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Unconstrained Trade: The Impact of EU Cage Bans on Exports of Poultry-Keeping Equipment

Shon M. Ferguson

Unconstrained Trade: The Impact of EU Cage Bans on Exports of Poultry-Keeping Equipment ^{*}

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Abstract

This study evaluates the impact of conventional cage bans for laying hens in the EU on exports of poultry-keeping equipment. Using detailed data on international trade in poultry-keeping equipment combined with an event study regression approach yields several new findings. The results suggest that the cage bans were associated with an increase in intra-EU trade, and also an increase in exports of poultry equipment from EU member states to non-EU countries where conventional cages are still permitted. The results suggest that some banned cages were likely exported to countries outside the EU to be used in egg production.

JEL Classification Codes: F14, F15, Q17

Keywords: International trade, Policy leakage, Animal welfare

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1 Introduction

Consumers and citizens in many countries continue to demand higher standards for the welfare of farm animals (Eurobarometer, 2016). Governments have thus responded by passing legislation with the objective to improve farm animal welfare. In the case of laying hens, the banning of conventional cages has been implemented in many countries. A potential concern, however, is that more stringent rules in one jurisdiction will lead to a shift in animal production to other jurisdictions where animal welfare regulations are less stringent. This phenomenon, known as policy leakage, is important because it can partially undermine the intent of the regulations. It is thus important to understand the scope of policy leakage with respect to animal welfare regulations. The export of banned production equipment is one way that animal welfare policies in one region can lead to leakage to “low animal welfare havens.”

This study presents the results of an ex-post evaluation of the impact of conventional cage bans for laying hens in the EU on exports of poultry-keeping equipment, which includes cages. The analysis focuses primarily on the impact of the 2012 EU conventional cage ban, but also includes EU countries that implemented bans before 2012. The analysis includes both intra-EU trade and exports of poultry cages from EU member states to non-EU countries where conventional cages are still permitted. Studying the impact of stricter animal welfare regulations on international trade in animal-keeping equipment is new in the literature. In contrast, other studies in this literature have focused on the impact on production and trade in animal-based food products.

Using detailed annual trade data at the country-pair-product level and an event study regression approach, the analysis finds that EU countries’ exports of poultry-keeping equipment increased around the time of the bans. These results suggest that some egg producers sold their conventional cage systems to egg producers in other countries outside the EU. In addition to a statistically significant impact on EU exports of poultry-keeping equipment, a large and temporary increase in intra-EU trade in poultry-keeping equipment is observed around the time of the bans. The increase in intra-EU trade around the time of the conventional cage bans is a natural consequence of procuring new poultry-keeping equipment within the EU single market. EU exports of poultry-keeping equipment may, however, indicate that used cages were sold to egg

producers outside the EU.

This study builds on a small and recent empirical literature evaluating ex post the impact of stricter animal welfare regulations on economic outcomes in general, and trade in particular. The most relevant studies of the trade effects of animal welfare regulations are based on the 2015 California cage ban. Mullally and Lusk (2018) find that egg production and the number of egg-laying hens were about 35 percent lower due to the law, but imports from other U.S. states compensated for this decrease in production. Carter et al. (2021) study the impact of inter-state trade in more detail, and find that imports to California were characterized by higher firm-level concentration. Carter et al. (2021) also find prices in other states rose in response to California’s law, resulting in a loss of consumer surplus and retailer surplus at the national level.¹

The potential for an increase in cage exports in response to a cage ban relates to the phenomenon of policy leakage via input markets, where the input in this case is cages. The leakage mechanism studied here is thus conceptually distinct from the earlier work by Malone and Lusk (2016), Mullally and Lusk (2018), and Carter et al. (2021), which focus on leakage via output markets (eggs). This study is the first to analyze international trade in animal-keeping equipment affecting farm animal welfare and its subsequent response to a ban.

The rest of the study proceeds as follows. In section 2 I characterize the market for poultry equipment in the EU and explain the historical details of conventional cage bans at the EU and national levels. Section 3 describes the international trade data used in the analysis. In section 4 I specify the event study methodology used in the analysis, and in section 5 the results of the event study are described and discussed. Conclusions follow in section 6.

2 The EU Conventional Cage Ban

The EU Council Directive 1999/74/EC stipulated a ban of conventional laying hen cages starting January 2012.² This directive was passed in 1999, which gave EU member states several years to comply. This directive forced egg producers to replace their

¹Malone and Lusk (2016) and Mullally and Lusk (2018) also evaluate the impact of the California cage ban on prices and consumer surplus, but their analysis is restricted to California.

²Cages for laying hens are also referred to as “battery cages,” as they are usually built in units with several cages in a row.

conventional cages with so-called “furnished” or “enriched” cages. The directive also permitted cage-free systems, which includes production in barns, free-range, and organic production. The directive stipulated that furnished cages must provide at least 750 cm² of area per hen, of which 600 cm² is at least 45 cm high. Furnished cages must also provide a nest, a littered area, a sufficiently large perch and food trough, and a claw shortening device.³

A few EU countries banned conventional cages prior to the EU-wide ban. The official date of these national bans usually did not correspond to the timing of full compliance, as phase-out periods were granted. In Sweden, for example, the final day of banning conventional cages according to the legislation was January 1st, 1999, but extensions were granted for most producers until 2004 (Berg and Yngvesson, 2006). Austria originally banned conventional cages in 2005, but extensions were granted until 2009 (Scrinis et al., 2017). Germany originally banned conventional cages in 2007, but extensions were granted until 2010 (Scrinis et al., 2017).

Several member states did not fully comply with the EU conventional cage ban by January 2012. The European Commission thus began proceedings against Belgium, Bulgaria, Greece, Spain, France, Italy, Cyprus, Latvia, Hungary, the Netherlands, Poland, Portugal and Romania.⁴ In April 2013 the European Commission decided to take Greece and Italy to the Court of Justice of the European Union over their failure to correctly implement Directive 1999/74/EC.⁵ Greece and Italy were both found guilty and order to pay all legal costs.⁶ Interestingly, there was no scrappage policy for used conventional cages, and egg producers were free to sell them onward to whoever they chose.

Outside of the EU, Switzerland is the only country to have imposed a national ban on conventional cages before the EU ban, which occurred in 1992. Norway imposed a conventional cage ban in 2012. Conventional cage bans have been implemented at the sub-national level during the study period (1998–2019). A prominent example is California’s Prevention of Farm Animal Cruelty Act (Proposition 2), passed in 2008 and implemented in 2015 (Malone and Lusk, 2016). Non-government initiatives to eliminate

³Council Directive 1999/74/EC is available at <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31999L0074>

⁴See https://ec.europa.eu/commission/presscorner/detail/en/IP_12_47

⁵See https://ec.europa.eu/commission/presscorner/detail/en/IP_13_366

⁶Cases numbers C-351/13 and C-339/13 respectively, see https://curia.europa.eu/jcms/jcms/j_6/en/

the use of conventional cages have also been implemented in many countries by private actors in the egg supply chain. Moreover, certified organic egg production prohibits the use of conventional cages. The impact of sub-national and non-government initiatives is beyond the scope of this study.

There is presently no EU-wide ban on furnished cages for laying hens. However, some EU countries have formalized plans to ban furnished cages. Austria officially banned furnished cages in 2020. As recently as 2020 there are large differences across EU countries in terms of the share of laying hens farmed in different methods.⁷ Almost all laying hens in Scandinavia, Germany, Austria and the Netherlands are housed in cage-free systems, whereas the majority of laying hens in other EU countries are housed in enriched cages. The shift to cage-free production systems has occurred in several EU countries despite a lack of a formal ban on furnished cages.

EU egg imports between 2004 and 2019 are illustrated in figure A.1 in the appendix. The EU is generally self-sufficient in egg production, with the value of annual imports ranging between EUR 20 million and EUR 40 million most years since 2004, which corresponds to import volumes of between 20 thousand and 40 thousand tonnes egg equivalent. In contrast, the EU produced a total of 7 million metric tonnes (mmt) of eggs in 2020, with the top 5 largest egg producers in being France (979 mmt), Germany (967 mmt), Spain (918 mmt), Italy (806 mmt) and the Netherlands (703 mmt). Figure A.1 reveals that EU egg imports peaked in 2012, which happened to be the year of the EU conventional cage ban. Some industry stakeholders were initially concerned about the prospect of increased egg imports due to the EU cage ban, but an increase in egg imports was at best temporary.⁸

3 Data and Descriptive Statistics

The analysis uses bilateral trade flow data from EU member states to each export destination, both within and outside the EU. This data is available at the 6-digit Harmonized System (HS) level. The source of the international trade data is CEPII's BACI

⁷Source: European Commission Market situation for eggs, see https://ec.europa.eu/info/food-farming-fisheries/animals-and-animal-products/animal-products/eggs_en

⁸See <https://www.fwi.co.uk/news/farm-policy/deluge-of-egg-imports-predicted-after-eu-cage-ban>

database (Gaulier and Zignago, 2010).⁹ The data is converted from USD to EUR using exchange rate data from the Penn World Table (Feenstra et al., 2015).¹⁰

The analysis uses bilateral trade flow data for the period 1998–2019, where 2019 is the latest available year available for the international trade data. This timespan provides at least seven years of pre-treatment period and a post-treatment periods in the event study. Exports to Switzerland are excluded from the analysis since they had already banned conventional cages in 1992. Croatia, Romania, and Bulgaria are excluded from the analysis since these countries joined the EU in 2007 and 2013, very close to the timing of the EU ban. Exports from Sweden to the 10 countries that joined the EU in 2004 are also excluded from the study, since their accession to the EU was very close to the timing of Sweden’s ban. The United Kingdom is included in the analysis, as it was an EU member throughout the study period. International trade data for 25 member states and up to 200 non-EU destinations is included in the analysis. Belgium and Luxembourg are treated as a single country in the analysis.

Cages for laying hens (both conventional and furnished) are captured in the trade data by HS product code 843629, “Other poultry-keeping machinery.” This product code captures both trade in new and used machinery. The control group include total exports of agricultural machinery captured by the 4-digit HS codes 8432, 8433, 8434, 8435, and 8437.¹¹ Exports of other agricultural machinery not used in poultry production are subject to many of the same shocks to agricultural machinery demand and supply as poultry cages, making them a suitable control group. The control group product is referred to as “Agricultural machinery” throughout the rest of the analysis.

According to manufacturing production data available via the EU PRODCOM database, Germany, Italy, Spain and the Netherlands are the largest producers of “Poultry-keeping machinery (excluding poultry incubators and brooders)” (PROD-

⁹The most recent documentation of the data is available at http://www.cepii.fr/DATA_DOWNLOAD/baci/doc/DescriptionBACI.html.

¹⁰Penn World Table version 10.0 is available at <https://www.rug.nl/ggdc/productivity/pwt/>.

¹¹HS 8432: Agricultural, horticultural or forestry machinery for soil preparation or cultivation; lawn or sports-ground rollers. HS 8433: Harvesting or threshing machinery, including straw or fodder balers; Grass or hay mowers; Machines for cleaning, sorting or grading eggs, fruit or other agricultural produce, other than machinery of heading 8437. HS 8434: Milking machines and dairy machinery. HS 8435: Presses, crushers similar machinery used in the manufacture of wine, cider, fruit juices or similar beverages. HS 8437: Machines for cleaning, sorting or grading seed, grain or dried leguminous vegetables; Machinery used in the milling industry or for the working or cereals or dried leguminous vegetables, other than farm-type machinery.

COM code 28308500).¹² At the same time, several EU member states report that they do not produce any such products. Replacing conventional cages with enriched cages thus requires EU member states to import equipment in many cases.

Figure 1 shows that EU exports of “Other poultry-keeping machinery” and “Ag. machinery” increased at roughly the same rate throughout the 2000’s, then diverged during the years between the Great Recession of 2007–2009 and the 2012 EU conventional cage ban. The decrease in agricultural machinery exports after 2012 was likely due to the Euro-crisis, and affected the manufacturing sector more generally as well. However, exports of poultry-keeping equipment rose during this time.

The total export value of “Other poultry-keeping machinery” to non-EU countries over the period 1998–2019, reported by EU member state, is provided in Table A.1 in the appendix. The largest producers of eggs and poultry-keeping equipment feature prominently among the EU exporters. Germany, Italy, Spain, and the Netherlands were the largest exporters of “Other poultry-keeping machinery” to countries outside the EU. Figure 2 provides an illustration of exports for the top-4 exporting EU member states. Germany’s exports reached their maximum in 2011. Many other countries’ exports reached their peak around the 2012 deadline. Exports from Italy, which was one of the countries with the worst record of implementation, did not reach their peak until 2016. The late peak in exports from Italy is likely part of the reason why overall EU exports decreased in 2013 and 2014, only to rise again in 2015 and 2016. Compliance well in advance of the 2012 deadline as well as delays in compliance imply that sales of used cages could be detected several years before and after the 2012 deadline.

The top-20 destinations for EU exports of “Other poultry-keeping machinery” over the period 1998–2019 are reported in Table A.2 in the appendix. Russia was the largest export destination during this period, followed by USA, Japan, and Ukraine. The pattern of imports over time by the top-4 destinations is illustrated in figure 3. EU exports to Russia and Ukraine peaked in 2008, fell during the Great Recession, then peaked again around the time of the 2012 EU conventional cage ban. Exports to Russia fell in 2014 during the Ukrainian Crisis, only to rise again in 2015.¹³ Exports to the

¹²Prodcom data is available at <https://ec.europa.eu/eurostat/web/prodcom/data/excel-files-nace-rev.2>. Since HS and CN product classifications are identical at the 6-digit level, it is possible to find the corresponding Prodcom product code using Eurostat’s Prodcom-CN concordances available at https://ec.europa.eu/eurostat/ramon/rerelations/index.cfm?TargetUrl=LST_REL.

¹³Russia banned the import of many food products from the EU, but not eggs, see <https://www.government.nl/binaries/government/documents/letters/2014/08/13/decree-of-the->

United States exhibit a different pattern, with no response to the cage bans in EU states. US imports peaked in 2016, a year after the battery cage ban in California. Japan’s imports peaked in 2006 and 2017.

4 Event Study Methodology

The analysis applies an event study regression methodology to study the impact of conventional cage bans. As noted earlier, the timing of the ban was 2012 for all EU countries except for Sweden, Austria, and Germany, which had national conventional cage bans in 2004, 2009 and 2010 respectively. As mentioned earlier, the treatment group product is “Other poultry-keeping machinery”, while the control group is “Agricultural machinery”.

The event study regressions employ a Poisson pseudo-likelihood regression with multiple levels of fixed effects (Correia et al., 2019, 2020). Poisson regressions have the advantage of allowing for zeros in the trade flow data, and have recently gained popularity in the international trade literature, starting with work by Silva and Tenreiro (2006). The estimation follows the standard event study approach, and includes seven pre-treatment and post-treatment periods. Pre- and post-treatment effects greater than seven years are included in the regression, but not reported.

The event study regression model takes the following form:

$$Y_{ijkt} = \alpha_{ijk} + \alpha_{ijt} + \beta_e \sum_{e < -7} D_{ikt}^e + \sum_{e = -7}^{-6} \beta_e \cdot D_{ikt}^e + \sum_{e = -4}^7 \beta_e \cdot D_{ikt}^e + \beta_e \sum_{e = < 7} \cdot D_{ikt}^e + \epsilon_{ijkt}, \quad (1)$$

where Y_{ijkt} is the value of exports from EU member state i to destination j of good k at time t . α_{ijk} and α_{ijt} are origin-destination-product and origin-destination-year fixed effects respectively. D_{ikt}^e is an indicator for member state i being e periods away from initial treatment at time t . D_{ikt}^e always takes a value of zero for the control good. ϵ_{ijkt} is the error term. Indicators greater than seven years before or after treatment are binned. $t - 5$ is used as the baseline event-time, for reasons explained below.

Fixed effects are used to control for other factors that affect international trade in the treatment and control goods. Origin-destination-year fixed effects control for all ex-

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planatory factors such as trade agreements that affect both poultry-keeping machinery (the treatment group) and other agricultural machinery (the control group). Origin-destination-product fixed effects control for any time-constant explanatory factors that are specific to either poultry-keeping machinery or agricultural machinery. These fixed effects also control for the standard “gravity model of trade” variables such as GDP, distance, and the price indices. The point estimates are clustered at the origin country and destination country level, which is the most conservative clustering choice.

The event study analysis is divided into two parts: an analysis of intra-EU trade due to the cage bans, and an analysis of exports from EU member states to non-EU countries. Estimating the impact of the bans on intra-EU trade is interesting in its own right, but is also useful for detecting how many years before the ban and after the ban that egg producers began replacing their old conventional cages with furnished cages, or with cage-free systems. If the bans on conventional cages is associated with increases in exports from EU countries to non-EU countries, this could be indicative of sales of used cages, implying that policy leakage occurred.

Egg producers could begin adapting to the cage ban well in advance of the deadline, and some egg producers did not comply with the cage bans on time. One can thus expect that trade in cages will be affected several years before and after the formal cage ban. The base year used as the benchmark for determining statistical significant effects is thus somewhat ambiguous. A standard event study would set event-time $t - 1$ as the base year, but since trade in cages may have preceded several years in advance of the ban, $t - 5$ is used as the baseline event-time.

5 Event Study Results

5.1 Intra-EU Imports

The analysis begins with the event study results focusing on intra-EU imports around the time of the cage bans, including all 25 EU member states in the same regression. The point estimates and 95 percent confidence intervals estimating the impact of the cage bans on imports of “Other poultry-keeping machinery” from other EU countries, relative to other agricultural machinery are illustrated in figure 4. Using year $t - 5$ as the baseline year is a reasonable choice, as intra-industry trade in “Other poultry-keeping

machinery” was steady five years before the ban and earlier.

The results suggest that imports of poultry equipment from other EU-countries increased rapidly during the three years before the ban, reaching its peak in the year of the ban in each country. Intra-EU trade then declined and fell back to a statistically insignificant level three years after the bans. The regression coefficient on the treatment indicator at time $t = 0$ is 1.01, which implies that intra-EU trade rose by $(exp(1.01) - 1) \times 100 = 174$ percent compared to 5 years prior to the cage ban deadline.

In sum, the results presented in in figure 4 suggest that intra-EU imports of “Other poultry-keeping machinery” clearly increased around the time of the ban. This trade likely included shipments of furnished cages meant to replace the banned conventional cages.

5.2 Exports to non-EU destinations

The next part of the event study analysis focuses on exports from EU member states to non-EU destinations, again including all 25 EU member states in the same regression. The results of this analysis are illustrated in figure 5. The results indicate that exports of “Other poultry-keeping machinery” was arguably steady until two years before the ban in each country. The point estimate is positive and statistically significant one year before the ban and during the year of the ban. The regression coefficient on the treatment indicator at time $t = 0$ is 0.415, which implies that exports to non-EU countries rose by $(exp(0.415) - 1) \times 100 = 51$ percent compared to 5 years prior to the cage ban deadline. The banning of conventional cages thus corresponded to a large percentage increase in the exports of poultry-keeping machinery to non-EU destinations. The point estimate is also positive at time $t = 5$, which I explore in more detail when studying the results by treatment cohort.

It is important to note that one cannot rule out that the exports of “Other poultry-keeping machinery” around the time of the conventional cage bans may be exports of furnished cages or other equipment used in cage-free systems. This limitation is due to the fact that data on international trade in used cages is not available. It is unlikely, however, that exports of poultry equipment would increase at exactly the same time as domestic demand for equipment to replace conventional cages is high due to the bans. The results are thus highly suggestive that such exports to destinations without

conventional cage bans could indeed be used conventional cages. Such trade may be replacing old cages in other non-EU countries, or it could be purchased by foreign egg producers that were aiming to increase egg production.

5.3 Exports to non-EU destinations, excluding the U.S.

In the main analysis of exports from EU member states to non-EU countries I included the U.S. as an export destination. Even though the U.S. has not implemented a national conventional cage ban, including the U.S. may be slightly problematic since California implemented a cage ban during the study period. As a robustness check I drop exports to the U.S. from the analysis. The event study results for EU exports are presented in figure 6. The main effect of excluding the U.S. is that there is no longer a statistically significant point estimate in the year $t + 5$.

5.4 Results by treatment cohort and quantifying the effects

Recent studies have shown that the coefficient of interest in a two way fixed effects specification is not guaranteed to recover an interpretable causal parameter if there is variation in treatment timing and heterogeneous treatment effects (de Chaisemartin and D’Haultfoeulle, 2020; Goodman-Bacon, 2021; Callaway and Sant’Anna, 2021). In an effort to deal with this potential concern, I perform the event study analysis separately for each treatment cohort.

There are four treatment cohorts in this study: Sweden (2004), Austria (2009), Germany (2010) and the rest of the EU (2012). The regression model for the countries treated in 2012 is identical to equation (1). The regression models for Sweden, Austria, and Germany employ different fixed effects and clustering due to the fact that there are not multiple origin and destination countries in the regression. Destination-year and product-year fixed effects and clustering by destination are employed in the case of extra-EU exports. Origin-year and product-year fixed effects and clustering by origin are employed in the case of intra-EU imports. A potential drawback of performing event studies for individual EU member states is that fewer fixed effects can be employed.

The results of the event study estimation for intra-EU imports and exports from EU member states to non-EU countries for each treatment cohort are presented in figures 7 and 8 respectively. The results in figure 7 suggest that the imports of other

poultry equipment to Austria from other EU member states were not affected by the Austrian conventional cage ban, but that imports of equipment to Sweden, Germany and other EU member states affected by the 2012 EU-wide ban did respond. The point estimates for the affected cohorts are at most around 1, which is nearly identical to the event study results including all cohorts in the same regression. Specifically, these point estimates imply that intra-EU imports rose by 200 percent, 194 percent, and 180 percent compared to 5 years prior to the cage ban deadline in Sweden, Germany, and the 2012 cohort respectively.

In order to quantify the effects of the cage bans, I convert the point estimates to monetary values by using the value of exports five years prior to the bans as a baseline. In the case of Sweden, intra-EU imports five years prior to the ban were valued at EUR 0.48 million, and the 200 percent change in trade implied by the point estimates imply a subsequent increase in trade by EUR 0.96 million. Imports from EU countries totalled EUR 42.3 million for Germany in 2005, and EUR 113.6 million in 2007 for EU countries affected by the 2012 EU ban. These baseline values, combined with the percentage increases in trade, imply increases in intra-EU imports of EUR 82 million for Germany and EUR 204 million for the 2012 treatment cohort. The value of these effects on intra-industry trade are reasonable given the large cost of replacing conventional cages with furnished cages, which was sometimes sourced from other EU countries.

The results from figure 8 reveal that the exports of other poultry equipment from Sweden or Austria to countries outside the EU were not affected by the Swedish and Austria conventional cage bans. However, the results suggest that extra-EU exports from Germany and other EU member states affected by the 2012 EU-wide ban did respond. The point estimate for German exports at $t = 0$ was 0.49, with a p-value of 0.06. German exports to non-EU destinations five years prior to the ban totalled EUR 136 million, and combining with the point estimate for time $t = 0$ implies an increase in exports of $(exp(0.49) - 1) \times 100 = 63$ percent, or EUR 86 million. Extra-EU exports among the 21 EU members affected by the 2012 ban totaled EUR 174 million 5 years prior, and combining with the point estimate for $t = 0$ implies an increase in exports of $(exp(0.38) - 1) \times 100 = 46$ percent, or EUR 80 million. The impact of the bans on extra-EU trade are thus economically important.

The event study results for Germany in year $t + 5$ and for the 2012 cohort in year

$t + 3$ also suggest that there was an increase in exports of “Other poultry-keeping machinery” relative to the control group that occurred in 2015. As exports to the U.S. are already dropped from the analysis, further inspection suggests that this temporary increase is driven by exports to Russia. A comparison of EU exports of “Other poultry-keeping machinery” and “Ag. machinery” to Russia is illustrated in figure A.2 in the appendix. The pattern of trade in the figure suggests that EU exports of “Other poultry-keeping machinery” temporarily diverged from the control group in 2015. This temporary divergence may have been driven by Russian import bans related to the Ukrainian Crisis, which began in 2014.

6 Conclusion

This study presents the results of an ex-post evaluation of the impact of conventional cage bans in the EU on international trade in poultry-keeping equipment. The results suggest that the cage bans were associated with an increase in intra-EU trade and exports of poultry equipment, such as cages, from EU member states to non-EU countries where conventional cages are still permitted. Although it is not possible to provide direct evidence that the increase in exports was in fact used conventional cages, the results are highly suggestive that some banned cages were exported to countries outside the EU to be used in egg production where conventional cages are still allowed.

The conventional cage bans implemented in EU countries did not include any policy to ensure that used cages were not sold to egg producers outside the EU. In order to avoid the risk of exporting banned cages in the future, the EU may want to implement measures to avoid such “leakage” of cages to other countries. This issue may become important as EU countries consider banning furnished cages for laying hens, and as other countries implement bans on conventional cages.

One important potential limitation of the analysis is that it relies on trade data for a broader category of poultry-keeping equipment, as data focusing specifically on trade in cages, especially used cages, is not available. Although the goal of this study is to show that it is possible to detect trade in cages using the data that is presently available, including new cages and used cages as a separate product codes in international trade data would greatly simplify the tracking of cross-border trade in cages. For example, including product codes for these items in new versions of the EU Combined

Nomenclature (CN) system of classifying goods would ease future work in this topic in the European context.

This study does not analyze the animal welfare implications of an export ban for animal welfare in other countries, and it is important to emphasize that the welfare implications are potentially ambiguous. For example, exports of conventional cages from the EU may be displacing worse cage systems in other countries. I leave the study of the animal welfare implications of international trade in cages for future research. In sum, this study highlights that the complex issue of cage exports requires more attention from researchers and policymakers.

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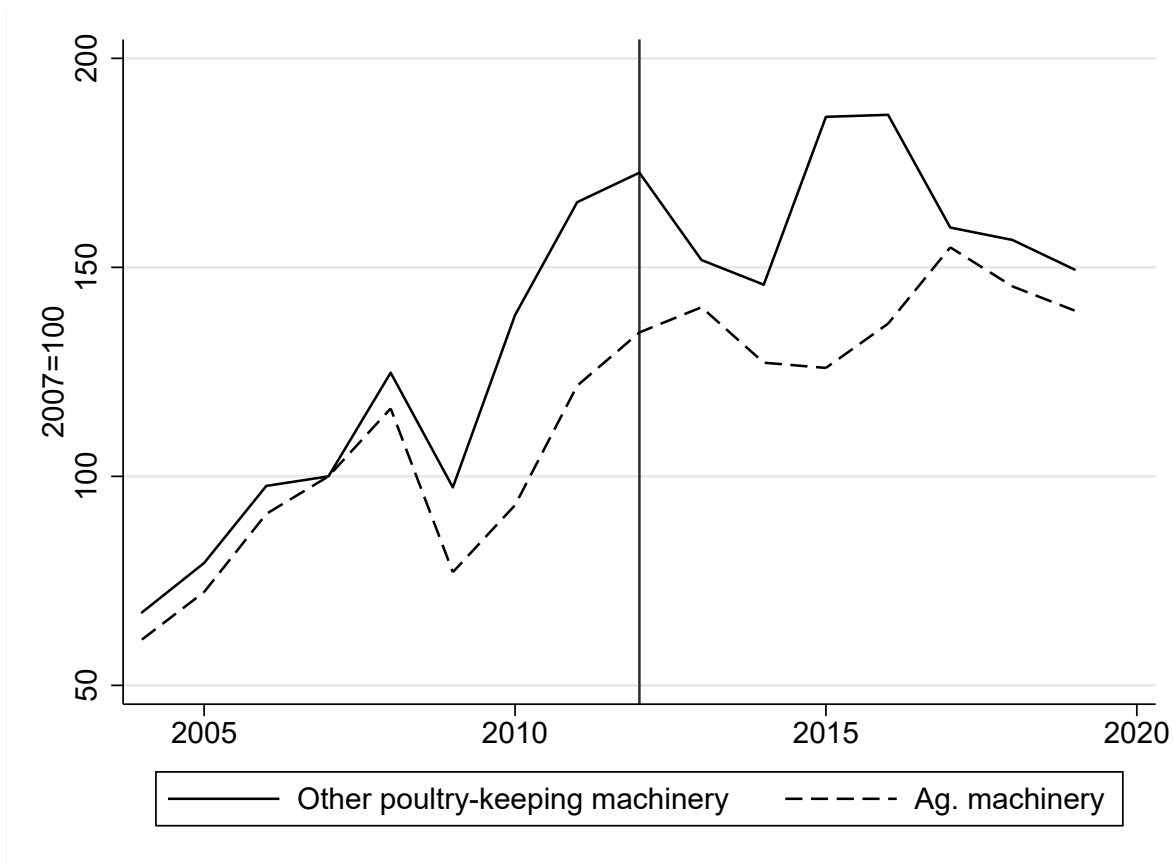


Figure 1: EU exports to the rest of the world, selected products, 2004–2019.
 Source: BACI database, authors' calculations

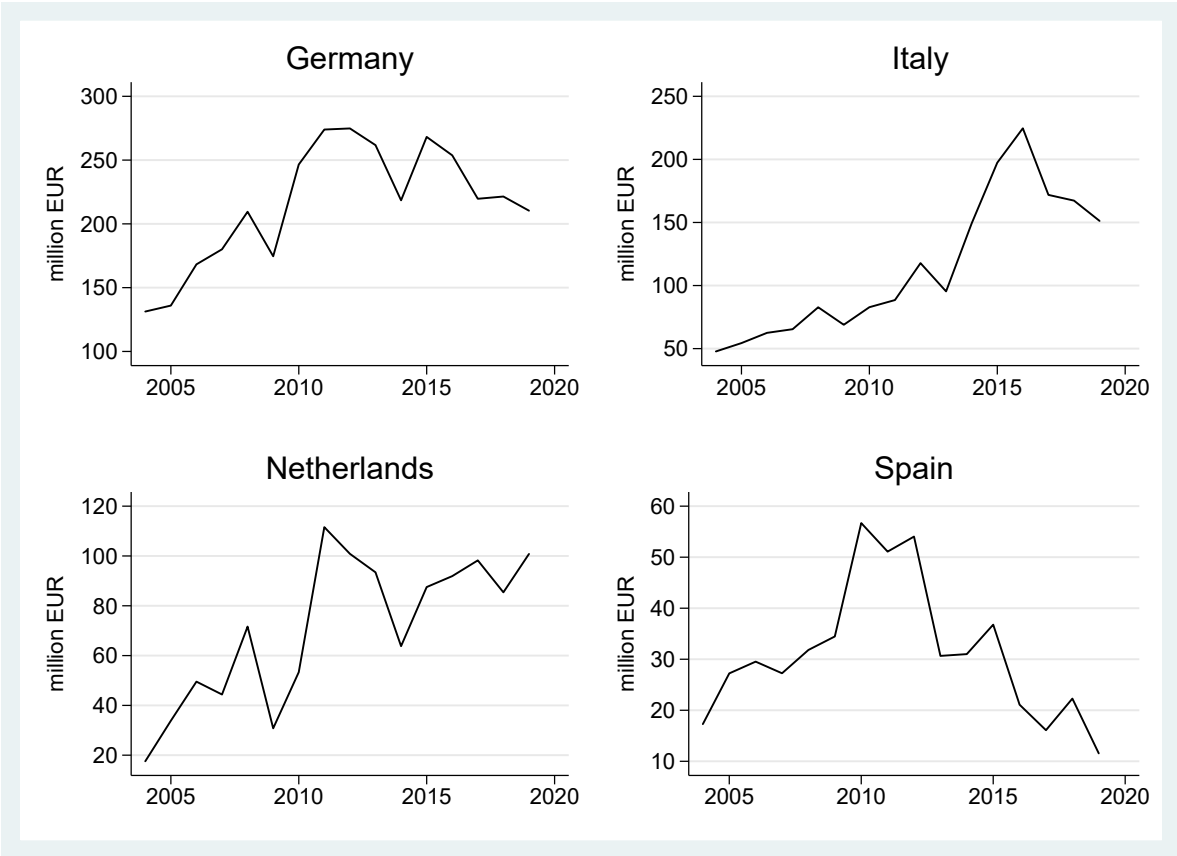


Figure 2: Top-4 exporters of “Other poultry-keeping machinery” (HS 843629) to all non-EU destinations, 2004–2019.

Source: BACI database, authors’ calculations

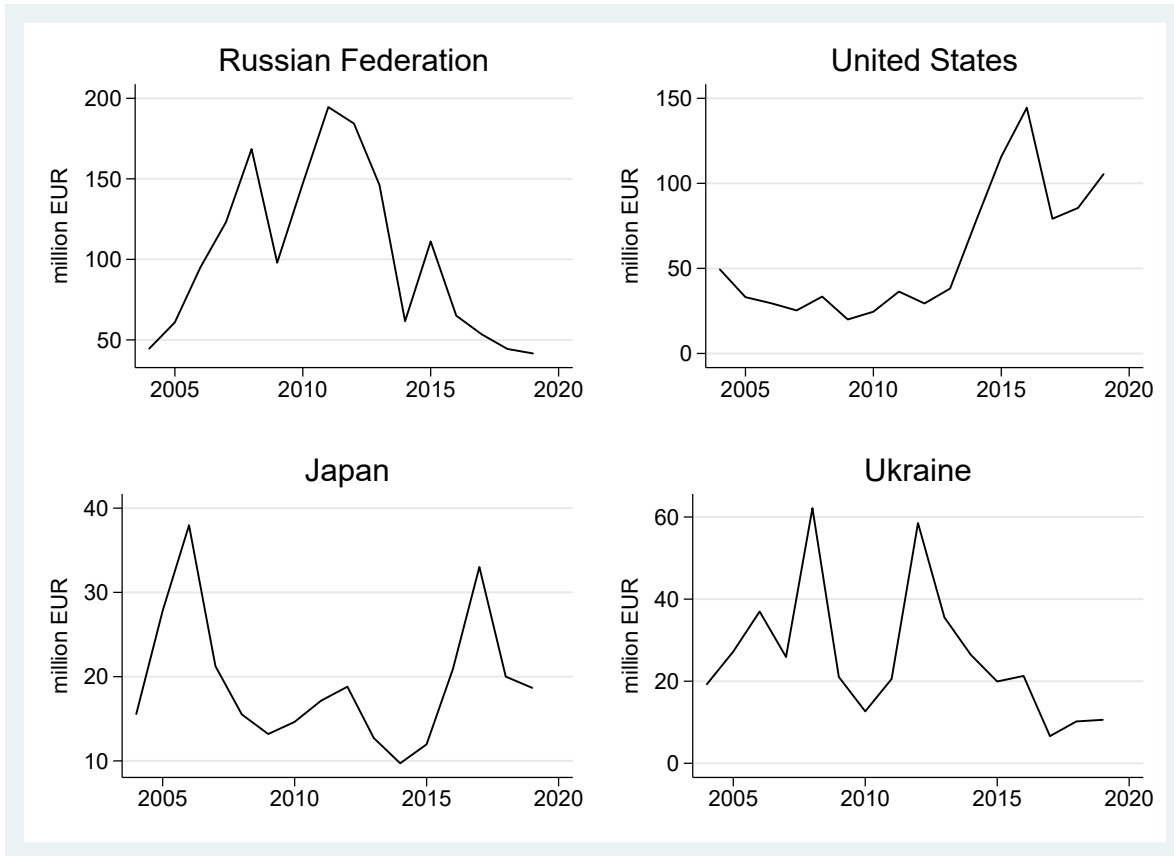


Figure 3: Top-4 importers of “Other poultry-keeping machinery” (HS 843629) from EU, 2004–2019.

Source: BACI database, authors’ calculations

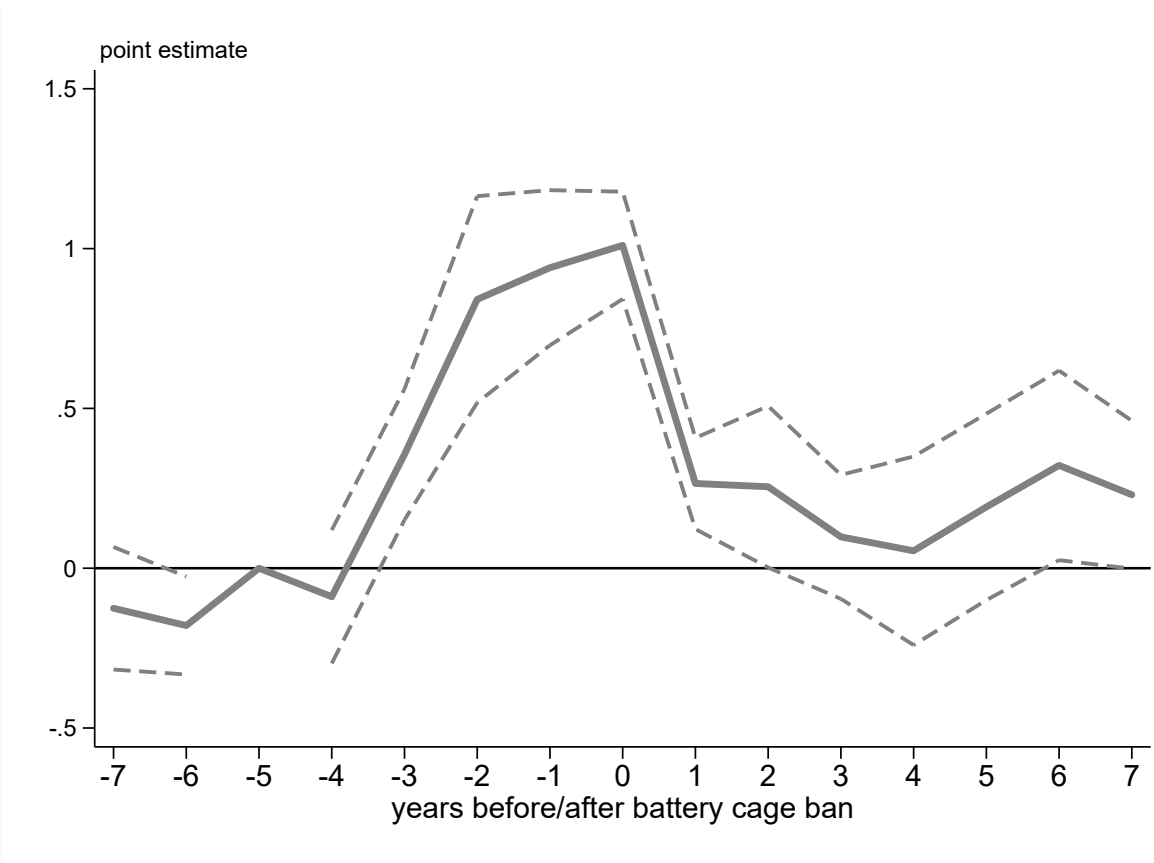


Figure 4: Event study results: Intra-EU imports, “Other poultry-keeping machinery” versus “Other agricultural machinery”
 Source: Authors’ calculations

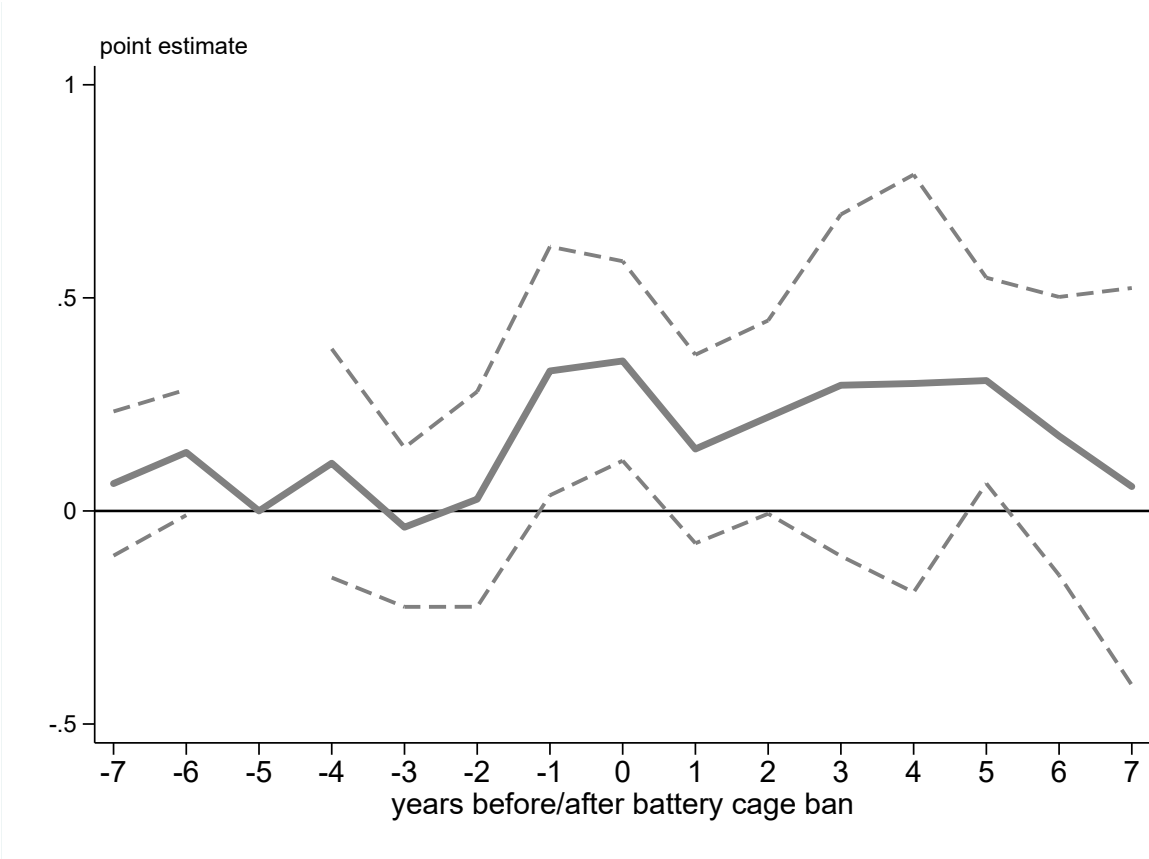


Figure 5: Event study results: Exports from EU countries to non-EU countries, “Other poultry-keeping machinery” versus “Other agricultural machinery”
 Source: Authors’ calculations

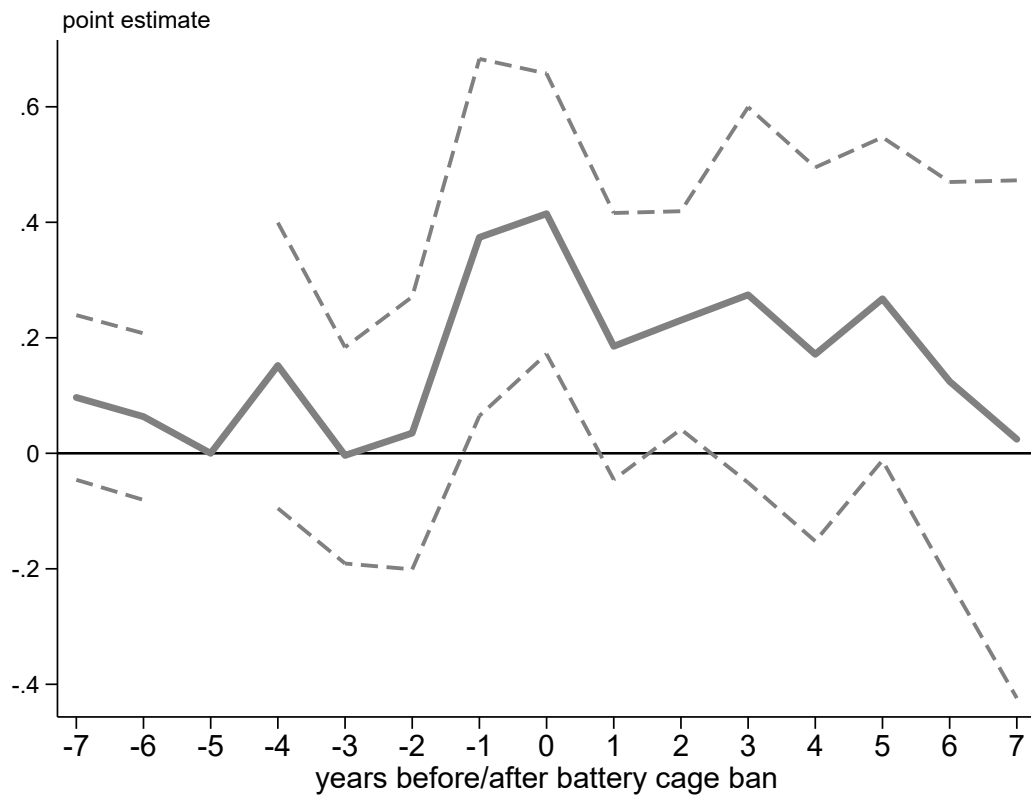


Figure 6: Robustness: Exports from EU countries to non-EU countries, excluding the U.S.
 Source: Authors' calculations



Figure 7: Results by treatment cohort: Intra-EU imports, “Other poultry-keeping machinery” versus “Other agricultural machinery”
 Source: Authors’ calculations

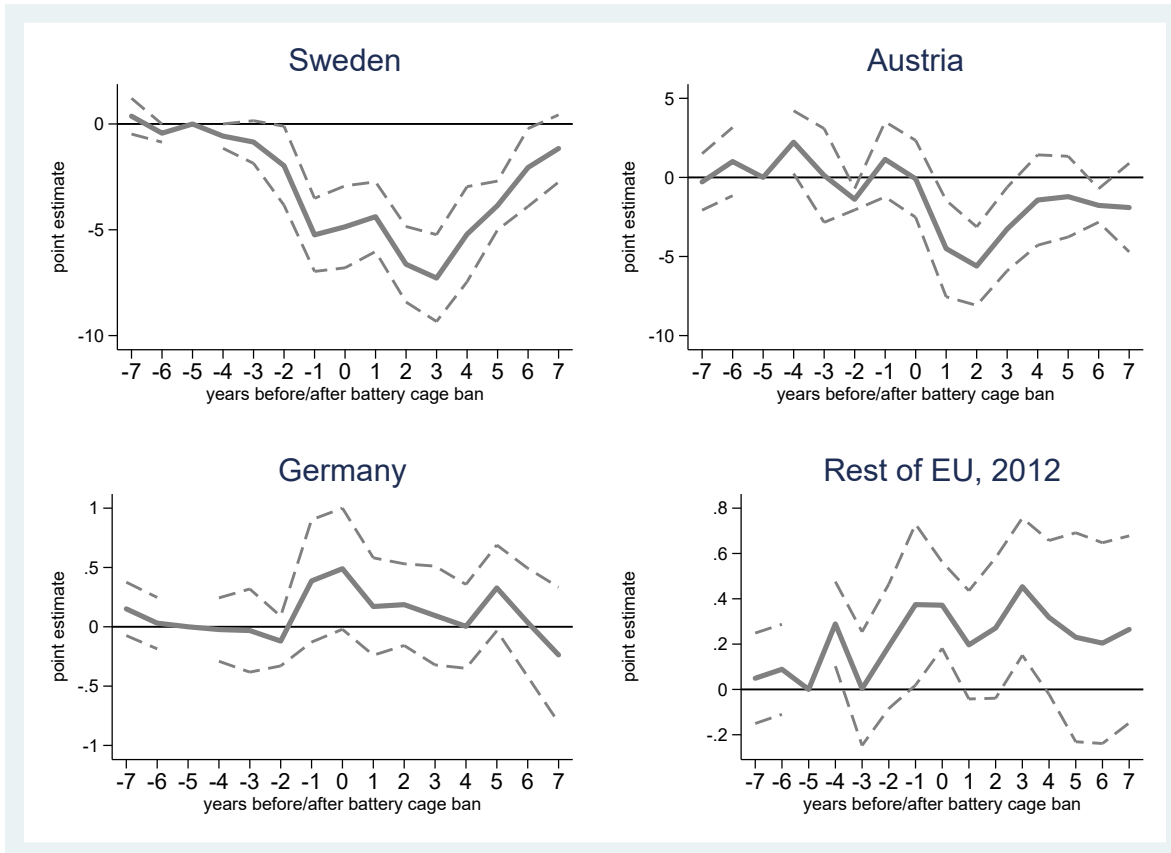


Figure 8: Results by treatment cohort: Exports from EU countries to non-EU countries, “Other poultry-keeping machinery” versus “Other agricultural machinery”
 Source: Authors’ calculations

A Appendix

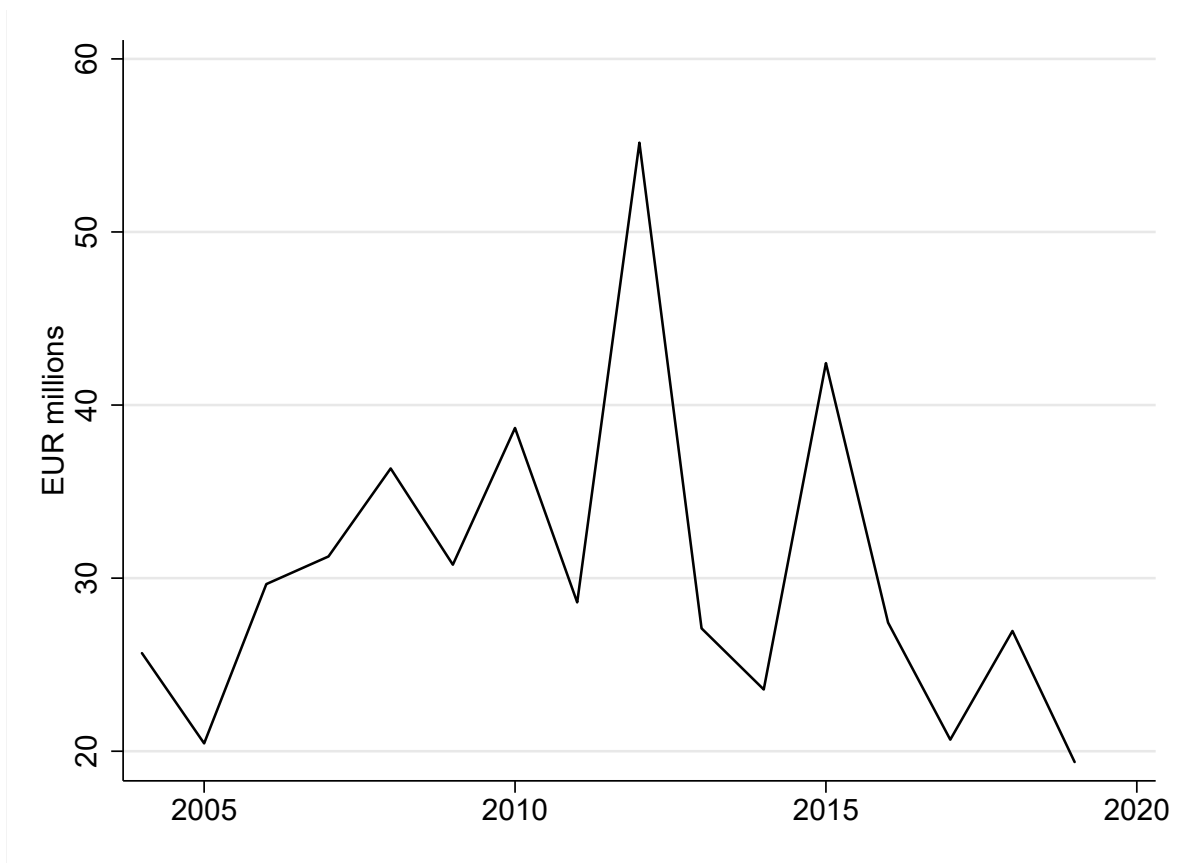


Figure A.1: Total value of EU imports of eggs from non-EU countries, 2004–2019.
Source: BACI database

Table A.1: Total export value of “Other poultry-keeping machinery” (HS 843629) to non-EU countries, by EU member state, 1998–2019

Origin	Value, EUR millions
Germany	4051.8
Italy	2099.8
Netherlands	1236
Spain	566.8
Belgium-Luxembourg	265.5
France	206.1
United Kingdom	93.2
Denmark	83.9
Poland	70.5
Lithuania	40.7
Hungary	14.6
Estonia	11.5
Austria	8.3
Czechia	8.3
Sweden	5.6
Portugal	5.3
Greece	4.2
Latvia	3.4
Ireland	1.9
Malta	.9
Slovakia	.8
Slovenia	.6
Finland	.3
Cyprus	.3

Notes: Based on observations from Figure 5. Source: BACI database.

Table A.2: Top-20 destinations for EU exports of “Other poultry-keeping machinery” (HS 843629), 1998–2019

Destination	Value, EUR millions
Russian Federation	1732.1
USA	1018.2
Japan	494
Ukraine	459.6
Canada	276.7
Algeria	268.1
Saudi Arabia	261.5
Rep. of Korea	260.0
Belarus	212.1
Mexico	206.4
Turkey	177.2
China	175.8
Australia	171.0
Malaysia	162.3
Kazakhstan	161.9
Morocco	135.2
Thailand	134.8
Egypt	131.8
Brazil	130.3

Notes: Based on observations from Figure 5. Source: BACI database.

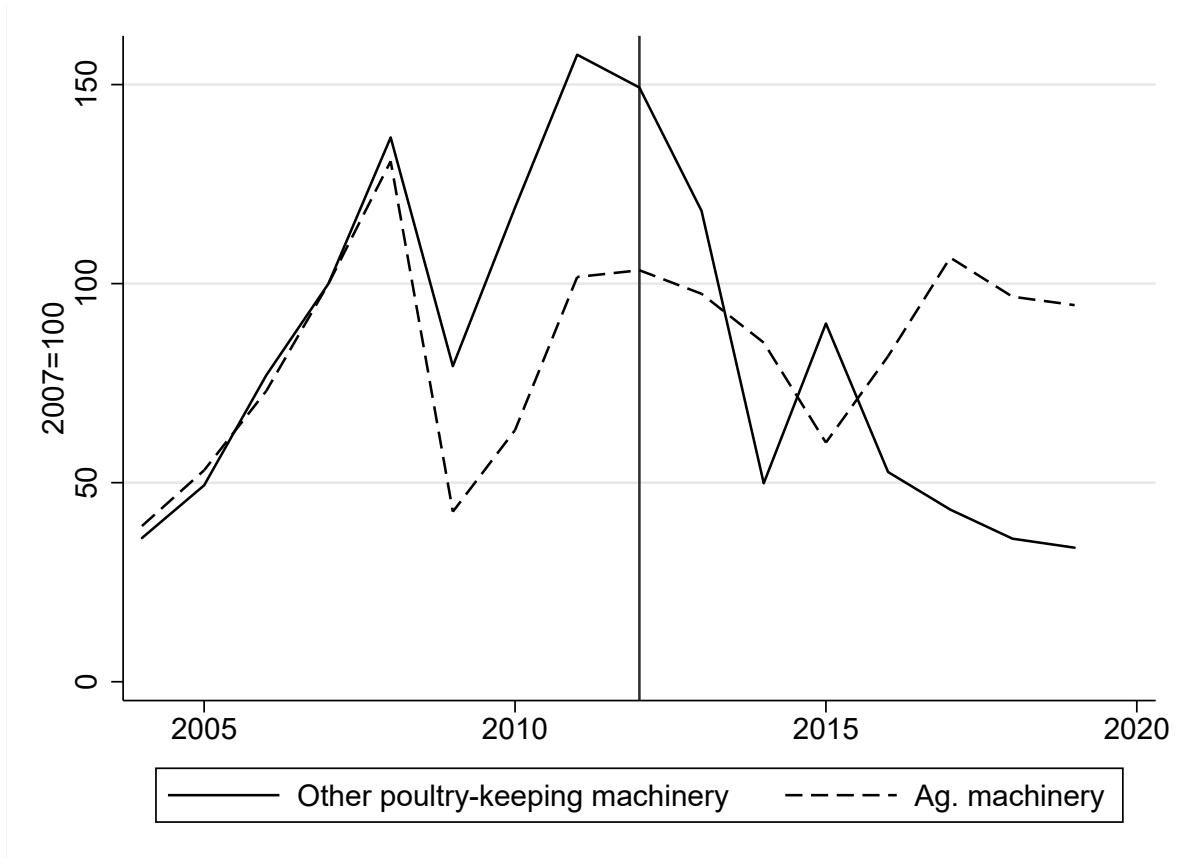


Figure A.2: Value of exports from EU to Russian Federation, treatment group and control group products, 2004–2019.
Source: BACI database