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Social or political cleavages? A spatial analysis of the party system in post-authoritarian Chile

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Abstract Lipset and Rokkan's (Party system and voter alignments: cross national perspectives, Lipset and Rokkan eds., New York: Free Press, pp. 1–64, 1967) sociological model of cleavages and the so-called "freezing hypothesis" dominate theorizing about party system formation. Torcal and Mainwaring (Br. J. Polit. Sci. 33:55–84, 2003) show the relevance of a purely political cleavage for structuring the party system in the case of Chile, challenging the freezing hypothesis's claims. They also dispute case-specific research that argues Chile's party system still reflects a "three-thirds" division between Left, Right, and Center. Revisiting this debate, our study employs spatial maps of the party system. Such political-economy models are rare in studies of Latin American politics. The application here supports a democratic/authoritarian political cleavage in Chile.

Keywords Political economy · Spatial theory · Voting

JEL Classification D71 · D72

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1 Introduction

Understanding how party systems form and evolve is central to the study of representative democracy. Lipset and Rokkan's (1967) seminal model traces the party systems of Western Europe in the 1960s to a mosaic of social cleavages that emerged from center-periphery, church-state, owner-worker, and land-industry conflicts touched off by the processes of nation-building and the industrial revolution in the 1920s. Where party elites politicized the collective identities, subcultures, institutions, and symbols these struggles produced, social cleavages translated into partisan cleavages. Once the political market was "exhausted", and proportional representation adopted, Lipset and Rokkan thought party systems would become "frozen", crystallizing the political landscape. Scholars continue to ask whether party systems in established and new democracies reflect social (or other) cleavages, and test the validity of the "freezing hypothesis.[1]

This study addresses one of the most contentious yet theoretically intriguing cases in this literature: Chile. How does Lipset and Rokkan's model apply to the party system that reemerged in 1989 after 17 years of military rule under General Augusto Pinochet? From one angle, the party system appears to have changed very little since full adult (18 years) suffrage was granted in 1970, suggesting that the model works fairly well (Scully 1992; Siavelis 1997; Valenzuela and Scully 1997; Valenzuela 1999; Valenzuela et al. 2007). From another angle, social cleavages seem to explain less about new patterns of political competition than a purely *political* cleavage shaped by party elites with opposing positions on the 1973 coup, Pinochet's legacy, and democracy (Carey 2002; Gamboa and Segovia 2006; Ortega 2003; Tironi and Agüero 1999; Torcal and Mainwaring 2003).

Our study sheds light on this debate by bringing an alternative set of theoretical and methodological tools to bear. The majority of research on Chile's party system cleavages examines the differences between citizens who identify with different political parties, or the effects of factors related to social cleavages on ideological and partisan identification. This line of analysis faces a major shortcoming. Because ideological and partisan identification in Chile have declined mightily, especially among youth (Riquelme 1999; Joignant 2003; Navia 2004; Madrid 2005), the differences between identifiers of distinct parties and coalitions are biased to reflect the weight of events (Allende's presidency, the 1973 coup, Pinochet's authoritarian regime, the plebiscite) that took place before a significant proportion of Chileans were socialized into politics. Therefore we propose a spatial modeling approach derived from the input of the politically identified and non-identified alike. Our results largely reinforce the conclusion that a political cleavage predominates over social cleavages.

This study proceeds as follows. First we review the literature on the party system in post-authoritarian Chile, highlighting the theoretical questions our study seeks to inform. Next we examine the logic and assumptions of spatial voting theory and the model upon which our analysis rests. From there we discuss our analytic strategy, including data, methods, and theoretical expectations. After presenting our results, a brief conclusion discusses the broader theoretical implications of this investigation.

2 Related literature

Research on Chile's post-authoritarian party system has been dominated by the question, posited initially by Valenzuela and Valenzuela (1986), of whether it reflects the same social

[1] See excellent literature reviews by Deegan-Krause (2007) and Torcal and Mainwaring (2003).

cleavages that underpinned the party system before the 1973 *coup d'état*. Responses can be split into two camps—those who believe social cleavages still divide the party system into roughly "three-thirds", and those who say that a political cleavage fundamentally altered the party system. The theoretical implications of this debate propel the current study.

In an early response to Valenzuela and Valenzuela's (1986) question, Scully (1992) combines Lipset and Rokkan's model with a critical juncture argument to explain three party-generative cleavages: (1) clerical–anticlerical, (2) urban owner-worker, and (3) rural landholder-peasant. The first critical juncture (1857–1861) forced Chile's parties to resolve typical church-state issues. By the late Nineteenth and early Twentieth Century, the resultant party system placed Conservatives on the clerical pole, the Liberals in the middle, and spurred dogmatic Liberals to split from the party to form the Radical Party that would occupy the anti-clerical pole. A second critical juncture (1920–1932) was precipitated by growing urbanization and industrialization which gave rise to the Socialist, Communist, and other small parties that eventually would define the Chilean Left. The third and final party-generative social cleavage grew out of the electoral incorporation of illiterates and a series of institutional reforms that created frenzy for votes in the countryside. While Marxist parties joined the fray, the Christian Democrats (PDC) made the most inroads. Led by otherwise conservative youth, the PDC sought political answers to social inequality, including nationalization and land reform. Seeking to reconcile their pro-clerical roots with working-class concerns, the PDC broke with the Radicals' long tradition of a pragmatic, coalition-seeking Center party, and embraced a new model—an ideological Center party. The resultant party system, according to Scully, became increasingly rigid and polarized into "three-thirds" with the National Party (PN), a powerful amalgam of conservative forces, on the right, the PDC in the center, and the left occupied by alliances among the Socialists, Communists, and some Radicals.

The military regime lasted from 1973 to 1990 and divided the Chilean political spectrum in two: the supporters and the detractors of Pinochet. On the supporters' side were the former members of the rightist PN; on the detractors' side were the centrist PDC and the leftists. After two national elections in the post-authoritarian period, Valenzuela and Scully (1997) reported impressive continuities in national vote shares for parties traditionally identified with the Right, Center, and Left before 1973, and high correlations in district-level votes shares for parties and candidates of the same ideological positions. These results suggested that established social cleavages still dominated Chile's party system, and prompted the conclusion that "[a]s the authoritarian period recedes into the past, ... the division between parties that supported and parties that opposed the military government will lose strength as a basis of party coalitions" (Valenzuela and Scully 1997: 526). The implications are that the Chilean party system had essentially frozen into place after 1970 and that the inter-party deals cut surrounding the transition would be short-lived.

Upon revisiting these questions, a second camp of scholars argued that party system cleavages in Chile are no longer social or class-based, as the Lipset-Rokkan model would suggest, but rather structured from above by elites around political issues (Tironi and Agüero 1999; Torcal and Mainwaring 2003). They identified a democratic/authoritarian cleavage that pitted critics of the military regime against its apologists. Critics claimed that the ends of the authoritarian regime—to resolve the economic crisis and restore political instability—did not justify the means—human rights violations and the suspension of democratic politics. The critics were split, however, between those whose experience under the military regime fostered political learning and a renewed passion for democratic politics, and those who rallied to defeat Pinochet in the 1988 plebiscite but rejected the subsequent approved transition and *de facto* politics of accommodation (Roberts 1998;

Posner 1999). Apologists, while divided by internecine disputes and rivalries, were bound by a belief that the neoliberal economic model devised under bureaucratic-authoritarian rule was sacrosanct and deserved political protection. The political battle lines drawn around these diverging interpretations supposedly defined a "fundamental generative cleavage" (Tironi and Agüero 1999).

If this is true, then it has four major theoretical implications (Torcal and Mainwaring 2003: 56–57). First, even as cleavages incorporate a social component, they may spring from primarily *political* causes. Second beyond the social, economic, and cultural factors typically cited, politics is critical for understanding the freezing and thawing of party system cleavages. Third, Lipset and Rokkan's social-cleavage model of party system formation may have temporal and/or geographic boundaries. Fourth and finally, it suggests that elites' political agency dramatically influences which conflicts (social, cultural, economic, or political) will form the axes of debate, and thereby re-craft party system cleavages from above. In the Chilean case, thus, the observable implications are clear. Despite continuities in national vote shares for parties traditionally identified with the Right, Center, and Left, some scholars argued, in essence, that those parties were no longer positioned at Right, Center, and Left, but clustered at the two poles of the Left-Right spectrum. Consequently, patterns in party identification and vote shares may not provide much leverage on the validity of the freezing hypothesis in Chile.

This debate has spawned multiple reactions (Siavelis 1997; Valenzuela 1999; Valenzuela et al. 2007; Carey 2002; Ortega 2003) and extensions (Altman 2004; Gamboa and Segovia 2006) without producing consensus. In this spirit, our study pits the sociological cleavage interpretation, which claims that the Chilean party system remains frozen into three identifiable thirds, against the political democratic/authoritarian cleavage thesis, which predicts a single cleavage. To address this debate, we construct spatial maps of the party system based on citizen evaluations of parties. Our method, developed by Cahoon (1975) and Cahoon et al. (1978), relies on "feeling thermometer scores" to place parties in multidimensional space. It works from the key assumption of the median-voter model, introduced by Black (1958) based on Hotelling's (1929) ideas, that to win elections you must win voters at the center of ideological space. While early empirical applications of this model required rather restrictive assumptions (e.g., one-dimensional choice, single-peaked preferences), later work adapted it to less restrictive situations (Davis and Hinich 1966, 1968; Romer and Rosenthal 1978; Cox 1990; Hinich and Munger 1994). Scholars have applied the Cahoon-Hinich spatial modeling technique to analyze party systems as diverse as the United States (Enelow and Hinich 1984; Ghobarah 2000), Taiwan (Lin et al. 1996), Germany (Pappi and Eckstein 1998), Ukraine (Hinich et al. 1999), and Turkey (Carkoglu and Hinich 2006).

Scholars have modeled Chile's party system spatially as well. Dow (1998a, 1998b) constructed unidimensional maps with data from the 1989 congressional and presidential elections. He interpreted them as resembling the configuration of parties we might expect if the party system had frozen after 1970. While Dow's works have been neglected unduly in this ongoing debate, his maps better fit the democratic/authoritarian divide interpretation. Viewed with an eye for this political cleavage, Dow's spatial maps (cf. Dow 1998a, Figs. 1–4: 460–462; Dow 1998b, Fig. 1: 65) more accurately depict two distinct blocks of parties rather than three. Indeed the Christian Democrat Party (PDC) is in all cases positioned closer to the average score of the Center-Left *Concertación* coalition and its other parties, the Socialist Party (PS) and the Party for Democracy (PPD) than to the midpoint between the PDC and average score of the Rightist *Democracia y Progreso* coalition and its two constituent parties, the National Renewal (RN) and Democratic Independent Union (UDI). In other words, our reinterpretation of Dow's spatial analyses is that a political cleavage had opened up in the minds of Chilean citizens with the return of electoral politics. Yet

other spatial analyses support Dow's original interpretation. Working from 2001 data for an electoral district within the Metropolitan Region,[2] Bonilla (2002) showed that presidential candidates were more or less uniformly distributed along the politico-economic left-right axis. Thus he concluded that the polarization on this dimension had muted. The generalizability of this finding was limited since data for a single electoral district may not apply to Chile as a whole.

In short, despite the promise of the spatial voting theory for this debate, existing studies have not set the record straight. The analysis that follows finds the broad contours of the democratic/authoritarian cleavage in spatial models of potential presidential candidates in 2003 and of political parties in 2008.

3 Data and methodology

Our spatial models employ two sources of survey data. The first was conducted face-to-face in the Metropolitan Region by Adimark in January 2003.[3] Its initial sample size of 1011 reduced to 793 after eliminating respondents list-wise who did not respond for one or more presidential candidates. Centro de Estudios Públicos (CEP)[4] conducted the second survey, *National Political System and Party Study, March–April 2008*, on a national probabilistic sample. Of its 1505 total respondents, our model retains 1166 after list-wise deletion.

From the standpoint of our study, both polls are ideal because they were taken at points in the electoral cycle when no campaigns were taking place. Therefore the data contain less noise from candidate signaling and appeals to the median voter. For the 2003 Adimark study, the scores for each potential presidential candidate range 1 to 7 in response to the question: "Thinking of the well-being of you and your family, how would you evaluate the following persons as president of the country?" The 2008 CEP poll asks, "How much do you like [Party Name]?" and responses range from 1 "Not at all" to 10 "Very much."

Both sets of scores were factor-analyzed with the Cahoon-Hinich method to determine their latent dimensions. In the 2003 candidate-centric analysis two relevant dimensions explain 90% of the variance of the endogenous variable, in line with previous studies of spatial voting that employ Cahoon-Hinich methodology (detailed in the Appendix). In the 2008 party-centric analysis, one dimension explains 82% of the variance. Like Dow's (1998b) spatial model of Chilean parties in 1989, additional dimensions were unintelligible.

4 Theoretical expectations & results

What can spatial maps tell us about this debate? Here we offer a more formal statement of the diverging theoretical expectations based on the previous literature. First, if spatial voting theory holds, our first extracted dimension should represent the main axis of political

[2] District Number 20 covers the Santiago municipalities of Maipú, Cerrillos, and Estación Central.

[3] The Metropolitan Region accounts for 40% of Chile's population, and presidential election outcomes in this Region are always consistent with national-level outcomes. For example, in the 2005 presidential election Michelle Bachelet was elected with 53.5% of the vote at the national level, while Sebastián Piñera finished second with 46.5%. In the Metropolitan Region, Bachelet obtained 54.0%, of the vote and Piñera 46.0%.

[4] Several other institutions supported this survey: Corporación de Estudios para Latinoamérica, Libertad y Desarrollo, United Nations Development Program, and ProyectAmérica. More information and data is available at www.cepchile.cl/bannerscep/bdatos_encuestas_cep/base_datos.php.

competition. Whether the party system remains frozen into three blocs, as the sociological argument runs, or two distinct ones, as the political argument claims, can be determined by the positioning of presidential candidates and political parties on the first dimension. Stated another way, if the sociological argument based on Lipset and Rokkan's (1967) freezing hypothesis is correct, then we should expect Rightist candidates and parties (RN and UDI) to cluster at the right pole of the dimension; the Christian Democrat Party (PDC) and its candidates to land squarely in the middle of the dimensional space; and progressive social-democratic candidates and parties (PRSD, PPD, PS) to cluster at the left pole. However, if the political cleavage interpretation is correct, then we should find the Christian Democrat Party and it candidates positioned on the Center-Left along with other *Concertación* candidates and parties (PRSD, PPD, and PS), and opposing *Alianza* candidates and parties (RN and UDI) on the Right.

4.1 Potential candidates & the political context of 2003

Before delving into the results, we briefly situate the potential presidential hopefuls as of January 2003 within their political context. The governing *Concertación* coalition had four such *presidenciables*. Christian Democrat Soledad Alvear (S) gained considerable popularity as Minister of External Relations in the Lagos administration. Another potential PDC candidate was former president Eduardo Frei Ruiz-Tagle (F), who floated his intentions to run again relatively early. The Socialist Party (PS) considered Camilo Escalona (E), a past and future party president, a potential contender. Finally, Guido Girardi (G), senator for Santiago and leader of the Party for Democracy (PPD), also threw his hat in the ring.[5] The opposition coalition, *Alianza por Chile*, touted three *presidenciables*. Andrés Allamand (A), a young ex-president of National Renovation (RN), was a leading neo-liberal intellectual, though somewhat removed from party politics after devoting himself to academic and professional activities at home and abroad. A second candidate, Sebastián Piñera (P), was a business mogul and former RN president. Finally, there was Joaquín Lavín (L), a member of the Independent Democratic Union (UDI) who won 47% of the vote as a presidential candidate in 1999–2000.

Michelle Bachelet, the eventual winner, was Minister of Defense and just beginning to attract media attention in early 2003. Since her explosive rise in public opinion ratings would not begin until later that year she was therefore not included in Adimark's survey. For details on this trend see the various editions of *Estudio Nacional de Opinión Pública* published by the Centro de Estudios Públicos, beginning with the June–July 2004 study.

4.2 Results: 2003 candidate analysis

With the 2003 political context as the backdrop, we now present the results of the spatial model.[6] In the empirical literature on the spatial voting model (see Enelow and Hinich 1984, 1994; Hinich et al. 1999), analysts typically find two dimensions that explain around 90% of the variation in the thermometer scores assigned to each candidate/party. The first dimension

[5]The PPD is a moderate offshoot of the PS formed as a short-term electoral strategy based around broad, non-ideological issues, which as of the survey date had not yet been tainted by the allegations of dishonesty that would later engulf it.

[6]The Cahoon-Hinich methodology was implemented using the Fortan Map.exe computer program and is available from the authors for use by other researchers. Map.exe can be open for download at http://web.austin.utexas.edu/hinich/.

Table 1 Candidate scores: first extracted dimension, 2003

Candidates, 2003	Dimension 1 estimates
E Camilo Escalona (PS)	1.14
G Guido Girardi (PPD)	0.93
F Eduardo Frei (PDC)	0.61
S Soledad Alvear (PDC)	0.58
A Andrés Allamand (RN)	4.00
P Sebastián Piñera (RN)	4.11
L Joaquín Lavín (UDI)	4.55

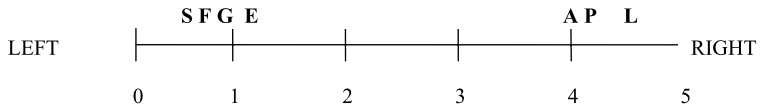

Fig. 1 Spatial map: candidates on first extracted dimension

is thought to represent politico-economic left-right positions.[7] Table 1 reports the estimates for the candidate on the first dimension as of January 2003, and Fig. 1 locates the candidates on a spatial map based on these estimates.

Examining these representations, the candidates clearly separate into two distinct groups: one on the left and one on the right—none in the center. The group bunched to the left consists of socialist candidates Girardi (G) and Escalona (E) of the PPD and PS, respectively, as well as PDC candidates Alvear (S), Frei (F). Each candidate comes from the *Concertación*—the coalition of parties opposed to Pinochet's rule and located in the democratic side of the political cleavage. The group of candidates bunched on the right includes Allamand (A), Piñera (P), and Lavín (L)—each representing parties (RN, UDI), of *Alianza por Chile*. These parties defend the military regime and, thus, sit on the authoritarian side of the cleavage.

Since these results heavily support the conclusion that a single, political cleavage defined Chile's party system in 2003, we label these endpoints "Left" and "Right." Chileans made only one distinction among the candidates: between those from *Concertación* parties, oppo-

[7]The second dimension can be interpreted as perceptions of a candidate's ability to put an end to the problems of stagnation and corruption that typically plague governments at the end of their terms (see Enelow and Hinich 1984, or Hinich and Shaw 2006); thus it represents reform versus the status quo.

nents of the military government, and those from the *Alianza por Chile*, whose leaders either defended and/or played prominent roles in it. None occupied the political Center, a finding inconsistent with a three-thirds party system. Do these results extend beyond presidential candidates to political parties *per se*? Such findings would further bolster the notion of a democratic/authoritarian cleavage in Chile and the theoretical implications it holds for the study of party systems in general.

4.3 Results: 2008 political party analysis

Our spatial analysis of parties in 2008 reaches a conclusion similar to the 2003 candidate analysis. Party scores on the politico-economic left-right dimension (Table 2) recreate two main blocs. And, as Fig. 2 illustrates, the parties cluster in much tighter patterns in 2008 than the candidates did in 2003. These results are strikingly similar to Dow's (1998b) results for 1989, further suggesting that a political cleavage took hold at the return of elections and controls ideological space in Chile 20 years on.

Though no Center third appears in Fig. 2, skeptics may still question whether the spatial maps are consistent with more straightforward approaches to identifying these dimensions or mere artifacts of the methodology. Moreover, they may worry about the potential for overlap between citizens' ideological positioning of parties and their perceptions of differences in their approaches to the political economy. So as a robustness check on our conclusion that the party system is primarily structured by a political cleavage, as Torcal and Mainwaring (2003) theorize, and not class-based socio-economic cleavages, as Valenzuela and Scully (1997) argue, we now compare how Chileans consciously rate the parties ideologically as well on parties' preferences for state involvement in the economy.

Table 2 Political party scores: first extracted dimension, 2008

Political parties, 2008	Dimension 1 estimates
Concertación	2.36
PS Socialist Party	2.34
PPD Party for Democracy	2.57
PDC Christian Democrat Party	2.88
PRSD Radical Social-Democrat Party	3.02
RN National Renovation	6.78
UDI Independent Democratic Union	7.30
Alianza por Chile	6.65

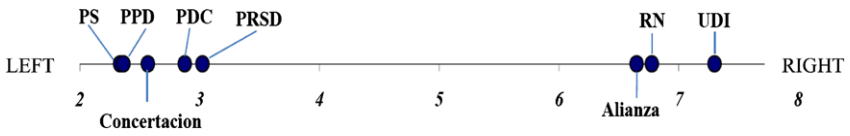

Fig. 2 Spatial map: parties on first extracted dimension, 2008

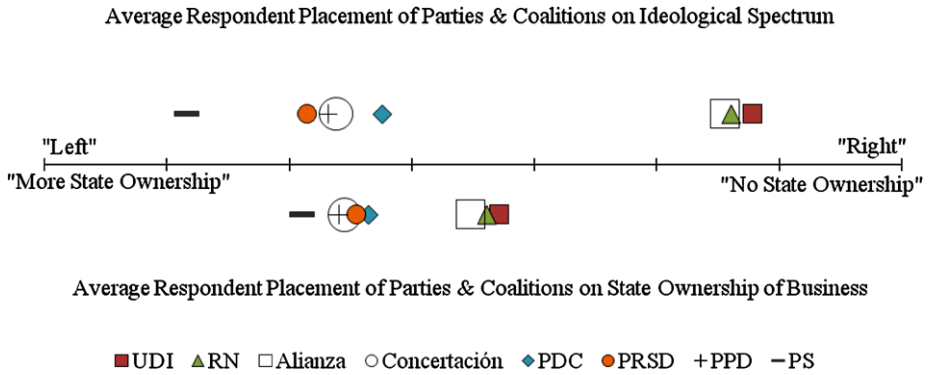

Fig. 3 Average respondent placement of parties: left-right ideological spectrum & state ownership of business, 2008

The same 2008 CEP asks respondents to score parties from Left (1) to Right (10) on the political spectrum. The first thing to note is that evidence from respondents' outright Left-Right placements of parties, reported in the top part of Fig. 3, matches the evidence presented in the spatial maps of candidates and parties above. Ideologically, Chileans locate the PDC (4.76) within half a point of the mean scores for the *Concertación*, the PPD, and the PRSD, and about a point and a half away from the PS (3.17). If the party system were divided into three-thirds by sociological cleavages, we would expect the PDC to fall much closer to the *Alianza por Chile* than it does. Average ideological scores for the UDI, RN, and the *Alianza* are a nearly three points further Right than the PDC. Again, we find groupings of parties on both the Left and the Right, but not in the Center.

But what is driving this singular party system cleavage—political or economic positions? The bottom half of Fig. 3 addresses this question by displaying average respondent placement of parties' positions regarding state involvement in the economy. If the ideological cleavage is derived from socioeconomic bases, then the parties' positions should be nearly identical in the top and bottom halves of Fig. 3. This is not the case. While citizens perceive a gap between the parties of the *Alianza* and the *Concertación* on state involvement, it is substantially smaller than the difference observed in ideological space. The difference between the placements of the *Alianza* and the *Concertación* on the economic question is roughly one point (1.02). In terms of Left-Right, it is greater than three points (3.17). So while citizens hardly differentiate party positions vis-à-vis state involvement in the economy, they discriminate mightily when it comes to placing the parties on the "left" and the "right" (though not the "center"). In sum, Fig. 3 shows that, to Chileans, the party system is not characterized by a three-thirds economic/class-based cleavage.

5 Conclusions

Chile's multiparty system remains a bit of an enigma. Its parties have long bloodlines and largely control access to power and representation at the national and municipal levels. But since the restoration of democracy in 1990 it has been divided along chiefly political, not sociological, lines. To the extent that political polarization exists today, it reflects the legacy of 17 years of military government under Pinochet. And while this cleavage may have been structured initially by elites, our study reveals just how deeply it has sunk into the psyches

of everyday Chileans. Much like the empirical work of Torcal and Mainwaring (2003) and the conjectures of Tironi and Agüero (1999), our findings challenge the notion that Chile's party system froze into place around sociological cleavages formed by 1973, as followers of Lipset and Rokkan (1967) have proposed (cf. Valenzuela and Scully 1997). So looks can be deceiving when it comes to Chilean parties.

Our conclusions are built on applications of the Cahoon-Hinich methodology, widely used in applied political economy. We draw unidimensional spatial maps using feeling thermometer scores for potential presidential candidates in 2003 and political parties in 2008. The main finding for the 2003 analysis is that Chileans perceived two classes of candidates on the political left-right dimension. These classes overlapped nicely with the parties Torcal and Mainwaring (2003) postulate to represent the democratic and authoritarian sides of the dominant political cleavage. Analyzing the political parties in 2008 strongly corroborated the results for the candidate analysis. If Lipset and Rokkan's freezing hypothesis were correct, Chile's historical socioeconomic cleavages would dominate this dimension, and the historical three-thirds division of Chilean political space would be evident. But the data, however, show a political space divided in half, with citizens positioning candidates and parties at extremes of the spectrum that match our expectations for a democratic/authoritarian cleavage. Therefore, the political cleavage born of the military regime continues to dominate the party system twenty years on.

Yet the foregoing discussion raises important issues about the past and future approaches to analyzing party system cleavages in Chile and elsewhere. Looking backwards, according to our spatial analyses in 2003 and 2008 and our reinterpretation of Dow's (1998a, 1998b) spatial analysis in 1988 and 1989, the Chilean party system did not freeze after 1973. It is, thus, possible that national vote shares, upon which one strand of the literature is built (Valenzuela and Scully 1997), conflate citizens' votes for parties with their perceived relative ideological positions. If this is indeed true, then perhaps the description of the party system pre-1973 as divided into three-thirds (Scully 1992) is an artifact of the use of national vote shares. Going forwards, the growing unwillingness of Chileans to identify with established parties, especially among youth, suggests that party identification, upon which Torcal and Mainwaring (2003) build their analysis, will become an increasingly less compelling way to monitor cleavage dynamics. The method employed here, spatial analysis based on feeling thermometer scores, seems like a reasonable way to analyze questions surrounding cleavage formation and longevity. Finally, our analysis suggests that Lipset and Rokkan's the social cleavage model may be geographically and historically bounded, and that Chile is a good example of that boundary.

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Appendix

The Cahoon-Hinich methodology is based on the following statistical model:

First, let Π be a dxk matrix containing the positions of the k candidates in the d dimensions of public policy that interest voters. The d dimensions are a generic way of denoting the issues of interest for the electorate when deciding for whom cast their vote. In practice, $d = 2$, where the first dimension is always the ideological left-right axis. The second dimension usually corresponds to the voters' perception about candidates' capacity to have an efficient and non-corrupt government, which is the reform/status-quo dimension.

Each candidate thus has a $dx1$ vector $\Pi_{\mathbf{k}}$ representing his or her position in Ω. Let Z be a dxn matrix containing the ideal public policy points in the d dimensions for the n voters in the sample. Then, for each voter there is an associated $dx1$ vector Z_i.

Second, let T be a kxn matrix containing the thermometer points assigned by each voter in the sample to each candidate, with t_{ki} being the score assigned by voter i to candidate k.

The empirical model applies a utility function that gives the Euclidean distance between a candidate's location and that of a voter. Thus,

$$t_{ki} = c_{ki} - [(\pi_{k1} - z_{i1})^2 + \cdots + (\pi_{kd} - z_{id})^2] = c_{ki} - \|\Pi_k - Z_i\|^2 \tag{1}$$

where c_{ki} is a random variable independent of t_{ki}, π_{kj} and z_{ij} for $j = 1, 2, \ldots, d$. The random error c_k has a variance of ψ_k^2 that is not correlated between candidates. Expanding (1) we obtain

$$t_{ki} = c_{ki} - \Pi_k^{'}\Pi_k + 2\Pi_k^{'}Z_i - Z_i^{'}Z_i \tag{2}$$

Third, let Σ be the matrix of variances and covariances of Z_i, and assume the matrix is diagonal with elements σ_j^2 $(j = 1, 2, \ldots, d)$. The expected value of z_{ij} $(j = 1, 2, \ldots, d)$ is denoted μ_j.[8]

Fourth, to convert the model to a linear one in Z_i, we choose a reference candidate or numeraire whose score will be deducted from that of each of the other candidates. Since the assignment of the origin is arbitrary we set it at $\pi_o = 0$, which then becomes the initial reference point, and

$$t_{ki} - t_{0i} = c_{ki} - c_{0i} - \Pi_k'\Pi_k + 2\Pi_k'Z_i \tag{3}$$

We now calculate the sample mean for each of the candidates and compute the difference between it and that of the reference candidate:

$$\overline{t_k} - \overline{t_0} = \overline{c_k} - \overline{c_0} - \Pi_k'\Pi_k + 2\Pi_k'\overline{Z} \tag{4}$$

Subtracting (4) from (3) we obtain

$$y_{ki} \equiv (t_{ki} - t_{0i}) - (\overline{t_k} - \overline{t_0}) = 2\Pi_k'(Z_i - \overline{Z}) + (c_{ki} - \overline{c_k}) - (c_{0i} - \overline{c_0}) \tag{5}$$

We then define the vector Y_i for all of the candidates given voter i, and from (5) we have

$$Y_i \equiv 2\Pi'(Z_i - \overline{Z}) + (-c_{0i} + \overline{c_0})\mathbf{1} + (C_i - \overline{C}) \tag{6}$$

for voter i, where $\mathbf{1}$ is a $kx1$ vector containing only 1's, C_i is a $kx1$ vector of the random component accompanying each voter, and $\overline{C}$ $kx1$ is a vector that contains the average errors for each candidate given the voter distribution.

Next, we calculate the sample variance and covariance matrix of Y_i. This kxk matrix converges in probability to the population variance and covariance matrix when $n \to \infty$:

$$\Sigma_y = 4\Pi'\Sigma\Pi + \psi_0^2\mathbf{1}\mathbf{1}' + \Psi \tag{7}$$

where Ψ is a kxk diagonal matrix of the variances of c_j $(j = 1, 2, \ldots, k)$. Note that (7) can be expressed as

$$\Lambda C \Lambda' + \Psi \tag{8}$$

[8] The subindex i can be eliminated since we take the expected value from the voters who make up the random sample.

where the symmetric root of $\Lambda C \Lambda'$ is $\Lambda C^{1/2}$. This allows us to apply the factor analysis method for finding maximum likelihood estimators of $\Lambda C^{1/2}\Gamma$, with Γ being the orthogonal rotation matrix to be found.[9]

Finally, we must estimate the ideal positions of the voters. This is done by running ordinary least squares on

$$t_{ki} - t_{0i} = y_{ki} + 2\widehat{\pi}_{k1} z_{i1} + 2\widehat{\pi}_{k2} z_{i2} + \cdots + 2\widehat{\pi}_{kd} z_{id} + u_{ki} \tag{9}$$

where $u_{ik} = c_{ki} - c_{0i}$ and the hats denote the estimators derived for $\hat{\Lambda}$ after applying the factor analysis method. We thus obtain an estimator of the most preferred positions $(z_{1i}, z_{2i}, \ldots, z_{di})$ for each voter in the d dimensions.

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