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Democracy, accountability, and forest loss: a cross-national analysis of low- and middle-income nations

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ABSTRACT

The existing cross-national research on democracy and forest loss has produced contradictory results. On the one hand, some studies find that democracy is related to less forest loss because of electoral accountability and guaranteeing political rights and civil liberties. On the other hand, studies find that democracy is related to increased forest loss in low- and middle-income nations because leaders promote policies that prioritize economic growth over protecting the natural environment. We use this research as a starting point for our study and build upon it in two ways. First, we examine how vertical, horizontal, and diagonal accountability – three different aspects of democracy – impacts forest loss in low- and middle-income nations. Second, we address the issue of endogeneity in the vertical, horizontal, and diagonal accountability. To do so, we analyze data for 80 low- and middle-income nations using a two-stage instrumental variable regression model. We find that higher levels of horizontal and diagonal accountability are related to less forest loss. We do not find that vertical accountability is related to forest loss in low- and middle-income nations. From the findings, we arrive at our theoretical implication, which support arguments concerning how actors at different scales work individually and together to promote conservation.

Introduction

According to the World Resources Institute's Global Forest Watch (2022), 278 million hectares of forest area were cleared from 2001 to 2015. Since 2000, this loss is equivalent to a 7% reduction in forest cover and corresponds with 107 trillion metric tons of carbon dioxide emissions being released into the atmosphere (World Resources Institute 2022). The loss of forests also contributes to biodiversity loss, flooding, soil erosion, and desertification (Seymour and Harris 2019). There are also impacts on humans. These impacts include lower agricultural productivity, growth in slums from rural-to-urban migration, higher prevalence rates of infectious diseases, and violence with people competing for natural resources (Franklin and Pindyck 2018).

Given these consequences, social scientists have considered what impact democracy may have on forest loss. However, the results have been mixed. For example, Didia (1997) and Li and Reuveny (2006) find that higher levels of democracy are related to less forest loss. Bhattarai and Hammig (2001) note a similar effect in Latin America and Sub-Saharan Africa. The authors argue that it may occur for two reasons. First, democratic nations protect freedoms related to speech, assembly, and press which concerned citizens, social movements, and non-governmental organizations can use to pressure governmental leaders to protect forests. Second, leaders

in democratic nations have to be elected and reelected. If elected officials do not keep promises to constituents, then they may lose their next election (Didia 1997).

However, Shafik (1994), Midlarsky (1998), Ehrhardt-Martinez, Crenshaw, and Jenkins (2002), and Marquart-Pyatt (2004) find that higher levels of democracy correspond with more forest loss. Bhattarai and Hammig (2001) find a similar pattern among Asian nations. The authors contend that their findings may be the result of government officials in low- and middle-income nations being more sympathetic to economic rather than environmental matters in pursuit of their industrialization. More recently, Sanford (2021) explained why this finding exists by demonstrating that more competitive elections are related to increased forest loss. Sanford (2021) speculates that incumbents involved in competitive elections engage in clientelism, which impacts forests. Shandra, Sommer, and Restivo (2023) confirm this in their cross-national study by demonstrating that higher levels of clientelism involving vote buying and particularistic public spending tend to increase forest loss in low- and middle-income nations.

Further, Buitenzorgy and Mol (2011) and Obydenkova, Nazarov, Salahodjaev (2016) find an inverted, u-shaped curve between democracy and forest loss. The authors argue that this non-linear relationship exists because nations with medium levels of

repression tend to be 'hybrid regimes' with mature institutions focused on promoting industrialization via natural resource extraction and few institutions concerned with environmental protection – see also Wullert and Williamson (2016). Once a nation passes the turning point, however, democracy is related to less forest loss. This occurs because government agencies concerned with the natural environment become more prevalent and mature and, as a result, pass and enforce regulations that protect forests (A. Obydenkova, Nazarov, and Salahodjaev 2016).

We use the contradictory findings regarding democracy and forest loss as the starting point for our study. We go on to extend the cross-national research frontier on forest loss in two ways. To begin, Karlsson-Vinkhuyzen, Dahl, and Persson (2018) argue that social scientists should consider the different ways that governments are held accountable so they can attend to the needs and concerns of their citizens. In this regard, Lührmann, Marquardt, and Mechkova (2020) note that constraints on political power can be exercised via vertical, horizontal, and diagonal accountability.[1] The authors note that vertical accountability includes formal political participation on the part of the citizens to freely organize in political parties and be able to participate in free and fair elections. Horizontal accountability involves limitations on political power via a system of checks and balances including the ability of legislature, judiciary, and oversight agencies to demand information, question government officials, and punish improper behavior (Lührmann, Marquardt, and Mechkova 2020). Lührmann, Marquardt, and Mechkova (2020) define diagonal accountability as the range of actions that concerned citizens, social movements, non-governmental organizations, or the media can use to hold government officials from any branch responsible for their actions.

While this preceding cross-national research on democracy and forest loss is insightful and implies that various forms of accountability are related to forest loss, it does not explicitly test this line of reasoning. Drawing on insights from Lührmann, Marquardt, and Mechkova (2020), we argue that it is important to consider if vertical, horizontal, and diagonal accountability may be related to forest loss in low- and middle-income nations. To do so, we use newly available data from the Varieties of Democracy (2023) database.

We move the cross-national research frontier on forest loss forward in a second way. We do so by analyzing the new data on accountability with a two-stage instrumental variable regression model to address any potential problems with endogeneity (Wooldridge Jeffery 2015). In other words, endogeneity is an issue when the same processes related to forest loss in a low- or middle-income nation also predict accountability measures (Wooldridge Jeffery 2015). If we fail to consider it, then we may estimate biased regression coefficients and inefficient tests of statistical significance (Wooldridge Jeffery 2015).

We now turn to a discussion of accountability to illustrate how we define and operationalize the concepts. Next, we explain why higher levels of vertical, horizontal, and diagonal accountability may correspond with less forest loss in low- and middle-income nations. Afterward, we describe our dependent variable, independent variables, and sample. We follow with a discussion of the two-stage instrumental variable model and how it addresses endogeneity. We conclude with a discussion of the findings along with the theoretical, methodological, and policy implications that follow from them.

Vertical accountability and forest loss

We note above that Lührmann, Marquardt, and Mechkova (2020) describe the existence of three forms of accountability. They include vertical, horizontal, and diagonal accountability. How might such factors impact forest loss in low- and middle-income nations? We begin with a discussion of how vertical accountability may impact forest loss in low- and middle-income nations.

According to Lührmann, Marquardt, and Mechkova (2020), vertical accountability involves formal political participation on the part of the citizens to hold government officials responsible. The authors note that formal political participation mainly involves citizens being able to organize into political parties and being able to participate in free and fair elections. Toward this end, there are a couple of reasons why this form of accountability may be related to less forest loss.

For instance, Didia (1997) argues that it is essential to differentiate between how government officials come into power and their tenure in office when thinking about the impact of electoral accountability on forest loss. As such, elected officials in nations with high levels of vertical accountability assume office by winning the majority of votes (Didia 1997). There also tend to be term limits set by a constitution so elected officials know the exact length of their time in office with the exceptions of being impeached or death (Didia 1997). Thus, elected officials may behave as if they will serve their entire term in office, and therefore potentially more likely to devote time to addressing campaign promises (A. Obydenkova, Nazarov, and Salahodjaev 2016). Obydenkova (2012) and (A. Obydenkova 2007) extend this argument to the subnational level, with local leaders being concerned with public opinion when elections are free, fair, and transparent.

However, Didia (1997) goes on to argue that leaders in nations with lower levels of vertical accountability usually come to power by force and not via elections. These leaders remain in office

until they are forcibly removed by a coup d'état or until they die. When tenure in office can end at any point because terms are not constitutionally guaranteed or secured by popular mandate, leaders do not have much incentive to prioritize long-term planning (Shandra, Sommer, and Restivo 2023). Rather, it is essential for them to secure and prolong their time in power by using various resources to appease disgruntled elements in the military or other political rivals (Sidha 2018). At the subnational level, Andersson and Ostrom (2008) describe the emergence of 'local tyrannies' where local officials use their exclusive access to forests to appease critics when elections are not free, fair, and transparent.

Toward this end, leaders in nations with higher levels of vertical accountability tend to be responsive to environmental activism and public opinion because of elections. Given that such nations hold regular, free, and fair elections, they have the potential to bring new parties, including green parties, into power. This is especially the case if incumbents do not follow through on campaign promises to protect forests (Didia 1997). In a nation with a lower level of vertical accountability, however, the distribution of political power is highly concentrated among the ruling elite, reducing the likelihood that environmentalists or any other political party, for that matter, will end up in power unless the government is overthrown (Hurst, P. 1990). Further, political rivals are often given unrestricted access to forests and how they are used, which decreases their incentive to push for change (Bryant Raymond and Bailey 1997).

To illustrate how (a lack of) vertical accountability may impact forest loss, let us consider a quintessential example from the Philippines. President Ferdinand Marcos, who was in power from 1964 to 1986, granted logging concessions to political rivals during his time in office (Broad and Cavanagh 2023). The recipients of the logging concessions exported valuable teak and mahogany even though it was prohibited by Philippine law. In an interview, Ernesto Maceda, Minister of Natural Resources, said '$960 million worth of hardwoods has been cut by Marcos' friends and associated between 1974 and 1980 and smuggled out of the country … (They) were the only ones who got logging concessions … and their shipments were cleared for export on instructions from the top' (Crewdson 1986, 25). Maceda continues, '(They) never complied with the reforestation agreements or selective logging. What they'd do is go in with a bulldozer and uproot everything (Crewdson 1986, 25)' As such, approximately 7 million of the Philippines' 12 million hectares of forests have been cleared with less than half of the remaining 5 million hectares being natural forests (J. M. Sommer, Restivo, and Shandra 2022).

Horizontal accountability and forest loss

According to Lührmann, Marquardt, and Mechkova (2020), horizontal accountability involves the power of a country's legislature, judiciary, and oversight agencies to demand information, question government officials, and punish improper behavior of public officials. In other words, it involves a system of checks and balances to ensure compliance with a country's laws and regulations (J. M. Sommer 2017). Typical examples involve the legislature holding public hearings concerning actions taken by executive branch members. In other instances, it may involve an inspector general carrying out an investigation, audit of public sector employees, or appointed officials leading a particular agency. Ideally, higher levels of horizontal accountability have the potential to limit corruption, nepotism, cronyism, or other forms of patronage and, as a result, lead to less forest loss.

Sommer (2017) links higher levels of grand and petty corruption to increased forest loss. It is common for public sector workers to take bribes and kickbacks to supplement their incomes (Miller 2011). Higher-level government officials often engage in embezzlement or misappropriation of government funds to enrich themselves, family members, or political allies (Haines 2019). However, horizontal accountability may make it less likely that public sector employees and high-level government officials will engage in such behaviors out of fear of being exposed and, ultimately, punished for their misdeeds (Opoku and Sommer 2023).

To illustrate this process, we provide an example from Indonesia. For the 30 years that President Suharto was in office, most positions in Indonesia's Ministry of Forests and Ministry of Agriculture were 'filled by unqualified candidates, and advancement was based on metrics other than performance' (Butler 2013, 1). As a result, corruption was pervasive with individuals bribing President Suharto for jobs in several ministries. In some instances, the newly appointed government officials would take bribes and kickbacks to falsify documents declaring lower values or volumes of logs being exported or misclassifying species being exported or marketed locally (Palmer 2001). In other instances, forestry regulations were not enforced. This includes extracting more timber than authorized, logging without authorization, logging protected species, logging in protected areas, and logging outside the boundaries of a concession (Dauvergne 2004). In the end, Indonesia became the largest exporter of logs during President Suharto's tenure in office. However, forest loss also increases, with 1.6 million hectares of forest being cleared annually, which is an area larger than the size of Connecticut (Vit 2015).

Following President Suharto's removal from office via a coup d'état, there were various attempts to reform by Indonesia's newly elected president.

President Yudhoyono pushed some of the most comprehensive changes during his tenure in office – efforts that included enhancing horizontal accountability (Wijaya et al. 2019). These reforms involved placing a moratorium on new government hiring, implementing a meritocratic hiring and promotion system once the moratorium was lifted, and, more importantly for this study, creating general inspector offices in the areas related to agriculture and forestry (Wijaya et al. 2019). With such changes in place, forest loss has declined in Indonesia. There is less corruption among public sector workers and higher-level government officials and, as a result, more enforcement efforts to prevent illegally setting fires to clear land for agriculture (Wijaya et al. 2019).

Diagonal accountability and forest loss

Lührmann, Marquardt, and Mechkova (2020) note that diagonal accountability involves a variety of actions and mechanisms that concerned citizens, social movements, non-governmental organizations, and the media can use separately or together to hold government officials responsible for their actions and decisions. It is generally believed that low- and middle-income nations with higher levels of diagonal accountability tend to have more environmental activism and, as a result, less forest loss (Davis and Zhang 2023). When governments guarantee their citizens certain freedoms like press, speech, assembly, and rights to a fair trial, citizens can organize and express their frustrations with government and corporate officials via protests, consumer boycotts, or monitoring, with little fear of reprisal and retaliation (Schofer and Hironaka 2005). In regard to forests, it may involve organizing logging blockages or exposing illegal logging via the media (Keck and Sikkink 1998). Further, social movements and non-governmental organizations can provide programs in the absence of governmental involvement like tree replanting or agroforestry projects (Tasmim et al. 2020).

However, a low- or middle-income nation with little diagonal accountability tends to suppress any form of protest or dissent by its citizens, which it views as a threat to its stability (London and Ross 1995). This repression can take several forms (Cole and Schofer 2023). At the minimum, a low- or middle-income nation can seek to delegitimize leaders of social movements or non-governmental organizations (Evans, Schofer, and Hironaka 2020). A low- or middle-income may also pass laws that outlaw strikes, protests, and unions or require members of non-governmental and social movements to register with the government (Bromley, Schofer, and Longhofer 2020). At the most extreme, a low- or middle-income nation may unlawfully detain its citizens, engage in torture, or commit extra-judicial killings (Julkif and

Julkif, Nabil "Bill." 2023). In such places, there also tends to be little to no recourse for citizens with the media and judiciary being controlled by the government (Xu and Ribot 2004). Thus, we argue that higher levels of diagonal accountability should correspond with less forest loss in low- and middle-income nations.

We can see this process at work by considering an example from Malaysia. Since the 1980s, the Penan have been engaged in protest activities (e.g. blockading of logging roads and sabotaging of logging equipment) to gain control over local forests (Hurst, P. 1990). Bryant and Bailey (1997, 182) write, 'The response of the Malaysian government to these activities has been to repress the dissent, but this move only prompted the intervention of non-governmental organizations, including Sahabat Alam Malaysia and the World Rainforest Movement on the side of the Penan.' These domestic non-governmental organizations have supported the Penan by urging its members to raise awareness by writing letters to elected officials, providing financing for legal challenges in the Malaysian courts, and directly lobbying Malaysia's political leaders (J. Sommer, Zhang, and Shandra 2023). As a result of the intervention by the non-governmental organizations, forest loss decreased on Penan land (Tasmim et al. 2020).

Summary

From the preceding discussion, we arrive at the following hypotheses. First, we hypothesize that higher levels of vertical accountability should be related to less forest loss in low- and middle-income nations. This is because elected officials must keep campaign promises, especially in regard to protecting forests, if they are to be elected or reelected. Second, we hypothesize that higher levels of horizontal accountability should be related to less forest loss in low- and middle-income nations. We expect that this is the case because a country's system of checks and balances between the branches of government ensures compliance with a country's laws and regulations. Third, we hypothesize that higher levels of diagonal accountability should be related to less forest loss in low- and middle-income nations. We expect this to be the case because concerned citizens, social movements, and non-governmental organizations have the space to pressure a government to protect forests.

Dependent variable

Forest loss ratio

Until recently, cross-national research on forest loss was largely based on data made available in the United Nations Food and Agriculture Organization's

Global Forest Resources Assessment (e.g. Tester 2020 or Shandra, Rademacher, and Coburn 2016). However, the reliability of this source has been called into question because the data are gathered using different data collection methods. In some countries, forestry statistics are very reliable because they are based on annual remote sensing surveys (Food and Agriculture Organization 2017). But, in other countries, estimates are much less reliable because they are based on expert opinions or extrapolated from outdated forest inventories (Grainger 2008). We use newly available data on forest loss that is derived from high-resolution satellite imagery (30 × 30 meters) to eliminate this potential source of error. The data may be obtained from the World Resources Institute's (2016) Global Forest Watch web page. See Hansen, Stehman, and Potapov (2010) for an in-depth discussion of the methodology used to arrive at the estimates.

We calculated the percentage of forest loss in the following way. First, we set the tree cover canopy density level upon which the estimates are based, which represents what is being counted as a forest in a nation. We follow Rudel (2017) and set the tree cover canopy density equal to 75% or greater, which represents dense forests and provides a conservative estimate of forest cover. This is because tree cover density for a nation represents the estimated percentage of a pixel taken from satellite imagery that is covered by tree canopy (World Resources Institute 2016). Second, we obtain the amount of the nation's land area in hectares with a 75% tree cover canopy density in 2000. Third, we collect the total number of hectares of forest cleared in a nation from 2001 to 2015. Fourth, we divide the total amount of hectares cleared from 2001 to 2015 by the total forest size in 2000 to compute the forest loss ratio for each nation (Rudel 2017). In Table 1, we present the descriptive statistics and correlation matrix for the variables used in the analysis.

Democracy

We begin by using the average of Freedom House's (2005) political rights and civil liberties scales to measure overall democracy in 2000. The political rights scale reflects whether a nation is governed by democratically elected representatives and has fair, open, and inclusive elections. The civil liberties measure reflects whether a nation has freedom of the press, freedom of assembly, general personal freedom, freedom of private organizations, and freedom of private property. The variables are measured on a seven-point scale: free (1–2), partially free (3–5), and not free (6–7). We multiply the average of the scales by −1 so that higher scores correspond with democracy. We note the contradictory evidence regarding how democracy is related to forest loss previously.

Table 1. Descriptive statistics and bivariate correlation matrix of forest loss analysis (2001–2015).

Variable	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Forest Loss Ratio	.164	.258	1.000														
(2) Freedom House Democracy	−4.231	1.605	−.046	1.000													
(3) Vertical Accountability	.426	.690	−.096	.815	1.000												
(4) Horizontal Accountability	.103	.801	−.095	.696	.677	1.000											
(5) Diagonal Accountability	.544	.758	−.064	.832	.753	.779	1.000										
(6) Total Agricultural Exports (square root)	3.006	2.161	.441	.133	.036	.176	.167	1.000									
(7) Agricultural Sector Size	43.747	20.300	.148	−.025	−.014	−.036	−.039	.012	1.000								
(8) Gross Domestic Product Per Capita (natural logarithm)	6.549	1.057	−.262	.415	.501	.244	.308	−.252	−.110	1.000							
(9) Gross Domestic Product Growth	3.386	2.471	−.123	−.249	−.210	−.298	.296	.029	.107	−.154	1.000						
(10) Environmental Non-Governmental Organizations	2.219	2.615	.055	.206	.100	.142	.161	−.067	−.283	.201	−.223	1.000					
(11) Total Population Growth	.217	.218	.046	−.086	−.041	.027	.048	.099	−.157	−.264	.154	.069	1.000				
(12) Rural Population Growth	.123	.257	.102	−.196	−.164	−.092	−.102	.114	−.123	−.516	.171	−.070	.838	1.000			
(13) Urban Population Growth	.504	.401	.096	−.142	−.139	.078	.027	.164	−.112	−.374	.056	.057	.868	.667	1.000		
(14) United Nations Voting Alignment with China	.961	.066	.123	−.355	−.347	−.414	−.326	−.004	−.141	−.289	.116	−.199	.372	.354	.392	1.000	
(15) Threatened Bird Species	2.514	.990	−.289	.158	.244	.262	.187	−.234	−.137	.242	−.017	−.370	.058	−.021	.089	.222	1.000

Table 2. Variables included in the accountability measures.

Index	Operationalization
Vertical Accountability	having an electoral regime
	autonomy and capacity of the electoral management body
	accuracy of the voter registry
	intentional irregularities conducted by the government
	opposition intimidation and harassment by the government and its agents
	to what extent the elections were multi-party in practice
	freedom and fairness of elections
	the percentage of people that have the legal right to vote
	relative power over the appointment and dismissal of cabinet ministers
	subjected to direct or indirect elections
Diagonal Accountability	the extent to which the government attempts to censor the media and information on the Internet as well
	the extent to which government
	and other powerful actors harass journalists
	the extent to which: the media
	−criticizes the government
	at least occasionally
	−there is bias against opposition candidates
	−the media offers a wide array of political perspectives in their coverage
	−there is self-censorship on salient issues for the government
	popular and voluntary participation in civil society organizations (CSOs)
	government control to the entry and exit of CSOs into the public life
	government oppression of CSOs
	the degree to which men and
	women are free to discuss political issues without fear of harassment
	freedom of academic and cultural expression
	engaged society (gives information
	on the width and depth of public deliberations when important policy changes are
	being considered)
Horizontal Accountability	judicial constraints on the
	executive index
	legislature activities
	degree to which the legislature routinely questions the executive
	degree to which a legislature is likely to investigate and produce a decision unfavorable to
	the executive if the latter were engaged in an illegal or unethical activity
	the degree to which other state bodies comptroller general, general prosecutor, or ombudsman are likely to investigate and
	report on potential illegal or unethical activities on part of the executive
	excludes legislature opposition parties as this aspect is part of vertical accountability

Source: Varieties of Democracy Database (2023).

Vertical accountability

We include the Varieties of Democracy (2023) measure of vertical accountability to capture the extent to which citizens have the power to hold the government accountable. The mechanisms of vertical accountability include formal political participation on the part of the citizens. In this regard, Table 2 lists the variables used to create the vertical accountability measure and, in turn, assesses the degree to which citizens are able to freely organize in political parties and participate in free and fair elections (Varieties of Democracy 2023). We expect that higher levels of vertical accountability should correspond with less forest loss.

It is important to note that the Varieties of Democracy (2023) data are based on expert surveys. Boese (2019) discusses several threats to validity and reliability that may emerge. First, it is often easier to find experts for certain nations and specific time periods. For example, Munck (2009) notes that organizations have difficulty identifying experts in particular nations because participation is dangerous for the experts and their relatives. Second, experts may disagree on how to classify a nation regarding a specific concept. For instance, Bush (2017) argues that the opinions of experts tend to correspond to a large extent with the perceptions of how scholars in the United States and Europe define the concept being

measured. Third, experts may have different thresholds for how to classify the concept being measured. In this regard, Paxton, Bollen, Lee, and Kim (2003) find that experts systematically rate Marxist-Leninist nations lower than other nations on various aspects of democracy.

Clearly, there are issues that threaten the validity and reliability of the data. However, scholars involved in collecting the data have taken several steps to address such problems. These steps include having a network of more than 3,500 country experts, with a minimum of 5 experts for any given nation, with approximately two-thirds being citizens or residents of the nations for which they provide information (Varieties of Democracy 2023). Further, the identities of country experts are held confidential and are not publicly revealed (Varieties of Democracy 2023). Additionally, experts come from diverse backgrounds that include not only academics but other professionals with specialized knowledge about a given nation (Varieties of Democracy 2023).

Finally, Boese (2019) notes that Varieties of Democracy (2023) uses a Bayesian item response theory estimation strategy to calculate its estimates, which allows for the possibility that experts have different thresholds and classifications for their ratings. These thresholds are estimated based on patterns in the data and then

incorporated into a final estimate of a latent concept being measured. This makes it possible to correct for the concern that one expert may respond with 'never' while another expert may respond 'always' to a given question (Varieties of Democracy 2023). Furthermore, the item response estimation strategy allows the reliability of the experts to idiosyncratically vary based on the degree to which they agree with other experts. The experts with higher reliability have a greater influence on concept estimation, thereby considering the concern that not all experts are equally knowledgeable (Varieties of Democracy 2023).

Horizontal accountability

We also include the Varieties of Democracy's (2023) horizontal accountability index in our models. This index assesses the extent to which public institutions oversee the government by demanding information, questioning officials, and punishing improper behavior (Varieties of Democracy 2023). This form of accountability ensures checks between institutions and prevents the abuse of power. The key agents in horizontal accountability include the legislature, judiciary, and government oversight agencies (Varieties of Democracy 2023). We list the variables used in the construction of this measure in Table 2. We expect that higher levels of horizontal accountability should be related to less forest loss.

Diagonal accountability

The diagonal accountability measure assesses the range of actions and mechanisms that citizens, social movements, non-governmental organizations, and an independent media can use to hold the government accountable (Varieties of Democracy 2023). These mechanisms include using informal tools such as mobilization of protests, other forms of collective action, and investigative journalism (Varieties of Democracy 2023). In Table 2, we list the variables included in this index. We expect that higher levels of diagonal accountability should lead to less forest loss.

International non-governmental organizations

We also include the number of international non-governmental organizations working on environmental and animal rights issues in a nation for 2000 per capita. The data on non-governmental organizations are collected by Smith and Wiest (2005) from the *Yearbook of International Associations*. The population size data comes from the World Bank (2015). We expect that higher levels of international non-governmental organizations per capita should be associated with less forest loss because they fund conservation programs and help to organize social movement activity around environmental issues in low- and middle-income nations (Schofer and Hironaka 2005).

Gross domestic product per capita

We employ a measure of gross domestic product per capita for 2000. The data come from the World Bank (2015). We log this variable to correct for its skewed distribution. We hypothesize that higher levels of gross domestic product per capita should correspond with more forest loss, as poorer nations tend to clear trees to expand their agricultural exports (Burns, Kick, and Davis 2003).

Economic growth

We include the average annual economic growth rate from 2000 to 2015 from the World Bank (2015). We expect that economic growth rate to be associated with higher forest loss among other environmental issues (Clausen and York 2008). This may be the case because nations experiencing rapid economic growth invest money in environmentally damaging activities like logging or export agriculture that leads to the clearing of forests (Rudel 1989).

Population growth

We account for demographic factors like population growth. We calculate the average annual percentage growth for the total population from 2000 to 2015. We obtain these estimates from the World Bank (2015). Rudel (1989) suggests that geometric growth in population outstrips arithmetic growth in the means of subsistence, leading to carrying capacity issues like forest loss.

Rural and urban population growth

York, Rosa, and Dietz (2003) argue that it is essential to decompose demographic factors in cross-national research. That is, sociologists should examine not only overall growth rates but also growth in different contexts. Jorgenson and Burns (2007) find that higher rates of rural population growth are associated with increased deforestation, while higher rates of urban population growth are associated with lower rates of deforestation. They argue that expanding urban centers often create economic opportunities other than agricultural ones, which leads to increased rural-to-urban migration and, ultimately, less forest loss. We also include the average annual percentage change in rural and urban populations from 2000 to 2015 in our models. These data come from the World Bank (2015).

Agricultural exports

We also control for a country's total agricultural exports. We measure this variable as a percentage of total merchandise exports for 2000. We take the square root of this variable due to non-linearity. The data may be obtained from the World Bank (2015). Because trees are often cleared in order to make space for bigger fields for export markets, we expect that higher levels of agricultural exports will be associated with more forest loss (Shandra, Restivo, and Sommer 2020).

Agricultural land area

We further assess the impact of a nation's agricultural sector by including the percentage of agricultural land as a percentage of a country's total land area for 2000. The data may also be obtained from the World Bank (2015). We take the square root of this variable because of its nonlinearity. We hypothesize that low- and middle-income nations with a larger agricultural sector should have higher rates of forest loss as farmers grow crops for export or domestic consumption (Austin 2010).

Statistical model

While ordinary least squares regression is employed in cross-national research, it is essential to address issues of endogeneity (Easterly 2006). In this instance, endogeneity on the accountability measures may lead to biased coefficients and inefficient tests of statistical significance (Wooldridge Jeffery 2015). This problem arises when one of the 'explanatory' variables, on the right-hand side of the regression equation, is jointly determined with the left-hand side 'dependent' variable to be explained (Wooldridge Jeffery 2015). Consider the ordinary least squares regression equation for forest loss in Equation 1 to illustrate this point:

$$y1 = \beta 0 + \beta 1\, y2 + \beta 2\, x1 + e \qquad (1)$$

where y1 represents the dependent variable, forest loss, y2 represents the endogenous variable or any of the government accountability measures, x1 represents variables assumed to be exogenous, and e represents the error term. In this case, y2 May be considered endogenous if the same processes that are related to forest loss in a country are also factors that predict vertical, horizontal, or diagonal accountability. Using ordinary least squares regression to estimate the effect of government accountability on forest loss will lead to biased estimates because this variable is not randomly assigned, and the regression equation is capturing the selection of the composition of vertical, horizontal, or diagonal accountability as well as the effects of these measures on forest loss in one parameter (Wooldridge Jeffery 2015). The estimate is also

inconsistent since the error term e will be correlated with the endogenous predictor or y2 (Wooldridge Jeffery 2015)

One way to address this problem is to find a variable or variables, called an instrument(s) or instrumental variable(s), that satisfies the property of having a statistically significant correlation with the various forms of government accountability but not a statistically significant correlation with forest loss (Wooldridge Jeffery 2015). In a two-stage model, the predicted values for the instrument are obtained in the first stage, which is then used in the second stage to obtain an unbiased estimate of forest loss. We carry out this analysis using Stata version 14 and its 'ivreg2' command (Baum 2006).

We can write the equation for our endogenous explanatory variable as follows:

$$y2 = \pi 0 + \pi 1\, z1 + \pi 2\, z2 + v \qquad (2)$$

where z1 is an instrument for y2 if it is still correlated with y2 after removing the effects of other exogenous predictors (z2) (Wooldridge Jeffery 2015). The residuals, v, are the part of the endogenous predictor y2 that is uncorrelated with the instrument z1, which can be inserted in the second stage to obtain the unbiased estimates (Wooldridge Jeffery 2015). This equation can be written as:

$$y1 = \beta 0 + \beta 1\, y2 + \beta 2\, x1 + \beta 3\, z1 + \beta 4\, v + \omega \qquad (3)$$

In the first stage, we include two exogenous predictors of vertical, horizontal, and diagonal accountability in low- or middle-income nations. The first is the likelihood of voting with China in the United Nations. We expect that low- and middle-income nations that are more closely aligned with China are less likely to have various forms of government accountability. We propose that this may be the case because low- and middle-income nations that are allied with China are more likely to adopt repressive policies and practices that China employs domestically.

The second instrumental variable is the number of threatened bird species in a nation for 2000. The data come from the World Bank (2016). We hypothesize that low- and middle-income nations that have a large number of threatened bird and mammal species should be related to higher levels of vertical, horizontal, and diagonal accountability. We draw upon Rudel (2019) to argue that when nations are confronted with pressing environmental concerns, citizens and elites mobilize to press their governments to address such issues.

There are assumptions that must be met concerning the choice of instruments when using this statistical methodology. First, we must determine if an instrument is 'relevant' or that it is correlated or statistically dependent with the endogenous variable but not the dependent variable (Wooldridge Jeffery 2015). To test

this assumption, we look at the coefficients for the Anderson canonical correlation. This chi-square test reaches a level of significance in every model. Thus, we reject the null hypothesis and conclude that our instruments are relevant (Wooldridge Jeffery 2015).

Second, we determine if the instruments are 'valid' by testing to ensure that they are uncorrelated with the error term (Baum 2006). We consider Sargan chi-square statistics for this purpose. The null hypothesis is statistical independence. The coefficients for this chi-square test do not reach a level of significance in any model, thereby indicating the instrumental variables are not correlated with the error term (Baum 2006).

Third, we test to see if the instruments are 'weak' or explain only a small amount of variation in the various dimensions of accountability. This does not appear to be the case. We calculate a Cragg-Donald F-statistics for each equation to reach this conclusion. We compare these values against Stock-Yogo critical values to determine if the instruments are weak (Wooldridge Jeffery 2015). The test statistics for the F-tests are greater than the Stock-Yogo critical values for a 15% bias level in every model.

We also must ensure that we are not violating traditional regression assumptions. As such, we begin by calculating the mean and highest variance inflation factor scores for each model. We report the values in Table 3. There do not appear to be any potential problems with multicollinearity, with mean and highest variance inflation factor scores not exceeding a value of 10 in the models (Tabachnick and Fidell 2013)

We also use Stata 14's ladder and gladder commands to determine if a variable is normally distributed or needs to be transformed. The ladder command reports a chi-square test for eight different transformations. The null hypothesis for the chi-square test is that a specific transformation approximates normality (Tukey John 1977). If the chi-square statistic is statistically significant, then we reject the null hypothesis and conclude that the specified transformation does not approximate normality (Tukey John 1977). We confirm the statistical tests by visually inspecting graphical distributions for each variable using the gladder command. We transform variables based on the results of this procedure and note any transformations (Tabachnick and Fidell 2013).

Further, we calculate standardized residuals to determine if outliers are a problem. We do not identify any multivariate outliers because no standardized residuals exceed an absolute value of 2.5 (Tabachnick and Fidell 2013). An examination of Cook's distance statistics indicates no potential problems with influential cases.

Finally, we calculate Pagan-Hall heteroskedasticity tests for each model. The null hypothesis for this chi-square test is that the error variances are homoscedastic or equally distributed (Tabachnick and Fidell 2013). The coefficients for the chi-square statistics only reach a level of significance in two models, indicating no discernible problems with heteroscedasticity (Tabachnick and Fidell 2013). We report conventional standard errors as a result.

Sample

After listwise deletion of missing data, the following 80 low- and middle-income nations according to the World Bank (2015). They include: Albania, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Benin, Bhutan Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Colombia, Democratic Republic of the Congo, Republic of the Congo, Costa Rica, Cote d'Ivoire, Cuba, Dominican Republic, Ecuador, Eritrea, Ethiopia, Gabon, The Gambia, Georgia, Ghana, Guatemala, Guinea, Guyana, Haiti, Honduras, Hungary, India, Indonesia, Kazakhstan, Kenya, Kyrgyz Republic, Lao People's Democratic Republic, Liberia, Macedonia, Madagascar, Malawi, Malaysia, Mali, Mexico, Moldova, Mongolia, Mozambique, Nepal, Nicaragua, Nigeria, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Russian Federation, Rwanda, Senegal, Sierra Leone, Solomon Islands, South Africa, Sri Lanka, Sudan, Tajikistan, Tanzania, Thailand, Turkmenistan, Uganda, Ukraine, Uzbekistan, Venezuela, Vietnam, and Zimbabwe.

Findings

In Table 3, we present the second-stage estimates of forest loss from the instrumental variable regression models. The first number reported is the regression coefficient, and the second number in parentheses is the standard error. We use the $p < .05$ level for a two-tailed test when discussing levels of statistical significance. We do so because of the contradictory findings pertaining to democracy on forest loss.

In models (3.1) and (3.2), we include a general measure of democracy – the average of Freedom House's (2005) political rights and civil liberties scales. In models (3.3) and (3.4), we include vertical accountability. In models (3.5) and (3.6), we examine horizontal accountability. In models (3.7) and (3.8), we include diagonal accountability. In odd-numbered models, we look at the relationship between total population growth and forest loss. In even-numbered models, we 'decompose' total population growth into rural and urban population growth following Jorgenson and Burns (2007). The models include all the other independent variables discussed.

Let us begin by focusing on the variables related to democracy and democratic accountability. To begin,

Table 3. Second stage of two-stage instrumental variable regression estimates forest loss (2001–2015).

Independent Variables	Model (3.1)	Model (3.2)	Model (3.3)	Model (3.4)	Model (3.5)	Model (3.6)	Model (3.7)	Model (3.8)
Freedom House Democracy, 2000	−.102 (.054)	−.990 (.054)						
Vertical Accountability, 2000			−.236 (.125)	−.235 (.126)				
Horizontal Accountability, 2000					−.118* (.055)	−.119* (.056)		
Diagonal Accountability, 2000							−.184* (.091)	−.188* (.094)
Total Agricultural Exports, 2000	.068*** (.017)	.068*** (.017)	.061*** (0.15)	.062*** (.015)	.059*** (.013)	.059*** (.013)	.065*** (.015)	.066*** (.015)
Agricultural Sector Size, 2000	.003* (.001)	.003* (.001)	.003 (.001)	.003* (.001)	.003* (.001)	.003* (.001)	.003* (.001)	.003* (.001)
Gross Domestic Product, 2000	.022 (.047)	.026 (.050)	.040 (.054)	.051 (.060)	−0.020 (.028)	−0.016 (.031)	.002 (.036)	.009 (.041)
Economic Growth Rate, 2000–2015	−.028* (.013)	−.028* (.013)	−.027* (.013)	−.027* (.013)	−.027** (.011)	−.026** (.011)	−.031** (.013)	−.031** (.013)
Environmental Non-Governmental Organizations, 2000	.021 (.012)	.022 (.012)	.012 (.012)	.014 (.011)	.015 (.010)	.015 (.010)	.016 (.011)	.017 (.011)
Total Population Growth, 2000–2015	.025 (.136)		.093 (.146)		.052 (.121)		.104 (.137)	
Rural Population Growth, 2000–2015		.132 (.162)		.194 (.175)		.047 (.140)		.088 (.151)
Urban Population Growth, 2000–2015		−.067 (.094)		−.061 (.095)		.010 (.085)		.005 (.091)
Constant	−.700 (.555)	−.699 (.569)	−.265 (.359)	−.318 (.396)	.067 (.220)	.033 (.246)	−.018 (.254)	−.059 (.286)
Pagan-Hall Heteroskedasticity Test	13	15	12	15	19.825*	22.522**	13	16
Anderson Canonical Correlation	11.259**	11.436**	12.058**	11.951**	30.093***	29.771***	14.860***	13.967***
Cragg-Donald F-Statistic	6	6	6.300	6	21	21	8	7
Sargan Chi-Square Test	.124	.358	.026	.189	.124	.130	.074	.147
Uncentered R-Square	.359	.374	.348	.357	.507	.507	.437	.432
Number of countries	80	80	80	80	80	80	80	80
Highest Variance Inflation Factor Score	4	4	4	5	2	2	2.80	3
Mean Variance Inflation Factor Score	2	2	2	2	1	1.60	1.70	2

(a) * indicates $p < .05$, ** indicates $p < .01$, and *** indicates $p < .001$ for a two-tailed test.
(b) The first number is the unstandardized coefficient and the second number in parentheses is the standard error.

we do not find that the overall measure of democracy is related to forest loss. In models (3.1) and (3.2), the coefficients for the average of Freedom House's (2005) civil rights and political liberties measure do not reach a level of statistical significance. Thus, there may be utility in examining how various forms of democratic accountability may impact forest loss rather than an overall measure of democracy.

We do not find that higher levels of vertical accountability are related to forest loss. In models (3.3) and (3.4), the coefficients for this measure do not reach a level of statistical significance at the $p < .05$ level for a two-tailed test level. However, we do observe that the other two measures of democratic accountability are related to forest loss. In models (3.5) and (3.6), we find that higher levels of horizontal accountability correspond with less forest loss. The coefficients for this variable are negative and significant at the $p < .05$ level for a two-tailed test level. A similar pattern exists for diagonal accountability. In models (3.7) and (3.8), the coefficients for this variable are negative and significant.

We also find other factors that predict significant variation in forest loss. First, we find that higher levels of agricultural exports are related to increased forest loss. The coefficients for this variable are positive and significant at the $p < .05$ level

for a two-tailed test across Table 3. Similarly, we find that a larger domestic agricultural sector, as measured by agricultural land area as a percentage of total land area, corresponds with higher levels of forest loss. In Table 3, the coefficients for this variable are also positive and significant in every model at the $p < .05$ for a two-tailed test. Finally, we find that economic growth corresponds with lower levels of forest loss in low- and middle-income nations. The coefficients for economic growth are negative and statistically significant at the $p < .05$ level for a two-tailed hypothesis test in every model of Table 3.

There are non-significant findings at the $p < .05$ level for a two-tailed test. First, we do not find that the other political factors – international non-governmental organizations – are related to forest loss. The coefficients for this variable do not reach a level of significance in Table 3.[2] Second, we do not find that our other economic factor – gross domestic product – predicts significant variation in forest loss. Third, we find no evidence that our demographic measures – the total population growth, rural population growth, or urban population growth – are related to forest loss. In Table 3, the coefficients for these independent variables do not reach a level of statistical significance at the $p < .05$ level for a two-tailed test.

Discussion and conclusion

We move the cross-national research frontier on forest loss forward in a novel way. We began by considering how the average of Freedom House's (2003) political rights and civil liberties measures impact forests. This tends to be used by cross-national researchers as an overall measure of democracy in a low- or middle-income nation. It does not explain any significant variation in forest loss.

We went on to demonstrate the utility of considering how democratic accountability is related to forest loss in low- and middle-income nations. Toward this end, we found that higher levels of horizontal and diagonal accountability are related to less forest loss in low- and middle-income nations. In Table 3, the coefficients for horizontal and diagonal accountability are negative and statistically significant in Table 3. We do not find that vertical accountability predicts significant variation in forest loss. The coefficients for vertical accountability do not reach a level of statistical significance.

Why may this be the case? We propose that vertical accountability is not related to forest loss because of competing interests regarding natural resource management (Orach, Duit, and Schlüter 2020). During an election, a candidate may be subject to competing demands regarding the use of forests. On the one hand, the candidate may experience pressure from loggers, ranchers, and farmers to promote industrialization by maximizing economic growth and limiting unemployment. On the other hand, an elected official may be pressured by concerned citizens, social movements, and non-governmental organizations concerned with protecting forests (Marquart-Pyatt 2007). In the end, an elected official may make decisions that promote forest loss in some instances while also implementing regulations related to conservation. Ehrhardt-Martinez, Crenshaw, and Jenkins (2002) argue that this situation is reinforced by 'divided' governments in democratic nations among political branches.

Petach (2023) describes how this process played out in Washington, California, and Oregon in the 1990s. During the Clinton Administration, Vice President Al Gore handled most environmental matters. Environmentalists were a key constituency in helping Clinton get elected. Shortly after taking office, however, issues emerged around listing the spotted owl as threatened under the United States Endangered Species Act. This was because forestry is an essential aspect of local economies in the states where the owls live (Petach 2023). If the owl was listed as threatened, then it was argued that old-growth forests would be off limits to logging and unemployment would increase in the region (Didia 1997).

Thus, conflict erupted between loggers, who were desperate to keep their jobs, and environmentalists, who wanted to protect the owl (Loomis 2021). There were bumper stickers supporting loggers that read, 'Kill a Spotted Owl and Save a Logger' and 'I Like Spotted Owls – Fried' (Gutiérrez 2020). The environmentalists hung plastic spotted owls in effigy at sawmills across the region (Didia 1997).

In the end, the conflict grew so intense that President Clinton visited the area at the behest of Vice President Gore. Clinton helped to devise a compromise between the loggers and environmentalists (Loomis 2021). The spotted owl would be listed as threatened under the United States Endangered Species Act, and logging would be allowed to continue under a harvesting quota system (Didia 1997). In the end, President Clinton balanced the demands of loggers and environmentalists in an effort to keep the dual campaign promises like listing the spotted owl as an endangered while promoting economic growth by not putting into place stringent logging restrictions that would lead to unemployment (Carroll 2019).

There are theoretical implications that follow from the findings related to horizontal and diagonal accountability. They lend support for Ostrom's (2010) polycentric governance arguments pertaining to how actors at different scales work individually and together to promote conservation. At the national level, it may include the legislature holding public hearings concerning actions taken by the executive branch. Administratively, it could include an inspector general carrying out an investigation or audit of public sector employees, or appointed officials leading a government agency to address corruption. Concerning forests, a hearing or investigation may be carried out concerning the process for distributing forest concessions, and issues related to monitoring illegal logging or permitting, among others.

At the sub-national level, citizens, social movements, and non-governmental organizations may exercise freedoms of press, speech, and assembly to voice their concerns and frustrations with government officials and companies. This may include collective action such as protests, consumer boycotts, or monitoring. Regarding forests, it may entail organizing logging blockages or exposing illegal logging via the media. Further, social movements and non-governmental organizations may deliver services in the absence of governmental involvement, like tree replanting or agroforestry projects.

Ideally, any efforts to address forest loss by different actors will reinforce one another. For example, investigative journalism may lead to a legislative oversight hearing to deal with corruption in the forestry sector. An inspector general's report may lead a non-governmental organization to organize a consumer boycott against a company engaged in illegal logging. Regardless of how this process plays out, Annis (1987) argues a 'virtuous circle' emerges that strengthens the ability of citizens and the legislative and judicial branches to address forest loss.

We also note two methodological implications of our study. First, we use newly available data on democratic accountability from the Varieties of Democracy (2023) database to add to our understanding of forest loss. For the first time, these data allow scholars to look at specific aspects of democracy and offer potential mechanisms that may help decrease forest loss. Second, we follow Restivo, Shandra, and Sommer's (2018) and Hermanrud and Soysa's (2016) recommendations regarding the need to use an appropriate statistical method that accounts for potential problems with endogeneity in cross-national research. A failure to account for endogeneity in this analysis would have produced biased regression coefficients and inefficient tests of statistical significance (Wooldridge Jeffery 2015). By using a two-stage instrumental variable regression model, we have greater confidence that the empirical findings are not the result of faulty inference due to the endogeneity of the vertical, horizontal, and diagonal accountability variables.

We offer the following policy recommendations, which are related to the theoretical implications that we discuss. There needs to be an emphasis on enhancing horizontal and diagonal accountability in low- and middle-income nations. To ensure horizontal accountability, low- and middle-income nations need to create government oversight agencies and ensure their independence from political interference (Mejia 2022). To ensure diagonal accountability, low- and middle-income nations should protect and expand freedoms of speech, assembly, and press for all their citizens while also creating legal frameworks that legitimize the formation and participation of citizens, social movements, and non-governmental organizations in the planning, implementation, and review of development projects in forests and forestry management plans (Mejia 2022). We are not naïve to think that a government may put such policy reforms into place on their own accord due to fiscal constraints or a lack of political will.

If low- and middle-income nations are reluctant to do so, however, then social movements and non-governmental organizations should press for such changes through various protest tactics, including using the media to reach the widest possible audience (Tasmim et al. 2020). This collective action should also ensure property rights to forests are clearly defined and equitably enforced by the government (Cai et al. 2022). When property rights are not clearly defined or not being equitably enforced, then social movements and non-governmental organizations should call for legislative hearings and support court challenges (Cai et al. 2022).

Let's consider an example from Brazil to illustrate how this may play out. In 1986, Brazil passed a law that required environmental impact assessments to be conducted for development projects which included that assessments must be written in publicly understandable languages and that public hearings be held to review the results (Rich 1994). In the first few years after the law passed, the Brazilian government ignored it and approved several projects that increased forest loss in the county (Rich 1994).

On 11 May 1990, however, more than 400 people gathered in the city of Acre. This was the first time a public hearing was held in the Amazon regarding a project that would produce a substantial amount of forest loss. A group of cattle ranchers had applied for a license to convert 14,300 acres of forest to pasture. The National Council of Rubber Tappers, with the help of scientists and non-governmental organizations, prepared a detailed rebuttal of the environmental impact assessment presented by the cattle ranchers (Rich 1994). While the ranchers argued that the pasture expansion would increase economic growth in Acre and allow the government to invest in conservation, the citizens countered that the project would lead to a forest loss and undermine the livelihoods of the local population, including the rubber tappers and other indigenous populations (Rich 1994). The report also noted the need for improved enforcement of property rights in the region. After a few days, Brazil's environmental protection agency ruled against the cattle ranching proposal (Rich 1994).

There is a limitation of our study that should be mentioned and directions for future research that follow from it. We are limited to cross-sectional data because the amount of forest area – the denominator of the forest loss ratio – is only available for 2000 (Rudel 2017). When panel data derived from the satellite imagery become available, however, sociologists should re-evaluate the relationship between democratic accountability and forest loss by integrating country-level and period-specific fixed effects to account for invariant characteristics of nations (i.e. topography) and time (i.e. recessions) that may affect forest loss (Wooldridge Jeffery 2015). This would allow for a more stringent test of how various aspects of accountability are related to forests.

Notes

1. It is important to note that our discussion of vertical, horizontal, and diagonal accountability is similar to Ostrom's (2010) theory of polycentric governance, which stresses multiple centers of decision-making that are semi-autonomous but overlap across because they are nested at multiple jurisdictional levels (e.g. local, state, and national).

2. The failure of the international non-governmental organization variable is surprising to us. However, it corresponds with previous cross-national research. Shandra (2007) initially finds that international non-governmental organizations have no impact on forest loss. However, the author finds support for an interaction effect with democratic nations providing

a 'political opportunity structure' that enhances the ability of international non-governmental organizations to decrease forest loss. We consider if this may be the case here by including an interaction term between international non-governmental organizations and diagonal accountability. However, the coefficient for the interaction term does not reach a level of statistical significance.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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