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Green Parties and the Quest for Biodiversity: The Political Economy of Fiscal Commitments in OECD Economies

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Abstract
This study focuses on green parties in government and analyzes the political economy of public spending for biodiversity and landscape protection, comparing it with other environmental and non-environmental spending categories. Using panel data covering 26 OECD economies during the sample period from 1995 to 2021, we employ an error-correction approach that effectively accounts for both the presence of stochastic trends in the data and the structure of public budgets. Our findings highlight significant differences in the political economy of biodiversity and landscape protection spending compared with other environmental expenditures. Firstly, while governments under the participation of green parties generally allocate more funds to other environmental issues, the same does not hold true for biodiversity. Secondly, growth rates of other environmental expenditures increase considerably during election periods, whereas expenditures dedicated to biodiversity and landscape protection tend to shrink. Thirdly, environmental expenditures are more procyclical in comparison with public spending for non-environmental purposes, where, however, under green parties in government the cyclicality of biodiversity and landscape protection expenditure is mitigated during periods of fiscal adjustments. These results underscore the importance of establishing enhanced and counter-cyclical funding mechanisms, bolstered by support from supranational organizations, to ensure continuous and effective preservation of biodiversity.

Keywords Biodiversity and landscape protection · Green parties in government · Public expenditure · Environmental expenditure · Error-correction model

JEL Classification H11 · Q57 · Q58

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1 Introduction

The loss of biodiversity has been internationally recognized as a common concern of humankind in 1992 when the United Nations Convention on Biological Diversity was signed (United Nations 1992). The magnitude of this problem can be seen from the Global Living Planet Index (LPI) that reports a reduction by almost 70% in population size of mammals, birds, amphibians, reptiles and fish between 1970 and 2016 (Haddaway and Leclére 2020). The continued loss of biodiversity is not only an environmental issue but a threat to the achievement of most of the UN Sustainable Development Goals such as, for instance, poverty and inequality alleviation, or food, water and energy security (Haddaway and Leclére 2020).

In this context, the provision of new and sufficient financial resources by national governments to halt and reverse the trend towards biodiversity loss has been a primary concern since the outset of the United Nations Convention on Biological Diversity (see Article 20, United Nations 1992).[1] Green parties are poised to play a pivotal role in this endeavor for two compelling reasons. Firstly, leveraging the mainstream parties' shift towards centrist ideologies, green parties emerged in the early 1980s as frontrunners deeply committed to addressing environmental and ecological challenges. Consequently, their party manifestos consistently underscore environmental protection as integral to sustainable development, encompassing the well-being of both humanity and the ecosystem. Secondly, over recent decades, green parties have witnessed a surge in electoral success, transitioning from opposition factions to integral components of government coalitions. Thus, the objective of this study is to scrutinize the extent to which green parties' participation in government influences expenditure on biodiversity, and whether this spending pattern diverges from that on other environmental concerns.

Our analysis is conducted using panel data from 26 OECD economies, covering the period from 1995 to 2021. It addresses two methodological challenges. Firstly, in order to investigate the influence of government parties on public expenditure and its spending categories, it is crucial to distinguish between the determinants affecting long-run equilibrium outcomes (e.g., stochastic trends and co-trending macroeconomic and demographic variables) and those influencing short-run dynamics, which include political variables. Secondly, due to top-down and bottom-up budgeting procedures used by the countries in our sample to allocate financial resources to specific budget categories (e.g., Ljungman 2009), expenditures on biodiversity protection are not independent from expenditures on other environmental issues or from other public expenditures. To tackle both challenges, we consider a cointegration and error-correction model (ECM) framework in the sense of Engle and Granger (1987) that takes account of a hierarchy of public spending patterns. When appropriate, we refer to this approach as *hierarchical* ECM, since it enables us to identify country-specific long-run equilibrium relationships for each spending category. Subsequently, its implementation unravels how changes in public, environmental, and biodiversity spending respond to deviations from a set of equilibrium spending levels and the involvement of green parties in government or electoral cycles. To the best of our knowledge, such a hierarchical ECM model has not yet been applied to analyze the dynamics of public spending categories, making it a further contribution to the existing literature.

[1] For instance, more than 75% of the average annual spending on global biodiversity and landscape protection over the period 2015–2017, which is estimated at \$78-91 billion, corresponds to domestic public expenditures (Perry and Karousakis 2020).

Our findings highlight significant differences in the political economy of biodiversity and landscape protection spending when compared with other environmental or public expenditures. Firstly, while governments involving green parties tend to allocate increased funds towards other environmental issues, the same is not observed for biodiversity and landscape protection. Secondly, a similar pattern emerges concerning electoral cycles, where biodiversity and landscape protection funds decrease during election periods, while other environmental expenditures experience notable increments. Thirdly, environmental expenditures are more procyclical in comparison with public spending for non-environmental purposes, where, however, under green parties in government the cyclicality of biodiversity and landscape protection expenditure is mitigated during periods of fiscal adjustments. The examination of robustness exercises and effect channels demonstrates that these findings remain unaffected by alternative criteria for data trimming, the inclusion of climate-related natural disasters, the strength of parliamentary representation by green parties, the ideological stance of coalition partners, the incorporation of major crisis events (such as the great financial crisis or the Corona pandemic), or the subsampling of countries based on the percentage of threatened species. However, it is important to note that, since green parties are more likely to enter governments in richer economies, the core insights primarily derive from evidence in the context of wealthier OECD economies.

Our study intersects with two bodies of literature. Firstly, it aligns with the research exploring the influence of political parties on environmental outcomes. Initially, this strand of literature concentrated on categorizing political parties along the left-wing and right-wing spectrum to analyze their impact on environmental policies. Left-wing parties were traditionally regarded as more inclined to adopt pro-environmental stances compared with their right-wing counterparts (Neumayer 2004). This stems from the notion that the constituents of left-wing parties, particularly the working class, are disproportionately affected by environmental degradation and its associated costs. Conversely, right-wing parties, supported by affluent individuals and entrepreneurs, often exhibit less enthusiasm towards implementing stringent environmental protection measures due to concerns regarding potential impacts on economic growth and the financial burdens imposed on their supporters. Indeed, evidence of party ideology shaping environmental policies is abundant across various domains, including air pollution (King and Borchardt 1994; Neumayer 2003), energy regulation (Chang and Berdiev 2011), CO2 emissions (Garmann 2014), overall environmental performance (Wen et al. 2016), and renewable energy policies (Cadoret and Padovano 2016). Recent contributions to this literature have directly examined the policy impact of green parties. For instance, Folke (2014) employed a regression discontinuity design to assess the influence of minor parties on environmental and immigration issues in Swedish municipalities. The study reveals that the party perceived as the most environmentally conscious by voters, despite its limited representation, exerted the greatest influence on environmental policy outcomes (e.g., wastewater treatment, waste collection, zoning, building permits). Similarly, Potrafke and Wüthrich (2020) leveraged the unexpected change in government following the Fukushima nuclear disaster in Japan to investigate the impact of green governance on environmental policy outcomes using the synthetic control method. Their findings indicate that while green governments had negligible effects on CO2 emissions and overall renewable energy usage, the proportion of wind power utilization even experienced a decline. In addition to examining a distinct policy domain such as biodiversity, our study contributes to this literature by elucidating the role of macroeconomic and budgetary considerations in evaluating the influence of green parties.

The second area of literature relevant to this study concerns the influence of party ideology on government expenditure across the economic cycle and during fiscal adjustments.

Recent research underscores that the distribution of public funds across specific spending categories by governing parties fluctuates between periods of fiscal consolidation and 'normal' economic conditions, contingent upon their ideological orientation (Herwartz and Theilen 2021). In 'normal' times, right-wing cabinets often prioritize defense spending, whereas their left-wing counterparts prioritize allocations towards education and environmental protection. Likewise, Abbott and Jones (2023) show that government environmental protection expenditures in OECD economies are procyclical, driven by political pressures. Economic upswings typically prompt an expansion of such expenditures, while recessions shift priorities towards other fiscal concerns, resulting in their reduction. In the case of expenditures for biodiversity and landscape protection, it is also widely recognized that these follow different spatial and temporal patterns, with economic crises having a notable impact. For instance, among the five regions distinguished by the Global LPI, Europe and Central Asia experienced the lowest loss in biodiversity (24%) over the period 1970–2016. However, this loss was predominantly concentrated in the period after the financial crisis in 2008 (see Figure 5, Haddaway and Leclére 2020). Our analysis contributes to the literature by considering these spatial and temporal patterns when evaluating the impact of green parties in government on biodiversity protection spending.

The remainder of this paper is organized as follows. Section 2 provides details on data sources, variable definitions and descriptive statistics. The empirical approach is developed in Sect. 3. The empirical results are reported and discussed in Sect. 4. Finally, Sect. 5 concludes and offers the policy implications of our study. In the Appendix we collect panel unit root tests and further materials on cross-sectional correlation in panel data and the significance of the suggested error-correction patterns.

2 Data, Variables and Descriptive Statistics

2.1 Data and Variables

The data set covers the period from 1995 until 2021 and 26 OECD economies: Austria, Australia, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, and the United Kingdom.[2]

2.1.1 Dependent Variables

Our dependent variables are: *(i)* general government expenditures except for environmental protection (*pub*), *(ii)* general government expenditures on environmental protection except on the protection of biodiversity and landscape (*env*), and *(iii)* general government expenditures on the protection of biodiversity and landscape (*bio*). By construction, the sum of *pub*, *env* and *bio* equals total general government expenditures. We use three additional variables for which these expenditure categories are calculated on the basis of expenditures by the central government instead of general government spending. Accordingly, these dependent variables are named as $pub^{(c)}$, $env^{(c)}$, and $bio^{(c)}$. Public spending is measured in US Dollar and US purchasing power parity implied prices. The base year is 2010. Throughout, the dependent variables enter our panel models in the form of (stationary)

[2] Due to country-specific missing values, the panel is unbalanced. For more details, see Tables 1 and 2.

Table 1 Data definitions and sources

Variable	Definition	Measurement and source
Δpub	Growth of general government spending (except environmental protection spending)	Log differences of spending in t and $t-1$ in US Dollar and US purchasing power parity implied prices with 2010 as the base year. Data from OECD (2023c)
Δenv	Growth of general government environmental protection spending (except biodiversity spending)	As for Δpub
Δbio	Growth of general government environmental spending on biodiversity and landscape protection	As for Δpub
$\Delta pub^{(c)}$	Growth of central government public spending (except *env*)	As for Δpub
$\Delta env^{(c)}$	Growth of central government environmental protection spending (except *bio*)	As for Δpub
$\Delta bio^{(c)}$	Growth of central government environmental spending on biodiversity and landscape protection	As for Δpub
gdp, Δgdp, gdp_{pc}	GPD, GDP growth, and per capita GDP	In US Dollar and US purchasing power parity implied prices (gdp and Δgdp in logarithms). Base year 2010. Data from OECD (2023b)
gap	Output gap	Percentage of potential GDP. Data from OECD (2023a)
capb	Cyclically adjusted primary balance	Percentage of potential GDP. Data from OECD (2023a)
debt	Gross debt of general government	Percentage of GDP in logarithms. Data from OECD (2023b)
dr	Dependency ratio	Ratio of population: under 15 & over 65 to 15-64. Data from OECD (2023d)
ue	Unemployment rate	Percentage of labour force. Data from OECD (2023b)
green	Dummy indicating that a green party forms part of the government coalition	One in periods with the participation of a green party, otherwise zero. Data from Döring et al. (2023)
election	Election date	Measured as in Franzese (2000)
damage	Per capita total damage from natural disasters	In thousands of US Dollar and US purchasing power parity implied prices. Base year 2015. Data from EM-DAT (2024)

For descriptive statistics see Table 2

Table 2 Descriptive statistics

		Mean	Sd	Min	Max		Mean	Sd	Min	Max
ov	Δbio	0.038	0.303	−3.111	2.730	$\Delta bio^{(c)}$	0.025	0.407	−3.986	2.730
be			0.046	−0.036	0.143			0.056	−0.113	0.122
wi			0.300	−3.148	2.693			0.403	−3.941	2.680
ov	Δenv	0.028	0.189	−2.122	1.339	$\Delta env^{(c)}$	0.044	0.288	−1.624	1.998
be			0.028	−0.025	0.113			0.037	−0.025	0.118
wi			0.187	−2.170	1.254			0.286	−1.692	2.011
ov	Δpub	0.023	0.053	−0.310	0.399	$\Delta pub^{(c)}$	0.023	0.067	−0.323	0.447
be			0.011	0.007	0.044			0.012	0.002	0.049
wi			0.052	−0.325	0.379			0.069	−0.335	0.436
ov	*green*	0.157	0.364	0	1	*election*	0.265	0.309		0
be			0.218	0	0.741			0.031	0.185	0.318
wi			0.295	−0.583	1.046			0.308	−0.053	0.969
ov	*capb*	−0.005	0.031	−0.247	0.152	*gap*	−0.005	0.033	−0.137	0.169
be			0.016	−0.049	0.021			0.007	−0.023	0.011
wi			0.026	−0.240	0.131			0.033	−0.125	0.159
ov	*ue*	0.078	0.042	0.018	0.275	*dr*	0.508	0.046	0.402	0.695
be			0.032	0.037	0.166			0.031	0.451	0.564
wi			0.028	−0.006	0.206			0.034	0.388	0.644
ov	*debt**	72.51	43.86	6.65	257.02	Δgdp	0.023	0.035	−0.161	0.218
be			38.36	11.72	185.92			0.012	0.004	0.057
wi			21.57	−20.27	165.60			0.033	−0.178	0.184
ov	*damage*	0.031	0.117	0	2.163	*gdp_pc*	39.93	17.14	9.002	114.8
be			0.043	0	0.202			16.39	19.82	101.6
wi			0.109	−0.172	1.991			5.917	14.40	82.14

Mean, standard deviation (sd), minimum (min), maximum (max) and observations (ob) for three data dimensions, i.e., 'ov' (overall) 'be' (between) and 'wi' (within). We do not document descriptive statistics for log public spending data and log GDP, as these lack an intutive interpretation. *Regarding *debt* we show descriptive statistics for shares of GDP (in percent) although this variable enters equations (1) to (3) in natural logarithms

growth rates, i.e., first differences of log expenditure data denoted as Δpub, Δenv, Δbio, $\Delta pub^{(c)}$, $\Delta env^{(c)}$, and $\Delta bio^{(c)}$.

The comparison of different expenditure categories that sum up to total government spending allows to test whether green parties in government, electoral cycles and macroeconomic stances of the business and budget cycle impact differently on biodiversity and landscape protection as compared with other environmental and governmental goals. Considering both general government expenditure and spending by the central government allows us to obtain a broader view of the interplay between parties in government and public spending, which is particularly relevant for decentralized economies. While it could be argued that the influence of parties in government is more promptly evident on the expenditures of the central government that are directly under their control, it also holds that even in fiscally decentralized economies the central government exerts substantial influence on the budget of sub-national layers. This is because these depend to a large degree on transfers from the central government, and transfers are often earmarked or co-financed.[3] Therefore, considering both general and central government expenditures allows to obtain a broader perspective on the quest of green parties in government on biodiversity and landscape protection expenditure.

The data for these variables comes from the *Classification of Functions of Government* (COFOG) database developed by the OECD.[4] As regards to the variables *bio* and $bio^{(c)}$, the data only includes expenditures whose declared primary objective is the protection of biodiversity and landscape. For example, expenditure on the protection of biodiversity and landscape encompasses all direct spending on activities and initiatives aimed at safeguarding and maintaining biological diversity, natural ecosystems, and landscapes, including: *i)* Funding for national parks, wildlife reserves, and other protected areas; *ii)* Conservation programs designed to preserve endangered species, safeguard critical habitats, and enhance biodiversity; *iii)* Investments in planning and executing strategies that encourage sustainable land use, thereby minimizing adverse effects on biodiversity; *iv)* Funding for projects aimed at restoring degraded ecosystems, reforesting areas, and rehabilitating habitats to bolster biodiversity support. Other expenditures that have an indirect effect on these objectives are not considered. While both direct and indirect expenditures are considered in the Convention on Biological Diversity Financial Reporting Framework (CBD-FRF) and the United Nations Biodiversity Finance Initiative Biodiversity Expenditure Reviews (BIOFIN-BER), the data in both cases is only available for recent periods and not straightforwardly comparable across countries (Perry and Karousakis 2020). Using the COFOG data therefore allows to obtain an internationally comparable standard for expenditures on the protection of biodiversity and landscape to assess to which extent variations in expenditures can be explained by green party participation in government, electoral cycles and macroeconomic stances.

2.1.2 Explanatory Variables

The participation of green parties in government (*green*) is measured as a dummy variable that takes value one for those years in which green or ecological parties have formed part of the government coalition.

An important confounding factor in the assessment of the impact of government ideology on public spending is the timing of elections. For example, before elections, we observe shifts from capital spending towards current spending (Katsimi and Sarantides 2012) or an increase in social expenditures (Herwartz and Theilen 2014b). To control for this, we define the variable *elec* as follows (see, Franzese (2000)): *(i)* in election years $elec_{it} = (M - 1 + d/D)/12$ with M, d and D denoting the election month, the election day, and the number of days in the month of an election, respectively; *(ii)* in years before elections $elec_{it} = 1 - (M - 1 + d/D)/12$; and *(iii)* in all remaining years $elec_{it} = 0$.

[3] In the OECD, on average, 56% of sub-national government expenditures are financed through transfers from the central government and 44% are financed through own tax revenues (OECD 2018).

[4] For some countries the sample period starts after 1995, namely: in 1998 (Australia), in 1999 (Germany), in 2000 (Belgium, Finland, Italy and Sweden), and in 2005 (Japan). For central government expenditures on biodiversity and landscape protection, no data is available for Austria, Germany, Greece and Japan. Hence, the number of clusters shrinks from 26 to 22 in the analysis of $\Delta pub^{(c)}$, $\Delta env^{(c)}$, and $\Delta bio^{(c)}$. The average share of central government spending over general government expenditures on biodiversity and landscape protection is: 100% (Finland, Hungry, Iceland, Ireland, Luxembourg, Norway, Slovenia, Sweden, the UK), 15.4% (Australia), 10.4% (Belgium), 44.7% (Czech Republic), 44.5% (Denmark), 52,5% (Estonia), 32.1% (France), 28.7% (Italy), 82,7% (Latvia), 74,4% (Lithuania), 64.8% (Netherlands), 91.6% (Poland), 10.9% (Portugal) and 34.8% (Spain).

In order to isolate the quest of green parties in government on biodiversity and landscape protection expenditures, it is important to control for the macroeconomic state. On the one hand, it is crucial to consider fiscal spending shocks. Indications of fiscal stress have been identified by means of the cyclically adjusted primary balance (CAPB) approach (see e.g., Mulas-Granados 2003). The cyclically adjusted primary balance (*capb*) is the structural government balance after adjustments for fluctuations in the business cycle. Positive (negative) values of *capb* indicate a structural surplus (deficit) in the fiscal balance. As such, the cyclically adjusted primary balance only includes fiscal adjustments with the objective to reduce budget deficits and policy measures that seek to curb economic expansion (i.e., provide economic stimulus) through budget execution. On the other hand, the state of the business cycle is likely to affect public spending patterns. As it is common in the literature, we measure the state of the business cycle by means of the output gap (*gap*), i.e., the difference between the actual aggregate output of an economy and its potential output.

Taking into account that the levels of public spending are influenced in the long-run by macroeconomic and demographic trends, we incorporate additional explanatory variables in our analysis. These variables include GDP (*gdp*), measured in logarithms of values in US Dollars and US purchasing power parity implied prices with base year 2010; general government gross debt (*debt*); the unemployment rate (*ue*); and the dependency ratio (*dr*), indicating the proportion of the population aged under 15 and over 65 relative to the population aged between 15 and 64. All details on the definition, measurement and data sources are documented in Table 1.

2.2 Descriptive Statistics

Regarding the levels of our dependent variables, Table 2 indicates that the average share of environmental expenditure in general public expenditures is 1.6% and varies between 0.5% (Finland) and 3.4% (the Netherlands). The average share of expenditure on biodiversity and landscape protection within environmental expenditures is 12.3%, ranging from 0.1% (Greece) to 33.1% (Denmark). Analyzing the unconditional growth rates of expenditures on biodiversity and landscape protection, we find it to be 3.9% concerning general public expenditures (Δbio) and 2.7% concerning central government expenditures ($\Delta bio^{(c)}$). These growth rates surpass those of public expenditures unrelated to environmental affairs, which are 2.3% and 2.4% for general (Δpub) and central public spending ($\Delta pub^{(c)}$), respectively. Moreover, the average growth rates of expenditures on biodiversity and landscape protection exceed the average growth rate of GDP, which is 2.3%. These facts suggest that financing the protection of biodiversity and landscape has been a significant objective in OECD countries between 1995 and 2021. In addition to biodiversity-related spending, the growth rates of environmental expenditures (excluding biodiversity) also exceed the average growth rates of GDP and public expenditures, and amount to 4.3% ($\Delta env^{(c)}$) and 2.7% (Δenv).

The average participation of green parties in government coalitions of 15.7% is subject to marked cross-sectional and time heterogeneities. With respect to the 26 sampled economies, green parties have never been part of the government coalition for 14 economies, while these parties have most frequently participated in government coalitions in Latvia (in 74.1% of all annual observations), Finland (70.4%) and Iceland (45.8%). Moreover, the participation of green parties in government has been, on average, weaker in the first part of the sample (1995–2006, 12.8% of respective observations) in comparison with the second half (2007–2021, 17.9%). Notably, green parties have been in government with a leading left-wing party 30 times, which is nearly as frequent as their partnerships with a leading right-wing party, occurring 36 times. Finally, the average electoral cycle is slightly below 4 years.

Overall it is worth observing that almost all variables show sizeable between variation, while the within variation accounts throughout for the largest fraction of the overall data variation. This variation is particularly important for the growth rates of all considered categories of public spending, hence, motivating the inclusion of country fixed effects in an analysis of the determinants behind adjustments patterns of (categorical) public expenditures. Table 2 provides further details on the descriptive statistics of the remaining variables employed in this study.

3 The Empirical Model

This section introduces our empirical model which requires the discussion of important time series characteristics, for instance, the presence of stochastic (unit root diagnosis) and eventually common trends (cointegration). While we consider an ECM as a reasonable econometric approach, this section also discusses relevant endogeneity issues. Preliminary ECM results lay the ground for the main empirical analysis documented in Sect. 4.

3.1 Unit Roots, Sequential Budgeting and Cointegration

The investigation of multi-country patterns of governmental expenditures for biodiversity and landscape protection faces, in particular, two econometric or measurement issues. On the one hand, time series of public expenditures are subject to stochastic trends and (most likely) also to co-trending (so-called cointegration, Engle and Granger 1987) with persistent macroeconomic or demographic variables (see, e.g., Herwartz and Theilen 2014a, b). For space considerations we do not provide detailed results for integration and co-integration tests with country-specific resolution. Unreported unit root diagnostics indicate that almost all (log) time series considered in this work can be regarded as integrated of order one, i.e., stationary after taking first differences. To mention a particular example, consider the (log) of general government expenditures for biodiversity and landscape protection. From the 26 country-specific ADF statistics (including a trend) 3 indicate a violation of the null hypothesis of non-stationarity with 5% significance. Switching to the first differences of these expenditures (including a constant only) yields 17 significant test statistics. For further evidence on panel unit root statistics we refer the reader to Appendix 1.

On the other hand, from the perspective of sequential public budgeting, expenditures for biodiversity and landscape protection are part of environmental expenditures, which, in turn, fall under the category of overall public spending. To adhere to this heterogeneous levels of budgeting in our empirical models, we consider three expenditure categories (and their growth rates), namely: (i) government spending for all purposes other than environmental issues (*pub*); (ii) environmental expenditures other than for biodiversity and landscape protection (*env*); and (iii) expenditures for biodiversity and landscape protection (*bio*). In a cointegration framework, these categories are expected to evolve with similar patterns of persistence. In other words, it is unlikely that these categorical expenditures will move arbitrarily far apart from each other. Therefore, within our information set comprising macroeconomic and demographic variables, along with public expenditures, we anticipate the presence of multiple long-run relations, making it necessary to identify the cointegrating relations.

To identify the cointegration space, we first hypothesize the existence of a stable long-run link among public expenditures (pub, $pub^{(c)}$) and macroeconomic and demographic variables (gdp, ue, $debt$, dr). This choice of long-run determinants of public spending follows the related literature (e.g., Herwartz and Theilen 2014a, b) and reflects the main potential determinants of pub or $pub^{(c)}$. Secondly, we assume the existence of a long-run relationship between environmental expenditures (env and $env^{(c)}$) and public expenditures (pub and $pub^{(c)}$). Thirdly, we posit a stable connection between expenditures for biodiversity and landscape protection (bio and $bio^{(c)}$) and environmental expenditures (env and $env^{(c)}$).

To further structure the cointegration model, we assume that adjustments in expenditures for a subcategory might respond to violations of long-run equilibrium relations at the category level. Specifically, adjustments in expenditures for biodiversity and landscape protection might respond to violations of long-run equilibrium relations at the levels of environmental and general government expenditures. Similarly, adjustments in expenditures for environmental protection might respond to violations of the long-run equilibrium relation at the level of total public expenditures. Throughout, we exclude the 'reverse' direction of adjustments of larger expenditure categories to equilibrium violations detected for smaller expenditure categories (for instance, adjustments in total public expenditure Δpub do not respond to violations of the equilibrium level of expenditures for biodiversity and landscape protection). To allow for nonlinear adjustment patterns within the panel ECM framework, we allow expenditure growth rates to respond to lagged squared violations of long-run equilibrium relations. Such a model augmentation is reasonable to represent scenarios where adjustments to large equilibrium errors could be subject to particular stickiness.

Letting i, $i = 1, \dots, N$, and t, $t = 1, \dots, T_i$, indicate a particular country and period, our models for growth rates of the three expenditure categories formally read as

$$\begin{aligned}\Delta pub_{it} = {} & \nu_{i1} + \phi_1 \Delta pub_{it-1} + \alpha_1 \underbrace{\left(pub_{it-1} - \beta_{i1} gdp_{it-1} - \beta_{i2} debt_{it-1} - \beta_{i3} dr_{it-1} - \beta_{i4} ue_{it-1}\right)}_{ec^{(pub)}_{it-1}} \\ & + \delta_1 \left(ec^{(pub)}_{it-1}\right)^2 + \theta_{11}\, green_{it} + \theta_{12}\, green_{it} \times capb_{it-1} + w'_{it-1} \boldsymbol{\gamma}_1 + u^{(1)}_{it}\end{aligned} \tag{1}$$

$$\begin{aligned}\Delta env_{it} = {} & \nu_{i2} + \phi_2 \Delta env_{it-1} + \alpha_2 \underbrace{\left(env_{it-1} - \beta_{i5} pub_{it-1}\right)}_{ec^{(env)}_{it-1}} + \alpha_3 ec^{(pub)}_{it-1} \\ & + \delta_2 \left(ec^{(env)}_{it-1}\right)^2 + \theta_{21}\, green_{it} + \theta_{22}\, green_{it} \times capb_{it-1} + w'_{it-1} \boldsymbol{\gamma}_2 + u^{(2)}_{it}\end{aligned} \tag{2}$$

$$\begin{aligned}\Delta bio_{it} = {} & \nu_{i3} + \phi_3 \Delta bio_{it-1} + \alpha_4 \underbrace{\left(bio_{it-1} - \beta_{i6} env_{it-1}\right)}_{ec^{(bio)}_{it-1}} + \alpha_5 ec^{(env)}_{it-1} + \alpha_6 ec^{(pub)}_{it-1} \\ & + \delta_3 \left(ec^{(bio)}_{it-1}\right)^2 + \theta_{31}\, green_{it} + \theta_{32}\, green_{it} \times capb_{it-1} + w'_{it-1} \boldsymbol{\gamma}_3 + u^{(3)}_{it},\end{aligned} \tag{3}$$

where $w_{it} = (capb_{it}, gap_{it}, election_{it})'$.

To establish that expenditure growth adjusts to lagged equilibrium errors without invoking an overshooting reaction the necessary stability conditions are $-2 < \alpha_1, \alpha_2, \alpha_4 < 0$.

Lagged dependent variables are included to account for transitory dynamics of expenditure growth rates. To immunize the empirical analysis against adverse effects of outlying observations or unreliable quotes of expenditures for biodiversity and landscape protection, we remove all observations for which Δbio (or $\Delta bio^{(c)}$) exceeds unity in absolute value (for a respective histogram, see Figure 1 in the Supplementary material of this article). All panel models include country fixed effects and documented *t*-ratios are robust against heteroskedasticity (i.e., we use Stata options 'FE' and 'robust'). Although we detect some evidence pointing to cross-sectional correlation among model residuals when analysing Δpub and $\Delta pub^{(c)}$ (see Appendix 2 for a detailed discussion of cross-sectional correlation), we do neither provide two-step estimates that are efficient under such a source of correlation nor robust inferential statistics.

3.2 Endogeneity

The empirical models in (1) to (3) build upon the implicit assumption that macroeconomic state variables can be reasonably considered to be predetermined and without effect on the participation of green parties in government. In fact, however, one might argue that the macroeconomic state variables collected in w_{it} could influence election outcomes. For instance, during periods of macroeconomic upswing, green or left-wing parties are more likely to be elected, while in periods of macroeconomic downturn, the election of right-wing parties becomes more probable. Hence, macroeconomic states could confound the quest of green parties in government on biodiversity and landscape protection expenditures. To get a first impression of the extent to which macroeconomic conditions have resulted in the election of green parties in government, we evaluate a stylized probit model for a binary variable which we construct for only those years when an election took place. Since elections are held every four to five years, on average, the definition of this variable comes with a sizeable reduction of sample information such that ultimately 171 observations are available. The binary indicator is zero unless an election gives rise to the participation of green parties in government. We quantify the conditional probability $P\,(green = 1 | elec = 1)$ using a set of lagged indicators of transitory macroeconomic conditions (output gap, cyclically adjusted primary budget balance) and GDP per capita.[5] Results are displayed in leftmost column of Table 3. As it turns out, transitory macroeconomic conditions, i.e., output gaps and cyclically adjusted primary balances, lack explanatory content for the probability to elect green parties in government. However, the probability in question increases with per capita income. This (preliminary) conclusion allows for two important insights. First, in the analysis of the quest of green parties in government on biodiversity and landscape protection expenditures we can interpret estimation results as largely immunized against transitory macroeconomic states. Second, given the persistent profiles of per capita income, the econometric panel data analysis warrants the use of a fixed effect specification.

As a matter of fact, the consideration of lagged explanatory variables in the stylized probit model is eventually not sufficient to guard the analysis against potential endogeneity biases. Potential sources of such biases include unobserved heterogeneities (i.e., the omission of country or time fixed effects) or omitted confounders that impact on

[5] Per capita GDP (*gdp_pc*) is measured in 1000 US Dollar and US purchasing power parity implied prices with the base year 2010.

Table 3 Modelling the participation of green parties in government (after election)

	Probit model		Linear probability model			
gap_{-1}	4.544	6.420	1.022	1.026	1.431	−0.370
	(1.20)	(1.63)	(1.22)	(1.44)	(1.08)	(−0.14)
$capb_{-1}$	2.903	0.835	0.700	−0.280	−0.198	0.737
	(0.91)	(0.25)	(0.80)	(−0.52)	(−0.33)	(0.78)
gdp_{pc}	0.0133	0.0135	0.0040	0.0146	0.0314	0.0042
	(1.95)	(1.81)	(1.85)	(3.31)	(3.60)	(1.93)
$damage_{-1}$		−3.878				
		(−1.30)				
Constant	−1.500	−1.466	0.016	−0.420	−0.662	0.002
	(−4.76)	(−4.03)	(0.18)	(−2.35)	(−2.45)	(0.03)
Country FE	–	-	–	Yes	Yes	–
Time FE	–	–	–	–	Yes	–
Instruments	–	–	–	–	–	Yes
# obs	171	149	171	171	171	171

Alternative models include: Probit models (columns 1 &2), a linear probability model (column 3) and versions thereof augmented with fixed country effects (column 4) and fixed country and time effects (column 5). The rightmost column shows results for a linear probability model estimated with internal heteroskedasticity based instruments for gap_{-1} (Lewbel 2012). t-ratios are in paranthesis (see also footnote 7 for further information)

macroeconomic performance and election outcomes simultaneously. For instance, one could argue that extreme weather events or - even more so - natural disasters may increase the probability of green parties to receive votes, while such events could also be relevant for macroeconomic performance. In these regards, it is worth pointing out that for our sample period insignificance of transitory macroeconomic conditions is maintained for a couple of robustness analysis that we perform in addition to the stylized probit model. These include, a probit model extended with an indicator of per-capita damage resulting from natural disasters (see column 2 of Table 3),[6] a stylized linear probability model (column 3), a linear probability model augmented with fixed country effects (column 4) and country and year effects (column 5). Moreover, the outcomes of the linear probability model are robust when applying an instrumental variable estimator with internal heteroskedasticity-based instruments (Lewbel 2012, see column 6 of Table 3).[7]

[6] For this purpose, we incorporate data from the international disaster database EM-DAT (2024) which covers the period 2000–2021.

[7] Instrumentation as suggested by Lewbel (2012) requires a decision about exogenous information. Results documented in Table 3 obtain when assuming $capb_{-1}$ and per capita GDP as exogenous. Diagnostic tests confirm both, instrument validity (insignificant Hansen-J statistic) and relevance (significant diagnostics against weak and/or underidentification). Using, instead, heteroskedasticity-based instruments for either $capb_{-1}$ or per capita GDP results in qualitatively identical estimation results, and confirm instrument validity. However, the heteroskedasticity-based instruments might be weak in these cases.

3.3 Assessment of the Error-Correction Model

3.3.1 Mean Group Estimation of Long-Run Relations

We estimate the following average relations between categories of general and central government expenditures, i.e., mean group long-run relations (Pesaran and Smith 1995, with *t*-ratios in parentheses):

$$pub = \underset{(1.501)}{3.153} + \underset{(4.972)}{0.726} gdp - \underset{(0.132)}{0.069} dr + \underset{(1.216)}{0.714} ue + \underset{(2.846)}{0.129} debt$$

$$env = \underset{(-1.489)}{-3.769} + \underset{(4.431)}{0.961} pub$$

$$bio = \underset{(-0.828)}{-1.387} + \underset{(4.096)}{0.815} env$$

$$pub^{(c)} = \underset{(1.100)}{2.889} + \underset{(3.777)}{0.704} gdp - \underset{(0.213)}{0.159} dr + \underset{(1.622)}{1.348} ue + \underset{(1.870)}{0.114} debt$$

$$env^{(c)} = \underset{(-1.780)}{-9.199} + \underset{(3.006)}{1.318} pub^{(c)}$$

$$bio^{(c)} = \underset{(3.073)}{2.671} + \underset{(2.038)}{0.313} env^{(c)}$$

Mean group (MG) estimators of country-specific regressions for general government expenditures capture the diverse marginal effects that explain public expenditure levels. As expected, government expenditures (pub and $pub^{(c)}$) demonstrate a strong positive correlation with real GDP and public debt. Instead, the effects of dependency ratios and unemployment rates on government expenditures lack a largely uniform direction across the considered cross section, leading to non-significant MG estimates. Additionally, long-run relationships indicate that non-environmental expenditures are, on average, proportionate to the overall level of government expenditures, while biodiversity and landscape protection expenditures are, on average, proportionate to environmental expenditures excluding those for biodiversity. MG estimates to explain central government spending $bio^{(c)}$ show a weaker responsiveness to $env^{(c)}$.

3.3.2 Error Correction Dynamics

The error correction dynamics documented in Table 4, align consistently with the core intuition of the cointegration and error-correction framework that adjustments in Δbio, Δenv and Δpub respond negatively to lagged equilibrium errors, $ec^{(bio)}$, $ec^{(env)}$ and $ec^{(pub)}$, respectively. Since all parameter estimates are smaller than one in absolute value, it is evident that these responses correct for some fraction of the equilibrium error without invoking an overshooting reaction. As it turns out, some adjustment patterns are subject to significant dampening if they occur in response to relatively large violations of the long run equilibrium (see, e.g., responses of Δpub to $ec^{(pub)}_{it-1}$ and $\left(ec^{(pub)}_{it-1}\right)^2$). Taking notice of sequential budgeting considerations, we observe that adjustments in Δbio do not significantly respond to lagged equilibrium errors $ec^{(env)}$ and $ec^{(pub)}$. Adjustments in $\Delta env^{(c)}$ in response to lagged equilibrium errors $ec^{(pub)}$ are positive with mild significance in the case of central

Table 4 Benchmark regression results

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.017	0.008	0.017	−0.016	0.076**	0.022
	(0.85)	(0.39)	(1.47)	(−0.54)	(2.60)	(1.25)
$capb_{-1}$	0.491	0.831**	0.416***	1.228**	1.165*	0.348*
	(0.93)	(2.11)	(4.37)	(2.42)	(1.83)	(2.02)
$green \times capb_{-1}$	−0.065	0.127	0.279	−1.666**	−0.166	0.390
	(−0.15)	(0.16)	(0.34)	(−2.14)	(−0.15)	(0.38)
gap_{-1}	0.520	0.803***	0.280**	0.978**	0.271	0.286**
	(1.67)	(5.60)	(2.52)	(2.57)	(0.94)	(2.36)
election	−0.059*	0.036**	0.004	−0.007	0.078**	−0.005
	(−2.06)	(2.10)	(0.72)	(−0.14)	(2.42)	(−0.70)
$ec_{-1}^{(bio)}$	−0.203***			−0.167***		
	(−6.74)			(−3.75)		
$ec_{-1}^{(env)}$	−0.043	−0.469***		−0.032	−0.417***	
	(−0.83)	(−4.26)		(−1.02)	(−6.78)	
$ec_{-1}^{(pub)}$	0.019	0.237	−0.267***	0.201	0.456*	−0.447***
	(0.06)	(1.48)	(−3.19)	(0.75)	(1.94)	(−5.38)
Squared $ec_{-1}^{(y)}$	0.024	0.030	−2.607***	−0.035	−0.206**	−1.638
	(0.73)	(0.32)	(−3.16)	(−1.68)	(−2.28)	(−1.22)
Lagged dependent	−0.020	0.109*	0.172***	−0.042	0.118**	0.108
variable (y_{-1})	(−0.56)	(1.99)	(2.96)	(−1.65)	(2.32)	(1.19)
Constant	0.050***	0.029***	0.024***	0.069***	0.033*	0.028***
	(6.73)	(3.29)	(7.58)	(4.08)	(1.85)	(7.04)
# obs	540	539	550	463	458	474
R^2	0.176	0.286	0.301	0.143	0.253	0.233

Robust standard errors clustered by country (*t*-statistics in parentheses). Stars *, ** and *** indicate significance at the 10, 5 and 1 percent level, respectively. The row labeled 'constant' documents an intercept estimate as provided by Stata, and '# obs.' is the number of observations

government expenditures. Apart from providing significant and economically reasonable expenditure adjustments in response to lagged patterns of over- or underspending, the empirical ECMs provide sizeable contributions to the explanation of expenditure growth rates (see also Table 14 in Appendix 3).[8]

[8] As an informal confirmation of cointegration that prevents the non-stationary series to drift to far apart from each other, the bottom panel of Table 13 in Appendix 1 reports panel unit root diagnostics for the extracted error correction patterns, which throughout indicate panel stationarity with conventional significance. Moreover, in stylized regressions of expenditure adjustments on the error correction terms and an autoregressive component (with fixed effects) robust *t*-ratios are −8.06, −4.50, −5.83 for Δbio, Δenv and Δpub, respectively. For central government expenditures, corresponding *t*-ratios are −3.10, −7.53 and −5.83 for $\Delta bio^{(c)}$, $\Delta env^{(c)}$ and $\Delta pub^{(c)}$, respectively. At the level of pooled economies (pooled OLS or fixed effects regressions), the adopted ECM framework points clearly towards strong adjustments of public expenditures towards their presumed long-run equilibrium outcomes.

Table 5 Robustness results (I): Regression results with trimming at the 5th and 95th percentiles of growth rates of spending for biodiversity and environmental protection (i.e. $-0.290 < \Delta bio < 0.399$ & $-0.423 < \Delta bio^{(c)} < 0.536$)

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.018	0.008	0.017	−0.008	0.077**	0.022
	(1.29)	(0.34)	(−0.44)	(2.80)	(1.20)	(1.25)
$capb_{-1}$	0.680**	0.951**	0.465***	1.358**	0.779	0.389**
	(2.06)	(2.09)	(4.20)	(2.59)	(1.27)	(2.24)
$green \times capb_{-1}$	−0.142	0.038	0.354	−1.248*	0.278	0.337
	(−0.33)	(0.04)	(0.41)	(−1.94)	(0.28)	(0.32)
gap_{-1}	0.475**	0.815***	0.266**	0.627	0.499	0.228
	(2.18)	(4.54)	(2.10)	(1.70)	(1.48)	(1.65)
election	−0.014	0.020	−0.003	−0.018	0.065**	−0.009
	(−0.66)	(1.20)	(−0.71)	(−0.52)	(2.33)	(−1.25)
$ec_{-1}^{(bio)}$	−0.127***			−0.081**		
	(−6.34)			(−2.39)		
$ec_{-1}^{(env)}$	0.002	−0.457***		0.000	−0.382***	
	(0.06)	(−4.12)		(0.06)	(−4.12)	
$ec_{-1}^{(pub)}$	0.259	0.485***	−0.269***	0.170	0.555**	−0.447***
	(1.19)	(3.26)	(−2.85)	(1.01)	(2.42)	(−4.70)
Squared $ec_{-1}^{(y)}$	0.011	−0.017	−2.802***	−0.037**	−0.229**	−1.574
	(0.26)	(−0.15)	(−3.58)	(−2.43)	(−2.98)	(−1.15)
Lagged dependent	−0.011	0.057	0.210***	−0.028	0.116*	0.102
variable (y_{-1})	(−0.37)	(0.66)	(3.94)	(−1.25)	(1.92)	(1.09)
Constant	0.040***	0.036***	0.024***	0.063***	0.039***	0.029***
	(4.83)	(3.55)	(6.85)	(4.86)	(2.86)	(6.78)
# obs	495	493	503	429	424	439
R^2	0.099	0.306	0.321	0.082	0.236	0.225

For further notes see Table 4

4 Green Parties and Biodiversity: Results

The estimation results for our benchmark regressions, as specified in equations (1) to (3), are displayed in Table 4. To gauge the robustness of the benchmark results, we test two alternative specifications, and the corresponding outcomes are presented in Tables 5 and 6. Additionally, we analyze several potential effect channels behind our benchmark evidence with results displayed in Tables 7 through 11. Finally, we will delve into the policy implications of the analysis and also address its limitations.

Table 6 Robustness results (II): Regression results including per capita damages from natural disasters

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.011	0.004	0.019	−0.017	0.095***	0.026
	(0.50)	(0.17)	(1.64)	(−0.53)	(2.98)	(1.44)
$capb_{-1}$	0.275	0.904**	0.496***	1.134**	1.383**	0.442**
	(0.52)	(2.23)	(4.63)	(2.08)	(2.15)	(2.39)
$green \times capb_{-1}$	0.096	0.149	0.244	−1.612*	−0.163	0.342
	(0.22)	(0.19)	(0.30)	(−2.00)	(−0.15)	(0.34)
gap_{-1}	0.460	0.753***	0.287**	0.994**	0.354	0.287**
	(1.45)	(5.35)	(2.49)	(2.43)	(1.08)	(2.30)
election	−0.059*	0.036*	0.004	−0.009	0.079**	−0.008
	(−1.94)	(1.98)	(0.65)	(−0.16)	(2.22)	(−0.90)
damage	0.123**	0.067	0.017**	0.356	0.464**	0.029
	(2.49)	(1.65)	(2.21)	(1.56)	(2.10)	(0.75)
$damage_{-1}$	0.014	0.051	0.026	−0.103	0.191	0.071
	(0.38)	(0.98)	(1.67)	(−0.47)	(1.22)	(1.46)
$ec^{(bio)}_{-1}$	−0.212***			−0.171***		
	(−5.89)			(−3.40)		
$ec^{(env)}_{-1}$	−0.020	−0.425***		−0.025	−0.419***	
	(−0.39)	(−4.01)		(−0.68)	(−6.12)	
$ec^{(pub)}_{-1}$	−0.053	0.239	−0.243***	0.233	0.482*	−0.428***
	(−0.16)	(1.42)	(−2.95)	(0.81)	(1.90)	(−5.37)
Squared $ec^{(y)}_{-1}$	0.024	0.082	−2.537***	−0.038*	−0.188*	−1.481
	(0.68)	(1.19)	(−3.17)	(−1.73)	(−1.95)	(−1.07)
Lagged dependent	−0.012	0.121*	0.168**	−0.049*	0.119**	0.090
variable (y_{-1})	(−0.33)	(1.94)	(2.75)	(−2.04)	(2.15)	(0.92)
Constant	0.045***	0.028***	0.024***	0.066***	0.020	0.029***
	(5.50)	(3.08)	(7.23)	(3.44)	(0.93)	(6.02)
# obs	490	489	500	417	412	428
R^2	0.177	0.261	0.311	0.144	0.251	0.245

For further notes see Table 4

4.1 Green Party Influence and Electoral Cycles

Starting with the analysis of direct influences on growth rates of public spending, we find that green parties in government do not strengthen average expenditures for biodiversity and landscape protection (Δbio or $\Delta bio^{(c)}$). While this result also holds for total public expenditures (other than environmental, i.e., Δpub or $\Delta pub^{(c)}$), it is interesting to observe that under green parties growth rates of central government environmental expenditures (excluding biodiversity, i.e., $\Delta env^{(c)}$) are by about 7.6 percentage points higher in comparison with governments without green party participation. This result is well in line with the findings in the literature on public spending (e.g., Cusack 1997;

Table 7 Effect channel results (I): Strong green parties; for further notes see Table 4

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.021	0.025	0.010	−0.023	0.089**	0.012
	(0.84)	(1.26)	(1.21)	(−0.61)	(2.17)	(0.79)
$capb_{-1}$	0.469	0.921**	0.280**	1.068*	1.082	0.184
	(0.93)	(2.74)	(2.14)	(2.00)	(1.65)	(1.44)
$green \times capb_{-1}$	0.013	−0.325	1.116*	−1.401	0.181	1.426**
	(0.03)	(−0.41)	(1.87)	(−1.49)	(0.14)	(2.10)
gap_{-1}	0.533	0.796***	0.274**	0.982**	0.322	0.286**
	(1.70)	(5.16)	(2.33)	(2.49)	(1.09)	(2.37)
election	−0.059**	0.036**	0.004	−0.009	0.077**	−0.005
	(−2.06)	(2.17)	(0.78)	(−0.17)	(2.46)	(−0.65)
$ec_{-1}^{(bio)}$	−0.204***			−0.169***		
	(−6.87)			(−3.81)		
$ec_{-1}^{(env)}$	−0.044	−0.467***		−0.031	−0.418***	
	(−0.85)	(−4.26)		(−1.00)	(−6.85)	
$ec_{-1}^{(pub)}$	0.013	0.246	−0.288***	0.170	0.442*	−0.467***
	(0.04)	(1.53)	(−3.03)	(0.61)	(1.94)	(−4.82)
Squared $ec_{-1}^{(y)}$	0.023	0.023	−3.010**	−0.036	−0.203**	− 2.161
	(0.71)	(0.25)	(−2.43)	(−1.67)	(−2.25)	(−1.34)
Lagged dependent	−0.020	0.107*	0.207**	−0.041	0.116**	0.143
	(−0.56)	(2.02)	(2.52)	(−1.59)	(2.28)	(1.29)
Constant	0.050***	0.028***	0.024***	0.071***	0.034*	0.030***
	(6.89)	(3.42)	(10.80)	(4.18)	(1.94)	(10.40)
# obs	540	539	550	463	458	474
R^2	0.176	0.288	0.331	0.141	0.253	0.260

Herwartz and Theilen 2014b) and on environmental expenditures and regulation (e.g., Cadoret and Padovano 2016; Herwartz and Theilen 2021).

Two remarks are worth making to explain this result. First, it is intuitive to detect that central government expenditures are more sensitive to government composition in comparison with general government expenditures that are in parts under the responsibility of state authorities. Second, while it is unsurprising that green parties assign high political relevance to issues of environmental protection, apparently, specific concerns of biodiversity and landscape protection have not attracted a comparable attention or consensus yet.

In periods of fiscal stress public expenditures are subject to consolidation. Regarding, for instance, a lagged deterioration of the cyclically adjusted primary balance by approximately 3% (equivalent to one standard deviation) our estimates imply that government expenditures (other than environmental, i.e., *pub* and $pub^{(c)}$) shrink by about 1.1% on average. In response to the same change of *capb*, central government expenditures for both remaining categories of environmental spending ($bio^{(c)}$ and $env^{(c)}$) shrink markedly stronger by about 3.5%. Interestingly, periods of fiscal stress are not characterized by significant central government spending cuts for biodiversity and landscape protection issues

($bio^{(c)}$) under green party participation in government. In qualitative terms, the described results also hold for growth rates of general government expenditures for biodiversity and landscape protection. However, in quantitative terms corresponding estimates are subject to larger estimation uncertainty that might again reflect heterogeneous transmissions of fiscal stress towards consolidation measures taken at state level. In summary, we can conclude that environmental expenditures are, on average, more sensitive to fiscal cycles in comparison with public spending for non-environmental purposes. This conclusion, however, deserves reconsideration in the case of green parties in government who can mitigate the (adverse) effects of budget adjustments on expenditures for biodiversity and landscape protection. To explain this result, it is conceivable that green parties in government act as veto players in the sense of Tsebelis (1995) when it comes to adjustments in spending categories that are core to their ideological identity.

Regarding electoral cycles, our findings indicate that total public spending growth does not exhibit a systematic change during election years, aligning well with recent literature findings (e.g., Herwartz and Theilen 2021). However, with a 5% significance level, we observe that general and central government environmental expenditures *env* and $env^{(c)}$ increase by 3.6 and 7.8 percentage points, respectively, during election periods. This suggests that environmental issues such as waste management, wastewater management, and pollution abatement receive higher priority during electoral campaigns. The influence of election periods on environmental policies is also supported by previous research, as demonstrated by List and Sturm (2006) for governor elections in the US and by Pailler (2018) for municipality elections in Brazil. Interestingly, despite the apparent high interest in environmental issues during electoral campaigns, we do not observe a similar prioritization for government expenditures directed towards biodiversity and landscape protection. In fact, for the case of general public expenditures, the growth rates of *bio* exhibit (with weak significance of 10%) a reduction by 5.9 percentage points during election periods.[9] While the cyclicality of environmental spending is certainly not desirable, the presence of a positive electoral spending cycle for environmental issues, excluding biodiversity, and a negative cycle for biodiversity and landscape protection indicates a lack of prioritization for the latter. This discrepancy could be attributed to lower public awareness of biodiversity and landscape protection problems compared with other environmental issues. Therefore, policymakers should raise the awareness about the importance of biodiversity conservation and landscape protection, ensuring that these issues are adequately addressed in policy agendas.

4.2 Cyclicality of Public Spending

The findings of this study reveal that public expenditures are throughout procyclical. Specifically, in response to a 3.3 percentage point increase in the lagged output gap (equivalent to one standard deviation), public expenditures *pub* and $pub^{(c)}$ increase by approximately 1%. This evidence conflicts with the recommendations of the OECD's *Principles of Budgetary Governance*, which advocate for counter-cyclical or cyclically neutral fiscal policies (OECD 2014) and, hence, represents an undesirable outcome from a fiscal policy perspective.

[9] The presence of a negative electoral spending cycle for biodiversity and landscape protection and a positive cycle for other environmental spending issues could potentially explain why Herwartz and Theilen (2021) did not observe any electoral cycles in general government environmental spending, encompassing both spending categories.

Moreover, the examination of environmental spending categories reveals even more pronounced patterns of procyclicality for *env* and $bio^{(c)}$. In response to the same 3.3 percentage point increase or decline in the lagged output gap, these categories demonstrate responses that are three times larger than those observed for total public expenditure, specifically 2.6 and 3.2 percentage points, respectively, with significance levels of 1% and 5%. These heightened levels of procyclicality in environmental spending emphasize the need for urgent adoption of more stable and sustainable fiscal policies, particularly in this domain, to support long-term environmental goals, including biodiversity preservation and landscape protection.

4.3 Robustness Checks

The benchmarking empirical evidence discussed above is obtained after removing rather extremely outlying observations for adjustments of expenditures for biodiversity from the data, namely, increases or reductions by more than 100%. As an alternative to this trimming scheme, one might use quantile-based information about expenditure adjustments for sample selection. In this regard Table 5 displays results for a more selective trimming of sample information focusing on observations between the 5% and 95% quantile of the empirical distribution of growth rates of expenditures for biodiversity and landscape protection. As it turns out, despite the loss of more than 40 observations in the case of general government expenditure and more than 30 observations in the case of central government expenditure, regarding the influence of green parties in government (i.e., the variable *green* and its interaction with $capb_{-1}$), we do not observe any remarkable change in terms of the size or significance of the estimated impacts between Tables 4 and 5. Similarly, the error-correction dynamics remain almost the same as those diagnosed in the benchmark regression. Instead, the alternative trimming indicates that the effect of election periods now appears to be insignificant in the case of Δbio and Δenv, whereas significance is confirmed for $\Delta env^{(c)}$. However, this result might be expected to a certain extent, as the non-consideration of particularly high expenditure increases and reductions due to the mentioned data trimming should disproportionately affect spending changes in election periods, as diagnosed in the benchmark results. As a result, we conclude that our main findings remain robust when considering alternative trimming schemes.

Introducing a second dimension of robustness analysis, we acknowledge that extreme weather events and climate-related natural disasters could potentially influence both the presence of green parties in government and short-term indicators of macroeconomic performance. To explore this possibility, we incorporate data from the international disaster database (EM-DAT 2024). To ascertain whether the benchmark results warrant reassessment following the mitigation of potential omitted variable biases, Table 6 presents regression outcomes after incorporating per capita damage from natural disasters into the model, with and without time lag. A comparison of the results with those of the benchmark regressions reveals that, despite the loss of approximately 50 observations, the parameter estimates in Table 4 remain robust with the inclusion of this variable, ensuring that none of our previous conclusions are altered. Regarding the new variable, it is observed (as expected) that contemporary per capita damages lead to an increase in government spending across all six expenditure categories considered. Notably, in the cases of general government spending on biodiversity, overall expenditures, and central government environmental expenditures, this increase is statistically significant at the 5% level. However, damages from the previous period lack a significant impact on government spending.

In sum, we can conclude that both directions of robustness analysis leave key insights from benchmark regressions intact. As both model variants come with a sizeable loss of sample information, we consider the trimming of extreme expenditure adjustments as suitable for our analysis, and refrain from the augmentation of the sample information with data on per capita damage for the subsequent analysis of potential effect channels.

4.4 Effect Channels

To further explore the mechanisms by which green parties may influence expenditure on biodiversity and landscape protection, we proceed to conduct five additional regressions for each of the three spending categories. As before, this analysis encompasses both general and central government expenditures.

First, we refine the definition of green parties in government by focusing on cases when green parties in government rely on more than 5% of seats in parliament. Hence, in such circumstances the Greens could be considered to be more influential on policy issues that are essential in their party manifestos. The estimation results documented in Table 7 show no remarkable qualitative differences in comparison with the benchmark outcomes of Table 4. This evidence is best understood under consideration of the role of veto players in multiparty systems (Tsebelis 1995). We conclude that, apparently, the bargaining strength of green parties for environmental policies depends in the first place on their necessity for government formation and, less so, on their parliamentary representation.

Second, while benchmark results aim to isolate the marginal contribution of green parties in government to patterns of government expenditure growth, it is important to notice that these growth rates might also reflect the political priorities of their coalition partners. In particular, left-wing parties have been found to be more pro-environmental than their right-wing counterparts (Neumayer 2004). Against this background one might argue that (i) green parties preferably form coalitions with left-wing parties, and (ii) in these coalitions left-wing partners also pursue environmental oriented policies. Putting the first argument into question for the present analysis, we find that green parties formed coalitions with left-wing, centrist and right-wing parties at 30, 14 and 36 sampled instances out of 550 observations, respectively.[10] Regarding the second argument, Table 8 documents regression results for a model specification including indications of left-wing parties being in government. It turns out that the benchmark effects documented above for the role of green parties in government for growth rates of environmental spending remain intact. Therefore, we conclude that the observed influence of green parties on biodiversity and environmental expenditures is not attributable to the ideology of their coalition partner.

Third, we investigate whether the political economy of biodiversity and landscape protection expenditures varies between relatively poor and rich countries.[11] The estimation results for richer and poorer OECD economies are displayed in Tables 9 and 10,

[10] Taking into account the non-linear relationship between government ideology and patterns of government spending (e.g., Herwartz and Theilen 2021), and utilizing data from Döring et al. (2023) that measure the ideology of the leading party in government on a scale from 0 (leftist) to 10 (rightist), we categorize governments as follows: *Left-wing* ([0, 4.5)); *Centrist* ([4.5, 6.5)) and *Right-wing* ([6.5, 10]). This classification considers the clustering observed in our data and ensures an almost equal distribution of observations among left-wing, centrist, and right-wing governments (see Figure 2 in the Supplementary material of this article).

[11] To classify countries into ‘poor’ and ‘rich’, we use the per capita income in 2008 as the criterion. Countries with an income below $39,000 are classified as ‘poor’, namely: Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Poland, Portugal, Slovenia, and Spain.

Table 8 Effect channel results (II): Left-wing parties in government; for further notes see Table 4

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.011	0.009	0.018	−0.028	0.072**	0.022
	(0.49)	(0.42)	(1.60)	(−0.91)	(2.43)	(1.28)
left	0.019	0.002	−0.006	0.042	0.018	−0.004
	(1.10)	(0.17)	(−1.14)	(1.50)	(0.52)	(−0.56)
$capb_{-1}$	0.158	1.112***	0.305**	1.037*	1.312**	0.251
	(0.32)	(3.96)	(2.21)	(1.89)	(2.29)	(1.42)
$green \times capb_{-1}$	−0.204	0.260	0.255	−1.730**	−0.087	0.353
	(−0.37)	(0.29)	(0.33)	(−2.26)	(−0.07)	(0.36)
$left \times capb_{-1}$	1.032*	−0.832	0.291	0.575	−0.453	0.285
	(1.85)	(−1.59)	(0.86)	(0.74)	(−0.45)	(0.78)
gap_{-1}	0.566*	0.758***	0.287**	1.003**	0.235	0.293**
	(1.96)	(5.58)	(2.66)	(2.81)	(0.76)	(2.41)
election	−0.058*	0.034*	0.005	−0.007	0.076**	−0.004
	(−2.01)	(1.97)	(0.89)	(−0.14)	(2.30)	(−0.62)
$ec_{-1}^{(bio)}$	−0.205***			−0.168***		
	(−7.01)			(−3.83)		
$ec_{-1}^{(env)}$	−0.043	−0.466***		−0.032	−0.415***	
	(−0.82)	(−4.23)		(−1.04)	(−6.65)	
$ec_{-1}^{(pub)}$	0.009	0.245	−0.267***	0.184	0.449*	−0.446***
	(0.03)	(1.55)	(−3.10)	(0.71)	(1.94)	(−5.43)
Squared $ec_{-1}^{(y)}$	0.027	0.036	−2.878***	−0.034	−0.209**	−1.787
	(0.82)	(0.37)	(−2.84)	(−1.58)	(−2.22)	(−1.24)
Lagged dependent	−0.018	0.105*	0.179***	−0.040	0.116**	0.115
	(−0.50)	(1.90)	(2.97)	(−1.39)	(2.30)	(1.21)
Constant	0.044***	0.028**	0.026***	0.058***	0.028	0.030***
	(5.32)	(2.75)	(7.73)	(3.08)	(1.47)	(7.90)
# obs	540	539	550	463	458	474
R^2	0.181	0.291	0.310	0.147	0.255	0.237

respectively. Average growth rates for all spending categories are notably higher in the panel of poorer OECD economies. While this result likely reflects catching-up effects, it is essential to highlight that green parties in government within these economies place a high emphasis on biodiversity and landscape protection. Specifically, with green parties in government, growth rates of general public expenditures for biodiversity and landscape protection are almost 10 percentage points higher compared with their absence from government.

Regarding the significance of environmental topics in electoral campaigns, the benchmark insights primarily stem from the richer OECD economies. However, when governments face fiscal stress, the participation of green parties leads to different behaviors in relatively poor and rich economies. Interaction effects $green \times capb_{-1}$ remain insignificant for the latter, while in poorer OECD countries, governments with green party participation

Table 9 Effect channel results (III): Relatively poor economies, for further notes see Table 4

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.098**	−0.060	−0.015***	0.045	0.245***	−0.046***
	(3.21)	(−0.46)	(−3.92)	(1.60)	(7.75)	(−3.68)
$capb_{-1}$	1.402	0.894	0.377**	3.012***	2.033	0.038
	(1.28)	(1.28)	(2.77)	(3.72)	(1.50)	(0.18)
$green \times capb_{-1}$	2.167**	−0.349	0.088	−0.086	−4.306**	−0.174
	(2.31)	(−0.14)	(0.65)	(−0.08)	(−2.44)	(−0.68)
gap_{-1}	1.141*	0.737**	0.430***	2.180***	−0.157	0.327*
	(2.16)	(3.19)	(5.27)	(5.62)	(−0.20)	(2.03)
election	−0.080	0.047	0.014	−0.018	0.062	0.006
	(−1.42)	(1.13)	(1.74)	(−0.18)	(0.92)	(0.36)
$ec_{-1}^{(bio)}$	−0.198***			−0.206***		
	(−3.95)			(−3.98)		
$ec_{-1}^{(env)}$	−0.028	−0.520**		−0.097	−0.600***	
	(−0.53)	(−2.92)		(−1.28)	(−8.45)	
$ec_{-1}^{(pub)}$	0.626	0.119	−0.247**	0.624	0.273	−0.591***
	(0.95)	(0.42)	(−3.16)	(1.19)	(0.73)	(−6.44)
Squared $ec_{-1}^{(y)}$	0.013	0.079	−0.920	−0.033	−0.167	0.751
	(0.42)	(1.54)	(−0.69)	(−1.52)	(−1.33)	(0.28)
Lagged dependent	−0.034	0.162**	0.089	−0.094***	0.172**	−0.037
	(−0.63)	(2.51)	(1.12)	(−3.64)	(2.37)	(−0.21)
Constant	0.067***	0.063**	0.032***	0.108***	0.060*	0.034***
	(3.47)	(2.37)	(8.06)	(3.63)	(1.93)	(4.93)
# obs	202	201	207	162	158	168
R^2	0.177	0.320	0.302	0.269	0.376	0.255

demonstrate procyclical spending for biodiversity and landscape protection (*bio*) and countercyclical spending for environmental protection ($env^{(c)}$) with high significance.

In summary, the benchmark results align more closely with the evidence documented for wealthier OECD economies, thereby corroborating the findings shown in Table 3 and supported by the evidence provided in Schumacher (2014).

Fourth, benchmark results discussed above have highlighted the role of states of fiscal stress for public spending. With regard to the sample period from 1995 until 2021 analysed in this study, one might assign a crucial importance to public balances reported in the context of two (very) important crisis events: The great financial and the pandemic crisis. Consequently, to assess the role of these events for our results, Table 11 shows empirical evidence that we obtain after removing observations for the years 2009, 2010, 2020 and 2021. As it turns out, almost all unconditional and marginal effects shown for benchmark regressions in Table 4 remain unaffected. Unsurprisingly, now, the lagged cyclically adjusted primary balance does not exert any significant impact on growth rates of the considered public expenditure categories. Apparently, the excluded crisis events have generated the most informative observations for the effects of this variable in the benchmark regressions.

Table 10 Effect channel results (IV): Relatively rich economies, for further notes see Table 4

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.017	0.017	0.020	−0.007	0.051*	0.027
	(0.69)	(1.08)	(1.44)	(−0.29)	(1.81)	(1.40)
$capb_{-1}$	0.227	0.712	0.521***	0.534	0.051	0.583**
	(0.58)	(1.44)	(4.39)	(1.21)	(0.06)	(2.71)
$green \times capb_{-1}$	−0.067	0.313	0.263	−1.120	1.389	0.405
	(−0.20)	(0.54)	(0.26)	(−1.31)	(1.27)	(0.33)
gap_{-1}	0.112	0.945***	0.101	0.575	1.146***	0.140
	(0.29)	(4.60)	(0.77)	(1.23)	(3.46)	(0.64)
election	−0.041	0.019*	−0.001	−0.017	0.065*	−0.009
	(−1.55)	(1.97)	(−0.09)	(−0.29)	(1.84)	(−1.00)
$ec^{(bio)}_{-1}$	−0.233***			−0.149**		
	(−7.62)			(−2.35)		
$ec^{(env)}_{-1}$	−0.113**	−0.270**		−0.015	−0.333***	
	(−2.80)	(−2.70)		(−0.43)	(−4.87)	
$ec^{(pub)}_{-1}$	−0.279	0.296	−0.282*	0.000	0.216	−0.319**
	(−1.11)	(1.33)	(−2.10)	(0.00)	(0.59)	(−2.67)
Squared $ec^{(y)}_{-1}$	0.063*	−0.843**	−3.202***	−0.062*	−0.310***	−2.697***
	(1.96)	(−2.87)	(−7.32)	(−1.93)	(−4.35)	(−3.03)
Lagged dependent	−0.023	0.017	0.224***	0.007	0.125	0.193***
	(0.55)	(0.23)	(4.04)	(0.55)	(1.77)	(4.36)
Constant	0.043***	0.030***	0.018***	0.067***	0.031*	0.024***
	(8.74)	(3.77)	(3.75)	(4.91)	(2.02)	(4.03)
# obs	338	338	343	301	300	306
R^2	0.220	0.360	0.328	0.083	0.227	0.275

Finally, as a fifth avenue of investigation, we explore whether the benchmark results are sensitive to subsampling based on the percentage of threatened species in a country. To achieve this, we categorize the countries in our sample into two groups: those with a percentage rate of threatened species above the median and those at or below the median. To ascertain the percentage rate of threatened species, we utilize data from OECD (2024b), and calculate the maximum number of threatened species across the groups of mammals, birds, reptiles, and amphibians. The regression results are presented in Table 12. We do not observe significant estimates of our core variables for either general or central government expenditure in the two subsamples that were found to be non-significant in the benchmark regression. Among the two estimates that are significant in our benchmark regression, we observe that the counter adjustment of biodiversity and landscape protection spending by green parties is particularly pronounced in countries with a low percentage rate of threatened species, while the spending reduction during election periods is notably prominent in countries with a high percentage of threatened species. However, in no case the evidence is strong enough to conclude that subsampling according to the percentage of threatened

Table 11 Effect channel results (V): Crisis observations removed; for further notes see Table 4

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	−0.002	0.009	0.007	−0.032	0.067*	0.011
	(−0.08)	(0.48)	(1.08)	(−0.71)	(2.07)	(1.07)
$capb_{-1}$	0.238	0.731	0.180	1.045	0.733	0.114
	(0.36)	(1.43)	(1.56)	(1.54)	(0.89)	(0.66)
$green \times capb_{-1}$	0.582	0.124	0.010	−3.038**	−0.442	−0.026
	(0.58)	(0.10)	(0.05)	(−2.21)	(−0.17)	(−0.09)
gap_{-1}	0.912**	1.193***	0.429***	1.316***	0.487	0.430***
	(2.34)	(5.85)	(4.89)	(3.14)	(1.16)	(3.64)
election	−0.067*	0.031	0.007	−0.029	0.065*	0.001
	(−2.04)	(1.48)	(1.51)	(−0.53)	(1.83)	(0.14)
$ec_{-1}^{(bio)}$	−0.205***			−0.169***		
	(−5.85)			(−3.03)		
$ec_{-1}^{(env)}$	−0.075	−0.557***		−0.035	−0.455***	
	(−1.47)	(−6.63)		(−0.71)	(−6.87)	
$ec_{-1}^{(pub)}$	−0.042	0.336*	−0.375***	0.048	0.359	−0.613***
	(−0.10)	(1.84)	(−4.97)	(0.15)	(1.17)	(−6.20)
Squared $ec_{-1}^{(y)}$	0.007	−0.039	−3.797***	−0.043	−0.188	−2.969***
	(0.18)	(−0.16)	(−7.32)	(−1.68)	(−1.70)	(−3.06)
Lagged dependent	−0.042	0.166***	0.131*	−0.063**	0.125*	0.122
	(−0.97)	(2.89)	(1.80)	(−2.22)	(1.98)	(1.55)
Constant	0.061***	0.036***	0.020***	0.077***	0.032	0.020***
	(7.09)	(3.53)	(9.96)	(3.84)	(1.63)	(7.16)
# obs	443	443	453	380	377	390
R^2	0.185	0.338	0.450	0.158	0.291	0.346

species allows us to uncover a specific channel that describes the influence of green parties on spending related to biodiversity and landscape protection.

4.5 Overall Assessment and Discussion

Nowadays, the protection of biodiversity and landscape is a major concern worldwide. To understand the political economy of this concern, our analysis has shown that it is misleading to subsume public efforts to protect biodiversity and landscapes with those in other fields of environmental policies such as pollution abatement or waste management. Specifically, our results allow for three major insights. First, while green parties in government assign high priority to environmental issues, significant enhancements of environmental expenditures are restricted to purposes other than biodiversity and landscape protection. Second, a similar conclusion applies with regard to the presence of electoral cycles. In periods of election, expenditures aiming at biodiversity and landscape protection tend to shrink, while growth rates of other environmental expenditures increase considerably. Third, reflecting the level of economic activity (*gap*) and adjustments of public balances

Table 12 Effect channel results (VI): Regression results from subsampling according to the percentage of threatened species (i.e., the maximum of threatened species among mammals, birds, reptiles and amphibians)

	General government expenditure (Δbio)			Central government expenditure ($\Delta bio^{(c)}$)		
	(1)	(2)	(3)	(1)	(2)	(3)
green	0.017	0.028	0.019	−0.016	0.015	−0.002
	(0.85)	(0.97)	(0.73)	(−0.54)	(0.56)	(−0.06)
$capb_{-1}$	0.491	−0.089	1.138	1.228**	1.031	0.956
	(0.93)	(−0.41)	(1.20)	(2.42)	(1.35)	(1.28)
$green \times capb_{-1}$	−0.065	0.187	−0.165	−1.666**	−1.817	−1.901**
	(−0.15)	(1.02)	(−0.16)	(−2.14)	(−1.79)	(−2.32)
gap_{-1}	0.520	0.518	0.798	0.978**	0.960	0.915
	(1.67)	(1.62)	(1.68)	(2.57)	(1.49)	(1.35)
election	−0.059*	−0.079***	−0.039	−0.007	−0.063	0.034
	(−2.06)	(−3.52)	(−0.83)	(−0.14)	(−0.79)	(0.50)
$ec_{-1}^{(bio)}$	−0.203***	−0.197***	−0.238**	−0.167***	−0.194**	−0.180***
	(−6.74)	(−9.53)	(−2.93)	(−3.75)	(−2.47)	(−4.41)
$ec_{-1}^{(env)}$	−0.043	−0.065	−0.033	−0.032	0.038	−0.076**
	(−0.83)	(−1.25)	(−0.50)	(−1.02)	(0.76)	(−2.56)
$ec_{-1}^{(pub)}$	0.019	−0.313	0.395	0.201	0.249	0.044
	(0.06)	(−0.76)	(0.84)	(0.75)	(0.66)	(0.12)
Squared $ec_{-1}^{(y)}$	0.024	0.088***	0.012	−0.035	−0.103**	−0.009
	(0.73)	(3.77)	(0.44)	(−1.68)	(−2.87)	(−0.44)
Lagged dependent	−0.020	−0.093	0.017	−0.042	−0.037	−0.038
variable (y_{-1})	(−0.56)	(−1.35)	(0.27)	(−1.65)	(−1.58)	(−1.22)
Constant	0.050***	0.037***	0.058***	0.069***	0.082***	0.060**
	(6.73)	(5.34)	(4.64)	(4.08)	(3.18)	(3.04)
# obs	540	247	293	463	217	246
R^2	0.176	0.214	0.175	0.143	0.116	0.225

For comparison, Model (1) is the benchmark regression (see Table 4). Model (2) includes countries with the percentage rate of threatened species above the median. Model (3) includes countries with the percentage rate of threatened species below (and including) the median. For further notes see Table 4

(*capb*) changes of environmental expenditure are more procyclical in comparison with public spending for non-environmental purposes, where, however, under green parties in government the cyclicality of biodiversity and landscape protection spending in periods of fiscal stress is slowed down.

These results have significant policy implications. First and foremost, policymakers should prioritize increasing funding for biodiversity conservation and landscape protection initiatives that, even under green participation in government, are not considered a priority. This will address the existing imbalance between these areas and other environmental and public spending categories to ensure the preservation of natural ecosystems. Second, it is crucial to establish consistent and stable funding for biodiversity and landscape protection projects, regardless of electoral and business cycles. Policymakers must take measures to mitigate the impact of election-related fluctuations on funding for biodiversity and landscape protection. Additionally, they should strive to implement counter-cyclical fiscal policies for environmental spending, particularly concerning biodiversity and landscape protection. These measures will help stabilize funding during economic fluctuations and ensure sustained efforts towards preserving biodiversity, even in times of economic or fiscal stress. Hence, the growing significance of projects funded by supranational organizations such as the United Nations or the European Commission, which are long-term oriented and less prone to cyclicality, represents a step in the right direction.

Naturally, our analysis has some limitations that need to be considered. Firstly, the COFOG data includes only those expenditures with a declared primary objective of protecting biodiversity and landscape. However, indirect expenditures can also have a significant impact on biodiversity protection. For example, Perry and Karousakis (2020) highlight that developed countries' governments spend five to six times more on activities that may be detrimental to these objectives, such as fossil fuel support or government subsidies for agricultural and fishery activities, compared with their expenditures on biodiversity and landscape protection. Although recent databases like CBD-FRF or BIOFIN-BER attempt to account for these indirect impacts, the short time spans of available data still prevent us from conducting a comprehensive (dynamic) panel data analysis. Thus, the analysis presented here may not capture the full scope of the indirect effects on biodiversity protection caused by these additional expenditures. Researchers and policymakers should keep these limitations in mind when interpreting and extending the findings of this study.

Secondly, biodiversity protection can also be influenced by policy instruments other than financial flows, such as biodiversity-relevant taxes, fees and charges, subsidies aimed at biodiversity protection, and tradable permit systems. These aspects are captured in the Policy Instruments for the Environment (PINE) database from the OECD (Perry and Karousakis 2020). Future research could consider incorporating such additional policy instruments to obtain a more comprehensive view of the relationship between parties in government and their efforts in biodiversity and landscape protection. This would enable a deeper understanding of the various mechanisms that impact on biodiversity conservation and inform more effective policies. For instance, as a measurable policy outcome one could consider unravelling ideological motives behind the evolution of protected areas (OECD 2024a), leaving, however, the methodological framework of the present study.[12]

Finally, as mentioned earlier, the role of supranational organizations in biodiversity protection is increasingly significant. For instance, the EU Biodiversity Strategy for 2030 aims to allocate a substantial share of its climate action financial flows and other parts of its budget to invest in biodiversity and landscape protection, with a

[12] With Δpa denoting the percentage change of protected areas a preliminary fixed effect regression outcome is,

$$\Delta pa = \underset{(9.88)}{0.435} - \underset{(-0.26)}{0.038}\, green - \underset{(-0.59)}{1.042}\, capb_{-1} - \underset{(-2.06)}{24.15}\, green \times capb_{-1} + \underset{(1.42)}{2.473}\, gap_{-1} + \underset{(1.44)}{0.186}\, election + \underset{(0.26)}{0.007}\, \Delta pa_{-1},\ \#obs 494,$$

and aligns qualitatively with benchmark results documented in column 4 of Table 4, insinuating that financial and regulatory policy instruments are employed as complements.

particular focus on the most vulnerable countries (see European Commission 2022). While a comprehensive analysis of the interplay between national and international financing for biodiversity and landscape protection presents an interesting avenue for future research, the findings of our study already underscore the necessity of such a strategy. Implementing such a strategy might reduce the reliance on national financial support for biodiversity and landscape protection, thereby weakening its vulnerability to the state of the business cycle, public budget situations and the ideology of parties in government.

5 Conclusions

The preservation of biodiversity has emerged as a critical global concern. For a cross section of 26 OECD economies and a time period from 1995-2021, this research focuses on green parties in government and examines the political economy of public spending on biodiversity and landscape protection, drawing comparisons with other environmental and non-environmental spending categories.

Our findings reveal important disparities in the political economy of biodiversity and landscape protection spending when contrasted with other environmental expenditures. Firstly, while governments with green party involvement tend to allocate more funds to other environmental issues, the same does not hold true for biodiversity and landscape protection. Secondly, a similar trend is observed in relation to electoral cycles. During election periods, funds allocated to biodiversity and landscape protection tend to decrease, while the growth rates of other environmental expenditures experience notable increments. Thirdly, environmental expenditures generally exhibit stronger procyclicality when contrasted with public spending for non-environmental purposes where, however, under green parties in government the cyclicality of biodiversity and landscape protection expenditure is dampened during periods of fiscal stress indicated by the cyclically adjusted primary balance. Robustness exercises and the study of effect channels reveal that these results are not affected by alternative criteria of data trimming, the consideration of climate-related natural disasters, the strength of green parties' parliamentary representation, by the ideological stance of coalition partners or the subsampling of countries according to the percentage of threatened species. However, as green parties are more likely to enter government in richer economies, the core insights are mainly driven by evidence from the richer OECD economies.

The study's policy implications highlight the need to prioritize increased funding for biodiversity conservation and landscape protection initiatives, regardless of party participation in government. Additionally, it is crucial to establish stable and counter-cyclical funding mechanisms to ensure sustained efforts in preserving biodiversity, supported by supranational organizations. Future research will allow to indicate to which extent these conclusions are modified by considering financial flows for which biodiversity protection is a secondary or tertiary goal. Additionally, considering non-financial policy instruments in the analysis and incorporating financial resources received from international organizations, which have gained increased significance in recent periods, will further enhance our understanding of the topic.

Table 13 Panel unit root tests. Results are drawn from the Stata module *xtpurt* (Herwartz et al. 2018), and include tests suggested by Herwartz and Siedenburg (2008), t_{hs}, Demetrescu and Hanck (2012), t_{dh}, and Herwartz et al. (2019), t_{hmw}

	bio	env	pub	$bio^{(c)}$	$env^{(c)}$	$pub^{(c)}$
t_{hs}	0.506	−1.000	0.394	−0.392	−0.480	−0.321
p val	0.6936	0.1587	0.6531	0.3475	0.3157	0.3742
t_{dh}	0.254	−0.133	1.190	−0.215	0.348	0.099
p val	0.6003	0.4471	0.8829	0.4148	0.6360	0.5396
t_{hmw}	−0.667	−1.171	0.333	−1.069	−1.064	−0.208
p val	0.2526	0.1208	0.6303	0.1426	0.1438	0.4174
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
t_{hs}	−0.797	−1.330	−2.155	−1.526	−2.441	−2.419
p val	0.2128	0.0917	0.0156	0.0636	0.0073	0.0078
t_{dh}	−1.279	−1.998	−2.581	−2.466	−2.341	−2.442
p val	0.1004	0.0229	0.0049	0.0068	0.0096	0.0073
	gdp	$debt^*$	ue	dr	gap	$capb$
t_{hs}	0.162	0.980	1.394	1.138	−1.996	−1.286
p val	0.5642	0.8364	0.9184	0.8725	0.0230	0.0991
t_{dh}	0.744	0.957	1.674	1.304	−1.710	−2.033
p val	0.7715	0.8307	0.9529	0.9039	0.0437	0.0210
t_{hmw}	0.071	1.099	1.610	1.678	–	–
p val	0.5284	0.8641	0.9463	0.9533		
	Δgdp	$\Delta ldebt$	Δue	$\Delta dr1565$	Δgap	$\Delta capb$
t_{hs}	−1.803	−2.440	−1.513	−1.342	−1.730	−1.900
p val	0.0357	0.0074	0.0652	0.0898	0.0418	0.0287
t_{dh}	−1.289	−2.413	−2.474	−0.469	−2.148	−2.177
p val	0.0987	0.0079	0.0067	0.3194	0.0159	0.0147
	$ec^{(bio)}$	$ec^{(env)}$	$ec^{(pub)}$	$ec^{(bio)}$	$ec^{(env)}$	$ec^{(pub)}$
t_{hs}	−1.468	−2.127	−3.059	−1.729	−2.802	−3.178
p val	0.0711	0.0167	0.0011	0.0419	0.0025	0.0007
t_{dh}	−1.906	−2.484	−3.225	−1.338	−2.604	−3.070
p val	0.0283	0.0065	0.0006	0.0905	0.0046	0.0011

While all tests are robust to heteroskedasticity and cross sectional correlation, the t_{hmw} statistic also accounts for trending panels. Under the null hypothesis of a panel unit root, all statistics have a Gaussian distribution. Test regressions include a constant throughout and a trend parameter for trending data. For testing in balanced panels, we consider the period 2001 until 2021. Most tests are performed for a cross section of 21 countries. Tests for central government spending condition on 17 countries. The lower panel shows results for residuals from 'cointegrating' regressions as in (1) to (3) for general (central) government expenditures in columns 1–3 (4-6). *Data on debt enter the tests in the form of natural logarithms

Appendix 1 Panel Unit Root Tests

An explicit testing for panel unit roots that is robust to cross sectional correlation comes with a sizeable reduction of sample information. For reduced cross sections we apply the

Stata module *xtpurt* (see also Herwartz et al. 2018), and conduct panel unit root tests suggested by Herwartz and Siedenburg (2008), denoted t_{hs}, Demetrescu and Hanck (2012), t_{dh}, and Herwartz et al. (2019), t_{hmw}. While all these panel unit root tests are robust to heteroskedasticity and cross sectional correlation, the t_{hmw} is unique in accounting also for the case of trending panels which is of particular relevance for macroeconomic panels.

Panel unit root statistics for balanced panels covering the period 2001 until 2021 are documented in Table 13. The panel tests confirm that most investigated time series can be considered as integrated of order one. Unlike considering first differenced data, subjecting the panels of level data to testing results in a non-rejection of the null hypothesis of non-stationarity with *gap* and *capb* being exceptions in this regard.

Appendix 2 Cross-Sectional Correlation

With regard to inferential analysis, it is important to notice that *t*-ratios as documented, for instance, in Table 4 lack robustness against eventual cross sectional residual correlation which is often observed in macroeconomic panel models. Since our empirical panels are inherently unbalanced any correction for cross sectional correlation comes at the cost of a loss of sample information. For diagnosing eventual cross-sectional correlation patterns, consider the benchmark model to explain growth rates of general government expenditures for biodiversity and environmental protection (first column of Table 4). Since this model explains data for 26 countries, overall, 26*25/2 = 325 pairwise correlation estimates $\hat{\rho}_{ij}, i,j = 1, 2, \ldots, N,\ i \neq j$, can be constructed from the country-specific model residuals. The number of time series observations entering the correlation statistics depends on the considered pair of residuals and we denote it with T_{ij}. Among these 325 correlation statistics 21 (i.e., 6.46%) exceed in absolute value a threshold of $2/\sqrt{T_{ij}}$ which indicates significance at the 5% level in a rule-of-thumb manner. Since the empirical rejection rate of these tests of 6.46% is rather close to the nominal test level of 5%, we do not consider cross-sectional correlation as a matter of concern for this particular panel model. Applying the CD test of Pesaran (2021) to test the null hypothesis of no cross sectional correlation at the overall level confirms this conclusion, and yields a statistic of 1.198 which is insignificant according to the Gaussian limit distribution. Regarding the remaining benchmark models documented in Table 4, we obtain the following empirical rejection frequencies of the null hypothesis of zero pairwise correlation: 10.46% (for modelling $\Delta\, env$), 22.46% ($\Delta\, pub$), 7.36% ($\Delta\, bio^{(c)}$), 7.36% ($\Delta\, env^{(c)}$) and 23.81% ($\Delta\, pub^{(c)}$), where the latter three empirical rejection rates refer to overall 231 correlation statistics that can be determined for the panel models addressing central government expenditures. Corresponding CD statistics are 2.25 (for modelling $\Delta\, env$), 26.25 ($\Delta\, pub$), 0.097 ($\Delta\, bio^{(c)}$), 0.652 ($\Delta\, env^{(c)}$) and 21.44 ($\Delta\, pub^{(c)}$)

In sum, for three out of six benchmark models (among which are the two models that are core to this study, $\Delta\, bio$ and $\Delta\, bio^{(c)}$), cross equation correlation cannot be detected at an overall level, since nominal and empirical rejection rates of correlation testing are rather close to each other, and CD statistics lack significance. For the remaining models (namely, $\Delta\, pub$, $\Delta\, env$ and $\Delta\, pub^{(c)}$) the CD test points to overall prevalent cross-sectional correlation, which could invoke biased inferential outcomes. We refrain from implementing fully fledged GLS estimation and inference for three reasons: First, the asymptotic distribution of the CD Test holds asymptotically as $T \to \infty$. Hence, the result for modelling $\Delta\, env$ might be flawed by a finite sample size distortion. Second, while sizeable shares of correlation statistics exceed the asymptotic critical value of $2/\sqrt{T}$, it also holds that many correlation statistics are rather small in absolute value. Specifically, for modelling $\Delta\, env$, $\Delta\, pub$ and $\Delta\, pub^{(c)}$ the shares of cross-sectional correlations being less than 0.1 (0.2) in absolute value are 23.38%, 31.08% and 19.91% (41.23%, 55.38% and 38.09%), respectively. Hence, any GLS adjustment could be considered at risk to be flawed with estimates of correlations that are likely negligible or even non-existent. Third, similar to issues of cross-sectional correlations, heteroskedasticity can be considered a stylized data feature of public expenditure patterns. Unmodelled heteroskedasticity, in turn, is also likely to affect the asymptotic distribution of the CD test statistic.

In conclusion, we consider eventually adverse effects of unmodeled cross-equation correlation as - at most - minor. Moreover, an adjustment for such correlation patterns comes with a sizeable loss in terms of time- and country-specific sample information and two-step GLS estimates will likely suffer from the spurious contributions of many small and insignificant pairwise correlations.

Appendix 3 ECM Degrees of Explanation

To confirm the argument that the suggested ECM approach holds economically significant content to explain adjustment patterns in (categorical) public expenditures, Table 14 documents estimation results of models excluding lagged equilibrium errors from the analysis. As it turns out, the benchmark ECMs documented in Table 4 show degrees of explanation between 14% and 33% which exceed by at least nine percentage points the accuracy of fit achieved by

Table 14 Panel regression results for models excluding lagged equilibrium errors (i.e., $ec_{-1}^{(bio)}, ec_{-1}^{(env)}, ec_{-1}^{(pub)}$ and squared ec_{-1}^{y}; see also Table 4 for benchmark results)

	General government expenditure			Central government expenditure		
	Δbio	Δenv	Δpub	$\Delta bio^{(c)}$	$\Delta env^{(c)}$	$\Delta pub^{(c)}$
green	0.008	0.006	0.015	−0.001	0.053**	0.016
	(0.48)	(0.27)	(1.17)	(−0.06)	(2.17)	(0.92)
$capb_{-1}$	0.828*	0.581	0.693***	1.672***	0.583	0.683***
	(2.05)	(1.33)	(4.23)	(3.93)	(0.91)	(3.45)
$green \times capb_{-1}$	0.016	0.085	−0.314	−1.312**	−0.294	−0.412
	(0.03)	(0.09)	(−0.52)	(−2.18)	(−0.31)	(−0.62)
gap_{-1}	0.282	0.287	0.472***	0.438	−0.064	0.480***
	(1.58)	(0.95)	(6.52)	(1.65)	(−0.20)	(5.50)
election	−0.059*	0.047*	0.006	−0.014	0.108***	−0.003
	(−1.95)	(1.91)	(1.13)	(−0.26)	(3.11)	(−0.43)
Lagged dependent	−0.119***	−0.116**	−0.010	−0.101**	−0.067	−0.117
	(−3.52)	(−2.70)	(−0.22)	(−2.67)	(−1.29)	(−1.70)
Constant	0.054***	0.022**	0.026***	0.055***	0.006	0.033***
	(6.34)	(2.44)	(10.14)	(3.86)	(0.53)	(8.67)
# obs	555	553	564	480	472	488
R^2	0.054	0.041	0.229	0.052	0.027	0.154

The table documents results in full analogy to Table 4 except for the exclusion of error correction dynamics stylized models that exclude error-correction patterns. These results complement the statistical evidence in favor of panel cointegration patterns as discussed in Sect. 3 of the main text.

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Declarations

Conflict of Interest The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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