System Dynamics of Regional Competitiveness: The Case of Busan, South Korea

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Agenda

- Background and Research Question
- System Dynamics modelling process
- Results and Policy suggestions
- Conclusions

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Background and Research Question

- Regional innovation has become increasingly important in recent decades (Doloreux and Parto, 2005).
- To improve regional competitiveness, efforts have been made to develop and implement regional innovation policies (Asheim and Coenen, 2005a, 2006b).
- However, policy decisions generate uncertainty and, sometimes, counterintuitive effects (Lee and von Tunzelmann, 2005)

Background and Research Question

- The scepticism concerning the relationship between policy implementation and regional competitiveness is attributable to a lack of understanding on the policy effect mechanism in terms of
  - difficulties associated with mapping complex innovation processes (Castellacci and Natera, 2013; Hekkert et al., 2007)
  - majority of policy evaluation themes in the literature have been confined within monetary instruments such as direct and indirect R&D funding (Guellec and van Pottelsberghe de la Potterie, 2003; Lach, 2002)

Research Question

- This study intends:
  - To synthesise the core structures that determine the system dynamics of knowledge-based innovation.
  - Then, a SD model is used to identify the structure that drive regional competitiveness from a knowledge-based innovation perspective.
  - Finally, we quantitatively evaluated regional policy effects on regional competitiveness.

Context for the Research

- This study uses Busan, a Korean region, as an example.
- Although Busan is designated as a leading Korean city in terms of its economy along with Seoul, a peer review report for Busan (Duke et al., 2006) notes that Busan suffers from ‘rust-belt’ decline and, thus, has declared a new slogan, ‘Dynamic Busan’, to remedy the image of a decaying local economy
- This study aims to specify what Busan should adjust to achieve the goal of robust development of regional competitiveness in the context of a knowledge-based innovation

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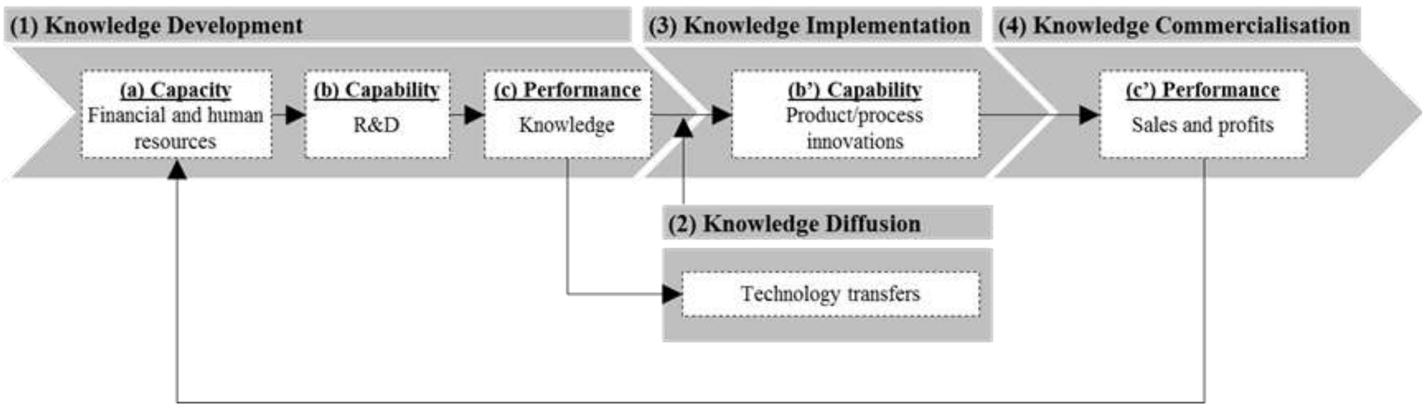
Problem articulation

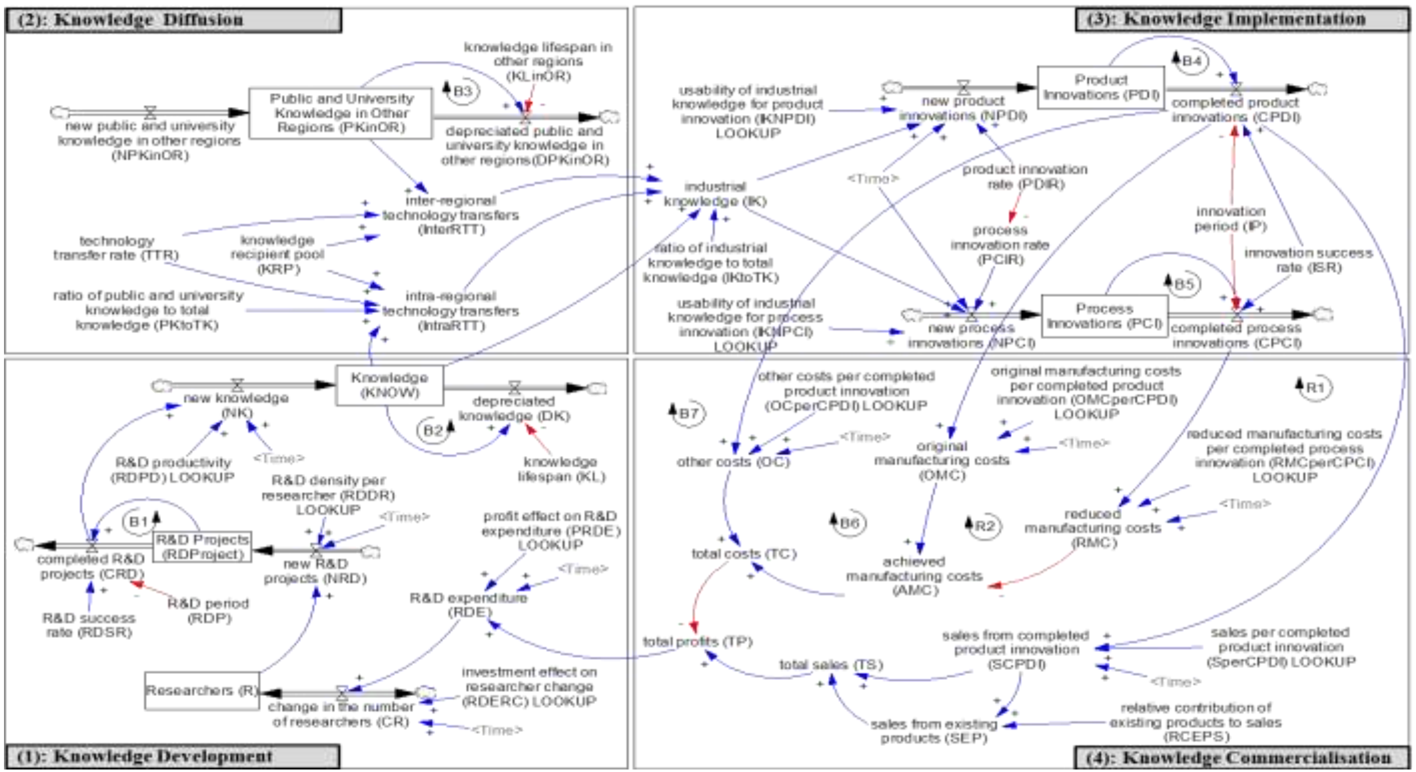
- Our theoretical framework consists of



Problem articulation

- Data collection process consisted of
  - 33 in-depth, multi-round interviews.
  - Participant explained the structure of Busan’s knowledge innovation process within the theoretical framework, and
  - Participants confirmed eight indices comprising regional competitiveness: (a) R&D expenditure, (b) researcher, (c) new R&D project, (d) new knowledge, (e) new product innovation, (f) new process innovation, (g) sales, and (h) profits
  - Data from on-line and off-line reports released by the Korean government and research institutes.
  - Region-wide yearly data for some variables were limited. To overcome this limitation, this study adopted proxy measures (e.g. technology transfer rate, TTR) by estimating mean values drawn from regional or national survey results produced by the government and research institutes.
  - Additionally, interviews provided quantifiable data (e.g. R&D period, RDP) that are not reported in the formal documents

Dynamic hypotheses

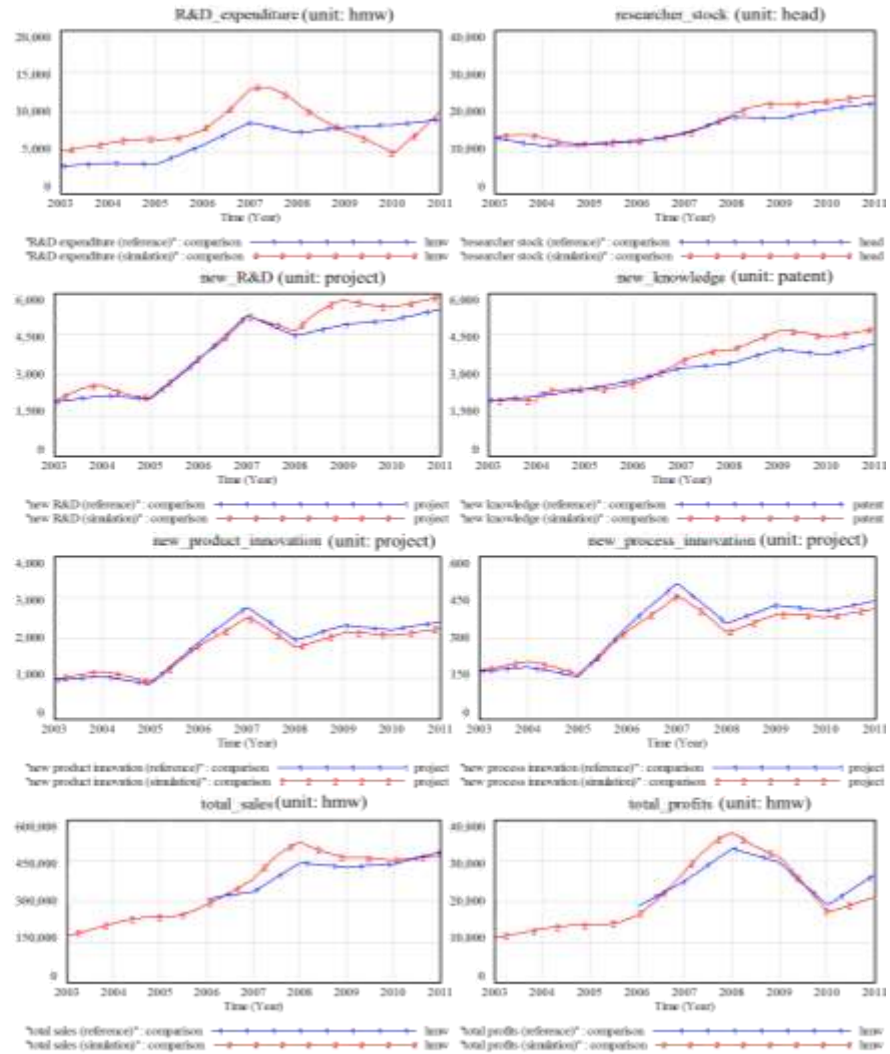


Dynamic hypotheses – Key Feedback Loops

Loop	Explanation
(R1) Product innovation-centred loop	R&D expenditure (RDE) enables researchers (CR and R) to conduct R&D (NRD, RDProject, and CRD) that produces knowledge (NK and KNOW). Industrial knowledge (IK) stimulates product innovations (NPDI and PDI). Successful product innovations (CPDI) generate sales (SCPDI and TS) and profits (TP) that boost R&D expenditure (RDE) for sequential R&D still more. Through this process, an innovation process shapes self-reinforcing behaviour over time.

Model Formulation and Testing

- The model contains 180 equations, tables and parameters.
- Each equation reflects the relationships between the variables shown in the stock and flow diagram.
- Statistical tests has been performed.



Experimentation and Policy Making

- Sensitivity tests (Tank-Nielsen, 1980) are used to evaluate potential policy effects on the regional competitiveness of Busan’s knowledge-based innovation process. The tests include two considerations.
  - First, the test excludes particular controlling factors that are impractical to adjust.
  - Second consideration is related to the maximum parameter change of policy interventions

Experimentation and Policy Making

Table 3. Controlling factors for the sensitivity test

Knowledge boundary	Controlling factor	Inclusion	Reason for exclusion	Maximum change	Reference for defining the maximum change
Knowledge development	profit effect on R&D expenditure (PRDE)	Yes	–	+20%	Largest change in historical data
	investment effect on researcher change (RDERC)	Yes	–	+119%	Largest change in historical data
	R&D density per researcher (RDDR)	Yes	–	+59%	Largest change in historical data
	R&D period (RDP)	Yes	–	−16 months	Until a negative value is evident
	R&D success rate (RDSR)	Yes	–	+26%	Difference to 100%
	R&D productivity (RDPD)	No	Quality-dependent	–	–
	knowledge lifespan (KL)	No	Market-dependent	–	–
Knowledge diffusion	ratio of public and university knowledge to total knowledge (PKtoTK)	No	Infrastructure-dependent	–	–
	technology transfer rate (TTR)	No	Infrastructure-dependent	–	–
	knowledge lifespan in other regions (KLinOR)	No	Out of Busan	–	–
Knowledge implementation	ratio of industrial knowledge to total knowledge (IKtoTK)	No	Infrastructure-dependent	–	–
	usability of industrial knowledge for product innovation (IKNPDI)	Yes	–	+73%	Largest change in historical data
	usability of industrial knowledge for process innovation (IKNPCI)	Yes	–	+73%	Largest change in historical data
	product innovation rate (PDIR)	Yes	–	+6%	Until a negative value is evident
Knowledge commercialisation	sales per completed product innovation (SperCPDI)	No	Market-dependent	–	–
	relative contribution of existing products to sales (RCEPS)	No	Market-dependent	–	–
	original manufacturing costs per completed product innovation (OMCperCPDI)	No	Market-dependent	–	–
	reduced manufacturing costs per completed process innovation (RMCperCPCI)	No	Market-dependent	–	–
	other costs per completed product innovation (OCperCPDI)	No	Market-dependent	–	–

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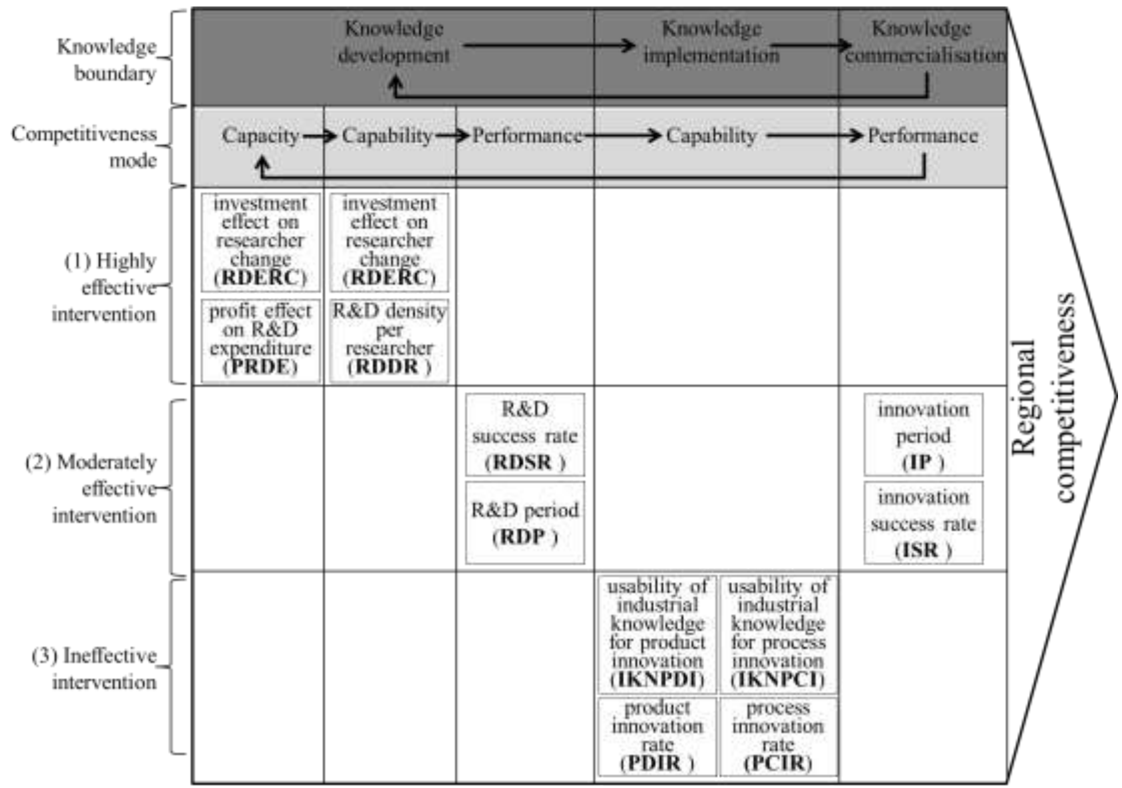
Results and Policy suggestions

- In this analysis, average change is estimated by calculating the average differences between incremental simulation results.
- In addition, time-based growth is estimated by calculating the change of differences between polar years

Table 4. Policy effects: Average change and time-based growth for 2003−2011

Controlling Factor	R&D expenditure (hmw)		Researcher (head)		New R&D (project)		New knowledge (patent)	
	Average change	Time-based growth	Average change	Time-based growth	Average change	Time-based growth	Average change	Time-based growth
profit effect on R&D expenditure (PRDE)	+215.37	+112.88	+122.29	+345.02	+30.36	+84.19	+12.53	+50.00
investment effect on researcher change (RDERC)	+61.17	+24.97	+1,190.77	+190.41	+299.14	+46.46	+156.28	+32.07
R&D density per researcher (RDDR)	+25.77	+72.13	+13.52	+38.26	+48.18	+50.80	+32.12	+56.12
R&D period (RDP)	+220.52	+343.97	+146.21	+411.45	+36.91	+100.39	+119.44	−1,040.71
R&D success rate (RDSR)	+29.09	+44.27	+19.71	+54.74	+4.95	+13.36	+18.44	−6.10
usability of industrial knowledge for product innovation (IKNPDI)	−21.89	−81.18	+2.55	−8.69	+0.63	−2.12	+0.62	+1.16
usability of industrial knowledge for process innovation (IKNPCI)	+89.18	+170.21	+24.34	+109.73	+6.10	+26.78	+1.12	+13.31
product innovation rate (PDIR)	−619.83	−1,302.84	−157.88	−681.12	−39.55	−166.19	−6.65	−75.57
process innovation rate (PCIR)	+564.45	+1,070.27	+146.11	+621.02	+36.63	+151.53	+5.99	+72.06
innovation period (IP)	+9,983.69	−1,115.86	+22,173.73	+1,814.54	+5,341.10	+442.75	+4,119.72	+341.25
innovation success rate (ISR)	+44.52	−126.66	+125.04	+191.95	+31.21	+46.84	+20.49	+38.49

Results and Policy suggestions



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Conclusions

- This study highlighted the increasing interest in policy effects on regional competitiveness in the field of innovation policy through evaluating the regional innovation process of Busan, South Korea.
- From the results, R&D human resources, time and success rate are core parameters for the sustainable development of Busan's regional competitiveness.
- The effects of all policies do not remain in particular knowledge boundaries and competitiveness modes, but are influential throughout the entire innovation process. That is, a specific system problem can be resolved by adjusting distant parts of the process.

Conclusions

- From a systems perspective, it is necessary to stimulate the reinforcing loop R2 (process innovation-centred loop) in order to offset the additional costs created by increased product innovations in the balancing loops B6 (manufacturing costs-centred loop) and B7 (other costs-centred loop).
- To this end, aid from central and local governments for localised SMEs should focus on multifaceted leverage points, including increasing funds expected to directly encourage the creation of new or improved products and services in the knowledge implementation boundary and reducing production, delivery, and marketing costs incurred from the innovation process.

Thank you and Questions