How Many Years Does It Take for AI Adopting Firms to Realize Productivity Effects?

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Research Questions

Despite recent progress in AI technologies, we are not observing a corresponding surge in aggregate productivity growth, yet. It is often attributed to the fact that a fundamental technological change usually takes time to realize its productivity effect. If so, how many years would it take?

What explains the seemingly insignificant aggregate effects of AI? Is it the slow diffusion of AI across firms, or the slow pace of innovation among adopting firms?

Data & Key Empirical Patterns

Data: "Survey of Business Activities", panel data covering all firms with more than 50 employees (14,566 firms in 2023) in South Korea.

The number of AI-adopting firms in South Korea has been increasing, and their **employment-weighted share** almost reaches **one-fourth**:

Figure 1-1. # of AI-adopting firms

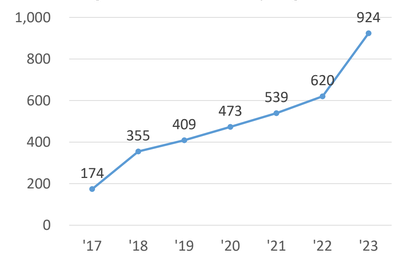
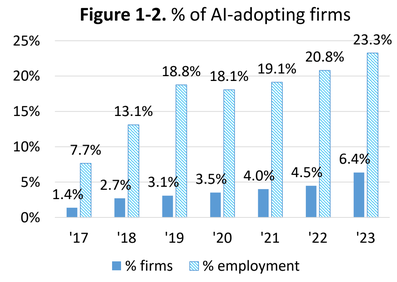


Figure 1-2. % of AI-adopting firms



AI-adopting firms are, on average, more productive than non-adopting firms, but the **differentials are declining** since 2019 as **late-adopters** tend to **be less productive** than the early-adopters:

Figure 2-1. Dist. of labor productivity (log)

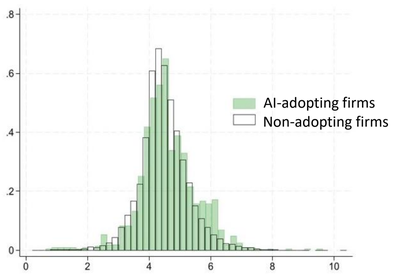
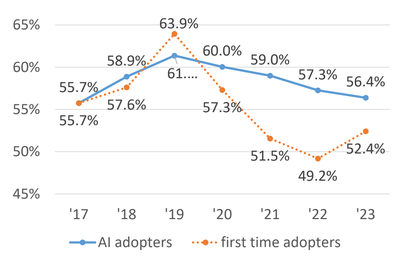


Figure 2-2. Top-50% Firm share (labor productivity, %)



However, AI-adopters differ from non-adopters in several dimensions, including size, age, industry and capital intensities, raising concerns about **endogeneity**.

OLS

To address endogeneity, a set of control variables is included:

$$y_{i,t} = \alpha + \beta_1 \cdot \boldsymbol{D_{i,t}^{AI}} + \beta_2 \cdot X_{i,t} + \mu_j + \mu_t + \epsilon_{i,t}$$

$y_{i,t}$: firm outcome variables ; $\boldsymbol{D_{i,t}^{AI}}$: AI adoption dummy ; $X_{i,t}$: control variables ;
μ_j : industry dummies ; μ_t : time(year) dummies

Table 1. OLS result: No significant contemporaneous productivity effect of AI adoption

	(1)	(2)	(3)	(4)
Dep. Variable ($y_{i,t}$) :	Labor Productivity (ln Q/L)		Employees (ln L)	Value Added (ln Q)
AI adoption (0/1)	0.135*** (0.023)	-0.004 (0.021)	0.914*** (0.047)	1.048*** (0.058)
$K_{tangible}/L$ (log)	-	0.116***	-	-
$K_{\boldsymbol{intangible}}$[1)]$/L$ (log)	-	0.070***	-	-
Export (0/1)	-	0.132***	-	-
Conglomerates (0/1)	-	0.258***	-	-
Employment (Deciles)	N	Y	N	N
Obs.	90,879	90,667	90,891	90,879
R-squared	0.241	0.328	0.214	0.188

Note: 1) $\boldsymbol{K_{intangible}}$: intellectual property rights, software and licenses for franchise, mining and fishing, etc.
2) Standard Errors are clustered at the firm level and reported in parenthesis.
3) Industry, time(year), and age(decile) dummies are included for all specifications.

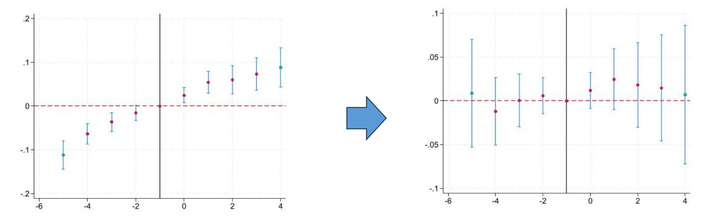
Event Study

To estimate the lagged effects of AI adoption on various firm outcomes:

$$y_{i,t} = \sum_{l} \beta_l \cdot D_{t-l}^{AI} + \delta_i + \mu_s + \mu_t + \epsilon_{i,t}$$

$y_{i,t}$: Firm outcomes likely affected by AI adoption ; l = lag (lead) ;
δ_i: firm fixed-effect ; μ_s: industry dummies; μ_t : time(year) dummies

To address pre-trend concerns for some outcome variables, including employment, the sample is restricted to firms that ever-adopted AI (ever-treated).



Horizontal axis: l (= 0 in the year of first AI adoption) ; green obs. : $l \geq 4$ (lag) or $l \leq -5$ (lead);
Vertical line: 95% confidence interval

Fig.3: No significant effect on productivity, output, or employment within 5 years after adoption

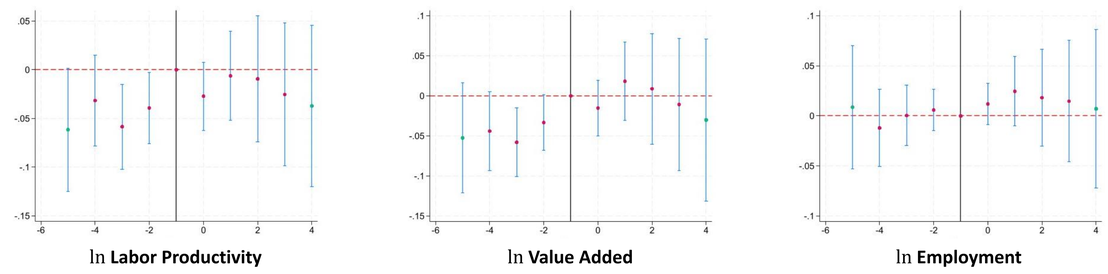


Fig.4: R&D rose through one year after initial adoption, but capital investments did not

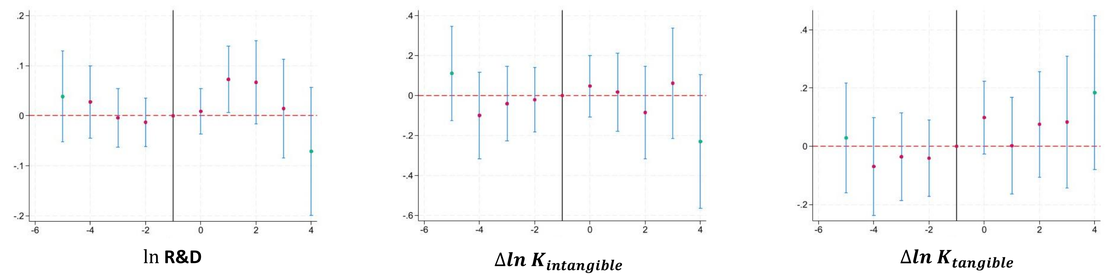
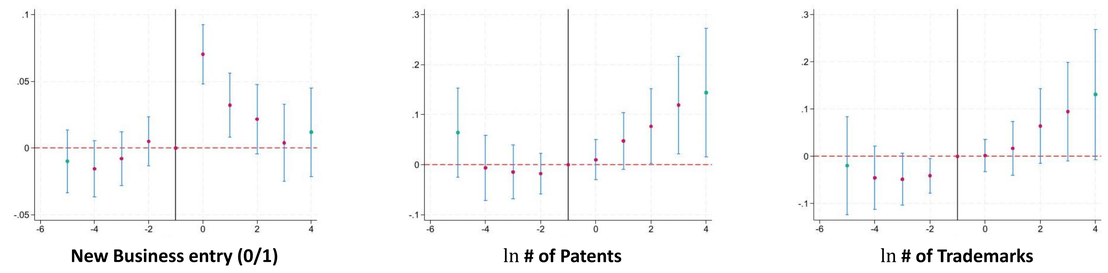


Fig.5: New Business increased through 1 year after adoption, patents & trademarks also increased



Conclusions

1. AI adoption in South Korea began with high-productivity firms and is spreading to lower-productivity firms, resulting in almost one-fourth of surveyed workers employed by AI-adopting firms.
2. Although AI-adopting firms are more productive than non-adopters, the productivity differentials are declining over time and becomes insignificant once firm characteristics are controlled for.
3. AI-adoption has no significant effect on productivity, either contemporaneously or within 5 years after initial adoption.
4. AI-adoption has not induced a sustained increase in investments, which may partly explain the limited productivity effects. However, certain measures of innovation, including new business entry, increased following AI adoption.
5. The time lag before AI yields measurable gains remains uncertain; 5 years appears insufficient, and greater investments may be required to accelerate it.

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