

# **The impact of R&D grants on the performance of NZ firms**

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# Seeking to understand impact of R&D grants on performance of NZ firms

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## MOTIVATION

- Low investment in knowledge-based capital blamed for up to 40% of NZ's productivity gap vis-à-vis OECD (de Serres et al, 2014)
- NZ Government target to raise BERD to 1% of GDP by 2018
- Primary tool is R&D grants (\$138M in 2015)

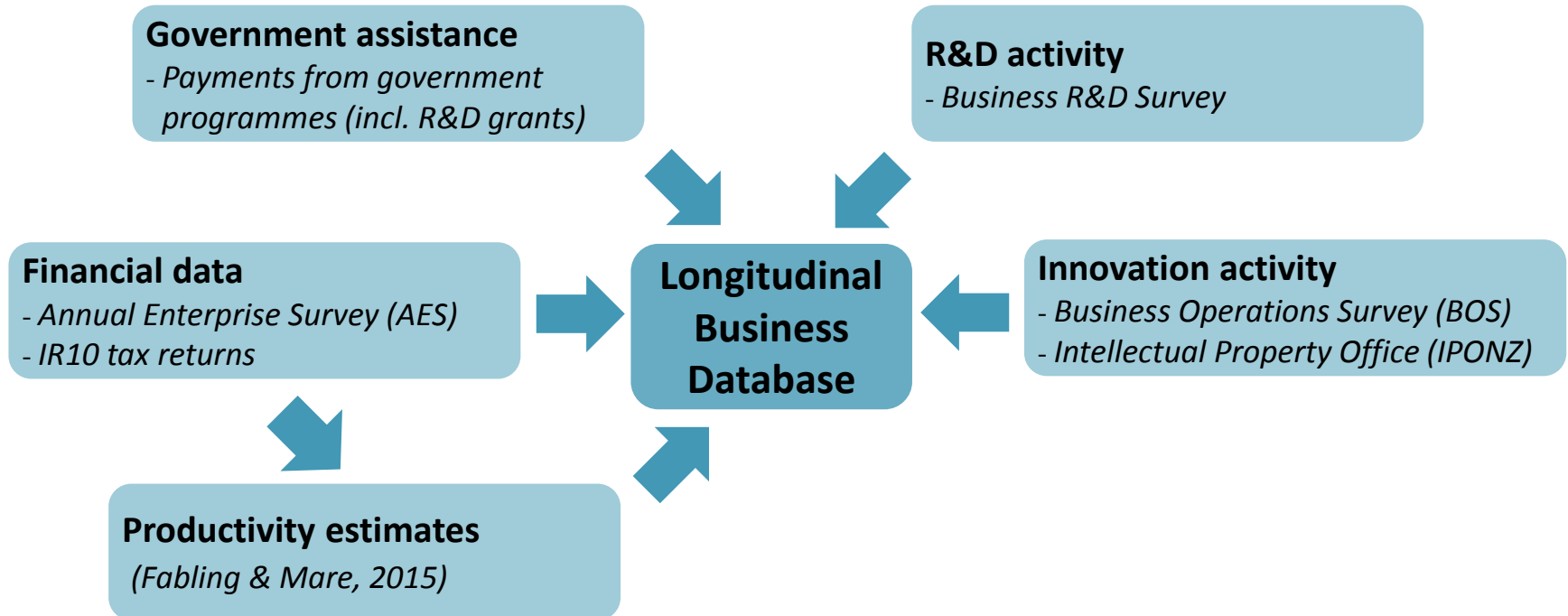
## RESEARCH QUESTIONS:

- How does obtaining R&D grants impact firm performance?
- For which firms does obtaining R&D grants have greatest impact?

# Use data from the LBD to evaluate the impact of these R&D grants on firm performance

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## DATA SOURCES



Access to the data presented was managed by Statistics New Zealand under strict micro-data access protocols and in accordance with the security and confidentiality provisions of the Statistic Act 1975. These findings are not Official Statistics. The opinions, findings, recommendations, and conclusions expressed are those of the author/researcher, not Statistics New Zealand or the New Zealand Productivity Commission.

## R&D grant scheme simplified to 3 types under Callaghan Innovation

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### CALLAGHAN INNOVATION GRANT TYPES

Type	Description	Value in 2015 (#)
<b>Growth</b>	Covers 20% of R&D costs up to \$5 million a year. They are available to businesses that invest over 1.5% of turnover in R&D	\$134,927,861 (85)
<b>Project</b>	Covers up to 50% of R&D costs and are awarded primarily to businesses undertaking research for the first time	\$24,114,907 (302)
<b>Student</b>	Help businesses access undergraduate and postgraduate students who can assist with R&D projects	\$6,402,790 (280)

*Source: Callaghan Innovation (2015) Annual Report*

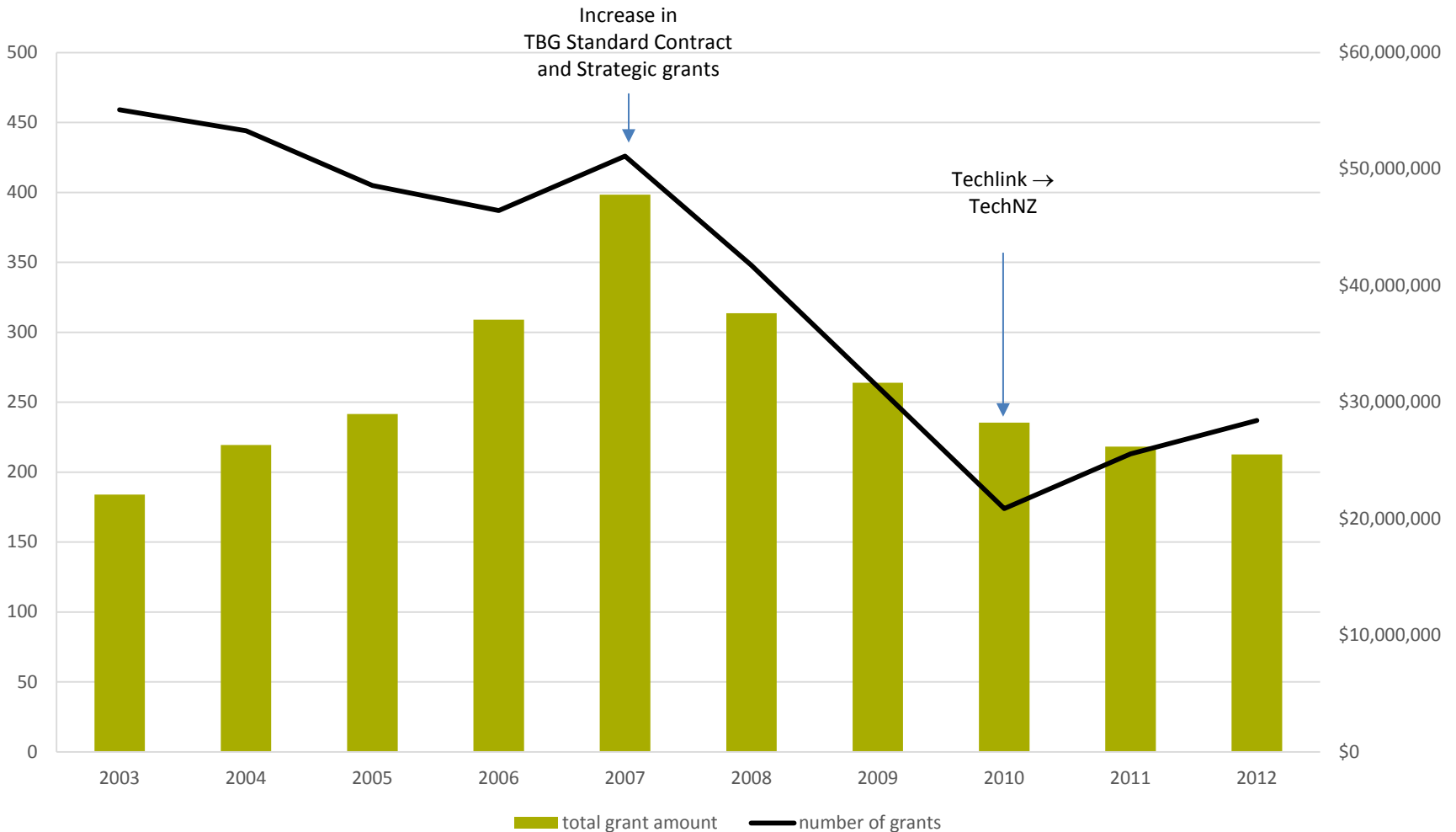
# Focus on grant types corresponding to Callaghan's "Project" grant with amounts above \$10,000

## PRE-CALLAGHAN "PROJECT" GRANTS

Grant Name	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TBG In-House R&D	■	■																		
TBG Technology Transfer	■	■	■																	
TBG Cooperative Research	■	■	■	■	■	■	■	■												
TIF Education	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK International Acquisitions				■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK Strategic Planning				■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK Technology Demos				■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK Seminars				■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK Evaluations				■	■	■	■	■	■	■	■	■	■	■	■	■				
TBG Consultancy				■	■	■	■	■	■	■	■	■	■	■	■	■				
TBG Small Research Contract				■	■	■	■	■	■	■	■	■	■	■	■	■				
TBG Technical Assessment				■	■	■	■	■	■	■	■	■	■	■	■	■				
TECHLINK TechNet				■	■	■	■	■	■	■	■	■	■	■	■	■				
TBG Standard Contract				■	■	■	■	■	■	■	■	■	■	■	■	■				
TIF Undergraduate				■	■	■	■	■	■	■	■	■	■	■	■	■				
TIF Expert				■	■	■	■	■	■	■	■	■	■	■	■	■	■			
GPSRD								■	■	■	■	■	■	■	■	■				
TECHLINK Consultancy									■	■	■	■	■	■	■	■				
TECHLINK SmartStart										■	■	■	■	■	■	■				
TECHLINK Special Projects										■	■	■	■	■	■	■				
TBG Strategic														■						
Project Funding																■	■	■	■	
Capability - via Business Managers																■	■	■	■	
Technology Project grants																■	■	■	■	■
Capability grants																■	■	■	■	
TechNZ - Accelerate (\$5 - \$30K)																■	■	■	■	
TechNZ - Getting started (max \$5K)																■	■	■	■	
Postgraduate internships																■	■	■	■	■
Technology Development Grant (2010/11 Round 1)																	■	■	■	■
TechNZ - Accelerate R&D																	■	■	■	■
TechNZ - Education																	■	■	■	■
TechNZ - Expert																	■	■	■	■
TechNZ - Getting Started																	■	■	■	■
TechNZ - Technology Projects **PILOT**																	■	■	■	■
Technology Development Grant (2010/11 Round 2)																	■	■	■	■
Capability grants (Education - PhD and Masters)																	■	■	■	■
Capability grants (Getting started and Expert)																	■	■	■	■
Technology Transfer Voucher																	■	■	■	■
Undergraduate internships																	■	■	■	■
Technology Development Grant Round 3 (2012/2013)																		■	■	■

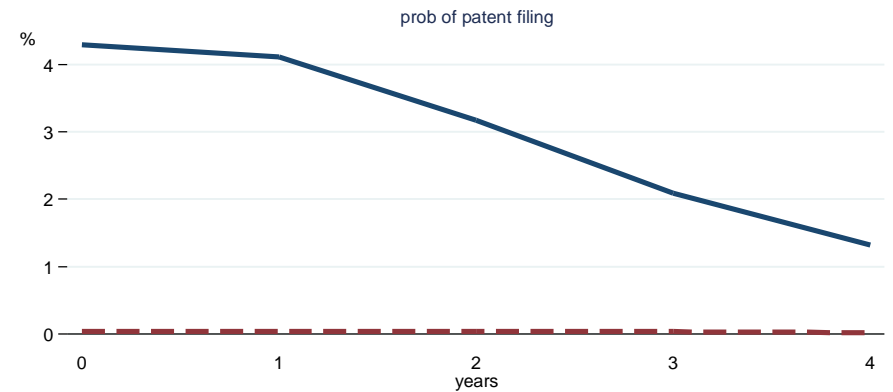
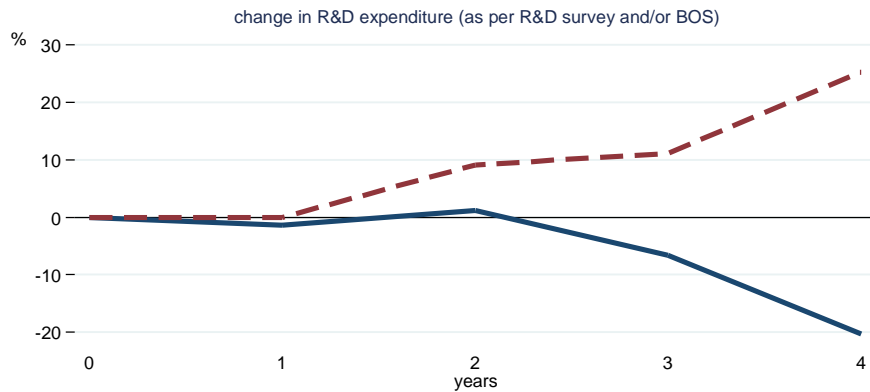
# Large variation in grant recipients and value across years, explained by scheme changes (plus possibly imperfect correspondence)

## PRE-CALLAGHAN "PROJECT" GRANT RECIPIENTS BY YEAR

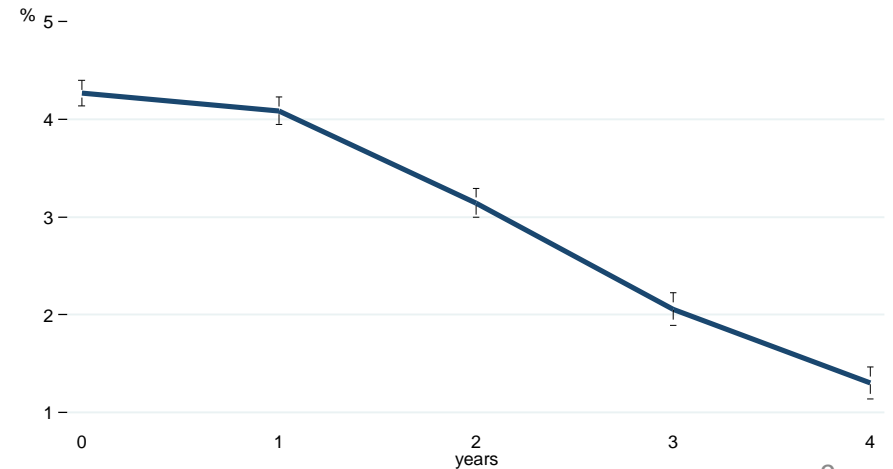
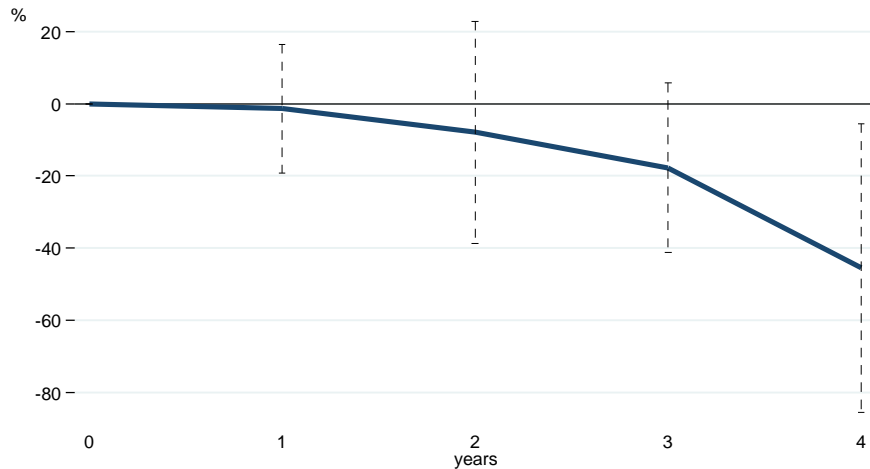


# Grant recipients have lower R&D expenditure in subsequent years, but higher likelihood of patenting

## R&D EXPENDITURE/PATENTING OF RECIPIENTS VS NON-RECIPIENTS (NOT MATCHED)

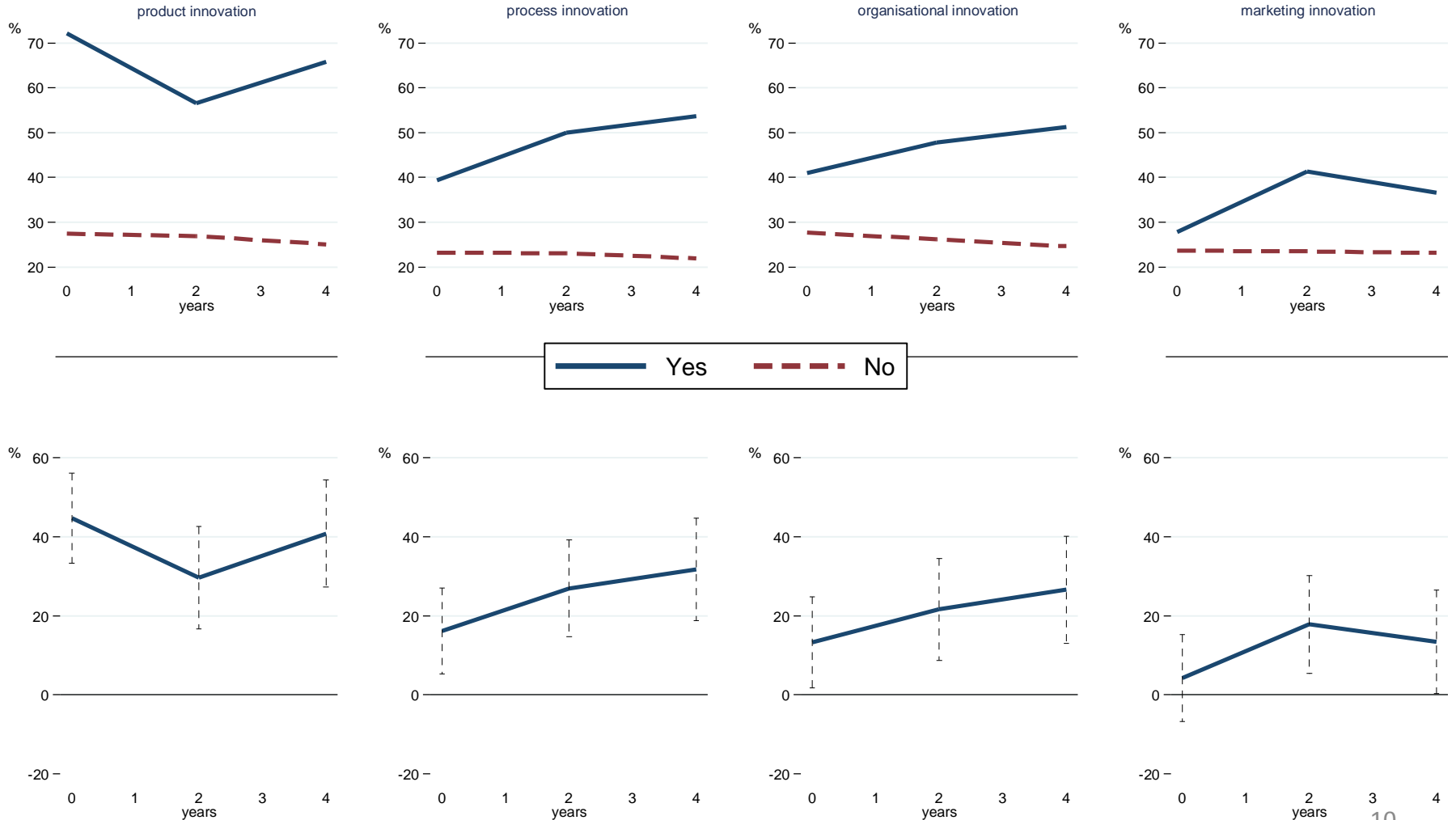


— Yes    - - - No



# Grant recipients significantly more likely to introduce any type of innovation

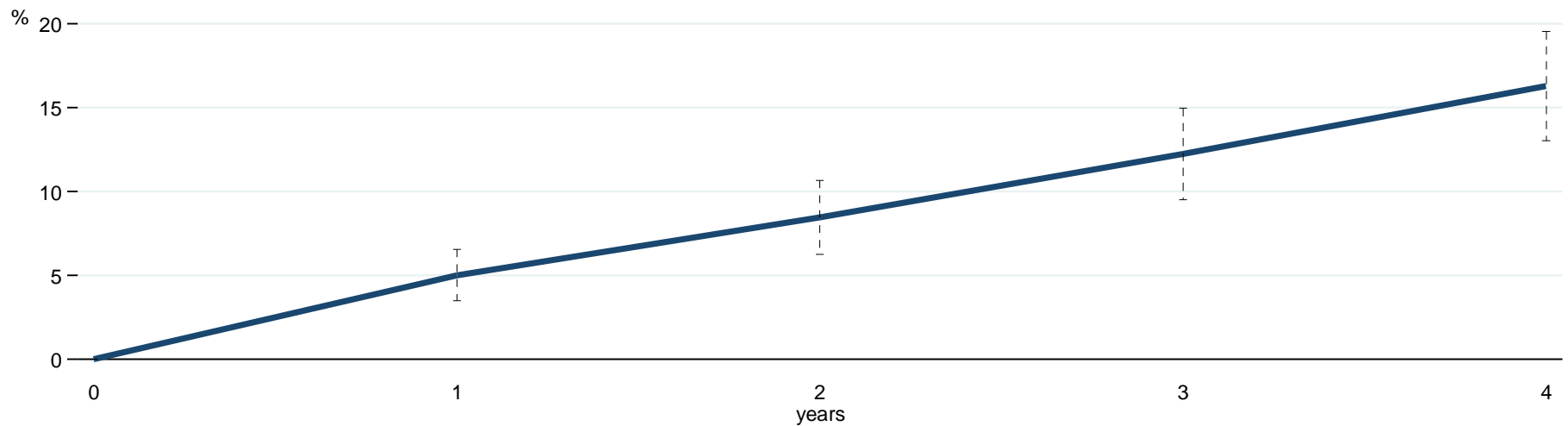
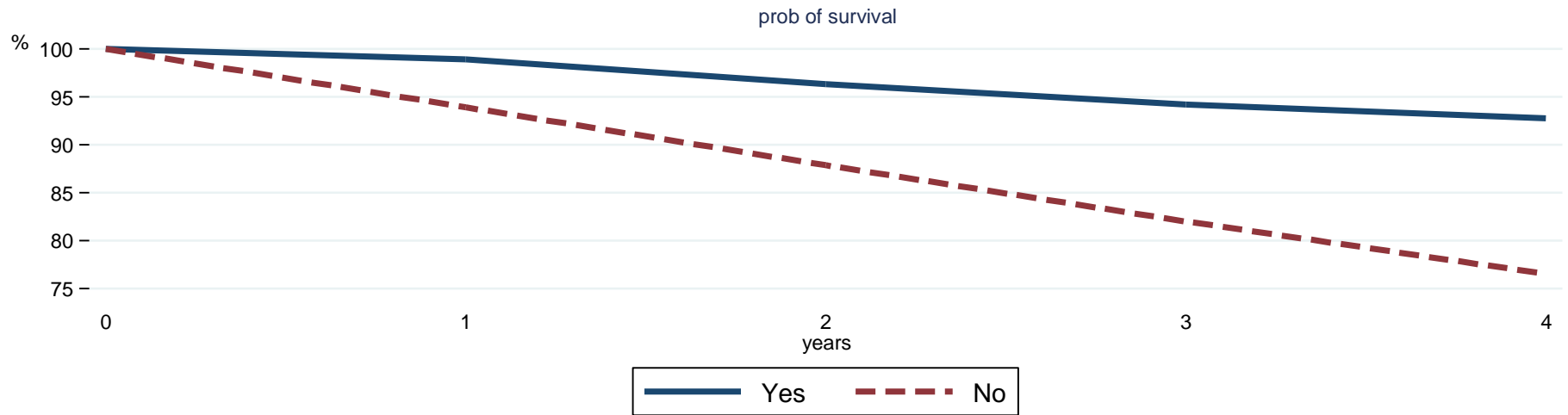
## PR(INNOVATION) OF GRANT RECIPIENTS VS NON-RECIPIENTS (NOT MATCHED)





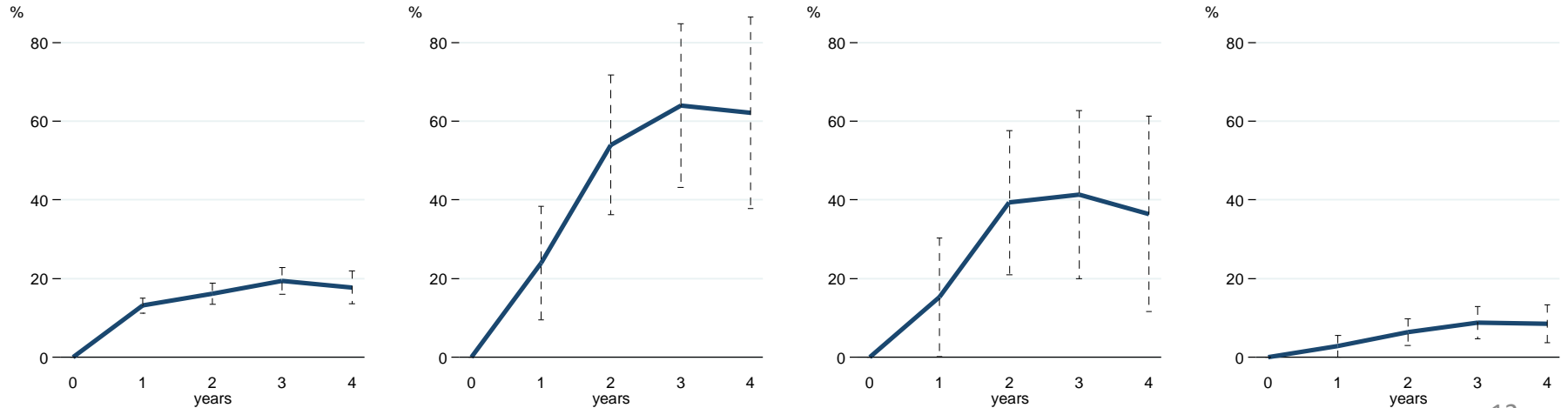
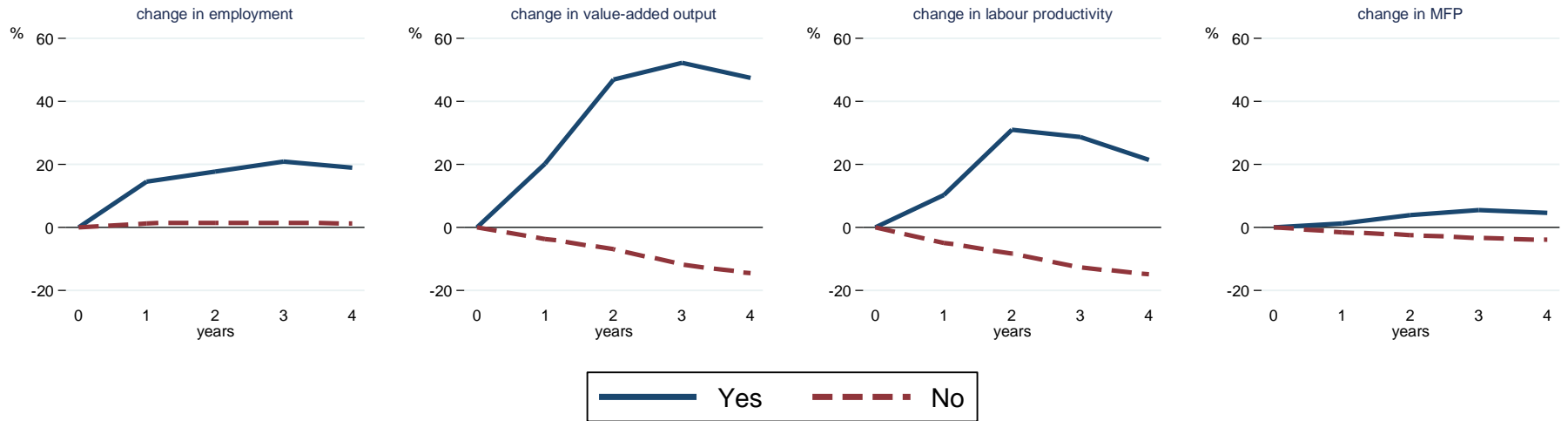
# Grant recipients more likely to survive in subsequent years than non-recipients

## PROB OF SURVIVAL OF GRANT RECIPIENTS VS NON-RECIPIENTS (NOT MATCHED)



# Grant recipients perform better than non-recipients across all measures

## PERFORMANCE OF GRANT RECIPIENTS VS NON-RECIPIENTS (NOT MATCHED)



## To measure impact of grant on recipients, need control group not systematically different

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### REFINING THE SET OF NON-RECIPIENTS

- Baseline: All non-recipients
  - *BUT may include non-recipients that are systematically different from R&D grant recipients*
- Alternatives:
  - *Match to non-recipients with same characteristics (e.g., size, age, industry, R&D activity)*
    - BUT unless characteristics affect eligibility/propensity, may exclude comparable firms  
⇒ do not want to impose too many exclusion criteria on untreated firms
    - May be non-linear relationship between firm characteristics and eligibility/propensity
    - Firms with the same observed characteristics may still differ on unobserved characteristics
  - *Match to non-recipients meeting grant eligibility criteria*
    - Replicate criteria required under Ministerial Directive (e.g., R&D expenditure of \$300k over past 2 years)
  - *Match to non-recipients with similar “propensity” to receive grant*
    - Estimate propensity score based on combination of all (potentially) relevant firm characteristics
  - *Match to non-recipients just below cut-off score (regression discontinuity analysis)*
  - *Instrument for non-random selection component (instrumental variables analysis)*

# To predict propensity score, use variables accounting for systematic differences between grant recipients and non-recipients

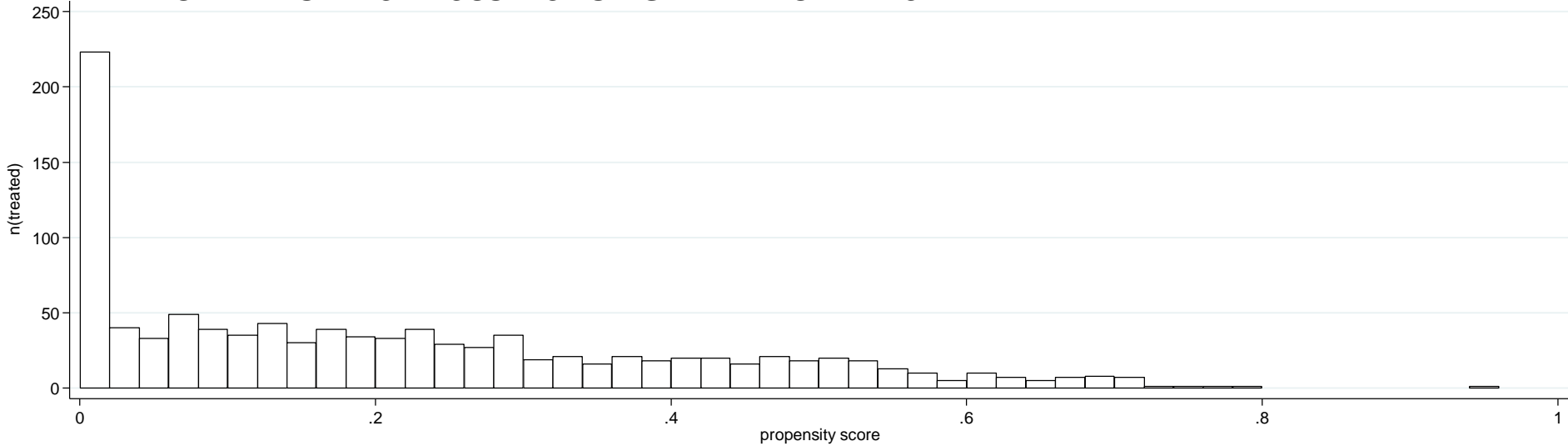
## PREDICTING PROPENSITY SCORE

		year dummies	industry dummies	year & industry	year-industry dummies	MED (2011)	Jaffe & Le (2015)
Age	$X+X^2$	$X+X^2$	$X+X^2$	$X+X^2$	$X+X^2$	$\ln(X)$	$\ln(X)$
Rolling mean employment	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X)+\ln(X)^2+d\ln(X)$	$\ln(X)$
MFP	$X_{t-1}+X_{t-2}$	$X_{t-1}+X_{t-2}$	$X_{t-1}+X_{t-2}$	$X_{t-1}+X_{t-2}$	$X_{t-1}+X_{t-2}$	$X+dX$	
Capital-labour ratio	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X_{t-1})+\ln(X_{t-2})$	$\ln(X)+d\ln(X)$	
Belongs to a business group						X	X
Exporter of non-manufactured goods	X	X	X	X	X	X	X
Exporter of manufactured goods						X	
Foreign owned	X	X	X	X	X	X	X
Reported positive R&D spending	$X_{t-1}$	$X_{t-1}$	$X_{t-1}$	$X_{t-1}$	$X_{t-1}$	X	
Received R&D grant in prior 3 years	X	X	X	X	X		
Received non-R&D government assistance in prior 3 years	X	X	X	X	X		
Received non-R&D government assistance in prior 5 years							X
Other firm characteristics (from BOS)							X
Year dummies		X		X	X		
Industry dummies			X	X	X		
Year-industry dummies					X		
# observations	790278	764499	790278	764502	531030	919398	18027
# grant recipients	1035	1032	1032	1032	1032	1326	237
# non-grant recipients	789243	763467	789246	763467	529995	918075	17787
Pseudo R <sup>2</sup>	0.524	0.540	0.527	0.543	0.531	0.316	0.223
Correct prediction rate	0.986	0.977	0.986	0.976	0.977	0.903	0.798
Correct prediction rate (grant recipients only)	0.880	0.912	0.883	0.910	0.902	0.838	0.772

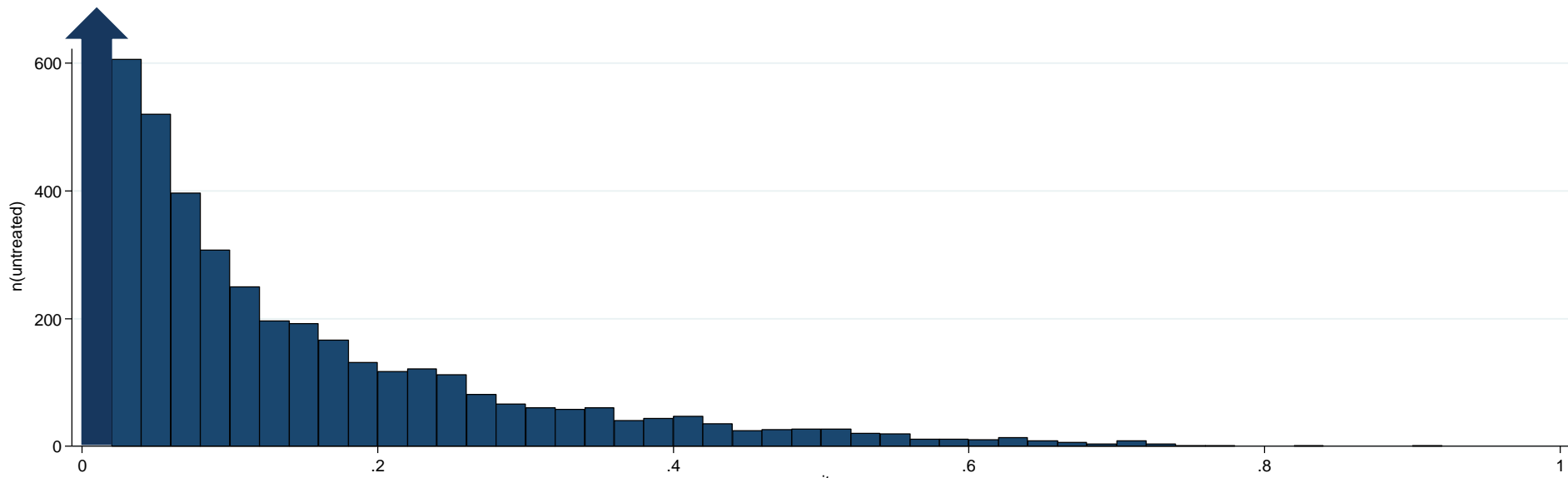
Predict propensity score with year & industry dummies, then stratify by industry/year

# Propensity scores of both recipients and non-recipients clustered near zero

## PREDICTED PROPENSITY SCORES FOR GRANT RECIPIENTS

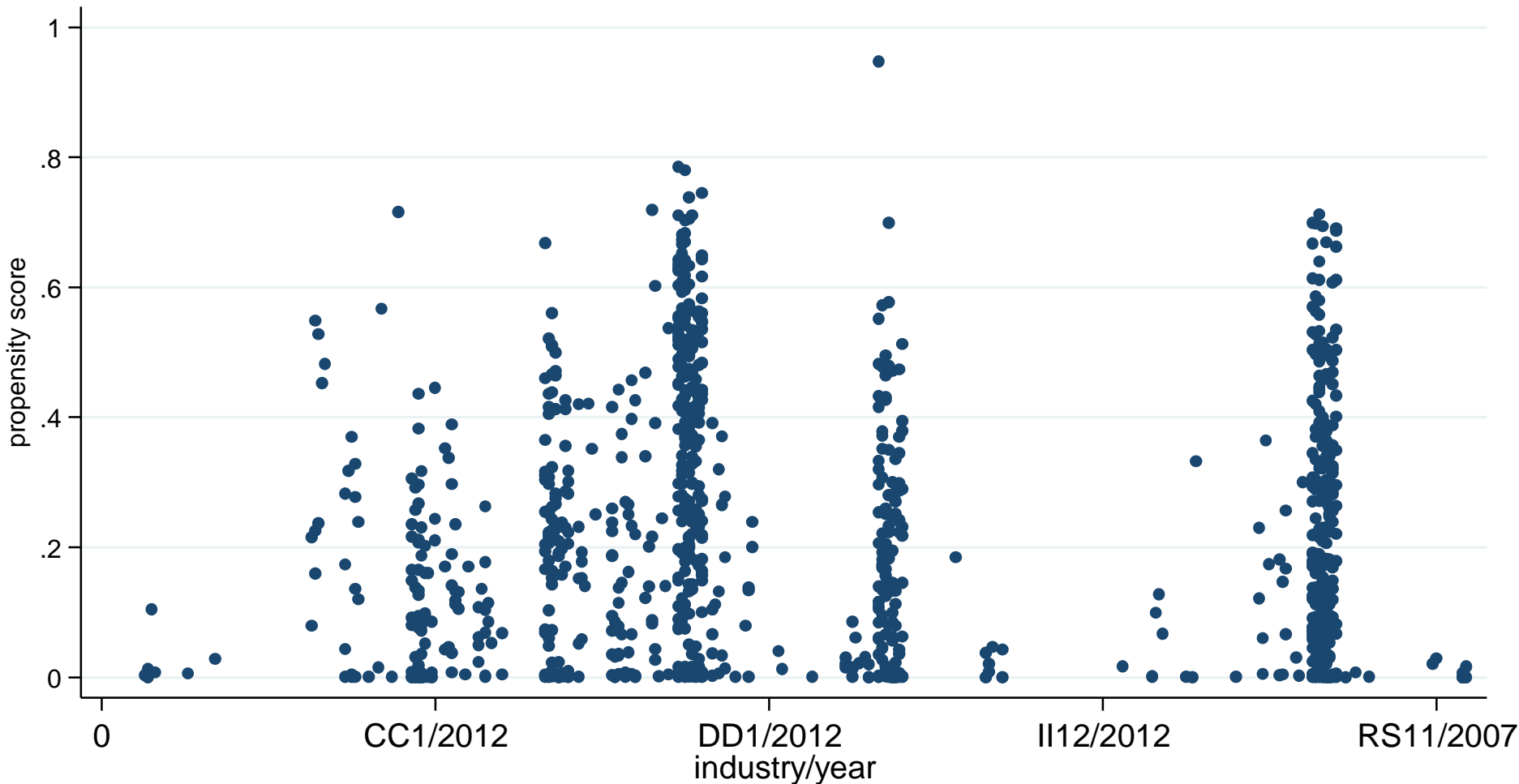


## PREDICTED PROPENSITY SCORES FOR NON-RECIPIENTS



# Distribution of propensity scores varies widely by industry/year

## PROPENSITY SCORES FOR GRANT RECIPIENTS BY INDUSTRY/YEAR



• all firms

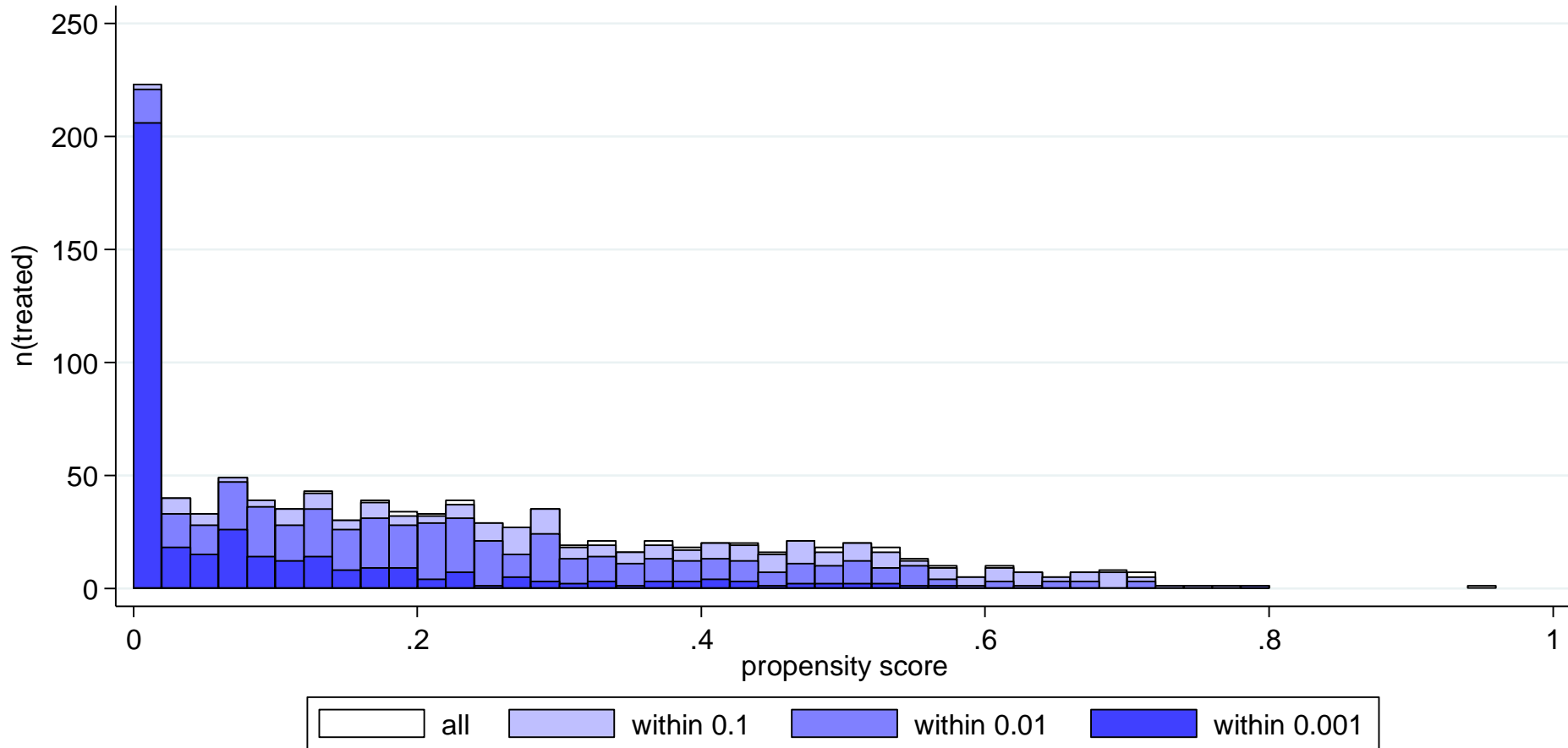
# Restricting matches to firms within range drops some higher-propensity recipients

## PROPENSITY SCORES FOR GRANT RECIPIENTS WITH MATCHES WITHIN $PS \pm 0.01$



# Restricting range skews distribution of matched recipients to lower propensity scores

## GRANT RECIPIENTS MATCHED BY SIZE OF RANGE



Use grant recipients matched within  $PS \pm 0.01$



## Choice of matching algorithm trades off benefits of larger sample vs inaccuracy of bad matches

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### MATCHING ALGORITHM

Algorithm	Condition
Nearest neighbour	Match each grant recipient to $k$ non-recipients with closest PS
Caliper	Match each grant recipient to $k$ non-recipients with closest PS <i>within range (e.g., 0.01)</i>
Radius	Match each grant recipient to <i>all</i> non-recipients with PS within range
Kernel	Match each grant recipient to all non-recipients with PS with range <i>and weight non-recipients based on difference vs recipient's PS</i>



**Use caliper method with 5 nearest neighbours within  $PS \pm 0.01$**

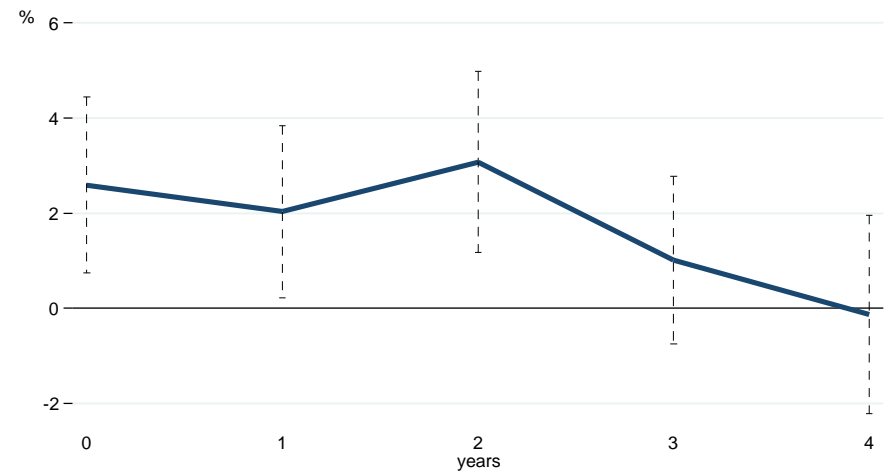
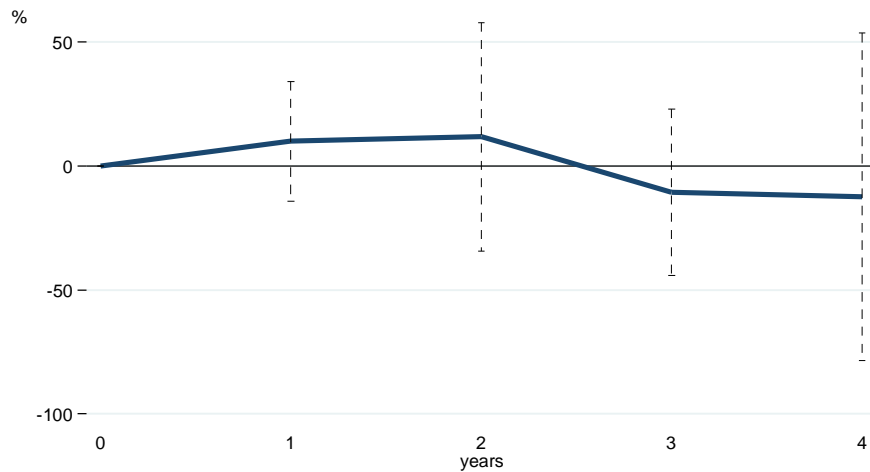
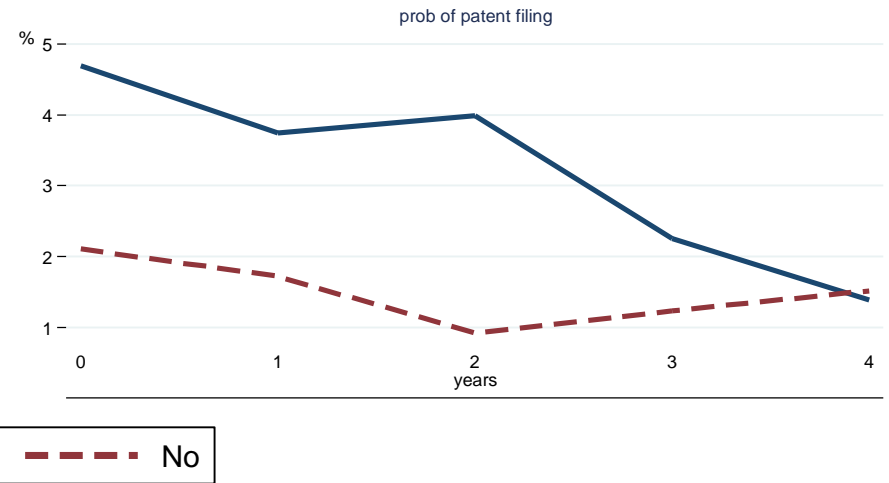
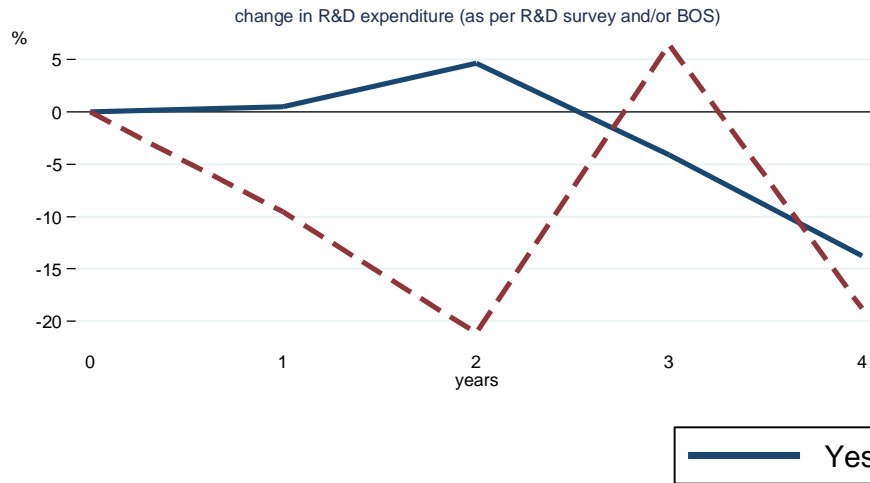
## After caliper matching with $PS \pm 0.01$ , grant recipients and control group are balanced on all variables used to predict propensity score

### BALANCE TEST OF VARIABLES USED TO ESTIMATE PROPENSITY SCORE (CALIPER=0.01)

Variable		Mean		%reduction in		t-test		V(T)/ V(C)
		Treated	Control	%bias	bias	t	p> t	
Age	Unmatched	17.14	12.97	31.10		13.36	0.00***	2.59*
	Matched	16.28	16.45	-1.30	95.70	-0.24	0.81	1.13
Rolling mean employment (log, t-1)	Unmatched	2.76	0.57	150.60		70.77	0.00***	3.29*
	Matched	2.57	2.64	-5.00	96.70	-0.82	0.41	1.02
Rolling mean employment (log, t-2)	Unmatched	2.63	0.55	138.30		67.58	0.00***	3.64*
	Matched	2.45	2.51	-4.40	96.80	-0.71	0.48	1.01
MFP (t-1)	Unmatched	-0.09	0.04	-19.40		-6.33	0.00***	1.06
	Matched	-0.05	-0.04	-0.80	95.80	-0.19	0.85	1.17*
MFP (t-2)	Unmatched	-0.12	0.04	-23.30		-7.92	0.00***	1.23*
	Matched	-0.06	-0.08	2.90	87.40	0.64	0.52	0.79*
Capital-labour ratio (log, t-1)	Unmatched	9.66	9.34	31.00		8.55	0.00***	0.47*
	Matched	9.61	9.60	1.30	95.80	0.32	0.75	0.96
Capital-labour ratio (log, t-2)	Unmatched	9.63	9.31	29.90		8.47	0.00***	0.56*
	Matched	9.58	9.59	-0.50	98.40	-0.11	0.91	1.07
Exporter	Unmatched	0.64	0.05	155.80		82.91	0.00***	
	Matched	0.59	0.62	-6.70	95.70	-1.02	0.31	
Foreign owned	Unmatched	0.10	0.01	41.10		28.79	0.00***	
	Matched	0.10	0.10	-1.00	97.70	-0.15	0.88	
Reported positive R&D spending in prior year	Unmatched	0.56	0.02	146.20		114.99	0.00***	
	Matched	0.49	0.48	2.30	98.40	0.34	0.73	
Received R&D grant in prior 3 years	Unmatched	0.80	0.01	276.50		336.73	0.00***	
	Matched	0.74	0.74	1.30	99.50	0.17	0.87	
Received non-R&D government assistance in prior 3 years	Unmatched	0.53	0.01	144.60		174.30	0.00***	
	Matched	0.47	0.45	4.60	96.80	0.67	0.50	

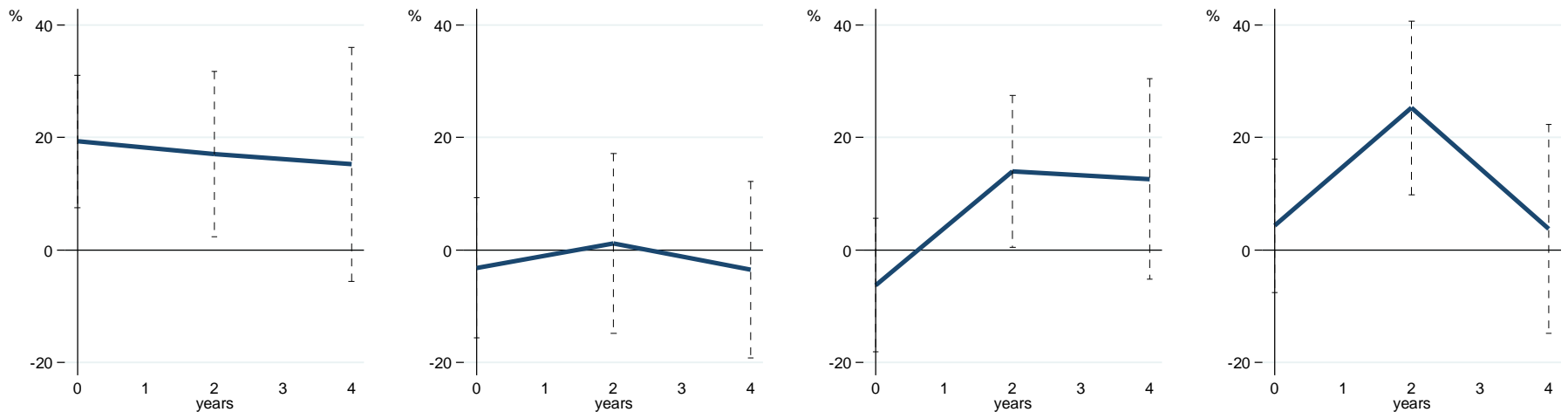
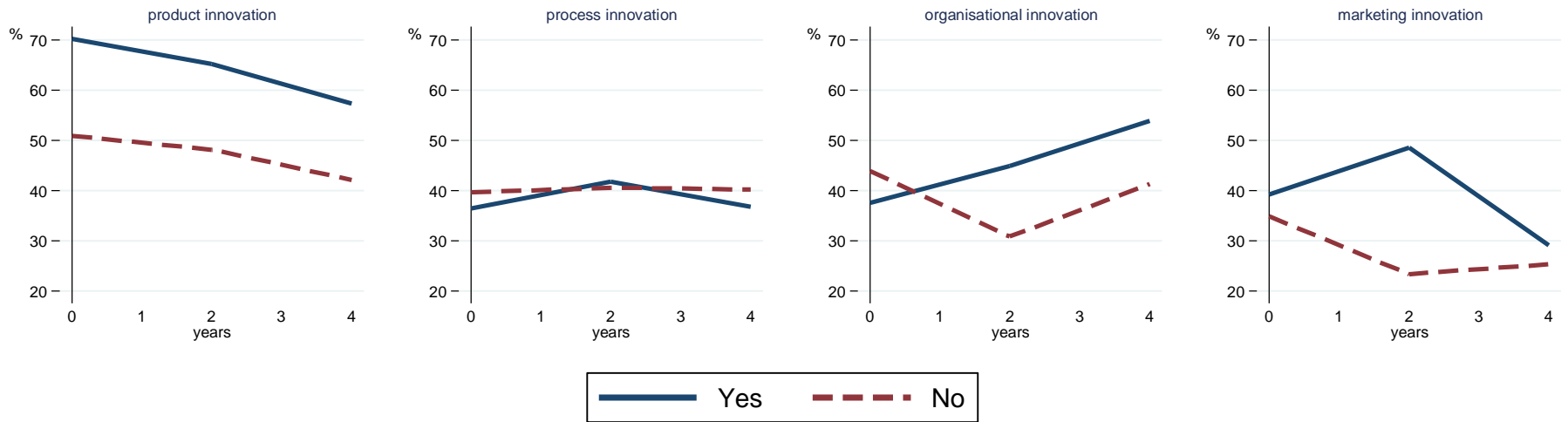
# Grant recipients not spending more on R&D in subsequent years, but more likely to file patents

## CHANGE IN R&D EXPENDITURE FOR GRANT RECIPIENTS VS CONTROLS



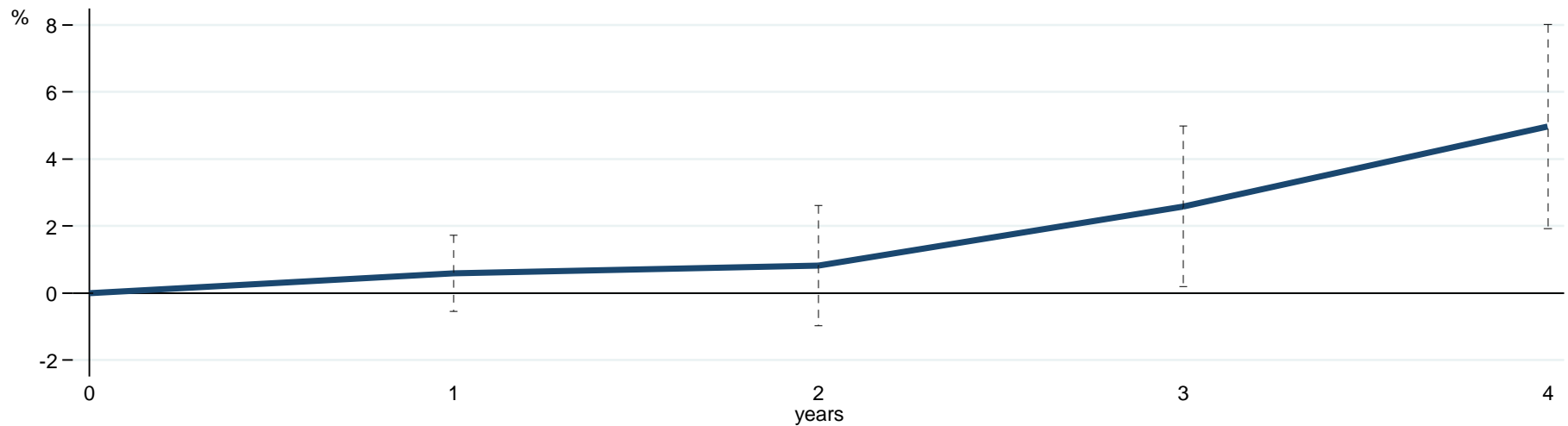
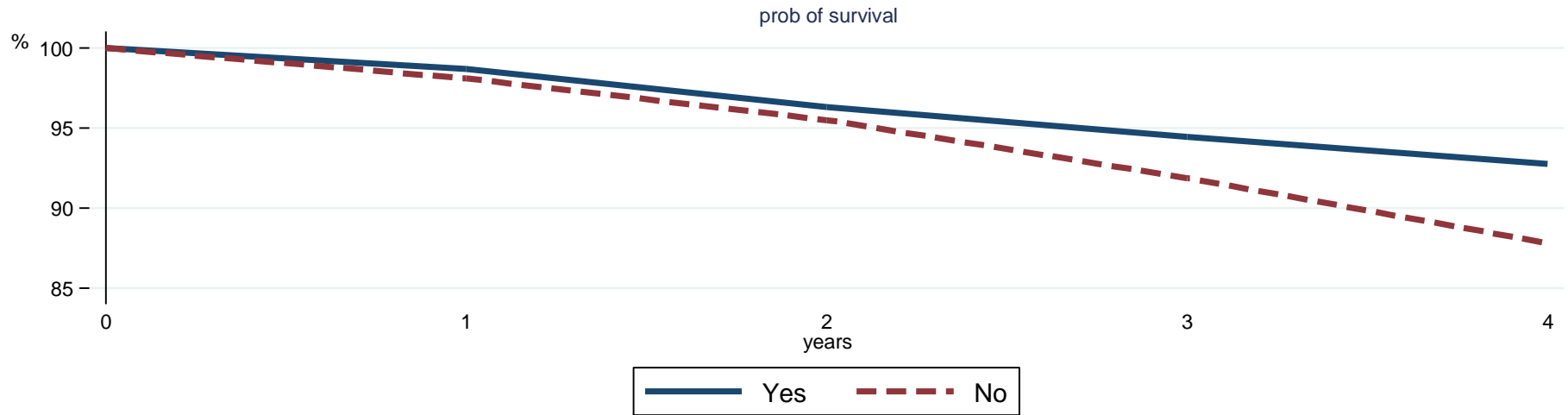
# Grant recipients more likely to introduce new product, and to do organisation and marketing innovation, in subsequent years

## PROBABILITY OF INNOVATION FOR GRANT RECIPIENTS VS CONTROLS



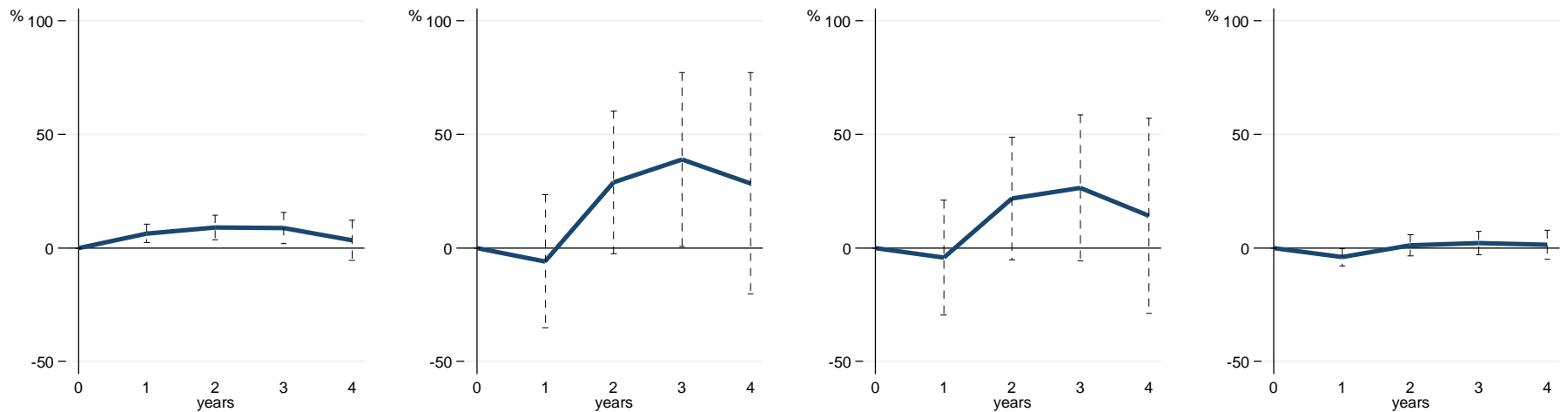
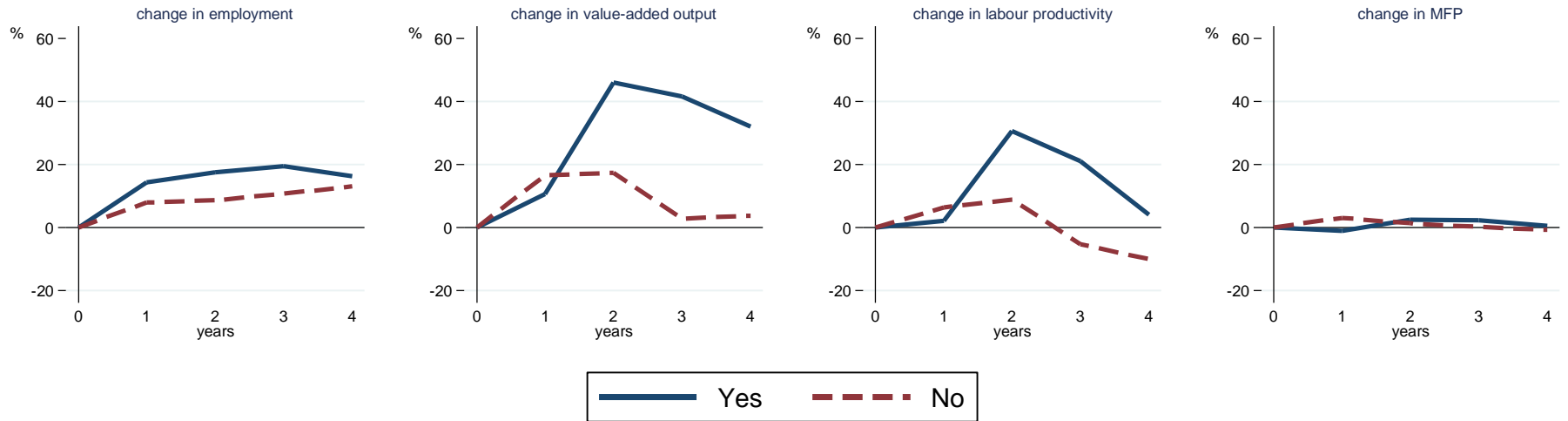
# Grant recipients more likely to remain economically active 3-4 years after grant

## PROB OF SURVIVAL FOR GRANT RECIPIENTS VS CONTROLS



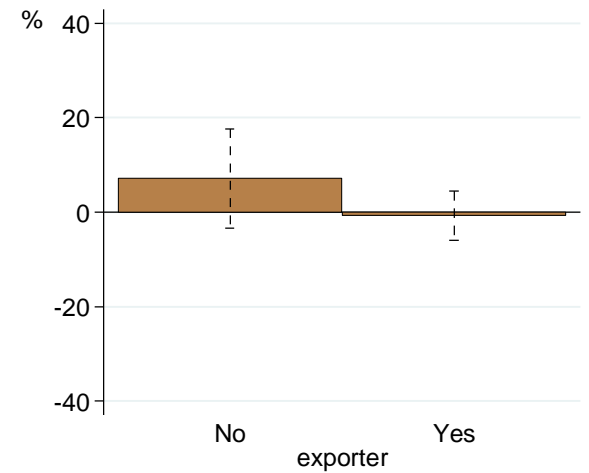
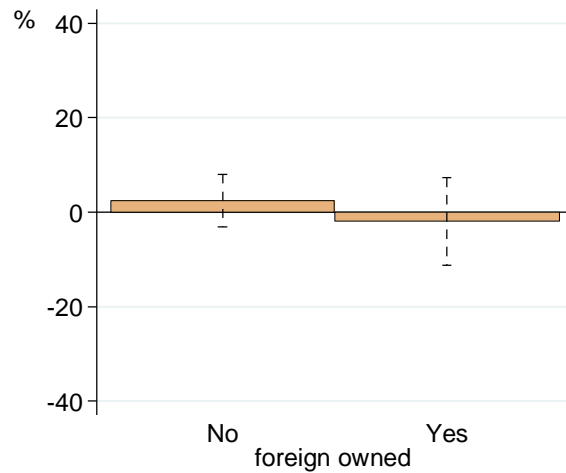
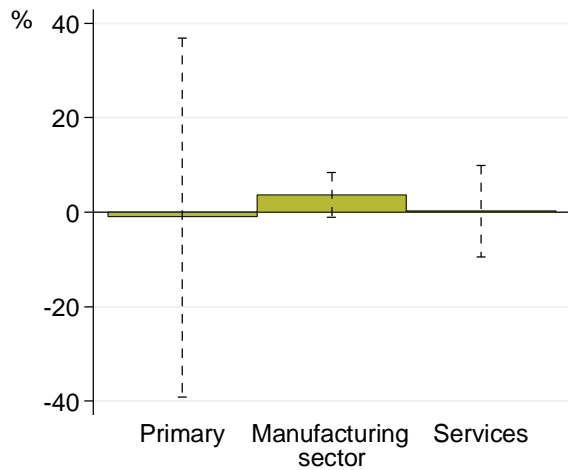
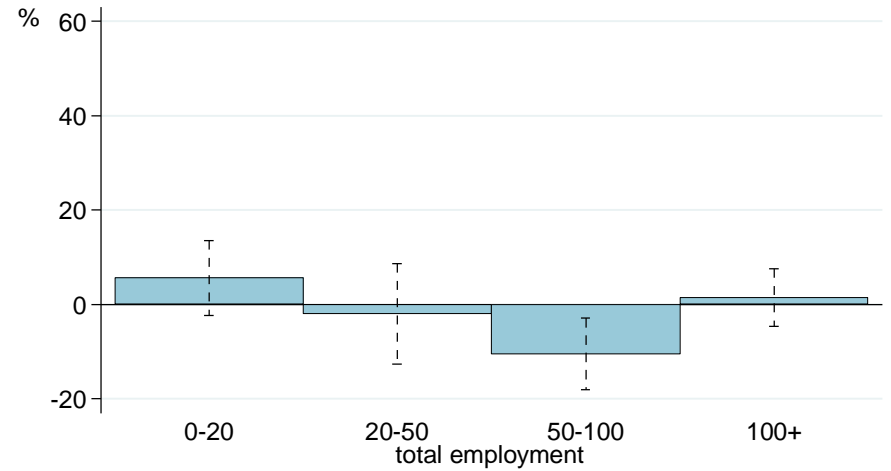
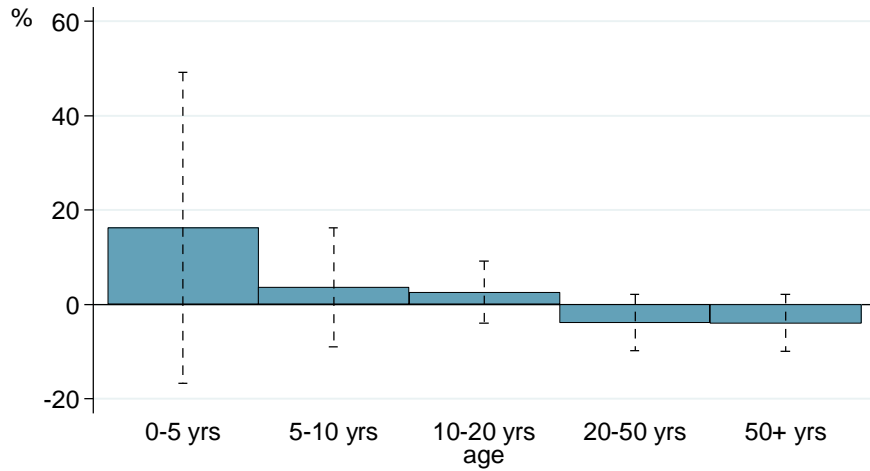
# Grant recipients have higher employment growth but no higher productivity growth

## ECONOMIC PERFORMANCE OF GRANT RECIPIENTS VS CONTROLS



# Impact of grant receipt on productivity negative for larger firms and otherwise not significant

## 3-YEAR CHANGE IN MFP FOR GRANT RECIPIENTS VS CONTROLS BY FIRM CHAR



## Need to be clear on programme objectives and collect data measuring outcomes

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### CONCLUSION

- Impact of receiving R&D grant appears mixed
  - *R&D expenditure not growing any faster*
  - *More likely to patent, introduce new products, do organisational & marketing innovation*
  - *More likely to survive*
  - *Growing faster but not increasing in productivity*
- Measuring impact limited by data
  - *Errors in matching grant recipients to other data*
  - *R&D expenditure only available for subset of recipients (and controls)*
  - *MFP noisy measure of economic value added*
- Measure of success depends on grant programme's objectives
  - *Overall objective to increase R&D spending but are project grants different?*
  - *Impact on innovation positive but not flowing through to productivity*