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Alliance Formation in Standard Setting

Abstract

We present a theoretical framework to describe coalition formation in standardisation alliances, combining different strands of standardisation literature about alliances and incentives to participation. Applying the game-theoretic concept of the core we discuss conditions for stable coalitions and calculate expected payoffs from a private good perspective by means of the Shapley value. Paying attention to the public good character of standards we apply the Holler value which accounts for non-rivalry and non-excludability. Given the characteristic function of the coalition formation game, the emergence of different alliances can be explained. We provide examples in which the technological flexibility of resources shapes the payoffs and thus the resulting standard.

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1 Introduction

This paper seeks to explain the formation of alliances in standardisation. We account for the different motives behind the decisions when and with whom to form a standardisation alliance, whether entering an existing one or leaving one. We provide a model that incorporates and combines different strands of the recent literature on incentives for participation in standardisation. In addition, the concepts available for computing payoffs in an alliance are explored in more detail.

A growing literature on alliances in standardisation is available. It started with the seminal article by Farrell and Saloner (1988) about committee standardisation. Recently, among others, Warner (2003) and van Wegberg (2004) discuss the different forms of alliances that might form in response to the different incentives for participation in the standardisation process. These incentives include e.g. stakeholder interests (e.g. Söderström 2004) and the relationship between standardisation and intellectual property rights (IPR) and patents (e.g. Blind 2004).

The field of formal standard setting in standard development organizations (SDOs) has largely been neglected. An exception is Goerke and Holler (1995), examining the theoretical possibilities of committee standardisation on one out of two possible standards or of choosing variety. They conclude that standardisation is efficient, if the network effects of the standard are superadditive in that they "are more than sufficient to compensate the outvoted group [of consumers of a standardized product] for the utility reduction it incurred due to the loss of choice" (p. 340). An alternative approach to analyse the decision-making processes and the related power to standardise in SDOs in more depth is provided in Gröndahl (2005) at the example of CEN.

There is evidence that the number of European standards is still growing (compare e.g. CEN 2004), while at the same time Blind (2004, p. 318) finds the role of formal standardisation by SDOs to be decreasing\(^1\), replaced by de-facto standards, including industry consortia standardisation, i.e. standardisation in alliances.

\(^1\) Blind refers particularly to the role of standards in technology diffusion and the related impact of standardisation on growth, which is not necessarily in contrast to the CEN statement.
In this article we examine alliances evolving in either a formal or market standardisation environment. This includes the variety of so called consortia, fora and other partnerships and groups.

The paper is structured as follows. Chapter 2 starts by providing an overview about important aspects linking coalition games and alliances and then outlines the rationale of the basic model. In addition, different types of alliances that might form and incentives for participation in standardisation are discussed. In the literature it is generally assumed that standards, at least the ones derived in a formal standardisation process, are public goods. In this chapter we consider the bearings that aspect might have on the formation and form of the alliance in more detail. The theoretical model in which the different motives for participation in the standardisation process are linked is presented in chapter 3. Since alliances will only form if all participants gain from its formation, we apply the game-theoretic concept of the core to test for stability. Stability (in alliance formation) is determined by the relevant alliance yielding a payoff vector in the core. For illustrative reasons we will present some examples in chapter 4. The article concludes in chapter 5 with a discussion of the results.

2 Types of alliances and incentives for participation

In the following we focus on the relationship between the goods character of the resulting standard and the type of alliance (if there is one) which most likely helped shaping it (see Figure 1). The relevant goods’ characteristics are rivalry in consumption and excludability. However, applying these characteristics to standards is not always easy as the following discussion will show. In addition, this chapter also investigates incentives for participating in standardisation processes and especially in alliances.

One factor explaining standardisation are network externalities. A technology is said to exhibit network externalities if consumers’ utilities increase with the number of consumers using the same
or a compatible technology. This translates into a higher willingness to pay for the technology in question and may lead consumers to choose, e.g. a more expensive brand over a cheaper brand, if the more expensive brand is supported by a larger network of users. For example, in the PC industry compatibility constitutes the second major factor (after the price) to determine which type of PC to buy (see Shy 2001, p. 16).

If one firm has sufficient resources to sustain its own technology in the market and can reasonably expect the market to tip in favour of its supported technology, there is no compelling reason to enter an alliance. However, if that is not the case, an alliance of firms might form in order to start a bandwagon. This is the case of a market based standards alliance (MBA) in the terminology of Warner (2003). A standards battle between competing technologies might still take place, but at least one technology would be backed by a MBA rather than by a single firm.

In case that markets fail to generate a standard or if the institutional framework demands that national or international SDOs are to endorse a standard for a specific market, often formal standardisation takes place. This frequently occurs even in the case when the respective technology is not yet developed, i.e. the standardisation process is still in the precompetitive phase and a market does not yet exist. We call an alliance that forms in order to influence the decision-making of SDOs or in anticipation of institutional failure an alliance in formal standardisation (AFS).

When analysing standards alliances, it seems useful not only to differentiate the type of standardisation alliance by the environment in which the standard is set, e.g. either formal or market standardisation, but also by the goods character of the ensuing standard (see figure 1). Although the standard-specifics as such are always non-rival in consumption, in that the resource "standard" cannot be depleted, there are differences in the grade of excludability. That holds true notwithstanding the fact that a standard as such cannot be consumed directly by consumers and that the consumer goods produced by means of this standard may indeed not only be excludable but also rival in consumption. The property rights with regard to the technology play an important role and there may yet be a "rivalry in appropriating gains from standardisation" for firms.
When a single firm is proprietor of the technology in question (Case I), no matter whether this technology is going to set a bandwagon in motion or not, we deal with a private good. If the technology is implemented as a standard, we have a case of market standardisation. The firm is free to license its technology to other firms or supply it to consumers on its own. Even in a tippy market, when the technology becomes the overall market standard used by every end-user, it remains excludable to suppliers. The coalition here consists of only one member. While other firms might be interested in joining the monopolist, the proprietary firm generally has no incentive to invite new members in².

In contrast to market standardisation, in formal standardisation (Cases III and IV) the standard is typically a public good. The standard’s specifications are made public and everyone is free to use them³. Correspondingly, all players may benefit from it, since there is no exclusion prac-

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² An incentive to do so despite the "competition effect" added rivals in the market have on profits is explored in Economides (1996). Here the monopolist has incentives to license his technology to potential rivals, in some cases even at negative licensing fees, since the rivals will increase the network effect and make a large network size credible.

³ We abstract from the (mostly very moderate) fees SDOs often charge for their standards. Furthermore we assume that applicable IPR and patents are disclosed and can be used at reasonable and nondiscriminatory (RAND) terms.
tised, even where possible. Nevertheless, there remains the question which technology to choose as a standard. Seeing that firms might be biased towards different technologies, this fact gives incentives to form a coalition for influencing the decision in the context of formal standardisation (Case III). Nevertheless, once a standard is formally endorsed and made public, it is not excludable\textsuperscript{4}. Note that depending on the participants we are concerned with different public goods. The public good produced by the coalition \{A, B, C, D\} is not necessarily the same public good as the good produced by \{A, C, D, E\}.

Another interesting case (Case II) is represented by the market based alliance. The standard generated by a MBA has the character of a club good. It is private in that it is proprietary, i.e. exclusion is practised, while at the same time the members of the coalition share the associated benefits. Entering the coalition is voluntary, although not every firm is free to do so. This is one of the main characteristics which distinguish a club good from a public good. A club good typically involves sharing, be it of costs of provision or of benefits. In addition, there may be partial rivalry for the benefits associated with the club. This leads to a limited size of the club to be optimal. Note that, again, the club good provided depends on the participants in the production process of the club good.

Alliances are only going to form if the participants gain directly or indirectly from participation. Gains from participation in standardisation alliances might be accruing to particular members, but are in principle transferable, e.g. via licensing fees or cost-sharing for R&D projects. In the following we will describe the main driving forces for and gains from participation.

An important reason for participation in a standardisation alliance is the influence that a participant may exert on the outcome of the standardisation process. Stakeholders participate in formal or informal standardisation in order to protect their interests by influencing the resulting standard. Another main factor driving the formation of standardisation alliances is dissatisfac-

\textsuperscript{4} An exception is e.g. in European standardisation the possibility for EFTA countries, which are like the EU countries members of CEN and CENELEC not to issue European norms (EN), if they voted against this norm and it nevertheless became a EN. Compare CEN/CENELEC (2004).
tion with official (national or international) SDOs. Both van Wegberg (2004) and Blind (2004) argue that in SDOs the formal setting is too slow. Formation of new alliances might also be fostered by vertical fragmentation (different alliances focus on different stages of the process) of the standardisation process (van Wegberg, 2004).

Additional factors influencing the decision on participation in an alliance are the size of the network-effects and economies of scale in production. Economies of scale and knowledge transfers in research and development (R&D), as well as informal ties in SDOs are also reasons for participation in formal standardisation and alliances. A larger installed base of a joint technology or compatible technologies, and the related market power are additional factors which positively influence participation. The quality of the related technologies improves with better communication and coordination among the alliance members. Reputation further influences participation in alliances in that the reputation of a technology might improve with the participants’ reputation. This would signal support for the technology and thus increase consumer trust.

A main concern that might caution firms from participation is the risk of rivals gaining information on their technologies, if these are not protected by patents and or IPR. Blind (2004) found that R&D intensive companies with insufficient protection of IPR or know-how of high value for competitors are unlikely to participate in standardisation. At the same time over-protection might also hinder standardisation, if the participants cannot agree on the terms of licensing.

3 The model

We analyse standardisation alliances in a game-theoretic model. The underlying assumption is that stakeholders, from here on called players $i \in N$, hold resources $r_i$ which can be combined with other players’ resources. These resources could for example be intellectual property rights, patents, or human capital (expertise of engineers). If players decide to combine their resources with each other, they form an alliance. The combination of resources will typically involve gains $g(r_1, r_2, ..., r_k)$ and costs $c(r_1, r_2, ..., r_k)$ simultaneously The gains as well as the transaction costs
of interaction of the resources (e.g. travelling costs, costs of time, etc.) depend on the resources involved - on how the resources fit together, on the number of participants of the alliance, etc. On the one hand, typically, more resources will increase the gains, while on the other hand the number of players (and thus the amount of resources to be employed) will generally have a negative influence on the outcome via increasing costs of communication, more difficulties in negotiating about the resulting standard etc. For each potential alliance with \( k \) participants the net benefit \( b(\cdot) \), which is the difference of the gains \( g(\cdot) \) and the costs \( c(\cdot) \) can be compared:

\[
g(r_1, r_2, ..., r_{i-1}, r_i, r_{i+1}, ..., r_k) - c(r_1, r_2, ..., r_{i-1}, r_i, r_{i+1}, ..., r_k) = b(r_1, r_2, ..., r_{i-1}, r_i, r_{i+1}, ..., r_k)
\]

(1)

The fact that some resources will be less compatible with one type of resources than with others - e.g. licenses for or R&D investments into a specific technology will only be of value for an alliance that intends to focus on that technology - is reflected in the net-benefit.

Since the resources we have been arguing with can be attributed to the respective players, we can easily simplify the description of the model to a standard game-theoretic coalition game: The game \( \Gamma = (N,v) \) is described by the set of players \( N \) and the characteristic function \( v(K) \) which determines the coalition value by attributing a real number to each coalition \( K \). The cardinalities \( N \) and \( K \) are \( n \) and \( k \), respectively.

A player \( i \in N \) (i.e. every possible participant \( i \)) will, in case that \( i \) joins a possible alliance \( K \), provide his resources \( r_i \). Whether a player will join the alliance or not depends on his payoff of participation, which must be compared with all potentially attainable payoffs of participation in other coalitions, including the stand-alone value. The respective payoff is his share of the coalition value. The coalition value of alliance \( K \) is determined by the positive and negative effects of the combination of resources: the gains of the resources provided by the \( k \) participants

We assume that each player in the game is endowed with specific resources. Since all players provide resources to an alliance and require a share of the resulting coalition value we apply
the concept of the core, assuming transferable utility. The latter assumption is justified by the
above mentioned reasoning concerning sharing the net-benefits of a standardisation alliance via
contractual agreements.

To determine whether a coalition is stable or not, we analyse the core of the game, the set of
all undominated imputations. A vector \( u \) is in the core \( C(\Gamma) \), i.e. individually rational, coalition-
rational, and group-rational, if:

\[
C(\Gamma) = \left\{ u \mid v(K) - \sum_{i \in K} u_i \leq 0 \right\} \forall i \in K \forall K \in N
\]  

Individual (coalition) rationality is fulfilled, if the coalition value \( u_i \) of any coalition in which player
\( i \) (subcoalition \( K \) ) participates is at least what he (they) could get as stand-alone value (sum of
stand-alone values over all members of \( K \) ) by refraining from participation. Group rationality is
pareto efficiency in that the coalition value of the grand coalition is the sum of stand-alone values
of all members of the group. This implies that if a coalition of rational players forms, its payoff
vector must be in the core. If it was not in the non-empty core, the coalition would therefore not
be stable\(^5\).

To determine whether a coalition is stable, we test the coalition payoffs according to the above
mentioned criteria. For instance the stand-alone test implies that the coalition value the coalition
\( T \) receives must be at least as big as the sum of the coalition values of subcoalition \( T \setminus \{i\} \) and
player \( i \) himself:

\[
v(T) \geq v(T \setminus \{i\}) + v(\{i\})
\]  

The surplus which \( i \) generated by joining the coalition is the difference between the coalition
values of \( T \) and \( T \setminus \{i\} \). The stand-alone test verifies that this surplus (which is the additional
coalition value) resulting from \( i \)'s participation in an existing alliance is not less than the stand-
alone value of \( i \) (individual rationality). The tests for coalition rationality and group rationality

\(^5\) Note that elements of the core are internally stable in that no element of the core dominates another element
of the core, but not externally stable. They might be dominated by vectors that are not in the core, but these
vectors would in turn be dominated by other vectors that are in turn dominated by a vector in the core.

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can be detailed in the same vein. If one or more tests fail, the coalition \( T \) will not form and therefore the corresponding allocation will not be part of the core.

However, there are three problems remaining: firstly, if the core is not empty\(^6\), it may contain more than one element (vector). Secondly, what is the solution, if the core is empty? Thirdly, the core as well as the SV are based on the assumption that the grand coalition is pareto-efficient, which need not be the case. We will now discuss these problems.

Since we are interested in the share of the coalition value that the different players \( i \) can reasonably expect to receive, we apply the Shapley value (SV) that yields a (single) vector that is an element of the non-empty core. The expected share for player \( i \) joining coalition \( K \) is \( \varphi_i(v) \):

\[
\varphi_i(v) = \sum_{K \subseteq N, K \ni i} \frac{(n-k)! (k-1)!}{n!} (v(K) - v(K - \{i\})) 
\]

Of course this does not necessarily mean that this expected value will be \( i \)'s share.

The SV that results for all players \( i \in N \): \( \varphi(v) = (\varphi_i(v)) \) yields the shares of the \( n \) players of the coalition value \( v(N) \).

In case of given conflict payoffs, the SV and the Nash bargaining solution coincide (compare Harsanyi, 1977, pp. 226-231). The SV thus is "fair and reasonable" inasmuch as the Nash bargaining solution is\(^7\). Thus we can propose a reasonable and fair distribution of the coalition value of the grand coalition, if the core is not empty.

Considering the second problem, we have to distinguish between two cases. The first case is a convex game, while the second case is a a non-convex game. For a non-convex game the core might be empty, while it is always non-empty for a convex game, for which the following condition has to hold:

\[
v(S \cup T) + v(S \cap T) \geq v(S) + v(T) \forall S, T \subseteq N
\]

Since we consider only games in which a player can only join a coalition or not join it, \( S \) and \( T \)

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\(^6\) Superadditivity is a necessary, but not a sufficient condition for a non-empty core, while in a convex game \((v(T \cup \{i\}) + v(T \cap \{i\}) \geq v(T) + v(i))\) the core is always non-empty.

\(^7\) For a compact and convex payoff space, the Nash solution exists and determines a unique payoff vector.
will always be disjoint coalitions in that \( S \cap T = \emptyset \). This means that for our purposes the question of whether a game is superadditive or not is sufficient for determining whether the core is empty or not\(^8\). I.e. we distinguish between two cases of combining resources. In superadditive games, where the resources combined with other resources create a coalition value that is larger than or at least as large as the summation of the single values, respectively, the core is not empty. If the characteristic function of the game is superadditive in that:

\[
v(S \cup T) \geq v(S) + v(T) \text{ if } S \cap T = \emptyset \forall S, T \subseteq N
\]

the coalition of subcoalitions \( S \) and \( T \) is stable. Otherwise there would be no gain from the formation of a coalition and each subcoalition could do better on their own. In case of a superadditive game, e.g. due to increasing returns to scale, network effects on the consumer side, or complementarities in R&D, the grand coalition would form and be stable.

In the second case, a non-superadditive game, the coalition value of a subcoalition \( S \) and another subcoalition \( T \) is not at least as big as the sum of \( S \)'s coalition value and the value \( T \) can get on their own. In sharing the coalition value \( v(S \cup T) \) either \( S \) or \( T \) would have to give up some of the value they could get on their own. Thus they would not form a coalition and the optimal coalition size might be smaller. In this case the core might be empty, because the concept of the core, as well as the SV, are based on the assumption of pareto-optimality of the grand coalition, i.e. the (efficient) grand coalition must yield the highest payoff.

This leads us to the third problem: if the grand coalition is not pareto-optimal, a subcoalition will be efficient. Suppose a coalition of \( k < n \) players was efficient, then the core would prove this coalition as stable in the reduced \((k\text{-player})\) game. If more than one (sub)coalition is stable in the respective reduced game, only the pareto-optimal \((k\text{-player})\) subcoalition will be stable in the original \((n\text{-player})\) game. If more than one subcoalition is pareto-optimal, they all will be stable. Thus the application of the core (or the SV) to the original game might not be sufficient to find

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\(^8\) Superadditivity is a necessary, but not a sufficient condition for a non-empty core, while in a convex game the core is always non-empty.
a stable coalition for a non-superadditive game.

Concerning the third problem, the allocation given by the SV is derived from a private good perspective about sharing the surplus of an alliance, which is reflected in its computation. It attributes the surplus a player created to this pivotal, i.e. decisive, player, considering all permutations of players. The question is, whether the coalition payoff is indeed a private good?

In the discussion of the different goods types in chapter 2 it became obvious that the coalition value might not be a private good. If the resulting standard produced by the coalition is a public good, players that do not contribute cannot be excluded from the resulting payoff. This would make free riding possible: a player acting as a dummy and contributing nothing might still profit from passively participating in the coalition.

The SV does not allow for the concept of public goods which is, in addition to the problems discussed above, the reason why we do not limit ourselves to the SV. It is trivial to conclude that since no player can be excluded from "consuming" the coalition value in case of a public good, every player has to be assigned the full coalition value. Still, we are interested in a measure that evaluates the players contributions and that subsequently can be used to share associated gains, costs, subsidies etc. In the case of a club good it is possible to exclude free riding by barring free riders from participation. In the case of a public good we can only limit the incentives to free riding. Thus in this measure we regard only coalitions in which every player contributes to the coalition value, i.e. the coalition value is assigned only to decisive sets of players, in which every player is decisive, rather than giving the surplus a pivotal player created to every pivotal player\(^9\).

We can only be certain that any given coalition member has contributed to the public good if the coalition is a decisive set. Adding up the coalition values for player \(i\) over all coalitions in which every player is decisive yields the decisiveness of player \(i\) in all possible coalitions in which there is no free rider. These concepts of the Holler index and decisive sets are unfortunately only defined

\(^9\) This is in contrast to the intuition behind the SV: the pivotal, i.e. decisive, player is assigned the entire surplus that she contributes to the coalition, times her probability of being in the pivotal position.
for simple (voting) games. Therefore we will instead use the related concept of a real gaining coalition (RGC) introduced in Holler (1991) and axiomatised in Holler and Li (1995): if $S \subseteq N$ and $\forall T \subset S : v(S) - v(T) > 0$, then $S \in R$, with $R$ being the set of all RGCs. Only if all players contribute to the coalition’s success, the coalition is a RGC.

The concept of the Holler value (HV) only regards payoffs from RGCs:

$$h(v) = (h_i(v)) \text{ with } h_i(v) = \sum_{K \in R, K \ni i} v(K)$$

(7)

and does not depend on the pareto-optimality of the grand coalition. It can exclude incentives for free riding we need not consider reduced games explicitly.

For comparison with the SV, as in Holler (1991), we apply a normalised HV to the coalition payoff of the grand coalition:

$$h^0(v) = (h_i^0(v)) \text{ with } h_i^0(v) = \frac{h_i(v)}{\sum_{i \in N} h_i(v)} v(N)$$

(8)

The vectors provided by SV and HV must not be confused with the share of the coalition value the players will receive, since every player that participates in the coalition will receive the entire coalition value, i.e. the standard produced by the standardisation alliance. In our case SV and normalised HV do not provide an allocation of gains of participation in a standardisation alliance, but might be interpreted as kind of relative probabilities that the players will participate in a coalition. The player with the biggest share of the coalition value (relative to the resources she provides) is most likely to participate in the alliance, while the player with the smallest share is least likely to participate. As long as the share is bigger than the cost of the resources provided, the probability of participation is positive.

4 Application of the model

As a demonstration for coalition formation in the case of standardisation alliances we use a variation of Faulhaber’s fee sharing game.

Initial setting
Imagine four identical firms, A, B, C and D, that have to decide about forming a standardisation alliance with the other firms, applying technology A. Forming an alliance with other firms increases the coalition value by a gain of g=50 for each link in the coalition, i.e. every possible connection between firms’ resources (as shown in Figure 2). For computational simplification we normalise $v(\{i\}) = 0$. The value of each link can be interpreted as the network effect, that is reflected in the characteristic values:

- $v(\{i\}) = v(A) = v(B) = v(C) = v(D) = 0$
- For $s=2$: $v(S) = v(A, B) = v(A, C) = v(A, D) = v(B, C) = v(B, D) = v(C, D) = 50$
- For $s=3$: $v(S) = v(A, B, C) = v(A, B, D) = v(A, C, D) = v(B, C, D) = 150$
- For $s=4$: $v(S) = v(A, B, C, D) = 300$

All players are attributed the same SVs of $\varphi_i = 75$ and HVs of $h_i = 900$ and $h'_i = 75$ for $i = A, B, C, D$, which is not surprising, since all players are symmetrical.

Naturally, the grand coalition is the one expected to form.
Asymmetric setting

Now we assume that e.g. player B has higher cost of cooperation than other players, so that each link with B incurs a cost of 25, yielding the characteristic values:

- $v(A) = v(B) = v(C) = v(D) = 0$
- $v(A, B) = v(B, C) = v(B, D) = 25$
- $v(A, C) = v(A, D) = v(C, D) = 50$
- $v(A, B, C) = v(A, B, D) = v(B, C, D) = 100$
- $v(A, C, D) = 150$
- $v(A, B, C, D) = 225$

The SVs would then be $\phi_i = 62, 5$ for $i = A, C, D$ and $\phi_i = 37, 5$ for $i = B$, while the HVs are $h_i = 700$ for $i = A, C, D$ and $h_i = 600$ for $i = B$, and $h'_i = 58, 33$ for $i = A, C, D$ and $h'_i = 50$ for $i = B$.

If a player either cannot contribute as much to an alliance, or has higher cost of cooperation than other players, then intuitively his share of the alliance payoff is lower than that of the other players. Naturally, the grand coalition is again the one which is going to form.

Since these cases are straightforward and the results provide no counterintuitive insights, we continue by introducing a second technology. The firms now must decide on which of the two technologies to focus on, which is generally an underlying reason for the formation of alliances in standard-setting games.

Two technologies with symmetric setting

Now imagine two technologies exist, tech A and tech B. While firms A and C would prefer tech A, firms B and D are closer to tech B. The underlying reason might be that the existing resources are specialised to some degree in the development of one of the two technologies and suffer compatibility losses when used for the other technology. For example IPR and patents that
are of high value for one technology generally have a lower value for the other technology or human capital might be technology-focused. Therefore, forming an alliance with a firm which has the same technology-bias yields the same gain per link as in the initial setting. However, connecting to the less preferred technology incurs a cost of the size \( c \) per link, which reduces the associated surplus. For \( c = 25 \) we obtain the following characteristic values:

\[
\begin{align*}
&\bullet v(A) = v(B) = v(C) = v(D) = 0 \\
&\bullet v(A, B) = v(A, D) = v(B, C) = v(C, D) = 25 \\
&\bullet v(A, C) = v(B, D) = 50 \\
&\bullet v(A, B, C) = v(A, B, D) = v(A, C, D) = v(B, C, D) = 100 \\
&\bullet v(A, B, C, D) = 200
\end{align*}
\]

Since the setting is effectively again symmetrical, all players are attributed the same SV of \( \varphi_i = 50 \) and HVs of \( h_i = 600, h'_i = 50 \) for \( i = A, B, C, D \).

Whether we interpret the standard as a private or a public good, it is not surprising that, again, every firm will gain the same payoff as shown in the SV and HV, since all firms are again symmetrical.

**Two technologies with asymmetric setting**

Let’s assume that firm B is even less compatible with tech A (as described in Figure 2) and incurs an even larger cost (e.g. due to a patent that is of value only for technology B) when connecting to a ’tech A focussed alliance’. In addition to that, the ’intra-technology’ link between firms A and C (firms B and D respectively) would suffer a loss of 25, if forced to connect to the ”wrong” technology. Since the alliances will always choose the technology which yields the highest payoff, the coalition values only change for the grand coalition and the coalition (A,B,C):

\[
\bullet v(A) = v(B) = v(C) = v(D) = 0
\]
\[ v(A, B) = v(A, D) = v(B, C) = v(C, D) = 25 \]
\[ v(A, C) = v(B, D) = 50 \]
\[ v(A, B, C) = 75 \]
\[ v(A, B, D) = v(A, C, D) = v(B, C, D) = 100 \]
\[ v(A, B, C, D) = 175 \]

One would expect that the SV and the HV would change the most for firm B, but it turns out that only firm D retains the same SV as before and suffers only a smaller decline in its HVs. A, B, and C all suffer (the highest) losses:

\[ \varphi_A = \varphi_B = \varphi_C = 41, \varphi_D = 50 \]
\[ h_A = h_B = h_C = 550, h_D = 575 \]
\[ h_A' = h_B' = h_C' = 43, 26, h_D' = 45, 22 \]

Player B does not contribute when forced to use tech A, while D only contributes less in tech A as A and C do when forced to use tech B.

Although player B is the inflexible one, players A and C "suffer along" with B while D is best off.

We conclude, that being strongly biased towards one technology (due to specialised resources, e.g. 'sunk' human capital, IPR, or patents, etc.) increases the probability of the (sunk) technology being used. It does not pay for others to deviate from this technology if we use our parameters. Since on one hand B cannot cooperate with A and C profitably on technology A, but on the other hand A and C also cannot cooperate with B as profitably on technology B, all three are treated and lose equally according to SV and HV.

Weakly convex game, some non-real gaining coalitions

In this example we assume, that firm B’s incompatibility not only occurs if it has to use tech A but in every cooperation with a firm specialised in the other technology, even if the resulting
alliance would standardise on tech B.

In our model this is reflected in the value of $g=0$ for the inter-technology links between firms A and B, and firms C and B respectively.

- $v(A) = v(B) = v(C) = v(D) = 0$
- $v(A, B) = v(B, C) = 0$
- $v(A, D) = v(C, D) = 25$
- $v(A, C) = v(B, D) = 50$
- $v(A, B, C) = 50$
- $v(A, B, D) = v(B, C, D) = 75$
- $v(A, C, D) = 100$
- $v(A, B, C, D) = 150$

The SV and HVs are:

$\varphi_A = \varphi_C = 37.5, \varphi_B = 25, \varphi_D = 50$

$h_A = h_C = 400, h_B = 350, h_D = 500$

$h'_A = h'_C = 36, 36, h'_B = 31, 82, h'_D = 45, 45$

In this case, B suffers the smallest payoff, while D can retain his $\varphi$ and even increase his payoff according to $h'$, although the coalition value of the grand coalition declines. Since B is now the only player that does not contribute to some coalitions, B is worse off than all other players.

In all examples with strictly convex games we computed the HV $h'$ is closer to the equal distribution than the SV (unless both yield the same vector). The HV - strictly speaking a linear transformation of the HV - is supposedly always closer to (not further from) the equal distribution than the SV. The rationale behind this is, that the HV yields the same payoffs as the SV, if all coalitions are real gaining coalitions. If some coalitions are not real gaining, the SV distributes
the coalition payoffs of these coalitions only to some (particularly strong') participants of these coalitions. These payoffs are disregarded by the HV, thus eliminating a potential for unequal distribution. Therefore the HV must always be closer to the equal distribution than the SV, if the game is convex. If we extend our analysis to non-convex games, the HV will simply disregard some coalitions that are "at the edge of decisiveness" in that \( v(T \cup \{i\}) = v(T) + v(i) \). Therefore it might be further from the equal distribution than the SV.

In the following we extend our examples, since the optimal size of an alliance will not always be the grand coalition. Therefore we first introduce an additional dummy player who contributes nothing to any coalition and give examples in which the dummy player is replaced by a harmful player who harms the coalition in contributing a negative amount to the coalition. Imagine a player that contributes nothing or that contributes, but less than the additional cost (e.g. of interaction of resources) he induces for the coalition. For ease of computation we consider an additional player \( E \) who contributes nothing (-1) per link.

The SVs for the initial setting will be \( \varphi_i = 75 \) (\( \varphi_i = 74, 5 \)) for \( i = A, B, C, D \) and \( \varphi_E = 0 \) (\( \varphi_E = -2 \)) for \( E \), while the HVs will then be \( h_i = 900 \) (\( h_i = 900 \)) for \( i = A, B, C, D \) and \( h_E = 0 \) (\( h_E = 0 \)) for \( E \) and \( h_i' = 75 \) (\( h_i' = 74 \)) for \( i = A, B, C, D \) and \( h_E' = 0 \) (\( h_E' = 0 \)), respectively.

For the asymmetric setting the SVs would then be \( \varphi_i = 62, 5 \) for \( i = A, C, D \), \( \varphi_i = 37, 5 \) for \( i = B \), and \( \varphi_i = 0 \) for \( i = E \), while the HVs are \( h_i = 700 \) for \( i = A, C, D \), \( h_i = 600 \) for \( i = B \), and \( h_i = 0 \) for \( i = E \), respectively.

In case of two technologies with symmetric setting the SVs will be \( \varphi_i = 50 \) (\( \varphi_i = 49, 5 \)) for \( i = A, B, C, D \) and \( \varphi_E = 0 \) (\( \varphi_E = -2 \)) for \( E \), while the HVs will then be \( h_i = 600 \) (\( h_i = 600 \)) for \( i = A, B, C, D \) and \( h_E = 0 \) (\( h_E = 0 \)) for \( E \) and \( h_i' = 50 \) (\( h_i' = 49 \)) for \( i = A, B, C, D \) and \( h_E' = 0 \) (\( h_E' = 0 \)), respectively.

In the example of two technologies with asymmetric setting the SVs and HVs will be:
\[
\varphi_A = \varphi_B = \varphi_C = 41, 67, \varphi_D = 50 \quad (\varphi_A = \varphi_B = \varphi_C = 41, 17, \varphi_D = 49, 5)
\]
In our last example of a weakly convex game, with some non-real gaining coalitions the SVs and HVs are:

\[ h_A = h_B = h_C = 550, h_D = 575 \quad (h_A = h_B = h_C = 550, h_D = 575) \]

\[ h'_A = h'_B = h'_C = 43, 26, h'_D = 45, 22 \quad (h'_A = h'_B = h'_C = 42, 27, h'_D = 44, 19) \]

Concerning the extension of the games with a fifth player E we can conclude the following:

SV and HV do not "punish" the incumbent players for cooperation with a dummy, although this does not pay for them.

SV and HV h' "punish" the incumbent players for cooperation with a player that harms the coalition - the SV divides the loss equally between the coalition of all incumbents and E, while h' divides the loss entirely between the incumbents (according to h).

The HV h does not "punish" any player for cooperation with a dummy or a harmful player, since coalitions with a dummy or a player that harms the subcoalition of incumbents are not RGCs. This is in line with the intuition not to cooperate with a dummy or a harmful player, since this would be irrational. Therefore no rational player can be punished, since there would not be a behaviour that might be punishable.

## 5 Conclusions

We analyse coalition formation in standardisation, combining different strands of standardisation literature with game-theoretic concepts. Given sufficient parameters the emergence of any alliance can be explained - from singleton to grand coalition. Due to the setting there is a tendency towards the grand coalition; for a convex game, it will naturally form. But in case that the respective
value yields the same results for the grand coalition with \(n-1\) players and the grand coalition with \(n\) players, the players will be indifferent between both alliances.

For symmetric, convex games, the allocations given by the SV and the allocation derived from the HV coincide, if all coalitions are real gaining coalitions. Otherwise \(h'\) must be closer to the equal distribution than \(\varphi\) - at least for strictly convex games \((v(T \cup \{i\}) > v(T) + v(i))\). In other words, \(h'\) smooths the allocation. The rationale behind this is, exhibits a tendency to favour that \(\varphi\) tends to favour players that contribute more to a coalition. If all coalitions are real gaining coalitions \(h'\) might yield at most the same value as \(\varphi\). If some coalitions are not real gaining, \(\varphi\) distributes these coalition payoffs only to the decisive participants of these non-real gaining coalitions. Payoffs of non-real gaining coalitions are not regarded by \(h\) and \(h'\), thus eliminating a potential for unequal distribution.

"At the edge of decisiveness" \((v(T \cup \{i\}) = v(T) + v(i))\), as well as for non-convex games, \(\varphi\) might be closer to the equal distribution than \(h'\), since \(h\) and \(h'\) will simply disregard some coalitions that are non-real gaining.

For asymmetric settings we provide the following conclusions:

A player being strongly biased (determined) towards one technology only due to specialised resources, e.g. 'sunk' human capital, IPR, or patents, etc., increases the probability of the (sunk) technology being used. It does not pay for others to deviate from this technology if we use our parameters. Since on the one hand B cannot cooperate with A and C profitably on technology A, but on the other hand A and C also cannot cooperate with B as profitably on technology B, all three are treated and lose equally according to \(\varphi\) and \(h\).

In the case that one player can only profitably cooperate with one other player (or a group of players), she suffers the smallest payoff, while the player(s) she can cooperate with profitably can retain her (their) \(\varphi\) and even increase her (their) payoff according to \(h'\), although the coalition value of the grand coalition declines. This means that the cooperation of all players does not pay, a smaller coalition would be favourable.
If we consider cooperation with a dummy player or a harmful player, both SV and HV do not "punish" players for cooperation with a dummy, although this cooperation does not pay for the players. The intuition behind this is, that it is not reasonable to cooperate with a dummy.

$\varphi$ and $h'$ "punish" the incumbent players for cooperation with a player that harms the coalition. $\varphi$ divides the loss equally between the coalition of all incumbents on one hand and the harmful player on the other hand. $h'$ divides the loss entirely between the incumbents (according to the relative distribution that results from a normalised $h$). Of course it also is not individually (coalition) rational to cooperate with a harmful player, which becomes obvious in comparison with the reduced game without the harmful player. The vectors in the non-reduced game are not in the core and since a smaller coalition is pareto-efficient contrary to the grand coalition, the grand coalition would not form.

$h$ does not "punish" any player for a cooperation with a dummy or a harmful player, since coalitions with a dummy or a player that harms the subcoalition of incumbents are not RGCs and therefore from a public good perspective not relevant.

Otherwise the two values do not differ qualitatively which begs the question, in how much they mirror characteristics of the private good (SV) and the public good (HV) - or whether in this respect there might be no or just a quantitative difference in the characteristics? Or whether the Holler value, in contrast to the Holler-Packel index has the property of monotonicity.

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References


