identified source or attribution and does not commit the originating delegation's country to the content.

[14] There was no reduction in the number of centrifuges mapped in the model. This was due to the parties not being able to agree on such a reduction at the time. Even in the negotiated agreement of July 2015, Iran and the U.S. could not accept a reduction below the level of 2007. On the contrary, Iran had, according to the data of the International Atomic Energy Agency (IAEA), 656 centrifuges in February 2007. Over the following years, Iran increased its nuclear program and in 2015, the P5+1 agreed to allow Iran 6104 operational centrifuges, with 5060 allowed to enrich uranium.

the same rate as before (β=1), with any possible value in between.[14] The parties would have to agree on this coefficient.



Iranian nuclear program

Construction of centrifuges

Let

t : time [measured in months]

t_0 : time of reference

t_i : deadline i, $i \geq 1$

$n(t_0)$: number of centrifuges at t_0

$n(t)$: number of centrifuges at t

a_0 : average number of centrifuges constructed per month in the time period before t_0

a_i : rate of increase of centrifuges constructed per month during the time period $[t_{i-1}, t_i]$

β_i : coefficient ; $0 \leq \beta_i \leq 1$

Then

$$n(t) = n(t_{i-1}) + (t - t_{i-1}) \cdot a_i \quad ; \quad t \in [t_{i-1}, t_i]$$

Whereas

$a_i = a_0 \cdot \beta_i$; $i \geq 1$

(If a differentiation does not prove to be necessary: $a_1 = a_2 = a_3 = \ldots$)

Figure 3: First set of formulas of thematic proposal in Swiss non-paper, concerning the construction of centrifuges.

The second set of formulas controlled the production of low-enriched uranium in research and development, as well as at industrial plants. It stated that the amount of low-enriched uranium produced had to be smaller or equal to the amount produced before the mechanism was in place, multiplied by a factor γ, which the parties had to agree upon.

3.2.3. Analysis

The decomposition of the problem into the crucial (yet not only important) question of the number of centrifuges, and the formalization of this question through a set of mathematical formulas, allowed the parties to define a key negotiation point and to indirectly illustrate that the problem itself was not unsolvable. The formulated mechanism helped to focus the negotiations on specific, clearly defined dimensions of the problem; in this case, a set of formulas that described and quantified the future development of nuclear enrichment activities. Once this negotiation framing was accomplished, the remaining problem (i.e., the determination of the values of the specific variables) could be tackled more efficiently. This is a typical Negotiation Engineering approach to facilitate the process and promote an agreement.

However, the two parties could not agree on beginning the negotiations at this stage and instead continued escalation.[15] The time was not politically ripe, as neither the U.S. nor Iran saw their respective preconditions for negotiations met.

Despite the fact that the lack of political will could not be overcome by the nature of these two formulas, the Swiss proposals nevertheless laid the groundwork for direct talks in Switzerland in July 2008.[17] Furthermore, elements of the proposals – such as the omission of preconditions, «freeze for freeze», confidence building measures, and phased negotiations – were taken up by the parties in the negotiations, which started in 2013 in Switzerland and came to an end in Vienna on 14 July 2015 with the «Joint Comprehensive Plan of Action».

Prof. Michael Ambühl

- *Dr. sc. techn. ETH*
- *1982 – 2013 member of the Swiss diplomatic service*
- *1999 Ambassador*
- *Swiss Chief Negotiator of the Bilateral Negotiations II with the EU*
- *2005 – 2010 State Secretary [civil service position], Foreign Ministry*
- *2008 facilitator of the dialogue between the P5+1 and Iran*
- *2009 mediator of the Armenia-Turkey Protocols («Zurich Protocols»)*
- *2010 – 2013 State Secretary [civil service position], Finance Ministry; negotiations Tax Agreements with USA, UK Tax, Austria*
- *Since 2013 full professor at the Chair of Negotiation and Conflict Management at ETH Zurich.*
- *2018/19 Head of Department (Dean of the Faculty) of Management, Technology and Economics at ETH*

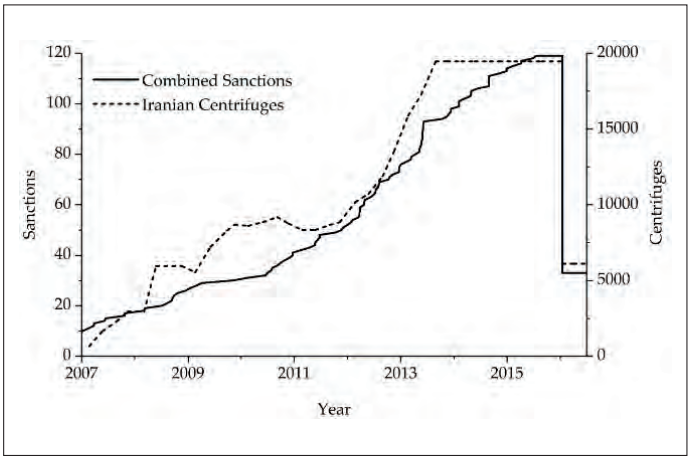


Figure 4: Shows the escalation of the development of the combined sanctions on one hand, and the number of Iranian centrifuges on the other hand (until 2015); and the de-escalation due to the Joint Comprehensive Plan of Action (JCPOA) in July 2015 (Langenegger, 2018).[16]

[15] A more detailed analysis of this escalation and the underlying mechanisms was presented at the International Conference on Group Decision & Negotiation 2016, Bellingham, USA (Langenegger, 2016). The two states are currently in a comparable situation. They cannot agree on preconditions. Iran stated that they would be willing to surrender its recently increased amount of highly enriched uranium if the U.S. took back sanctions imposed under President Trump and returned to the nuclear agreement. However, new U.S. President Biden has signaled that he is only willing to return to the nuclear agreement with Iran if and once Tehran complied with all the terms of the deal (Neue Zürcher Zeitung, 25.1.2021, accessed on March 11, 2021).

[16] This analysis was part of the dissertation of T. Langenegger (2018). His dissertation won an ETH-Medal in 2019, an award for outstanding doctoral thesis projects at ETH.

[17] These talks were the first of its kind between American and Iranian officials since the cessation of diplomatic relations in 1980.

Figure 5: Javier Solana (then EU High Representative for the Common Foreign and Security Policy) and Ali Larijani (then Secretary-General of the Iranian Supreme National Security Council and Iran's chief nuclear negotiator) at the Geneva Talks in July of 2008. Source: Reuters.

4. Strengths and Limitations

We identify several strengths as well as weaknesses and limitations of Negotiation Engineering:

4.1. Strengths

- The reduction of the problem to its most formal structure through the highest possible abstraction helps to reveal the core of the problem and provides an understanding of its underlying mechanisms. Using mathematical language forces an increased logical accuracy. In addition, using such language enables access to many helpful mathematical tools that can be of analytic (e.g., game theory) or solutions-oriented (e.g., mathematical optimization methods) nature.

- The formal description of a problem allows a solution mechanism to be defined without implying the outcome of the negotiated agreement. That way, the solution mechanism can be incorporated in a formula while leaving room to negotiate the values of the variables in the formula. Such a process helps to frame the negotiation, indicating a list of questions to be discussed. A solution can be reached more easily due to more precise knowledge of the issue(s) being negotiated based on objective, measurable criteria.

- The «technical» approach of Negotiation Engineering can lead to a de-emotionalization of the problem, which often helps in finding pragmatic solutions to complex negotiation problems.

4.2. Limitations and Weaknesses

- The method's orientation toward technical problem solving can be perceived as not strategic enough. It can be argued that such a solution-focused approach does not thoroughly consider higher-level inquiries, such as the questions of whether the right problem has been defined or whether solving it is justified in the first place.[18] It is evident that Negotiation Engineering cannot replace the discussion of certain questions of principles. However, it can be an important addition to such a discussion. Both levels have to be considered for real-world problems.

- The formalization of a problem is always a reduction, leaving out some aspects of the problem, which can be controversial for the other party. Therefore, it is important to find the essential underlying problem accepted by all involved parties to increase the acceptance of the formal representation and modeling. If an aspect, which is considered essential by a party, is left out, then a formalization might not be helpful in finding a solution. Furthermore, a reduction should only be applied to sub-problems.[19] A mutually accepted formalization of the larger initial problem is often not possible due to its complexity. It is important to note that there is no universal solution to this process of reduction. The art of formalization in a constructive way lies in using it in a mutually accepted way in sub-problems. This process remains a difficult aspect of negotiations.

- There are limits to where Negotiation Engineering can be applied. Problems may exist that are not quantifiable or should not be reduced to a quantitative level. Examples include deep value disputes or interpersonal conflicts, such as family disputes. The Negotiation Engineering method is most suitable for problems with a particular degree of complexity, involving actors that hold a certain analytical capacity and are open to a rational approach.

5. Conclusions

In this paper, we examined Negotiation Engineering – previously developed by Langenegger and Ambühl (2017) – as an approach that could be useful in contributing to solving a wide variety of problems in different fields and contexts.

With its consideration of complex properties of real-world negotiation problems and the application of proven methods from the problem-solving discipline of engineering, Negotiation Engineering differs from other established practice methodologies. This focus on quantitative methods and on a solution-oriented direction are exemplified by the analysis and conceptualization of two cases.

Negotiation Engineering is based on four elements – all of which help to solve negotiation problems: (i) decomposition of the problem, (ii) translation of a sub-problem into mathematical language along with the reduction to its most formal structure, and (ii) the application of mathematical tools (iv) in a heuristic way. Such a process leads to increased logical accuracy in the analysis using mathematical language and allows for the development of suitable solutions, particularly through the application of quantitative, mathematical tools. Thereby, the focus lies on the heuristic approach to find pragmatic solutions under existing constraints.

Heuristic and quantitative problem-solving methods, such as Negotiation Engineering do not have to be limited to their use in international diplomacy. On the contrary, practical application is possible in many fields in governmental or business (company or individual) negotiations – also in the pharmaceutical industry. Negotiation Engineering could be particularly beneficial for professionals with a technical training and a background in natural science.

[18] An interesting example was the debate around the distribution of the EUR 750-billion corona virus recovery fund of the EU among members states (Grech et al., 2020).

[19] Examples of such key issues are the definition of the tariffs in Case 1 and the number of centrifuges in Case 2. They were identified as key sub-problems to the negotiation and their formalization helped to facilitate the discussion.

References

Bundesverfassung der Schweizerischen Eidgenossenschaft (1999). SR 101

Cambridge Dictionary (2021a) Engineering. In Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/negotiation. Accessed 7 March 2021

Cambridge Dictionary (2021b) Negotiation. In Cambridge Dictionary. https://dictionary.cambridge.org/de/worterbuch/englisch/engineering. Accessed 7 March 2021

ElBaradei M (2011) The Age of Deception: Nuclear Diplomacy in Treacherous Times. Metropolitan Books, New York, NY

European Commission (2020) Alpine Traffic Observatory Annual. https://ec.europa.eu/transport/modes/road/non-eu-countries_en). Accessed on 3 March 2021

Federal Department of Foreign Affairs. Protecting Power Mandates. https://www.eda.admin.ch/eda/en/fdfa/foreign-policy/human-rights/peace/switzerland-s-good-offices/protective-power-mandates.html. Accessed on 13 March 2021

Federal Office of Transport (2019) 2. Semesterbericht: Alpenquerender Güterverkehr durch die Schweiz. https://www.bav.admin.ch/bav/de/home/verkehrsmittel/eisenbahn0/gueterverkehr/verlagerung/berichte-und-zahlen.html. Accessed on 5 March 2021

Feigenbaum EA, Feldman J (1963) Computers and Thought. McGraw-Hill, Inc., New York, NY

Fisher R, Ury WL (1981) Getting to Yes: Negotiating Agreement Without Giving In. Penguin, London

Flickr (1999). Impressionen vom Gotthard. https://www.moba-forum.ch/index.php?thread/750-impressionen-vom-gotthard/&pageNo=2. Accessed on 25 March 2021.

Grech P, Chopard B, Wernli D, Davidshofer St, Levrat N (2020) Negotiation Engineering and Computational Diplomacy – A GESDA Scientific Anticipatory Brief

Koen BV (1985) Definition of the Engineering Method. American Society for Engineering, Washington, D.C.

Langenegger T (2016) A Sequential Repeated Sanction Model Exemplified by the Case of Iran. In: Proceedings of the International Conference on Group Decision & Negotiation. Western Washington University, WA, USA

Langenegger T, Ambühl M (2017) Negotiation Engineering: A Quantitative Problem-Solving

Approach to Negotiation. Group Decis Negot 27:9-31. doi: 10.1007/s10726-017-9547-5

Langenegger T (2018) The Iran Nuclear Dispute – An Analysis in Graph Form. In: Proceedings of the 18th International Conference on Group Decision and Negotiation. Nanjing University of Aeronautics and Astronautics, China, pp 144–151

Neue Zürcher Zeitung (2021) Irans Raketenprogramm beunruhigt den Westen, doch Beschränkungen sind schwer zu erreichen. https://www.nzz.ch/international/iran-die-usa-wollen-die-beschraenkung-des-raketenprogramms-ld.1597234. Accessed on 11 March 2021

Nora Meier

- *Master of Public Administration / B.A. Political Science*
- *2016 – 2018 program assistant and consultant for international organization, lead author of publication on farmer seed systems and sustaining peace*
- *Since 2019 at ETH Swiss School of Public Governance, since Sept. 2020 as Managing Director*

Polya G (1957) How to Solve It: A New Aspect of Mathematical Method, 2nd Edition. Princeton University Press, Princeton, NJ

Raiffa H (2007) Negotiation Analysis: The Science and Art of Collaborative Decision Making, 1st edn. Harvard University Press, Cambridge, MA

Reuters (2008) Iran Geneva Talks: Whose Interpretation Will Triumph? http://blogs.reuters.com/global/2008/07/29/iran-geneva-talks-whose-interpretation-will-triumph-2/. Accessed on 2 March 2021

Swiss Federal Council (1999) Botschaft zur Genehmigung der sektoriellen Abkommen zwischen der Schweiz und der EG. BBl 1999 028, Bern

von Neumann J, Morgenstern O (1944) Theory of Games and Economic Behavior. Princeton University Press, Princeton, NJ

Contacts

Prof. Michael Ambühl
ETH Zurich
Department of Management, Technology, and Economics
Chair of Negotiation and Conflict Management
Weinbergstrasse 56
CH-8092 Zürich
Phone: +41 44 632 98 87
E-Mail: mambuehl@ethz.ch
https://necom.ethz.ch/

Nora Meier
ETH Zurich
Department of Management, Technology, and Economics
Chair of Negotiation and Conflict Management
Swiss School of Public Governance
Weinbergstrasse 56
CH-8092 Zürich
Phone: +41 44 632 61 53
E-Mail: meiernor@ethz.ch
https://sspg.ethz.ch/