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Cancellation of overhang seats: the price of unkept promises

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Abstract

Mixed Member Proportional (MMP) electoral systems aim to balance territorial representation, personal voter-politician connections, and party proportionality. However, legislators face significant challenges in achieving these goals simultaneously. In Germany, these efforts led to the pressing issue of overhang seats, which prompted a reform of the electoral system in 2023. This study examines the effects of this reform and three alternative solutions discarded during the legislative process, focusing on their impact on representation and proportionality. We evaluate these solutions using various inequality indexes and their specific components to address issues such as disproportionality, malapportionment, and wasted votes. Our analysis includes counterfactual recalculations of the 2025 Bundestag election results across four alternative electoral systems: the German electoral system first used in the 2025 elections, the German electoral system used until 2021 elections, and two systems using the restricted Sainte-Laguë/Webster method to allocate votes, with or without inviolability of direct mandates. Our findings reveal minimal differences in unequal representation among the systems. However, the adopted solution introduces the controversial phenomenon of “orphaned seats” disproportionately affecting major political forces like the CDU/CSU and AfD. This fact is particularly significant in the specific context of German politics, but it reveals a certain vulnerability in the reform — it is difficult to expect stability from a solution whose most controversial effect is felt most acutely by the strongest players.

Keywords Representation · Proportionality · Electoral reform in Germany · 2025 Bundestag election · Surplus seats · Orphaned seats

1 Introduction

The MMP system, lauded as “the best of both worlds” (Shugart and Wattenberg 2001), made a promise to simultaneously achieve the goals of various other models of representation— in particular territorial representation, personal connection between a politician and a voter, and party proportionality. However, an attempt to strictly fulfil these promises in the

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German electoral system led to the growing problem of overhang seats and corresponding balancing seats, amounting to as much as 23% of all seats in 2021. The search for a solution to this problem identified several possibilities (Behnke 2025). However, each of them meant violating one of the four initial promises of the just electoral system, which include: (a) preserving the regular size of the Bundestag, (b) inviolability of direct mandates, (c) inviolability of mandates of a *Landesliste*, and (d) maintaining of inter-party proportionality. The reform of the electoral law passed by the ruling coalition of SPD, Greens, and FDP in March 2023, which was vehemently rejected by the opposition CDU/CSU in particular, took effect in b) and no longer allocated a constituency seat in all constituencies.

The choice of solution can be based on theoretic and normative considerations, comparing the importance of each of these promises from the point of view of democratic principles (Behnke 2019). However, one can also evaluate these solutions by calculating the weight of violations of these promises based on specific outcomes. One measure needed for this could be an index of general unequal representation (Wada and Kamahara 2024). The effects of the analyzed solutions can be estimated before the election based on poll-based simulations (Behnke 2020a). However, such an index can also be calculated after the election compared to other MMP systems. The latest Bundestag election in February 2025, which was held after the system change has been implemented, offers a good opportunity to follow the second approach and recalculate the results according to the alternatives, with a special focus on those debated before the reform (Behnke 2023) as well as those used in other countries with MMP systems, e.g. Scotland.

This article aims to compare four different electoral systems in terms of different inequality indexes and their specific components. The electoral systems we take into consideration are: the German electoral system first used in the 2025 elections (System 2023), the German electoral system used from 2013 to 2021 (System 2020), a system where the seats are allocated proportionally to the parties at the national level and then distributed among the *Länder* using at both levels the restricted Sainte-Laguë/Webster method with inviolability of direct mandates (RUD), and a similar system but without inviolability of direct mandates at the national level, where mandates over the number of seats a party gets nationwide are not given (RLD). We believe that comparing such solutions can provide valuable insights for all countries that use or are considering the use of mixed electoral systems.

Our paper is structured in such a way that we first present the new German electoral system and the election results. We then explain what tensions in the old system determined its change and what alternative ways to prevent such tensions were considered during the reform work. Next, we discuss ways to measure the mechanical effects of the electoral system, particularly unequal representation. Through a counterfactual recalculation of election results in alternative electoral systems, we compare the solutions used and those discarded during the work on the reform. In the penultimate section, we discuss the issue of the localized voter-MP bond at the single-member district (constituencies) level, which is particularly relevant to the MMP electoral system. We finalize our analysis by presenting the conclusions arising from the 2023 reform of the electoral system for the Bundestag.

2 The German electoral system after the 2023 reform

In the German electoral system, each citizen has two votes. With the ‘first vote’ (ger. *Erststimme*), the voter selects one of the candidates in his constituency. With the ‘second vote’ (ger. *Zweitstimme*), the voter votes for a so-called *Landesliste*, which is a party list valid for one of the sixteen *Länder* of the German Federal Republic.

The distribution of the seats happens in several steps. Before the distribution takes place, the parties participating in the seat distribution are determined. These are only the parties that have won more than 5% of all valid second votes or have won at least three constituency seats. In 2023, this was the case for six parties: the CDU, CSU, SPD, the Green Party, the left-wing party DIE LINKE and the right-wing party AfD. According to an agreement between Germany and Denmark, the party of the Danish minority, the SSW, which only competes in the northern *Land* of Schleswig-Holstein, is exempt from the 5% threshold. Table 1 contains the number of second votes the parties that fulfilled one or both criteria gained in the individual *Länder*.

In the first step, to determine the so-called upper distribution (ger. *Oberverteilung*), which is the distribution of seats between the parties according to their nationwide number of second votes, the formula of Sainte-Laguë/Webster is used. The Christian Democratic Union (CDU), for example, had won 11,196,374 valid second votes. The results of all seven parties together amounted to 42,833,356 valid second votes. With this share of 26,14% of the allocation-relevant second votes, the CDU was entitled to 164 seats out of the total of 630 seats, the SPD to 120, etc. (see Table 2, second-last line).

In the second step, the total number of each party’s seats is distributed among the individual lists of the party in the *Länder*, in proportion to the lists’ second votes, using the Sainte-Laguë/Webster procedure again. The results are the so-called lower distribution (ger. *Unterverteilung*) and can be seen in Table 2 in the “PM” (proportional mandates) rows¹. For example, of the 164 seats that the CDU achieved nationwide, the list of Baden-Württemberg accounted for 29, the list of Berlin for 5, etc.

Next, a constituency seat winner is determined in each of the 299 districts—the candidate who won a plurality of the first votes. This element has a key role in the subsequent procedure, and how it is taken into account is of fundamental importance for the various possible variants of the mechanism and, consequently, for all the disputes over the reform of the German electoral system.

The number calculated by the lower distribution is subtracted from the number of constituency mandates that the party gained in the given *Land* (the “CM” rows in Table 2). The remaining seats are distributed according to the ranks on the *Landesliste*. Candidates on the list who have already won a constituency seat are not considered.

This is where we come to the key change of the introduced reform. A constituency mandate is won if and only if the candidate obtains the most first votes in the constituency and the party’s second votes cover the mandate. Suppose the party’s candidates have received the plurality of the first votes in more constituencies than the party is entitled to. In that case, a ranking list is formed according to the share of first votes, and only those candidates

¹ This two-step procedure for the distribution of the proportional mandates was already in use in Germany from 1953 to 2009. Between 2013 and 2021, the seats were first distributed among the *Länder* according to their population numbers and then within the *Länder* among the party lists according to their number of second votes. This caused some dysfunctional effects, so the law of 2023 meant a switch back to the roots.

Table 1 The distribution of second votes among the *Länder*

Region	CDU	CSU	SPD	GRU	LINKE	AFD	SSW	Total
Baden-Württemberg	2,006,866	0	898,778	865,738	429,484	1,256,430	0	5,457,296
Bavaria	0	2,964,028	920,675	957,435	456,935	1,515,731	0	6,814,804
Berlin	356,099	0	295,182	328,035	387,222	296,990	0	1,663,528
Brandenburg	298,048	0	244,010	108,598	176,224	535,275	0	1,362,155
Bremen	71,573	0	80,604	54,280	51,461	52,496	0	310,414
Hamburg	216,935	0	237,740	201,713	151,115	113,608	0	921,111
Hesse	1,033,842	0	657,510	451,510	311,058	636,778	0	3,090,698
Mecklenburg-Western Pomerania	181,956	0	126,687	54,719	123,059	357,361	0	843,782
Lower Saxony	1,410,418	0	1,153,523	576,845	405,519	894,540	0	4,440,845
North Rhine-Westphalia	3,170,627	0	2,108,434	1,300,901	877,123	1,770,379	0	9,227,464
Rhineland-Palatinate	760,623	0	462,705	256,869	161,867	498,695	0	2,140,759
Saarland	161,113	0	131,136	43,371	44,080	129,294	0	508,994
Saxony	507,247	0	217,144	167,269	290,462	958,401	0	2,140,523
Saxony-Anhalt	256,538	0	146,535	59,077	143,807	496,110	0	1,102,067
Schleswig-Holstein	518,424	0	352,546	279,923	146,428	306,165	76,138	1,679,624
Thuringia	246,065	0	115,915	56,097	200,688	510,527	0	1,129,292
Nation	11,196,374	2,964,028	8,149,124	5,762,380	4,356,532	10,328,780	76,138	42,833,356

Note: German political parties in the table are CDU - Christlich Demokratische Union Deutschlands, CSU - Christlich-Soziale Union in Bayern, SPD - Sozialdemokratische Partei Deutschlands, GRU - Bündnis 90/Die Grünen, LINKE - Die Linke, AFD - Alternative für Deutschland, SSW - Südschleswigscher Wählerverband

whose ranking is lower than or equal to the number of mandates that the party receives are elected. For example, in Baden-Württemberg, 35 candidates of the CDU had a plurality of first votes, but the CDU was only entitled to 29 mandates according to its second votes. Thus, of the 35 CDU candidates who were winners in their districts, only those ranked in the top 29 places in the ranking created on the share of first votes they had obtained, won a seat in the Bundestag. The number of plurality winners who go away empty-handed is given in brackets. There will be no directly elected member of parliament from the affected constituencies. They are, therefore, referred to as “orphaned constituencies”. The number of orphaned constituencies corresponds to the number of overhang mandates that would have arisen if each constituency had been represented.

Table 2 Distribution of the proportional and the constituency mandates across the *Länder* and parties

Region	Type	CDU	CSU	SPD	GRU	LINKE	AFD	SSW	Total
Baden-Württemberg	PM	29	0	13	12	6	19	0	79
	CM	29 (-6)	0	0	3	0	0	0	32
Bavaria	PM	0	44	14	14	7	22	0	101
	CM	0	44 (-3)	0	0	0	0	0	44
Berlin	PM	5	0	4	5	6	4	0	24
	CM	3	0	1	3	4	1	0	12
Brandenburg	PM	4	0	4	2	3	8	0	21
	CM	0	0	1	0	0	8 (-1)	0	9
Bremen	PM	1	0	1	1	1	1	0	5
	CM	0	0	1 (-1)	0	0	0	0	1
Hamburg	PM	3	0	3	3	2	2	0	13
	CM	1	0	3	2	0	0	0	6
Hesse	PM	15	0	10	7	4	9	0	45
	CM	15 (-5)	0	2	0	0	0	0	17
Meckl.-Western Pomerania	PM	3	0	2	1	2	5	0	13
	CM	0	0	0	0	0	5 (-1)	0	5
Lower Saxony	PM	21	0	17	8	6	13	0	65
	CM	15	0	15	0	0	0	0	30
North Rhine-Westphalia	PM	47	0	31	19	13	26	0	136
	CM	44	0	17	3	0	0	0	64
Rhineland-Palatinate	PM	11	0	7	4	2	7	0	31
	CM	11 (-3)	0	1	0	0	0	0	12
Saarland	PM	2	0	2	1	1	2	0	8
	CM	2	0	2	0	0	0	0	4
Saxony	PM	7	0	3	2	4	14	0	30
	CM	0	0	0	0	1	14 (-1)	0	15
Saxony-Anhalt	PM	4	0	2	1	2	7	0	16
	CM	0	0	0	0	0	7 (-1)	0	7
Schleswig-Holstein	PM	8	0	5	4	2	5	1	25
	CM	8 (-1)	0	1	1	0	0	0	10
Thuringen	PM	4	0	2	1	3	8	0	18
	CM	0	0	0	0	1	7	0	8
Nation	PM	164	44	120	85	64	152	1	630
	CM	128	44	44	12	6	42	0	276

Note: PM=proportional mandates; CM=constituency mandates

3 Tensions in the MMP system and ways to resolve them

The purpose of mixed electoral systems is to combine the advantages of personal voting in constituencies with those of party lists. However, these advantages come at a price. In particular, in mixed-member proportional systems, such as the German electoral system, tensions between the different promises, such as preserving the regular size of the Bundestag, inviolability of direct mandates, inviolability of the list mandates, and maintaining inter-party proportionality, are logically unavoidable if directly won constituencies cannot be fully integrated into the proportional distribution of seats and votes (see Behnke 2025). In such cases, the tensions often result in overhang mandates, understood as a situation in

which a party wins more constituency mandates than it would be entitled to based on proportional representation. The only way to resolve this situation is to enlarge parliament so that the overhang mandates eventually disappear within the mandates allocated according to the principle of proportionality. This was the approach in Germany from 2013 to 2021, which led to an increase in the size of the Bundestag that was generally perceived as unacceptable and resulted in the 2023 reform (Behnke 2025).

However, suppose the regular size of parliament is guaranteed. In that case, we face the impossible trade-off between personal choice, expressed by the election in constituencies, which is the cause of the emergence of overhang mandates, and proportional representation. Such cases require a decision on which principle to restrict. There is no correct answer, as the decision depends on the normative value attributed to each principle. In Germany, historical and constitutional reasons favor proportionality, while systems like Scotland prioritize constituency seats, even at the expense of proportionality.

This tension is further complicated in federal states like Germany, where two perspectives should be considered: that of the central or federal state and that of regional units in Germany called *Länder*. In such cases, restrictions of proportionality can occur in two ways. Firstly, the nationwide proportionality between parties can be violated. Secondly, there may be a violation of proportionality within parties if their national quota of seats is not distributed among the *Länder* in proportion to the votes, which also results in a corresponding violation of the overall proportionality between the regional units. While an infringement of the principle of proportionality between parties is often called disproportionality, restrictions of the principle of proportionality between regional units are referred to as malapportionment (MLP; Wada and Kamahara 2024).

To express the different forms in which a conflict between overhang mandates or the principle of constituency-based personal voting and the principle of proportionality arises, it is helpful to distinguish between internal and external overhang mandates (Behnke 2025). Internal overhang mandates arise when a party wins more constituency seats in a *Land* than it would be entitled to based on the second votes cast there. By contrast, external overhang mandates occur when a party has won more direct mandates nationwide than it would be entitled to based on the second votes cast.

To address the tension between overhang mandates and the proportionality principle, there are four viable options described below, depending on which of the four conditions mentioned in the introduction we decide to break (Behnke 2025). The first solution is to enlarge the size of the Bundestag:

3.1 System 2020: enlargement of the Bundestag through compensatory mandates

This was the solution implemented in the 2013 and 2020 electoral laws and its drawbacks, as described earlier in this section. In our analysis, we use the results of the seat distribution that would have resulted from the 2025 Bundestag election if the seats had been allocated according to the 2020 electoral law as a reference case.

In the following three solutions, we assume that the Bundestag should adhere to the regular size:

3.2 System 2023: non-allocation of constituency seats if the second vote result does not cover them

The most radical solution for dealing with the tension between overhang mandates and the principle of proportionality is to maintain inter-party proportionality in its entirety by restricting the allocation of constituency mandates. The overhang mandates are capped, i.e. only so many constituency mandates are allocated that no overhang mandates arise in the first place. This solution's additional advantage is that it fully maintains the proportionality between the number of seats a party wins in the various *Länder*. This is the solution that was introduced in the electoral law of 2023. The consequence of the system is that there are so-called orphaned constituencies, which are not represented by any directly elected member of the Bundestag. In the 2025 federal election, 23 such orphaned constituencies emerged.

3.3 Restricted lower distribution (RLD): offsetting of *Landesliste* with overhang mandates

Of the 23 orphaned constituencies in 2025, 15 were held by the CDU, three by the CSU, 4 by the AfD and 1 by the SPD. These would have become overhang mandates if all of these had been filled. However, only the CSU's overhang mandates would have been external overhang mandates. The overhang mandates of the other parties could have been compensated for by subtracting the list mandates of the affected party in other *Länder*. This option does not exist for the CSU because it only competes in one *Land*, namely Bavaria. The compensation of internal overhang mandates by offsetting them against list mandates thus reaches its limits due to the list mandates made available for compensation. In the 2020 electoral law, this was regulated in such a way that a maximum of half of the list mandates were available for compensation for overhang mandates. In the extreme case, however, which we assume in our simulation, all remaining list mandates should be used to compensate for overhang mandates.

The distribution of the mandates is done according to a divisor method. We use the Sainte-Laguë/Webster method, where the seats are awarded along a defined order that corresponds to their "priorities". The constituencies won by a party are assumed to be set, i.e. a party or a list of a party starts the procedure with this guaranteed number of seats. Suppose a particular list follows the line under the divisor method. In that case, it is only assigned a seat if this does not result in its seat quota in that *Land* being larger than the number of seats to which it is entitled according to the proportional system. It is skipped as long as the party has more seats at its disposal due to its "starting asset" of pre-allocated constituency mandates than it would receive in the total under the divisor method. The divisor method is terminated when all seats— including the starting quotas— have been allocated according to the rule. This means that in some cases, there are still parts of the "starting asset" of pre-allocated constituency mandates "overhanging". However, in this case, it only leads to a violation of proportionality between the *Länder* lists of a party.

This regulation of a conditional or restricted application of the Sainte-Laguë/Webster formula (see also Flis et al. 2025 in this issue) regarding the lower distribution has to be combined with a corresponding regulation for treating external overhang mandates. As proposed by the Green Party in 2009, these could remain with the overhang party as a kind of bonus without any compensation for the other parties or, as proposed by the Green Party

in 2011, be capped. We apply the latter variant in our simulation. This model thus has the element of capping in common with the electoral law of 2023. However, it only applies this to external overhang mandates that cannot be compensated for within the party by shifts between the *Länder* quotas. Accordingly, there are three orphaned constituencies in the case of the CSU.

3.4 Restricted upper distribution (RUD): balancing external overhang mandates with mandates of other parties

If all constituencies are to be filled while still adhering to the regular size of the Bundestag, and if external overhang mandates exist, the proportionality between the parties at the national level, i.e. in the upper distribution, must be violated. This corresponds to the basic logic of AMS systems such as that of Scotland (Siaroff 2000). This can be implemented very easily by applying the procedure of the conditional or restricted Sainte-Laguë/Webster formula as early as the calculation of the upper distribution. The three external overhang mandates of the CSU are then compensated for by giving the SPD, Greens and AfD one seat less in the upper distribution. The nationwide seat quotas of the parties are then distributed among the *Länder* lists using the restricted Sainte-Laguë/Webster formula so that any remaining internal overhang mandates are compensated for within the party.

There is one more possible solution—reducing the number of SMDs. In our analysis, we did not consider this option for two reasons. Firstly, it would constitute the most significant change to the system—a change that could also alter voter behavior, for example, due to different candidates running in the districts. As a result, the recalculation of results would be significantly less reliable. At the same time, examining the mathematical consequences of such a solution would require drawing the boundaries of new electoral districts. Aside from the labor-intensive nature of such a task, districting is an arbitrary decision with significant political implications such as the risk of potential bias. Therefore, we considered only those solutions that make use of the existing SMDs. Apart from that, solving the problem would require a far-reaching reduction to 200 to 220 constituencies, for which there is no discernible political majority.

4 Unequal representation— methods of measurement

Daniel Bochsler, Miriam Hänni, and Bernard Grofman (2024, 10) point out that “electoral system proportionality is a central variable in myriad applications in comparative politics, political economy and conflict studies”. In this context, however, a fundamental question arises about the perspective from which the level of proportionality of a given electoral system should be examined. This dilemma becomes all the more pertinent because, in electoral practice, it is not uncommon for an electoral system included in the family of PR systems to generate far from proportional election results. In this context, researchers point to two main approaches. On the one hand, “scholars investigating the opportunities offered by electoral systems for (proportional) party representation address the (a priori) institutional side of the equation as electoral system ‘permissiveness’ or ‘openness’” (Bochsler et al. 2024, 2). This approach can be described as institutions-based, since the proportionality of a given electoral system is analyzed through the prism of its elements, which, depending

on the design adopted, can either strengthen or weaken this variable. On the other hand, we are dealing with an approach referred to as outcome-based (a posteriori), which evaluates the proportionality of a given electoral system through the perspective of its actual political effects described by such indicators as vote-seat disproportionality or the effective number of parties in parliament. According to Daniel Bochsler, Miriam Hänni, and Bernard Grofman (2024, 2), “a posteriori measures vary among countries with similar electoral rules, and from election to election, as they reflect not only the set rules on elections, but also the social cleavages in place, or the strategic behavior of parties and voters”.

A phenomenon closely related to disproportionality is malapportionment (MLP). Malapportionment refers to the discrepancy between the shares of legislative seats and the shares of population held by geographical units (Samuels and Snyder 2001, 652). In other words, malapportionment involves awarding some areas of a country more seats in relation to population than others (Gallagher and Mitchel 2018, 34; Norris 2004; Grofman et al. 1997). The key cause of this phenomenon is the division of the electoral area into districts, which violates the principle of equality of votes. Lijphart (1999, 156) pointed out that “in single-member districts, malapportionment means that the districts have substantially unequal voting populations; malapportioned multimember districts have magnitudes that are not commensurate with their voting populations”. The literature distinguishes between passive malapportionment, which occurs when the electoral boundaries are not redrawn for an extended period, and active malapportionment, which occurs when the boundary authority consciously draws constituencies that vary substantially in population. (Handley 2018, 525–526). Apart from different sizes of populations, malapportionment can also refer to voters or votes, e.g. in case of different turnouts (Wada and Kamahara 2024).

According to Arendt Lijphart, malapportionment is difficult to avoid, especially in plurality and majority systems with single-member districts; it occurs on a smaller scale in PR systems. On the other hand, “malapportionment is entirely eliminated as a problem when elections are conducted in one large nationwide district as in Israel and the Netherlands or with a nationwide upper tier as in Germany and Sweden.” (Lijphart 1999, p. 156). Nohlen (2004, 75–76) notes, however, that in the single-member districts that make up the plurality tier of the electoral system for the German Bundestag, malapportionment does occur but is nevertheless mitigated by a distribution of seats at higher tiers. In the context of the electoral system for the Bundestag — and, more broadly, the systems included in the MMP family — the question arises as to the level at which malapportionment should be measured: should it be done concerning the single-member districts that make up the plurality tier of the system, or to individual *Länder*, where the distribution of seats among party lists is carried out?

A constant problem with most electoral systems is what should be the basis for the distribution of seats among districts. If the division is done before the election — a must for single-mandate elections — it can be done based on the number of residents or voters. These two quantities do not have to be perfectly correlated, but the differences are unlikely to be significant. However, in the case of multimember districts, it also comes into play to determine the number of seats after the election, based on the number of votes cast. Here, the differences in the number of voters or residents can already be significant as turnout variation comes into play.

The second dilemma is whether to allocate seats to districts before dividing them between parties or to divide them between parties first and then between districts. The last is that which was usually used in Germany. However, as long as overhang mandates are not bal-

anced, which was the case until 2013, this mechanism can lead to a so-called negative voting weight. This effect meant that an elector's vote for a party could cause a seat loss for a party when this additional second vote leads to a shift in seats from one *Land* where surplus mandates arise to another country. Vice versa, fewer second votes could lead to an additional seat, which happened in a by-election in Dresden in the election of 2005. If the CDU had received a few thousand more votes there, it would have received one fewer seat overall in 2005 (Behnke 2008). This effect was declared unconstitutional by the Federal Constitutional Court in 2008. The ruling was then responsible for the regulation that was first implemented with the 2011 election law, namely that seats should first be allocated to the states according to population figures and then within the states to the party lists. However, the 2011 Election Law was never applied. Nevertheless, the new sequence for allocating seats was retained in the 2013 electoral law, even though it was no longer necessary, as the 2013 electoral law provided for compensation for over-representation, thereby annihilating the impact of the negative vote weighting by making the direction of its effect unforeseeable. In principle, the effect of negative voting weight would also have disappeared with any other measure that would have prevented the creation of overhang mandates, such as the introduction of two-person constituencies or a reduction in the number of constituencies (Behnke 2010).

Distributing seats among districts in each party separately can increase inequality of representation because the biases inevitably created by rounding when allocating seats can accumulate from district to district. This also means that malapportionment increases when support for parties that do not win a seat is unevenly distributed among districts.

The result of the malapportionment is to undermine the principle of equal votes. However, Nohlen (2004, 76) points out that “malapportionment is empirically a perfectly normal phenomenon. What is crucial is its scale. The limits of tolerance for deviation from the postulate of equality are often exceeded to such an extent that it is no longer possible to claim equal electoral rights, which makes us deal with manipulation”. Malapportionment, next to differences like the vote shares of the winning candidates of different parties and turnout rate differences across districts, contributes to biased partisan representation (Grofman et al. 1997) and, vital in federal states, biased territorial (geographic) representation.

4.1 The whole picture of unequal representation (WPUR)

Wada and Kamahara (2024) present a compelling unified approach to measuring unequal representation. As they point out, electoral inequalities are traditionally assessed either from a party perspective, known as disproportionality, or from a district perspective, referred to as malapportionment. Both perspectives measure the discrepancy between the expected state and actual electoral outcomes resulting from general norms. Wada and Kamahara propose combining these perspectives by measuring the ratio of seats to votes for each party in each district separately, thereby creating a comprehensive view of unequal representation, termed the Whole Picture of Unequal Representation (WPUR).

Utilizing alpha-divergence to measure these inequalities allows for the decomposition of this overall picture into its constituent parts, leveraging the mathematical properties of this measure. Although the use of alpha-divergence may seem novel, it is closely related to the well-established Sainte-Laguë Index (SLI) in political science, providing that alpha equals 2 and the measure is multiplied by 2. Despite being less popular than the Gallagher Index

(IGh), the SLI offers several intriguing properties that enhance the analysis of inequality. Consequently, this paper primarily employs the Sainte-Laguë Index to examine various aspects of unequal representation, as discussed by Wada and Kamahara.

$$SLI = \sum_{i=1}^n V_i * \left(\frac{S_i}{V_i} - 1 \right)^2$$

Wada and Kamahara demonstrated that the Whole Picture of Unequal Representation (WPUR) can be decomposed into its constituent parts in two distinct ways. The first method involves separating it into inter-party disproportionality (DSP) and intra-party unequal representation (IPUR). The IPUR metric quantifies the deviation in seat allocation between districts within each party relative to the proportion of votes the party received in those districts. For instance, consider an election held in two single-member districts, each with an identical number of votes, where one party receives 50% of the votes plus one in one district, and 50% minus one in the other, while the second party has the reverse outcome. If the outcome results in one party winning one constituency and the other party winning the other, the DSP would be zero, while the WPUR would be almost perfectly 100%, solely comprising IPUR. This scenario illustrates that although each party secured 25% of all votes in each district, this translated into 50% of the seats in half of the districts and 0% in the other half.

IPUR can be interpreted as showing the ratio of votes cast for candidates who did not win a seat to the number of votes received by the winners (assuming that each seat winner received the same number of votes). Thus, an analogous situation with three districts and three parties results in an IPUR of 200%, because in each party the losers receive almost twice as many votes as the seat winner.

The second method of decomposing the Whole Picture of Unequal Representation (WPUR) begins with calculating malapportionment (MLP). This involves disregarding party divisions and assessing deviations between districts. Wada and Kamahara refer to the difference between WPUR and MLP as ‘wasted votes’ (WV), a concept broader than the conventional understanding, which typically includes only votes cast for losing candidates. WV also encompasses votes that winning candidates lacked to justify their awarded seats and votes won over what was necessary to secure the seat. For example, in an election with two single-member districts, each having an equal number of votes, where two parties each receive 50% of the vote, and each party wins one constituency, the MLP would be 0% due to the equal constituencies. However, the WV would be 100%, as in each constituency, the losing candidate received 50% of the votes, while the winner fell 50% short of the proportion needed to justify the seat won.

$$WPUR = DSP + IPUR = MLP + WV$$

This toolkit for analyzing unequal representation is particularly valuable when evaluating the impacts and alternatives of reforming the German electoral system. Different solutions to the issue of overhang seats may violate various normative criteria for the quality of representative democracy, necessitating a single measure to compare the extent of these violations. However, applying this measure to the German system also requires clarity on what exactly is being measured. The challenge lies in the two levels of mandate allocation and the

two votes cast by German voters. The first issue pertains specifically to malapportionment, while the second relates to disproportionality.

4.2 The detailed dilemmas

Another important thing to consider when calculating WPUR is whether to include the outcomes from the first or the second vote, or both. The MMP system aims to combine the promise of connection between voters and their representatives (first vote) with the promise of proportionality (second vote). The first vote, also known as ‘personalized’, represents the voter’s preference directly, and it is placed earlier on the ballot list, suggesting its significance to the voters. Thus, it should not be omitted in the calculations, even though it is the second vote considered more important by researchers as it influences the proportional division of seats and most seats in the Bundestag are obtained through it. Moreover, voters often overlook the significance of the first and second votes. In 1998, only around half of the voters in Germany were able to correctly identify the second vote as the most important in terms of determining the composition of the Bundestag, while a significant percentage considered their importance to be equal (Karp 2006). In 2017, only 43% of Germans were able to correctly interpret the political meaning of the second vote (Jankowski et al. 2022). The percentage of correctly informed voters increases slightly shortly before elections (Schmitt-Beck 1993), but when corrected for guessing, it still amounts to around 50% (Behnke 2015). This creates an important tension because, on the formal side, the final distribution of seats in the System 2023 is based solely on the second vote. Therefore, we have adopted a solution that combines both perspectives — lawmakers and voters. In the first step, we calculate the values of the basic proportionality indexes — Gallagher and Sainte-Laguë — taking into account only second votes. In the second step, on the other hand, we also take into account the voters’ perspective. Since a considerable share of voters do not understand the importance of the first and the second vote and the final distribution of seats is a complex combination of both the first and second votes, we decided to calculate WPUR based on the sum of both votes. To this end, we summed the first and second votes cast for each party in every district, and this total was taken as the party’s result.

5 Recalculation

The recalculation of results within alternative electoral systems can be achieved using detailed data from *Länder* and districts. This data enables the computation of the number of seats allocated to each party in these regions based on the specific algorithms of each system. The coefficients defining each scenario are analyzed. The WPUR value and its four constituent indexes have been determined for the four systems under comparison. In the first step, the calculation is carried out at the *Länder* level, and in the second step at the SMD level. Additionally, Table 3 highlights the number of disputed seats in orphaned districts — seats that might have been reassigned to a different party (inter-party shift) or the same party in a different *Land* (inter-*Länder* shift). It also outlines the extra seats by which the Bundestag would have expanded under the System 2020.

The calculations presented here reveal that despite intense debate, the reform options show minimal differences when assessed using quantitative measures. This holds true

Table 3 Indexes of disproportionality for different electoral systems recalculated based on 2025 election outcomes

	Basic indexes		Controversial seats			WPUR (both votes)	WPUR components			WV
	IGH	SLI	orphanded districts	inter-Länder shift	inter-party shift		additional seats	DSP	MLP	
System 2023	6,49	15,92%	23			13,20%	12,66%	0,10%	0,54%	13,10%
Restricted Lower Distribution	6,49	15,92%	3	20		14,44%	12,66%	0,35%	1,77%	14,08%
Restricted Upper Distribution	6,44	15,97%		20	3	14,46%	12,68%	0,33%	1,78%	14,13%
System 2020	6,44	15,96%		20		14,47%	12,68%	0,37%	1,79%	14,10%
System 2023	1,92	4,63%	37			8,80%	6,96%	0,14%	1,84%	8,65%
Restricted Lower Distribution	1,92	4,63%	8	29		12,46%	6,96%	0,55%	5,50%	11,91%
Restricted Upper Distribution	2,00	4,89%		29	8	12,80%	6,82%	0,48%	5,97%	12,32%
System 2020	1,89	4,67%		7		9,41%	6,79%	0,26%	2,62%	9,16%

Note: The upper table shows disproportionality indexes for 5% electoral threshold, while the lower table shows disproportionality indexes if the electoral threshold was 4%. IGH = Gallagher Index; SLI = Sainte-Lagué Index; WPUR = Whole Picture of Unequal Representation; DSP = inter-party disproportionality; IPUR = intra-party unequal representation; MLP = malapportionment; WV = wasted votes

for both the Gallagher Index and the SLI when calculated solely based on second votes. Regardless of which boundary conditions of the system are violated to prevent the Bundestag's expansion due to overhang seats, the changes in unequal representation remain marginal, with the WPUR increasing by just 1% point. Decisions between orphaned districts and favoring a party in one state at the expense of another involve 20 seats. However, these shifts do not significantly distort the election outcome. While they slightly raise the malapportionment rate, it remains below 1 per cent. Some shifts balance out at the state level — one party loses a seat in that state to another state, but the other gains.

In the system prioritizing direct mandates over nationally calculated proportionality (RUD), inter-party shifts are limited to three mandates, with proportionality indices changing only marginally. Notably, larger variations in the SLI stem from which votes are the basis of its calculation. Amid such differences — arising from interpretations of the electoral system — the distinctions between system variants are barely perceptible.

The System 2020 would have produced a seat distribution strikingly similar to the new system. However, this similarity underscores the need for caution and the exploration of alternative scenarios. Notably, deviations from proportionality in the 2025 election primarily resulted from the significant share of votes cast for parties failing to meet the electoral threshold. This reduced the number of parties surpassing the threshold compared to the 2021 election, which had driven the reform. However, in the 2025 election, the number of parties in parliament was not far from increasing. Lowering the threshold to 4%, as proposed during reform discussions, would have led to recalculated results where both the FDP (*Freie Demokratische Partei*) and BSW (*Bündnis Sahra Wagenknecht*) participated in seat distribution. This is also a very important form of stress test, examining how these four systems would respond to more demanding distributions of party support and an increase in the number of parties.

The results recalculated for the 2020 system, and the 4% threshold confirm the need for reform. In such a scenario, 71 additional seats in the Bundestag would be necessary. However, the adopted solution demands caution, as it would result in 37 orphaned districts — nearly one in eight — where the candidate with the most support would not secure a seat, undermining the purpose of the first ballot. Shifting seats between states would necessitate 29 transfers, while malapportionment rates continue to shift incrementally. Surprisingly, the eight seats allocated against proportionality criteria reduce inter-party disproportionality ratios. This is because the FDP and BSW, with 4–5% second-vote support, had significantly lower first-vote support. Hence, in particular, systems rewarding parties winning in SMDs with extra seats reflect voter behavior in utilizing the two-vote system. The ratio of the whole picture of unequal representation rises due to shifting seats in favor of district winners, although it remains below the 5% threshold.

A similar simulation is also worth considering to verify the new system's adequacy and show how it performs under more challenging party system dynamics. Parameters from such a simulation closely resemble those from recalculations of the 2021 election results in 2025 districts. Such a calculation was possible because the official data presenting the results of the 2025 elections also include information on the parties' results from the previous election recalculated for the new districts. These results were converted into seats in all the electoral systems being compared. Detailed citations are unnecessary, as these changes minimally alter the overall picture. However, it is worth mentioning that the System 2023

would generate 30 orphaned districts, including 11 involving CDU candidates in Baden-Württemberg, where over a quarter of districts would be orphaned.

Calculating WPUR at the single-member district rather than *the Länder* level provides a deeper understanding of system functionality and alternatives. This recalculation considers direct seats — won by parties through first-vote pluralities — and all seats won through the party list but awarded to candidates who simultaneously ran in districts.

Among Germany's four dominant parties — CDU, SPD, Grünen, and CSU — all candidates who won list seats ran simultaneously in districts. For AfD and Die Linke, 19 MPs secured seats without district candidacy. These seats were excluded from unequal representation coefficient recalculations, except for DSP index calculations, which are independent of the division into districts within the parties.

The table shows the index values for the four tested systems and, in addition, for the system modelled on the solution used in the elections in Slovenia. The latter system will be discussed in the next section, but capturing its effects is easiest when comparing the System 2023 and the alternatives discussed.

Analyzing the single-member district level reveals a significantly larger issue: the challenge of aligning the distribution of individually won seats within districts. Lucas Haffert, Pascal Langenbach and Tobias Rommel (2024) highlighted this problem, though we will not delve into the socio-geographic factors contributing to the skewing observed here. Instead, tools that provide a comprehensive view of unequal representation allow us to quantify the scale and components of this issue. WPUR values exceeding 100% are driven by intra-party rivalries among candidates, with inter-party disproportionality largely overshadowed by unequal intra-party representation. The internal divisions within each party only partially offset the imbalance at the single-member district level, resulting in a marked increase in malapportionment, with the index surpassing 20% under the System 2023.

Orphaned districts account for only a minor portion of this malapportionment. Their reduction (RLD system) or elimination (RUD system) lowers the IPUR by 1–2% points, yet WPUR values remain disproportionately high. Two key factors contribute to this. For smaller parties, the disparity arises because the number of seats they secure represents only a fraction of the total number of districts. Consequently, in cases of undifferentiated support, most votes cast for a party inevitably go to candidates who fail to win a seat. For the dominant CDU/CSU bloc, the number of seats won exceeds two-thirds of the districts, whereas for Die Linke, it is just over one-fifth. Notably, over 77% of votes for the CDU/CSU bloc were cast in districts where their candidates won seats, compared to less than 30% for Die Linke. Other parties fall somewhere between these extremes.

A factor compounding this problem is that the list order, which determines the allocation of seats other than those won through plurality in a district, weakly correlates with the number of first votes received by candidates in their respective districts. This is particularly evident for smaller parties, such as the AfD. The high proportion of wasted votes underscores the significance of this factor.

The comparison of three alternative versions of the German electoral system with the Slovenian system yields a surprising result. While the German alternatives — each prioritizing one key condition over others — do not differ significantly from one another, the Slovenian system clearly stands out. Without altering the level of proportionality, it reduces malapportionment, waste votes, and lowers the IPUR. This demonstrates that the personalization of an electoral system does not have to come at the expense of other characteristics.

This analysis also confirms that WPUR can be a highly useful tool for analyzing electoral systems and can aid in their design.

6 Personalization of elections

The MMP electoral system was designed to balance proportional representation with preserving the connection between MPs and voters in small constituencies. This bond was emphasized through the first vote, placed prominently at the top of the ballot and reflected in its name. When the two-vote system was introduced, Germany’s political landscape was hailed as a prime example of a two-and-a-half-party system (Blondel 1968, p. 185). During the 1957 election the two dominant parties garnered in the constituencies they won usually at least 40% and often more than 50% of the vote, with the average district winner securing 52% of the first votes (Fig. 1). This meant candidates receiving direct mandates often achieved a majority rather than just a plurality, solidifying their legitimacy as outright winners. By casting their first vote, most voters were actively fostering a connection with their representative — a key factor that made the German electoral system a model for numerous countries worldwide.

However, as the German party system became more fragmented, support for the largest party consistently declined. At the national level, the informal rule that the leader of the largest party becomes chancellor was nevertheless not challenged (e.g. Bräuninger et al. 2019). However, the general weakening of the parties also changed the situation at the single-member district level. The weakening of local winners, alongside the fragmented vote

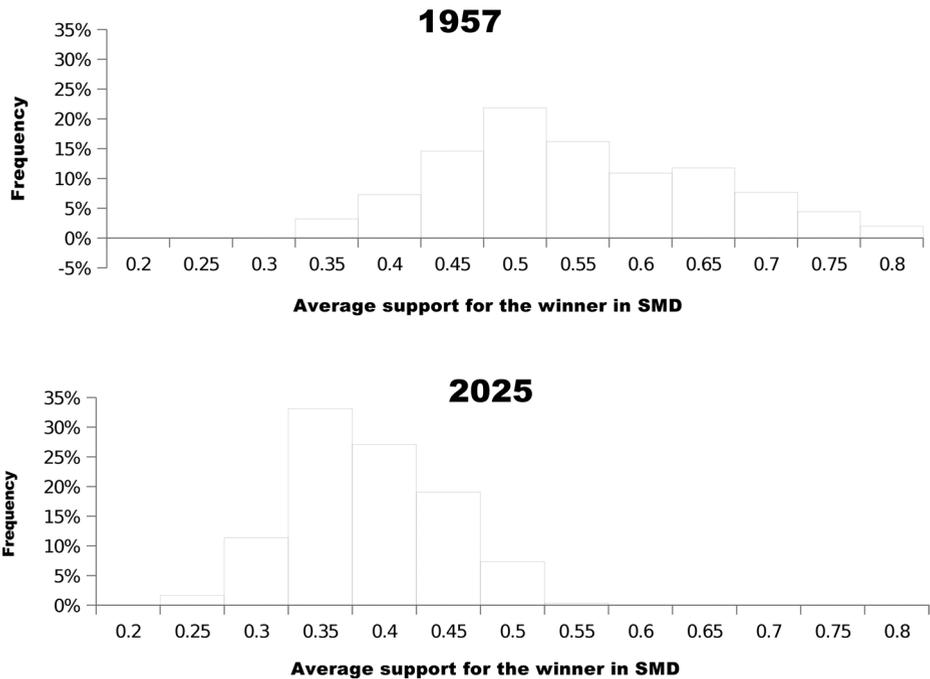


Fig. 1 Average support for the winner in SMD in 1957 and 2025 Bundestag elections

distributions, generated the problem of overhang seats and caused an increasingly smaller share of voters to provide local winners with their seats.

The two ways used so far to address the problem of overhang seats — enlarging the Bundestag and System 2023 — have had a similar effect. More than half of MPs obtain their seats through the second vote. At the same time, the overwhelming number of candidates placed at the top of party lists also run in districts, which suggests that the localized voter-MP bond at the single-member district level remains an important political factor. This practice is rational behavior in political communication, which is part of the logic of contamination (Guinjoan 2016). This situation prompts the search for other solutions, offering a chance to rebuild the formal bond between voters and their local representatives and preserve the meaning of the first vote.

This prompts us to trace what alternative approaches to personalizing elections were considered. The motivations of the initiators did not always follow a logic such as the one outlined above, but always the measures discussed would have a significant effect precisely in the field of personalization of elections.

Orphaned constituencies pose another significant issue in terms of personalization and the adequate representation of citizens residing within these constituencies. While the interests of most constituents may be sufficiently represented by MPs from other constituencies, aligning with Edmund Burke’s concept of “virtual representation,” specific local interests may suffer competitive disadvantages in pork barrel politics without a dedicated MP. If one thinks along the lines of this argument, the party affiliation of the constituency member would be less important; the crucial factor would be the presence of a parliamentary representative from the constituency. The first-vote winner would be sufficient but not necessary to fulfil this purpose. In many of these constituencies, there will be another MP who did not successfully obtain a direct mandate but still gets into the Bundestag from the *Landesliste*. Only four of the 23 “orphaned constituencies” do not have any parliament members from their constituencies. If not all 23 orphaned constituencies, at least these four would still constitute a problem.

Consequently, the initial draft of the “traffic light coalition” agreement included provisions for successors from other parties, ensuring each constituency would still have a parliamentary representative (Hartmann et al. 2022; Behnke 2023). In this scenario, votes from voters whose preferred candidate was not elected due to insufficient second votes would be transferred to candidates from other parties as substitute votes. The candidate with the highest recalculated first votes would then receive the constituency mandate as a “successor”. Another proposal suggested awarding the constituency mandate to the candidate with the second-highest number of first votes (Meier and Potrafke 2019). Both proposals aimed to resolve the issue of orphaned constituencies but were ultimately rejected, particularly by the CDU. Suppose it is necessary to reduce the number of won constituency seats. In that case, the Sainte-Laguë/Webster procedure leaves us only with the general number of overhang seats without determining which constituencies should be stripped of their representatives. However, at the personalized level of elections, the decision of which constituency should not have its representative is crucial.

It is necessary to establish a ranking to determine which constituencies will have representatives and which will not. In the new German system, the chosen criterion for constructing this rank order is the share of first votes. So the capped constituency seats are those with the lowest shares of first votes of a party within a *Land*.

The logic of a restricted allocation of constituency seats is reminiscent of a procedure which is used in Slovenia. The Slovenian electoral system does not include strict constituency seats (compare Difford 2022; Renwick and Pilet 2016, 163–165). Instead, there are eight constituencies, each comprising eleven electoral districts. Seats are allocated using a largest-remainder system with Droop Quota and then distributed based on candidates' vote shares, creating a dynamic "virtual" list. Candidates from the districts form such a list separately in each constituency, with the order determined based on their share of the votes received in the district. This system resembles open list systems, where MPs are chosen based on outperforming party candidates in other districts. So no person can be labelled as a district winner because there are no district winners in the strict sense of the word; indeed, it is not guaranteed that every district will produce an MP (so we have something like "orphaned districts"), but the success probability of every candidate depends on his or her results in the district. So, all members of parliament were chosen because they outperformed the candidates of their own party in other districts. So even when Slovenia may have "in terms of personalization... the strangest electoral system in Europe" (Renwick and Pilet 2016, 163), it certainly is an electoral system with a high degree of personalization. One especially attractive aspect of personalization in this system consists in the fact that the personalization effect would be evident for all candidates, not only the two or three most viable ones. In the Slovenian system, the importance of constituencies or, respectively, districts is in some way diminished as these are no longer autonomous areas which create an MP of their own through their strength; otherwise, the district is the only relevant place in which the result of the competition between candidates is decided, even though it is not the competition between the candidates of one district, but the competition between the candidates of one party across the districts within one constituency.

With the capping of overhang seats, the German system of 2023 moved slightly in the direction of the Slovenian system. So, it is not surprising that versions of this system were also discussed in Germany (Funk 2018; Behnke 2019) even though they never came into the narrow focus of attention for reforms.

The Slovenian procedure was used in Baden-Württemberg for the distribution of the so-called *Zweitmandate* (second mandates) and in Japan, in a procedure called *Sekihairitsu* (McKean and Scheiner 2000). In both cases, however, it is about tickets for "best losers" in a situation where the winner in the district always gets a seat (Trefs 2003).

We verified the effects of such far-reaching personalization by recalculating the 2025 election results according to the Slovenian system. We distributed all 630 seats in this way, including those 19 AfD and Die Linke seats that went to candidates who did not run in the districts. In this calculation, the *Länder* corresponded to the Slovenian constituencies, and the SMDs to the Slovenian districts. The WPUR calculation results for such a system are presented in Table 4.

As expected, intra-party unequal representation dropped significantly — by one-fifth. There is no district from which there is no MP this time (in the real election, there were four such districts of 23 orphaned ones). Clearly, malapportionment falls — the seats are more evenly distributed than when guided by the position of the candidates on the lists. The index of wasted votes also dropped significantly.

There are three non-trivial cases where, according to Slovenian procedure, the winner in a district would not get a seat compared to the 2023 system. This is because the candidate of a particular party in another district of the same *Land* had higher support, although he

Table 4 WPUR index and its components calculated at the SMD level for four analyzed systems and the Slovenian system

	WPUR (both votes)	WPUR components			
		DSP	MLP	IPUR	WV
System 2023	160,4%	12,66%	20,09%	147,75%	140,33%
Restricted Lower Distribution	158,4%	12,66%	19,51%	145,75%	138,90%
Restricted Upper Distribution	158,2%	12,68%	19,36%	145,53%	138,86%
System 2020	158,6%	12,68%	19,30%	145,90%	139,28%
Slovenian system	122,7%	12,66%	15,91%	110,04%	106,80%

Note: WPUR = Whole Picture of Unequal Representation; DSP = inter-party disproportionality; MLP = malapportionment; IPUR = intra-party unequal representation; WV = wasted votes

was not the winner in the district. As is well known, under the FPTP system, the loser in one district can be stronger than the winner in another; it all depends on the support of the other candidates.

The discussions and calculations show that personalizing the German electoral system is a multi-faceted problem. There is still room for maneuver, and solutions can be sought to the problem created by changes in the party system and electoral reforms caused by such changes.

7 Conclusions

The analysis of the effects of the reform of the German mixed electoral system evokes mixed feelings. There is no doubt that changing the System 2020 was necessary. Admittedly, this conclusion does not stem from a simple recalculation of election results according to the earlier rules — the differences here are surprisingly small. However, the unpredictability of the old system becomes evident when tested against a counterfactual scenario. More importantly, there are no visible benefits to retaining the complex rules for compensating overhang seats. All three alternative systems considered in our analysis do not differ significantly from the abandoned one in terms of characteristics of unequal representation. The cost of any of the solutions that ensure predictability in the size of the Bundestag is not excessive.

More surprisingly, the three considered solutions do not differ significantly from each other regarding key characteristics — whether disproportionality, malapportionment, or wasted votes. Although the costs of the two alternatives to the adopted solution are similar, they are paid in different “currencies.” While the actual costs are low, they carry substantial symbolic weight. The question of what is better to compromise — normative notions of proportionality, the balance between *Länder*, or the meaning of the first vote — is not made easier when empirical indicators do not point to a clear winner.

However, it is worth noting that the solution pushed through by the previous traffic-light coalition — despite protests from the opposition parties — resulted in controversial “orphaned seats,” almost exclusively affecting the two political forces with the greatest support in the 2025 elections: the CDU/CSU bloc and the AfD, which became the main opposition party after the election. It is no coincidence that the problem of “orphaned seats” affects the largest parties the most. This is a direct consequence of such a system. By their very

nature, these parties are the strongest players in parliament, and it is unrealistic to expect them to simply accept a solution by which they feel disadvantaged. Therefore, this issue is unlikely to be settled. We believe that our analysis can contribute to a rational approach to the topic in future debates.

One point we would like to highlight particularly is the personalization of elections. The weakening of the bond between voters and direct mandate winners — as reflected in the strength of their support — has been a source of tension throughout the system. Sacrificing the weakest element of the system might seem rational, though it raises a fundamental question — will this not disrupt the entire construction, the entire promise offered by the mixed electoral system? Analysis at the single-member district level, rather than at the level of parties or *Länder*, reveals the problem hidden within the system. Perhaps in future discussions, the topic of increasing the system's personalization and adjusting its parameters to the evolving shape of the political landscape will return. Since the system — most likely unintentionally — is already drifting towards solutions used in Slovenia or Japan, this may be the direction in which the search for a new model will move: one that retains the system's old strengths but is free from its new weaknesses.

The case of the German reform is highly relevant for all countries using the MMP system, or more broadly, mixed electoral systems. Such systems create a fragile balance between different components. Tensions and controversies are inherent. New methods of linking these components and tools for analyzing potential outcomes offer valuable insights that can help avoid mistakes and find the best solutions in conflict situations.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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