Revisiting declining R&D productivity in Korea

Team YSJ
Name: Dongjoo Kim, Sungwoo Jang, Hyunsik Yoon

R&D Productivity

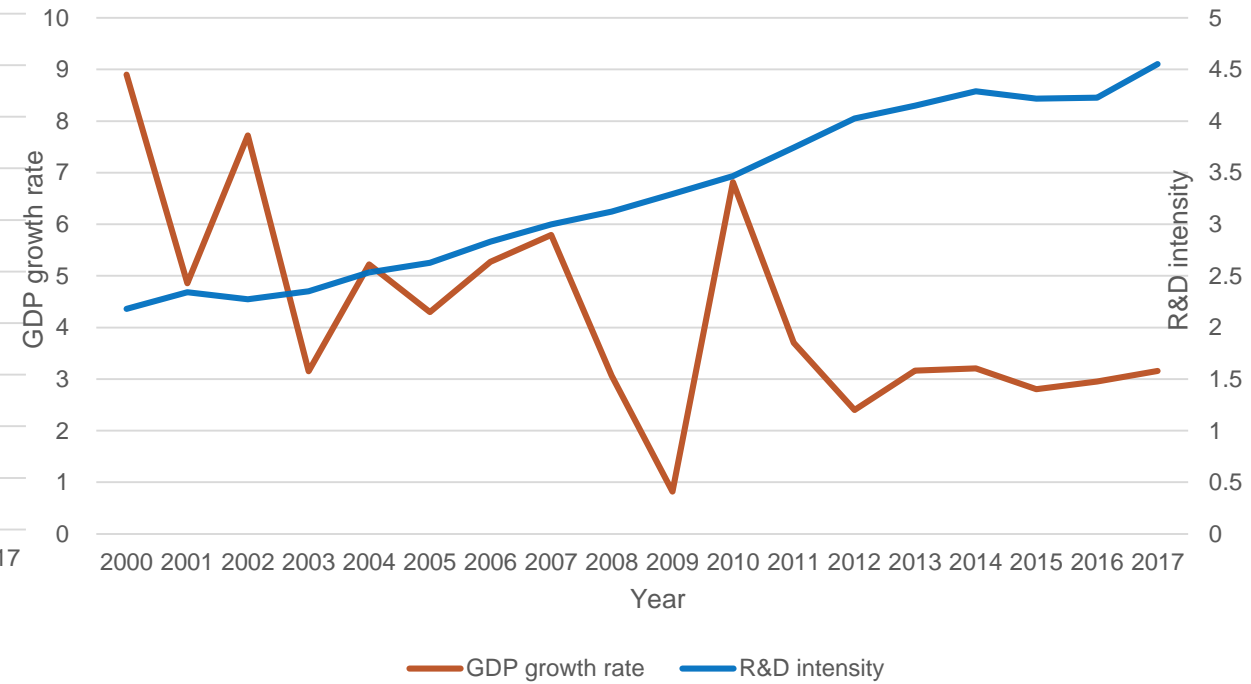| Aggregate level	Industry level
$\equiv \dfrac{GDP\ growth\ rate}{R\&D\ intensity}$	$\equiv \dfrac{Sales\ growth\ rate}{R\&D\ intensity}$

➢ R&D intensity $\equiv \dfrac{R\&D\ expenditure}{GDP}$ ➡ $\dfrac{R\&D\ expenditure}{Total\ sales}$

Trend of R&D Intensity

R&D Intensity across countries
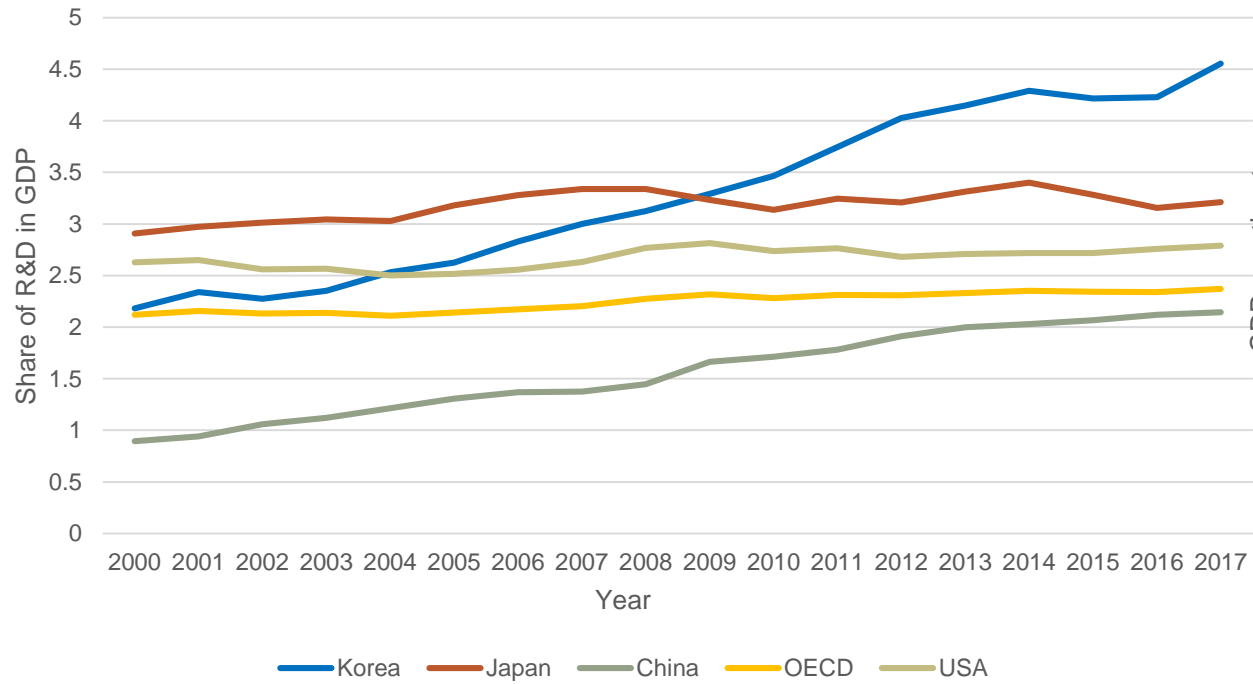
R&D Intensity and GDP growth rate

Key paper:

Nicholas Bloom (2019, NBER working paper)
- finds R&D productivity has been declining since 1980's in the US

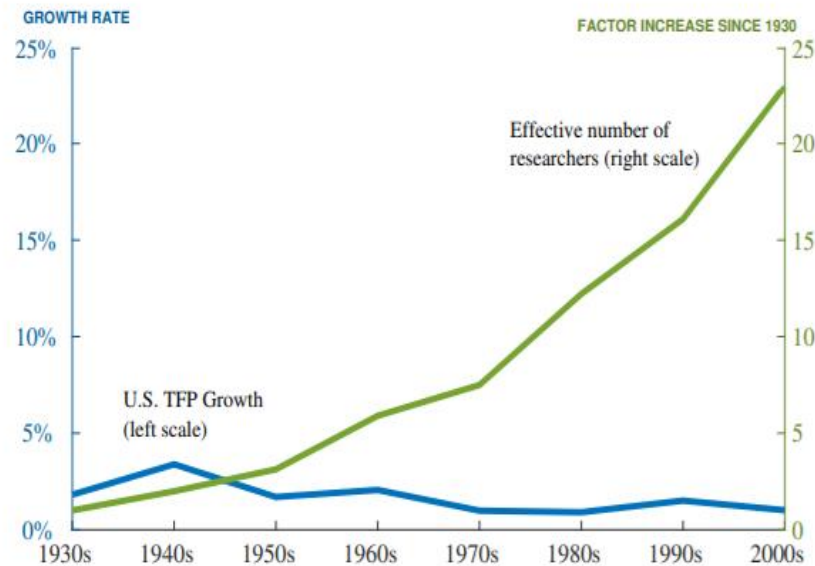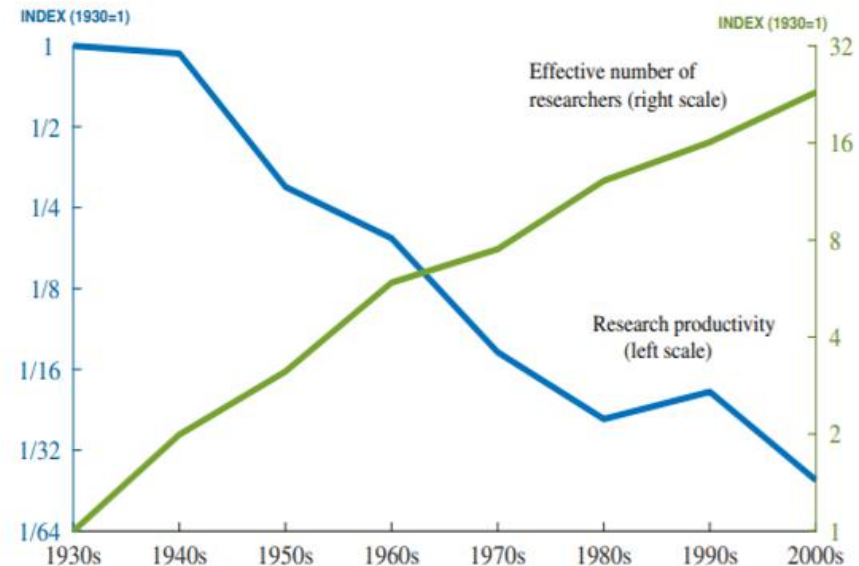Figure 1: Aggregate Data on Growth and Research Effort

Figure 2: Aggregate Evidence on Research Productivity

Objectives

1. The firm-level R&D productivities in Korea for the last 15 years, by using the financial statement data (KisValue).

2. Time varying effects of R&D intensity on firm's economic activity

3. Comparison between electronics and non-electronics

Data and Sample

Data

◦ KOSPI and KOSDAQ listed firms' financial statements panel data from KisValue

◦ Period: 2001~2018

◦ The number of firms : 2,228 (based on 2018)

Our sample

◦ Removing data if R&D investment is zero or omitted during the period

◦ Removing upper 1% data to adjust bias

◦ The number of firms: 1,439
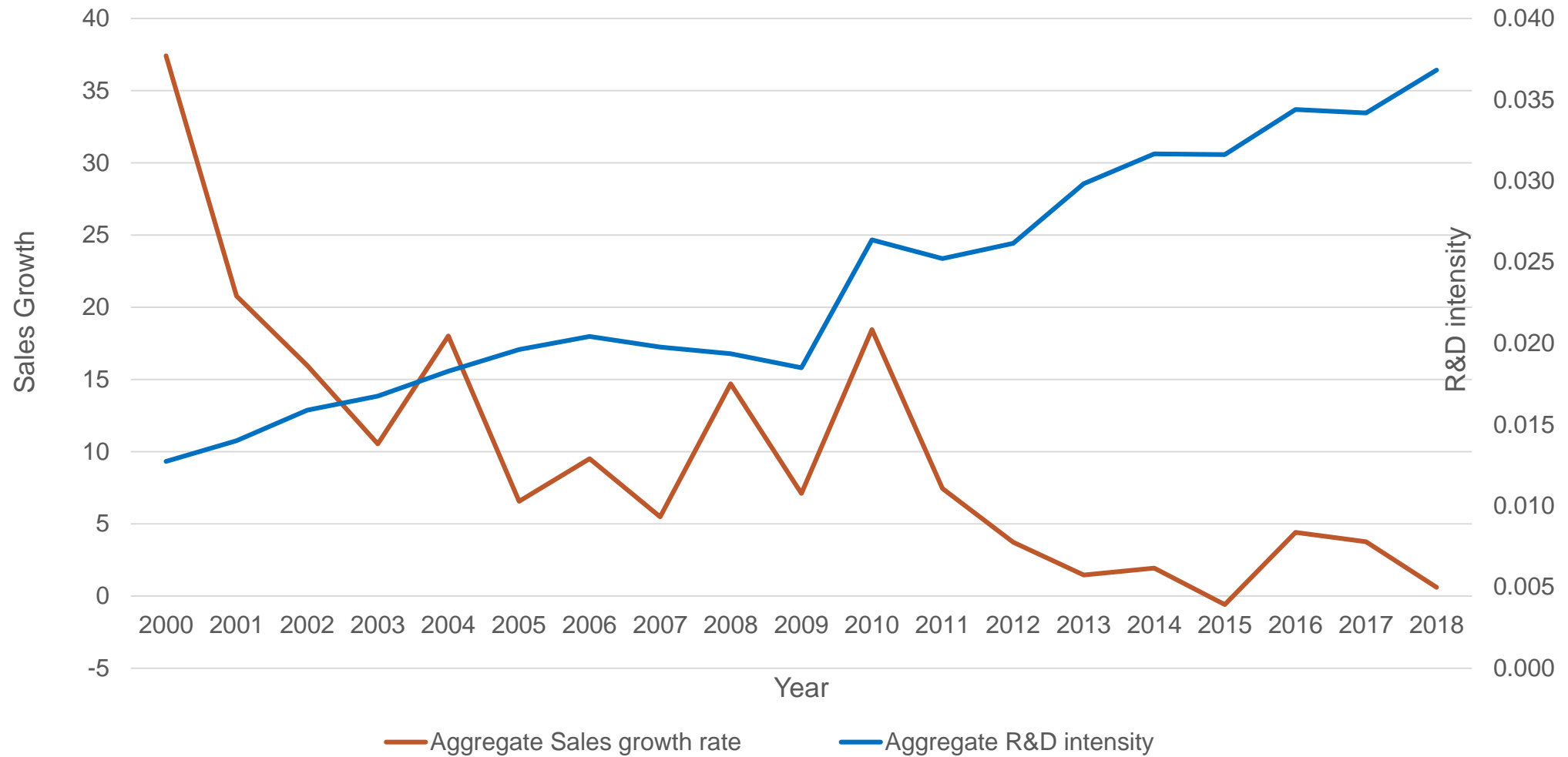
Measure of R&D expenditure/output

R&D expenditure=

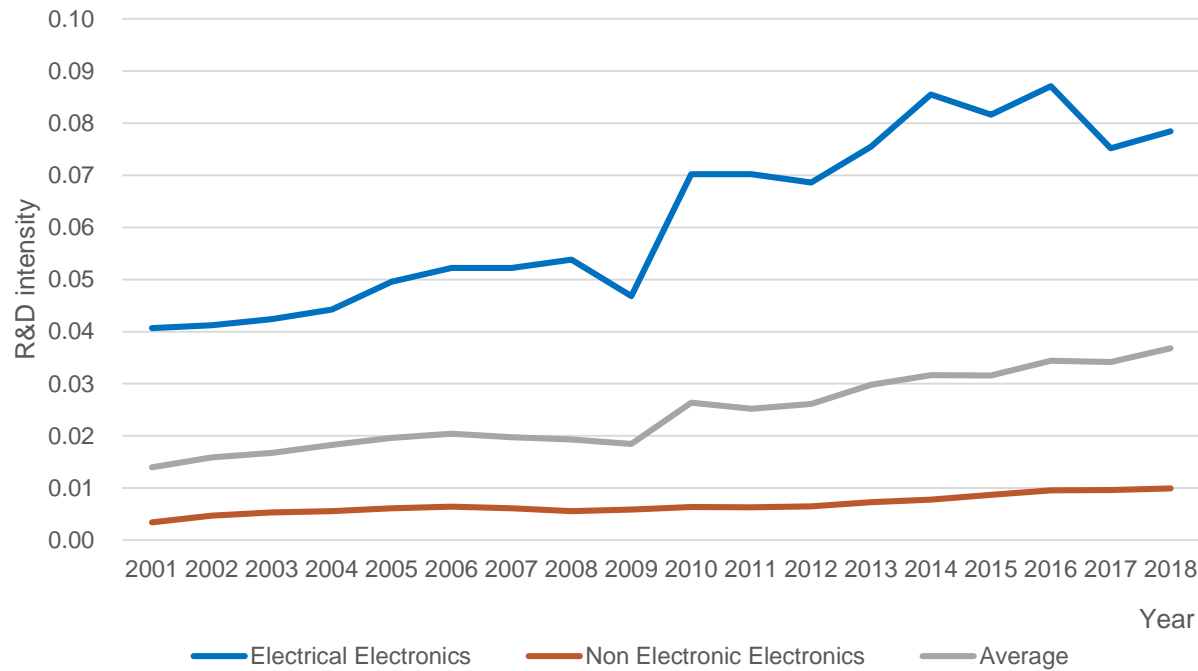**Development cost+ R&D cost+ Ordinary development expense**

R&D output
- ◦ Total sales growth rate
- ◦ Profit ratio
- ◦ Tobin's q

Aggregate R&D intensity and Sales growth rate of the Listed firms

Sector: Electronics vs Non-Electronics

R&D intensity

R&D Expenditures
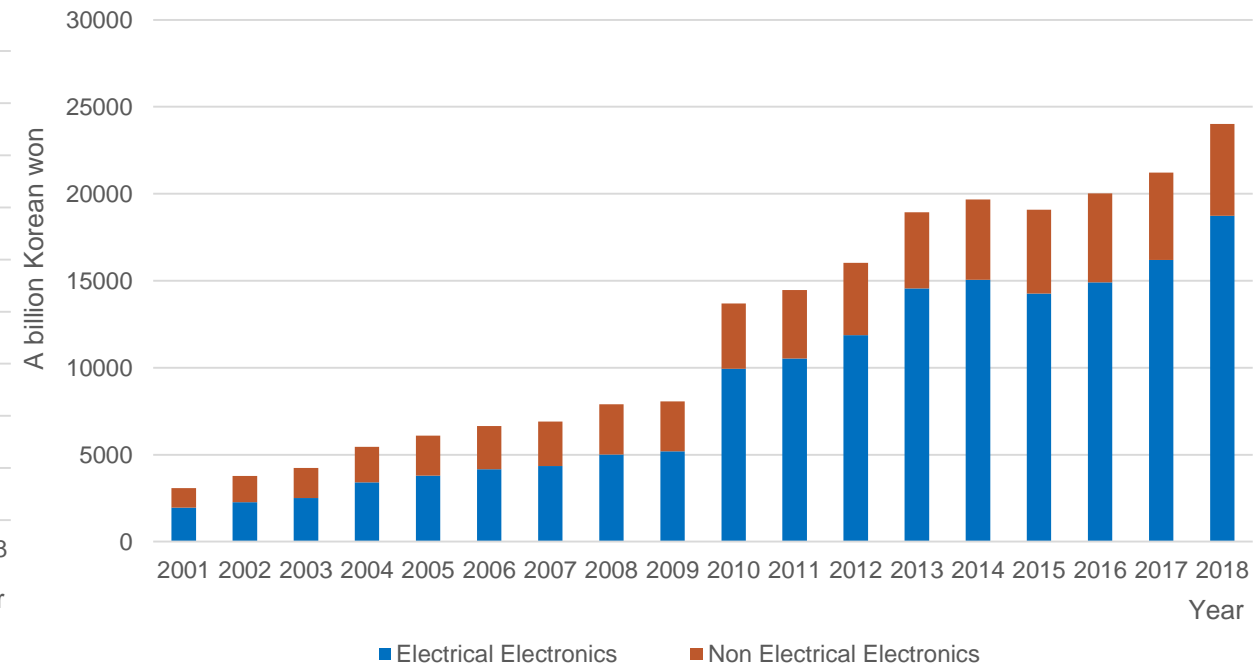
Panel analysis – Fixed effect model

$$y_{it} = \alpha + \beta x_{i,t-n} + X_{it}\gamma + \lambda_i + \varepsilon_{it}$$

where y_{it} = Firm's R&D $output\ at$ t period

$x_{i,t-n}$ = Firm's R&D intensity at $(t-n)$ period $(3 \leq n \leq 7)$

λ_i = the unobservable individual heterogeneity

$$X_{it} = \begin{bmatrix} \log(\text{Ad Expenditure Ratio})_{it} \\ \text{Debt Ratio}_{it} \\ \text{Log(total equity)}_{it} \\ \text{Real GDP Growth}_{t} \end{bmatrix}'$$

Time lag effects (Sales growth rate)

- Time lags between R&D and actual performances: 3~7 year
- The effect of $R\&D\ intensity_{t-n}$ on $R\&D\ outputs_t$ $(3 \leq n \leq 7)$

$R\&D\ intensity_{t-n}$	Whole period (2001~2018)		
	$n = 3$	n = 5	n = 7
Total firms	0.485*** (5.27)	0.193*** (5.79)	0.097*** (3.35)
Electronics	2.046*** (2.69)	-0.353 (-0.42)	-1.767** (-2.03)
Non-Electronics	0.472*** (5.03)	0.193*** (5.71)	0.098*** (3.36)

*: 10% significance level   **:5% significance level   ***:1% significance level
The number in parentheses means t-value

Panel analysis

The effect of R&D intensity on R&D outputs with 3 years time lag

- The effect during the whole period 2004-2018

- The effect during 2004–2010 and 2011-2018

- Compare the effect between former period and latter period

- Compare the effect between electronics and non-electronics

Panel Analysis Result (Sales growth rate)

Sales growth$_t$	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)
R&D intensity$_{t-3}$	0.485*** (5.27)	0.687*** (3.51)	0.463*** (3.68)
Log(Ad Ratio)$_t$	-0.027*** (-9.05)	-0.020*** (-3.41)	-0.039*** (-8.97)
Debt Ratio$_t$	0.256*** (6.41)	0.582*** (7.04)	0.434*** (7.61)
Log(total equity)$_t$	0.047*** (4.78)	0.123*** (5.57)	0.138*** (8.47)
Real GDP growth$_t$	0.027*** (10.20)	0.016*** (4.65)	0.045*** (3.88)
Constant$_t$	-1.013*** (-3.74)	-2.800*** (-4.88)	-3.741*** (-8.39)

*: 10% significance level   **:5% significance level   ***:1% significance level
The number in parentheses means t-value

Panel Analysis Result (Sales growth rate)

$Sales\ growth_t$	Electronics			Non-Electronics		
	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)
$R\&D\ intensity_{t-3}$	2.046*** (2.69)	5.725*** (3.00)	1.753* (1.83)	0.472*** (5.03)	0.648*** (3.25)	0.450*** (3.51)
$Log(Ad\ Ratio)_t$	-0.029*** (-2.74)	-0.033 (-1.63)	-0.042*** (-2.90)	-0.027*** (-8.75)	-0.018*** (-3.10)	-0.388*** (-8.58)
$Debt\ Ratio_t$	0.333** (2.23)	0.372 (1.00)	0.724*** (3.59)	0.254*** (6.14)	0.594*** (6.94)	0.420*** (7.09)
$Log(total\ equity)_t$	0.052 (1.29)	0.246*** (2.82)	0.158*** (2.49)	0.047*** (4.61)	0.116*** (5.05)	0.138*** (8.14)
$Real\ GDP\ growth_t$	0.020** (2.37)	0.010 (0.98)	0.014*** (0.42)	0.027*** (9.95)	0.016*** (4.57)	0.047*** (3.87)
$Constant_t$	-1.242 (-1.15)	-6.318*** (-2.69)	-4.438*** (-2.57)	-1.018*** (-3.63)	-2.611*** (-4.37)	-3.711*** (-8.05)

*: 10% significance level **:5% significance level ***:1% significance level
The number in parentheses means t-value

Other R&D Outputs

- Profit ratio

  Profit ratio = $\dfrac{Gross\ Margin}{Sales}$

  ➔ It reflects the profitability of the firms.

- Tobin's q

  Tobin's q $= \dfrac{Total\ Market\ Value\ of\ Firm}{Total\ Asset\ Value\ of\ Firm}$

  : Relationship between market valuation and asset value.

  ➔ Tobin's q reflects the future value of the firms.

Panel Analysis Result (Profit ratio)

$Profit\ ratio_t$	Electronics			Non-Electronics		
	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)
$R\&D\ intensity_{t-3}$	0.452*** (2.99)	0.905*** (2.85)	-0.185 (-0.93)	0.056*** (2.86)	0.067** (2.07)	0.048* (1.90)
$Log(Ad\ Ratio)_t$	0.004* (1.72)	-0.005 (1.57)	-0.003 (-1.17)	0.003*** (5.08)	0.004*** (4.56)	0.002*** (2.80)
$Debt\ Ratio_t$	-0.790** (-2.70)	-0.160*** (-2.66)	-0.059 (-1.41)	-0.101*** (-11.56)	-0.038*** (-2.72)	-0.114*** (-9.67)
$Log(total\ equity)_t$	0.022*** (2.90)	0.007 (0.51)	0.058*** (4.36)	0.001 (0.77)	0.001 (0.34)	0.012*** (3.72)
$Real\ GDP\ growth_t$	0.002 (1.42)	-0.000 (-0.13)	0.000 (0.04)	0.002*** (3.90)	0.000 (0.15)	0.004** (2.01)
$Constant_t$	-0.303 (-1.45)	0.159 (0.41)	-1.372*** (-3.82)	0.334*** (5.62)	0.356*** (3.62)	0.035 (- 0.38)

*: 10% significance level   **:5% significance level   ***:1% significance level
The number in parentheses means t-value

Panel Analysis Result (Tobin's q)

Whole industries

$Tobin's\ q_t$	Whole period (2004~2018)	First Half (2004-2010)	Second Half (2011-2018)
$R\&D\ intensity_{t-3}$	1.014*** (5.37)	1.466*** (5.26)	0.805*** (2.86)
$Log(Ad\ Ratio)_t$	0.085*** (13.76)	0.062*** (7.49)	0.088*** (9.10)
$Debt\ Ratio_t$	-0.165** (-2.02)	-0.074 (-0.63)	-0.396*** (-3.10)
$Log(total\ equity)_t$	-0.049** (-2.44)	-0.317*** (-10.13)	-0.070* (-1.90)
$Real\ GDP\ growth_t$	-0.009 (-1.63)	0.021*** (4.39)	-0.126*** (-4.84)
$Constant_t$	4.866*** (8.79)	10.751*** (13.20)	5.989*** (6.00)

*: 10% significance level   **:5% significance level   ***:1% significance level
The number in parentheses means t-value

Summary

1. R&D productivities have been declining for the last 15 years.
   (All listed firms, electronics firms, and non-electronics firms)

2. The effects of R&D investment on sales growth rate, profit ratio and Tobin's q show declining trend.

3. R&D productivities in electronics show steeper declining trend. Despite the trend, R&D productivities in electronics are higher than non-electronics.

Further research

1. Insufficient Electronics sample

   - Collecting more data from KONEX

2. Foundation year as proxy of firm size

   - Omitted variable problem caused by fixed effect

3. Policy implications for decreasing R&D productivity

   - Misallocation of R&D expenditure

Thank you for listening