The geography of the Robotisation-Health nexus

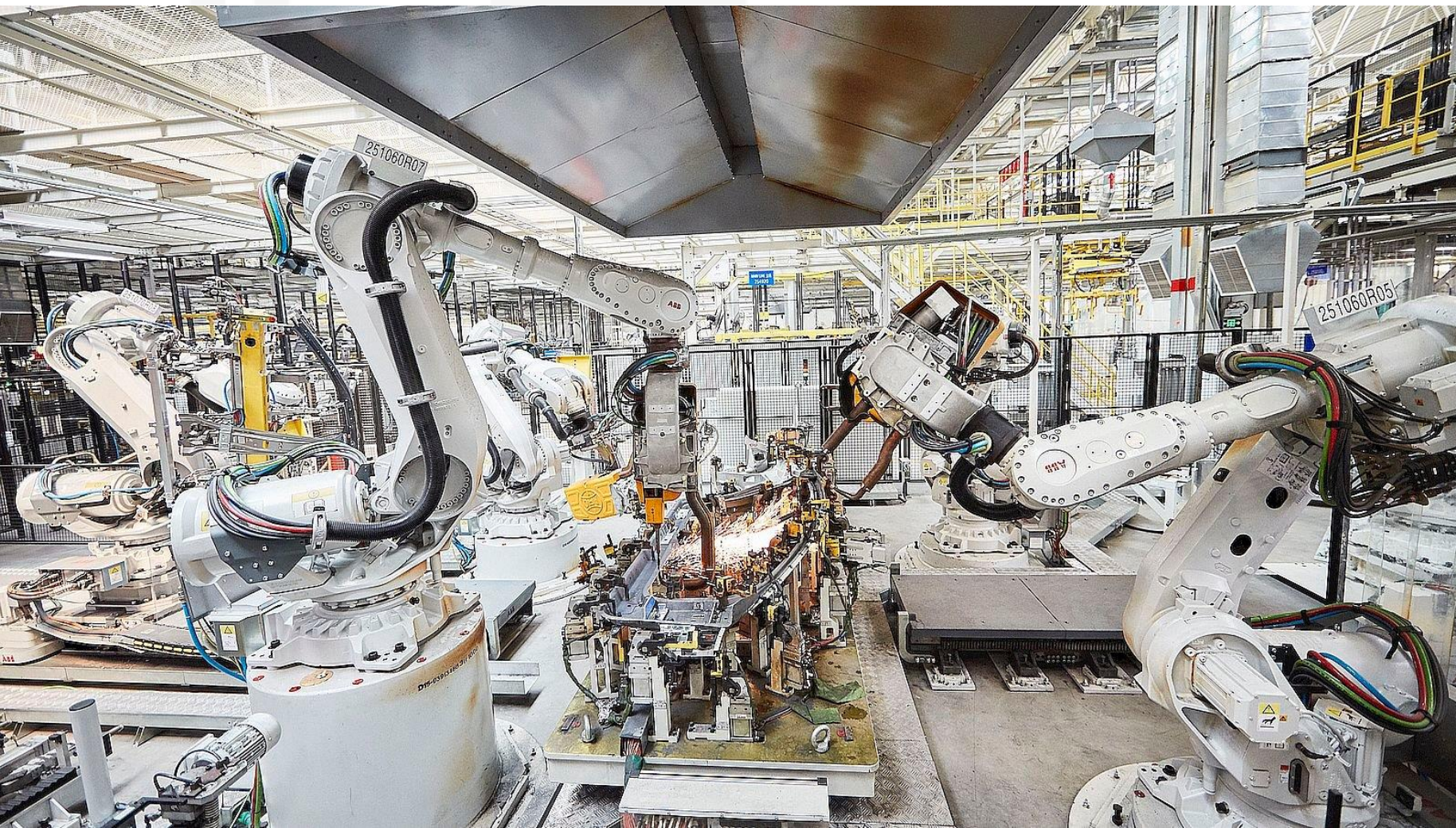## *Evidence from Italian provinces*

Arsène Perrot**,** Fabiano Compagnucci, Paolo Veneri

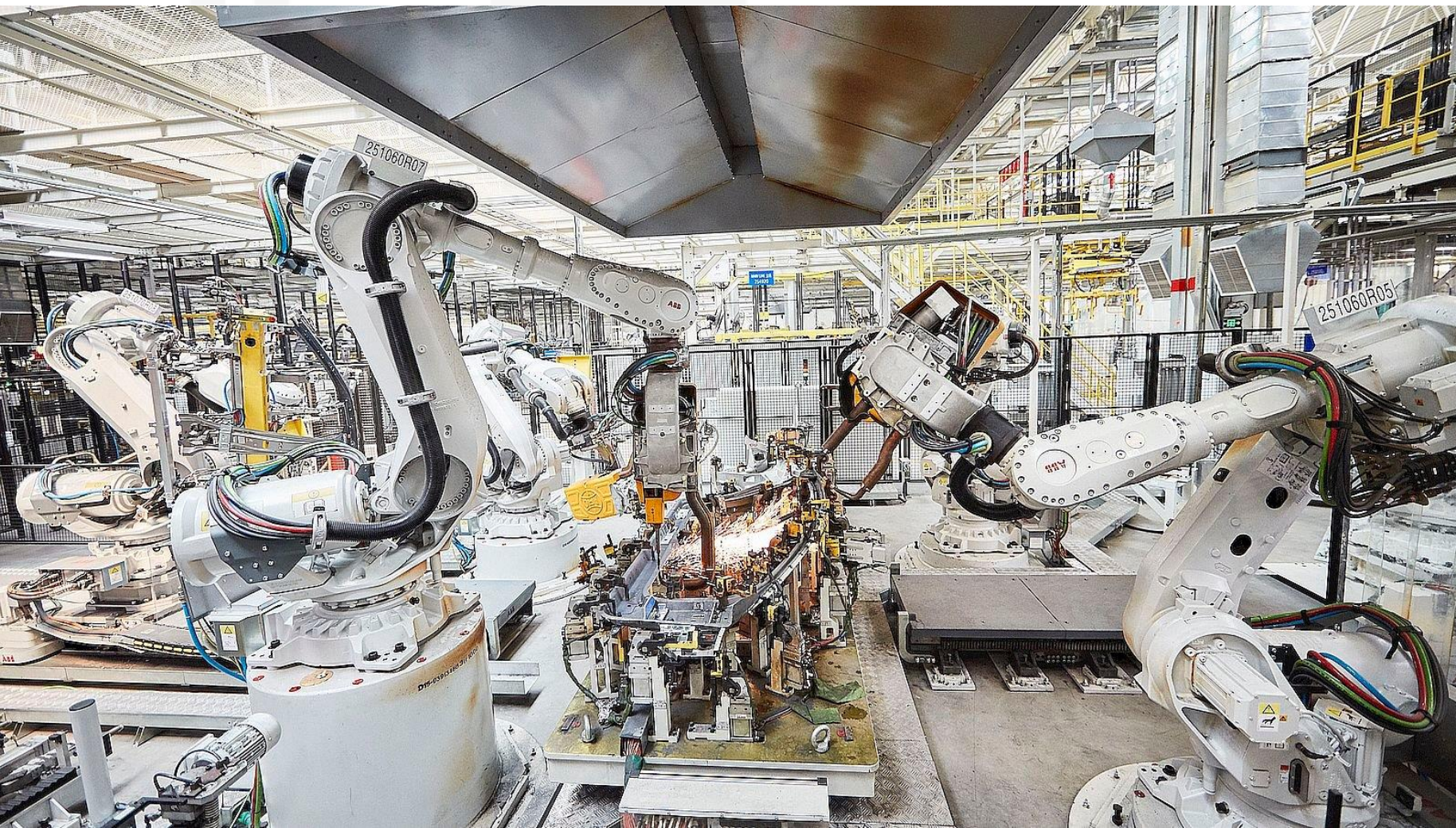Young Economists Conference – Wien, 26-27 September 2024

www.gssi.it

Motivation

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Effects of robots are usually considered from the labour market perspective – wages, employment

Acemoglu & Restrepo, 2020; Graetz & Michaels, 2018

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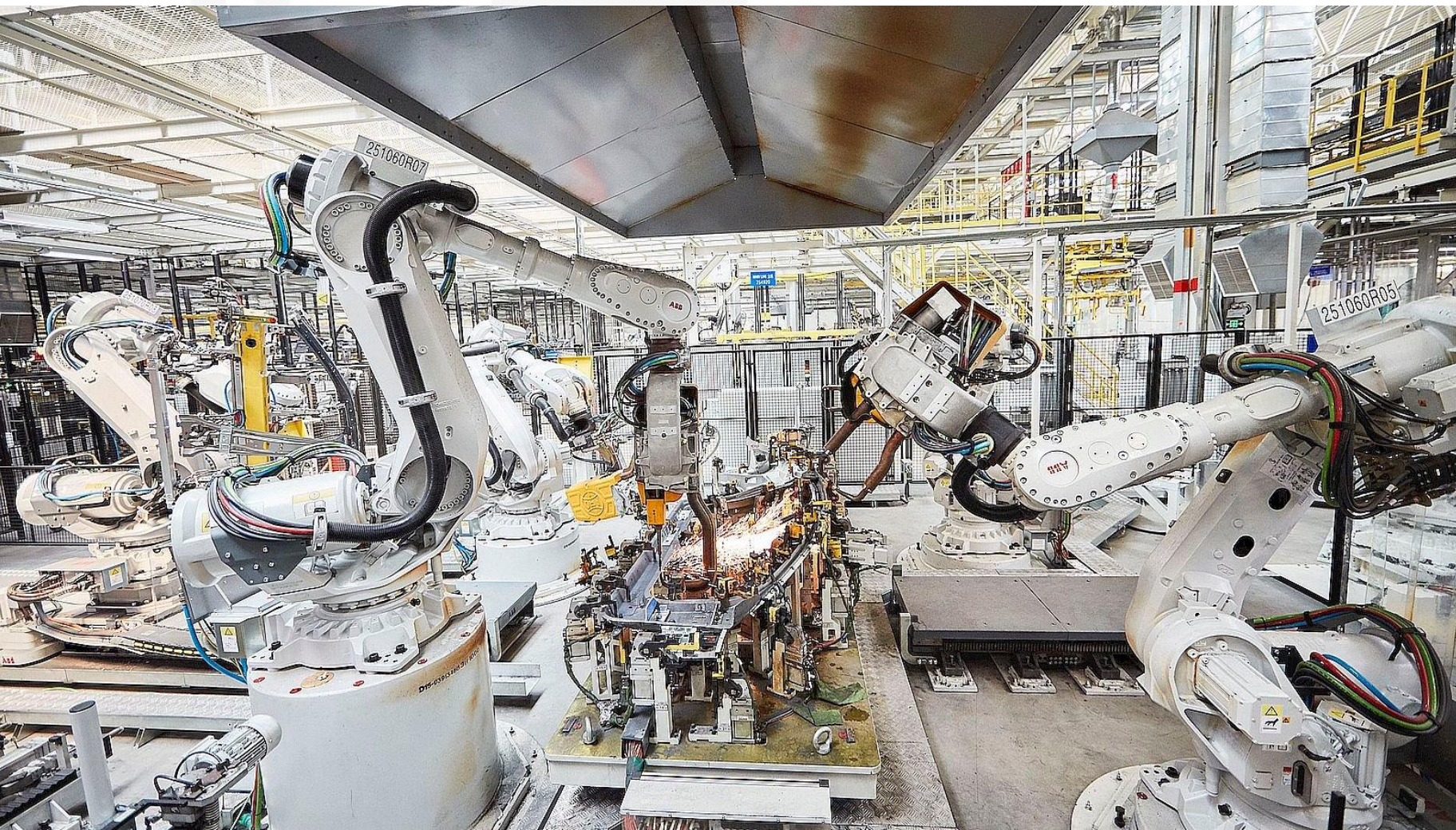
Angner et al., 2009, 2013

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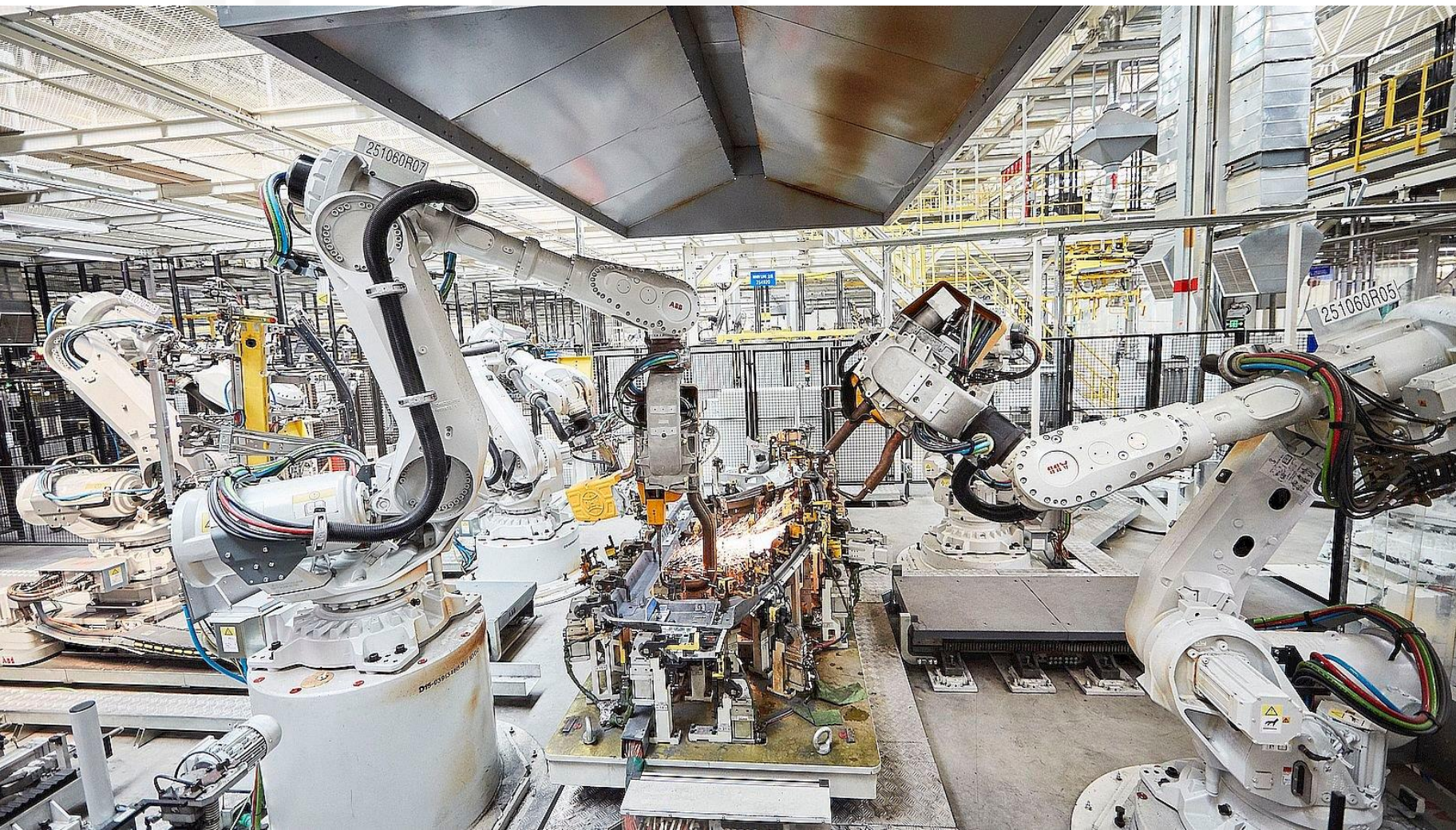
Acemoglu & Restrepo, 2020; Graetz & Michaels, 2018

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Robots have civil applications (e.g., Service Robots)

Gentili et al., 2020; Hägele et al., 2016

Literature

Literature

Economic effects of automation differ across

- The workforce

  Acemoglu et al., 2023; Compagnucci et al., 2022; Cuccu & Royuela, 2024

- Space: positive in "dynamic", high-skill (metropolitan) regions

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- Mediated by local factors : skills, cultures, conventions…

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Scarce literature on robots and health (China, US, Germany)

- Robots improve physical health

- Ambiguous trend for mental health

    Abeliansky et al., 2024; Gihleb et al., 2022; Gunadi & Ryu, 2021; Liu et al., 2024

G S
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Research Question

Mechanisms

Mechanisms

Reallocation away from physically intensive tasks…

Gihleb et al., 2022; Gunadi & Ryu, 2021; Karwowski et al., 1988; Spath & Braun, 2021

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DIRECT

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Mechanisms (2)

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Space is relevant

- Industrialisation's geography

  Storper & Walker, 1989

- Institutional variations

  Brenner et al., 2010

- Job behaviours, quality, functions

  Akerlof, 1976; Lunardon, 2024; OECD, 2017; Rosenthal & Strange, 2008

- Workplace relations, conventions and cultures

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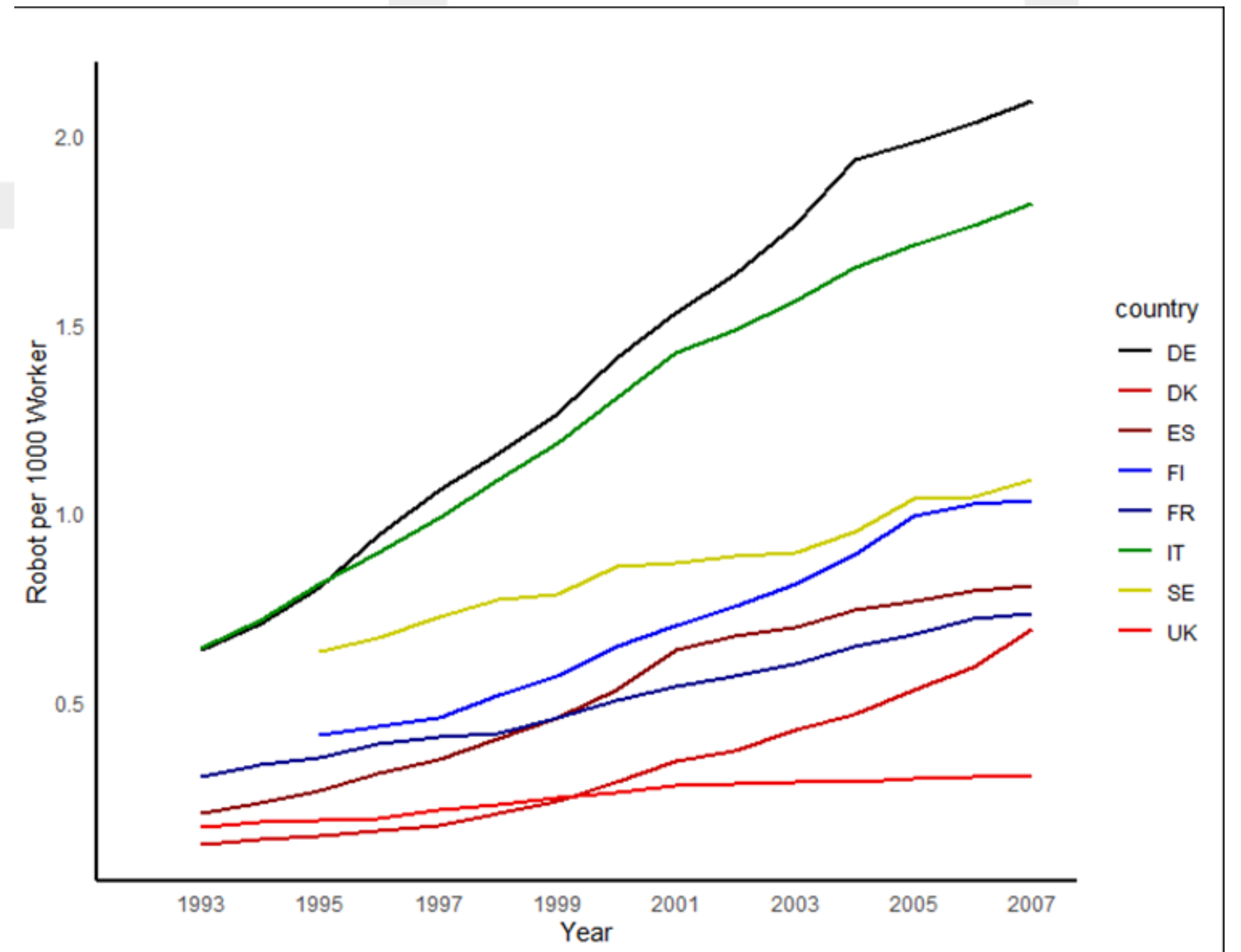## Focus on the Large Metropolitan Regions and their specific behaviours

Iammarino et al., 2019; Moretti, 2012; OECD, 2017; Storper, 2018; …

Typology

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Data - Robots

Robot / 1000 Workers in European Countries

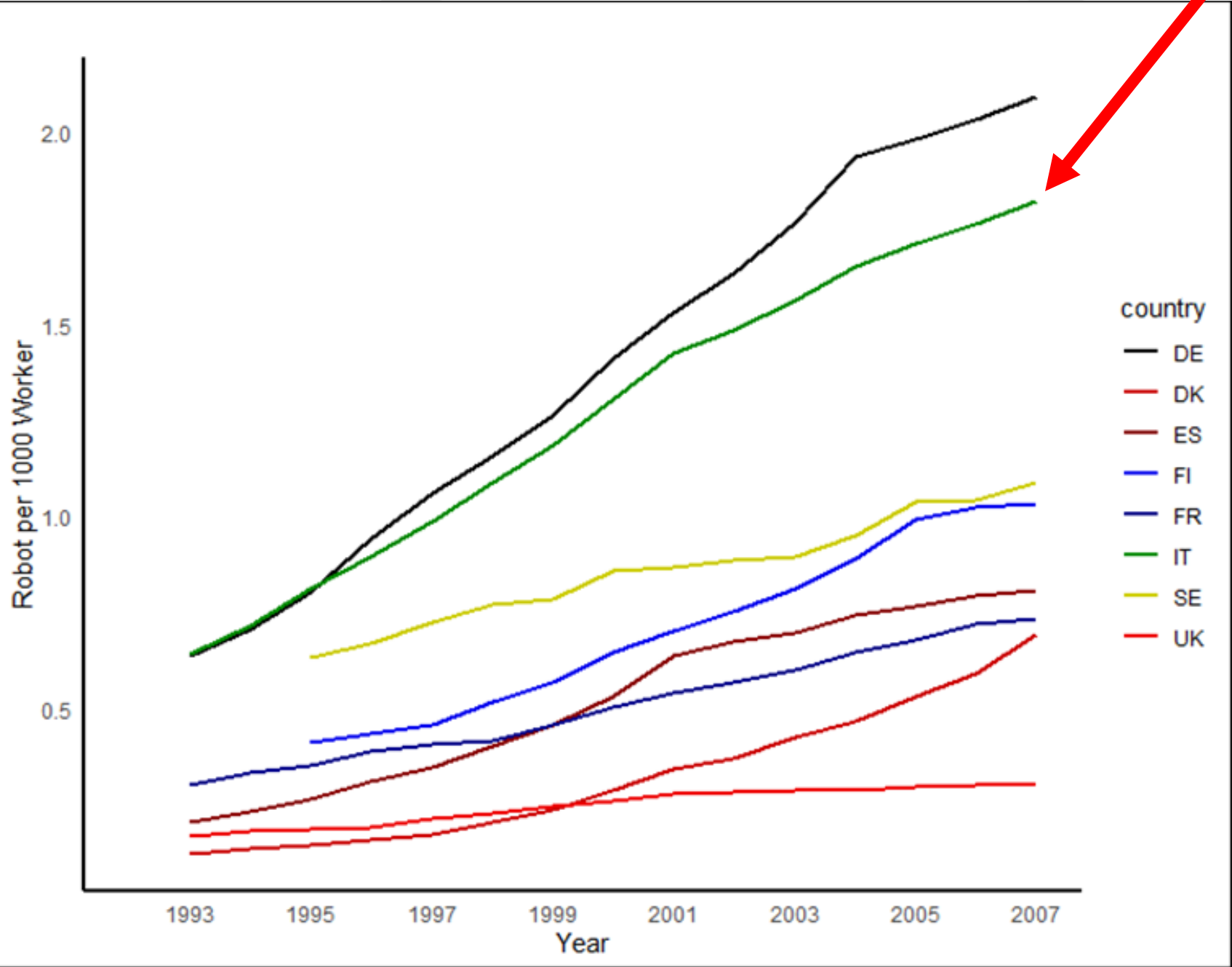## International Federation of Robotics (IFR) data

➢ Number of industrial robots in operation per country-sector-year

Definition

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Method - Robots

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Exposure to Robots Acemoglu & Restrepo, 2020

Adjusted Penetration of Robots based on sectoral distribution at NUTS-3 levels ISTAT Data

Method - Robots
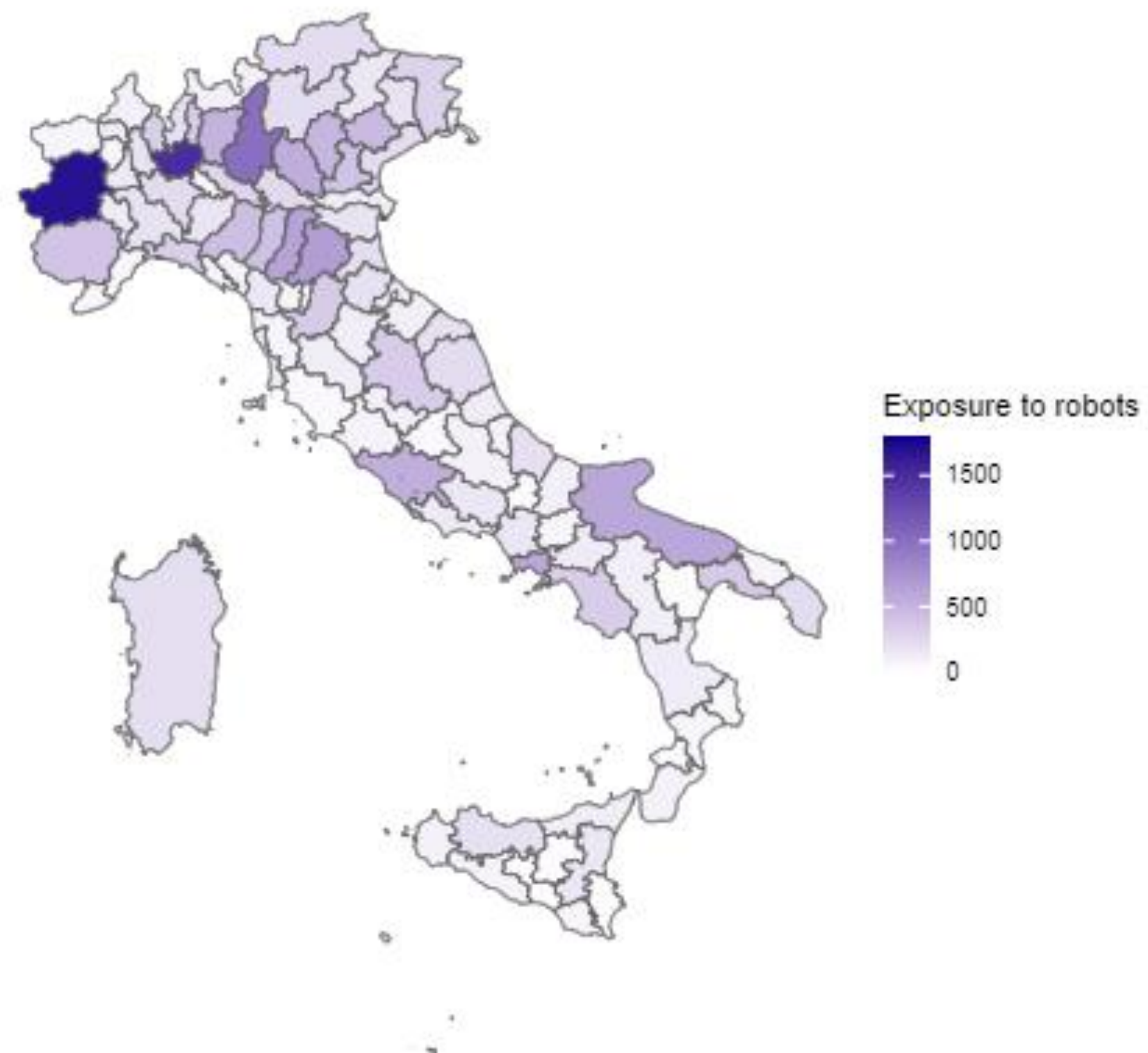
Exposure to Robots <small>Acemoglu & Restrepo, 2020</small>

Adjusted Penetration of Robots based on sectoral distribution at NUTS-3 levels <small>ISTAT Data</small>

$$Exposure\ to\ robots_{rt} = \sum_{s\,\epsilon\,S} employment_{rs}^{1991} \left(\frac{Robot\ Stock_{st}}{Labour\ Force_{s,1991}} \right)$$

Exposure to Robots
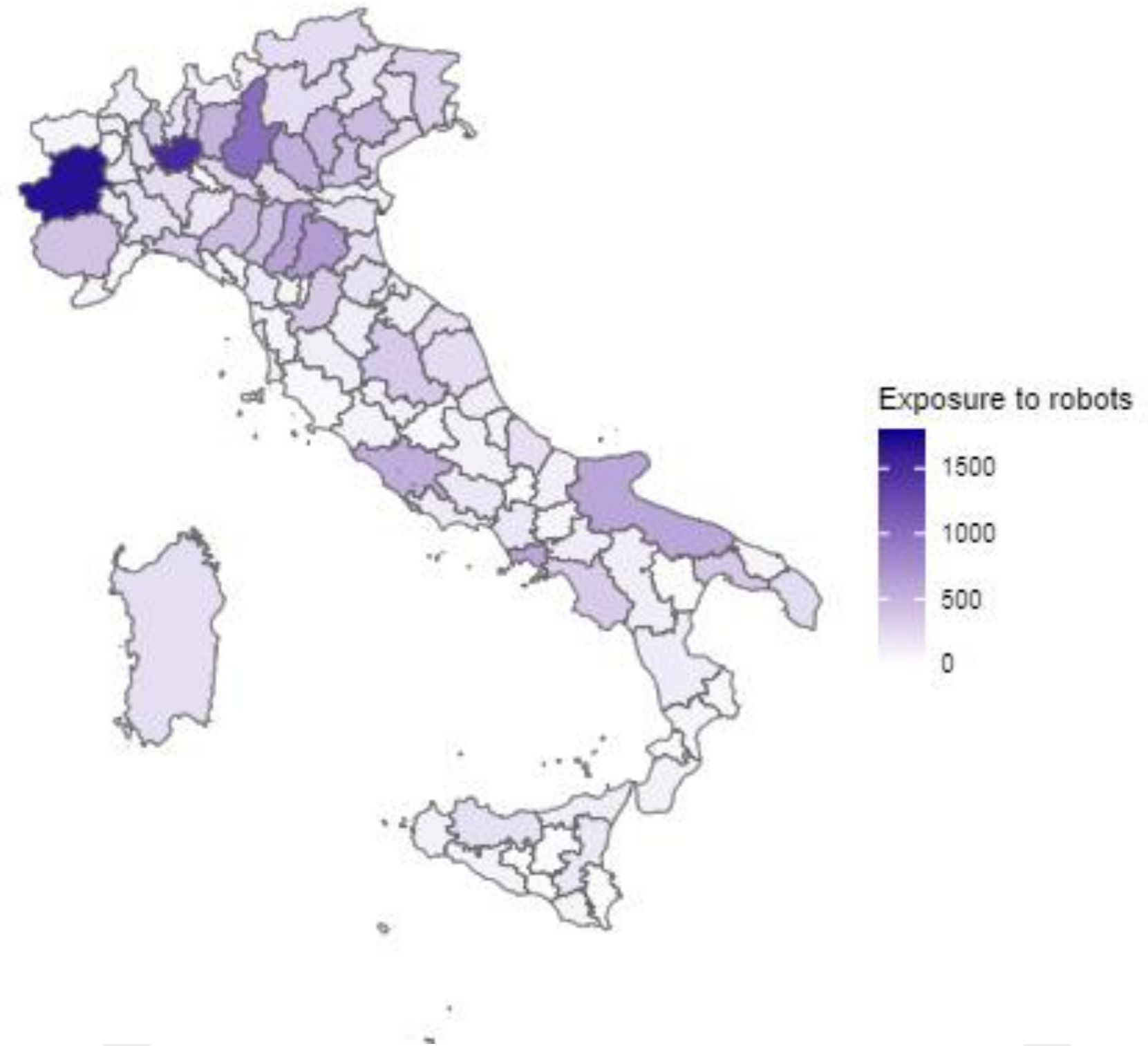
Evolution of Exposure to Robots

Δ 2008-2020

Exposure to Robots

Spatial imbalances
- North of Italy

Evolution of Exposure to Robots
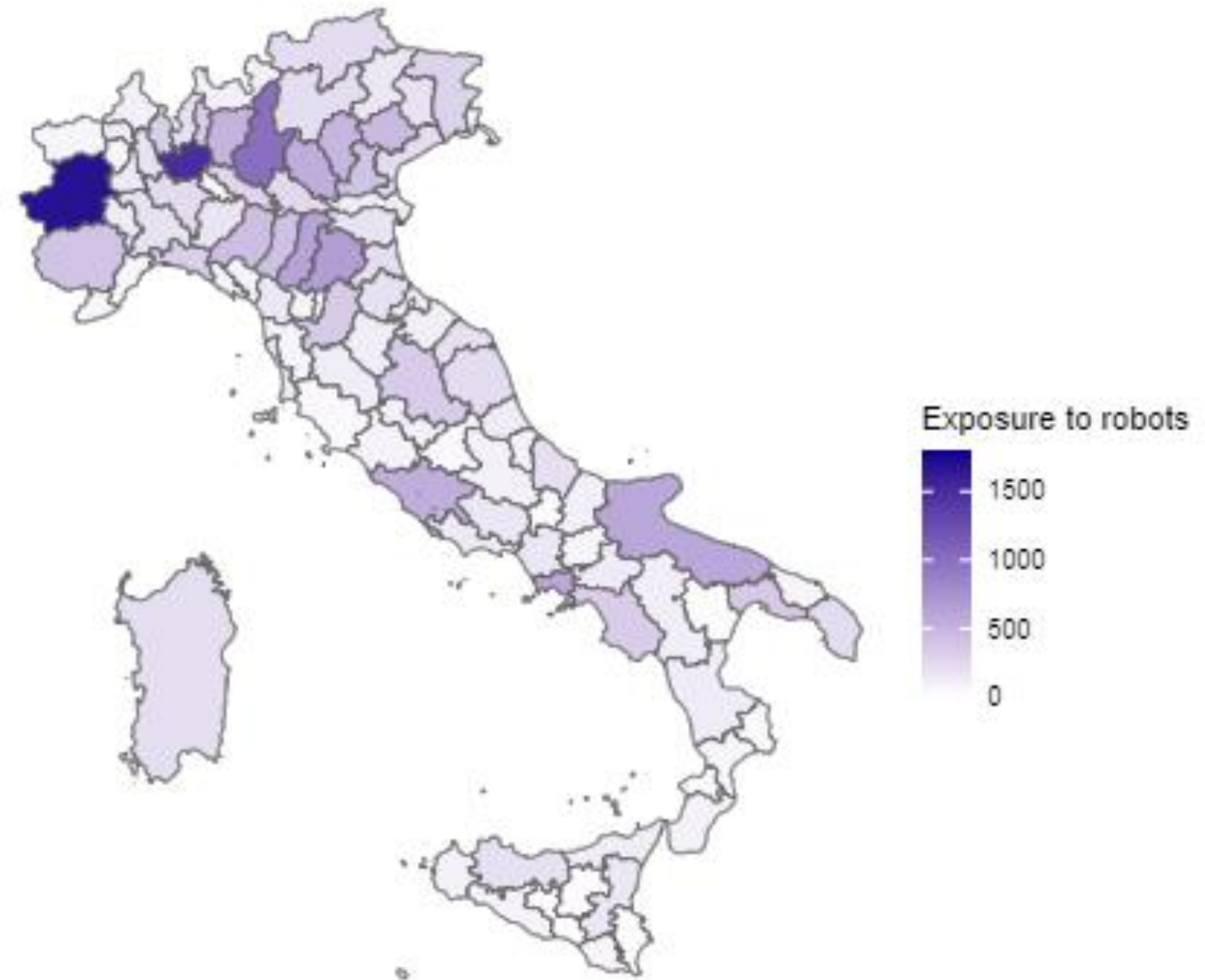
Δ 2008-2020

Exposure to robots

1500

1000

500

0

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Exposure to Robots

Spatial imbalances

- North of Italy

Evolution

- Differences within macro-regions

Evolution of Exposure to Robots

Δ 2008-2020

Exposure to robots

- 1500
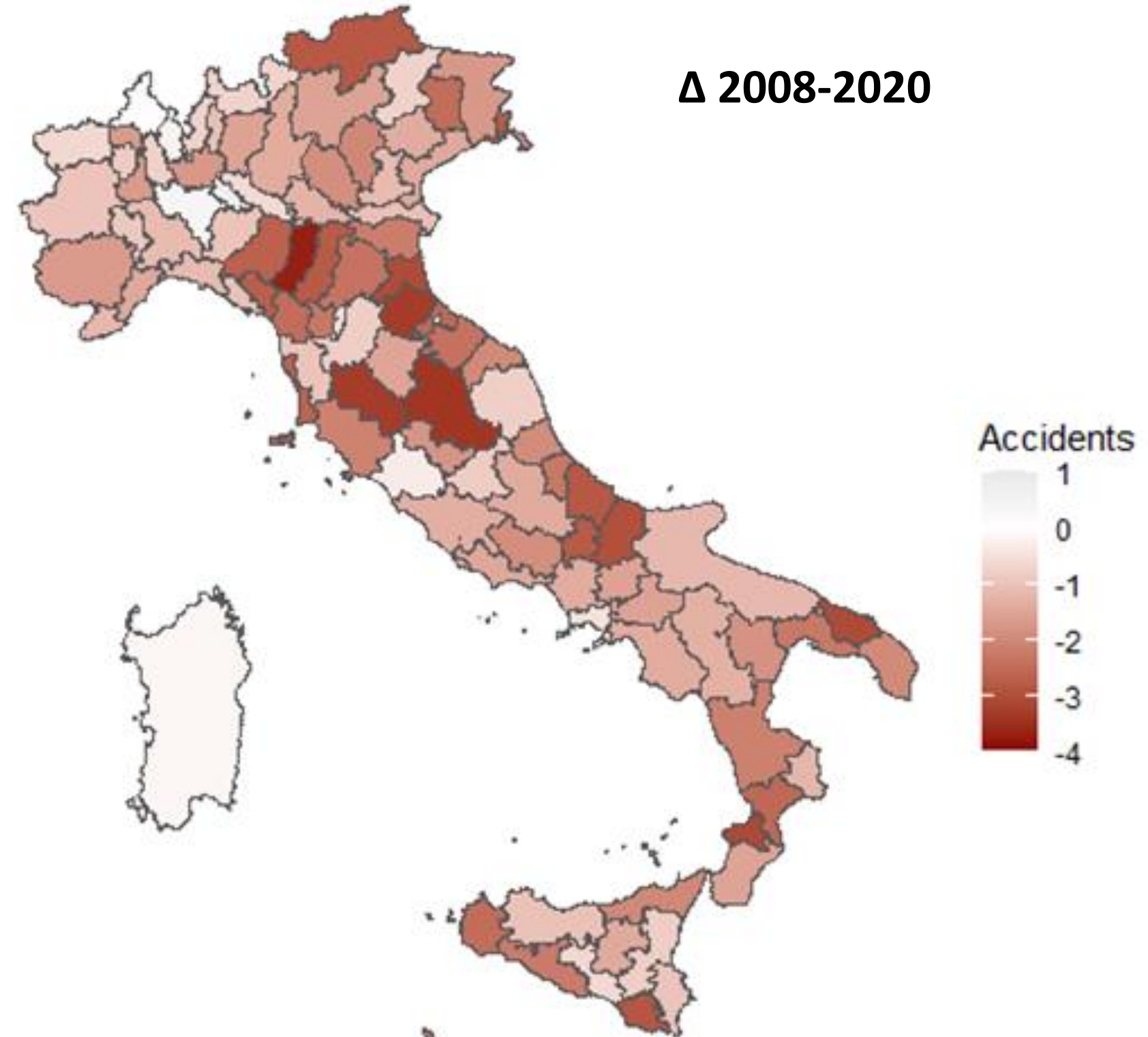- 1000
- 500
- 0

Levels

Accidents

INAIL Data

Administrative database

- Province

- Severity

- Age, Gender

- …

Accidents / 100K Workers

Evolution of Accidents / 100K Workers

Δ 2008-2020

Accidents
1
0
-1
-2
-3
-4

Levels

Data – Mental Health

Data – Mental Health

Deaths due to Alcohol & Drugs, Suicides

Gihleb et al., 2022; ISTAT

Data – Mental Health

Deaths due to Alcohol & Drugs, Suicides
Gihleb et al., 2022; ISTAT

Hospitalizations for mental disorders due to Alcohol & Drug abuse
ISTAT

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Method – Physical Health

Panel Linear Model with province-year FEs

$$Y_{rt} = \alpha + \beta(Exposure\ to\ Robots)_{rt} + \tau_t + \omega_r + \varepsilon_{ert}$$

Method – Physical Health (2)

Method – Physical Health (2)

Reverse causality concern due to *task displacement*

Method – Physical Health (2)

Reverse causality concern due to *task displacement*

IV: level of Robot Installations in other European economies as a proxy for improvement in the robot technology frontier

$$Exposure\ to\ Robots_{rt}^{IV} = \sum_{s\,\epsilon\,S} employment_{rs}^{1971} \left(\frac{Robot\ Stock_{st}^{Others}}{Labour\ Force_{s,1991}^{Others}} \right)$$

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Method – Challenges

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The data captures rare events, creating potential bias in the estimations through OLS

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- ✓ Count Data approach

Over dispersed data
- ✓ Negative Binomial standard errors

Distributions

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Method – Mental Health

Method – Mental Health

Generalized Linear Model (GLM) with Negative Binomial Standard Errors

$$Y_{rt} = \alpha + \beta(Exposure\ to\ Robots)_{rt} + Pop_{r,t} + \varepsilon_{rt}$$

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IV with a Control Function Method

Woolridge, 2015

G S
S I

Method – Mental Health

Generalized Linear Model (GLM) with Negative
Binomial Standard Errors

FE Issues in GLM Models

Allison & Waterman, 2002; Hilbe, 2011

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G S
S I

Results – Physical Health

Table 1: *Baseline results, Effect of Exposure to Robots on Workplace Accidents*

	Dependent variable: Workplace accidents			
	Log-Log	IHS	Log-Log	IHS
	OLS	*OLS*	*IV*	*IV*
	(1)	(2)	(3)	(4)
Exposure to Robots	−0.225***	−0.219***	−0.743***	−0.722***
	(0.030)	(0.029)	(0.139)	(0.134)
Observations	1,274	1,274	1,274	1,274
R^2	0.045	0.047	0.045	0.047
F Statistic (df = 1; 1163)	55.375***	57.294***	28.388***	28.938***

Note: *p<0.1; **p<0.05; ***p<0.01

Models' FE are twoways (province-year)

Severity

Lagged

A 1% increase in exposure to robots is associated with a 0.2/0.7% decrease in accidents per 100K workers

Around 200.000 accidents avoided over the period, or a cost to society of around EUR 10 billion (estimation based on Tompa et al., 2021)

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Results – Physical Health

Table 3: *Spatial Analysis w/ KIABI, Effect of Exposure to Robots on Workplace Accidents*

	Dependent variable: Workplace accidents			
	Log-Log	IHS	Log-Log	IHS
	OLS	OLS	IV	IV
	(1)	(2)	(3)	(4)
Exposure to Robots	−0.219***	−0.213***	−0.846***	−0.800***
	(0.029)	(0.028)	(0.169)	(0.161)
Exposure to Robots X Large Metro	−0.106	−0.070	−0.274**	−0.211*
	(0.065)	(0.063)	(0.133)	(0.126)
KIABI LQ	−0.132***	−0.130***	−0.134***	−0.132***
	(0.031)	(0.030)	(0.037)	(0.035)
Observations	1,248	1,248	1,248	1,248
R^2	0.062	0.063	0.054	0.055
F Statistic (df = 3; 1137)	24.955***	25.386***	40.818***	43.038***

Note: $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Models' FE are twoways (province-year)

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Results – Mental Health

Table 2: *Effect of Exposure to Robots on Mental Health Indicators, Summary*

| | Dependent variable | | | | |
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs	FEs	Controls
GLM	+***	+***	+***		
GLM-IV	+***	+***	+***		
GLM	NS	NS	+***	Yes	
GLM-IV	+**	+***	+***	Yes	
GLM	NS	+***	+*		Yes
GLM-IV	NS	+***	NS		Yes
GLM	NS	NS	+**	Yes	Yes
GLM-IV	NS	NS	NS	Yes	Yes

Note: NS for non-significant results; *$p<0.1$; **$p<0.05$; ***$p<0.01$

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Results – Mental Health

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM *Neg. Bin.*	*GLM* *Neg. Bin.*	*GLM* *Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000670*** (0.000082)	0.000632*** (0.000045)	0.000737*** (0.000071)
Large Metro	0.425958** (0.181401)	−0.417905*** (0.091936)	0.070995 (0.123655)
Exposure to Robots X Large Metro	−0.000705*** (0.000086)	−0.000488*** (0.000046)	−0.000820*** (0.000070)
KIABI LQ	−0.089317 (0.151669)	−0.072618 (0.074894)	0.524268*** (0.110406)

Full Table

Results – Mental Health, IV

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM-IV *Neg. Bin.*	*GLM-IV* *Neg. Bin.*	*GLM-IV* *Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000674*** (0.000091)	0.000639*** (0.000054)	0.000737*** (0.000083)
Large Metro	0.425694* (0.227690)	−0.423763*** (0.121612)	0.071173 (0.117299)
Exposure to Robots X Large Metro	−0.000706*** (0.000095)	−0.000486*** (0.000057)	−0.000820*** (0.000072)
KIABI LQ	−0.092634 (0.163645)	−0.075254 (0.078259)	0.524212*** (0.143892)

Full Table

Results – Mental Health w/ FE

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM *Neg. Bin.*	*GLM* *Neg. Bin.*	*GLM* *Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000576** (0.000280)	−0.000065 (0.000092)	0.000404*** (0.000119)
Large Metro	4.935980*** (0.824859)	2.063403*** (0.282307)	1.893171*** (0.581011)
Exposure to Robots X Large Metro	−0.000682*** (0.000255)	0.000065 (0.000086)	−0.000313** (0.000126)
KIABI LQ	0.047098 (0.272899)	−0.086905 (0.081843)	−0.019792 (0.099131)

Results – Mental Health w/ FE-IV

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.
	(1)	(2)	(3)
Exposure to Robots	0.000073	0.000101	0.000232**
	(0.000436)	(0.000069)	(0.000097)
Large Metro	0.000003	0.0000008	0.000091
	(3.543116)	(0.000109)	(0.206228)
Exposure to Robots X Large Metro	0.000173	0.000037	−0.000040
	(0.000527)	(0.000157)	(0.000206)
KIABI LQ	−0.000054	−0.002646	−0.001688
	(0.259487)	(0.001667)	(0.003168)

Full Table

Results – Mental Health

Table 4: *Spatial Analysis, Effect of Exposure to Robots on Mental Health Indicators, Summary*

		Dependent variable			
Model	Var.	Deaths	Suicides	Hospitalisation	FEs
GLM	Exp. Rob.	+***	+***	+***	
	X Large Metro	$-$***	$-$***	$-$***	
GLM-IV	Exp. Rob.	+***	+***	+***	
	X Large Metro	$-$***	$-$***	$-$***	
GLM	Exp. Rob.	+**	NS	+***	Yes
	X Large Metro	$-$***	NS	$-$**	
GLM-IV	Exp. Rob.	NS	NS	+**	Yes
	X Large Metro	NS	NS	NS	

Note: NS for non-significant results; *p<0.1; **p<0.05; ***p<0.01

Results – Mental Health

A **one standard deviation increase in the exposure to robots** in provinces is associated with an increase of :

0.14 deaths due to alcohol and drugs

0.16 suicides

0.23 hospitalizations due to alcohol and drugs

Heterogeneous effects across space seem to be mitigated in Large Metropolitan Areas

Baseline
Space
Controls

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Conclusion

"Some dangerous tasks disappear, but new ones are generated"

Backstrom & Harms-Ringdahl, 1984; Karwowski et al., 1988, p. 218

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Increased usage of robotization has improved workers' short & medium-term physical health (proxied by accidents)

G S
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Increased usage of robotization has improved workers' short & medium-term physical health (proxied by accidents)

But this analysis raises concerns about the effects on populations' mental health

GS
SI

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Effects are different across space: large metropolitan areas appear to benefit more

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Effects are different across space: large metropolitan areas appear to benefit more

- Functional and structural differences (type of activities, HQ bias…)

- Compositional differences (individual characteristics, skills…)

- Agglomeration benefits (labour pooling and matching, exit options…)

Next steps

- Integrate other controls (e.g., trade intensity, temporary employment, education…)

- Identifying the drivers of the "Metropolitan effect"

Thank you for your attention

Arsène Perrot

arsene.perrot@gssi.it

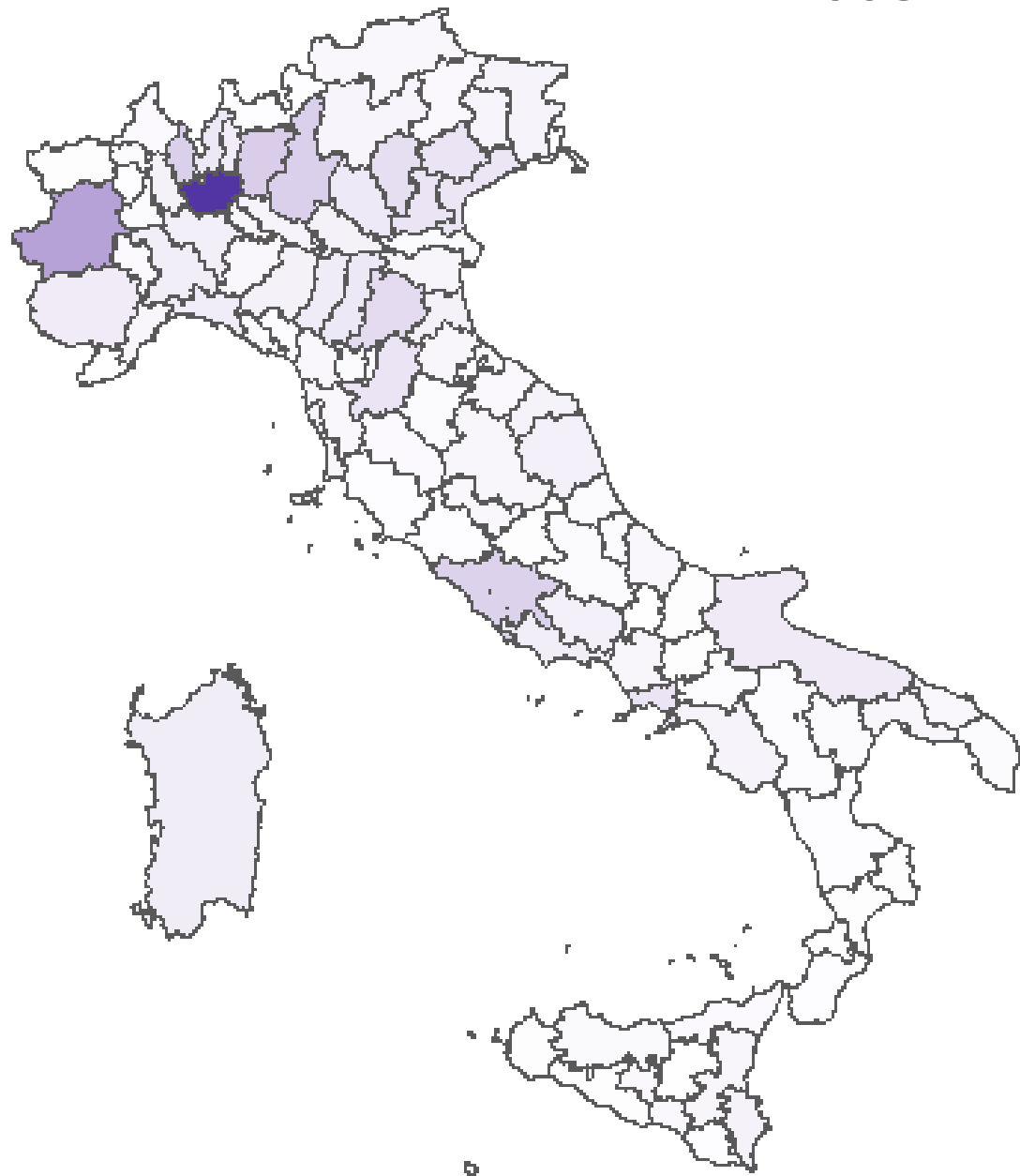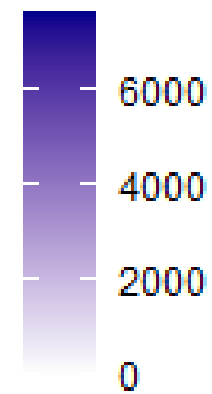www.gssi.it

Appendix Robot
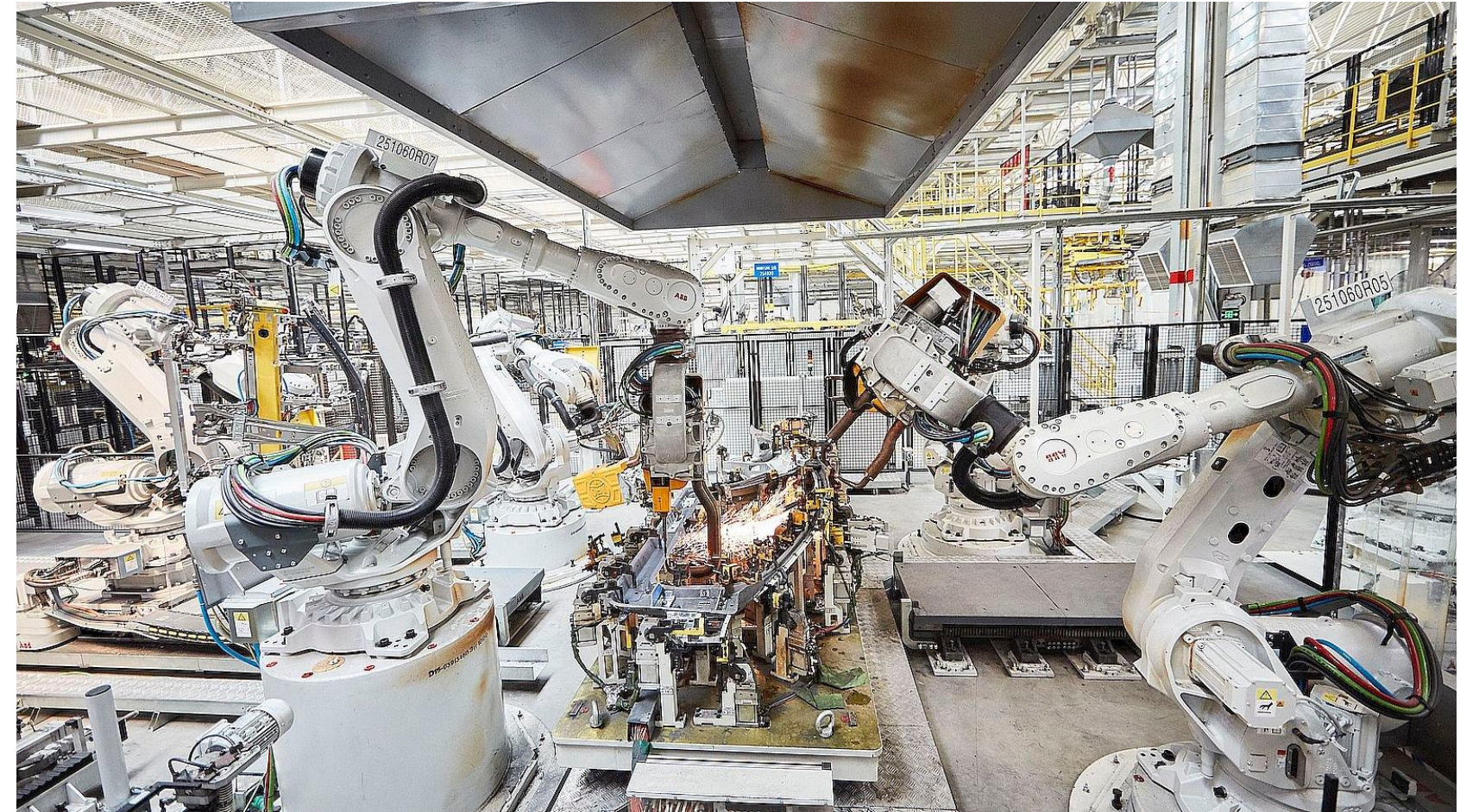
ISO Definition

An "automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or fixed to a mobile platform for use in automation applications in an industrial environment". (ISO 8373:2021)
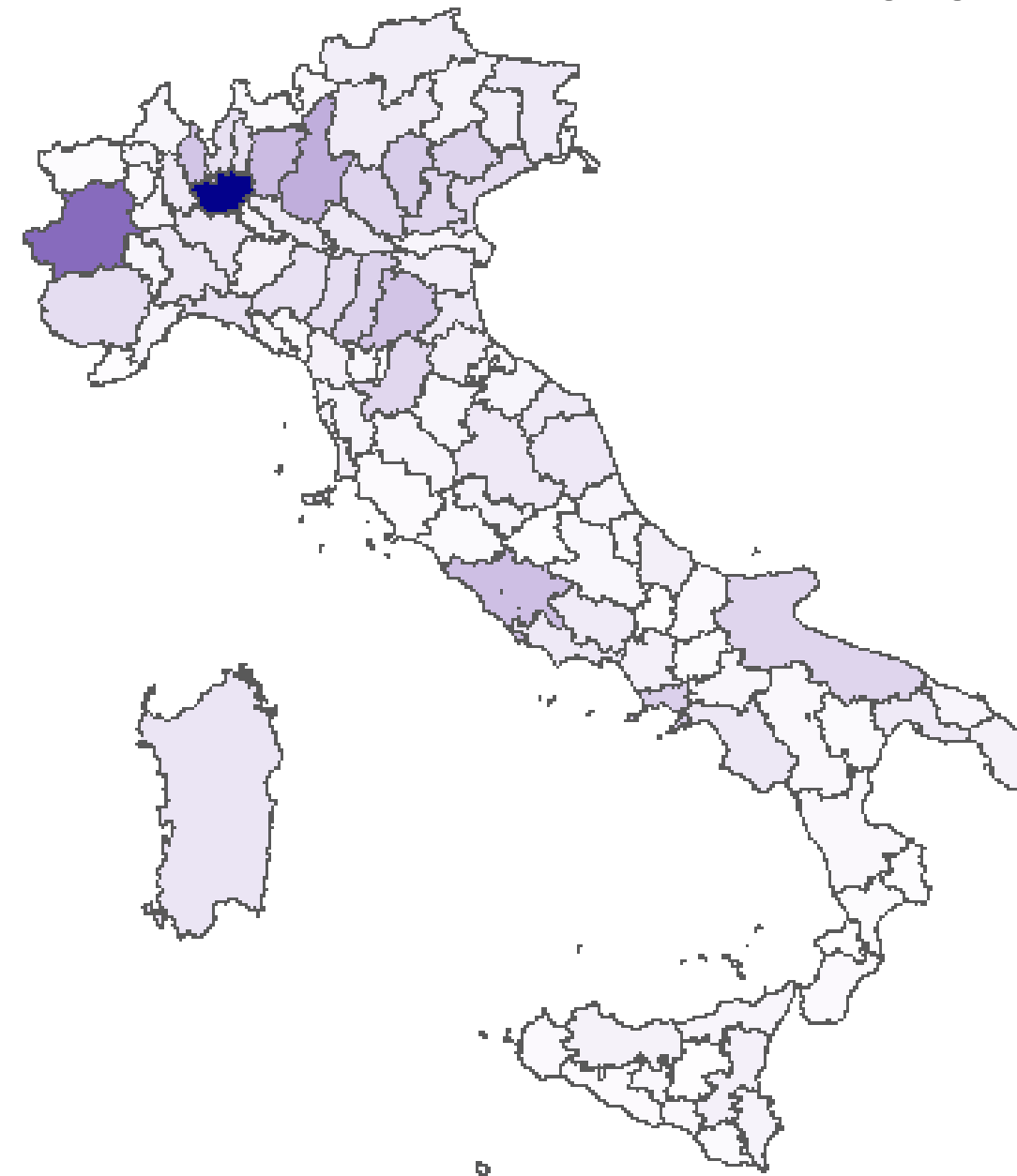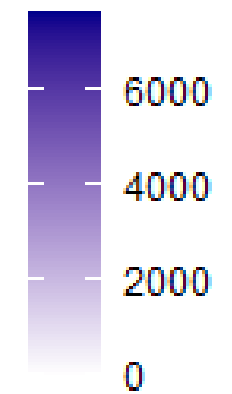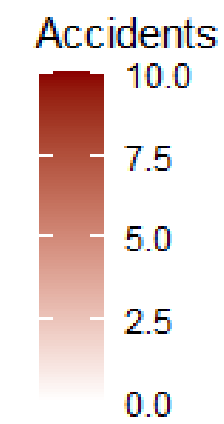
Appendix Exposure to Robot

2008

2020

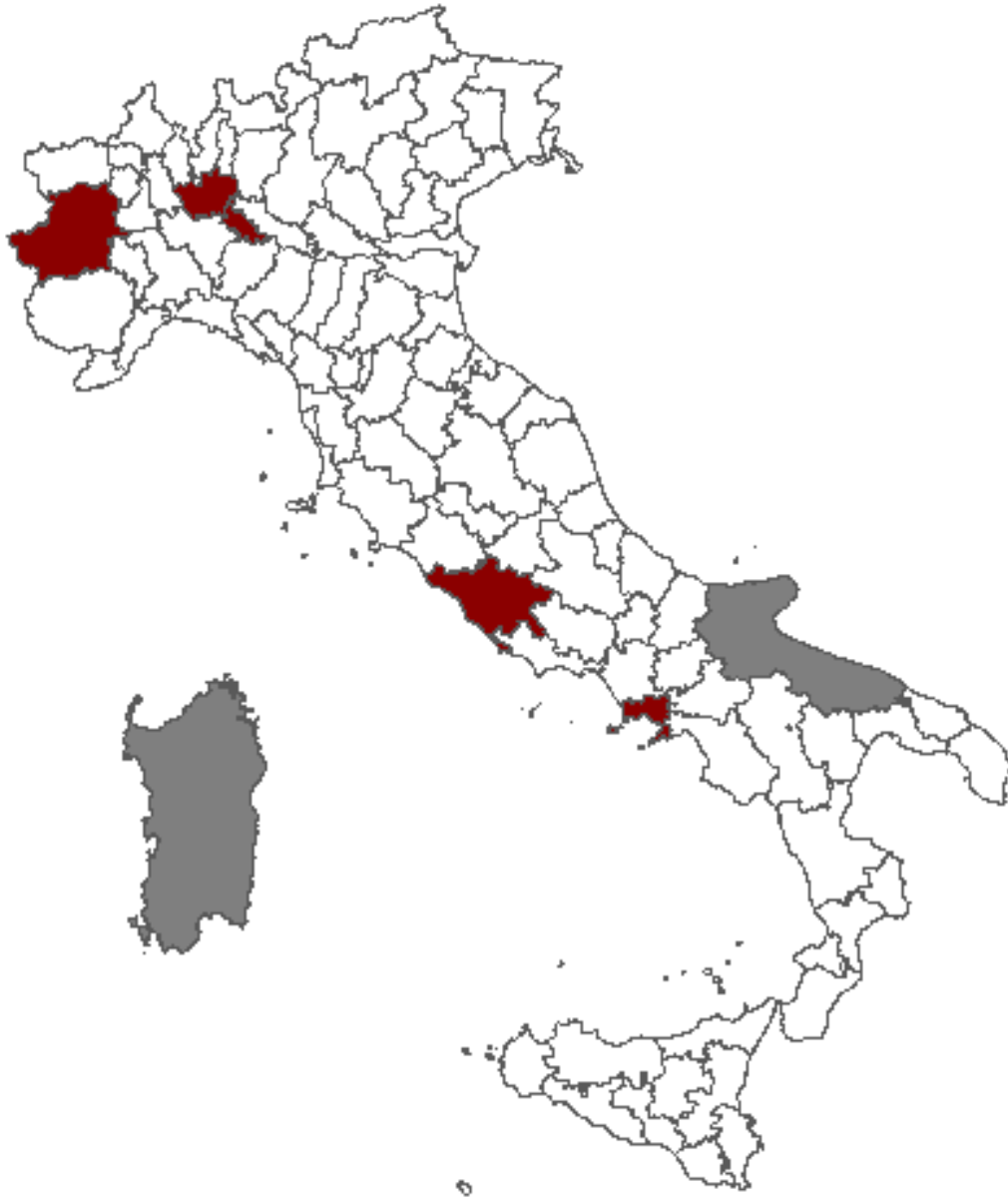# Appendix Accidents

2008

2020
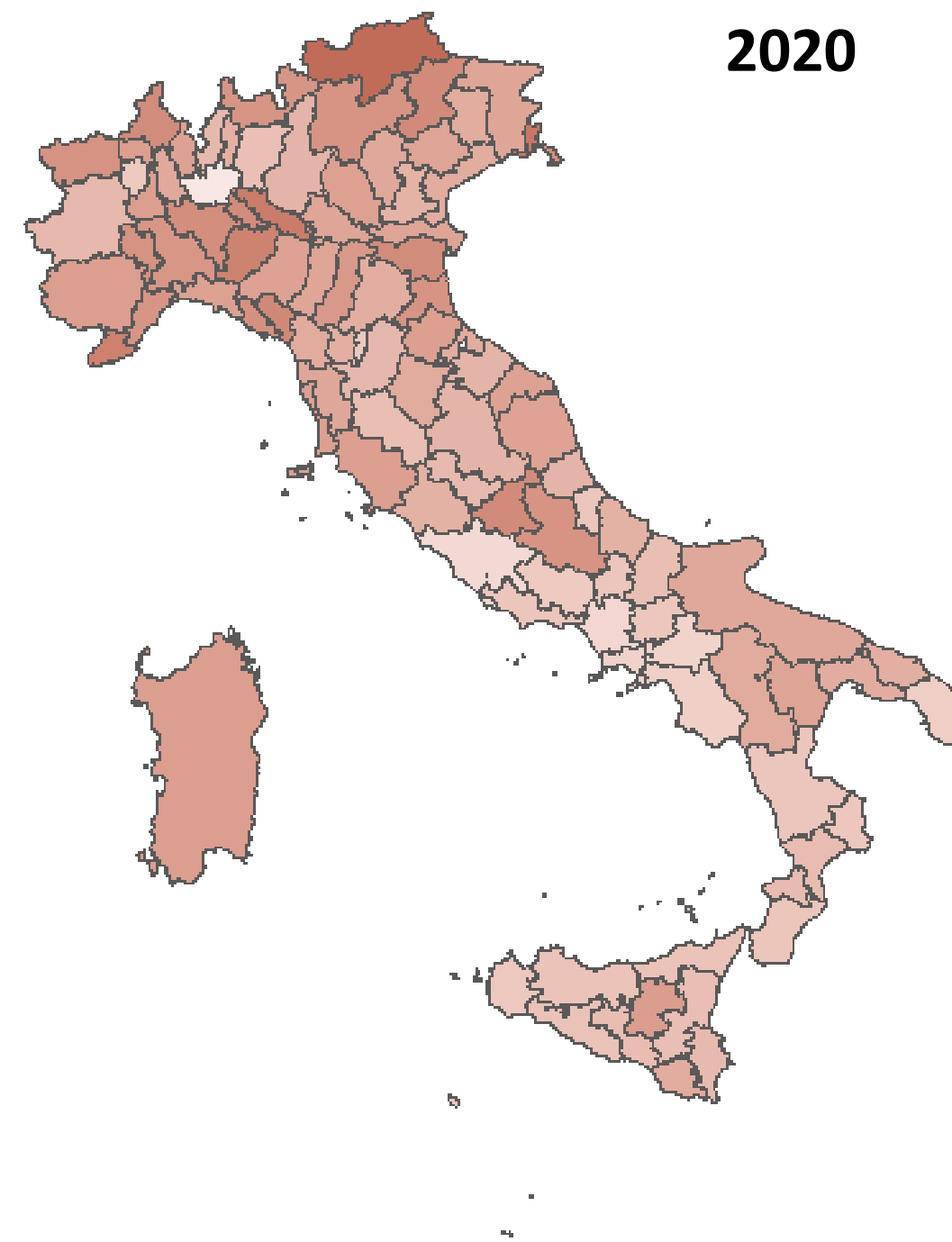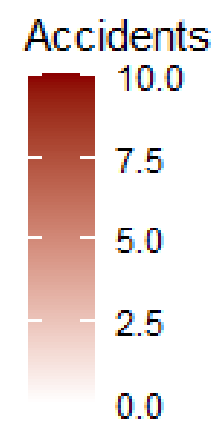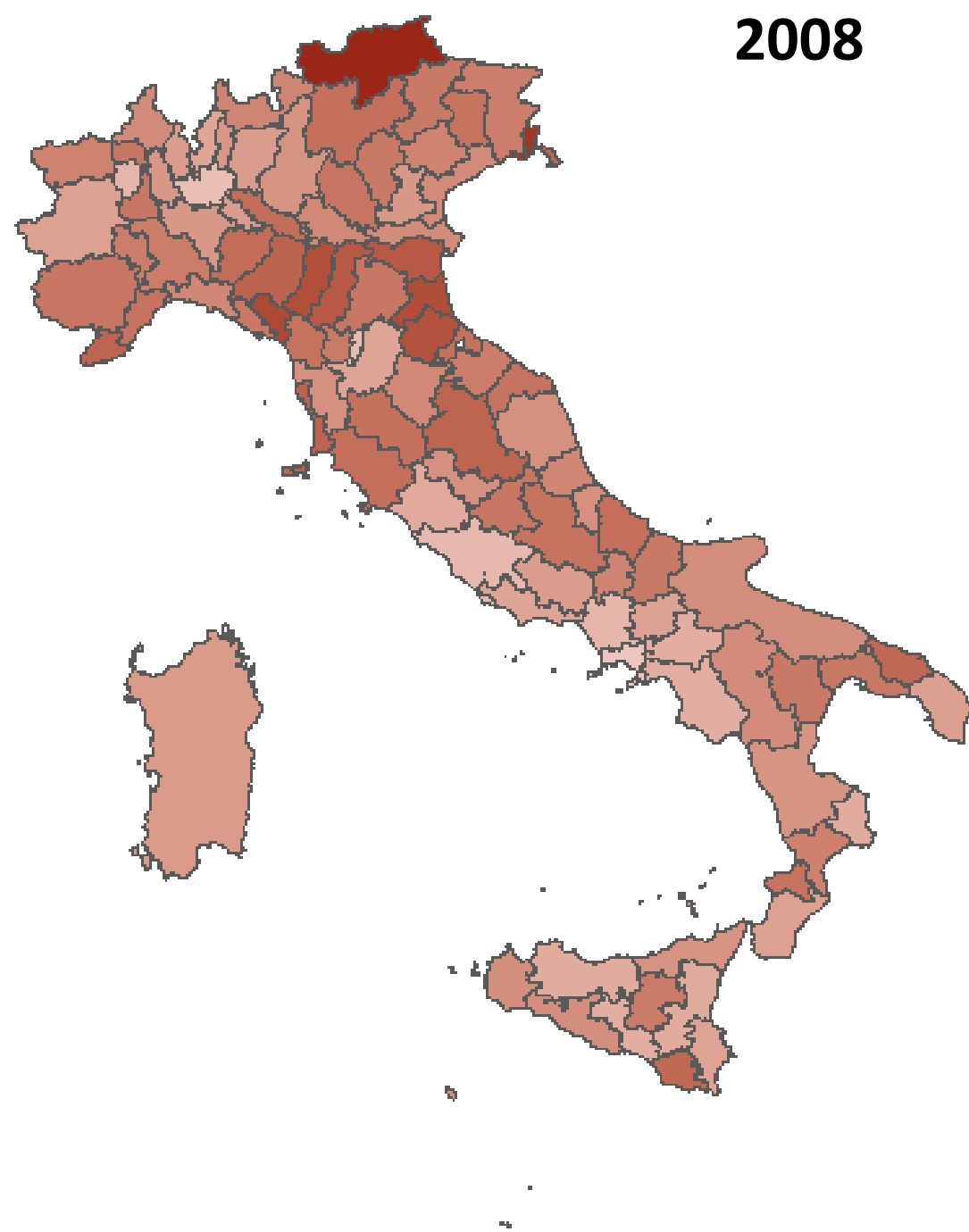
Appendix Regional Typology

Large Metropolitan Regions

Based on regional population's access to metropolitan FUAs
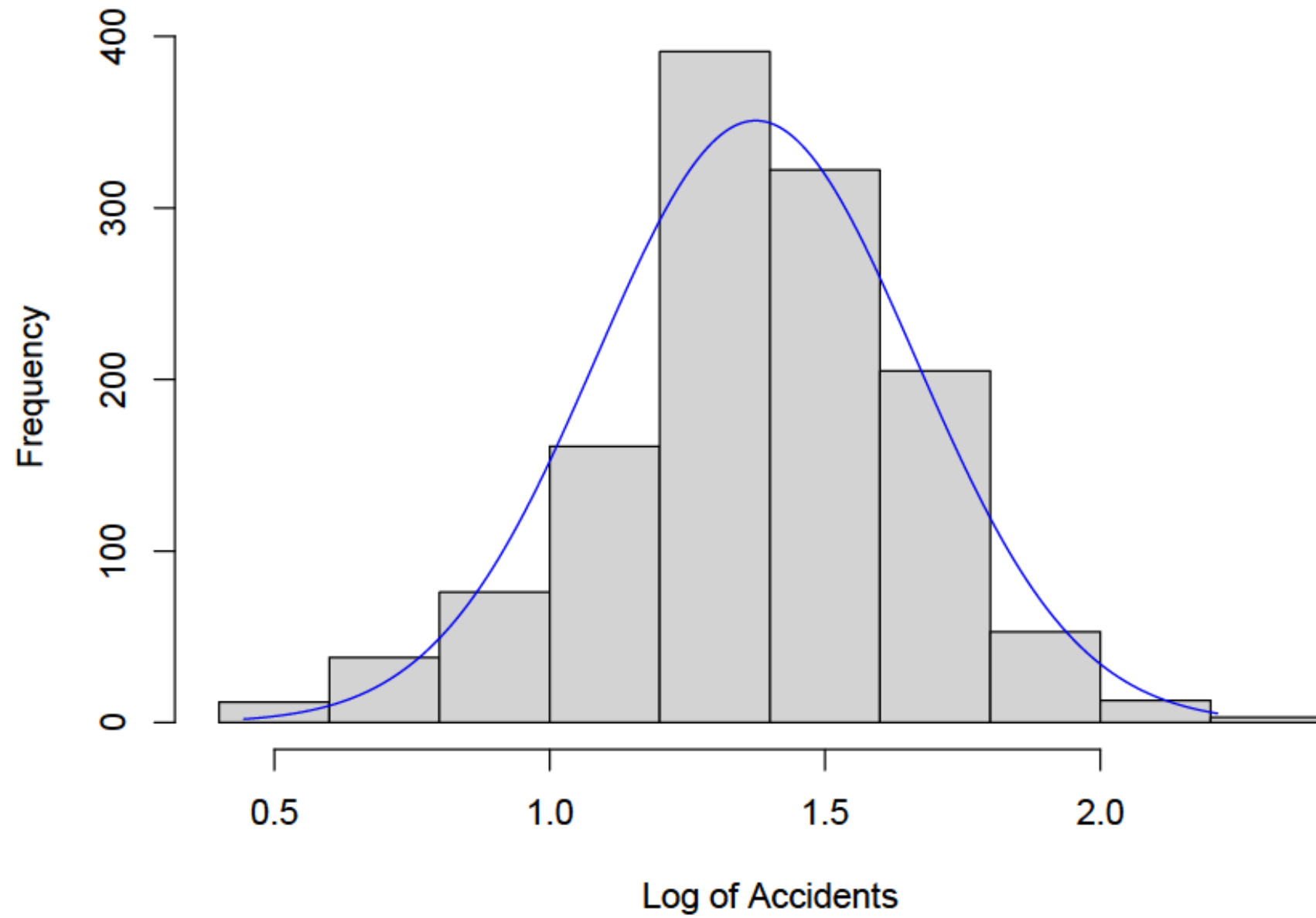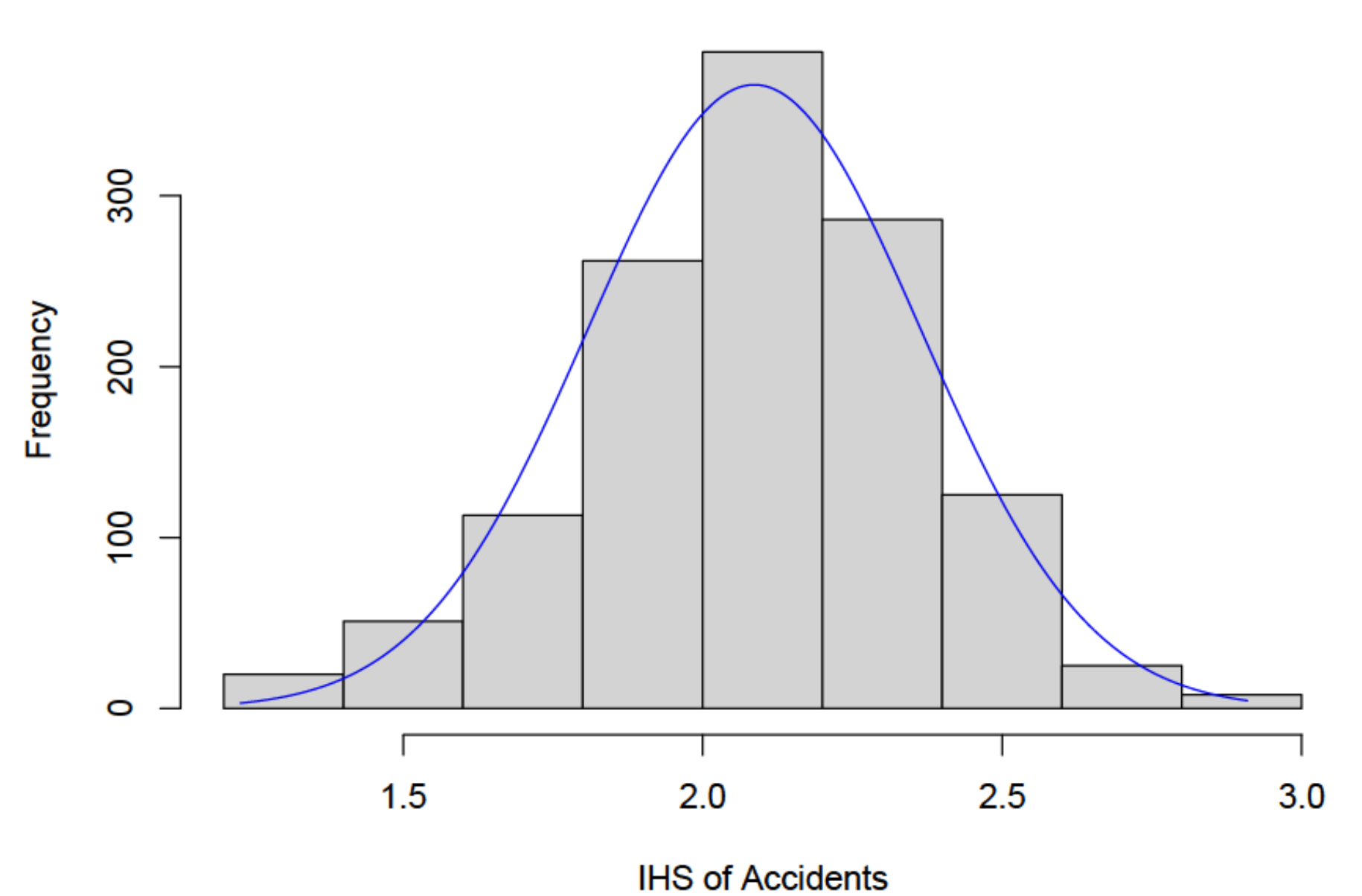
Fadic et al., 2019; OECD, 2024

Appendix Dispersion

Distribution of Log of Workplace Accidents

Distribution of IHS of Workplace Accidents

Appendix Dispersion (2)
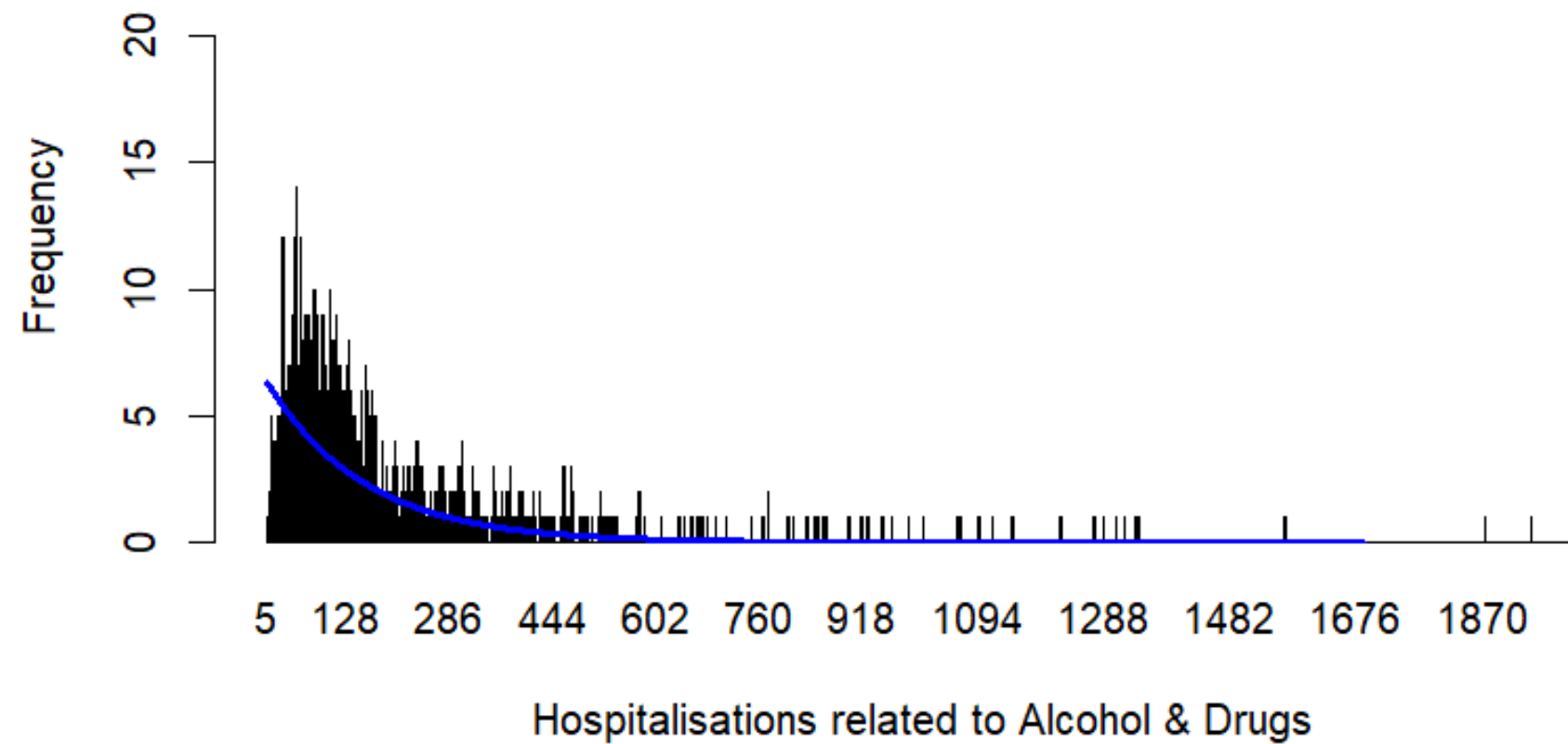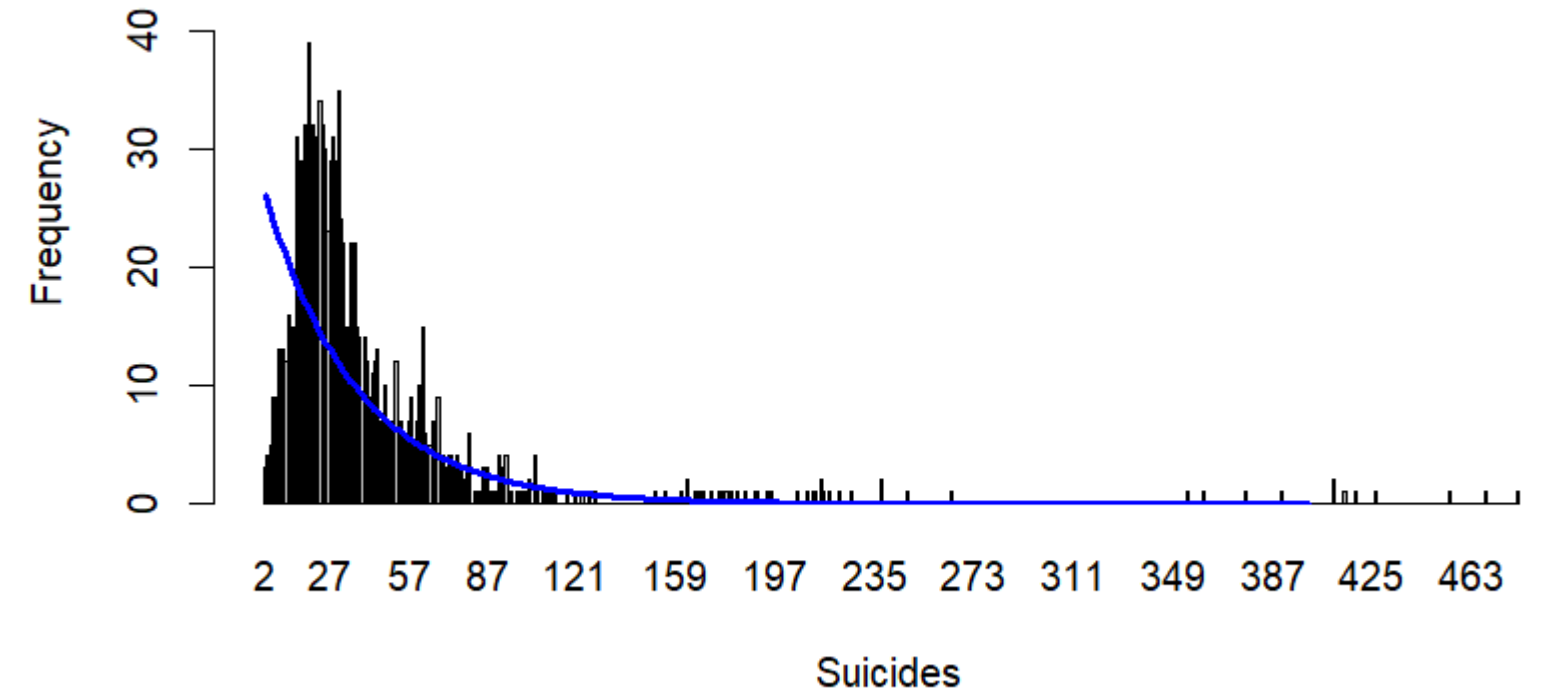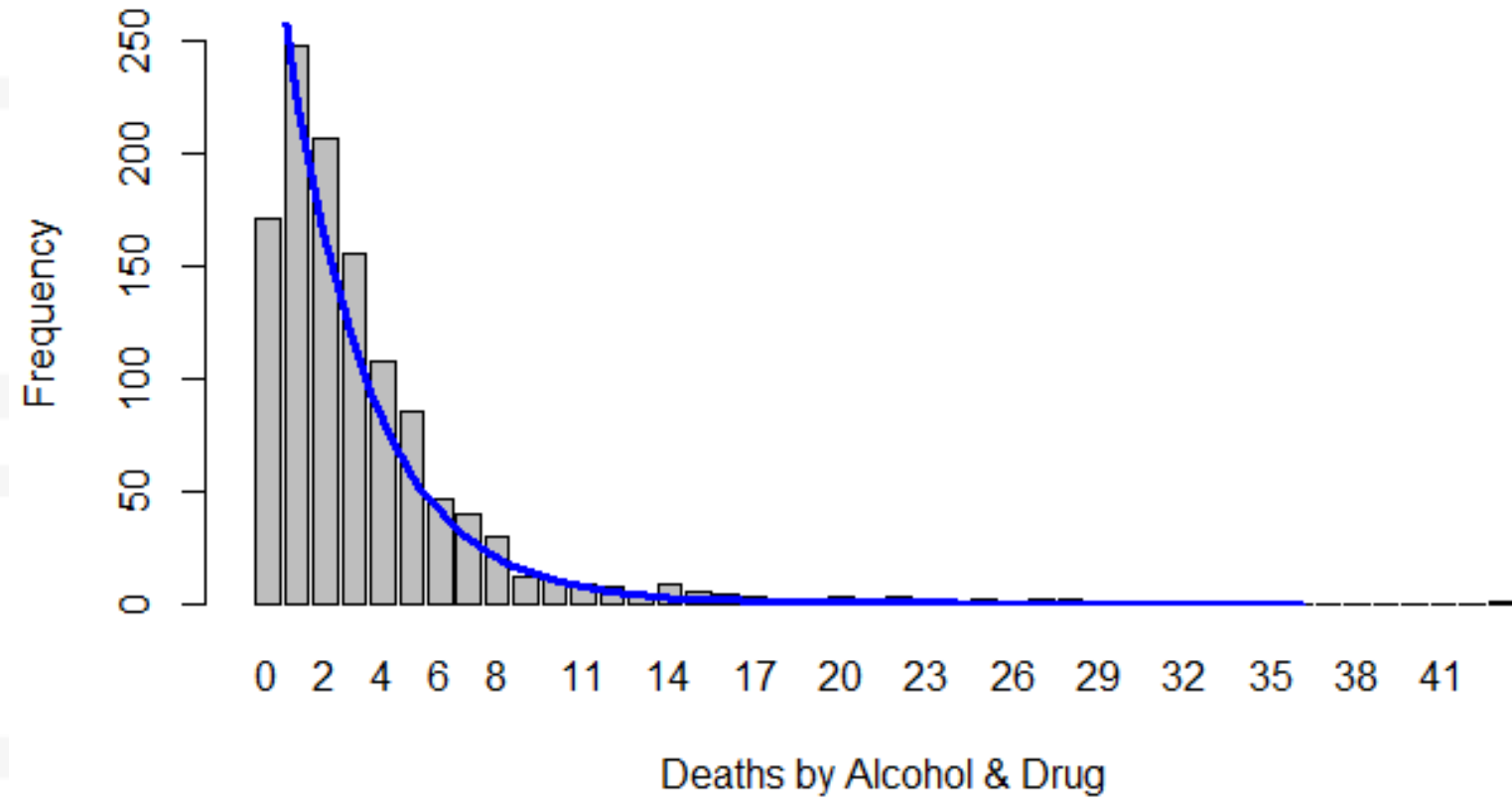
Appendix Lagged Relation

Table A3: *Lagged relation results, Workplace Accidents*

	Dependent variable: Workplace Accidents			
	Log-Log	IHS	Log-Log	IHS
	OLS	*OLS*	*IV*	*IV*
	(1)	(2)	(3)	(4)
Exposure to Robots *t-1*	−0.222***	−0.217***	−0.759***	−0.734***
	(0.032)	(0.030)	(0.157)	(0.151)
Observations	1,176	1,176	1,176	1,176
R^2	0.044	0.046	0.044	0.046
F Statistic (df = 1; 1066)	49.382***	50.995***	23.277***	23.642***

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Models' FE are twoways (province-year)

Appendix Accident Severity (1)

Table A21: *Effect of Exposure to robots on lower severity accidents*

	Dependent variable:			
	DAW	HAAW10	HAAW25	HAAW50
	OLS	*OLS*	*OLS*	*OLS*
	(1)	(2)	(3)	(4)
Exposure to Robots	−0.218***	−0.224***	−0.165***	−0.081***
	(0.030)	(0.032)	(0.027)	(0.020)
Observations	1,274	1,274	1,274	1,274
R^2	0.042	0.040	0.032	0.014
F Statistic (df = 1; 1163)	51.566***	47.916***	38.406***	15.971***

Note: *p<0.1; **p<0.05; ***p<0.01
Models' FE are twoways (province-year)

Table A22: *Effect of Exposure to robots on lower severity accidents IV*

	Dependent variable:			
	DAW	HAAW10	HAAW25	HAAW50
	IV	*IV*	*IV*	*IV*
	(1)	(2)	(3)	(4)
Exposure to Robots	−0.951***	−1.058***	−0.651***	−0.234***
	(0.154)	(0.167)	(0.125)	(0.085)
Observations	1,274	1,274	1,274	1,274
R^2	0.042	0.040	0.032	0.014
F Statistic	38.372***	40.013***	27.334***	7.466***

Note: *p<0.1; **p<0.05; ***p<0.01
Models' FE are twoways (province-year)

Appendix Accident Severity (2)

Table A23: *Effect of Exposure to robots on higher severities accidents*

	Dependent variable:			
	HAAW100	HAAW100	DEATH	DEATH
	OLS	*IV*	*OLS*	*IV*
	(1)	(2)	(3)	(4)
Exposure to Robots	−0.014	−0.043	0.001	−0.006
	(0.012)	(0.050)	(0.001)	(0.006)
Observations	1,274	1,274	1,274	1,274
R^2	0.001	0.001	0.001	0.001
F Statistic (df = 1; 1163)	1.295	0.763	1.026	1.327

Note: $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Models' FE are twoways (province-year)

Appendix Mental Health (1)

Table A6: *Baseline results for mental health, no FE*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM	*GLM*	*GLM*
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000283***	0.000245***	0.000550***
	(0.000049)	(0.000031)	(0.000056)
Population	0.0000005***	0.0000007***	0.0000004***
	(0.00000004)	(0.00000003)	(0.00000005)
Constant	0.609907***	2.984111***	4.463725***
	(0.033567)	(0.019081)	(0.029329)
Observations	1,176	1,176	1,176
Akaike Inf. Crit.	4992.52514	9510.637208	13694.595078

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Control for population level, no FE

Appendix Mental Health (2)

Table A7: *Baseline IV estimation for mental health indicators, no FE*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM-IV	GLM-IV	GLM-IV
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000283***	0.000254***	0.000577***
	(0.000083)	(0.000060)	(0.000106)
Population	0.0000005***	0.0000007***	0.0000004***
	(0.00000003)	(0.00000005)	(0.00000003)
Predicted Residuals	−0.000014	−0.000456	−0.000988
	(0.000610)	(0.000413)	(0.000628)
Constant	0.609912***	2.983898***	4.461235***
	(0.037374)	(0.026155)	(0.040379)
Observations	1,176	1,176	1,176
Akaike Inf. Crit.	4994.523772	9509.07983	13690.567531

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Control for population level, no FE

Appendix Mental Health (3)

Table A4: *Baseline results for mental health indicators*

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM	*GLM*	*GLM*
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	−0.000069	−0.000012	0.000173***
	(0.000105)	(0.000034)	(0.000066)
Population	−0.000001***	0.0000002	0.0000002
	(0.0000004)	(0.0000002)	(0.0000003)
Constant	6.245353***	4.894285***	6.033427***
	(0.945969)	(0.344181)	(0.722326)
Observations	1,176	1,176	1,176
Akaike Inf. Crit.	4395.240757	7686.377172	11062.587211

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Province-Year unconditional FE

Appendix Mental Health (4)

Table A5: *Baseline IV estimation for mental health indicators*

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM	*GLM*	*GLM*
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000189**	0.000226***	0.000317***
	(0.000083)	(0.000032)	(0.000064)
Population	0.0000002	0.0000002*	0.00000009
	(0.0000003)	(0.00000009)	(0.00000007)
Predicted Residuals	−0.000136	−0.000653	−0.000347
	(0.000496)	(0.000443)	(0.000508)
Constant	1.247164	3.736717***	6.112111***
	(0.951118)	(0.135072)	(0.882)
Observations	1,176	1,176	1,176
Akaike Inf. Crit.	5583.022851	10827.268974	14452.795597

Note: *p<0.1; **p<0.05; ***p<0.01
Province-Year unconditional FE

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Appendix Mental Controls (1)

Table A8: *Control results for mental health*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM	*GLM*	*GLM*
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000068	0.000185***	0.000087*
	(0.000048)	(0.000032)	(0.000049)
Population	0.0000007***	0.0000007***	0.0000009***
	(0.00000005)	(0.00000003)	(0.00000005)
Unemp. Rate	−0.053108***	−0.025339***	−0.074259***
	(0.005148)	(0.002473)	(0.003379)
Unemp. Delta	0.002322	0.0189705***	0.037123***
	(0.014742)	(0.007137)	(0.009318)
Constant	1.092356***	3.226970***	5.084156***
	(0.096077)	(0.029787)	(0.040997)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4583.430708	8785.579496	12492.434753

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

No FE

Appendix Mental Controls (2)

Table A9: *IV estimation with controls for mental health indicators*

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM-IV *Neg. Bin.*	*GLM-IV* *Neg. Bin.*	*GLM-IV* *Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000062 (0.000080)	0.000194*** (0.000059)	0.000084 (0.000086)
Population	0.0000007*** (0.00000005)	0.0000007*** (0.00000006)	0.0000009*** (0.00000008)
Unemp. Rate	−0.053351*** (0.005247)	−0.024986*** (0.002873)	−0.074389*** (0.004140)
Unemp. Delta	0.002874 (0.013474)	0.018721** (0.007293)	0.037192*** (0.010075)
Predicted Residuals	0.000271 (0.000603)	−0.000346 (0.000357)	0.000103 (0.00001)
Constant	1.093933*** (0.063122)	3.223909*** (0.035585)	5.085291*** (0.051942)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4584.889837	8785.114312	12494.340975

Note: *p<0.1; **p<0.05; ***p<0.01

No FE

Table A10: *Unemployment controls for mental health indicators*

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM	*GLM*	*GLM*
	Neg. Bin.	*Neg. Bin.*	*Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	−0.000106	−0.000016	0.000158**
	(0.000106)	(0.000033)	(0.000067)
Population	−0.000002***	0.00000004	0.00000002
	(0.0000004)	(0.0000002)	(0.0000003)
Unemp. Rate	−0.024779*	−0.006705*	−0.019540***
	(0.013123)	(0.003933)	(0.004310)
Unemp. Delta	−0.003525	0.002102	0.005705
	(0.015015)	(0.004512)	(0.004866)
Constant	6.967862***	5.250796***	6.622485***
	(1.005861)	(0.355978)	(0.742305)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4138.111269	7220.083108	10448.745285

Note: *p<0.1; **p<0.05; ***p<0.01

Province-Year unconditional FE

Appendix Mental Controls (4)

Table A11: *IV estimation with controls for mental health indicators*

	Dependent variable:		
	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.
	(1)	(2)	(3)
Exposure to Robots	−0.000093	0.000063	0.000062
	(0.000399)	(0.000075)	(0.000094)
Population	−0.000002	0.0000006***	0.0000008***
	(0.000002)	(0.0000002)	(0.0000002)
Unemp. Rate	−0.024594	−0.049874***	−0.074638***
	(0.016782)	(0.012269)	(0.016083)
Unemp. Delta	−0.003569	−0.000704	0.000243
	(0.018806)	(0.003171)	(0.006656)
Predicted Residuals	−0.00003	−0.000050	0.000213
	(0.000565)	(0.000429)	(0.000696)
Constant	6.922034	3.689886***	5.177572***
	(5.044010)	(0.037609)	(0.036674)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4140.082805	9765.417514	13175.044434

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Province-Year unconditional FE

Appendix Mental – Space (1)

Table A14: *Spatial analysis for mental health*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	GLM *Neg. Bin.*	**GLM** *Neg. Bin.*	**GLM** *Neg. Bin.*
	(1)	(2)	(3)
Exposure to Robots	0.000670*** (0.000082)	0.000632*** (0.000045)	0.000737*** (0.000071)
Large Metro	0.425958** (0.181401)	−0.417905*** (0.091936)	0.070995 (0.123655)
Exposure to Robots X Large Metro	−0.000705*** (0.000086)	−0.000488*** (0.000046)	−0.000820*** (0.000070)
KIABI LQ	−0.089317 (0.151669)	−0.072618 (0.074894)	0.524268*** (0.110406)
Population	0.0000007*** (0.00000006)	0.0000008*** (0.00000003)	0.0000008*** (0.00000005)
Unemp. Rate	−0.037939*** (0.005448)	−0.015566*** (0.002390)	−0.055940*** (0.003463)
Unemp. Delta	0.00776 (0.014226)	0.022527*** (0.006318)	0.035510*** (0.008615)
Constant	0.806884*** (0.149183)	2.980706*** (0.070888)	4.272868*** (0.105691)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4505.727976	8502.986889	12307.483298

Note: *p<0.1; **p<0.05; ***p<0.01
No FE

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Appendix Mental – Space (2)

Table A15: *IV Spatial analysis for mental health*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.	GLM-IV Neg. Bin.
	(1)	(2)	(3)
Exposure to Robots	0.000674***	0.000639***	0.000737***
	(0.000091)	(0.000054)	(0.000083)
Large Metro	0.425694*	−0.423763***	0.071173
	(0.227690)	(0.121612)	(0.117299)
Exposure to Robots X Large Metro	−0.000706***	−0.000486***	−0.000820***
	(0.000095)	(0.000057)	(0.000072)
KIABI LQ	−0.092634	−0.075254	0.524212***
	(0.163645)	(0.078259)	(0.143892)
Population	0.0000007***	0.0000008***	0.0000008***
	(0.00000008)	(0.00000004)	(0.00000007)
Unemp. Rate	−0.037821***	−0.015346***	−0.055947***
	(0.005504)	(0.002570)	(0.004049)
Unemp. Delta	0.007613	0.022500***	0.035511***
	(0.013506)	(0.006878)	(0.009532)
Predicted Residuals	−0.000137	−0.000365	0.000008
	(0.000381)	(0.000276)	(0.000364)
Constant	0.807883***	2.980933***	4.272971***
	(0.158076)	(0.069178)	(0.129320)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4507.539111	8501.111231	12309.482526

Note: $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
No FE

Appendix Mental – Space (3)

Table A12: *Spatial analysis for mental health*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM Neg. Bin.	*GLM* Neg. Bin.	*GLM* Neg. Bin.
	(1)	(2)	(3)
Exposure to Robots	0.000576** (0.000280)	−0.000065 (0.000092)	0.000404*** (0.000119)
Large Metro	4.935980*** (0.824859)	2.063403*** (0.282307)	1.893171*** (0.581011)
Exposure to Robots X Large Metro	−0.000682*** (0.000255)	0.000065 (0.000086)	−0.000313** (0.000126)
KIABI LQ	0.047098 (0.272899)	−0.086905 (0.081843)	−0.019792 (0.099131)
Population	−0.000001*** (0.0000004)	0.000000001 (0.0000002)	0.0000001 (0.0000003)
Unemp. Rate	−0.016941 (0.013548)	−0.007609* (0.004034)	−0.017809*** (0.004370)
Unemp. Delta	−0.009366 (0.015138)	0.002810 (0.004559)	0.004411 (0.004892)
Constant	1.341398*** (0.449495)	3.333583*** (0.141775)	4.772787*** (0.206783)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	4135.038931	7222.495086	10446.387776

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Province-Year unconditional FE

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Appendix Mental – Space (4)

Table A13: *Spatial analysis for mental health with IV*

	Death-Alcohol/Drugs	Suicides	Hospitalization-Alcohol/Drugs
	Dependent variable:		
	GLM-IV	GLM-IV	GLM-IV
	Neg. Bin.	Neg. Bin.	Neg. Bin.
	(1)	(2)	(3)
Exposure to Robots	0.000073	0.000101	0.000232**
	(0.000436)	(0.000069)	(0.000097)
Large Metro	0.000003	0.0000008	0.000091
	(3.543116)	(0.000109)	(0.206228)
Exposure to Robots X Large Metro	0.000173	0.000037	−0.000040
	(0.000527)	(0.000157)	(0.000206)
KIABI LQ	−0.000054	−0.002646	−0.001688
	(0.259487)	(0.001667)	(0.003168)
Population	0.0000002	0.0000005**	0.0000004
	(0.000001)	(0.0000002)	(0.0000003)
Unemp. Rate	−0.001000	−0.038008**	−0.033414
	(0.014206)	(0.018430)	(0.026123)
Unemp. Delta	−0.000036	−0.000586	−0.000528
	(0.011997)	(0.001156)	(0.001417)
Predicted Residuals	−0.000062	−0.000012	0.000793
	(0.000655)	(0.000534)	(0.000974)
Constant	1.230165**	3.691283***	5.180854**
	(0.623757)	(0.038716)	(0.042256)
Observations	1,116	1,116	1,116
Akaike Inf. Crit.	5255.972500	9803.337470	13362.444012

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Province-Year unconditional FE

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