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DISCUSSION PAPER SERIES

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ABSTRACT

The Causal Effects of Enclosures on Production and Productivity

Enclosures enforced private property rights at the onset of industrialization, yet numerous estimations of the enclosures' effects on production and productivity rely on non-experimental designs. We estimate the causal effects of enclosure reforms applying state-of-the-art difference-in-differences and event-study methods to a large panel of farms observed between 1781 and 1865 in Sweden. Our results demonstrate that enclosures led to a 3.4 percent annual growth in land productivity in the first decade and overall production increase reached 82 percent after 30 years. Such results are much larger than previous estimates, suggesting that land enclosures were a prerequisite for modern economic growth.

JEL Classification: Q15, Q24, N53

Keywords: enclosures, property rights, production, agriculture, difference-in-differences, event-study

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Introduction

Enclosures were a significant part of the Agricultural Revolution and potentially of the Industrial Revolution, aiming to boost farm productivity. However, evaluations of their effects vary, and so far, there has been no solid evidence confirming their positive economic impact. Open-field systems, overruled by enclosures, had advantages like efficient labor use with small strips and economies of scale in grazing (Dahlman 1980; Fenoaltea 1976; Richardson 2003). But such system also had downsides, such as transportation inefficiencies and the spread of weeds and diseases. Enclosures were promoted through legal measures to feed growing population, although enclosures' implementation likewise came with costs, including investments in land conversion and relocation of houses (Heckscher 1941; Allen 1992). The debate over whether enclosures were truly beneficial or just land reallocations remains unsettled (Allen 1999), with attempts at addressing it with experimental designs to a limited extent (Heldring, Robinson, and Vollmer 2022).

We take a causal approach to estimate the production effects of the enclosures in Sweden. We replicate enclosures as a natural experiment by applying difference-in-differences and event-study methods under plausible assumptions, including homogeneous and heterogeneous treatment effects and unconditional and conditional parallel trends, with and without anticipation. Our rich and detailed data come from the Historical Database of Scanian Agriculture (HDSA), which includes annual follow-up information for more than 2,500 farms in Scania (known as a country's "breadbasket") between 1702 and 1881 (Olsson and Svensson 2017), representing an unprecedentedly large dataset on historical farm production from an international perspective. While enclosures were stipulated by several enclosure acts meant to abandon the open-field system, actual enclosures were implemented farm- or village-wise in different years, which the data provide. Moreover, the measures of production that we use are not based on estimates, which has often been used in previous research, but historical accounts of real crop and animal production from tithes in addition to many observable farm characteristics, including farm size, soil type, land ownership, investments in schools, and other relevant details. We follow enclosed farms for 10 years before and 30 years after enclosures took place and farms that were not enclosed in the same study period, obtaining pertinent details regarding the immediate and truly long-term effects of enclosures on production.

Our results reveal that enclosures led to a 39 percent increase in crop production in a decade and the increase in crop production reached 82 percent by the end of the third decade. Productivity growth became almost linear and reached 3.4 percent annually. In initial decade, enclosures also led to a 29 percent increase in animal production and enabled the land reclamation. In longer term, enforcement of property rights helped farmers to sustain enclosures' production effects, through investments in new efficient crop technologies and better plows and market redistribution of land to the hands of more efficient farmers. On the methodological side, every estimator that we applied elicits strong and statistically significant enclosure estimates, and we also observe that the unaccounted heterogeneity of enclosed farms has led to underestimation and misinterpretation of the enclosures' effects in canonical two-way fixed-effects regressions and subsequently recommend the use of alternative estimators in future research.

A large body of research has measured changes in production before and after enclosure acts in the early nineteenth century, implicitly interpreting these changes as enclosure effects. Due to the lack of farm-level income data, various attempts have been made to evaluate the effects of enclosures on production and productivity. According to population-based estimations, production increased annually by 1.1 percent in England and 1.2 percent in Sweden during the first half of the nineteenth century, a period of parliamentary enclosures (Overton 1996; Schön 1995). Using a demand theory approach reveals a slightly lower increase, indicating a 1.0 percent production increase per year in England (Allen 1999). When data on rents are used, production is shown to increase by 1.4 percent annually, indicating substantial improvements in farming that were not yet large enough to cause the Agricultural Revolution. According to contemporary methodological standards (de Chaisemartin and D'Haultfœuille 2022), production estimates over time are only suited for descriptive purposes because of the influences of time trends and/or multiple other factors developing over time as alternative explanations for enclosures' effects.

Another line of research has compared enclosed and non-enclosed villages at certain points in time. In parts of England in 1801, crop production in villages that were enclosed during the previous 50-year period was 11–23 percent higher than in those that became enclosed in the following 50-year period (Turner 1986). The results vary considerably depending on the type of land (Allen 1992). A study comparing enclosed and open-field farms using data from the same database that we use in this study, revealed modest effects from nineteenth-century enclosures and appearing only for farms in the woodlands, representing an annual increase of 0.4–0.8 percent over a 15–30-year period (Nyström 2019). Another study found that production was 17 percent higher in enclosed than non-enclosed villages after 10 years (Olsson and Svensson 2010). The estimates provided in previous studies are also descriptive because the farms' choice of enclosure implies the selection of farms enclosing, which introduced omitted variable bias due to the influence of observed and unobserved farm characteristics on enclosures' effects as a result.

Several recent studies have applied various causal approaches to estimate the production effects of land property rights acts. An examination of the impact of parliamentary English enclosure acts using an instrumental variable method showed a large effect on wheat production, representing a 45 percent increase (Heldring, Robinson, and Vollmer 2022). However, this effect is a local average treatment effect (i.e., the treatment effect for parishes that complied with the act) on one crop; hence, the study does not provide an answer to the question regarding the average impact of enclosures on overall production. Other studies have analyzed the impact of twentieth-century reforms made to equalize land ownership via property rights laws on production. Based on a regression discontinuity design, gains due to well-enforced property rights were shown to be persistent, as land affected by the 1934 act had 10 percent higher productivity 70 years later (Bühler 2023). Enforcement or restriction of private property rights in developing countries has also been found to impact the distribution of household wealth and farm productivity (Adamopoulos and Restuccia 2020; Galiani and Schargrodsky 2010). Therefore, the average treatment effects of enclosures on production remain unknown, and our study fills this gap in the previous research.

The enclosure reform in Sweden

In the open-field system in Sweden, cultivators in a village had many plots of land dispersed over the village area. In the mid-eighteenth century, Swedish agricultural reformists (e.g., Jacob Faggott) proposed that consolidating the plots into single units per farm would greatly enhance the possibility for more effective and productive agriculture (Utterström 1957). In some parts of Sweden, the farmers had already started exchanging plots with one another but this rested on the mutual interest of such exchanges, and these rearrangements incurred high transaction costs, particularly if villages included many landholders (Gadd 2005; Granér 2002). To solve this, the King issued the Enclosure Act of 1757, stating that the initiative of one landowner in the village was enough for the whole village to be enclosed. This act was not successful in promoting consolidated plots. In most cases, the result was that the open-field system was preserved but each farmer had fewer plots than before.

With the Enclosure Act of 1783, particularly the *Enskifte* (single unit) Act of 1803 and the *Laga Skifte* Act of 1827, the possibilities for forming consolidated units were considerably improved. With the 1803 Act, village landowners could combine their land into a single unit, and the result was most often that the entire village was enclosed. Due to the diverse natural conditions across Sweden, villages situated on the plains had an easier task of combining the land into one unit per farm, than those on land that was of very different nature (including forests, mountains, lakes, and other complex landscapes). The Act of 1827 considered this and allowed more than one unit per farm, but still broke up the open-field collective organization for cultivation. Altogether, in these enclosures, no significant transfers of wealth from one group to another took place, as they constituted rearrangements of holdings creating consolidated plots, and the costs for the enclosure were shared among the villagers.

Since most of the land in Sweden was freehold land, owned by the peasant farmers, or Crown land, owned by the State and cultivated by tenants, the reforms rested upon the active participation of the farmers themselves. For villages where all land was owned by a noble landlord, the Enclosure

Acts made no theoretical difference since landlords could already rearrange the land in whatever way they chose prior to the reforms. However, in practice, many of these villages were also enclosed according to the Enclosure Acts by means of landlords' application. In other cases, particularly in Scania, landlords evicted their tenants and enlarged the manorial domain, a feature resembling some of the early English enclosures.

Theoretical mechanisms

The purpose of the enclosure reform was to increase the agricultural production in order to provide food for the rapidly growing population. In what ways did this take place? It is useful to distinguish between direct and indirect effects of enclosures.

Starting with direct effects, enclosures lead to land reclamation, that sometimes continued over a period of time. For one of the parishes in the HDSA, the parish of Hög, we can follow the conversion of land to arable land over time using earlier estimations from land surveyors' acts. In 1804, more than two thirds of the land was arable (Svensson 2006). After the enclosure, a previously inarable land comprised of meadows began to be converted to arable land. The meadows acreage was halved, and the arable land increased to 90 percent in two decades. By the mid-nineteenth century, all land had become arable. Similar development took place in other parts of Sweden (Hoppe and Langton 1994). While the increase in arable land always led to an increase in production, it did not automatically affect land productivity.

With enclosures, the total cultivated area of the village also expanded since some of the village farmers were obliged to move out of the village to previously non-arable land. Scholars have debated whether all farmers involved gained from enclosures. One view is that farmers who relocated were likely to perform worse than those who remained. The rationale for this is that the land surveyor decided that those with inadequate houses and gardens in the village should move, which could be an indication that such households were already performing worse than others (Gadd 2005). Furthermore, in many cases, farmers who moved received land that had not been previously cultivated as arable land. As compensation, such areas were commonly larger relative to those who stayed in the village; however, since this land had to be prepared for cultivation, which was costly, as well as the possibility of lower soil fertility, such farmers could perform worse than villagers who remained (Utterström 1957).

The opposing view is that since those who took the initiative to create single unit farms during the earliest radical enclosures (1783 to 1803) had to move out of the village, it indicated that there was something to gain from moving (Gadd 2005). This previously uncultivated land could have the same soil fertility as in the rest of the village but with one important difference: it had not been cultivated but used for grazing or treated as waste; therefore, the nutrients would likely be higher. Thus, innovative farmers with capital could exploit this potential. By moving to this land, a short period of decline due to the investments required for land improvement would transition to a heightened period of production than that of those who remained on the old arable land (Utterström 1957).

Another direct effect of enclosures was that it allowed for new crop rotations to decrease the share of fallows; these changes had a long-term impact on productivity. In the eighteenth century, most farms on the plains used a three-course rotation, where one third was a fallow. With the radical enclosures, farmers introduced a more advanced crop rotation with turnips and fodder crops which decreased the share of fallow and thus increased the yearly sown acreage. Such intensification in the land use was connected to the possibilities of land reclamation since integrating fodder crops into the rotation permitted converting meadows into arable land. A further sign of intensification was that ditching became more prevalent after the enclosures, increasing the yields and the quality of the grain on the arable fields (Svensson 2006).

Even though both the land reclamation and the introduction of new crop rotations were possible in the open-field system (Allen 2009), the enclosures became necessary for their continuation. Expanding outside traditional arable village land meant that transportation costs, which had been relatively low in the open-field system, despite scattered holdings, increased drastically, thus needing a re-arrangement of plots into single units of land (Jupiter 2020). While some of the new crops were introduced before the radical enclosures (Utterström 1957; Gadd 2005), only after the enclosures the introduction of new crops became common. The introduction of new crop rotations required a substantial re-organization of village land use, possible due to the enclosures (Gadd 2005).

Turning to indirect effects, the creation of single unit farms paved the way for more developed land markets. In many countries in Europe, land markets had existed since the Middle Ages, but with restrictions and constraints (Schofield 1996; Gerard Béaur 1998). Throughout the early modern period, the market developed, coinciding with a growing general commercialization and agricultural transformation (Allen 1992). For Sweden, a well-functioning, developed land market emerged in the early 1800s (Svensson 2013). Studies from both southern and eastern Sweden have found that land was sold and bought more frequently after the enclosures than before (Hoppe and Langton 1994; Svensson 2006). The emergence of land market is also connected to the introduction of new ways of obtaining credit. Private banks, savings banks and other institutional credit lenders established in Sweden in the nineteenth century; the use of mortgage was older but increased significantly from the early nineteenth century onwards. Well-functioning land markets opened up opportunities to accumulate wealth and transfer profits because efficient farmers could accumulate land through purchases from less efficient farmers (Olsson and Svensson 2010).

Taken together, enclosures had a direct impact on production by land reclamations, new crop rotations, and increased intensification of the land use. In addition, it allowed for more developed land markets leading to profits' transfer and increasing productivity. While the effects of land reclamation and land conversion became most pronounced in production growth shortly after the enclosures, the other factors had long-lasting effects. When a potential of land expansion was reached, growth depended on the long-term investments in intensification, the choice of crops and crop rotations, and entrepreneurship of the farmers.

Area and data

Our data come from the HDSA which is based on tithe data from the southernmost province of Sweden, Scania, for the period 1702–1881 (Olsson and Svensson 2017). The province became the main surplus-producing area in Sweden in terms of grain. Grain tithes there were paid to the Crown and the church. During 1702–1881, the tithe was registered for the vicar's own purposes to administer the collection of his personal income. The vicar had a farm of his own, and therefore had direct access to information on the local harvest by both assessing his own production and by taking a few steps out of his courtyard and observing his neighbors', the tithe-payers, production.

Preserved tithe rolls are available for many parishes in Scania. Only those with a consecutive period of information longer than 20 years in the HDSA are used, and all parishes and periods within parishes, where tithes did not vary in relation to production (e.g., tithes that were fixed over consecutive years or went from yearly variations to almost fixed amounts in consecutive years are excluded). The reasoning behind fixed tithes was either that the vicar and his tithe-payers settled the tithes to fixed amounts, or that for some reason the priest decided not to check the variations in harvests for a shorter period.

The magnitude of the information in the database is extremely large, even from an international perspective, covering more than 1,000 farms per year in the early nineteenth century. The database includes data from 37 different parishes scattered across Scania (see Figure A.1 in Appendix A). These parishes were situated in all the diverse forms of geographical conditions in Scania and exhibit differences in property rights (freehold, Crown land, and land owned by nobility). The data cover the period 1702 to 1881, with a total number of tithe-paying units of around 2,500, generating more than 85,000 observations. The database presents an unbalanced sample, with farms entering and exiting the records at different times.

Internationally, a major problem with using tithes as a proxy for production has been that they do not reflect all production (Hoffman 1996). For Scania, in principle, all production is reflected in tithe payments, including that from reclaimed land. The crop tithes were collected un-threshed, in sheaves, and varied with the regional production patterns in Scania. For most farms, the staple crops rye, barley, and oats were collected, but for some farms, wheat, buckwheat, and peas or beans were also included. Information from the threshing accounts kept by tithe-collecting vicars and from estate accounts in the region is used to convert crop tithes in un-threshed sheaves into production (Olsson and Svensson 2011). Each crop's output is then multiplied with its relative price in comparison with the average price of rye and barley for each year. Potato production is added to each individual farm's production by its share of total parish crop production using parish-level statistics (Tabular Commission 1677-1899).

The HDSA also includes data on animal production (animals born). Any conversion of production from vegetable to animal or vice versa was reflected in the tithe records, which include information on the number of calves, foals, piglets, lambs, and goslings born and surviving each year. Total animal production is attained in the HDSA by converting all animals into cow units through annual price differences; a horse commanded about one and a half times a cow, while a lamb commanded about one-ninth of a cow, and geese were about one-twentieth of a cow (Jörberg 1972).

Sample

To estimate the effects of the enclosures, we use a subsample from the HDSA, restricting it based on several conditions. We limit the pre- and post-treatment periods for the enclosed farms to 11 and 30 years, respectively, which allows us to capture any pre-treatment differences in the development of the outcomes close to the enclosure event as well as estimate the effects emerging in the immediate through an extremely long term. Never-enclosed farms enter the sample for the same observation period with as many years as permitted by the data (up to 62 years). Consequently, our study period is 1781–1865 for both enclosed and non-enclosed farms, which includes all enclosures taking place from 1792 to 1853. Among the enclosed farms, we only focus on those that are observed both before and after the enclosure and for at least one year in each of these periods. Finally, we include only farms for which production data are available.

The period studied included the process of splitting farms due to increased land reclamation, turning wastelands and meadows into arable land, and increased potential to provide for more than one family, in addition to large farms selling smaller tracts to previously landless people to attach them to the main farm as labor (Gadd 2005). We opt to use the results for original farm units for the enclosed farms, excluding observations for all larger pre-split farm units before enclosure, and all pre-split farm units for the non-enclosed farms. Notably, aggregating farms that were split into single units produced similar results (available upon request).

Because of data limitations concerning animal production, we used two different samples when examining the impact of enclosures on crop and animal production. The reason for the lack of data on animals is primarily due to peasants paying a fixed number of animals each year instead of according to the number of animals born, although still paying tithes in grain based on annual production (i.e., replacing tithes with fixed money payments came earlier for animals than for grain). Table B.1 in Appendix B provides descriptive statistics for our estimation samples.

Our two samples include farms observed between 1781 and 1865. The crop sample contains 29,532 observations for 1,239 farms (8,772 farm-years/438 ever-enclosed farms and 20,760 farm-years/801 never-enclosed farms), while the animal sample is smaller, with 15,465 observations for 674 farms (5,858 farm-years/278 ever-enclosed farms and 9,607 farm-years/396 never-enclosed farms); one observation represents one year's production for one farm. Following the general unbalanced structure of the HDSA, in practice, this means that farms are observed at different lengths of time, with 16 years on average.

Previous research on the development of agricultural production in Scania has shown a rapid increase in grain production during the first half of the nineteenth century of almost 90 percent (Olsson and Svensson 2016). Our estimation using the same data indicates a similar development trajectory, which is possibly a bit more erratic due to the smaller sample size but presents an almost continuous increase (see Figure 1). As for animal production, both a previous study (Olsson and Svensson 2011) and our own data show falling production over time (by 30 percent), particularly in the 1820s to 1830s. This reduction has been related to the lesser need for draft animals with the implementation of more effective plows (Gadd 2005).

[Figure 1 is about here]

Figure 2 presents the number of enclosed and non-enclosed (i.e., never-enclosed) farms between 1781 and 1865, generally indicating that enclosure movement occurred in two waves in the periods before and after 1826, in accordance with the two different acts issued, with a more even process before and a sharper one after. We also include enclosures taking place before 1803, following the 1783 Act, although the numbers are minimal. In each year, the number of never-enclosed farms is much larger, consistent with the observation of erecting enclosures being a long-term process to complete (Olsson and Svensson 2011).

[Figure 2 is about here]

The characteristics of enclosed and non-enclosed farms differed. In Appendix C, we show the numbers of enclosed and non-enclosed farms across the range of observable economic and demographic characteristics for each year in 1781–1865. Enclosed farms were more likely to be owned by peasant farmers or sold to the manor by farmers compared with the purely manorial ownership that dominated among non-enclosed farms. This plausibly increased the incentives for efficient production regardless of whether a farm was enclosed. In addition, compared with farms in wooded areas, proprietors on the plains, whose farms were commonly large, completed enclosures earlier, creating opportunities for the economies of scale. The features of the enclosed farms are important regarding our choice of method, as we describe below.

Method

Our study endeavors to determine the causal effects of enclosures on land production and productivity. Comparing the production of enclosed farms before and after enclosure does not produce causal effects because time trends or other factors developing over time can be correlated with the effects instead of enclosures. Comparing enclosed and non-enclosed farms in a single year or period of time means that unaccounted selection and different farm compositions can drive any obtained effects. To avoid the bias due to time trends or geographical differences, we applied the difference-in-differences method.

We exploited the variation in enclosure movement both across farms and over time, with staggered timing of enclosures, and the difference-in-differences method, under reasonable assumptions, enables us to obtain enclosures' causal effects. We follow recent methodological literature that recommends using several difference-in-differences estimators (Roth et al. 2023; de Chaisemartin and D'Haultfœuille 2022). We used two sets of methods, including (1) a canonical two-way fixed effects (TWFE) estimation and (2) group–time estimation and aggregation that address unresolved biases or those additionally created by the canonical method.

We start with the TWFE specification, which is commonly used with the difference-in-differences approach:

$$Y_{ft} = \alpha + \delta_f + \lambda_t + enclosure_{ft} + \varepsilon_{ft} \quad (1)$$

where Y_{ft} is the measure of land productivity (inverse hyperbolic sine of crop or animal production) for farm f in year t. δ_f is farm fixed effects that absorb time-invariant differences in observable and unobservable farm characteristics. λ_t is year fixed effects that capture the time-varying national changes that are applicable to all farms, such as market growth or institutional changes (e.g., the abolition of the export-ban on grain or effect of the Napoleonic wars). $enclosure_{ft}$ is a binary indicator indicating a farm being enclosed in a particular year, which is a permanent state once the farm has been enclosed. In this and other specifications, we cluster standard errors at the farm level to account for within-farm correlation or heteroskedasticity.

Under common trends and homogeneity assumptions, Eq.1 produces the average treatment effect on the treated. As explained Goodman-Bacon (2021), a TWFE with staggered timing produces a weighted average of all possible 2 × 2 difference-in-differences estimators that compare treated units to each other, where the weights are proportional to the timing, sizes of the treatment groups, and the variance of the treatment indicator in each pair. As enclosure initiation varies over a 60-year period in our sample, and the size of the average farm under study at the time was 0.3 mantal, we compare outcomes at many points in time and within very small geographical units.

Because enclosed and non-enclosed farms differed and their composition changed over time, different treatment groups of farms, in the absence of enclosure, could potentially follow different development paths, which may violate parallel trends assumption. We address this potential issue by relying on the conditional parallel trends assumption, introducing a set of interactions of linear year trends with observable farm characteristics into Eq.1. Such characteristics include the type of property rights (owned by the Crown, owned by a peasant farmer, and manorial), the type of land (plains, intermediate, and forest), soil quality (referencing the metrics from Bohman 2010), mantal, cultivator's age, and distance from the village center to the main market towns and to Malmö, which is a town with a major port for grain exports. We also introduce a dummy for the availability of primary schools into Eq.1, which improved in a drastic manner across villages following the implementation of primary school reform (Klose 2011). Primary schools likely boosted literacy, which became an important characteristic of the enclosure applicants (Svensson 2006).

A canonical TWFE estimation does to guarantee to demonstrate an interpretable causal parameter. It is not robust to effects' heterogeneity over time or between units, embeds weights that might be negative, and consequently may produce estimates that are severely biased compared to the true treatment effects (Goodman-Bacon 2021; Sun and Abraham 2021; de Chaisemartin and D'Haultfœuille 2020). To obtain accurate estimates of the average treatment effects on the treatment group, we further apply a group-time estimation of the difference-in-differences effects proposed by Callaway and P. H. C. Sant'Anna (2020).

With the group-time estimator, a group is defined as a group of enclosed or never-enclosed farms in a particular year and time is a calendar year. The estimator produces the two-group-by-two-period effects separately for each group for a specific year using never-treated and not-yet-treated units for comparison, assigns non-negative weights, and aggregates the effects. Through the combination of the group–time method and the outcome regression estimator, as proposed by Heckman, Ichimura, and Todd (1997) and Callaway and P. H. C. Sant'Anna (2020), we also control for trends in observable farm characteristics.

Because enclosures' effects likely developed over time since enclosure, we estimate response dynamic effects by running an (unconditional) event-study specification of TWFE as follows:

$$Y_{ft} = \alpha + \sum_{y=-10}^{-2} \pi_y enclosure_f 1\left(t - T_f^* = y\right) + \sum_{y=0}^{29} \tau_y enclosure_f 1\left(t - T_f^* = y\right) + \delta_f + \lambda_t + \varepsilon_{ft} \quad (2)$$

The estimates characterizing the effects of enclosure are the coefficients of the interaction of $enclosure_f$ with event-year dummies, $1\left(t - T_f^* = y\right)$, which are equal to 1 when the year of observation is $y = -10, \ldots, -2, 0$ [year of enclosure], …, 29 years from T_f^*, the year of enclosure. We omit years that are far apart (−11 and −1), making nonlinear pre-trends detectable (see Borusyak, Jaravel, and Spiess 2021). We also run a conditional version of Eq.2, adding observable characteristics. The point estimates (π_y) describe the evolution of land production (productivity) in eventually enclosed farms before enclosure compared with the sample of never-enclosed farms and ever-enclosed farms in the referenced event years. Compared to the TWFE estimator of the event studies, a group-time estimator produces estimates that are free from the weighting problem and the influences of compositional changes across event years.

Results

The enclosures' effects on production

Table 1 presents the estimates for the enclosures' effects that we obtained with TWFE and group–time estimators; the effects are to be interpreted as percentages. All results indicate that the enclosures' effects are strong, positive, and statistically significant at a 99 percent confidence level. When enclosed farms are assumed to follow parallel trends, the TWFE estimates show that crop production grew by 11 percent and animal production grew by 12.9 percent on average across the enclosed farms between 1792 and 1865 (as compared to the production of enclosed farms had they not been enclosed). The effects are somewhat larger when parallel trends are assumed only for the groups of farms with similar characteristics (i.e., unconditional parallel trends). Group–time enclosures' estimates show a twice larger effects: up to 24.8 percent increase for crop production and 24.4 for animal production. The difference between the TWFE and group-time estimates is statistically significant; therefore, we should rely on the group–time estimates for the causal effects of enclosures.

[Table 1 is about here]

Figure 2 presents the event-study estimates for the enclosures' effects obtained with the TWFE estimator. The results indicate that for both crop and animal production the effects of enclosures have been dynamic. Because of enclosure, crop production increased by 22.7 percent a decade following enclosure and then doubled by the end of a third decade. Enclosure effects for animal production exhibited a different path: effects gradually rose 21 percent in a decade yet increases for later years are imprecise. The effects for the later years also become imprecise because the share of farms observed for a long time shrinks. The differential paths for crop and animal production suggest that enclosed farmers first used animals to support expanding grain production but then relied instead on more efficient crop technologies and better plows.

[Figure 2 is about here]

Figure 3 presents the estimates for dynamic enclosures' effects obtained by means of a group–time estimator. The positive effects of enclosures, again, develop over time, but their magnitudes do not exhibit constant growth, as we found with the TWFE estimates. The group-time estimates are also less precise because of more conservative standard errors. The estimates show larger effects of enclosures, revealing that crop production increased much faster in the decade since (and because of) enclosure (by 39 percent), and afterwards crop production continued to rise at a slower rate (reaching 81.5 percent by the end of the third decade). In annual terms, enclosures led to an average 3.4 percent increase in crop production in three decades after enclosure [$1.815^{1/30}$ - 1], revealing a 3.7 percent increase in the first decade and a 3.2 percent increase afterward. Animal production increased by 29 percent in the first decade. Such developments in outputs are congruent with the direct, but short-term, effect of land reclamation following the enclosures and the fact that after this growth had to rely on intensification and in-direct factors.

[Figure 3 is about here]

We also find that in case of crop production the estimates for the pre-treatment years differ between the estimators. The pre-treatment effects are important to know in order to assess the validity of the main, parallel trends assumption. Group–time estimates for such effects are small and statistically insignificant, supporting the perspective that the assumption is plausible. In contrast, TWFE estimates suggest the presence of nonlinear trends. Again, our empirical result point to the bias arising in the linear regression due to weighting, as discussed in the methodological literature (Sun and Abraham 2021), and emphasize the importance of using several difference-in-differences estimators to obtain true causal effects.

[Figure 3 is about here]

The enclosures' effects on productivity

We study further whether enclosures improved land productivity. It helps to understand a summary impact of all mechanisms laying behind the enclosure effects. Because information on farms' size (mantal) was available, we calculated farms' production per mantal as an indicator of productivity and estimated enclosures' effects using the same previously applied estimators.

The results presented in Table 2 and Figure 4 demonstrate that enclosures led to substantial growth in farms' productivity. The TWFE estimate amount to 10.8 percent increase and the group-time estimate to 20.1 percent increase under the unconditional parallel trends assumption. Conditional estimates indicate an even larger effect. Event-study estimates show almost a linear increase in land productivity over three decades, with a period of slowdown in a decade after enclosure and then, again, a rise. The aggregated and event-study results suggest that land reclamation was not the only factor behind the production growth immediately from the start of enclosure, and other factors mattered, including land intensification (new crops and rotations), farmer's entrepreneurship, and macroeconomic conditions. A productivity slowdown in a decade since enclosure implies that by that time land expansion had realized its potential; this result aligns well with our previous finding that by then the positive effects for animal production had disappeared. Because an increase in productivity became long-lasting, enclosures overall challenged the relative efficiency of the open-field system.

[Table 2 and Figure 4 are about here]

Mechanisms of the enclosures' effects

We further study the mechanisms behind the enclosure effects for production, looking at land reclamation, composition of crops, entrepreneurship, and favorable market conditions.

We have information on the relocation status of the farmer after the enclosure—whether the farmer stayed on the same farm or had to relocate their farmhouse outside the village; because of receipt of nonarable land, relocated farmers reclaimed land. As we show in Appendix D, both relocated and non-relocated obtained similarly large returns due to enclosures, revealing 20–25 percent increase in crop production. The positive effects on animal production are only precise and strong for relocated farms, with a 28.6 percent increase, which is congruent with the need for and usage of cattle for cultivating previously unused land. The pattern of event-study estimates shows delayed yet accelerating returns in grain production for relocated farms compared with non-relocated farms that experienced a gradual increase. Such results suggest that land reclamation was not the prime factor driving production growth; after moving to new and potentially more fertile land, a short period of no growth in production due to investments in land improvement transitioned into a period of much higher production.

Additional variables measuring mechanisms during the study period were available to us, such as whether the farmer introduced new crops, whether the farm was ever sold, and whether the farm belonged to the Crown or an individual farmer. For each group of farms in a separate sample, we estimated the aggregated production effects of enclosures only by means of a group-time estimator (because it is robust to heterogeneous effects across time and space) and present the results in Table 3. The production effects of enclosures are 50 percent larger for farms that introduced new crops (pointing to land intensification) or were sold to a new owner (suggesting the importance of the entrepreneurial qualities of the farmer), but such mechanisms did not operate in isolation because other farms also gained from enclosures. Only in case the farm was not in private ownership, the effects disappear. Hence, the realized opportunity to exercise private property rights, nourished with individual incentives and the development of markets, drove the lasting effects of enclosures.

[Table 3 is about here]

We further examine the role of macroeconomic factors in enclosures' production effects by grouping farms enclosed under different acts, such as the Enclosure Act 1803 (analyzed along with the 1783 act for which we had only a small number of enclosed farms) and that of 1827. The estimates for the aggregated and event-study effects are presented in Appendix E. Results based on the group–time estimates show that enclosures in both waves have yielded high returns, if measured using crop production, with somewhat larger returns in the first wave (24.4 percent in 1792–1826) than in the second wave (15.4 percent in 1827–1865). There are also positive effects for animal production for farmers enclosed in the first wave, revealing an 18.9 percent increase. Our findings align well with the observation that the markets for grain and animal products expanded during the Napoleonic wars in the 1800s to 1810s and was followed by an "agricultural depression" in the 1820s.

For the earlier enclosures, we observe increased production in pre-treatment years that might signal that not-yet-enclosed farms could be affected before the factual year of enclosure (i.e., the assumption of no anticipation is violated). It is clear that some farmers applied for enclosures directly after the Act of 1803 was issued. Many of these farmers were located in the villages which were close to the market towns and implemented early enclosures that redistributed arable strips in the village without abandoning the open field system and lowered the number of plots per farm. As a result, even non-enclosed farmers had to invest into ditching and conversion of meadows and wasteland to arable land prior to the radical enclosures.

To account for the anticipation, we rerun the estimations using the dates of enclosures assigned to the year when the first farm was enclosed in the village. Allowing for anticipation, the results presented in Appendix F are similar to the results in the main text and therefore downturn the role of gradual developments in the land use and expansion in favor of the changes brought in with the enclosure reform.

Conclusions

We apply difference-in-differences and event-study methods under plausible assumptions that replicate enclosures as a natural experiment to study the enclosures' effects on production and productivity. Our rich and detailed data are from more than 1,200 farms in southern Sweden followed annually between 1781 and 1865. The study demonstrates strong and positive effects of enclosures on both crop and animal production, with estimates indicating significant growth. The evolving impact of enclosures over time indicates changes in farming practices. Additionally, enclosures led to substantial improvements in land productivity, driven by factors beyond simple land reclamation. Mechanisms like new crop introduction and private ownership played a role in amplifying production effects. The magnitude of the enclosures' growth effects—a 3.4 percent annual increase—suggests considering enclosures as a prerequisite for industrialization.

Our analysis relies on the data for the parts of Sweden specialized in agriculture in the period of analysis, which may suggest that our large enclosure effects on land productivity may not apply to the settings of other western countries. However, there are several arguments in favor of external validity of our results. First, enclosure reforms were implemented in southern Sweden with the same motivations and procedures as in the rest of Sweden (cf. Persarvet, Erikson, and Morell 2022) and Europe (Allen 1999). Second, previous historical research on southern Sweden found that the expansion of financial borrowing and entrepreneurship, which laid in the heart of industrialization universally, accompanied enclosures (Svensson 2006). Finally, our results of the positive enclosure effects on crop production exist not only for the farmers who worked on fertile and arable land, but also for the farmers who had to reallocate to the unused and wooded lands. We therefore encourage future research to collect farm-level panel data and apply causal strategies to uncover the effects on enclosures in other industrialized or industrializing countries.

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Table 1 – Enclosures' aggregated treatment effects estimates for production.

	Crop production		**Animal production**	
	TWFE	Group-time	TWFE	Group-time
(a) Unconditional parallel trends	0.110***	0.204***	0.129***	0.131***
	(0.015)	(0.023)	(0.032)	(0.054)
(b) Conditional parallel trends	0.116***	0.248***	0.102***	0.244***
	(0.014)	(0.031)	(0.033)	(0.103)
Observations	29,532	29,532	15,465	15,465

*** p<0.01, ** p<0.05, * p<0.1

Note: The table reports aggregated treatment effect parameters under the conditional and unconditional common trends assumptions, with clustering at the farm level. The column "TWFE" reports the coefficient on $enclosure_{ft}$ from Eq1. without (unconditional) and with controls (conditional), where controls include a dummy for a schooling reform and interactions between linear time trends and observable farm characteristics. The column "Group-time" reports the weighted average (by group size) of all available group-time average treatment effects (unconditional); conditional group-time estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. For the group-time estimates, inference procedures used bootstrapped standard errors.

Table 2 – Enclosures' aggregated treatment effects estimates for productivity.

	TWFE	**Group-time**
(a) Unconditional parallel trends	0.108***	0.201***
	(0.015)	(0.022)
(b) Conditional parallel trends	0.118***	0.254***
	(0.013)	(0.029)
Observations	29,532	29,532

*** p<0.01, ** p<0.05, * p<0.1

Note: The table reports aggregated treatment effect parameters under the conditional and unconditional common trends assumptions on crop productivity. Standard errors are clustered at the farm level. For the group-time estimates, inference procedures used bootstrapped standard errors. For other details, see the note to Table 1.

Table 3 – Enclosures' group-time heterogenous treatment effects for production.

	New crops		**Land sold**		**Property rights**		
	Never	Ever	Never	Ever	Crown	Manorial	Freehold
Unconditional	0.127**	0.209***	0.141***	0.211***	-0.016	0.051	0.198***
parallel trends	(0.059)	(0.024)	(0.039)	(0.027)	(0.052)	(0.065)	(0.031)
Conditional	0.145*	0.245***	0.116**	0.267***	-0.043	0.105	0.254***
parallel trends	(0.086)	(0.031)	(0.046)	(0.036)	(0.052)	(0.065)	(0.045)
Observations	3,222	26,310	4,511	25,021	3,156	15,447	10,899

*** p<0.01, ** p<0.05, * p<0.1

Note: The table reports aggregated treatment effect parameters estimated with a group-time estimator under the conditional and unconditional common trends assumptions for crop production. Standard errors are clustered at the farm level. For the group-time estimates, inference procedures used bootstrapped standard errors. For other details, see the note to Table 1.

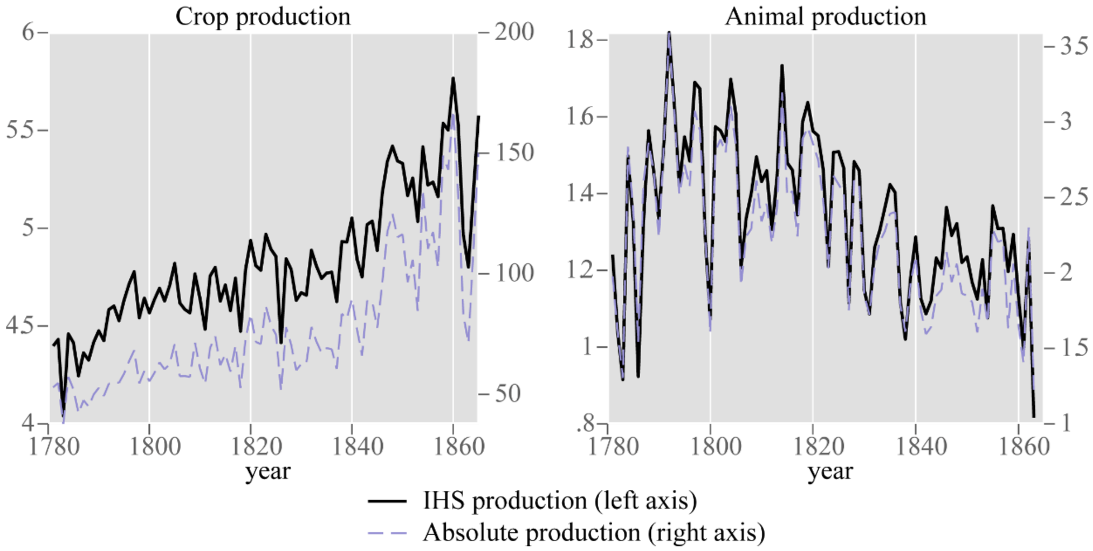


Figure 1 – Development of productivity in Scanian parishes between 1781 and 1865

Source: Own calculations from the HDSA based on the estimation sample.

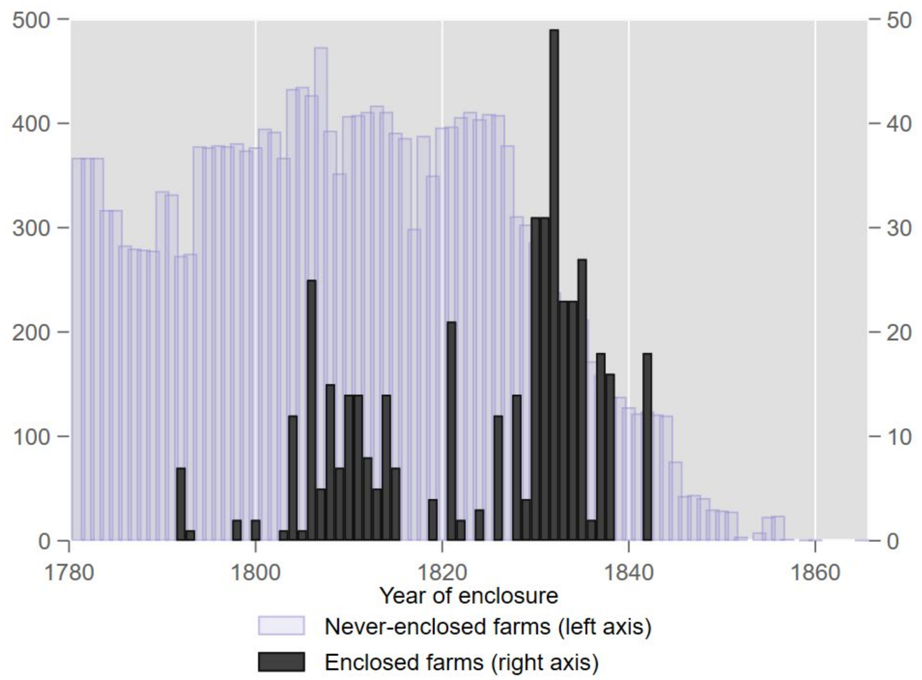


Figure 2 – Entry to enclosure in Scanian parishes between 1781 and 1865

Source: Own calculations from the HDSA based on the estimation sample.

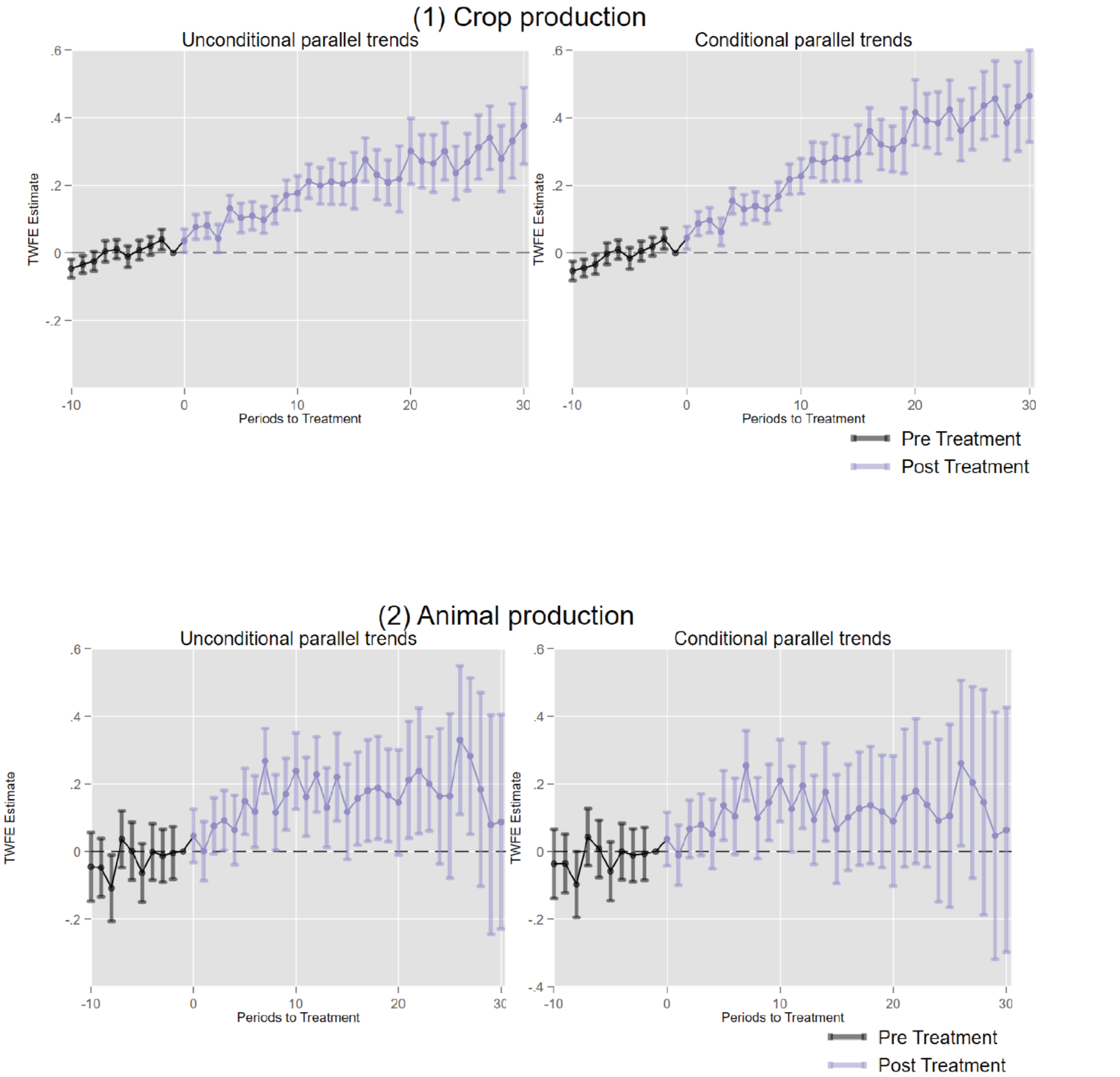


Figure 2 – Enclosures' TWFE event-study estimates.

Notes: The figure reports event-study treatment effect parameters estimated with a TWFE estimator under the conditional and unconditional common trends assumptions, with clustering at the farm level. (1) reports unconditional estimates obtained from Eq.2, and (2) reports conditional estimates obtained from Eq.2 with additional controls, such as a dummy for a schooling reform and interactions between linear time trends and observable farm characteristics. Event-years -11 and -1 are reference years.

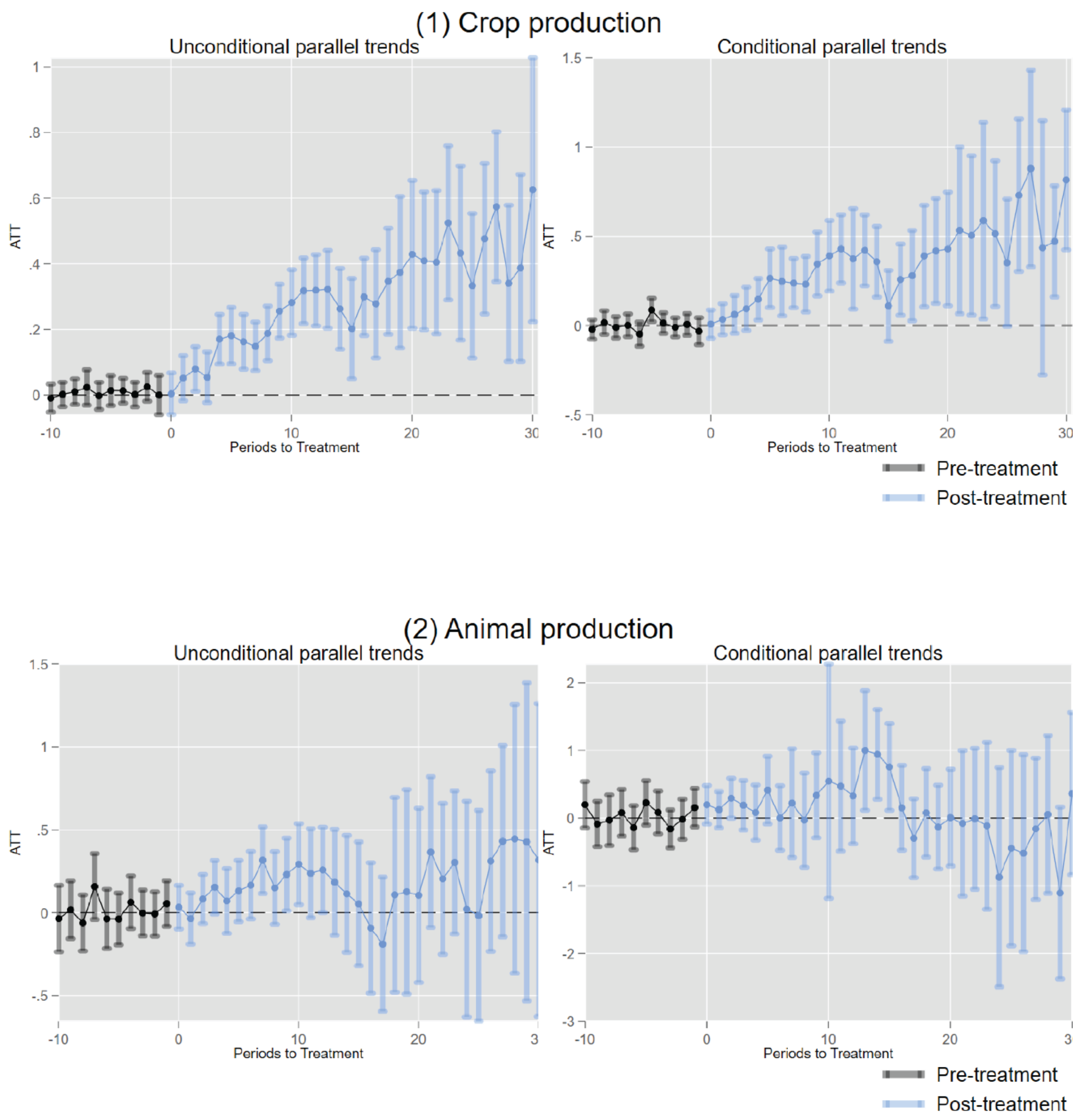


Figure 3 – Enclosures' group-time event-study estimates.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions, with clustering at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. Inference procedures used bootstrapped standard errors.

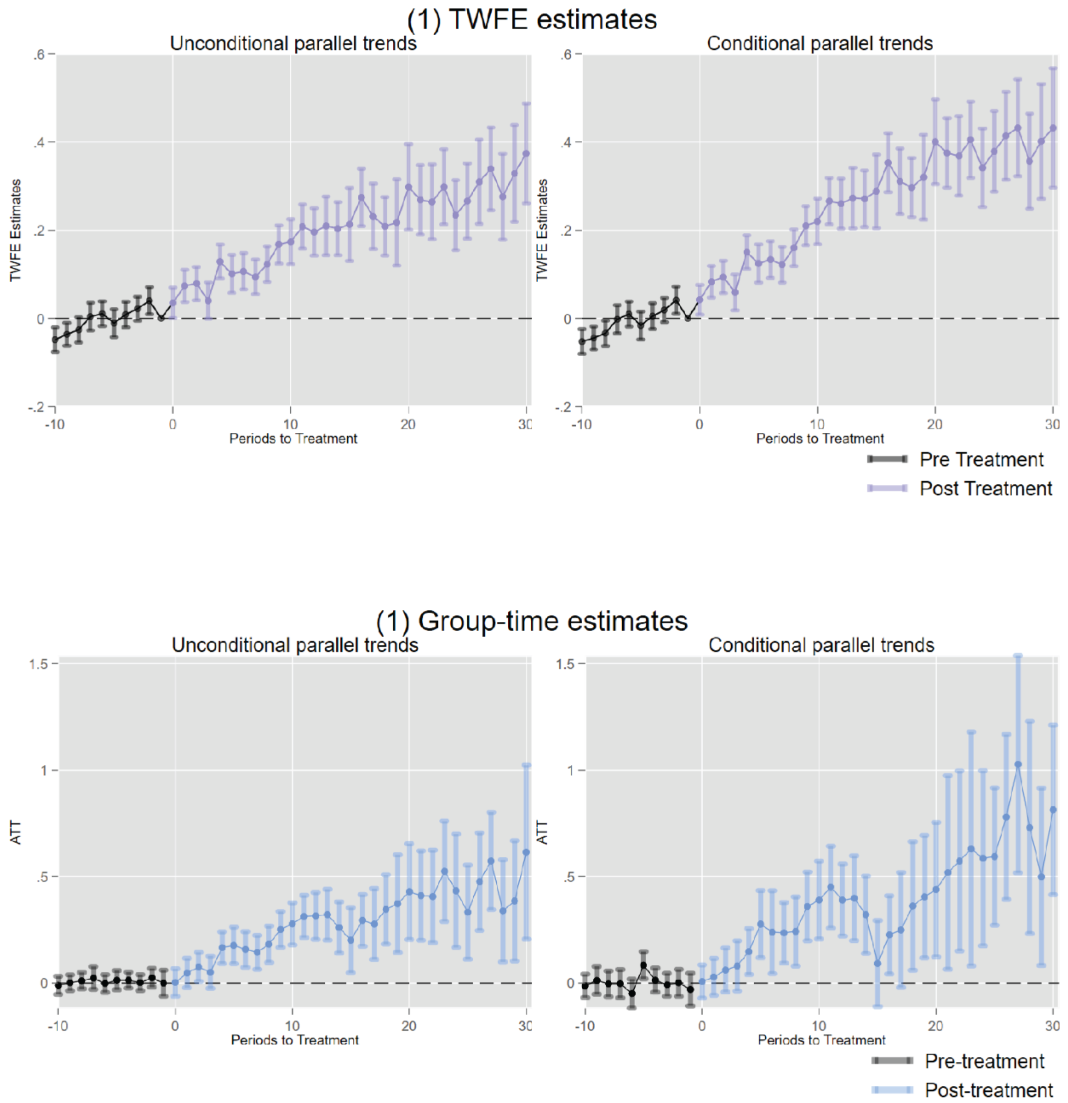


Figure 4 – Enclosures' event-study estimates for productivity.

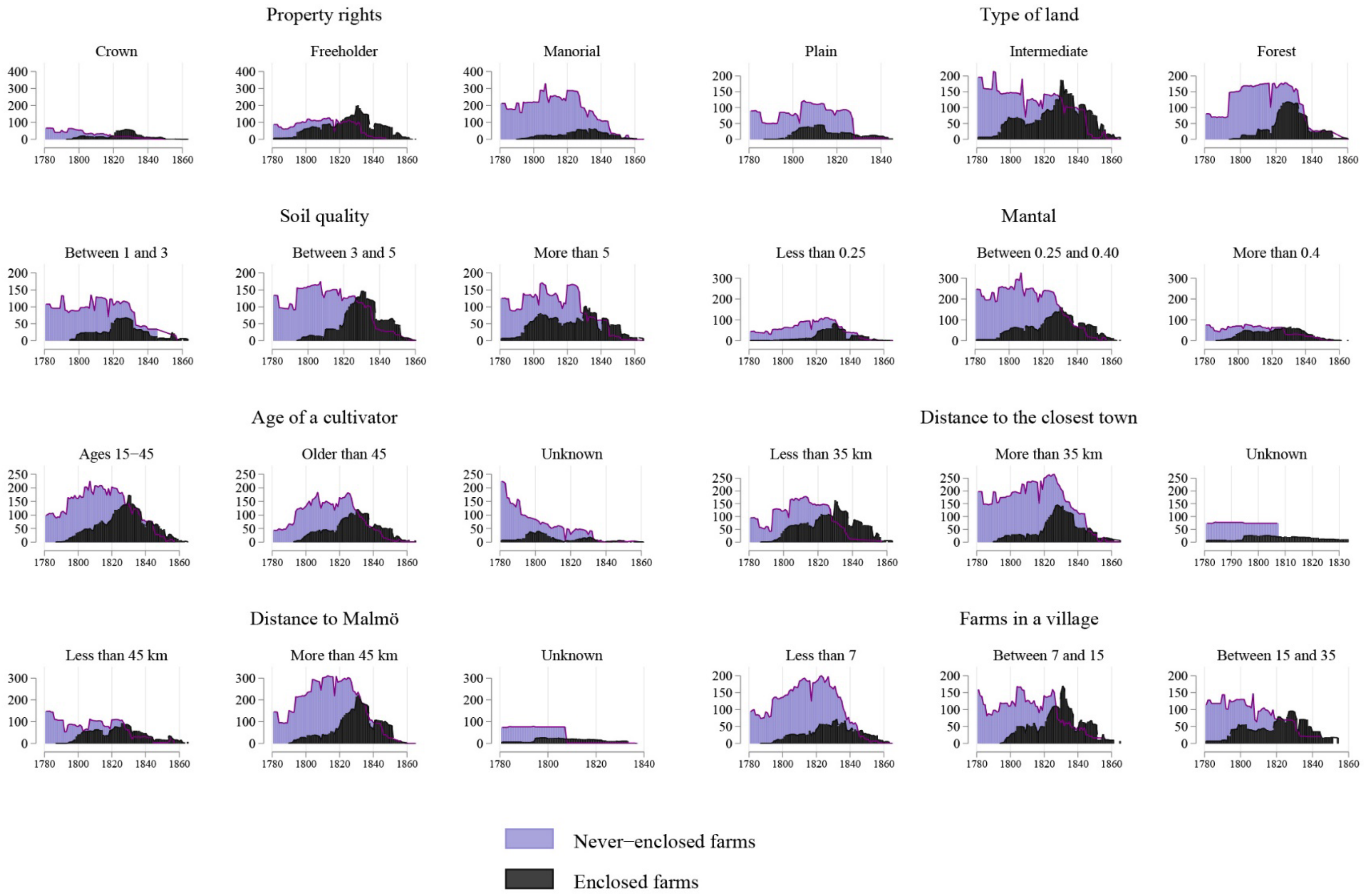
Notes: The figure reports event-study treatment effect parameters under the conditional (1) and unconditional (2) common trends assumptions on crop productivity, with clustering at the farm level. The TWFE event-study estimates are obtained according to Eq.2 without and with controls (excluding mantal), with event-years -11 and -1 as reference years. The group-time event-study estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. Inference procedures used bootstrapped standard errors.

Appendix A – Parishes in the HDSA

Appendix B – Descriptive statistics for the estimation samples.

	Grain production sample			Animal production sample		
	N	Mean	SD	N	Mean	SD
IHS grain production	29532	4.698	0.631			
IHS animal production				15465	1.376	0.716
$enclosure_{ft}$	29532	0.169	0.375	15465	0.236	0.425
mandatory $schooling_{ft}$	29532	0.332	0.471	15465	0.471	0.499
Type of property rights						
crown	29532	0.107	0.309	15465	0.072	0.259
freeholder	29532	0.369	0.483	15465	0.375	0.484
manorial	29532	0.524	0.499	15465	0.553	0.497
Type of land						
plains	29532	0.174	0.379	15465	0.098	0.297
intermediate	29532	0.461	0.499	15465	0.556	0.497
forest	29532	0.364	0.481	15465	0.347	0.476
Soil quality						
≥1-<3	29532	0.263	0.440	15465	0.200	0.400
≥3-<5	29532	0.368	0.482	15465	0.427	0.495
≥5	29532	0.369	0.483	15465	0.373	0.484
Mantal						
≥0.01-<0.25	29532	0.198	0.399	15465	0.209	0.406
≥0.25-<0.40	29532	0.606	0.489	15465	0.600	0.490
≥0.40	29532	0.196	0.397	15465	0.192	0.394
Age of a cultivator						
≥15-<45	29532	0.471	0.499	15465	0.506	0.500
≥45	29532	0.351	0.477	15465	0.394	0.489
Unknown	29532	0.178	0.382	15465	0.100	0.299
Distance to the closest town						
≥1-<35 km	29532	0.375	0.484	15465	0.467	0.499
≥35 km	29532	0.530	0.499	15465	0.483	0.500
unknown	29532	0.096	0.294	15465	0.050	0.217
Distance to Malmö						
≥1-<45 km	29532	0.275	0.446	15465	0.273	0.446
≥45 km	29532	0.627	0.484	15465	0.672	0.470
unknown	29532	0.099	0.298	15465	0.055	0.228
Num. of farms in a village						
≥1-<7	29532	0.366	0.482	15465	0.377	0.485
≥7-<15	29532	0.350	0.477	15465	0.396	0.489
≥15	29532	0.284	0.451	15465	0.227	0.419

Appendix C – Number of enclosed and never-enclosed farms across observable characteristics in 1781–1865.



Source: Own calculations from the HDSA based on the estimation sample.

Appendix D – Enclosures' treatment effects estimates for the relocated and non-relocated farms.

Table – Enclosures' aggregated treatment effects estimates for relocated and non-relocated farms.

	Non-relocated				**Relocated**			
	Crop production		*Animal production*		*Crop production*		*Animal production*	
	TWFE	Group-time	TWFE	Group-time	TWFE	Group-time	TWFE	Group-time
(a) Unconditional parallel trends	0.136***	0.197***	0.086*	0.120***	0.100***	0.213***	0.185***	0.149*
	(0.021)	(0.030)	(0.041)	(0.057)	(0.021)	(0.032)	(0.044)	(0.077)
(b) Conditional parallel trends	0.152***	0.250***	0.060	0.199	0.127***	0.244***	0.169***	0.286***
	(0.018)	(0.041)	(0.040)	(0.115)	(0.021)	(0.041)	(0.047)	(0.131)

Note: The table reports aggregated treatment effect parameters under the conditional and unconditional common trends assumptions for farms relocated and non-relocated because of enclosures, with clustering at the farm level. The column "TWFE" reports the coefficient on $enclosure_{ft}$ from Eq1. without (unconditional) and with controls (conditional), where controls include a dummy for a schooling reform and interactions between linear time trends and observable farm characteristics. The column "Group-time" reports the weighted average (by group size) of all available group-time average treatment effects (unconditional); conditional group-time estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. For the group-time estimates, inference procedures used bootstrapped standard errors.

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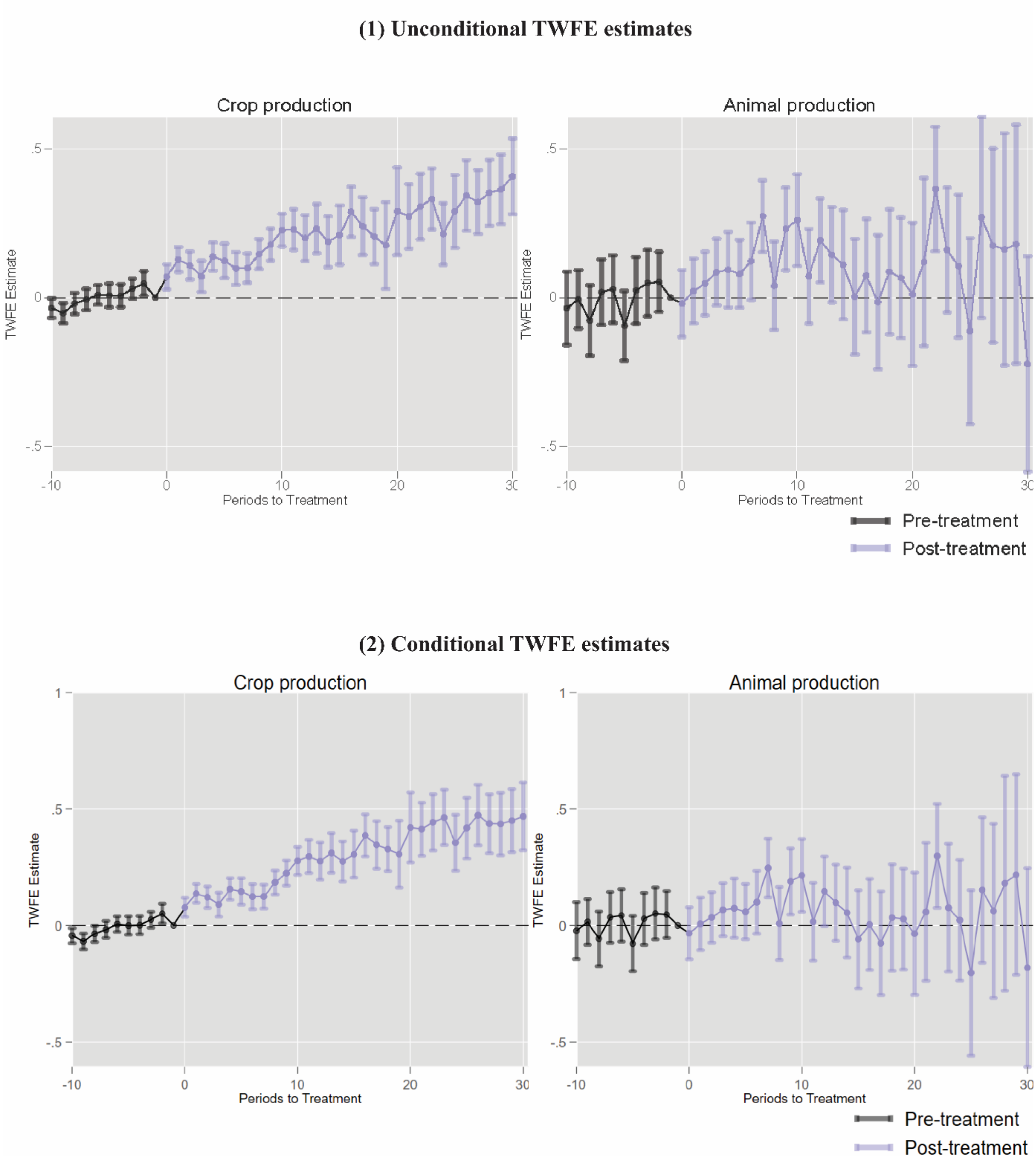

Figure D1 – TWFE estimates for non-relocated farms.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions for farms non-relocated because of enclosures. Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

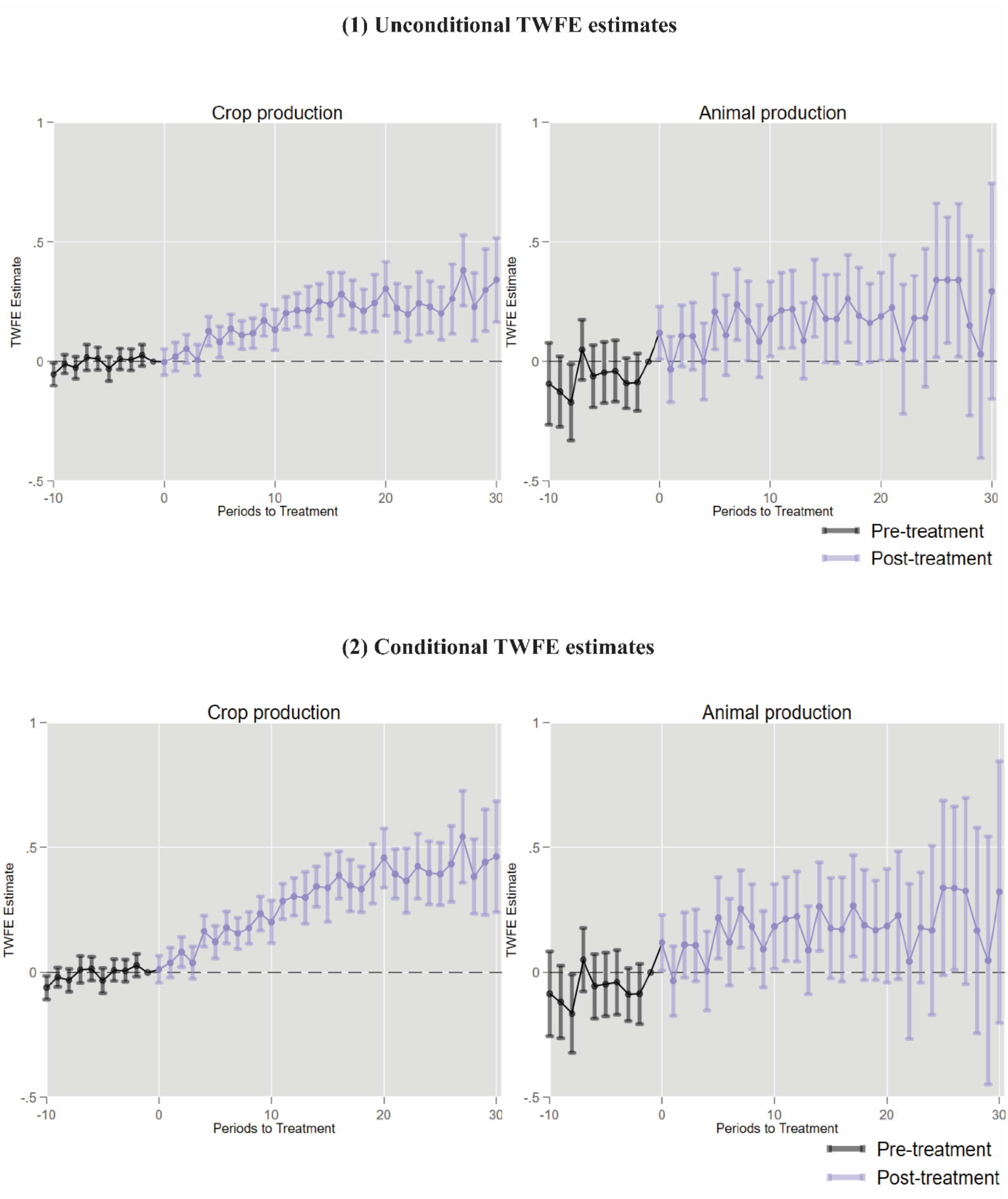

Figure D2 – TWFE estimates for relocated farms.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions for farms relocated because of enclosures. Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

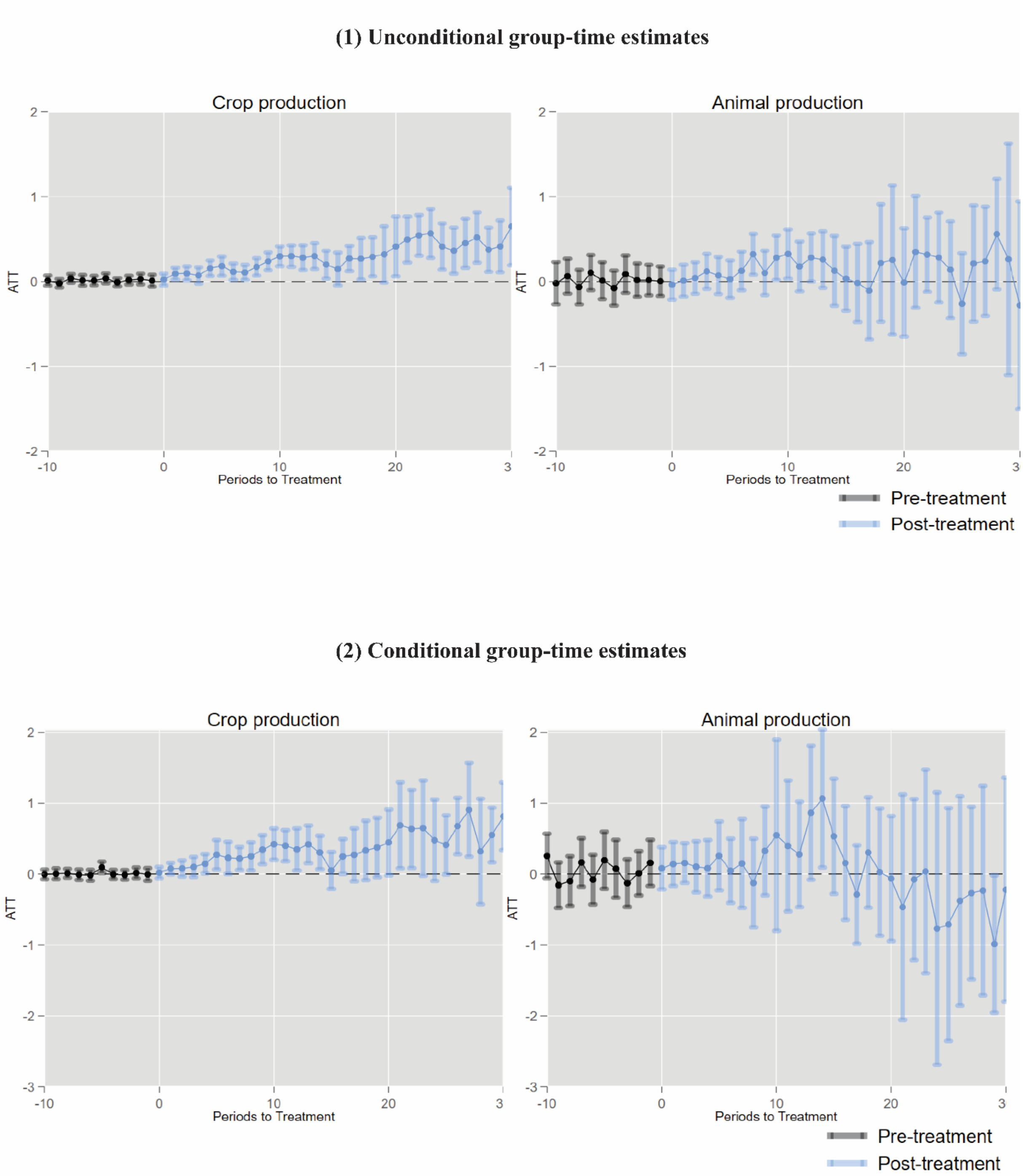

Figure D3 – Group-time estimates for non-relocated farms.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions for farms non-relocated because of enclosures. Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

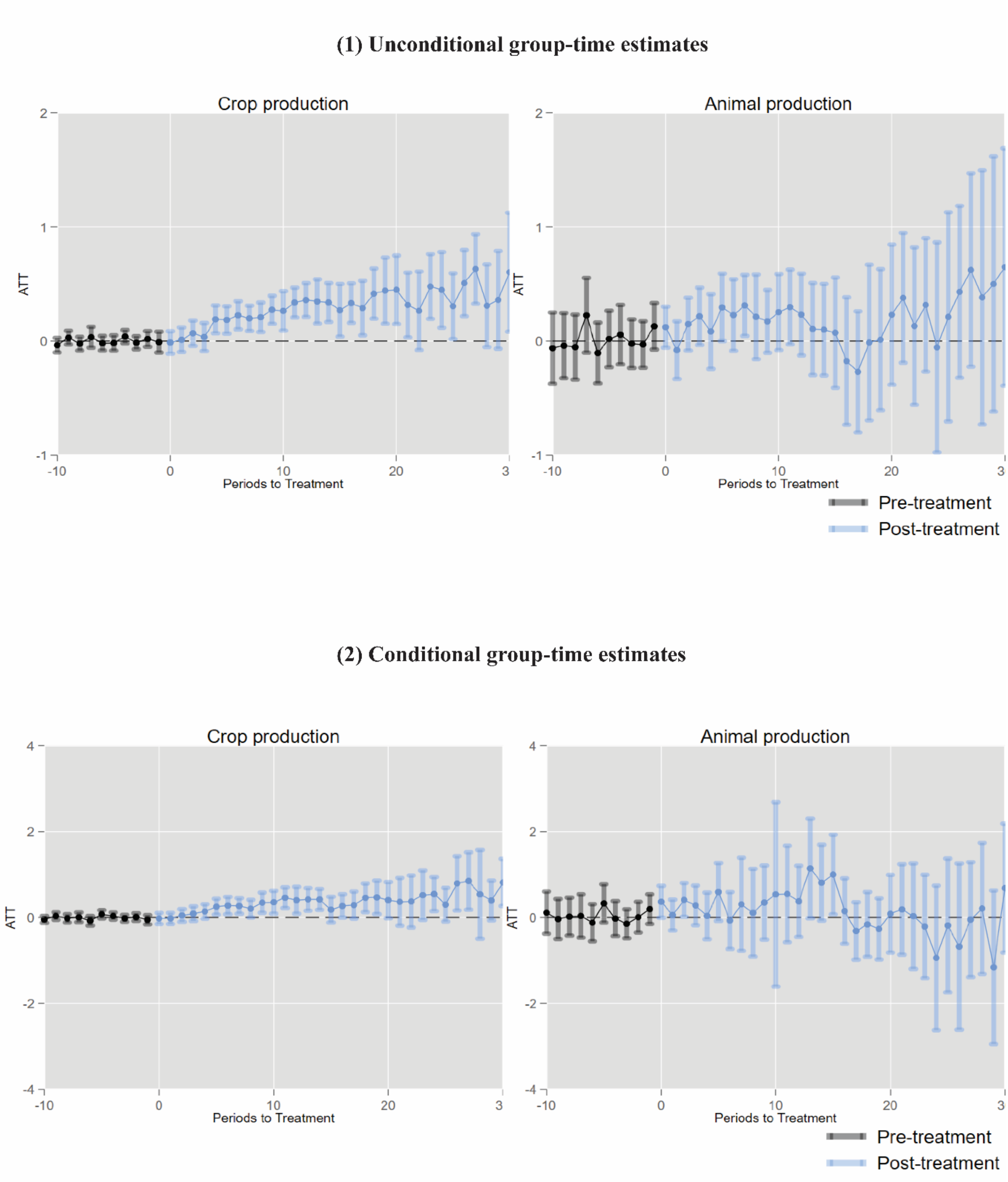

Figure D4 – Group-time estimates for relocated farms.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions for farms relocated because of enclosures. Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

Appendix E – Enclosures' treatment effects estimates for the farms enclosed according to different enclosure acts.

Table – Enclosures' aggregated treatment effects estimates by the enclosure wave.

	Enclosure Act 1783 and 1803				**Enclosure Act 1827**			
	Crop production		*Animal production*		*Crop production*		*Animal production*	
	TWFE	Group-time	TWFE	Group-time	TWFE	Group-time	TWFE	Group-time
(a) Unconditional parallel trends	0.161***	0.244***	0.178**	0.189***	0.054**	0.154***	0.067*	0.089
	(0.023)	(0.035)	(0.052)	(0.083)	(0.016)	(0.026)	(0.033)	(0.061)
(b) Conditional parallel trends	0.172***	0.277***	0.095	0.059	0.067***	0.215***	0.074*	0.385***
	(0.021)	(0.045)	(0.060)	(0.157)	(0.017)	(0.037)	(0.033)	(0.122)

Note: The table reports aggregated treatment effect parameters under the conditional and unconditional common trends assumptions for farms enclosed according to different acts, with clustering at the farm level. The column "TWFE" reports the coefficient on $enclosure_{ft}$ from Eq1. without (unconditional) and with controls (conditional), where controls include a dummy for a schooling reform and interactions between linear time trends and observable farm characteristics. The column "Group-time" reports the weighted average (by group size) of all available group-time average treatment effects (unconditional); conditional group-time estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. For the group-time estimates, inference procedures used bootstrapped standard errors.

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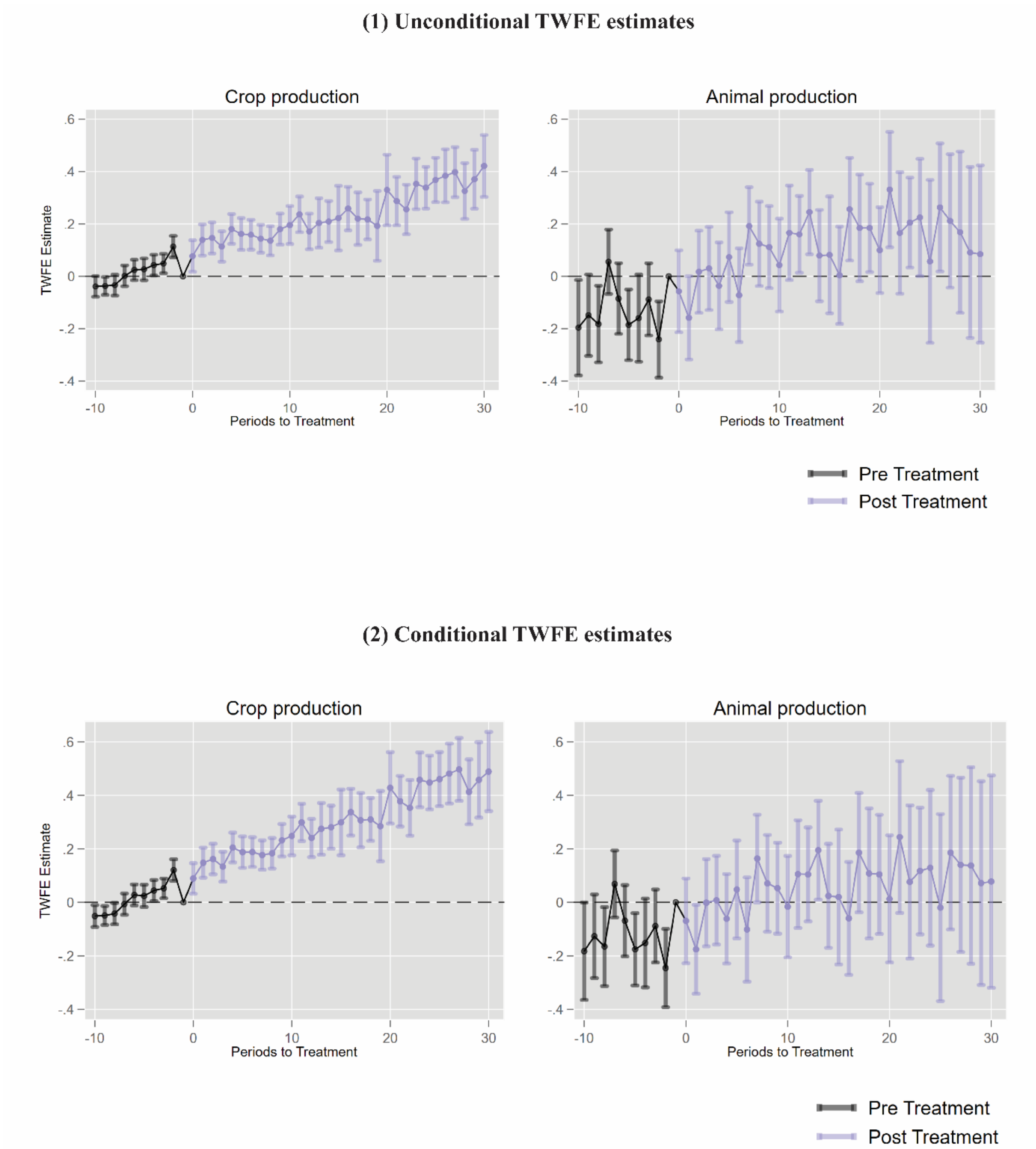


Figure E1 – TWFE estimates: farms enclosed according to the acts 1783 and 1803.

Notes: The figure reports event-study treatment effect parameters estimated with a TWFE estimator under the conditional and unconditional common trends assumptions where enclosure year does not exceed 1826 or not available (for never-treated farms), with clustering at the farm level. (1) reports unconditional estimates obtained from Eq.2, and (2) reports conditional estimates obtained from Eq.2 with additional controls, such as a dummy for a schooling reform and interactions between linear time trends and observable farm charactersitics. Event-years -11 and -1 are reference years.

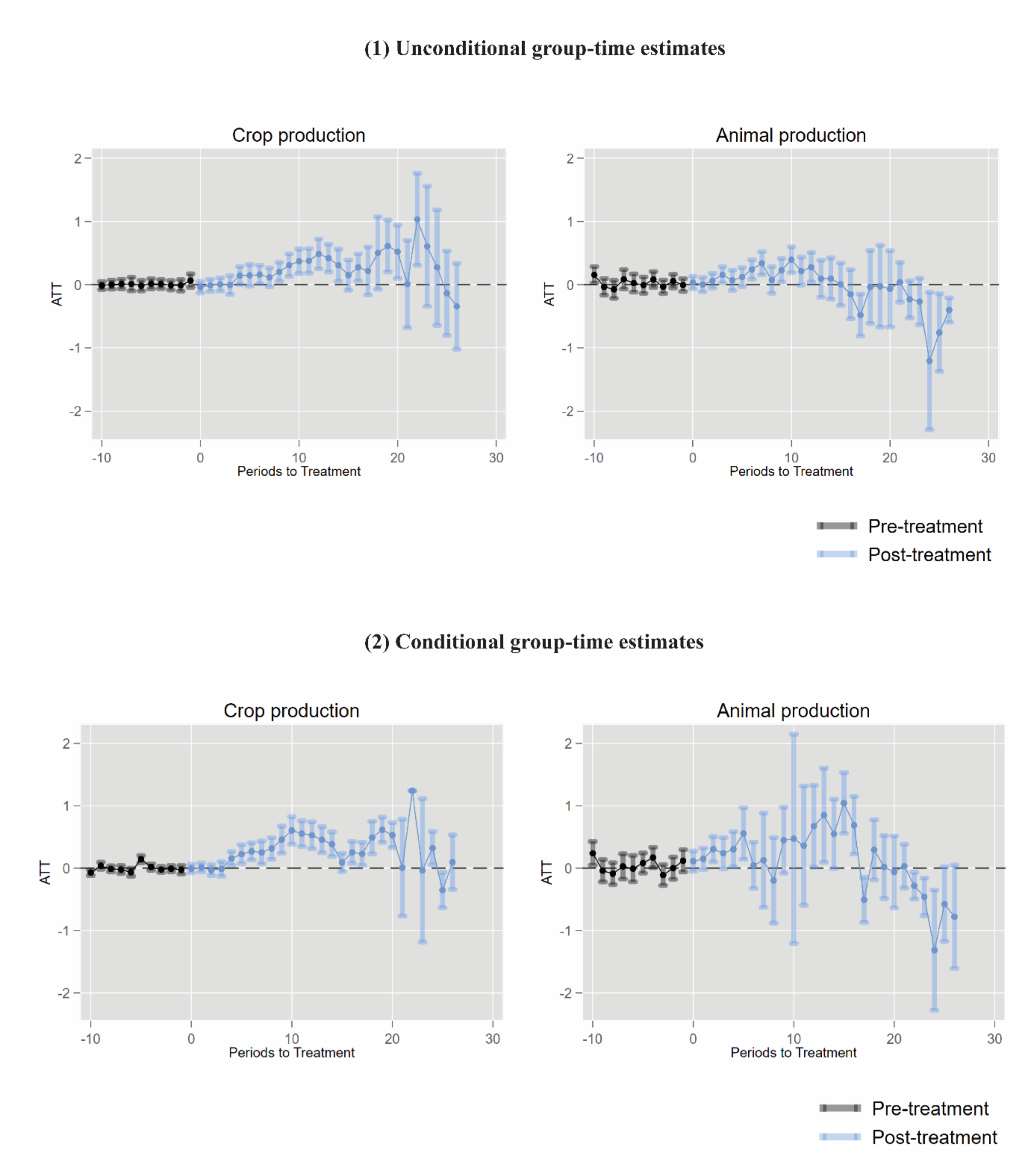


Figure E2 – Group-time estimates: farms enclosed according to the acts 1783 and 1803.
Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions where enclosure year does not exceed 1826 or not available (for never-treated farms), with clustering at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

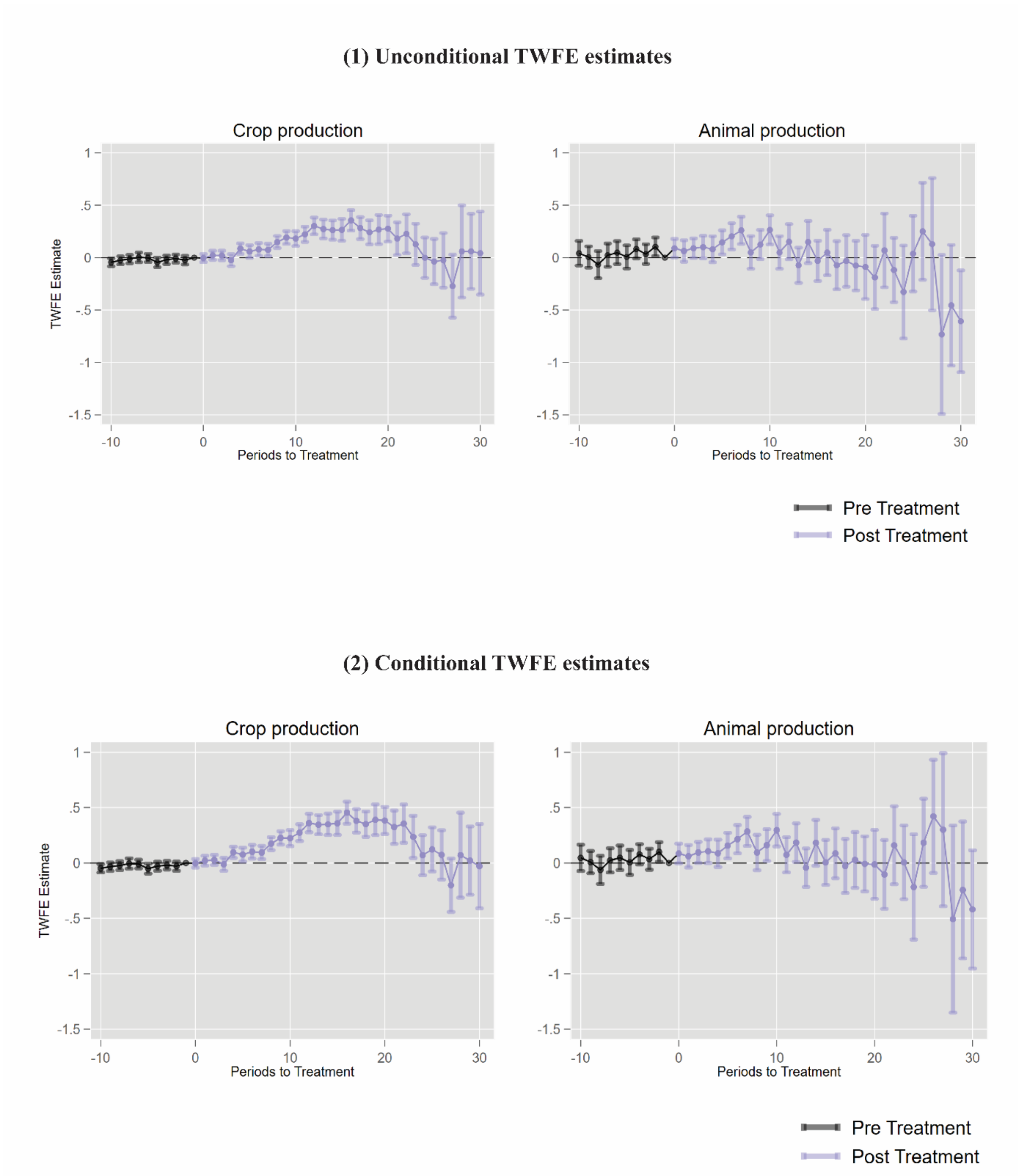
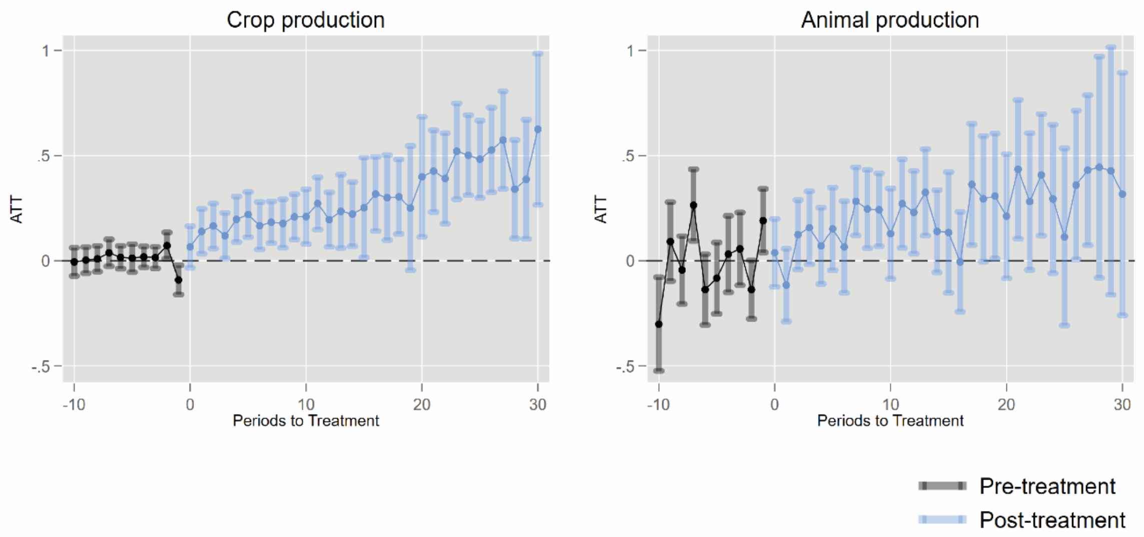


Figure E3 – TWFE estimates: farms enclosed according to the 1827 act.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions where enclosure year exceeds 1826 or not available (for never-treated farms), with clustering at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

(1) Unconditional group-time estimates



(2) Conditional group-time estimates

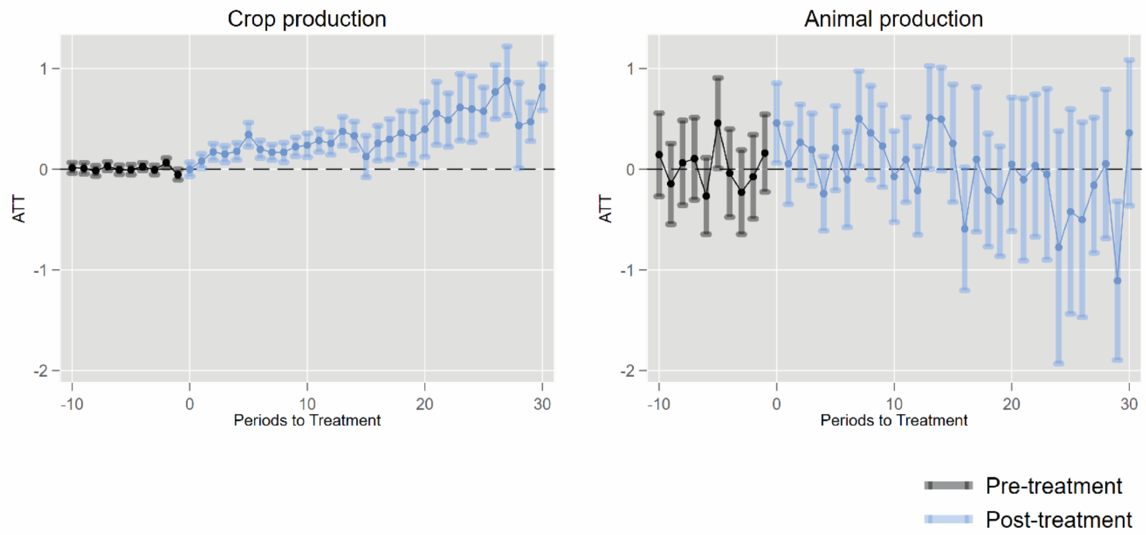


Figure E4 – Group-time estimates: farms enclosed according to the 1827 act.
Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions where enclosure year exceeds 1826 or not available (for never-treated farms), with clustering at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with observable farm charactersitics as controls. The dummy for a schooling reform is not included because of no variation in the schooling dummy after 1842 (i.e., from this year every parish had a school). Inference procedures used bootstrapped standard errors.

Appendix F – Enclosures' treatment effects estimates with anticipation.

Table – Enclosures' aggregated treatment effects estimates with anticipation.

	Crop production		**Animal production**	
	TWFE	Group-time	TWFE	Group-time
(a) Unconditional parallel trends	0.085***	0.155***	0.104**	0.142***
	(0.013)	(0.021)	(0.032)	(0.049)
(b) Conditional parallel trends	0.101***	0.176***	0.083*	0.303***
	(0.012)	(0.027)	(0.035)	(0.118)

Note: The table reports aggregated treatment effect parameters under the conditional and unconditional common trends assumptions with anticipation (where $enclosure_{ft}$ has been assigned across the treated farms to the year when the first farm in the village was enclosed). The column "TWFE" reports the coefficient on $enclosure_{ft}$ from Eq1. without (unconditional) and with controls (conditional), where controls include a dummy for a schooling reform and interactions between linear time trends and observable farm characteristics. The column "Group-time" reports the weighted average (by group size) of all available group-time average treatment effects (unconditional); conditional group-time estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm characteristics as controls. For the group-time estimates, inference procedures used bootstrapped standard errors.

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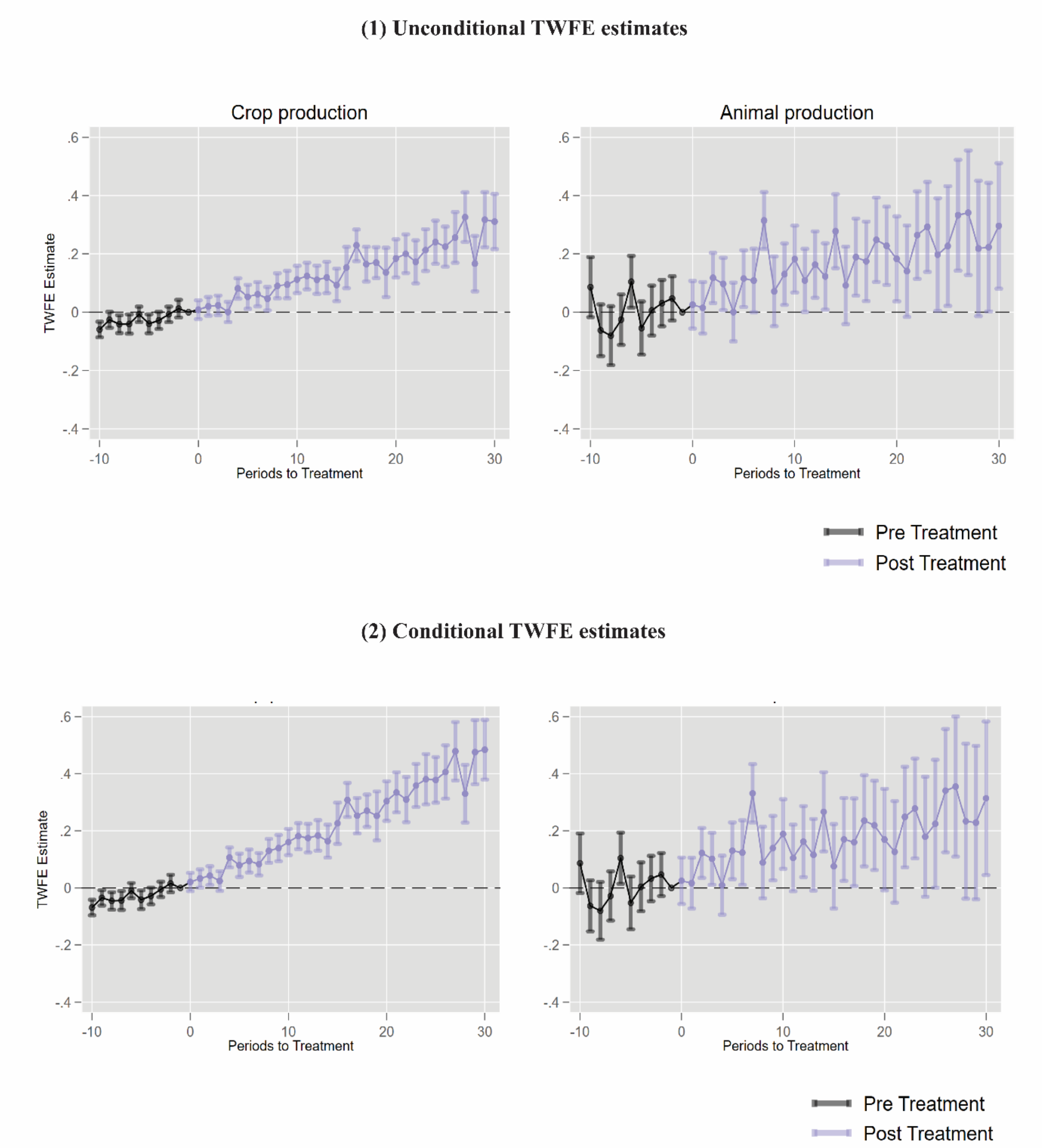

Figure F1 – TWFE estimates with anticipation.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions and with anticipation (where $enclosure_{ft}$ has been assigned across the treated farms to the year when the first farm in the village was enclosed). Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.

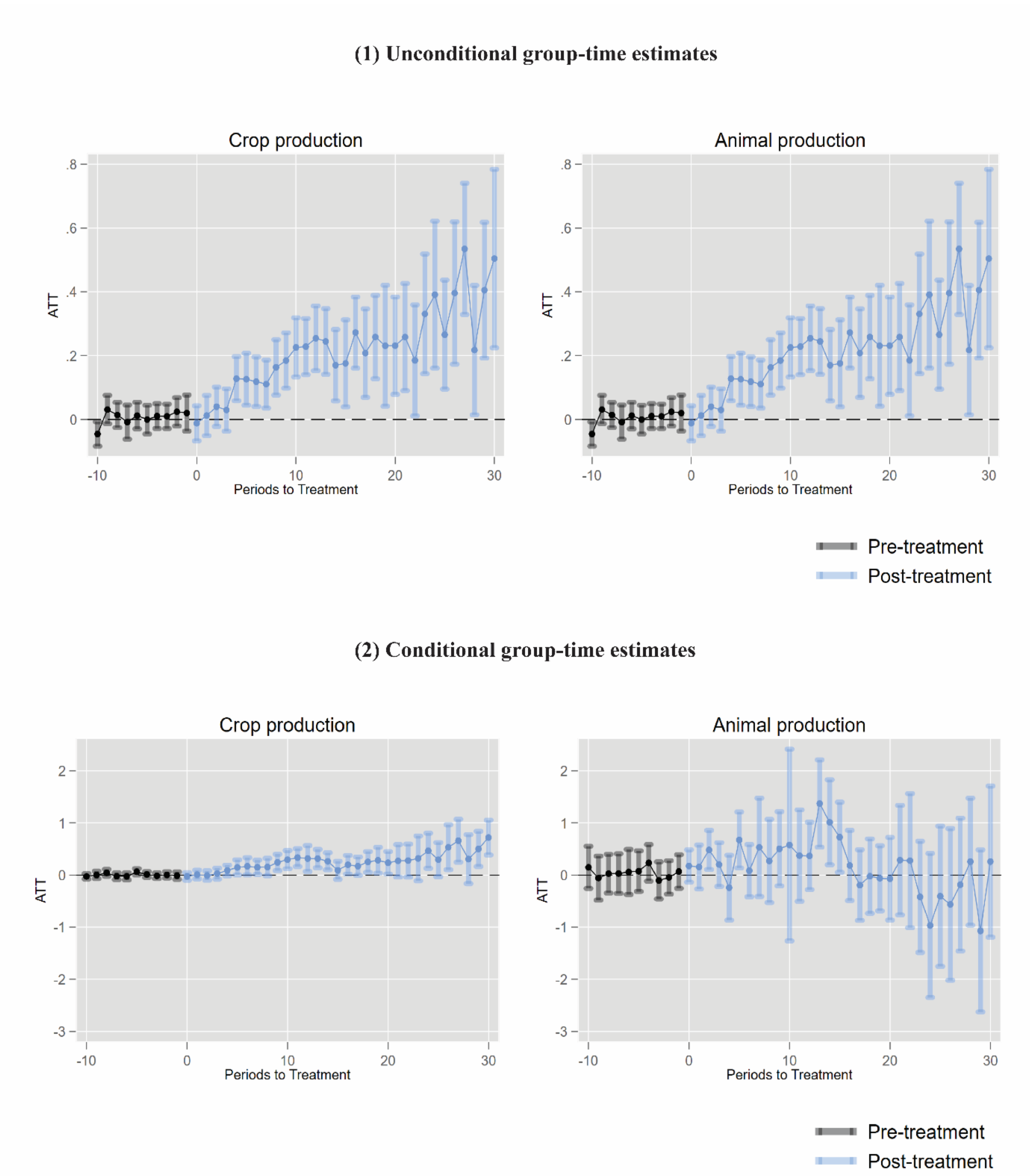

Figure F2 – Group-time estimates with anticipation.

Notes: The figure reports event-study treatment effect parameters estimated with a group-time estimator under the conditional (1) and unconditional (2) common trends assumptions and with anticipation (where $enclosure_{ft}$ has been assigned across the treated farms to the year when the first farm in the village was enclosed). Standard errors are clustered at the farm level. The estimates report the weighted average (by group size) of all available group-time average treatment effects by the length of exposure to enclosure (unconditional); conditional estimates report the estimates from the outcome regression estimator with a dummy for a schooling reform and observable farm charactersitics as controls. Inference procedures used bootstrapped standard errors.