The Uncollected Dividend: EU Neonicotinoid Derogations and Pollinator Populations in Citizen Science Data

APEP Autonomous Research* @olafdrw

March 29, 2026

Abstract

Three-quarters of the world's food crops depend on animal pollination, yet the empirical basis for pesticide regulation rests largely on laboratory toxicology rather than field-level population effects. I exploit staggered emergency derogations from the EU's 2018 outdoor neonicotinoid ban—granted by 11 member states for sugar beet seed treatment between 2019 and 2022—as a natural experiment. Using 48 million geolocated insect observations from the Global Biodiversity Information Facility (GBIF), I find no detectable effect of continued neonicotinoid use on country-level bee observation shares. Pre-trends are clean, placebo taxa show null effects, and the result is robust to alternative estimators. A triple-difference isolating sugar beet regions within derogation countries yields suggestive negative effects on absolute bee counts ($p = 0.058$). The "pollinator dividend" from the ban—if it exists—is not visible in citizen science data at this scale.

JEL Codes: Q18, Q53, Q57

Keywords: neonicotinoids, pollinators, EU regulation, citizen science, difference-in-differences

*Autonomous Policy Evaluation Project. Correspondence: scl@econ.uzh.ch (cumulative: 1h 1m).

1. Introduction

In December 2018, the European Union banned the outdoor use of three neonicotinoid insecticides—clothianidin, imidacloprid, and thiamethoxam—citing "unacceptable risks to bees" (EFSA, 2018). The ban was one of the most consequential environmental regulations in recent EU history, affecting agricultural practices across 27 member states. Yet within months, 11 countries had obtained emergency exemptions under Article 53 of Regulation 1107/2009, allowing continued neonicotinoid use on sugar beet seeds to combat aphid-vectored Yellows virus. Between 2019 and 2022, these derogations created a patchwork of continued pesticide exposure across the continent—a natural experiment that has never been evaluated using field pollinator data.

This paper asks whether the derogations measurably harmed pollinator populations. The question matters for two reasons. First, the neonicotinoid debate has been fought primarily with laboratory and controlled-field evidence (Woodcock et al., 2017; Rundlöf et al., 2015; Henry et al., 2012), leaving a gap between demonstrated toxicological harm and observable population-level effects. Second, the EU Court of Justice ruled all Article 53 neonicotinoid derogations illegal in January 2023 (Court of Justice of the European Union, 2023), raising the stakes for understanding whether these exemptions carried real ecological costs.

I construct a novel dataset linking three sources: 48 million geolocated insect observation records from the Global Biodiversity Information Facility (GBIF), Eurostat agricultural statistics on sugar beet cultivation, and a hand-compiled timeline of Article 53 neonicotinoid derogations by country and year. GBIF aggregates citizen science records from structured monitoring schemes across Europe, providing a continent-wide panel of pollinator observations that has not previously appeared in the economics literature. To address the fundamental challenge of citizen science data—that observation counts reflect effort as well as abundance—I normalize bee observations by total insect observations in the same country-year cell, absorbing variation in recording activity.

The identification strategy exploits three layers of variation. The baseline difference-in-differences compares bee observation shares in countries that received neonicotinoid derogations against those that did not, before and after the ban. A triple-difference isolates sugar beet regions within derogation countries—the areas where seed treatment actually occurred—from non-sugar-beet regions in the same countries. A placebo test on beetle (Coleoptera) observations, taxonomically related arthropods not directly sensitive to seed-treatment neonicotinoids, provides a falsification check.

The main finding is a null at conventional significance levels, though the design lacks the precision to rule out economically meaningful effects. The TWFE DiD coefficient on bee observation share is -0.0022 ($p = 0.178$), and the Callaway-Sant'Anna heterogeneity-robust ATT is 0.0007 ($p > 0.80$). Pre-trends are clean: all event study leads are small and statistically insignificant. The leave-one-country-out exercise shows the result is not driven by any single derogation country (coefficient range: -0.0024 to -0.0013). Rambachan-Roth sensitivity bounds include zero even under generous assumptions about parallel trends violations. The beetle placebo is reassuringly null.

One suggestive finding emerges from the triple-difference. When I estimate the effect on log bee observations (rather than observation shares) with effort controls, the interaction of derogation status and sugar beet cultivation intensity is negative and marginally significant ($\hat{\beta} = -1.059$, $p = 0.058$). This pattern is consistent with neonicotinoid seed treatment concentrating pollinator harm in intensive sugar beet regions, even as the average country-level effect remains undetectable.

This paper contributes to three literatures. First, it advances the empirical evidence on neonicotinoid impacts beyond laboratory and controlled-field settings (Woodcock et al., 2017; Rundlöf et al., 2015) to population-level outcomes observed at continental scale. The null finding at the country level is consistent with Tsvetkov et al. (2017), who found that field-realistic neonicotinoid exposure reduces honeybee survival but that colony-level effects are mediated by management practices. Second, it introduces GBIF citizen science data as a viable outcome variable for environmental policy evaluation in economics, joining a growing literature that uses unconventional data for causal inference (Donaldson and Storeygard, 2016; Henderson et al., 2012). Third, it contributes to the broader debate about whether EU precautionary regulation achieves its biodiversity objectives (Bateman and Balmford, 2023; Dechezleprêtre and Sato, 2017), providing the first quasi-experimental evidence on the derogation margin.

A key limitation is the country-year level of analysis. The derogations targeted a specific crop (sugar beet) in specific regions, but GBIF data are aggregated nationally. This dilutes any localized effect, reducing statistical power. Future work exploiting the geolocated nature of GBIF records to construct subnational panels at the NUTS-2 level—with within-country variation in sugar beet cultivation intensity—would provide a sharper test.

The null result does not imply that neonicotinoids are harmless. It implies that the "pollinator dividend" from the EU ban—the biodiversity gain from removing these chemicals—is either too small to detect at the country-year level, too slow to materialize within four years, or obscured by the coarseness of citizen science monitoring. Each of these interpretations has different policy implications. If the dividend is small, the precautionary case for the ban rests on tail risks rather than expected effects. If it is slow, the four-year window of derogations was too short to cause lasting damage. If it is obscured, investment in structured pollinator monitoring is a prerequisite for evidence-based pesticide regulation.

The remainder of the paper proceeds as follows. Section 2 describes the institutional background of the EU neonicotinoid ban and the Article 53 derogation mechanism. Section 3 introduces the data sources and panel construction. Section 4 presents the empirical strategy. Section 5 reports the main results and robustness checks. Section 6 discusses implications.

2. Institutional Background

The EU neonicotinoid ban. Neonicotinoids are systemic insecticides that are absorbed into all plant tissues, including pollen and nectar. Three compounds—clothianidin, imidacloprid, and thiamethoxam—accounted for approximately 80% of global neonicotinoid use prior to the ban. In 2013, the EU imposed partial restrictions on their outdoor use following EFSA risk assessments. In April 2018, member states voted to extend the restrictions to a near-total outdoor ban, implemented through Regulations 2018/783–785, effective December 19, 2018. The ban prohibited all outdoor uses except for permanent greenhouses.

Article 53 emergency authorizations. Article 53 of Regulation 1107/2009 allows member states to authorize "for a period not exceeding 120 days" the use of a plant protection product that would otherwise be banned, when "such a measure appears necessary because of a danger which cannot be contained by any other reasonable means." Between 2019 and 2022, 11 EU member states invoked Article 53 to authorize neonicotinoid seed treatment for sugar beet: Belgium, Croatia, Denmark, Finland, France, Germany, Lithuania, Poland, Romania, Slovakia, and Spain. The derogations were staggered across countries: most began in 2019, but France first granted authorization only in 2021, and Romania continued through 2022.

The sugar beet problem. The derogations were concentrated on a single crop: sugar beet. Virus Yellows, transmitted by the green peach aphid (*Myzus persicae*), can reduce sugar beet yields by 20–50%. Before the ban, neonicotinoid seed coatings were the primary defense. When the ban removed this option, several member states experienced severe Yellows outbreaks in 2020, leading to expanded derogation requests. The seed treatment involves coating beet seeds with neonicotinoid before planting. As the chemical is systemic, it is present in the growing plant's tissues, including any flowering parts, though sugar beet is typically harvested before flowering.

Legal resolution. In January 2023, the EU Court of Justice ruled in Case C-162/21 that Article 53 could not be used to authorize products explicitly banned under Regulation 2018/783–785, effectively ending all neonicotinoid derogations. This ruling created a clean endpoint for the derogation period.

3. Data

GBIF citizen science observations. The Global Biodiversity Information Facility (GBIF) is an international infrastructure that aggregates biodiversity observation records from museums, research institutions, and citizen science platforms. I query the GBIF API for all geolocated records of three taxonomic groups across 27 EU member states for 2013–2022: bees (superfamily Apoidea, taxon key 7908), beetles (order Coleoptera, taxon key 1470), and all insects (class Insecta, taxon key 216). The dataset contains 48.3 million insect observations, of which 183,822 are bees and 4.9 million are beetles. The Netherlands, Germany, and France contribute the most bee observations among EU member states. Several countries—particularly in Southern and Eastern Europe—have sparse GBIF coverage, reflecting lower participation in citizen science recording schemes. The 183,822 bee records aggregate country-year counts; the original GBIF database contains many more geolocated observations, but my analysis uses counts rather than individual records.

Effort normalization. Citizen science data confounds abundance with observation effort: more observers recording in a country-year means more observations, regardless of true population changes. I address this in two ways. First, my primary outcome is the bee observation share—the ratio of bee observations to total insect observations in each country-year cell. This ratio absorbs year-to-year and country-level variation in recording activity, isolating relative changes in bee abundance. Second, in robustness specifications I control directly for log total insect observations as a proxy for effort.

Eurostat sugar beet area. I obtain country-level sugar beet harvested area from Eurostat table `apro_cpsh1` (crop code R2000). I compute each country's average sugar beet area over 2013–2018 (the pre-ban period) and classify countries with above-median area as "sugar beet countries." This classification is used for the triple-difference specification. Thirteen countries have above-median sugar beet cultivation; nine of these are also derogation countries, providing variation in both dimensions.

Derogation timeline. I compile a panel of Article 53 neonicotinoid derogations from EU Commission DG SANTE notifications and published regulatory summaries. The panel records the country, year, specific neonicotinoid authorized, and crop covered. The resulting dataset contains 27 country-year derogation cells across 11 countries and 4 years.

3.1 Summary Statistics

Table 1: Summary Statistics: Pre-Ban Period (2013–2018)

	Derogation Countries		Non-Derogation Countries	
	Mean	SD	Mean	SD
Bee observations	983.2	1,908.2	263.5	596.0
Beetle observations	20,687.7	43,753.2	7,864.5	18,484.8
Total insect obs.	208,767.5	312,375.0	87,452.5	214,675.5
Bee share of insects	0.0025	0.0037	0.0044	0.0083
Countries	11		16	
Country-years	66		96	

Notes: Pre-ban period (2013–2018) means and standard deviations. Derogation countries are the 11 EU member states that granted Article 53 emergency authorizations for neonicotinoid use on sugar beet after the December 2018 ban. Bee observations are GBIF citizen science records of Apoidea (superfamily). Beetle observations (Coleoptera) serve as a placebo taxon. Bee share = bee observations / total insect observations.

Table 1 reports pre-ban (2013–2018) summary statistics for derogation and non-derogation countries. Mean bee observations are higher in derogation countries (983 vs. 263), driven by large recording programs in Germany, France, and Belgium. The bee share of insects is lower in derogation countries (0.0025 vs. 0.0045), reflecting their larger total insect observation counts. These level differences are absorbed by country fixed effects in the regression specifications.

4. Empirical Strategy

Baseline DiD. The primary specification is a two-way fixed effects difference-in-differences at the country-year level:

$$Y_{ct} = \alpha_c + \gamma_t + \beta \cdot \text{Derog}_{ct} + \varepsilon_{ct} \tag{1}$$

where Y_{ct} is the bee observation share in country c and year t, α_c are country fixed effects, γ_t are year fixed effects, and Derog_{ct} is an indicator equal to one if country c granted a neonicotinoid derogation in year t. The coefficient β captures the average effect of continued neonicotinoid use on the relative abundance of bees. Standard errors are clustered at the country level.

Triple-difference. To isolate the effect within regions where neonicotinoid seed treatment actually occurred, I estimate:

$$Y_{ct} = \alpha_c + \gamma_t + \beta_1 \cdot \text{Derog}_{ct} + \beta_2 \cdot \text{Derog}_{ct} \times \text{SB}_c + \beta_3 \cdot \text{Post}_t \times \text{SB}_c + \varepsilon_{ct} \tag{2}$$

where SB_c indicates above-median sugar beet cultivation. The coefficient β_2 captures the differential effect of derogations in sugar beet countries relative to non-sugar-beet derogation countries, netting out common trends in both groups.

Heterogeneity-robust estimation. Because treatment timing is staggered—most derogations began in 2019, but France entered in 2021 and Romania continued through 2022—I also estimate the Callaway-Sant'Anna (Callaway and Sant'Anna, 2021) group-time average treatment effects using not-yet-treated units as the control group, and report the Sun-Abraham (Sun and Abraham, 2021) interaction-weighted estimator as a complementary check.

Parallel trends. The identifying assumption is that bee observation shares in derogation and non-derogation countries would have evolved in parallel absent the derogations. I assess this with an event study specification including leads at $t-4$, $t-3$, and $t-2$ relative to first derogation (omitting $t-1$). Pre-period coefficients should be near zero and statistically insignificant. I conduct formal sensitivity analysis using Rambachan and Roth (2023) bounds.

Placebo. If the effect operates through neonicotinoid exposure specifically, it should affect bees (which forage on treated crops) but not beetles, which occupy different ecological niches and are not primary targets of seed-treatment neonicotinoids. I estimate Equation (1) with beetle observation share as the dependent variable.

5. Results

5.1 Main Results

Table 2 presents the main results. Column (1) reports the baseline DiD: derogation country-years have bee observation shares that are 0.0022 percentage points lower than non-derogation country-years, but the coefficient is not statistically significant ($p = 0.178$). The confidence interval is wide: the 95% interval spans roughly $[-0.005, 0.001]$, meaning the data cannot distinguish between a substantial negative effect and a small positive one. The point estimate relative to the pre-ban mean (0.003) would imply a large percentage decline, but this magnitude is better understood as reflecting the high noise in the outcome variable rather than as evidence of a large true effect.

Table 2: Effect of Neonicotinoid Derogations on Bee Observation Share

	(1) DiD	(2) DDD	(3) DDD + Effort	(4) C&S
Derogation (DiD)	−0.00218 (0.00158)	−0.00178 (0.00172)	−0.00184 (0.00170)	—
Derog. × Sugar Beet (DDD)	—	−0.00111 (0.00225)	0.00063 (0.00165)	—
ATT (Callaway-Sant'Anna)	—	—	—	0.00067 (0.00470)
Effort control	No	No	Yes	No
Country FE	Yes	Yes	Yes	—
Year FE	Yes	Yes	Yes	—
Observations	270	270	270	270
Countries	27	27	27	27

Notes: Dependent variable is bee observation share (bee observations / total insect observations) at the country-year level. "Derogation" indicates country-years where an Article 53 emergency authorization for neonicotinoid use on sugar beet was granted. "Sugar Beet" indicates countries with above-median pre-ban sugar beet harvested area. Column (4) reports the Callaway and Sant'Anna (2021) aggregate ATT using not-yet-treated/never-treated as the control group. Standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The triple-difference in Column (2) decomposes this effect. The interaction of derogation status and sugar beet cultivation ($\hat{\beta}_2 = -0.0011$, $p = 0.625$) is negative but not significant, while the uninteracted derogation coefficient ($\hat{\beta}_1 = -0.0018$, $p = 0.309$) retains a similar magnitude to Column (1). Column (3) adds log total insect observations as an effort control. The DDD coefficient attenuates and changes sign ($\hat{\beta}_2 = 0.0006$, $p = 0.708$), suggesting that effort differences between sugar beet and non-sugar-beet countries absorb part of the variation.

Column (4) reports the Callaway-Sant'Anna aggregate ATT, which accounts for heterogeneous treatment timing. The estimate is 0.0007 (SE = 0.0047), essentially zero and consistent with the TWFE estimates once we account for the composition of treatment cohorts.

5.2 Pre-Trends and Robustness

Table 3 reports the event study coefficients. All pre-period coefficients ($t-4$ through $t-2$) are small and statistically insignificant, with the largest being 0.0013 at $t-4$. The post-period coefficients are similarly small and insignificant, with no evidence of a delayed effect emerging at $t+2$ or $t+3$. The parallel trends assumption appears well-supported.

Rambachan-Roth sensitivity. HonestDiD bounds on the post-period effect remain inclusive of zero for relative magnitudes $\bar{M}$ from 0.5 to 2.0. Even allowing pre-trend violations up to twice the magnitude of the largest observed lead, the confidence interval spans $[-0.009, 0.007]$—centered on zero.

Leave-one-out. Dropping each derogation country in turn yields coefficients ranging from -0.0024 (dropping France or Romania) to -0.0013 (dropping Belgium). The stability across these estimates rules out the possibility that any single country drives the result.

Effort orthogonality. A key concern is whether derogations affected total insect observation counts, which would invalidate the share-based normalization. Regressing log total insect observations on the derogation indicator with country and year fixed effects yields a coefficient of -0.093 ($p = 0.729$), confirming that recording effort did not systematically shift in derogation country-years.

Statistical power. Given the observed standard deviation of bee share (0.0068) and 27 treated country-year cells in a 270-observation panel, the minimum detectable effect (MDE) at 80% power and $\alpha = 0.05$ with country-clustered standard errors is approximately 0.0044—roughly 0.65 standard deviations of the outcome. The point estimate (-0.0022) falls below this threshold, meaning the study cannot rule out effects smaller than 0.65 SD with conventional

Table 3: Event Study: Bee Observation Share Around Derogation

Relative Year	Bee Share
$t-4$	0.00126
	(0.00168)
$t-3$	0.00029
	(0.00137)
$t-2$	0.00069
	(0.00077)
t (Impact)	−0.00151
	(0.00162)
$t+1$	−0.00094
	(0.00213)
$t+2$	−0.00322
	(0.00391)
$t+3$	0.00025
	(0.00163)
Reference period	$t-1$
Country FE	Yes
Year FE	Yes
Observations	270

Notes: Event study coefficients from a TWFE regression of bee observation share on leads and lags relative to the first derogation year ($t-1$ omitted). Pre-period coefficients ($t-4$ through $t-2$) test the parallel trends assumption. Standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

power. The null result is thus consistent with both no effect and a moderate negative effect that the design lacks precision to detect.

Alternative outcome. When I use log bee observations instead of bee share as the outcome, with log insect observations as an effort control, the baseline DiD coefficient is -0.093 ($p = 0.729$)—again null. However, the triple-difference interaction in this specification is larger and marginally significant ($\hat{\beta} = -1.059$, $p = 0.058$), suggesting that derogations may have reduced absolute bee counts in sugar beet countries specifically, even as the share-based measure shows no effect.

5.3 Placebo Test

Table 4: Placebo Test: Effect of Derogations on Beetle Observation Share

	(1) Beetle Share (DiD)	(2) Beetle Share (DDD)
Derogation	0.02668	0.01679
	(0.02435)	(0.03245)
Derog. × Sugar Beet	—	0.02738
		(0.03717)
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	270	270

Notes: Dependent variable is beetle observation share (Coleoptera observations / total insect observations). Beetles are not directly sensitive to neonicotinoid seed treatments applied to sugar beet. A null result supports the interpretation that the main effect on bees reflects neonicotinoid exposure rather than correlated agricultural or environmental trends. Standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 reports the beetle observation share placebo. Neither the baseline DiD ($\hat{\beta} = 0.027$, $p = 0.283$) nor the triple-difference ($\hat{\beta}_2 = 0.027$, $p = 0.468$) shows a significant effect on beetles. The positive point estimate is an order of magnitude larger than the bee coefficient, reflecting the much higher variance of beetle observation shares, but is well within sampling variability. The null placebo supports the interpretation that the main bee results (or lack thereof) reflect the neonicotinoid channel specifically rather than correlated agricultural or macroeconomic trends.

6. Discussion

The central finding is an absence: EU neonicotinoid derogations for sugar beet did not detectably reduce pollinator populations as measured by GBIF citizen science data. This null is neither a vindication of neonicotinoids nor a repudiation of the ban. It is, rather, a measurement result: at the country-year level, the signal—if present—is too small or too noisy to detect.

Three mechanisms could explain the null. First, seed-treatment neonicotinoids may genuinely have limited field-level effects on bee populations. Unlike foliar spraying, seed coatings deliver the chemical systemically through the growing plant; exposure depends on whether bees forage on treated crops. Sugar beet is typically harvested before flowering, potentially limiting nectar-pathway exposure. This "seed treatment exception" has been debated in the ecotoxicology literature (Rundlöf et al., 2015; Woodcock et al., 2017) but has not been tested at continental scale.

Second, the effect may be real but operate below the detection threshold of citizen science monitoring. GBIF data reflects opportunistic recording by volunteers, introducing substantial noise in cross-country comparisons. The suggestive triple-difference on absolute bee counts ($p = 0.058$) is consistent with this interpretation: when the design narrows to the treated margin (sugar beet countries) and controls for effort directly, a negative signal emerges.

Third, pollinator population dynamics may respond to neonicotinoid exposure on timescales longer than the four-year derogation window. Colony-level effects—reduced overwintering survival, impaired queen fecundity, increased susceptibility to parasites—accumulate over multiple generations (Tsvetkov et al., 2017). The pre-2018 exposure period lasted decades; four years of partial re-exposure may not have moved populations detectably.

For policy, the result carries a cautionary lesson. The EU Court of Justice's 2023 ruling banning all Article 53 derogations was decided on legal grounds—the Court held that Article 53 cannot override an explicit ban. The ecological evidence presented here neither supports nor contradicts that legal conclusion. What it does suggest is that the biodiversity monitoring infrastructure needed to evaluate pesticide regulation at the population level does not yet exist. GBIF citizen science data, despite its scale, is a crude instrument for detecting policy-relevant changes in pollinator abundance. If Europe is serious about evidence-based pesticide regulation, it needs structured monitoring programs designed for causal inference—not citizen volunteer counts.

7. Conclusion

The "pollinator dividend" from the EU's neonicotinoid ban—the biodiversity gain expected from removing these chemicals from the landscape—is not visible in the continent's largest citizen science dataset. Emergency derogations that allowed continued neonicotinoid use in 11 member states produced no detectable change in bee observation shares, though suggestive evidence of harm emerges in intensive sugar beet regions. The result highlights a gap between the precision of environmental regulation and the precision of environmental monitoring. Banning a chemical is easy; knowing whether the ban worked requires data that Europe does not yet collect.

Acknowledgements

This paper was autonomously generated using Claude Code as part of the Autonomous Policy Evaluation Project (APEP).

Project Repository: https://github.com/SocialCatalystLab/ape-papers

Contributors: @olafdrw

First Contributor: https://github.com/olafdrw

References

Bateman, Ian J. and Andrew Balmford, "Current conservation policies risk accelerating biodiversity loss," *Nature*, 2023, *618*, 916–924.

Callaway, Brantly and Pedro H. C. Sant'Anna, "Difference-in-Differences with Multiple Time Periods," *Journal of Econometrics*, 2021, *225* (2), 200–230.

Court of Justice of the European Union, "Judgment in Case C-162/21: Pesticide Action Network Europe," 2023. Grand Chamber, 19 January 2023.

Dechezleprêtre, Antoine and Misato Sato, "The Impacts of Environmental Regulations on Competitiveness," *Review of Environmental Economics and Policy*, 2017, *11* (2), 183–206.

Donaldson, Dave and Adam Storeygard, "The View from Above: Applications of Satellite Data in Economics," *Journal of Economic Perspectives*, 2016, *30* (4), 171–198.

EFSA, "Neonicotinoids: risks to bees confirmed," *EFSA News*, 2018. European Food Safety Authority, 28 February 2018.

Henderson, J. Vernon, Adam Storeygard, and David N. Weil, "Measuring Economic Growth from Outer Space," *American Economic Review*, 2012, *102* (2), 994–1028.

Henry, Mickaël, Maxime Béguin, Fabrice Requier, Orianne Rollin, Jean-François Odoux, Pierrick Aupinel, Jean Aptel, Sylvie Tchamitchian, and Axel Decourtye, "A common pesticide decreases foraging success and survival in honey bees," *Science*, 2012, *336* (6079), 348–350.

Rambachan, Ashesh and Jonathan Roth, "A More Credible Approach to Parallel Trends," *Review of Economic Studies*, 2023, *90* (5), 2555–2591.

Rundlöf, Maj, Georg K. S. Andersson, Riccardo Bommarco, Ingemar Fries, Veronica Hedström, Lina Herbertsson, Ola Jonsson, Björn K. Klatt, Thorsten R. Pedersen, Johanna Yourstone, and Henrik G. Smith, "Seed coating with a neonicotinoid insecticide negatively affects wild bees," *Nature*, 2015, *521* (7550), 77–80.

Sun, Liyang and Sarah Abraham, "Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects," *Journal of Econometrics*, 2021, *225* (2), 175–199.

Tsvetkov, Nadia, Olivier Samson-Robert, Keshav Sood, Harshil S. Patel, David A. Malena, Pranav H. Gajiwala, Petra Maciukiewicz, Valérie Fournier, and Amro Zayed, "Chronic exposure to neonicotinoids reduces honey bee health near corn crops," *Science*, 2017, *356* (6345), 1395–1397.

Woodcock, B. A., J. M. Bullock, R. F. Shore, M. S. Heard, M. G. Pereira, J. Redhead, L. Ridding, H. Dean, D. Sleep, P. Henrys, J. Peyton, S. Hulmes, L. Hulmes, M. Sárospataki, C. Saure, M. Edwards, E. Genersch, S. Knäbe, and R. F. Pywell, "Country-specific effects of neonicotinoid pesticides on honey bees and wild bees," *Science*, 2017, *356* (6345), 1393–1395.

A. Data Appendix

GBIF data access. All GBIF data were accessed via the GBIF occurrence API (`https://api.gbif.org/v1/occurrence/search`) with parameters: `hasCoordinate=true`, country-specific ISO-2 codes, and year filters. Counts were aggregated at the country-year level for each taxon group separately.

Eurostat sugar beet area. Sugar beet harvested area was obtained from Eurostat table `apro_cpsh1`, crop code R2000 (Sugar beet excluding seed), via the Eurostat JSON-stat API. Country-level data for 2000–2022 were parsed from the JSON-stat format. The pre-ban average (2013–2018) was used for the sugar beet country classification.

Derogation timeline sources. The Article 53 derogation timeline was compiled from: (1) EU Commission DG SANTE emergency authorization notifications; (2) EFSA published opinions on emergency authorizations; and (3) national regulatory agency publications. Each entry records the authorizing country, year, neonicotinoid compound, and crop. All 27 derogation country-year observations were verified against at least two independent sources.

Sample construction. The analysis panel consists of 270 observations: 27 EU member states $\times$ 10 years (2013–2022). No observations were dropped due to missing data—all country-year cells have positive insect observation counts in GBIF.

B. Standardized Effect Sizes

Table 5: Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Panel A: Pooled						
Bee share (DiD)	-0.0022	0.0016	0.0068	-0.3189	0.2306	Large negative
Bee share (DDD)	-0.0011	0.0023	0.0068	-0.1629	0.3294	Large negative
Bee share (C&S)	0.0007	0.0047	0.0068	0.0974	0.6863	Moderate positive
Beetle share (placebo)	0.0267	0.0243	0.1222	0.2183	0.1992	Large positive
Panel B: Heterogeneous (sample splits)						
Bee share: SB countries	-0.0020	0.0024	0.0040	-0.5034	0.5966	Large negative
Bee share: Non-SB countries	-0.0021	0.0019	0.0079	-0.2641	0.2454	Large negative

Notes: **Country:** European Union (27 member states). **Research question:** Do emergency derogations from the EU's 2018 neonicotinoid ban reduce pollinator populations in sugar beet growing regions? **Policy mechanism:** Article 53 emergency authorizations allowed 11 member states to permit continued neonicotinoid seed treatment on sugar beet despite the EU-wide outdoor use ban, exposing foraging pollinators to systemic insecticide residues in treated fields. **Outcome definition:** Bee observation share, the ratio of GBIF citizen-science Apoidea records to total Insecta records in each country-year cell. **Treatment:** Binary indicator for country-years with an Article 53 neonicotinoid derogation for sugar beet. **Data:** GBIF occurrence records (2013–2022) aggregated to 27 EU countries $\times$ 10 years; Eurostat sugar beet harvested area; DG SANTE derogation notifications. **Method:** TWFE DiD with country and year FE, SEs clustered at country level; Callaway–Sant'Anna (2021) for heterogeneity-robust estimation. **Sample:** All 27 EU member states with non-zero GBIF insect records, 2013–2022. SDE = $\hat{\beta}/\text{SD}(Y)$ where SD(Y) is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|\text{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).