Innovation & the performance of New Zealand firms

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NEW ZEALAND
PRODUCTIVITY COMMISSION
Te Kōmihana Whai Hua o Aotearoa

Low investment in knowledge-based capital may explain up to 40% of the productivity gap relative to the OECD average

WHY THE PRODUCTIVITY GAP?
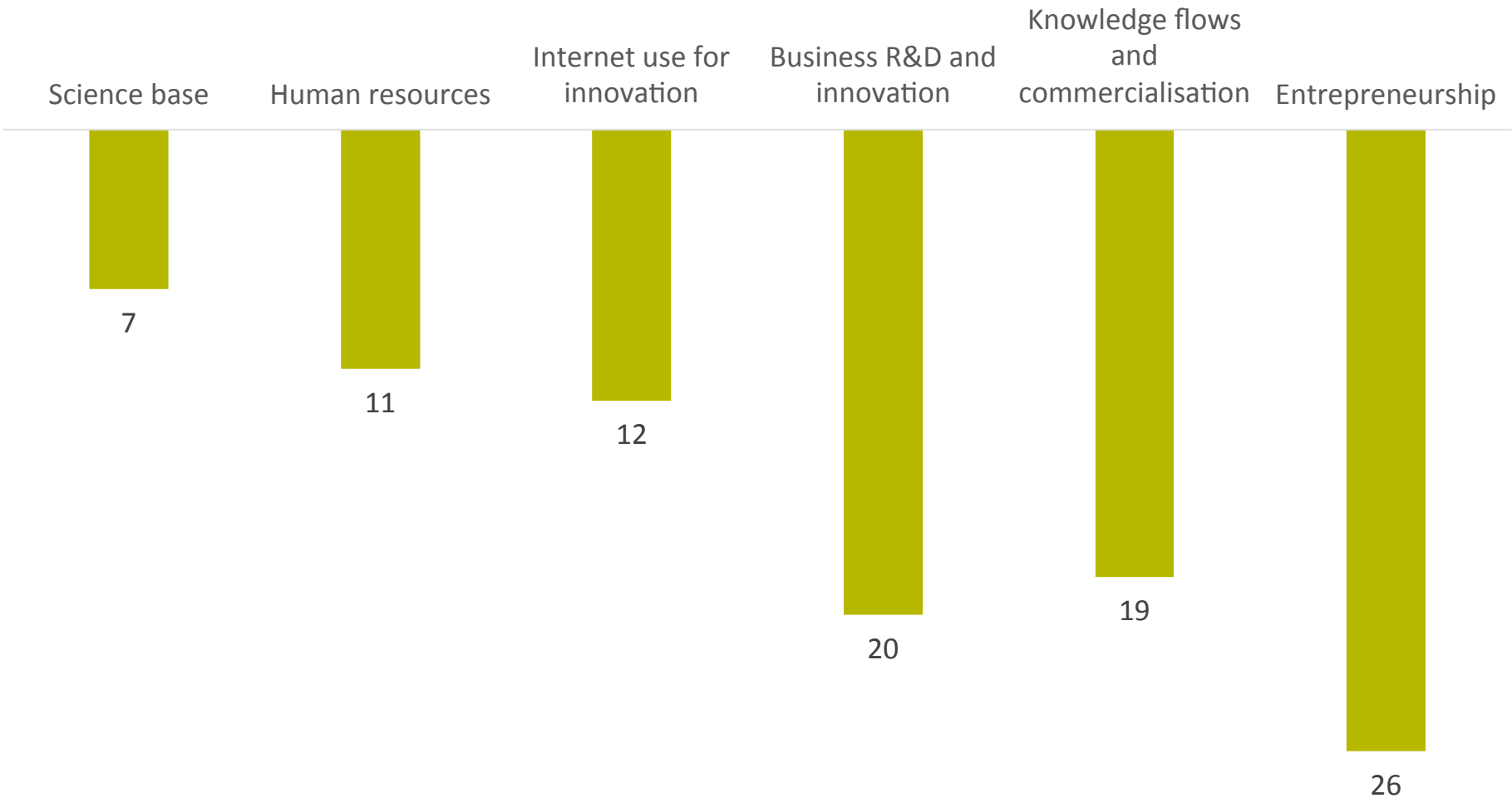## AND HOW IT COULD CLOSE

WEAK INTERNATIONAL **CONNECTIONS** **55%**

UNDERINVESTMENT IN **KNOWLEDGE, INNOVATION AND IDEAS** **40%**

OTHER INCLUDING LOW SKILLS **5%**

GREATER PARTICIPATION **IN GLOBAL VALUE CHAINS**

INNOVATIVE, ADAPTABLE, WELL-RUN FIRMS

MORE HIGHLY-SKILLED WORKERS
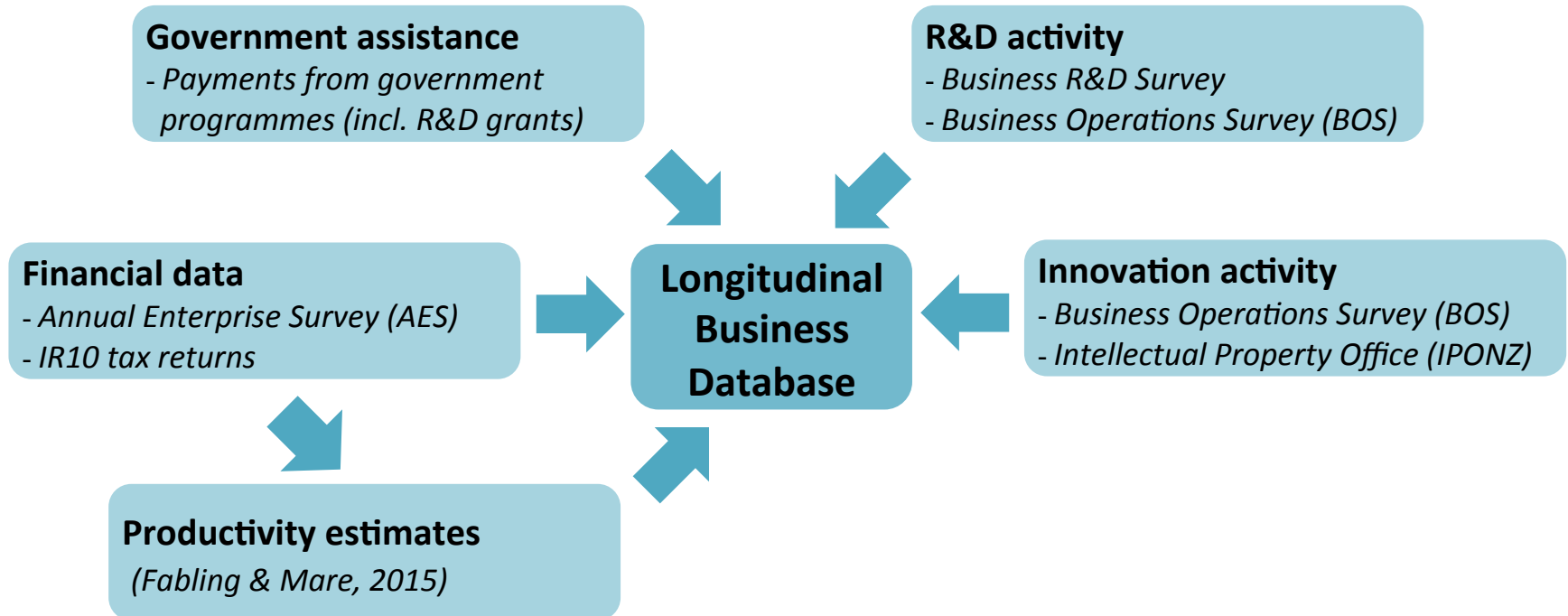
Source: NZPC; de Serres et al. (2014)
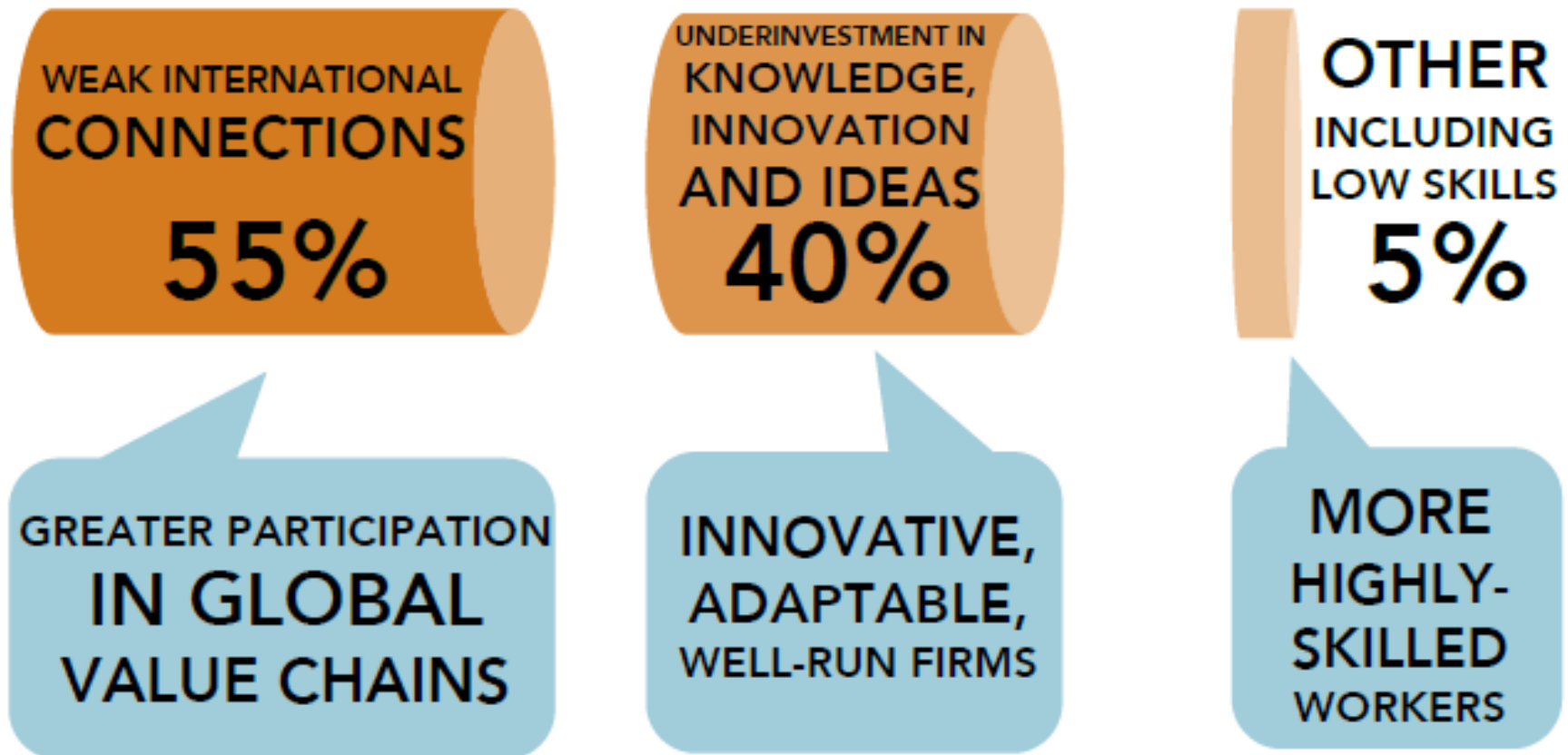
International comparisons show NZ near top of OECD rankings in generating science but lower ranked in commercialising innovation

NZ'S AVERAGE RANKING IN TOP-LEVEL CATEGORIES OF OECD STATISTICS

Science base	Human resources	Internet use for innovation	Business R&D and innovation	Knowledge flows and commercialisation	Entrepreneurship
7	11	12	20	19	26

Source: OECD (2012). Comparative performance of national science and innovation systems

Use Statistics NZ's Longitudinal Business Database to study relationship between innovation and productivity for New Zealand firms

**DATA SOURCES**

Government assistance
- *Payments from government programmes (incl. R&D grants)*

R&D activity
- *Business R&D Survey*
- *Business Operations Survey (BOS)*

Financial data
- *Annual Enterprise Survey (AES)*
- *IR10 tax returns*

Longitudinal Business Database

Innovation activity
- *Business Operations Survey (BOS)*
- *Intellectual Property Office (IPONZ)*

Productivity estimates
(Fabling & Mare, 2015)

LBD contains a range of measures reflecting different aspects of innovation

MEASURES OF INNOVATIVE ACTIVITY

Sample contains responses to Business Operations Survey (2005-2013).
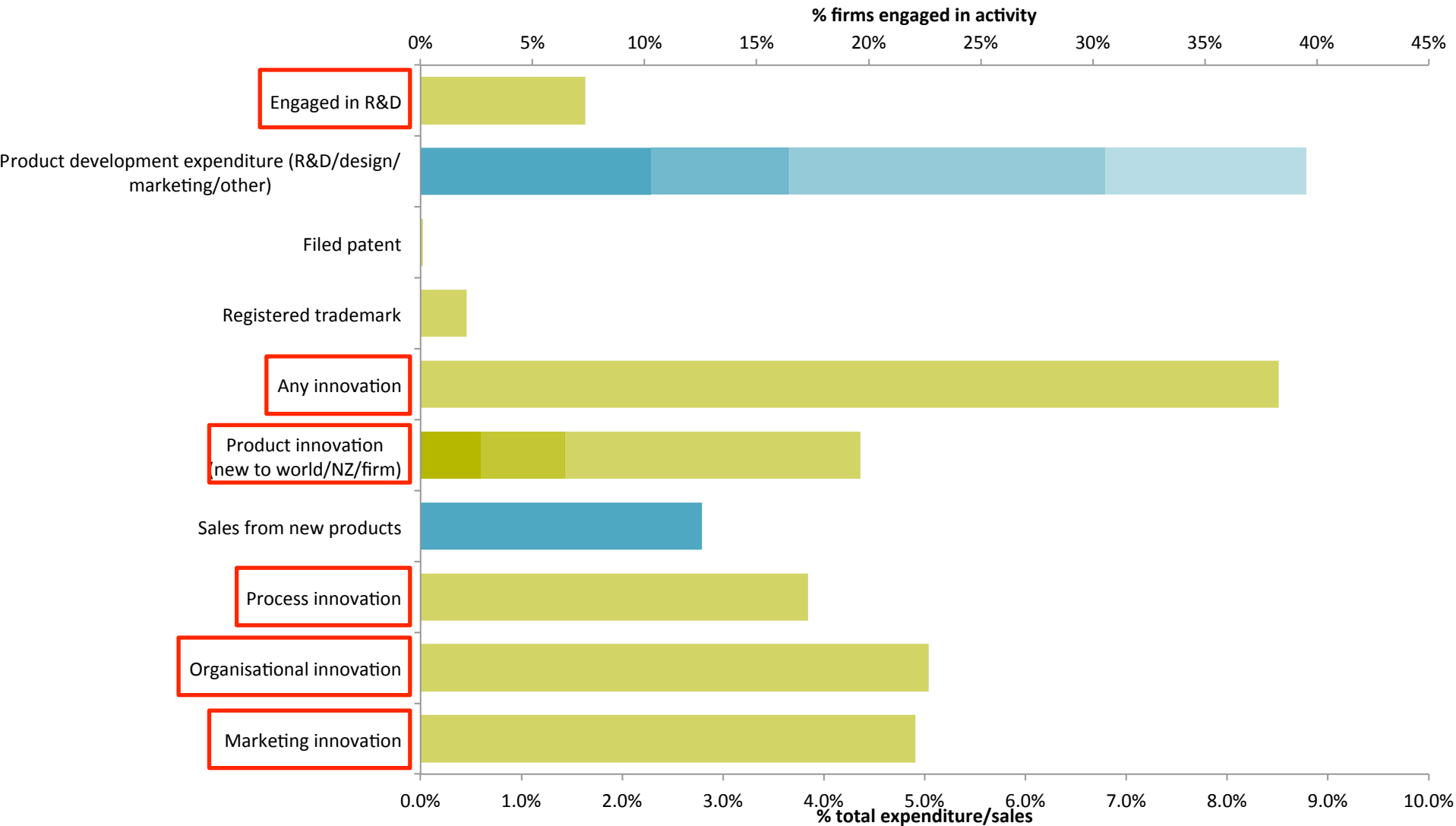
R&D expenditure is not a good proxy for innovation output in all cases

R&D ACTIVITY VS INNOVATION ACTIVITY

		Ever engaged in innovation	
		No	Yes
Ever engaged in R&D	No	27.5%	54.7%
	Yes	1.5%	16.3%

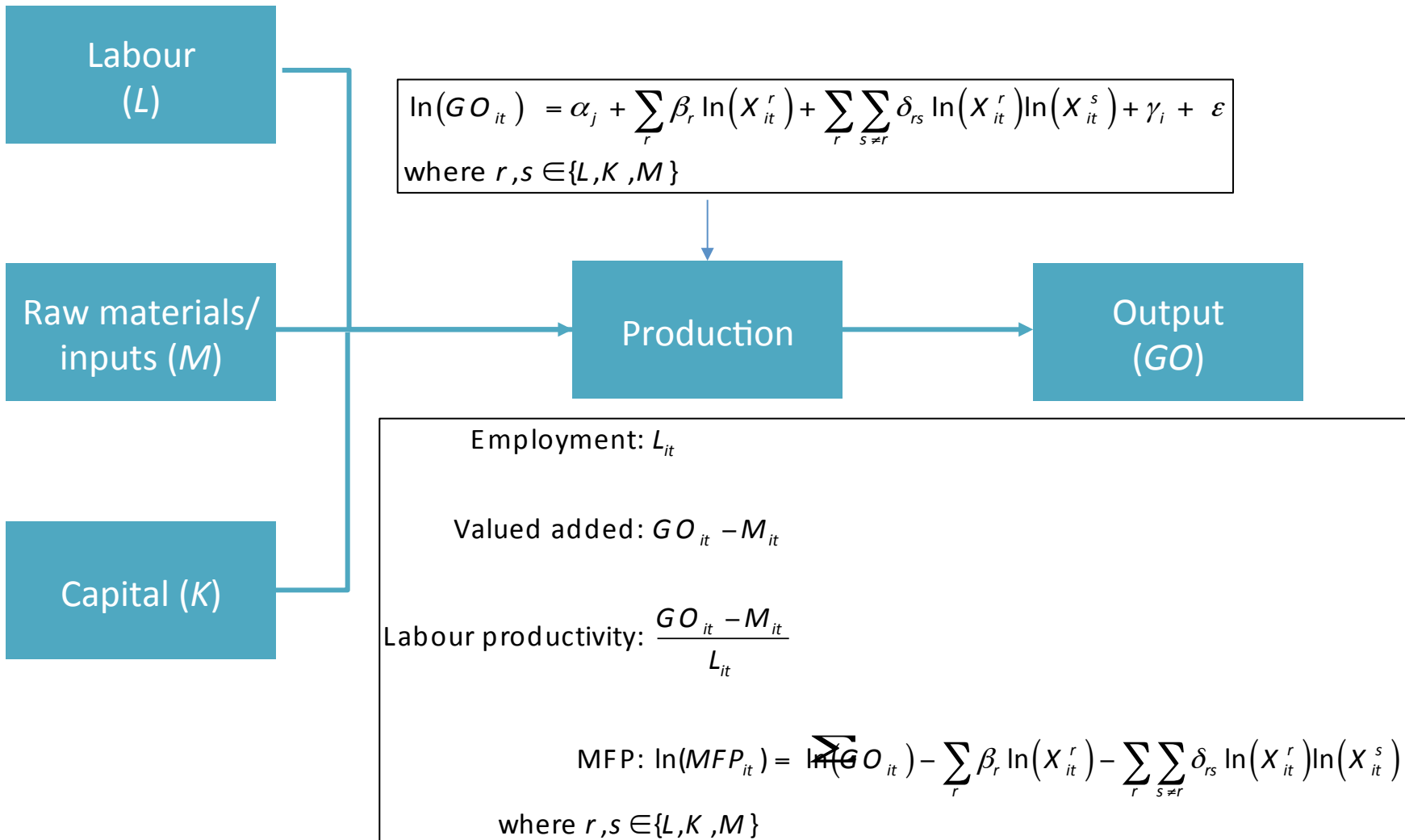*Sample contains firms responding to Business Operations Survey (2005-2012).*

TYPE OF INNOVATION EXPENDITURE BY SECTOR

■ R&D expenditure   ■ Design expenditure   ■ Marketing expenditure   ■ Other expenditure
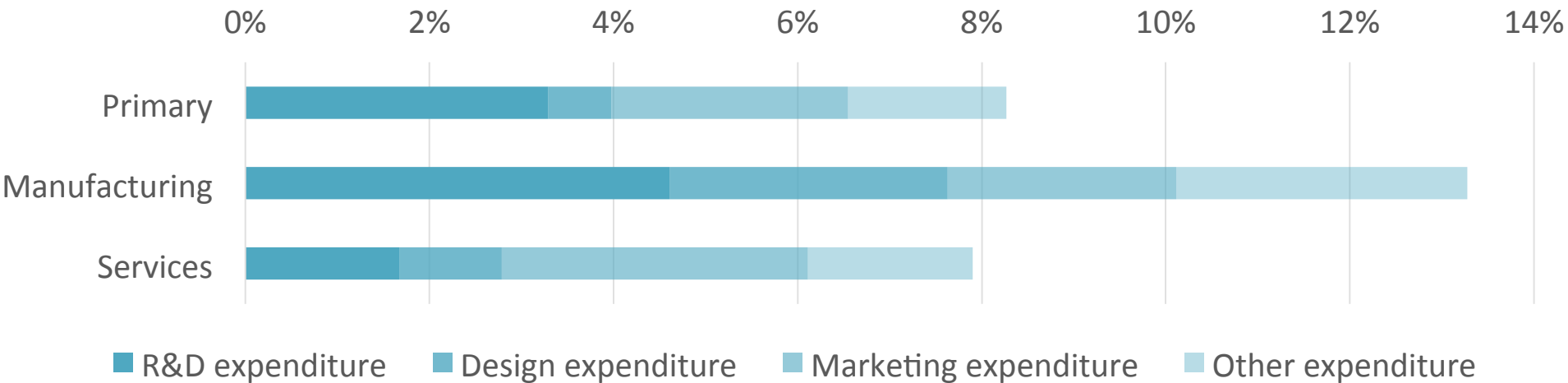
Sample contains firms responding to Business Operations Survey Innovation module in 2007, 2009 & 2011.

Use approach developed by Fabling & Mare (2015) to estimate firm productivity

MEASURING FIRM PERFORMANCE

Labour (L)

Raw materials/ inputs (M)

Capital (K)

Production

Output (GO)

$$\ln(GO_{it}) = \alpha_j + \sum_r \beta_r \ln(X_{it}^r) + \sum_r \sum_{s \neq r} \delta_{rs} \ln(X_{it}^r) \ln(X_{it}^s) + \gamma_i + \varepsilon$$

where $r, s \in \{L, K, M\}$

Employment: L_{it}

Valued added: $GO_{it} - M_{it}$

Labour productivity: $\dfrac{GO_{it} - M_{it}}{L_{it}}$

MFP: $\ln(MFP_{it}) = \ln(GO_{it}) - \sum_r \beta_r \ln(X_{it}^r) - \sum_r \sum_{s \neq r} \delta_{rs} \ln(X_{it}^r) \ln(X_{it}^s)$

where $r, s \in \{L, K, M\}$

On average innovating firms larger but less productive than non-innovating firms in year in which innovation occurs

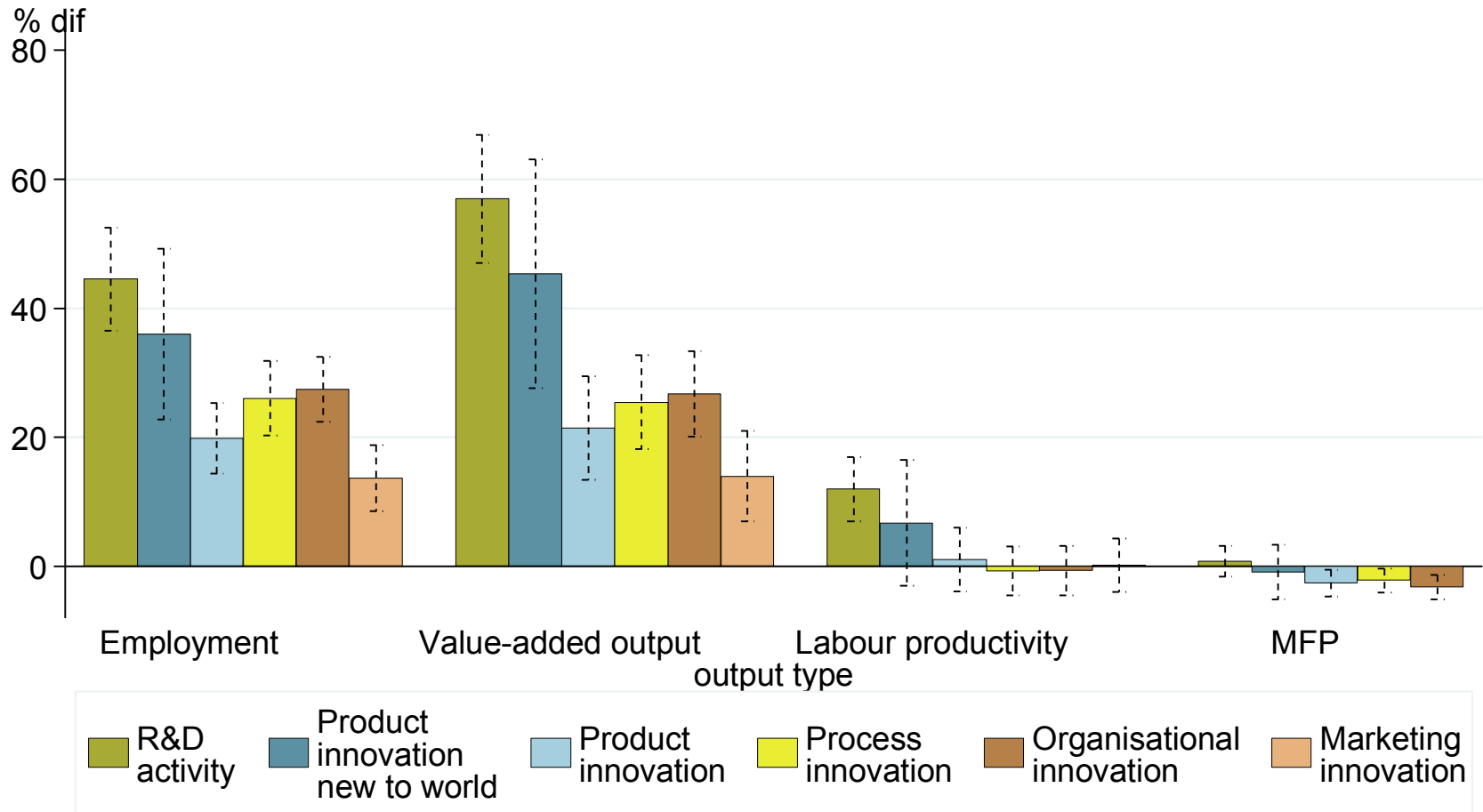**RELATIVE OUTPUT LEVEL INNOVATORS VS. NON-INNOVATORS BY INNOVATION MEASURE**

Chart shows difference in performance measure predicted from series of OLS regressions of output level in year 0 on innovation in year 0 with controls for year and industry. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with performance measures up to 2012. Observations weighted by BOS sampling weights.

Most productive firms least likely to innovate

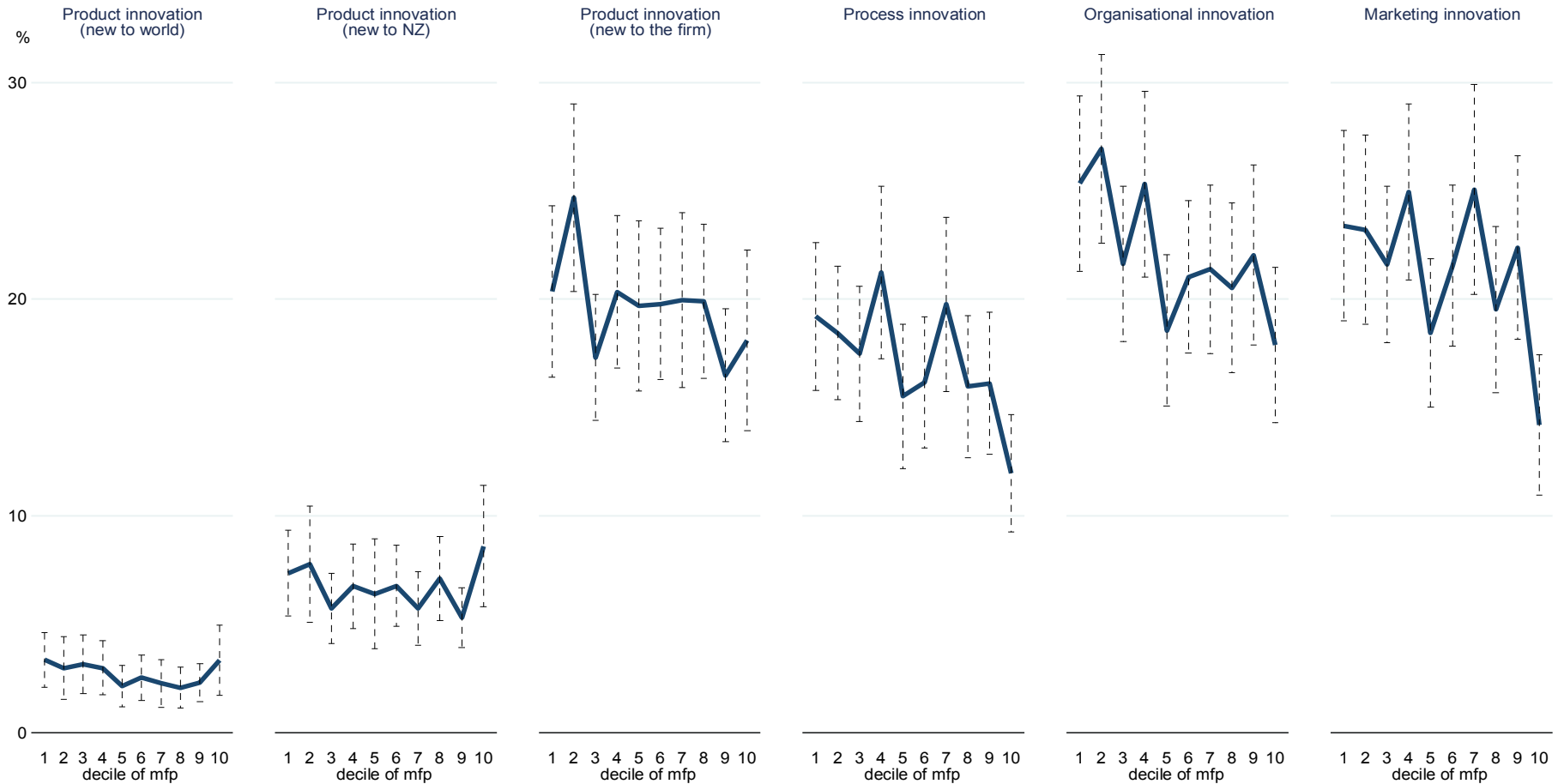## PROPORTION OF FIRMS ENGAGED IN INNOVATION BY DECILE OF PRODUCTIVITY IN YEAR 0

Chart shows likelihood of firm innovation predicted from probit regression of innovation activity in year 0 on productivity decile in year 0. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011. Observations weighted by BOS sampling weights

# Use difference-in-differences approach to measure impact of innovation on productivity

EMPIRICAL APPROACH

- Regress change in firm output/productivity ($\ln Y_{in}$ - $\ln Y_{i0}$) on innovation in year 0 (I_0)

$$\ln Y_{in} - \ln Y_{i0} = \alpha + \beta_I I_{i0} + \beta_X X_{i0} + t + \varepsilon$$

- Compare within-firm differences in output

    ☒ controls for unobserved firm characteristics affecting output levels

- Control for observed firm characteristics (age, size, industry, etc.)

    ☒ controls for observed firm characteristics affecting changes in output

- For MFP, use 2-year moving average

    ☒ accounts for measurement error

- Weight observations by BOS sampling weights times predicted gross output

    ☒ quantities corresponds to aggregate economic output/productivity

- Do not instrument for innovation (cf Crepon, Duguet & Mairesse, 1998)

Firms engaged in R&D activity have faster employment and output growth than non-R&D-active firms but productivity growth not different
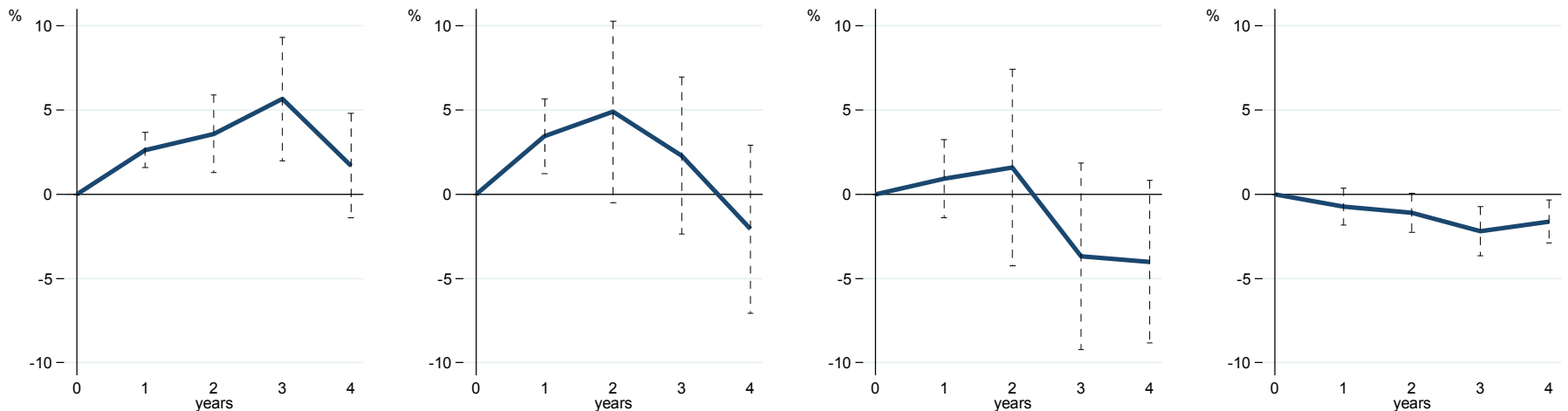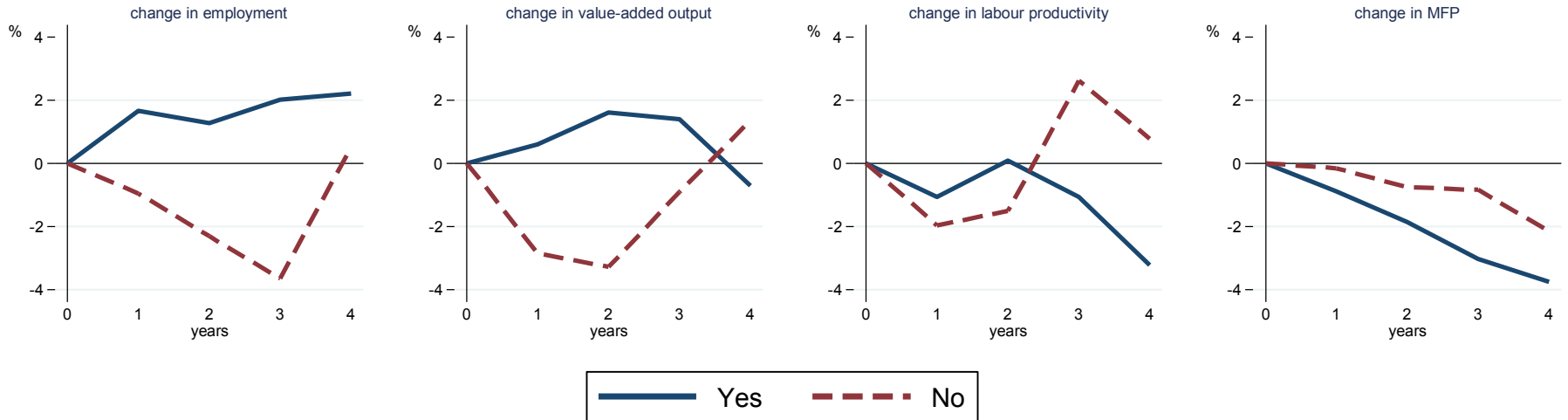
RELATIVE GROWTH BY OUTPUT TYPE OF R&D ACTIVE VS NON-ACTIVE FIRMS
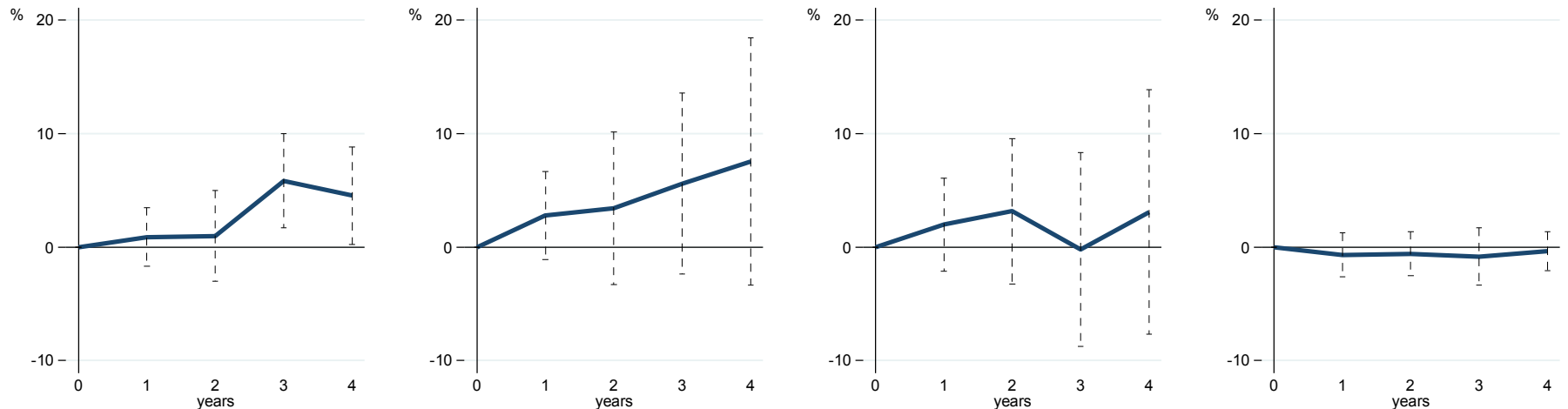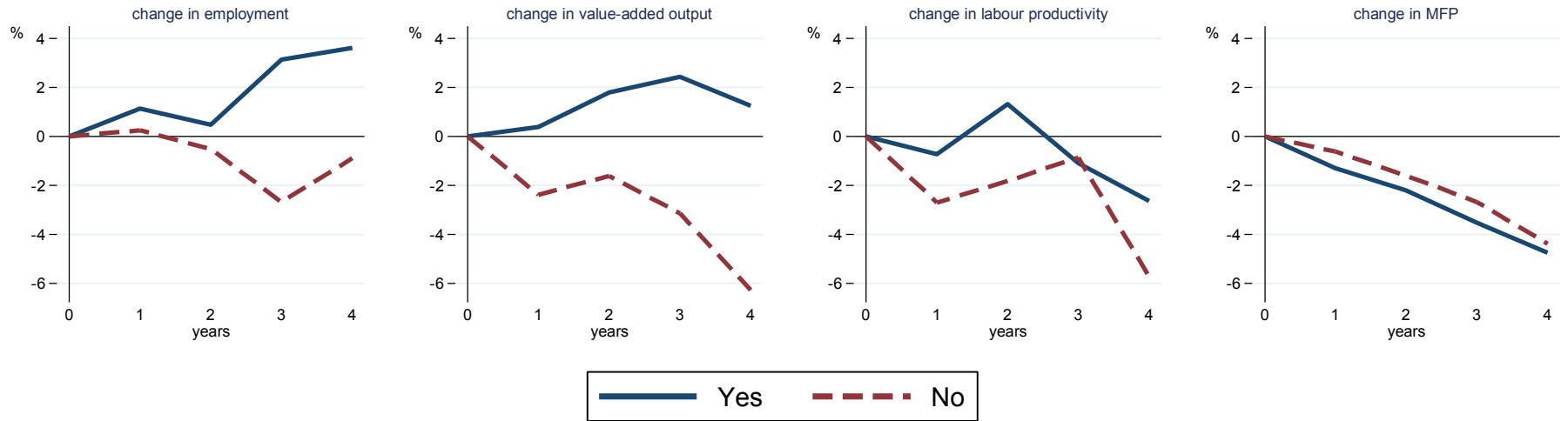
Charts show difference in predictive margins from series of OLS regressions of change in output from year 0 to year t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Similarly firms engaged in innovation grow faster in size but not productivity

RELATIVE GROWTH BY INNOVATION ACTIVITY OF INNOVATORS VS NON-INNOVATORS

Charts show difference in predictive margins from series of OLS regressions of change in output from year 0 to year t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Only firms engaged in marketing innovation experience significantly higher productivity growth
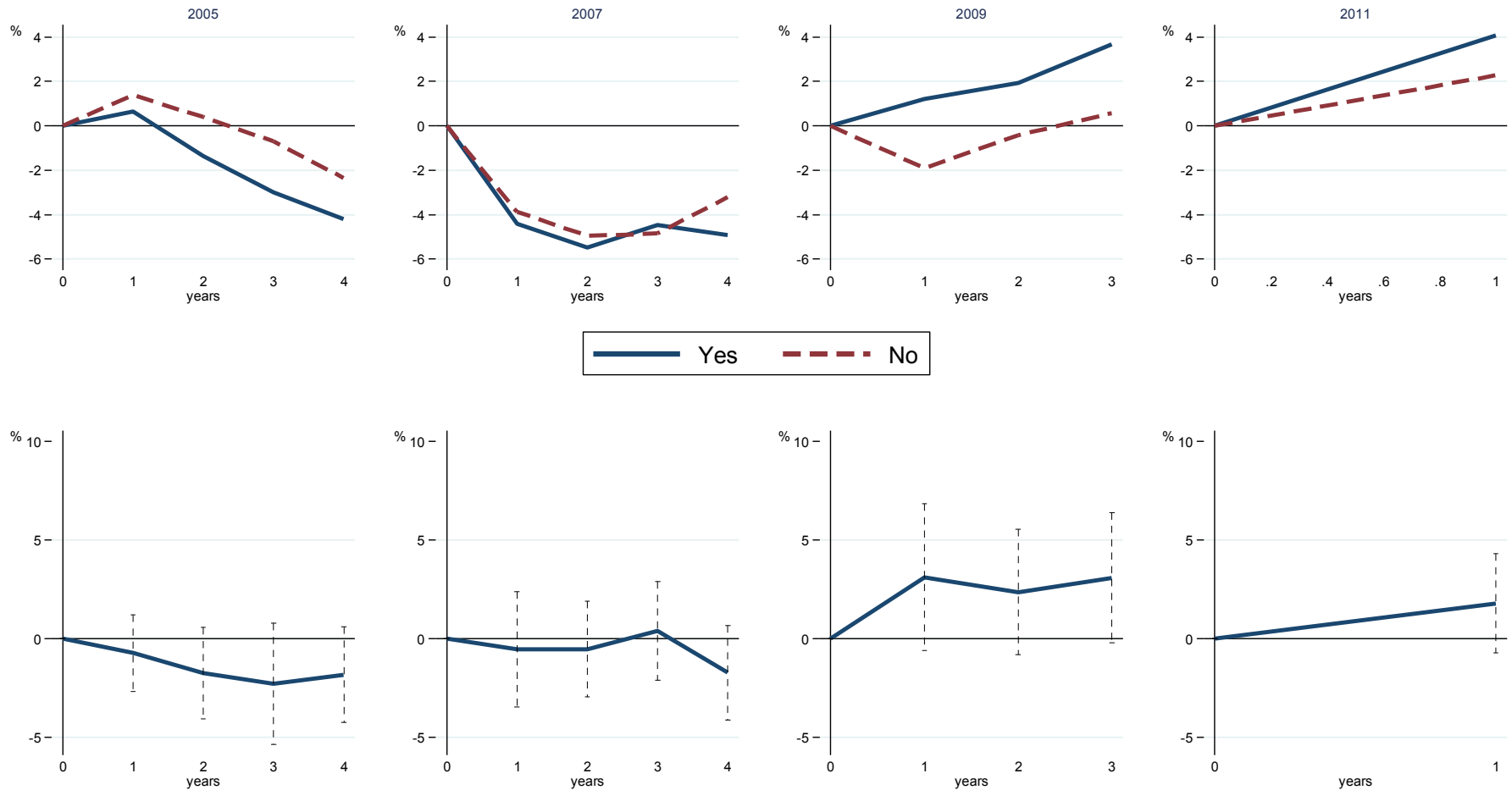
RELATIVE MFP GROWTH BY INNOVATION TYPE OF INNOVATORS VS NON-INNOVATORS
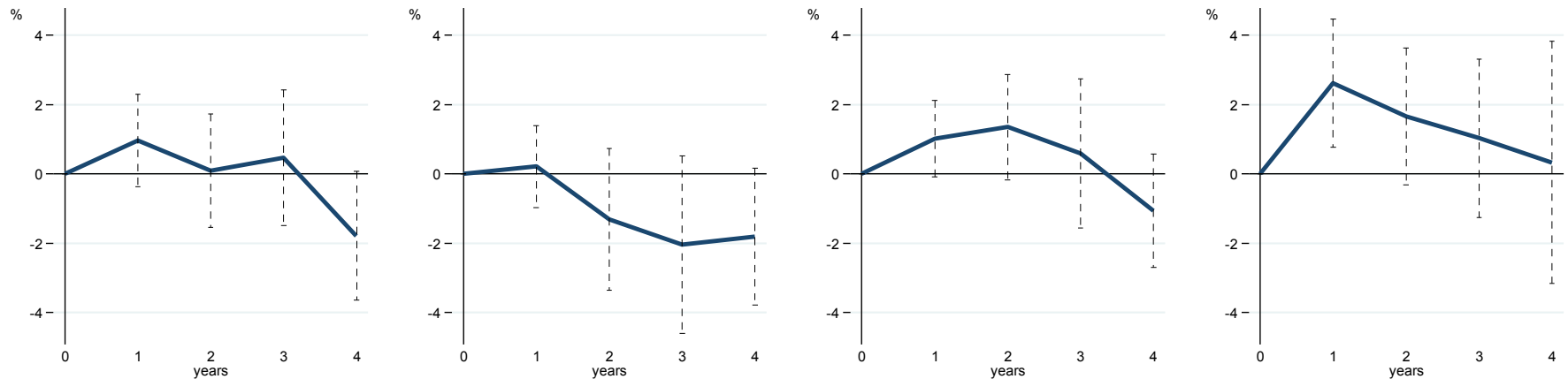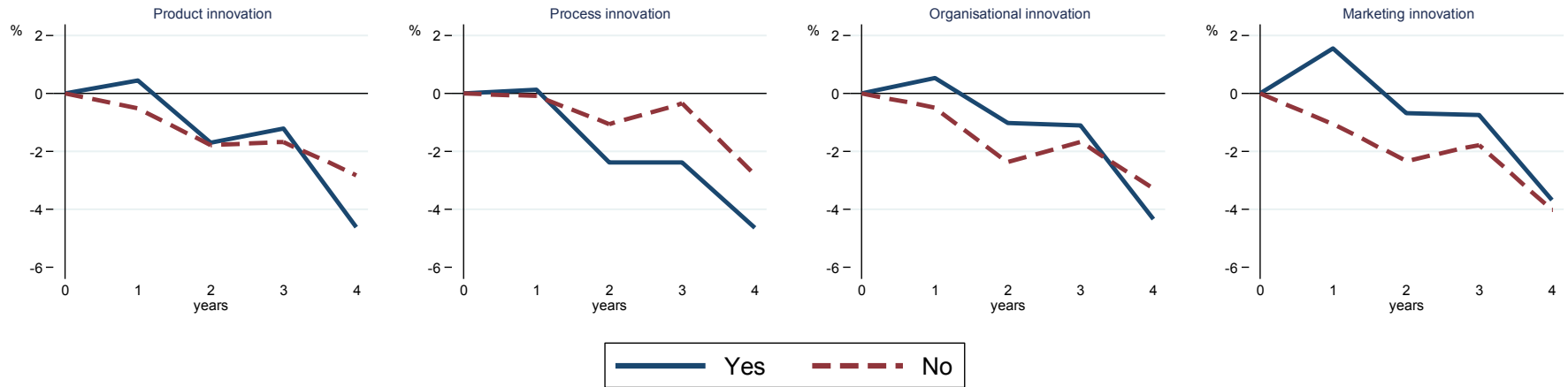
Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Returns to innovation vary dramatically by year

RELATIVE MFP GROWTH BY YEAR OF PRODUCT INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
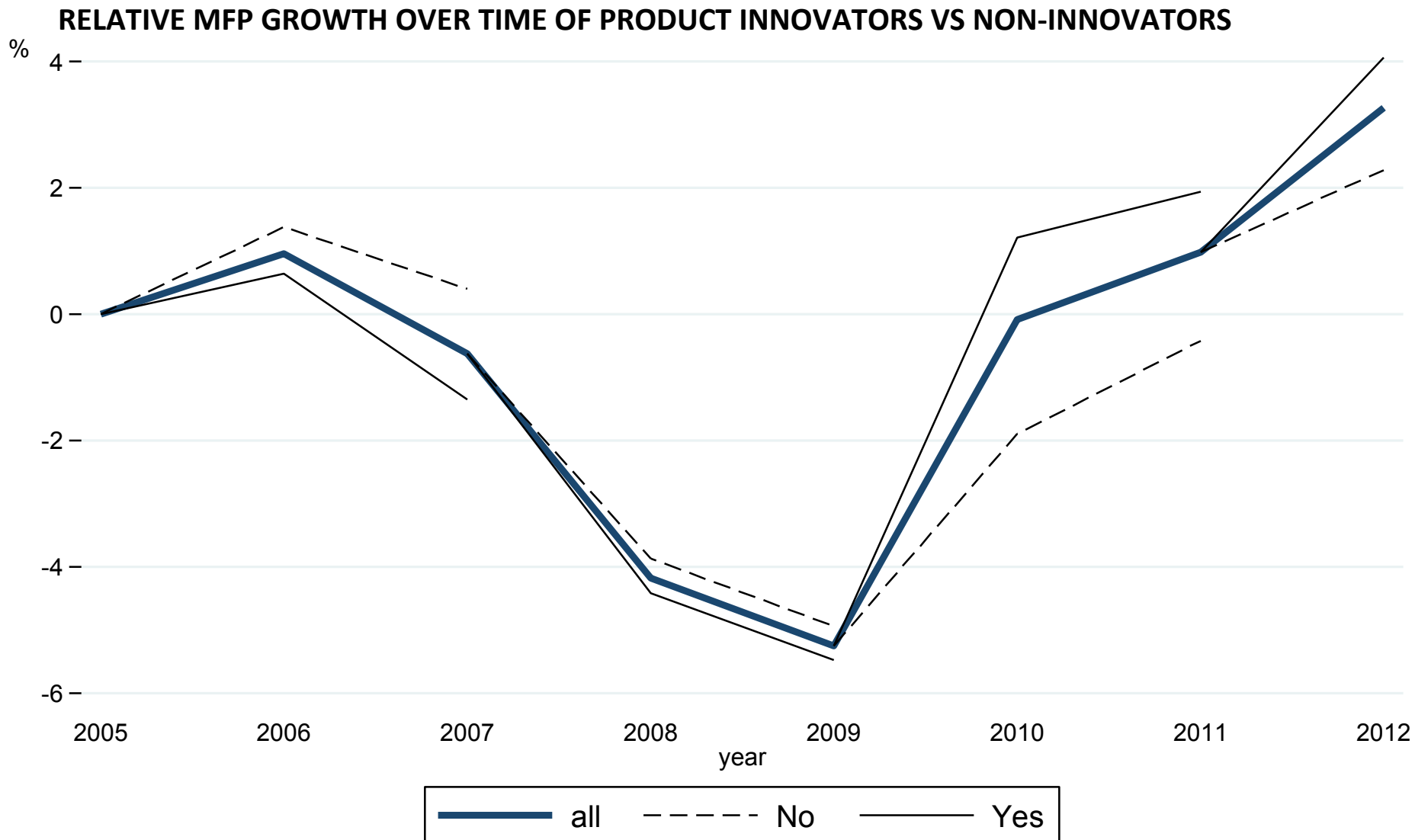
Product innovators experience higher MFP growth during economic recovery but possibly lower growth during economic downtown

RELATIVE MFP GROWTH OVER TIME OF PRODUCT INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
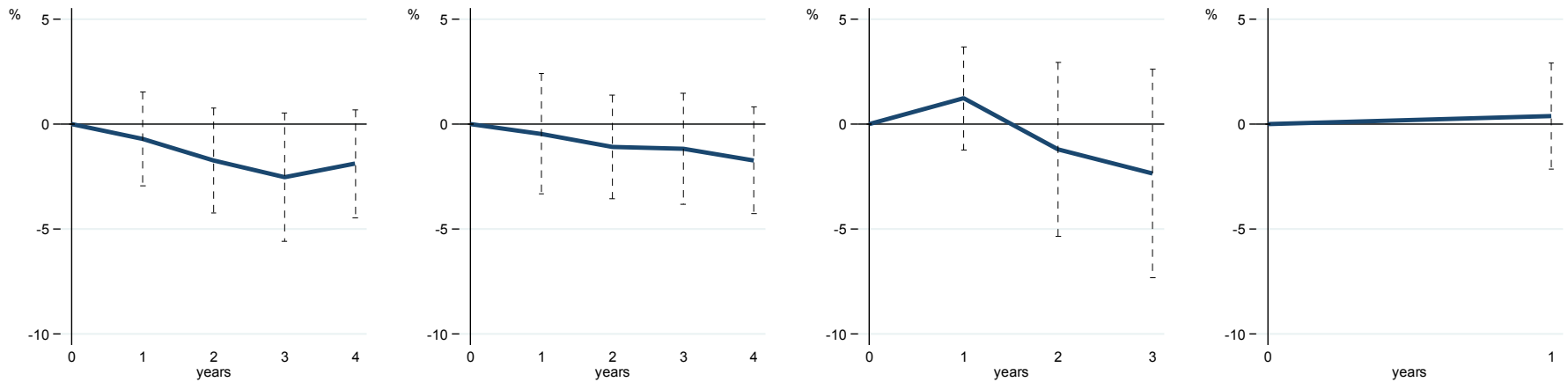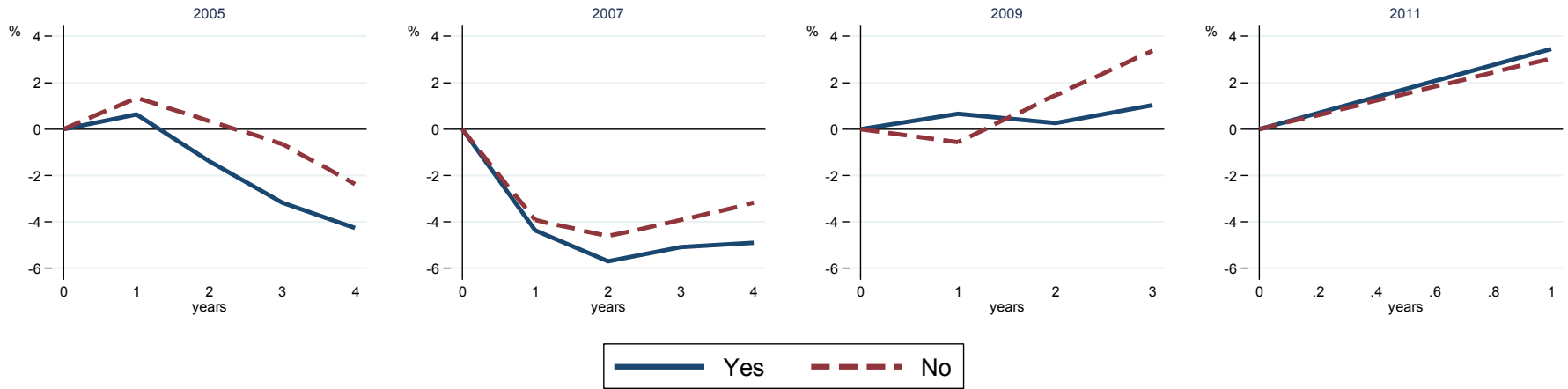
Process innovators appear not to do significantly better or worse than non-innovators

RELATIVE MFP GROWTH BY YEAR OF PROCESS INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
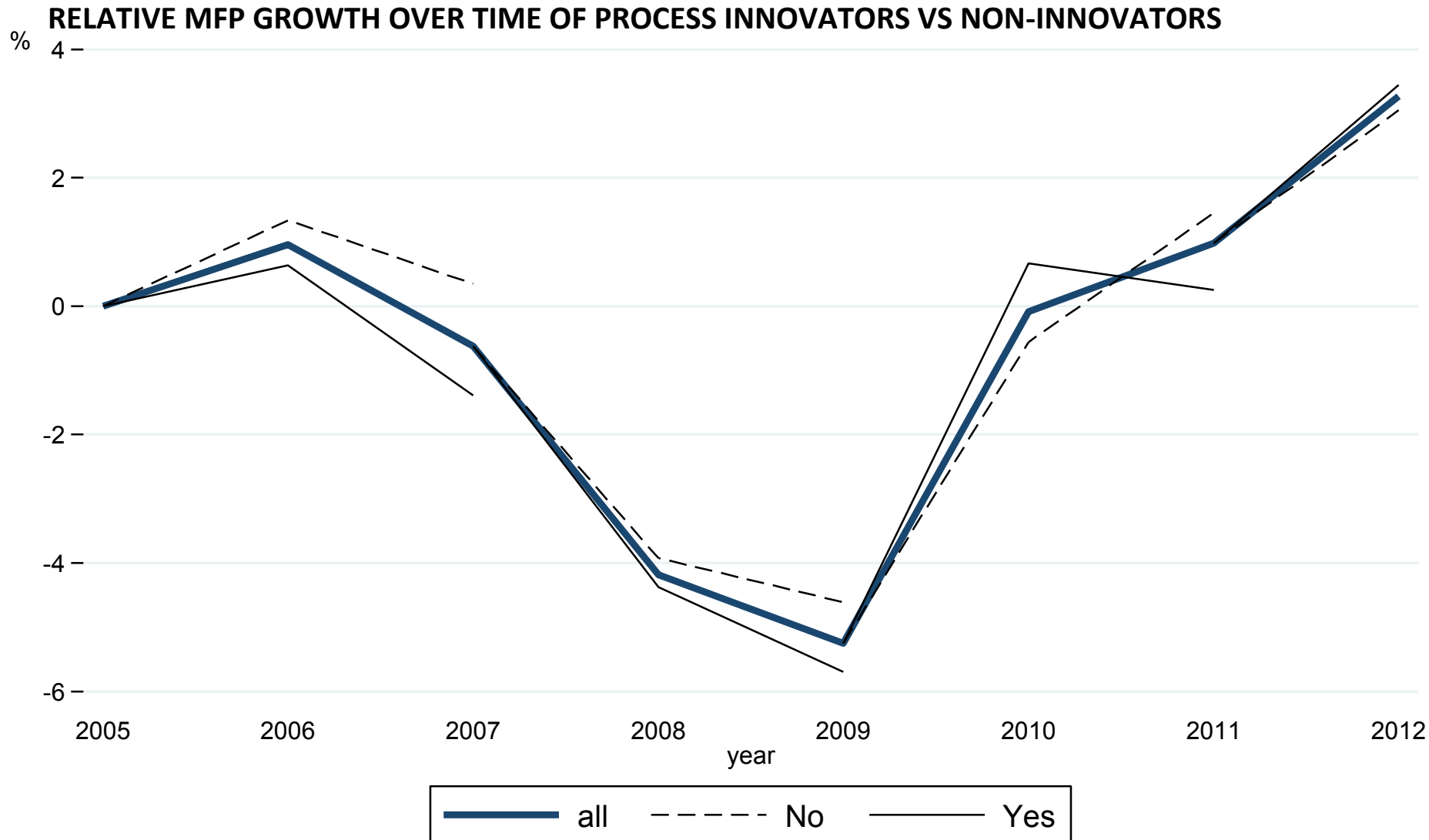
Returns to process innovation do not vary significantly by year

RELATIVE MFP GROWTH OVER TIME OF PROCESS INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
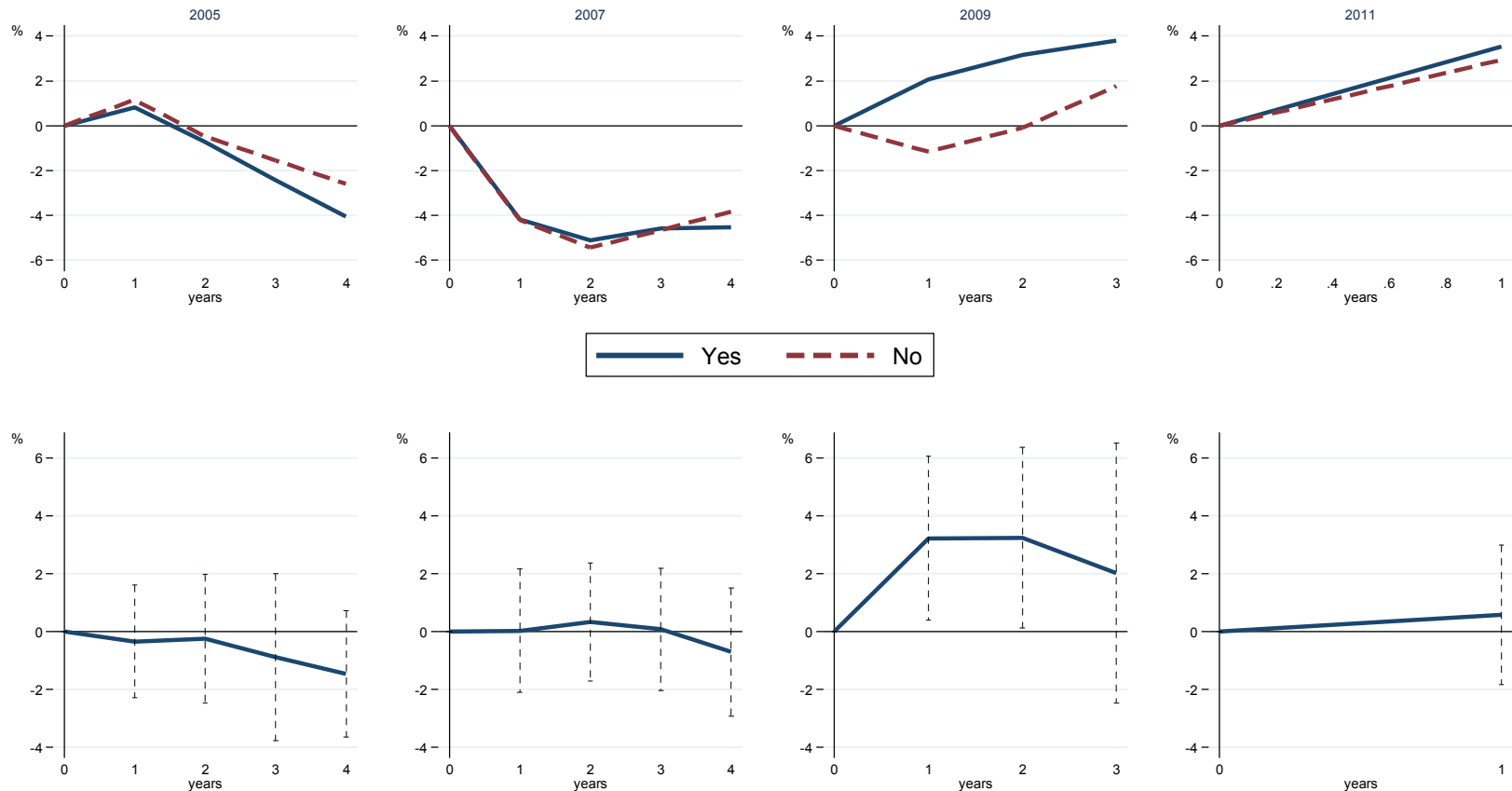
Similarly returns to organisational innovation in 2009 significantly higher but not in other years

RELATIVE MFP GROWTH BY YEAR OF ORGANISATIONAL INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Firms doing organisational innovation during economic downturn experience significantly higher returns during economic recovery

RELATIVE MFP GROWTH OVER TIME OF ORGANISATIONAL INNOVATORS VS NON-INNOVATORS

Legend: all — No — Yes

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
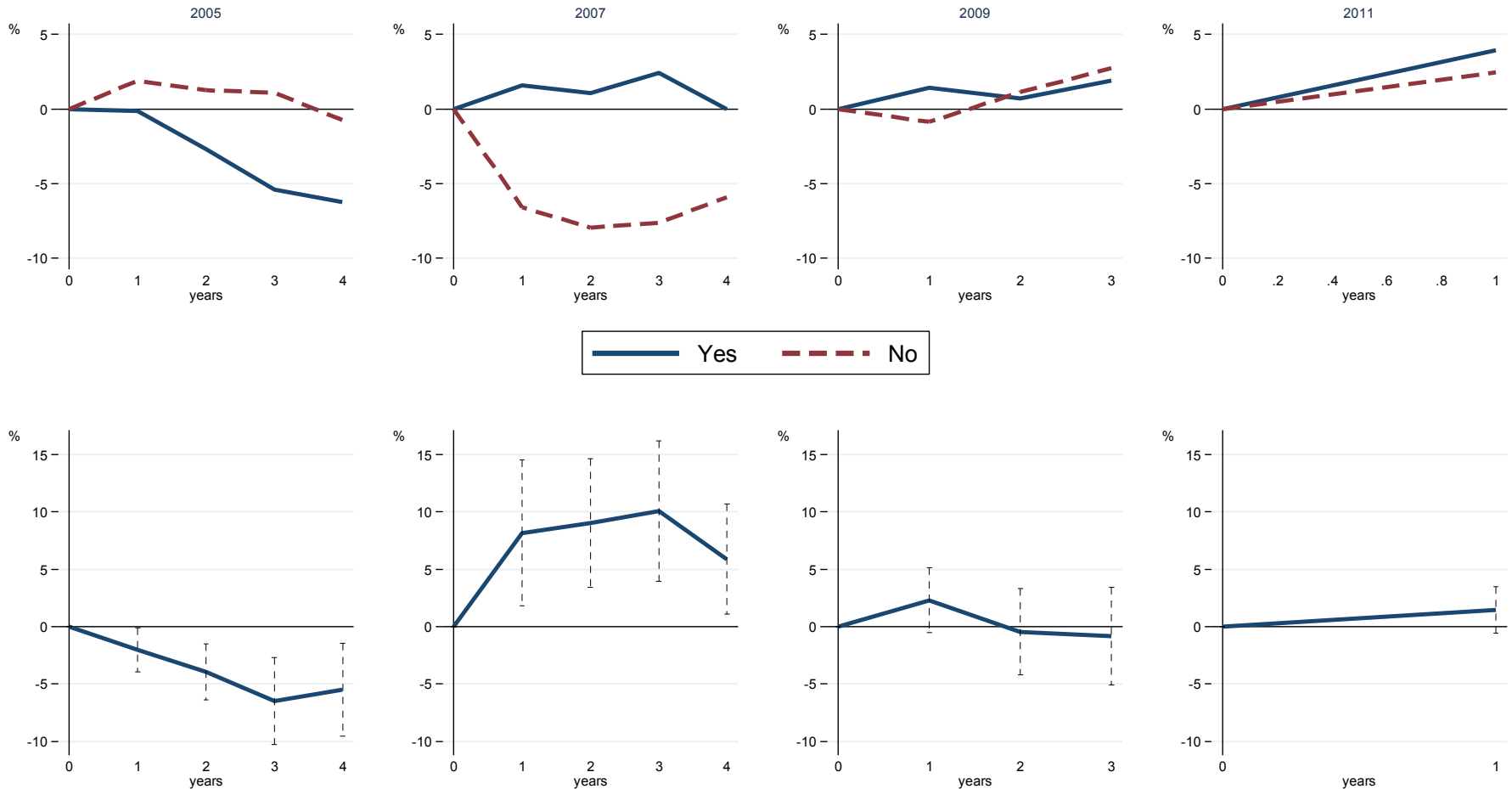
By contrast, marketing innovators in 2005 experienced lower productivity growth but in 2007 experienced higher growth

RELATIVE MFP GROWTH BY YEAR OF MARKETING INNOVATORS VS NON-INNOVATORS

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
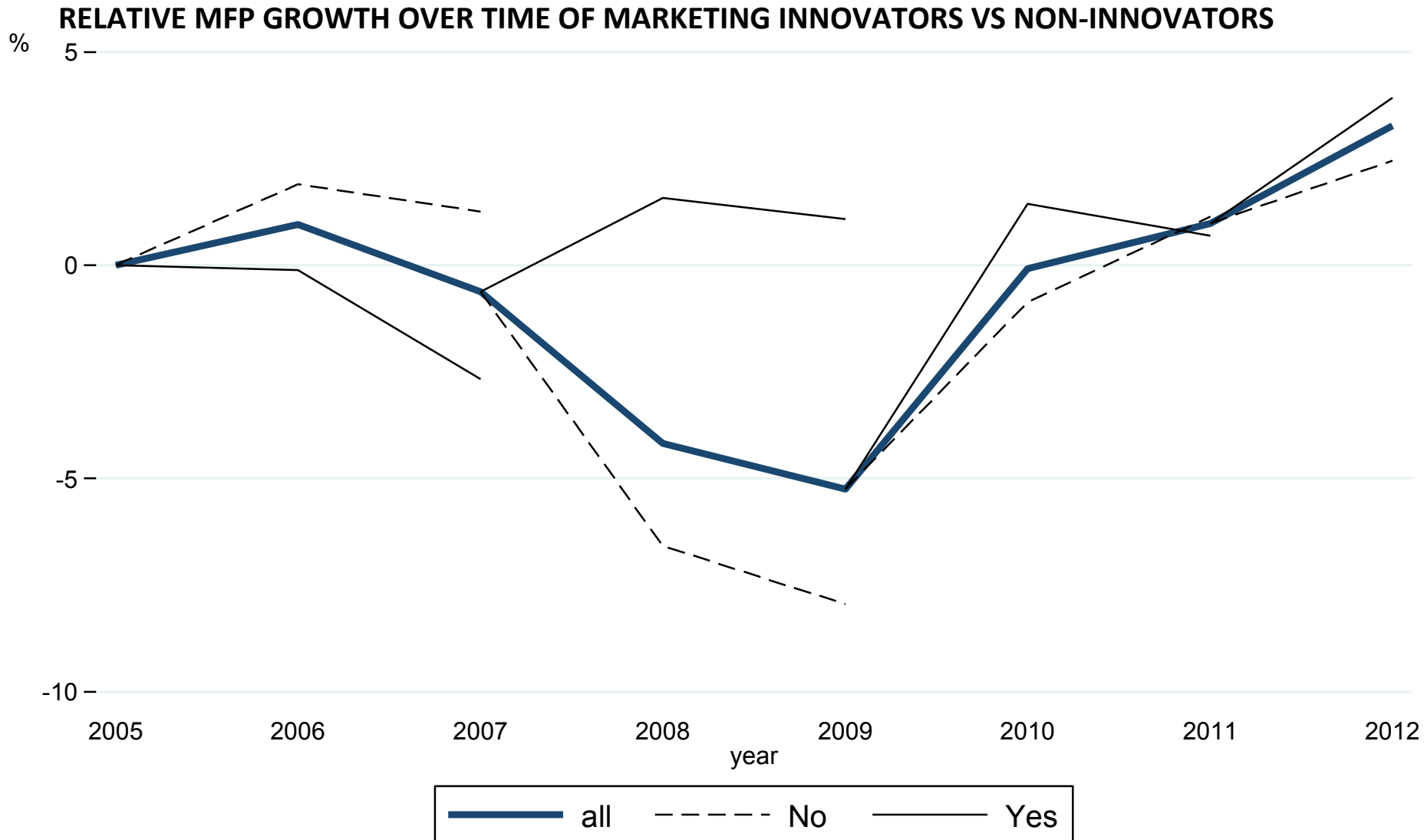
Firms that had introduced marketing innovation did significantly better during economic downturn

RELATIVE MFP GROWTH OVER TIME OF MARKETING INNOVATORS VS NON-INNOVATORS

Legend: all / No / Yes

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
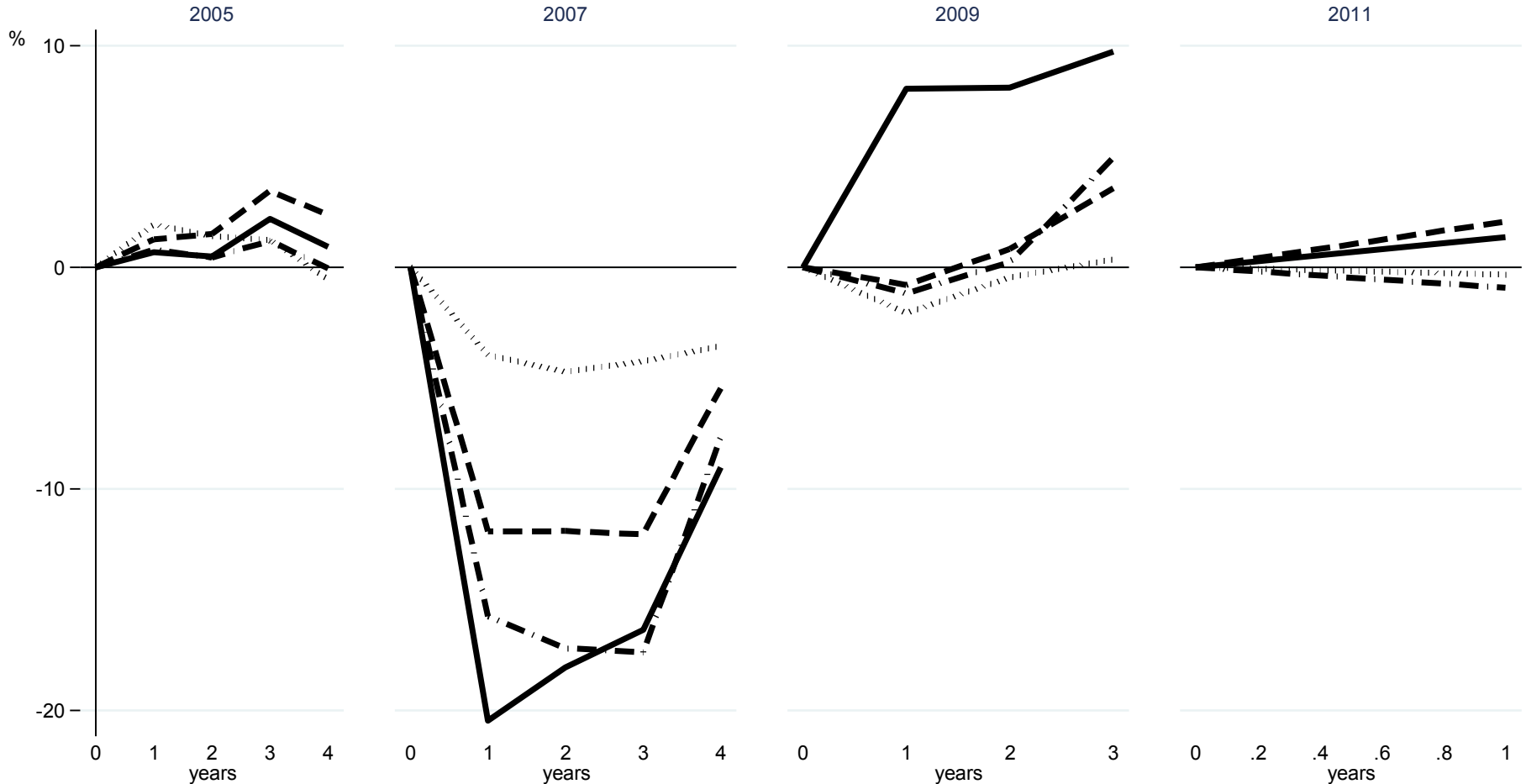
Innovation followers did better than innovation leaders in 2005 & 2007 but innovation leaders did better in 2009
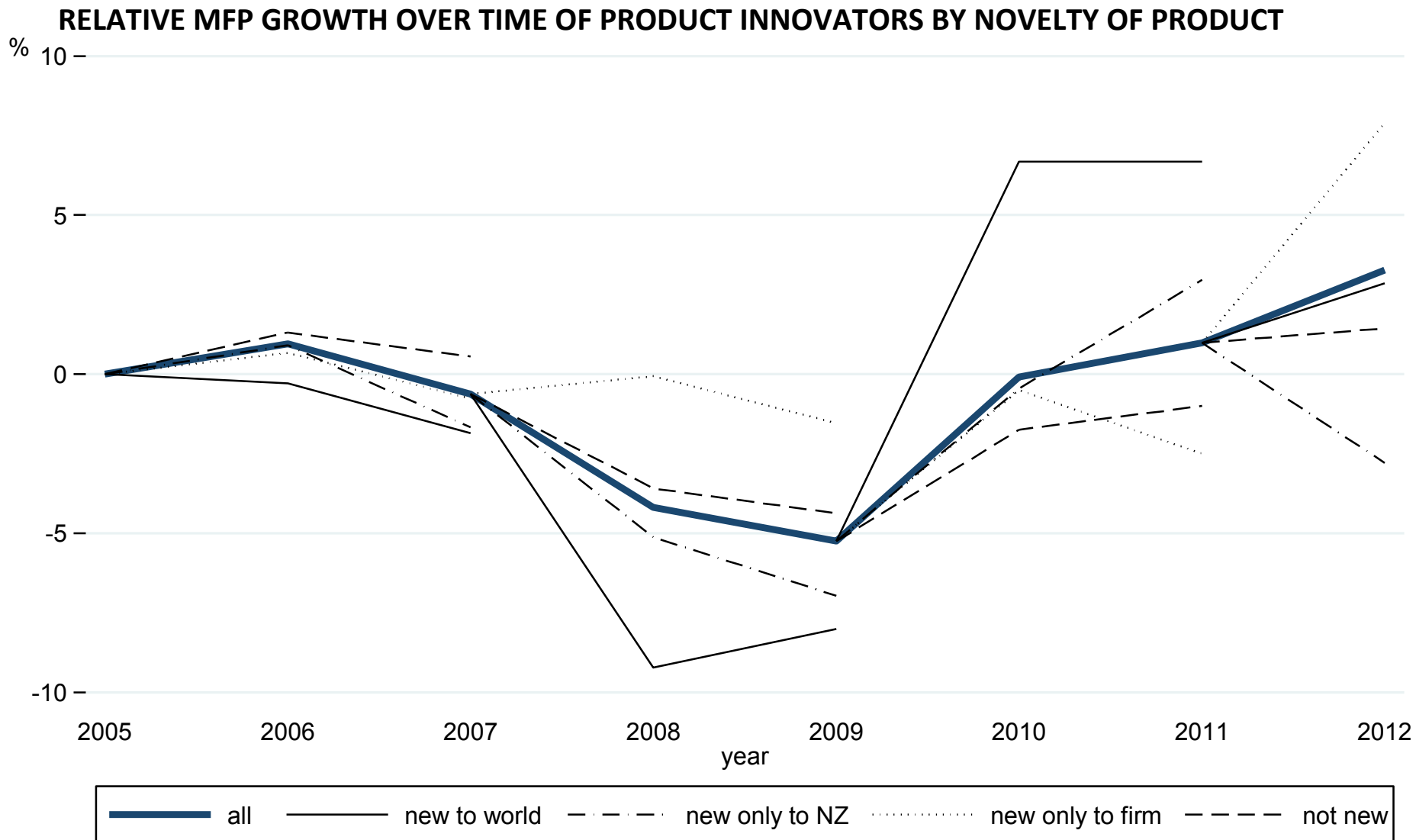
RELATIVE MFP GROWTH BY YEAR OF PRODUCT INNOVATORS BY NOVELTY OF PRODUCT

Legend: —— new to world · —·—·— new only to NZ · – – – new only to firm · ·········· not new

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Innovation followers performed better during economic downtown but innovation leaders performed better during the recovery

RELATIVE MFP GROWTH OVER TIME OF PRODUCT INNOVATORS BY NOVELTY OF PRODUCT

Legend: all · new to world · new only to NZ · new only to firm · not new

Charts show coefficients from OLS regressions of change in 2-yr-MA of MFP from year 0 to t on innovation in year 0. Regressions include controls for base year and firm characteristics. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Younger firms experience highest boost in productivity growth following innovation
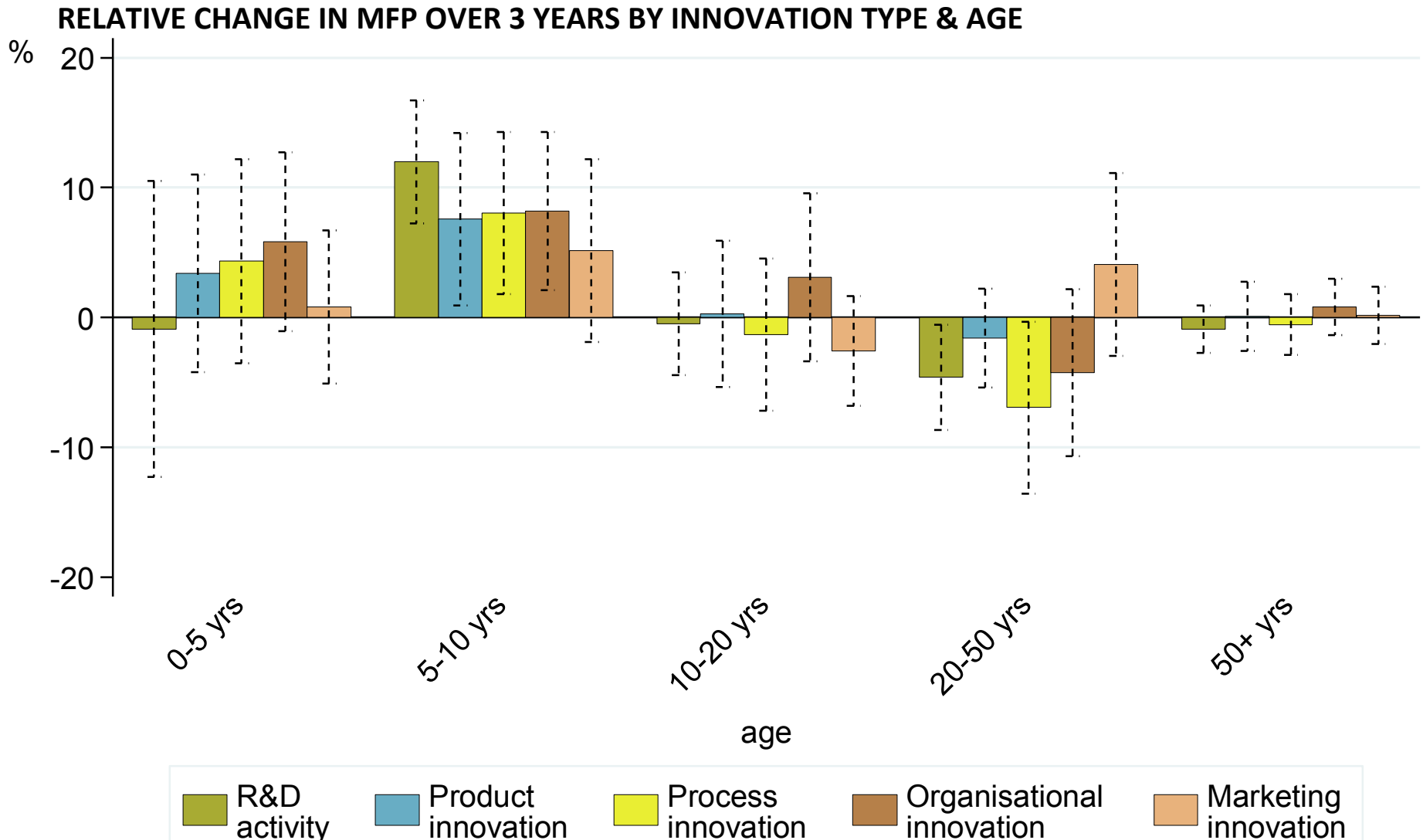
RELATIVE CHANGE IN MFP OVER 3 YEARS BY INNOVATION TYPE & AGE

Legend:
- R&D activity
- Product innovation
- Process innovation
- Organisational innovation
- Marketing innovation

x-axis: age — 0-5 yrs, 5-10 yrs, 10-20 yrs, 20-50 yrs, 50+ yrs

y-axis: % from -20 to 20

Charts show difference in predictive margins from series of OLS regressions of change in 3-yr MA of MFP from year 0 to year t on innovation in year 0 interacted with firm characteristics and controls for base year. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
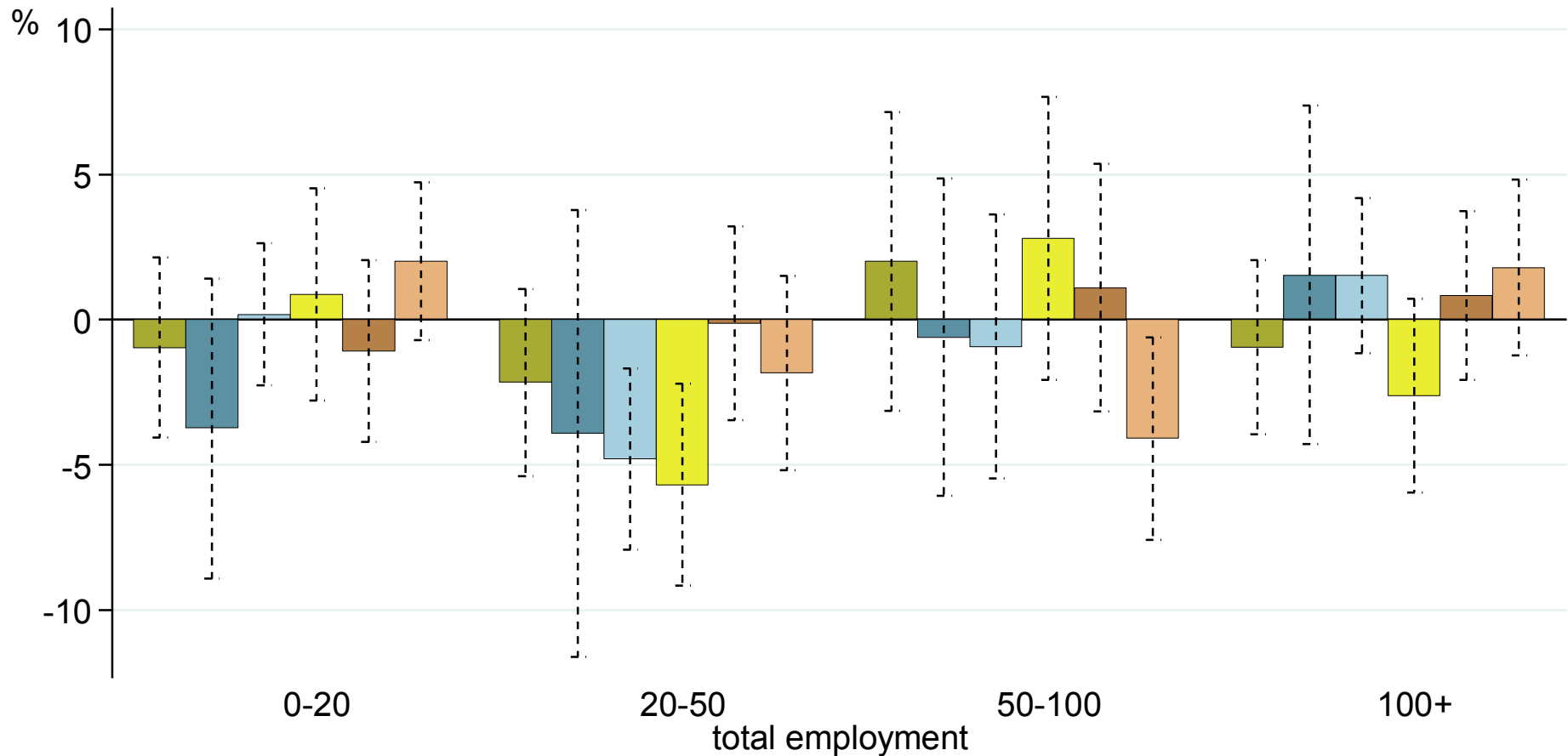
Small-to-medium size firms appear to do worse if they innovate

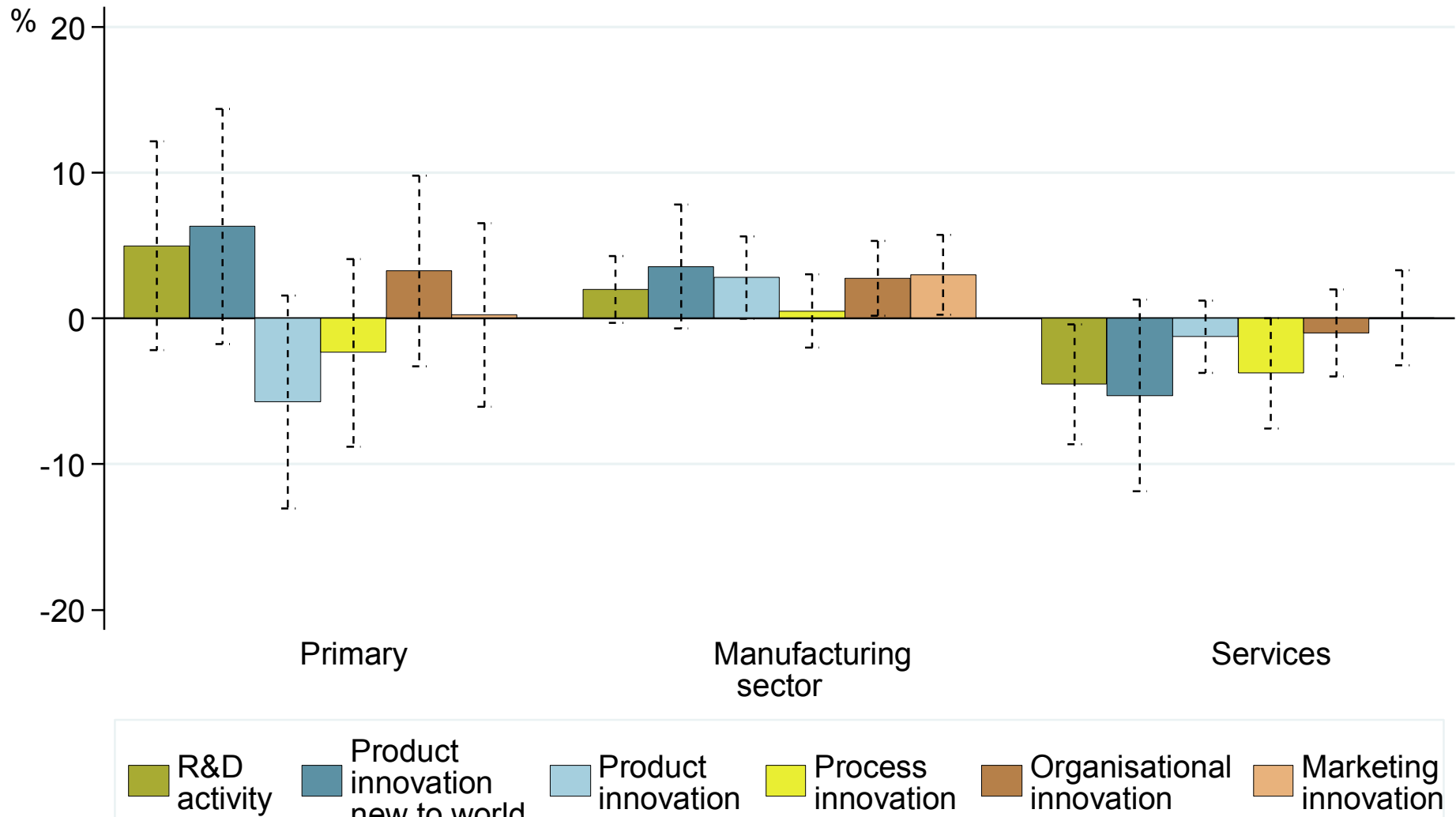**RELATIVE CHANGE IN MFP OVER 3 YEARS BY INNOVATION TYPE & FIRM SIZE**

Charts show difference in predictive margins from series of OLS regressions of change in 3-yr MA of MFP from year 0 to year t on innovation in year 0 interacted with firm characteristics and controls for base year. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

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Firms in manufacturing sector experience strongest impact of innovation on MFP growth

RELATIVE CHANGE IN MFP OVER 3 YEARS BY INNOVATION TYPE & SECTOR

Charts show difference in predictive margins from series of OLS regressions of change in 3-yr MA of MFP from year 0 to year t on innovation in year 0 interacted with firm characteristics and controls for base year. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.
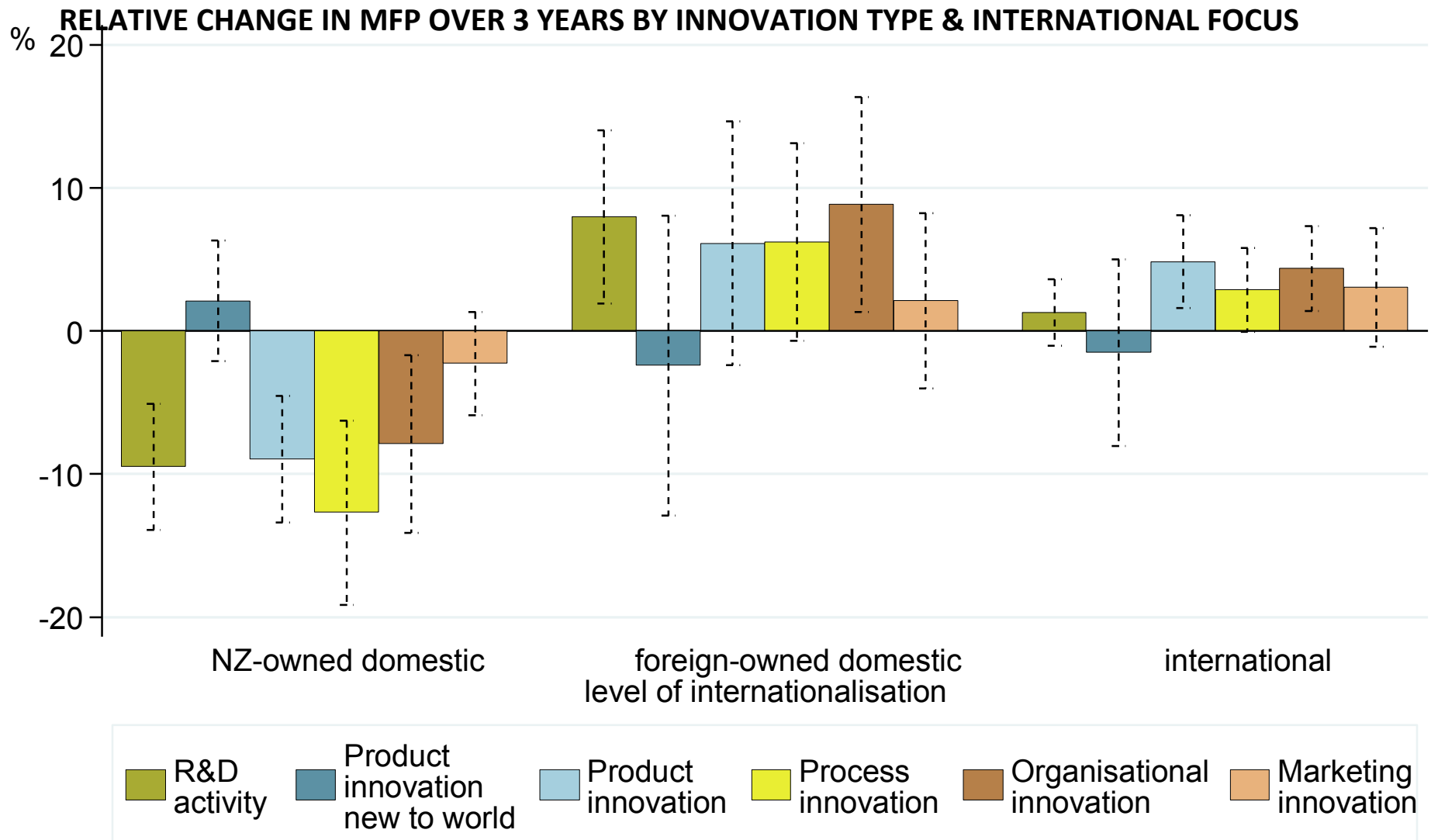
Internationally connected firms engaged in product or organisational innovation experience higher MFP growth, while domestic firms have lower growth

RELATIVE CHANGE IN MFP OVER 3 YEARS BY INNOVATION TYPE & INTERNATIONAL FOCUS

Legend:
- R&D activity
- Product innovation new to world
- Product innovation
- Process innovation
- Organisational innovation
- Marketing innovation

X-axis categories: NZ-owned domestic | foreign-owned domestic | international (level of internationalisation)

Charts show difference in predictive margins from series of OLS regressions of change in 3-yr MA of MFP from year 0 to year t on innovation in year 0 interacted with firm characteristics and controls for base year. Bars show 95% confidence intervals. Sample contains firms in BOS 2005-2011 with output measures until 2012. Observations weighted by BOS sampling weights times predicted output.

Innovation matters for productivity, but more for some firms than others

FINDINGS

- R&D and innovation associated with growth in size but not necessarily with productivity
- Firms doing marketing innovation show clearest returns overall, especially in 2007-2009 (economic downturn)
- Firms doing product and organisational innovation performed better after 2009 (economy recovery), but possibly worse before
- Younger firms, manufacturing firms, and firms with international connections have highest returns to innovation

CONCLUSIONS

- More to innovation than R&D
- Non-technological-types of innovation matter as much if not more
- Market conditions important
- Some types of firms get more value out of innovation than others

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