In a nutshell

• Land fragmentation is believed to be detrimental to agricultural productivity, specially by misusing, impeding or delaying the adoption of new technologies.

• Land consolidation programs aim at redesigning the cadastre, so that the new plots are less numerous, larger and closer together and to the main farm holdings, making mechanized agriculture more efficient.

• We study the impact of a major French land consolidation program on tractor adoption and farm size.

• We do not find a detectable impact of land consolidation on the adoption of this new technology nor on the concentration process of the agricultural sector.
Why is it important?

Consequences of a fragmented land

- Increase transportation costs
- Decrease the actual amount of land used
- Restrictions to human, machinery, and irrigation access
- Increase labor costs

Therefore, land consolidation might

- Trigger tractor adoption
- Increase farm productivity or output
- Release agricultural labor to nonfarm sectors
- In the long run, facilitate the expansion of farmers holdings
Why is it new?

- Land reallocation events are in general for redistributive reasons: Adamopoulos and Restuccia (2014), Kitamura (2016)
- If so, Land consolidation can increase agricultural productivity and possibly trigger Structural Transformation: Bustos et al. (2014), Nguyen (2014)
- Causes of market frictions and land allocation: Bleakley and Ferrie (2014), Blarel et al. (1992)
In this paper

• We take advantage of a Natural experiment in the setting of the French land consolidation reform.


• Differences-in-Differences (DID) approach exploiting the different timing of the adoption.

• We study the effects on tractor adoption and farm size.

• Our results enable us to rule out that land consolidation has increased farm size by more than 0.1% and tractor adoption by 0.01 tractor per farm.
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Tipping point: the Law of 1941

- Any individual owner, tenant or administrative body can ask the Prefet to start a procedure of land consolidation in a commune. If accepted,
  - The commission selects the perimeter to reallocate
  - All the plots and their owners are listed
  - Each plot is attributed to a quality class
  - New lanes are decided
  - The new lanes define the contours of the new plots
  - The geometer selects for each owner new plots closer to his farm and as contiguous as possible
  - Each owner’s final endowment equals his initial one

Between 1945 and 2008, 18 millions ha of agricultural land changed hands in France thanks to land consolidation.
Visual evidence

Images from the documentary “Adieu Paysans”.
Outcome variables: Agricultural censuses

(a) Farm size (in ha)  
(b) Tractors per farm

Figure: Distribution across communes
Data on Land consolidation

- Dataset on 22,374 land consolidation events since 1945
  - Commune ID
  - Date of formation of the commission
  - Date of notification to geometer
  - Date of notification of the final allocation
  - Area of the land consolidation event
  - Number of owners
  - Number of plots before and after
Land consolidation events over time

(a) Number of land consolidation events

(b) Map of the land consolidation events
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Difference in Differences

\[ Y_{c,t} = \mu_c + \delta_t + \alpha D_{c,t} + \epsilon_{c,t} \]  \hspace{1cm} (1)

- We exploit the repeated observation of the same commune over time.
- The treatment is exogenous conditional on the commune fixed effect.
- Several periods and Treatment groups allow us to test the validity of our identification assumptions and long run effects:

\[ Y_{c,t} = \mu_c + \delta_t + \sum_{t=1}^{T} \sum_{i=1}^{N} \alpha_{it} D_{it} + \epsilon_{c,t}, \]  \hspace{1cm} (2)

- \( D_{it} \) takes value one, for a given year \( t \), if the commune will reallocate after date \( i \) and zero otherwise.
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### Plot size: Evidence from later events

<table>
<thead>
<tr>
<th></th>
<th>Intercept (mean before)</th>
<th>Treatment (difference before-after)</th>
<th>N</th>
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<tbody>
<tr>
<td>Plot size</td>
<td>0.78***</td>
<td>1.34***</td>
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<td></td>
<td>(0.14)</td>
<td>(0.20)</td>
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<tr>
<td>Number of plots</td>
<td>1782.58***</td>
<td>-1231.11***</td>
<td>868.00</td>
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<tr>
<td></td>
<td>(58.79)</td>
<td>(83.14)</td>
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</table>

**Figure:** quantile regression
Farm size: Defining the optimal treatment group

Figure: Farm size: Trends and counterfactuals of the different treatment groups

(a) Not treated as control

(b) T00-10 as control
Farm size: DID results using T00-10 as controls

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>T55-70</td>
<td>0.014</td>
<td>-0.006</td>
<td>-0.021</td>
<td>-0.016</td>
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<tr>
<td></td>
<td>(0.015)</td>
<td>(0.015)</td>
<td>(0.015)</td>
<td>(0.015)</td>
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<tr>
<td>T70-79</td>
<td>0.018</td>
<td>0.026</td>
<td>0.018</td>
<td>0.038**</td>
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<tr>
<td>T79-88</td>
<td>0.030*</td>
<td>0.019</td>
<td>0.013</td>
<td>0.028*</td>
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<td>(0.016)</td>
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<tr>
<td>T88-00</td>
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<td>(0.016)</td>
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Observations: 71,315
Adjusted $R^2$: 0.54858
Tractor per farm: DID results using T00-10 as controls

<table>
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<td>0.090***</td>
<td>0.098***</td>
<td>0.105***</td>
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<tr>
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<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.021)</td>
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<tr>
<td>T70-79</td>
<td>0.053**</td>
<td>0.066***</td>
<td>0.064***</td>
<td>0.093***</td>
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<tr>
<td></td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>T79-88</td>
<td>0.047**</td>
<td>0.063***</td>
<td>0.041*</td>
<td>0.071***</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.023)</td>
<td>(0.023)</td>
<td>(0.023)</td>
</tr>
<tr>
<td>T88-00</td>
<td>0.011</td>
<td>0.020</td>
<td>0.006</td>
<td>0.014</td>
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<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
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Observations: 70584
Adjusted $R^2$: 0.62893
### Average effects among all treated groups

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<th>Including region time trends</th>
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<td><strong>A. Farm size</strong></td>
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<tr>
<td>Treated</td>
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<td>0.01</td>
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<td>(0.004)</td>
<td>(0.012)</td>
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<tr>
<td>Future Treated</td>
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<td></td>
<td>(0.012)</td>
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<td>Region time trends</td>
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<td>Observations</td>
<td>64,225</td>
<td>64,225</td>
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<tr>
<td><strong>B. Tractor per farm</strong></td>
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<td></td>
</tr>
<tr>
<td>Treated</td>
<td>0.022***</td>
<td>0.071***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>Future Treated</td>
<td>0.054***</td>
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<tr>
<td></td>
<td>(0.016)</td>
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<td>Region time trends</td>
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<td>63,580</td>
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</table>
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- Other measures: tractor per agricultural ha
- Starting date for treatment definition
- Difference in Differences with Regional time trends
- Controlling for neighboring reallocated communes
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What’s next?

- Other measures: crop choices and agricultural workers
- Data on plot size
- Owned land vs cropped land
- Other reasons for implementing the policy beyond efficiency:
  - Build roads, irrigation systems, settlement schemes
  - Reduction of intermediaries in the land market
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Evolution over time

(a) Farm size (log scale)

(b) Tractors per 100 ha

Figure: Distribution across communes
Evolution of average farm size

(a) 1955  (b) 1970  (c) 1979
(d) 1988  (e) 2000  (f) 2010
Evolution of tractors

(a) 1955  (b) 1970  (c) 1979
(d) 1988  (e) 2000
**Definition and characteristics of treatment groups**

<table>
<thead>
<tr>
<th></th>
<th>NT</th>
<th>T55</th>
<th>T55-70</th>
<th>T70-79</th>
<th>T79-88</th>
<th>T88-00</th>
<th>T00-10</th>
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<td>Farms</td>
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<td>31.80</td>
<td>54.74</td>
<td>75.80</td>
<td>79.26</td>
<td>79.39</td>
<td>93.14</td>
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<tr>
<td>(81.16 )</td>
<td>(30.99 )</td>
<td>(63.58 )</td>
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<td>(94.37 )</td>
<td>(88.02 )</td>
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<td>Agricultural area</td>
<td>1038.29</td>
<td>912.09</td>
<td>982.16</td>
<td>1136.17</td>
<td>1112.40</td>
<td>1074.15</td>
<td>1254.25</td>
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<td>(UAA) (ha)</td>
<td>(948.02)</td>
<td>(609.16)</td>
<td>(838.04)</td>
<td>(1030.93)</td>
<td>(955.44)</td>
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<td>Farm size</td>
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<td>(24.22 )</td>
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<tr>
<td>Altitude</td>
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<td>183.22</td>
<td>225.98</td>
<td>210.46</td>
<td>207.84</td>
<td>216.24</td>
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<tr>
<td>(m)</td>
<td>(290.36)</td>
<td>(84.61 )</td>
<td>(138.02)</td>
<td>(204.77)</td>
<td>(190.58)</td>
<td>(196.38)</td>
<td>(194.98)</td>
</tr>
<tr>
<td>cereals share</td>
<td>0.34</td>
<td>0.83</td>
<td>0.69</td>
<td>0.56</td>
<td>0.46</td>
<td>0.44</td>
<td>0.40</td>
</tr>
<tr>
<td>(0.47 )</td>
<td>(0.37 )</td>
<td>(0.46 )</td>
<td>(0.5 )</td>
<td>(0.5 )</td>
<td>(0.5 )</td>
<td>(0.49 )</td>
<td></td>
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<tr>
<td>vineyards share</td>
<td>0.10</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
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<tr>
<td>(0.3 )</td>
<td>(0.04 )</td>
<td>(0.12 )</td>
<td>(0.11 )</td>
<td>(0.15 )</td>
<td>(0.16 )</td>
<td>(0.2 )</td>
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<tr>
<td>grasslands share</td>
<td>0.56</td>
<td>0.16</td>
<td>0.30</td>
<td>0.43</td>
<td>0.52</td>
<td>0.54</td>
<td>0.56</td>
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<tr>
<td>(0.5 )</td>
<td>(0.37 )</td>
<td>(0.46 )</td>
<td>(0.5 )</td>
<td>(0.5 )</td>
<td>(0.5 )</td>
<td>(0.5 )</td>
<td></td>
</tr>
</tbody>
</table>
Tractor per ha: Trends and counterfactuals

![Graph showing tractor per ha trends over years with different treatment dates.](image-url)
Tractor per ha: DID results changing control group

(a) NT as control group
(b) T00-10 as control group
Starting date for treatment definition

(a) Baseline model

(b) Starting date as reference

Figure: Farm size using T00-10 as control group
Starting date for treatment definition

(a) Baseline model

(b) Starting date as reference

Figure: Tractor per farm using T00-10 as control group
Difference in Differences with Regional time trends

(a) Baseline model

(b) Regional time trends

Figure: Farm size using T00-10 as control group
Difference in Differences with Regional time trends

(a) Baseline model

(b) Regional time trends

Figure: Tractor per farm using T00-10 as control group
Controlling for neighboring reallocated communes

(a) Baseline model
(b) Controlling for treated neighbors

Figure: Farm size using T00-10 as control group
Controlling for neighboring reallocated communes

Figure: Tractor per farm using T00-10 as control group

(a) Baseline model

(b) Controlling for treated neighbors
Controlling for neighboring reallocated communes

Figure: Estimates for the proportion of reallocated communes within Agricultural regions