

Agricultural Mechanization and Structural Transformation in China

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Does agricultural mechanization facilitate structural transformation by increasing employment in non-agricultural sectors in China?

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 - ▶ Small farm size (Wang, Yamauchi, Huang, & Rozelle, 2020), collective land ownership (Kumar, Turvey, & Kropp, 2013; Lohmar, Gale, Tuan, & Hansen, 2009)
- ▶ The labor displacement of capital depends on the type of machinery/labor and the adoption scenario (Autor, Mindell, & Reynolds, 2019; Autor & Salomons, 2018).

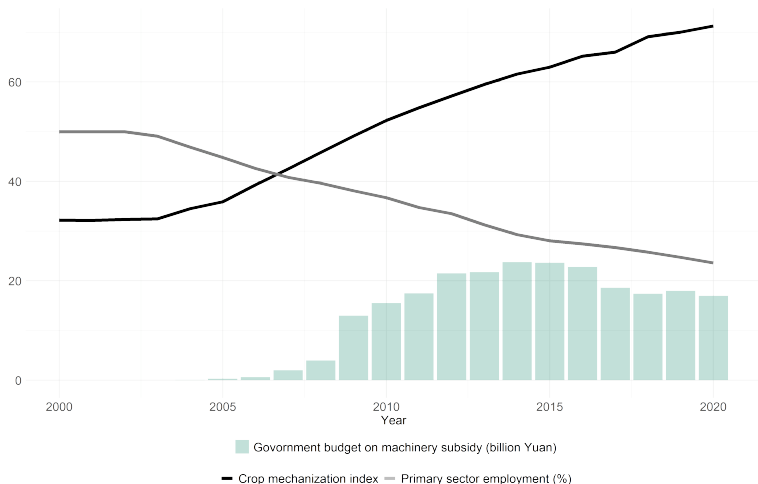


Figure 1: Crop mechanization index, primary sector employment and subsidy budget

Antecedents

- ▶ Farming system evolution theory (1986; Prabhu Pingali, 2007; P. Pingali, Bigot, & Binswanger, 1987) predicts various labor displacement effect of mechanization.

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- ▶ Mixed empirical evidence on unemployment, as summarized by Daum & Birner (2020).
- ▶ An RCT study shows that mechanization improves household welfare by releasing family labor from supervision to non-agricultural jobs (Caunedo & Keller, 2021).

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Contribution

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- ▶ Extend the view from employment outcomes within ag to non-ag sectors.
- ▶ Measure mechanization at the regional level, rather than by household possession or usage ← large presence of regional custom machinery service.
- ▶ Combine panel data with shift-share instrument to estimate Local Average Treatment Effects.

Method: Shift-share IV

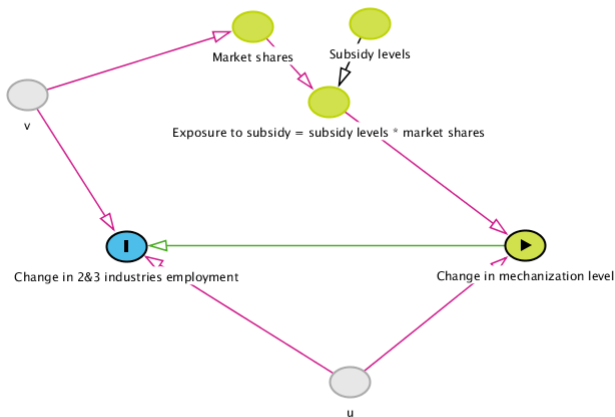


Figure 2: Directed acyclic graph of the shift-share IV design

A snippet of the 2019 Jilin Province subsidy catalog

Category	Sub-category	Item	Size	Size code	Subsidy (<i>yuan</i>)
Power machine	Tractors	Wheeled tractors	30-40 horsepower, 2 wheels	03	5500
Power machine	Tractors	Wheeled tractors	40-50 horsepower, 2 wheels	04	8300
Power machine	Tractors	Wheeled tractors	50-60 horsepower, 2 wheels	05	10350
Power machine	Tractors	Wheeled tractors	60-70 horsepower, 2 wheels	06	11000
...
Power machine	Tractors	Wheeled tractors	30-40 horsepower, 4 wheels	13	10560
Power machine	Tractors	Wheeled tractors	40-50 horsepower, 4 wheels	14	11840
...
Power machine	Tractors	Crawler tractors	40-50 horsepower	26	13000
Power machine	Tractors	Crawler tractors	50-60 horsepower	27	13000
Power machine	Tractors	Crawler tractors	60-70 horsepower	28	20000
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Shift-share IV construction

Table 1: A hypothetical example

Size	Size code	Subsidy (<i>yuan</i>)	County 1 market shares	County 2 market shares
30-40 horsepower, 2 wheels	03	5500	70 %	0 %
40-50 horsepower, 2 wheels	04	8300	10 %	0 %
50-60 horsepower, 2 wheels	05	10350	5 %	10 %
60-70 horsepower, 2 wheels	06	11000	0 %	30 %
...
30-40 horsepower, 4 wheels	13	10560	10 %	0 %
40-50 horsepower, 4 wheels	14	11840	5 %	10 %
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40-50 horsepower, crawler	26	13000	0 %	10 %
50-60 horsepower, crawler	27	13000	0 %	20 %
60-70 horsepower, crawler	28	20000	0 %	30 %
...
Exposure to subsidy			12173.5	14235



Model

$$\widetilde{\Delta Y}_{ct} = \gamma_0^m + \gamma_1^m \widetilde{purchase}_{ct}^m + \gamma_2^m \widetilde{\Delta X}_{ct}^m + e_{ct}^m \quad (1)$$

$$\widetilde{purchase}_{ct}^m = \delta_0^m + \delta_1^m \sum_{j=1}^J share_{jct}^m \times \widetilde{subsidy}_{jpt}^m + \delta_2^m \widetilde{\Delta X}_{ct}^m + u_{ct}^m \quad (2)$$

- c - county/city; t - year; p - province, j - machinery size; m - machinery category

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- ▶ The tildes denote residualizing on county and period FEs
- ▶ ΔY_{ct} - change in the number of non-agricultural employees in formal sectors
- ▶ $purchase_{ct}^m$ - machinery purchase, as proxy for change in mechanization level

Data

Data on mechanization (2015 - 2020)

- ▶ Machinery subsidy catalogs (shift)

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 - ▶ China Health and Retirement Longitudinal Survey 2015 and 2018 waves
 - ▶ Matched to city level mechanization

County-level result

Table 2: 2SLS estimates with county and period fixed effects - county level regressions

	<i>Dependent variable:</i>					
	Change in the number of employee in the 2nd and 3rd industries (1000 people)					
	Tractor (1)	Rotary tiller (2)	Seeder,transplanter (3)	Grain harvester (4)	Corn harvester (5)	Grain dryer (6)
Subsidized machinery purchase	-0.501 (0.660)	-0.029 (0.032)	-6.276 (26.007)	-32.634 (60.911)	446.203 (496.969)	31.542 (26.054)
Sum of shares (0/1)	-6.057*** (2.340)	-4.828** (2.207)	-4.197*** (1.591)	-5.492** (2.486)	0.377 (3.254)	-1.852 (2.504)
Observations	3,783	3,377	3,227	3,601	1,821	2,584
R ²	-0.008	-0.010	-0.001	-0.010	-1.658	-0.010
Adjusted R ²	-0.009	-0.010	-0.001	-0.011	-1.661	-0.011
Residual Std. Error	43.640	45.520	46.537	44.406	54.876	44.329
First stage F-stat	100.649	29.820	25.761	9.441	0.771	25.182

Falsification test: reduced-form regression

Table 3: Falsification test with county and period fixed effects - county level regressions

	<i>Dependent variable:</i>					
	Number of industrial firms					
	Tractors	Rotary tiller	Seeder,transplanter	Grain harvester	Corn harvester	Grain dryer
	(1)	(2)	(3)	(4)	(5)	(6)
Shift-share IV	6.197 (4.932)	5.059 (7.083)	-7.714 (12.264)	-14.943*** (5.693)	-2.772 (10.114)	12.989 (11.730)
Sum of shares (0/1)	0.100 (0.448)	0.812* (0.437)	1.072* (0.577)	0.983** (0.466)	0.398 (0.658)	0.870 (0.715)
Observations	4,946	4,675	4,113	4,634	2,283	3,328
R ²	0.0001	0.0003	0.001	0.002	0.0001	0.001
Adjusted R ²	-0.0003	-0.0001	0.0002	0.001	-0.001	0.0002
Residual Std. Error	25.652	25.276	22.208	21.115	21.770	23.710
F Statistic	0.216	0.721	1.332	3.640**	0.110	1.278

Prefecture city level result

Table 4: 2SLS estimates with city and period fixed effects - city level regressions

	<i>Dependent variable:</i>					
	Change in the number of employees in the 2nd and 3rd industries (1000 people)					
	Tractors	Rotary tiller	Seeder,transplanter	Grain harvester	Corn harvester	Grain dryer
	(1)	(2)	(3)	(4)	(5)	(6)
Subsidized machinery purchase	-0.208 (0.440)	0.005 (0.030)	15.778* (8.951)	18.781 (81.589)	-42.779 (690.982)	-1.408 (17.506)
Sum of shares (0/1)	9.283* (5.045)	11.012** (4.684)	10.231*** (3.841)	12.111 (7.568)	21.575*** (5.995)	5.772* (3.495)
Observations	464	410	460	455	273	440
R ²	-0.017	0.010	-0.182	-0.013	-0.106	0.002
Adjusted R ²	-0.021	0.005	-0.187	-0.017	-0.114	-0.002
Residual Std. Error	47.421	49.060	51.112	47.412	58.343	47.817
First stage F-stat	33.416	11.861	4.987	2.115	0.022	4.112

Prefecture city level result by sector, focus on tractors

Table 5: 2SLS estimates with city and period fixed effects - city level regressions

	<i>Dependent variable:</i>				
	Change in the number of employee by sectors (1000 people)				
	Manufacturing	Construction	Wholesale and retail	Hotel and food service	Logistic
	(1)	(2)	(3)	(4)	(5)
Subsidized tractor purchase (1000 horsepower)	-0.158 (0.158)	0.152** (0.072)	0.013 (0.025)	-0.067 (0.083)	0.002 (0.015)
Sum of shares (0/1)	4.434* (2.427)	3.021*** (0.985)	1.797*** (0.636)	-0.414 (0.700)	0.474** (0.194)
Observations	464	464	464	464	464
R ²	-0.063	-0.079	0.017	-0.068	0.005
Adjusted R ²	-0.068	-0.084	0.013	-0.072	0.001
Residual Std. Error	19.563	11.946	5.867	7.414	3.021
First stage F-stat	33.434	33.434	33.434	33.434	33.434

Individual level descriptive statistics

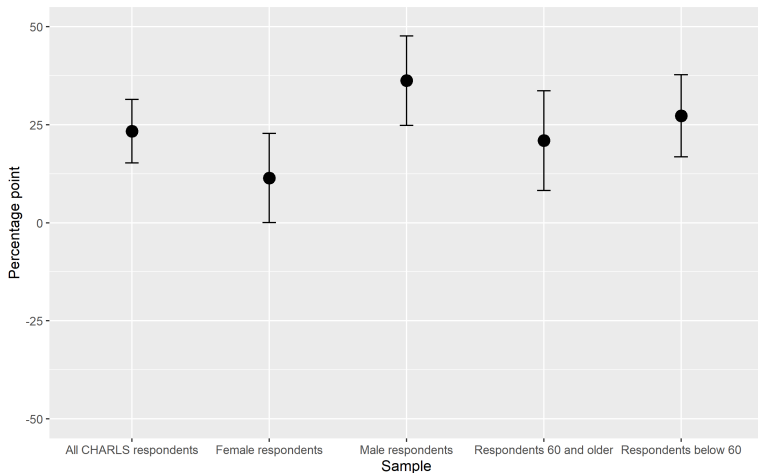


Figure 3: Correlation between probability of working in agriculture and tractor purchase in residing city (horsepower/hectare of farmland)

Individual level descriptive statistics

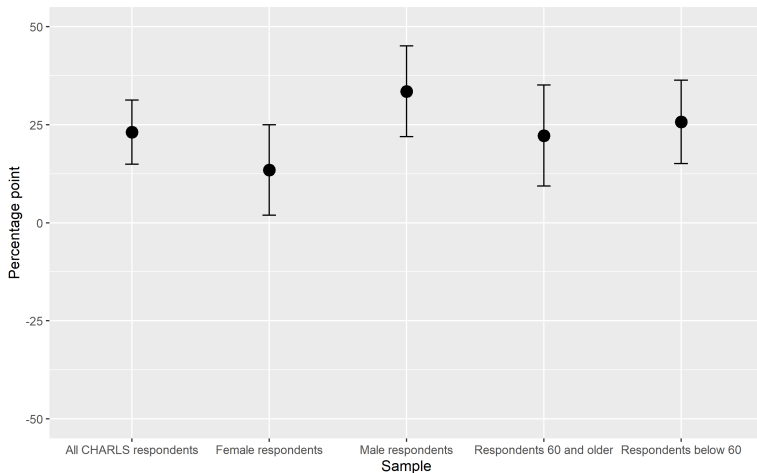


Figure 4: Correlation between probability of working on own farm and tractor purchase in residing city (horsepower/hectare of farmland)

Individual level descriptive statistics

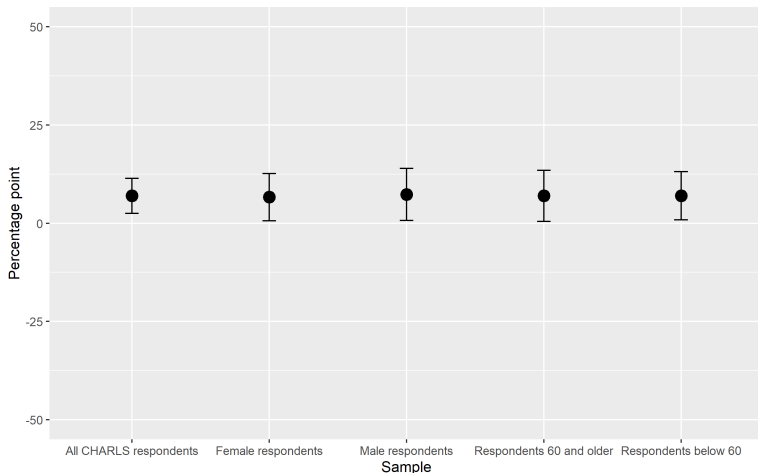


Figure 5: Correlation between probability of working as hired agricultural worker and tractor purchase in residing city (horsepower/hectare of farmland)

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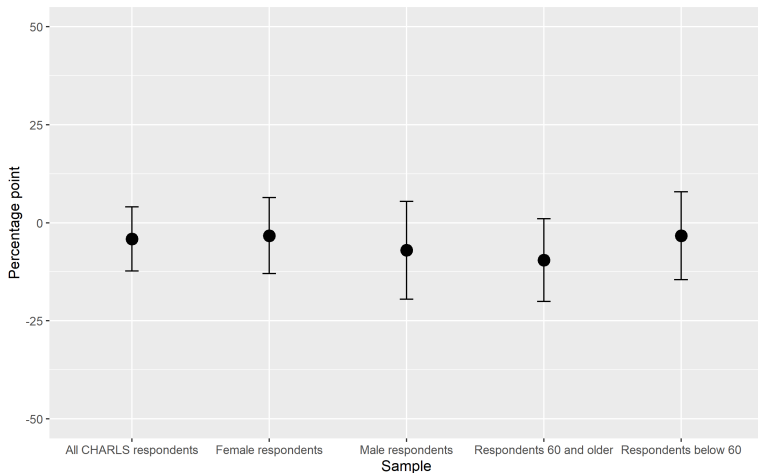


Figure 6: Correlation between probability of working in nonag jobs and tractor purchase in residing city (horsepower/hectare of farmland)

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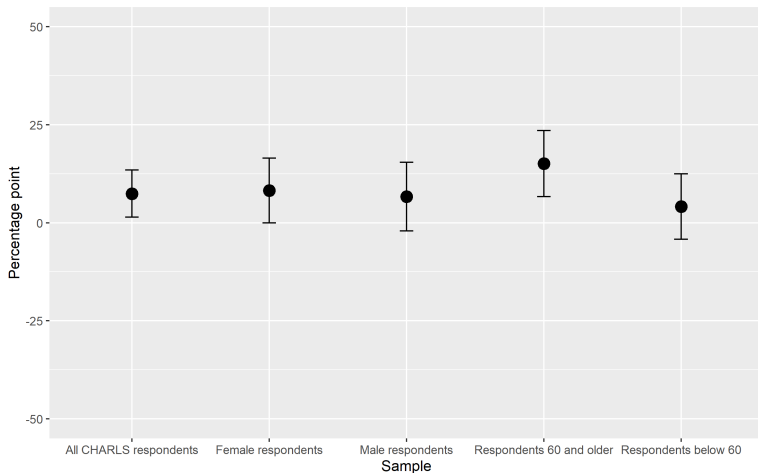


Figure 7: Correlation between probability of living in rural and tractor purchase in residing city (horsepower/hectare of farmland)

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- ▶ Subsidized mechanization in China is more likely to have picked up ag production slack left by labor leaving ag and even revived rural economy than further facilitated structural transformation.
- ▶ Due to data limitations, I cannot rule out the possibility that mechanization also led to more unemployment and employment in informal sector jobs.

