EXHIBIT 1
An Evaluation of the Compactness of the Enacted and Alternative State Legislative Plans in Ohio

Christopher Warshaw*

April 11, 2022

*Associate Professor, Department of Political Science, George Washington University. warshaw@gwu.edu. Note that the analyses and views in this report are my own, and do not represent the views of George Washington University.
Contents

1 Introduction 1

2 Qualifications, Publications and Compensation 1

3 Compactness 2

4 Conclusion 3
1 Introduction

My name is Christopher Warshaw. I am an Associate Professor of Political Science at George Washington University. Previously, I was an Associate Professor at the Massachusetts Institute of Technology from July 2016 - July 2017, and an Assistant Professor at MIT from July 2012 - July 2016.

I have been asked by counsel representing the relators in this case to analyze relevant data and evaluate the compactness of the Commission’s March 28 House and Senate plans, as well as three alternative sets of plans that have been submitted for consideration. Specifically, I was asked to compare the average compactness of districts on the Commission’s March 28 plans for each chamber with Professor Rodden’s Plan III, the Independent Mapmaker’s Plan, and Prof. Rodden’s corrected revision of the Independent Map Drawer’s plan that was uploaded on April 8th.

2 Qualifications, Publications and Compensation

My Ph.D. is in Political Science, from Stanford University, where my graduate training included courses in political science and statistics. I also have a J.D. from Stanford Law School. My academic research focuses on public opinion, representation, elections, and polarization in American Politics. I have written multiple papers that focus on elections and two published articles that focus specifically on partisan gerrymandering. I also have a forthcoming book that includes an extensive analysis on the causes and consequences of partisan gerrymandering in state governments.

My curriculum vitae is attached to this report. All publications that I have authored and published appear in my curriculum vitae. My work is published or forthcoming in peer-reviewed journals such as: the American Political Science Review, the American Journal of Political Science, the Journal of Politics, Political Analysis, Political Science Research and Methods, the British Journal of Political Science, Political Behavior, Science Advances, the Election Law Journal, Nature Energy, Public Choice, and edited volumes from Cambridge University Press and Oxford University Press. My book entitled Dynamic Democracy in the American States is forthcoming from the University of Chicago Press. My non-academic writing has been published in the New York Times and the Washington Post. My work has also been discussed in the Economist and many other prominent media outlets.

My opinions in this case are based on the knowledge I have amassed over my education, training and experience, including a detailed review of the relevant academic literature.
They also follow from quantitative analysis of block assignment files of the Commission’s March 28 plans and the alternative plans I obtained from Counsel.

I have previously provided expert reports in this case, as well as eight other redistricting-related cases and several Census-related cases (see my CV for a current list). I am being compensated at a rate of $325 per hour. The opinions in this report are my own, and do not represent the views of George Washington University.

3 Compactness

In this section, I examine the compactness of the districts on the Commission’s March 28 plans and three alternative plans. I focus on two commonly used compactness metrics to evaluate the compactness of the plans. First, the Reock Score is the ratio of the area of the district to the area of a minimum bounding circle that encloses the district’s geometry. Second, the Polsby-Popper measure is the ratio of the area of the district to the area of a circle whose circumference is equal to the perimeter of the district (See Figure 1 for illustrations of each metric from Ansolabehere and Palmer (2016, 751)). Each of these metrics falls within the range of [0,1] and a score closer to 1 indicates a more compact district.\(^1\)

![Figure 1: Illustration of Compactness Measures from Ansolabehere and Palmer (2016)](image)

Table 1 shows the compactness metrics for the Commission’s March 28 plans and three alternative plans. The Reock and Polsby-Popper metrics are closely related both theoretically and empirically. At the district-level, they have a correlation of about .62 across state legislative districts in usage in 2020. At the state-level, they are even more closely related. The average Reock and Polsby-Popper scores for each state legislative chamber have a correlation of .72 in 2020.
the three sets of alternative plans. The Commission’s March 28 Plans have the lowest compactness scores on both the Reock and Polsby-Popper metrics. For the House, all three alternative plans are clearly more compact than the Commission’s March 28 plan. Moreover, all three alternative plans have similar compactness scores.

The alternative Senate plans are also more compact than the Commission’s March 28 plan. Here, Professor Rodden’s Plan III is more compact, especially on the Polsby-Popper metric, than the Independent Mapmaker’s plan or the revised version of this plan.

<table>
<thead>
<tr>
<th></th>
<th>Reock</th>
<th>Polsby-Popper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ohio State House</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commission’s March 28 Plan</td>
<td>0.39</td>
<td>0.31</td>
</tr>
<tr>
<td>Prof. Rodden’s Plan III</td>
<td>0.42</td>
<td>0.35</td>
</tr>
<tr>
<td>Independent Mapmaker’s Plan</td>
<td>0.41</td>
<td>0.33</td>
</tr>
<tr>
<td>Prof. Rodden’s corrected revision of the Independent Mapmaker’s plan</td>
<td>0.41</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Ohio State Senate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commission’s March 28 Plan</td>
<td>0.39</td>
<td>0.28</td>
</tr>
<tr>
<td>Prof. Rodden’s Plan III</td>
<td>0.44</td>
<td>0.37</td>
</tr>
<tr>
<td>Independent Mapmaker’s Plan</td>
<td>0.43</td>
<td>0.31</td>
</tr>
<tr>
<td>Prof. Rodden’s corrected revision of the Independent Mapmaker’s plan</td>
<td>0.43</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Table 1: Compactness Metrics for Districts on the Commission’s March 28 Plan and alternative plans. Higher scores indicate higher levels of compactness.

### 4 Conclusion

This report has examined the compactness of the Commission’s March 28 plans and compared them to three alternative sets of plans. It finds that the Commission’s plans have the lowest compactness scores. Each of the alternative plans have higher compactness scores than the Commission’s plans.

---

2. The compactness scores were calculated using the open source software program, R, with the redistmetrics package. I also verified the scores using the PlanScore.org website, and obtained nearly identical scores there.
References


I declare under penalty of perjury that the foregoing is true and correct. Executed on this 11th day of April, 2022.

[Signature]

4
Christopher S. Warshaw

Department of Political Science
2115 G Street, N.W.
Monroe Hall 440
Washington, D.C. 20052

Office: 202-994-6290
Fax: 202-994-1974
Email: warshaw@gwu.edu
Homepage: www.chriswarshaw.com

Academic Employment

George Washington University, Washington, DC
Associate Professor (2020-present)
Assistant Professor, 2017 - 2020

Massachusetts Institute of Technology, Cambridge, MA
Associate Professor of Political Science (without tenure), 2016 - 2017
Assistant Professor of Political Science, 2012 - 2016

Education

Stanford University, Ph.D., Political Science, 2012
Fields: American Politics, Comparative Politics, and Political Methodology (Statistics)

Stanford Law School, Juris Doctorate, 2011

Williams College, B.A., magna cum laude, 2002

Research Interests

American Politics, Representation, Elections, Public Opinion, State & Local Politics, Environmental Politics and Policy, Statistical Methodology

Research

Publications

Book


Peer Reviewed Articles


Editor Reviewed Articles in Journals and Law Reviews


Book Chapters


Policy Reports


Articles Under Review

"The Effect of Fox News Channel on U.S. Elections: 2000-2020" (with Elliott Ash, Sergio Galletta, and Matteo Pinna)
(Invited to revise and resubmit at the American Political Science Review)

"Moderates" (with Anthony Fowler, Seth Hill, Jeff Lewis, Chris Tausanovitch, Lynn Vavreck)
(Invited to revise and resubmit at the American Political Science Review)
"Partisan Polarization in the Mass Public in South Korea and the United States"
"How Partisanship in Cities Influences Housing Policy" (with Justin de Benedictis-Kessner and Dan Jones)

**Works in Progress**

"Electoral Accountability for Ideological Extremism in American Elections" (with Devin Caughey)
"Gerrymandering in Local Governments" (with Yamil Valez)
"When Mass Opinion Goes to the Ballot Box: A National Assessment of State Level Issue Opinion and Ballot Initiative Results" (with Jonathan Robinson and John Sides)
"Inequalities in Participation, Voting, and Representation in Local Governments" (with Justin de Benedictis-Kessner and John Sides)
"The Ideology of State Party Platforms" (with Justin Phillips and Gerald Gamm)

**Non-Academic Writing**

"Here are six big takeaways from the 2020 elections." Washington Post. November 7, 2020. (with Emily Thorson)
"TV ads still win elections. And Democrats are buying a lot more of them." Washington Post. October 28, 2020. (with John Sides and Lynn Vavreck)
"The Supreme Court is deciding a gerrymandering case. Here’s the social science that the Justices need to know." Washington Post, Monkey Cage. June 1, 2019.
"New research shows just how badly a citizenship question would hurt the 2020 Census." Washington Post, Monkey Cage. April 22, 2019. (with Matt Barreto, Matthew A. Baum, Bryce J. Dietrich, Rebecca Goldstein, and Maya Sen)

**Invited Talks**

2021-2022: American University
2020-2021: University of Maryland; Stony Brook University
2019-2020: Princeton; UC Berkeley
2018-2019: Stanford; Northeast Political Methodology Meeting at NYU; University of Maryland
2017-2018: USC PIPE Symposium on Studying Subnational Policy Making; BYU; University of Chicago Conference on Political Polarization
2016-2017: University of Virginia; UCLA
2015-2016: Washington University in St. Louis; Texas A&M; Arizona State University Conference on Campaigns, Elections and Representation
2014-2015: Yale; Columbia; Duke
2013-2014: Princeton; Boston University; Rochester University
2012-2013: MIT American Politics Conference; Columbia Representation Conference; Princeton Media & Politics Conference; Annual Meeting of the Society for Political Methodology

Grants
- Russell Sage Foundation, 2019-2021 ($119,475)
- GW UFF, 2019-2020 ($14,433)
- MIT Elections Lab, 2019-2020 ($14,000)
- Jeptha H. and Emily V. Wade Award, 2014-2016 ($59,686)
- MIT Energy Institute (MITEI) Seed Grant, 2014-2016 ($137,147)
- MIT SHASS Research Fund, 2012-2014 ($8,734)

Software

Awards and Honors
- APSA award for best journal article on State Politics & Policy in 2016.
- Award for best paper on State Politics & Policy at the 2014 American Political Science Conference.
- Graduate Fellowship, Dept. of Political Science, Stanford University, 2006-2012
- David A. Wells Prize in Political Economy for Best Undergraduate Economics Thesis, Williams College, 2002
- Phi Beta Kappa, Williams College, 2002

Teaching Experience
- Instructor:
  - Measurement Models (Graduate-level) (GW), 2020
  - Political Representation (Graduate-level) (GW), 2019
  - Elections (GW), 2018, 2019, 2021
  - Multi-level and Panel Models (Graduate-level) (GW), 2017, 2018, 2019, 2021
Public Opinion (GW), 2017
American Political Institutions (Graduate-level) (MIT), 2014, 2016
Public Opinion and Elections (MIT), 2016
Energy Policy (MIT), 2013
Democracy in America (MIT), 2013, 2014
Constitutional Law & Judicial Politics (MIT), 2013, 2015
Making Public Policy (MIT), 2012, 2014

Teaching Assistant:
Introduction to American Law (Stanford University), 2010
Judicial Politics and Constitutional Law (Stanford University), 2009
Political Economy of Energy Policy (Stanford University), 2008
Introduction to International Relations (Stanford University), 2008
Introduction to Public Policy (Stanford University), 2007
Introduction to Econometrics (Williams College), 2002

Graduate Advising

George Washington University:
Alex Beck (Dissertation committee chair)
Dickson Su (Dissertation committee chair)
Kerry Synan (Dissertation committee co-chair)
Jared Heern (Dissertation committee member)
Colin Emrich (Graduates in 2021, Dissertation committee member)

Massachusetts Institute of Technology:
Leah Stokes (Graduated in 2015, Dissertation committee member)
Krista Loose (2016, Dissertation committee member)
Tom O’Grady (2017, Dissertation committee member)
Justin de Benedictis-Kessner (2017, Dissertation committee member)
Alex Copulsky (2017, Masters thesis committee member)
James Dunham (2018, Dissertation committee member)
Parrish Bergquist (2018, Dissertation committee member)
Meg Goldberg (2019, Dissertation committee member)
University Service

**George Washington University:**
- Member, Academic Program Review Committee, Sociology Dept., 2021
- Coordinator, Graduate Political Science Admissions Committee, 2019-2020
- Coordinator, American Politics Workshop, 2018-2020
- Member, Methods Exam Committee, 2017-2020
- Member, Graduate Political Science Admissions Committee, 2018-2019

**Massachusetts Institute of Technology:**
- Member, Energy Education Task Force, 2012-2017
- Parking and Transit Committee, 2013-2017
- Member, Graduate Political Science Admissions Committee, 2013-2015
- Faculty Fellow, Burchard Scholars, 2013-2015

**Stanford University (as graduate student):**
- President, Stanford Environmental Law Society, 2009-2010
- Executive Board Member, Stanford Environmental Law Society 2008-2010
- Member, University Committee on Graduate Studies, 2007-2009
- Member, University Library Committee, 2007-2008
- President, Political Science Graduate Students Association, 2007-2008

Professional Service


**Member,** Best Dissertation Committee, Urban Politics Section of the American Political Science Assoc., 2021

**Member,** Program Committee, Midwest Political Science Association Conference, 2020

**Lead Organizer,** Local Political Economy APSA Pre-Conference at George Washington University, 2019

**Member,** Planning Committee, Cooperative Congressional Election Study (CCES), 2018

**Member,** Best Paper Committee, State Politics Section of the American Political Science Assoc., 2018

**Editorial Board,** Journal of Politics, 2017-18

**Executive Committee,** Urban Politics Section of the American Political Science Association, 2015-2017

Consulting

Partisan Gerrymandering:


Expert, *Benninghoff vs. Pennsylvania Legislative Reapportionment Commission*; and invited expert for the Pennsylvania Legislative Reapportionment Commission as it considered potential plans (2021-2022)


Expert, *League of Women Voters vs. Kent County Apportionment Commission* (2021), County districting plan


Census:


Policy Reports:


Community Service

PlanScore: Social Science Advisory Team (2020-2021)