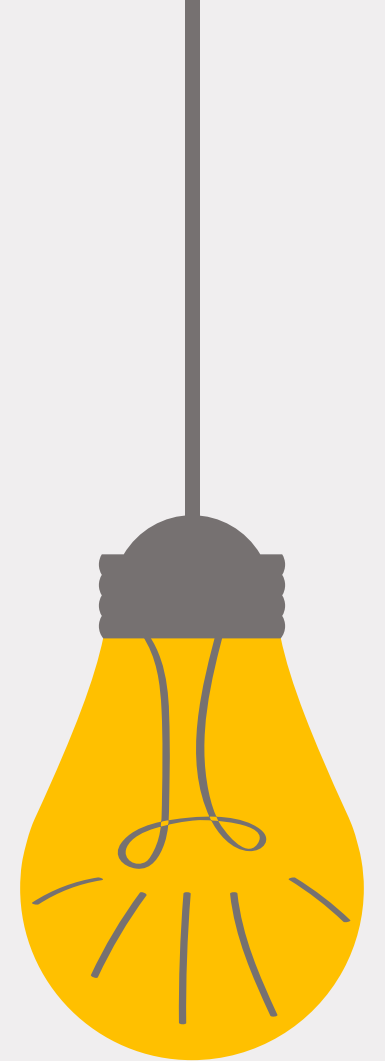


HETEROGENOUS INNOVATIONS AND GROWTH UNDER IMPERFECT TECHNOLOGY SPILLOVERS

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Discussed by Marta Prato
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Summary

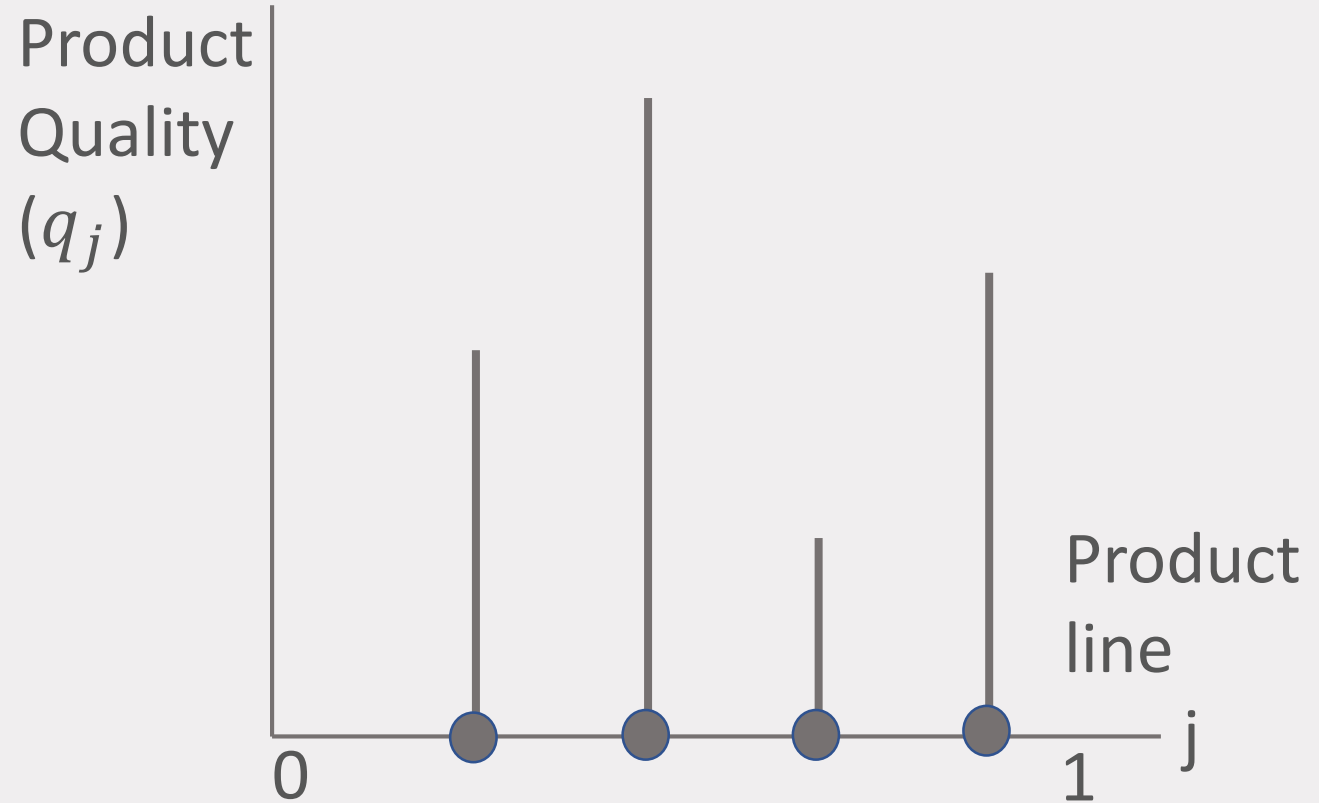
- A very rich paper, with theoretical, empirical and quantitative contributions
- I enjoyed reading this version and the previous one, with lots of improvements!

Research Question

- What's the effect of competition/learning frictions on firm's innovation composition (own-improvement vs. horizontal expansion)?
- Why is this important? This matters to understand firm performance, aggregate effects of innovation and competition

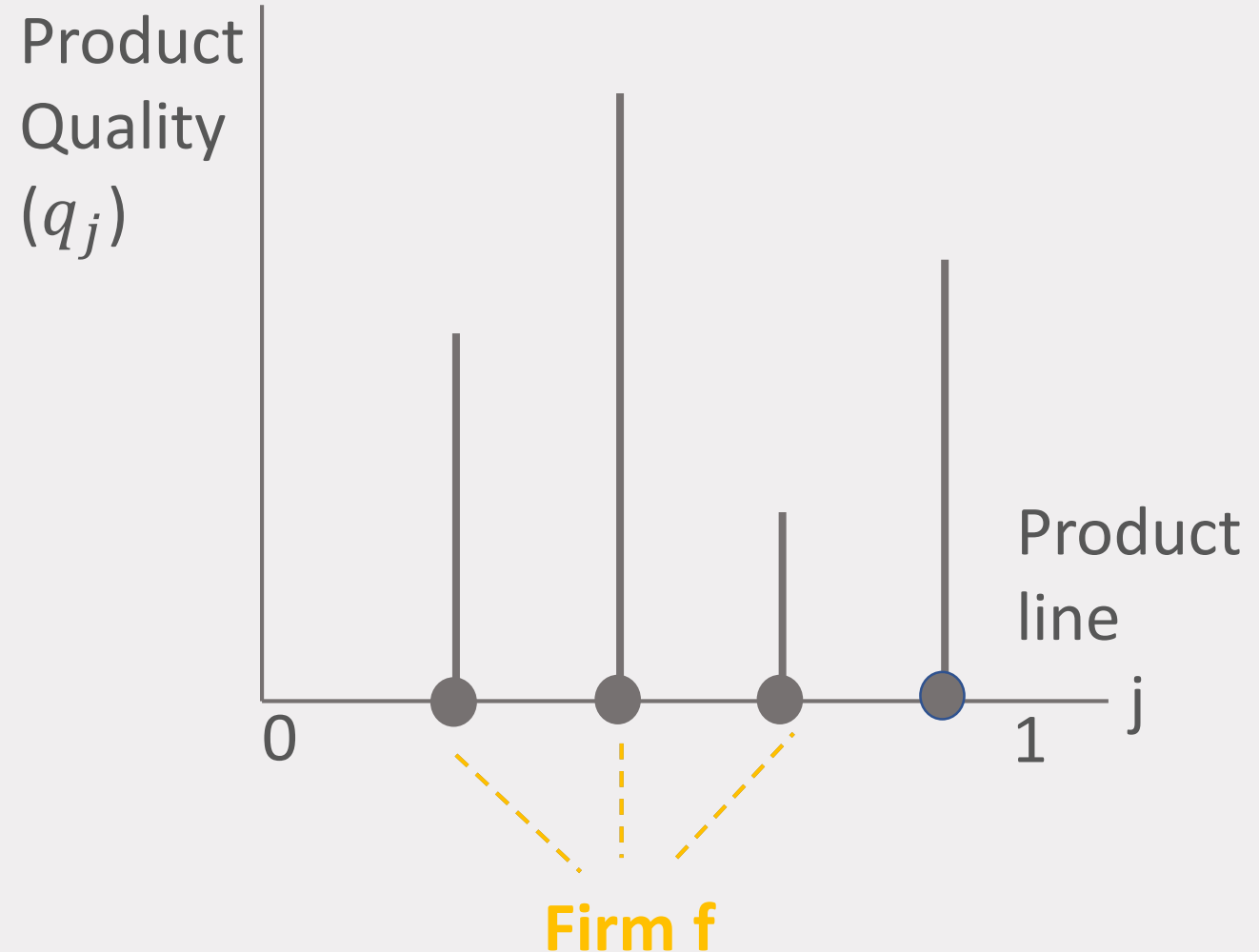
Building on existing models

- Final good produced with labor and a continuum of intermediates with heterogenous quality
- Each intermediate owned by a monopolist



Building on existing models

- Final good produced with labor and a continuum of intermediates with heterogenous quality
- Each intermediate owned by a monopolist
- A **firm** is a collection of product lines



Building on existing models

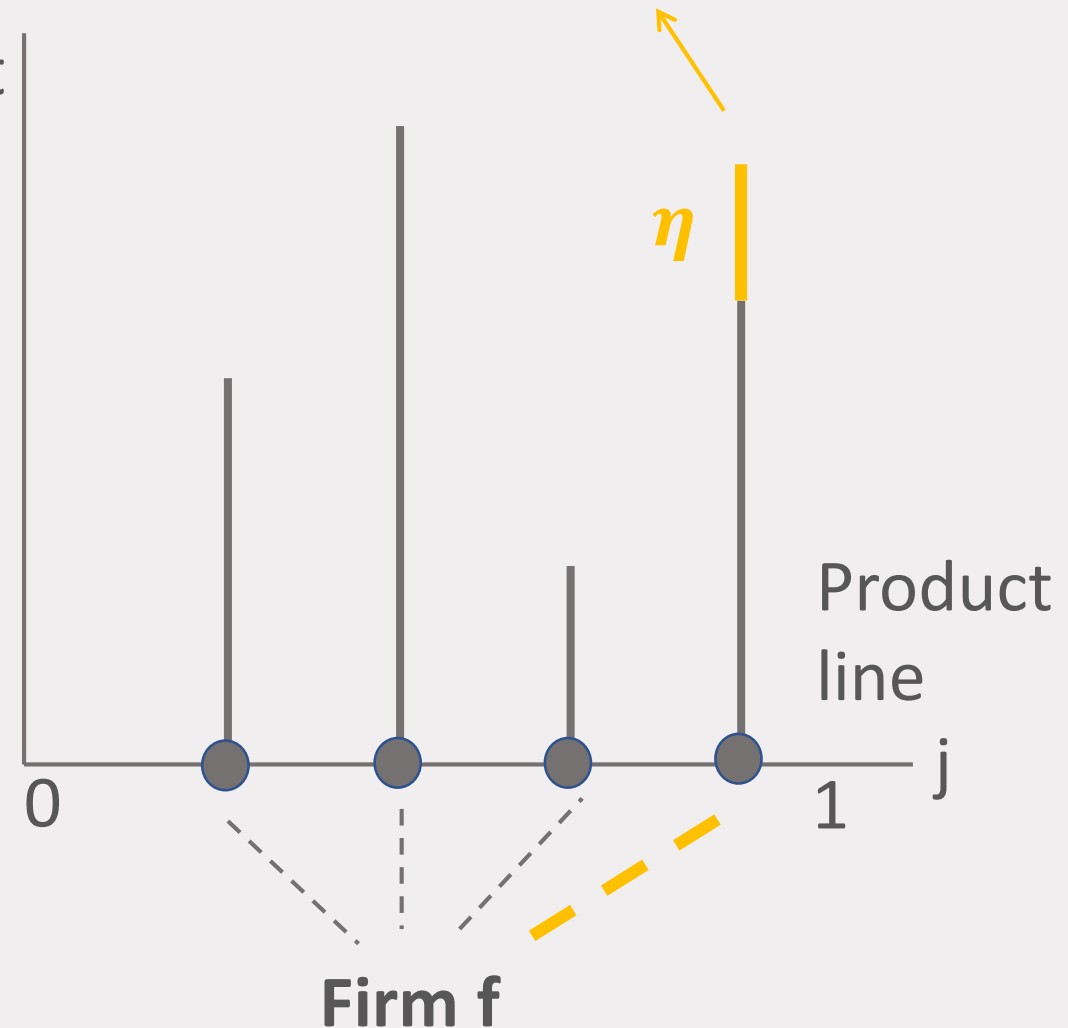
- Quality ladder
(Aghion-Howitt, Grossman Helpman)

- Two types of innovation

1. Creative Destruction/ Horizontal / External innovation

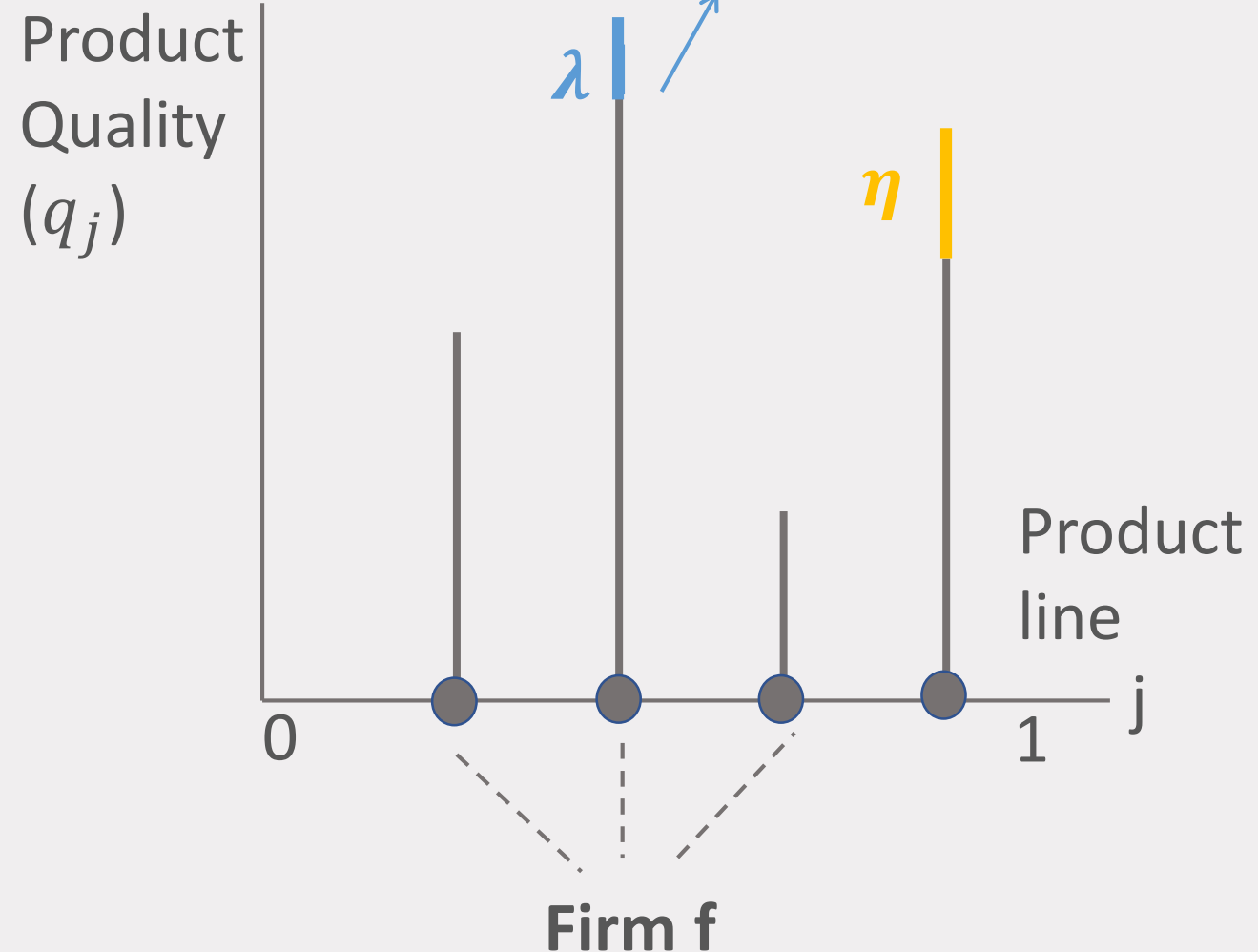
(Klette-Kortum 2004)

Product
Quality
(q_j)



Building on existing models

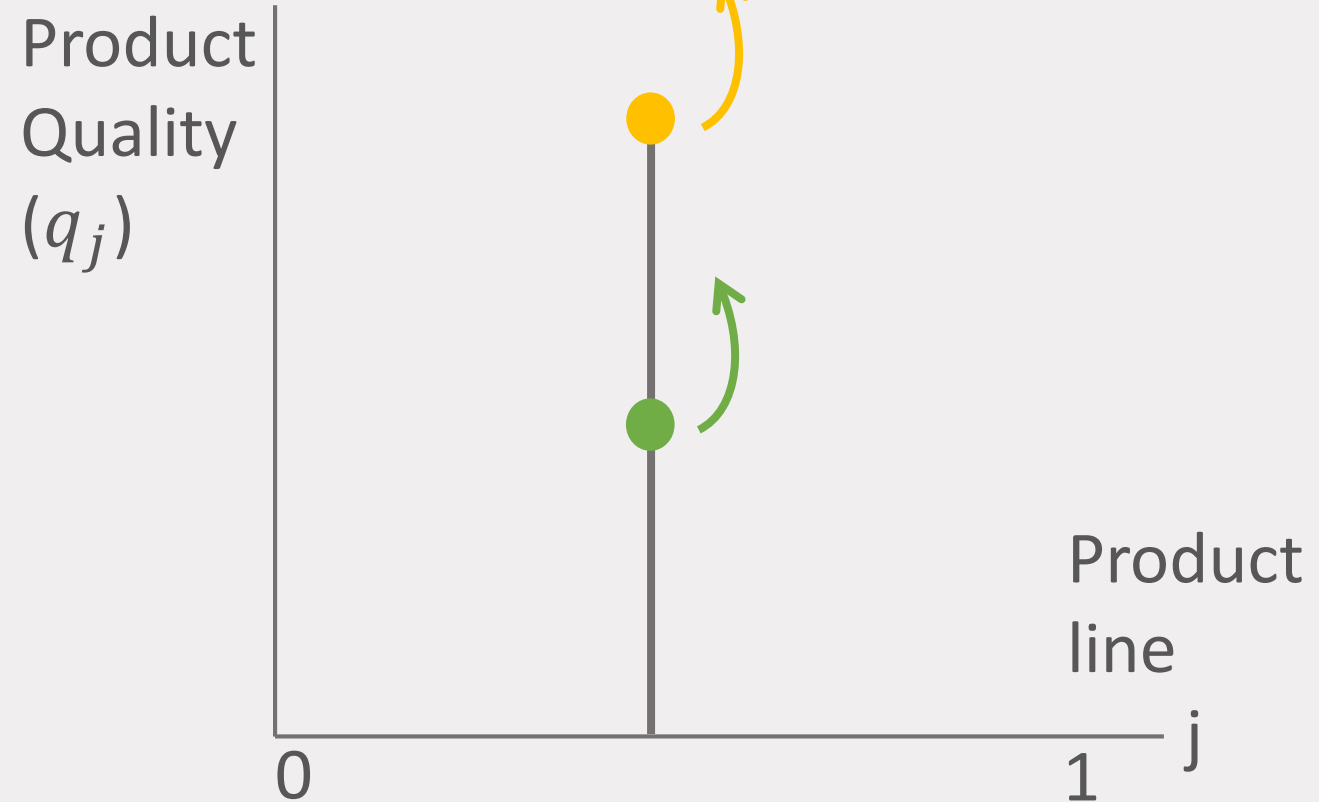
- Quality ladder
(Aghion-Howitt, Grossman Helpman)
- Two types of innovation
 1. **Creative Destruction** / Horizontal / External innovation
(Klette-Kortum 2004)
 2. **Own-innovation** / vertical with heterogenous step sizes
(Akcigit Kerr 2018, Garcia-Macia Hsieh Klenow 2019, Atkeson and Burstein 2019, Peters 2020, ...)



Building on existing models

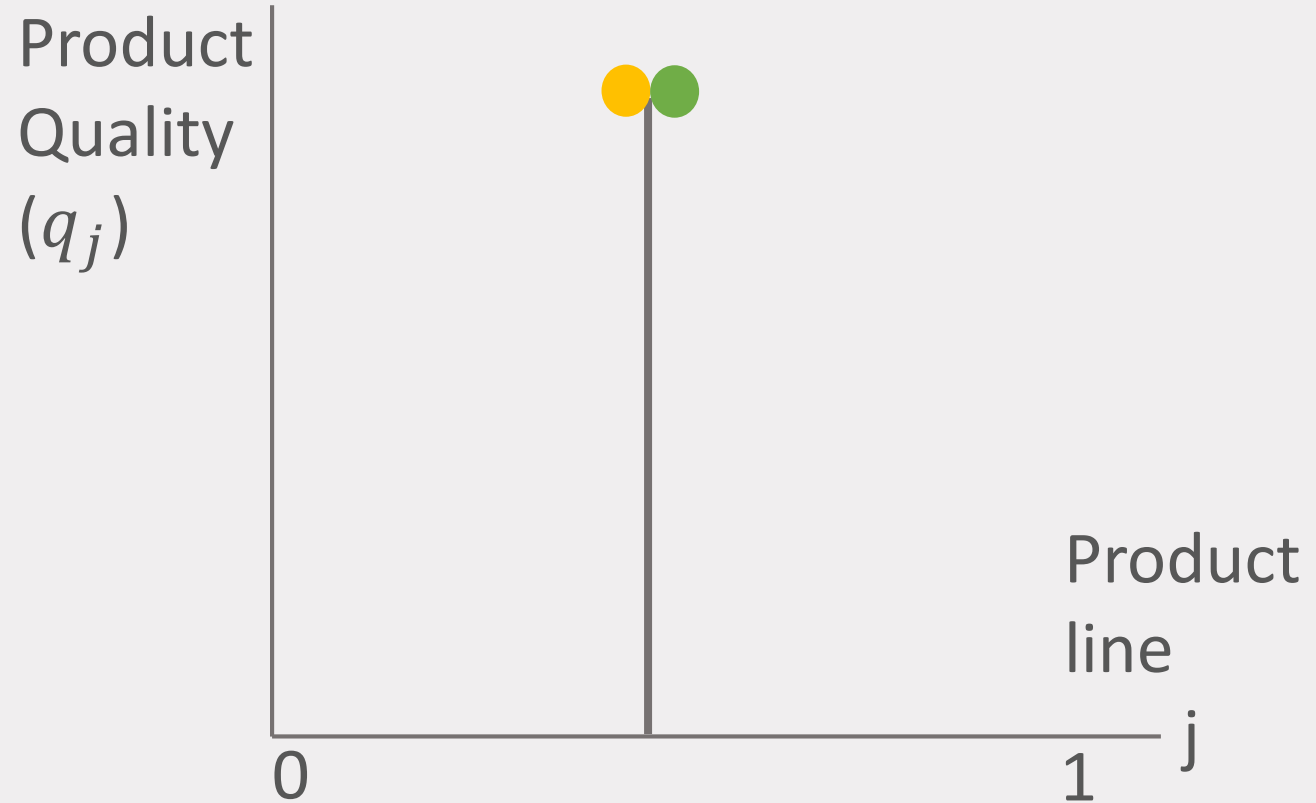
- Another class of models in the literature: step-by-step innovation
(Aghion et al 2001, Acemoglu Akcigit 2012, Akcigit et al 2018, ...)

- Competition between leader and follower on the same line
- Leader gets all (or most of) market share
- Follower innovates to catch up
- Leader innovates to escape



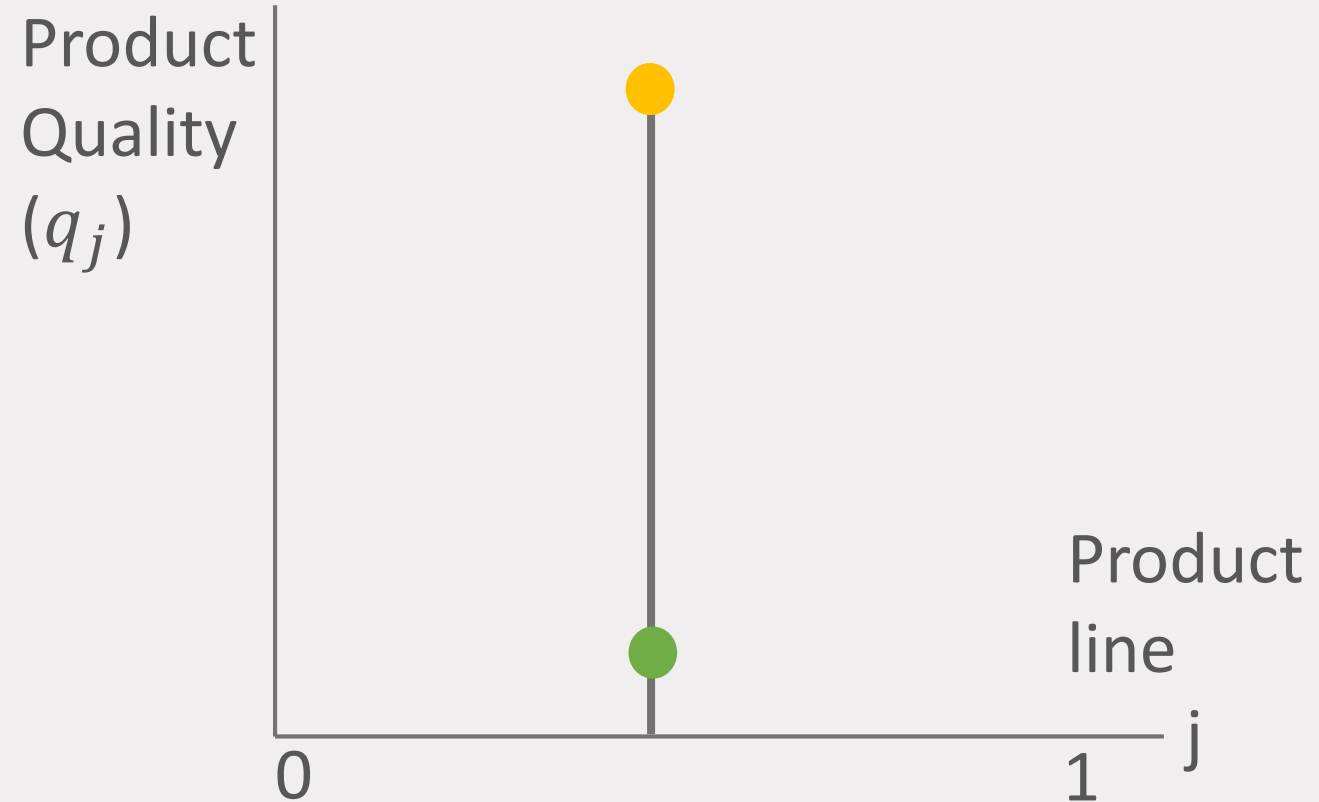
Building on existing models

- In step-by-step models, when the two firms are **neck-and-neck**, the **innovation** incentive is the **strongest**, because successful innovation wins the market



Building on existing models

- In step-by-step models, when the **technology gap is large**:
- The **follower is discouraged, reduces innovation** because cannot catch up
- The leader reduces innovation effort (relative to neck-neck) because of limited gains from further advances



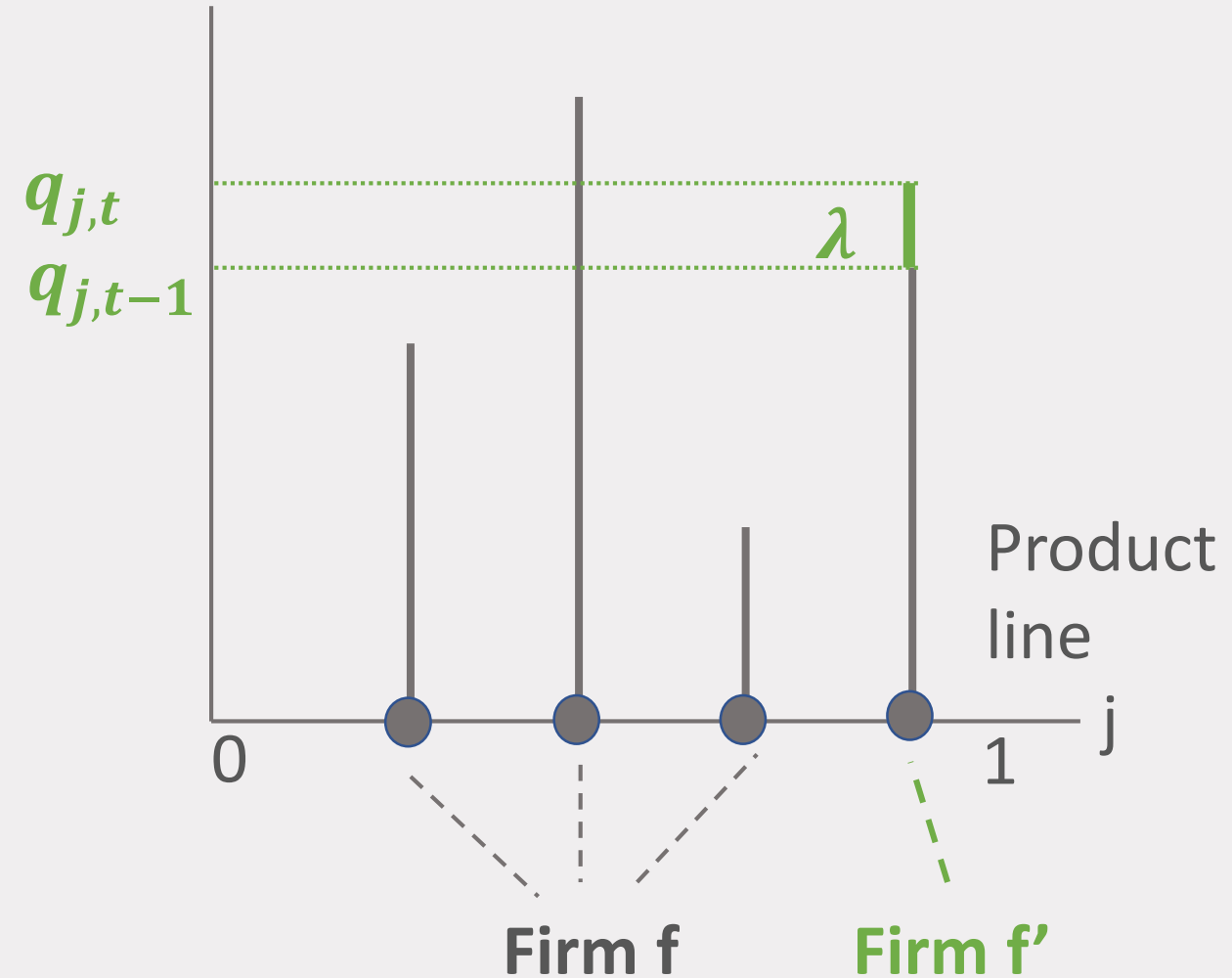
Model: contribution

Combine multi-product firms and heterogenous innovations with step-by-step competition

Key novelty in this paper: at time t

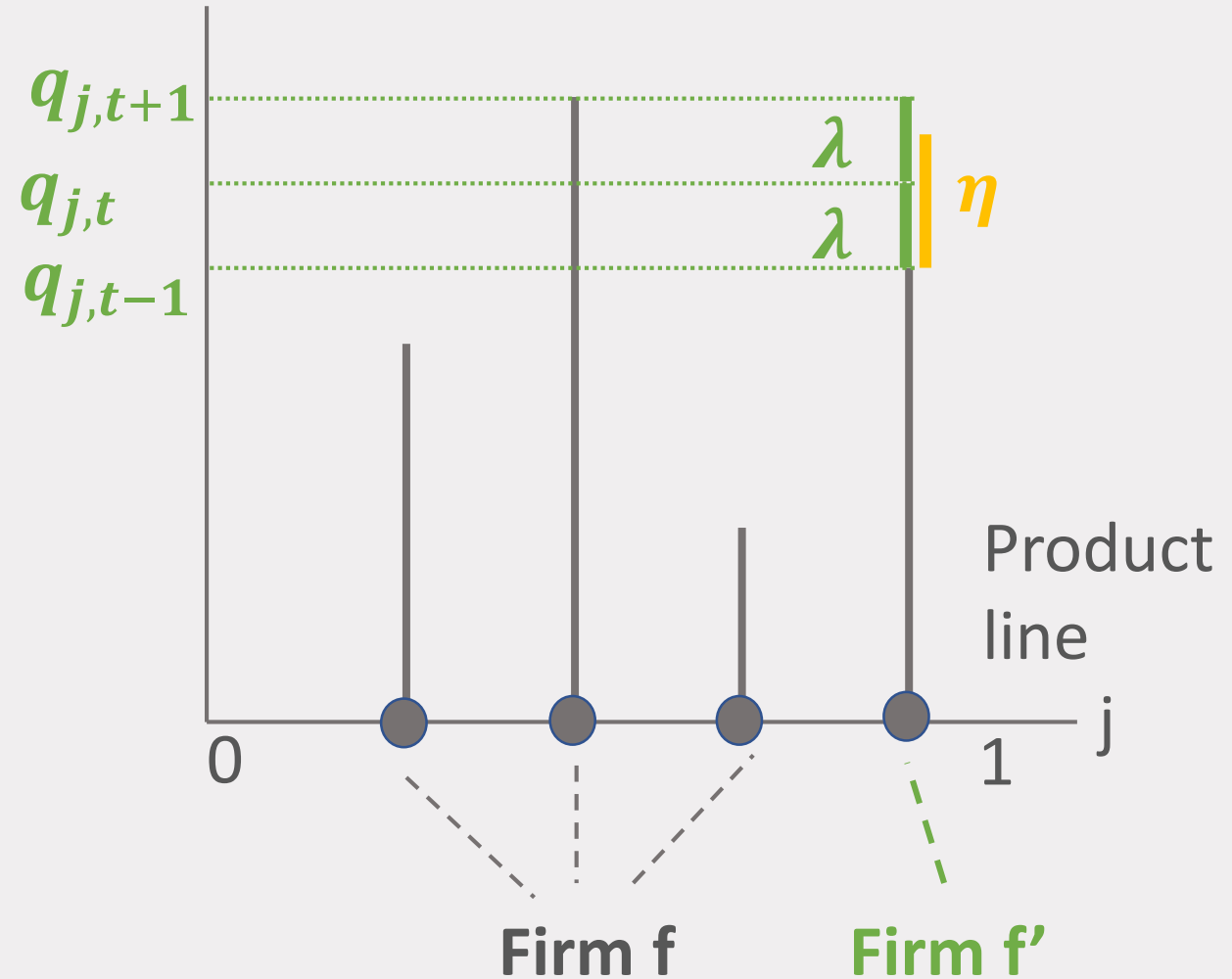
- Firm f' builds on q_t technology
- Firm f builds on q_{t-1} technology

→ imperfect technology spillover



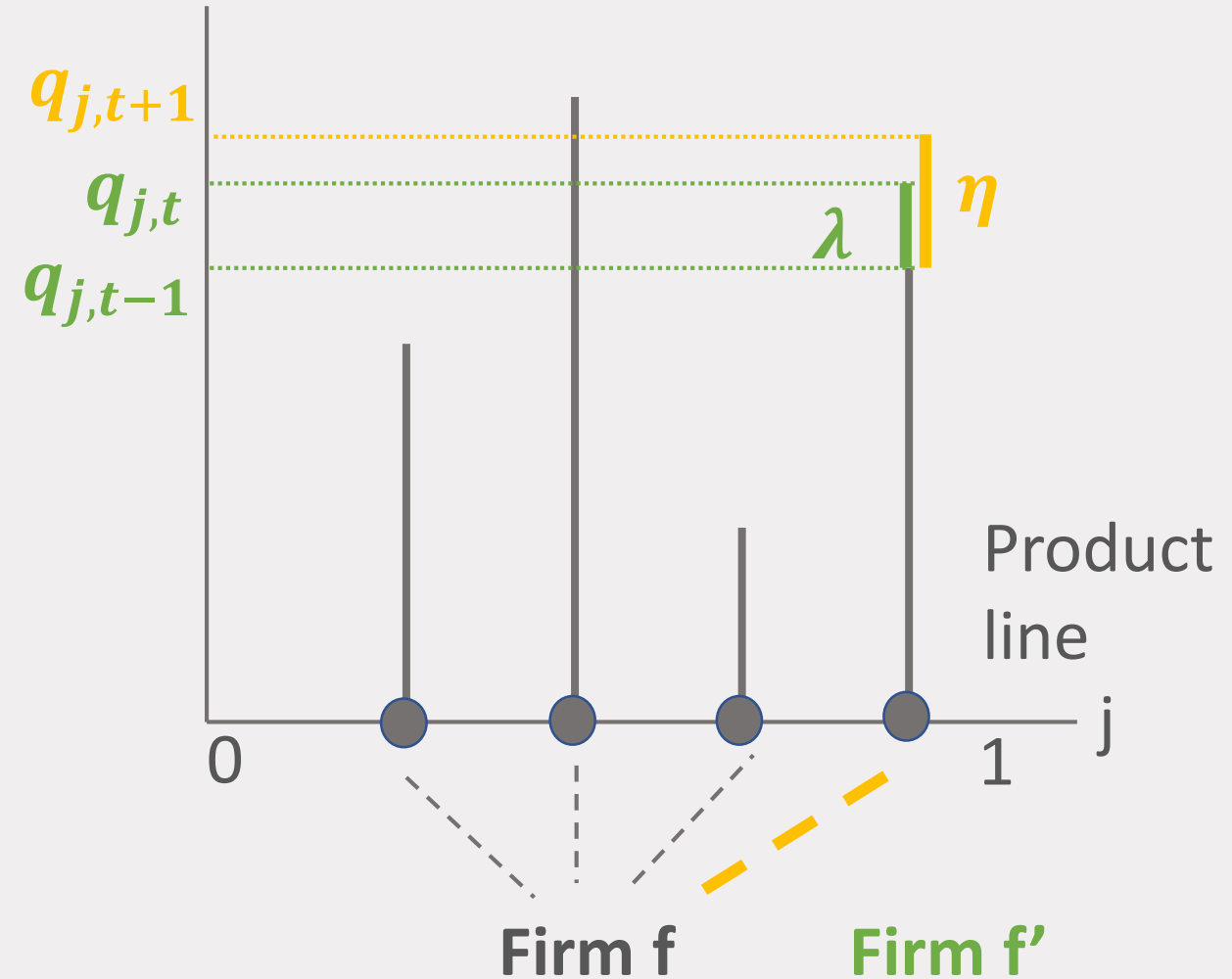
Model: contribution

- If both firms are successful at time t (f with external and f' with own-innovation)
- Firm f' defends the product line



Model: contribution

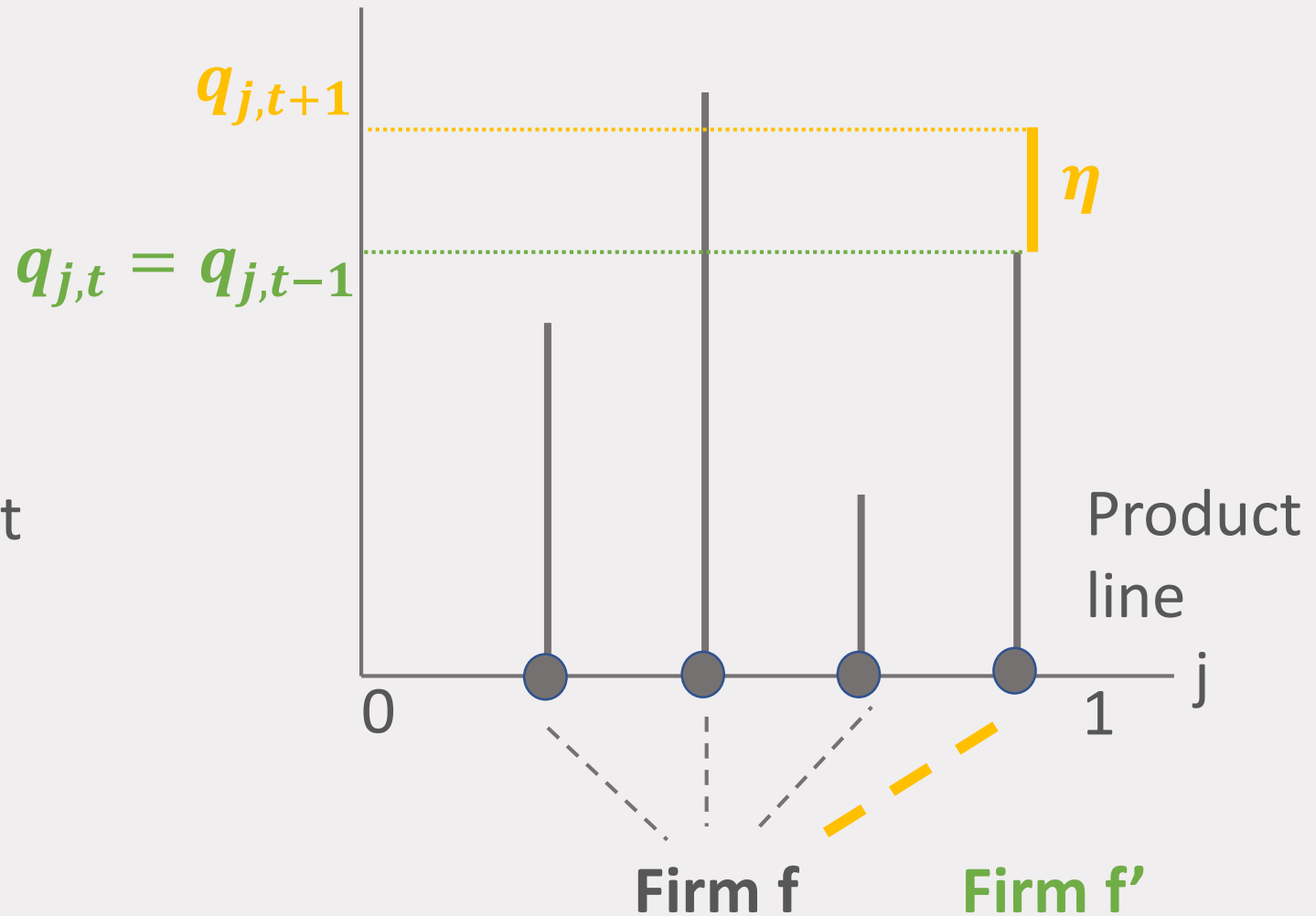
- If only firm f is successful
- Firm f' loses the product line



Model: contribution

- If innovation firm f 's own-innovation at time $t-1$ was unsuccessful
- Firm f ' cannot defend the product line even with a successful innovation at time t

→ **no incentive for own-innovation at time t without a technology gap**



Model: contribution

- Combine multi-product firms with step-by-step competition
- implication: competition affects not only the level of innovation (as in step-by-step models), but also its composition
 - Note here only one firm per line (unlike step-by-step models)

Main results: When creative destruction increases:

- Own-innovation increases if technology gap large enough for incumbent to defend the market (highest increase for Δ^1)
- Own-innovation decreases if no technology gap

Model: comments

1. When there is no technology gap:
 - This paper: lowest innovation incentive
 - Step-by-step models: highest innovation incentive! Is this at odds?
 - In practice, the intuition is similar: firm is discouraged when too far behind to catch up, innovation highest when trying to win the market
 - This happens at slightly different technology levels in the two papers
 - An accurate measurement of the mapping from technology gap to innovation efforts might be important for competition policy
 - The discouraged firm would rather start over with creative destruction ... maybe directed innovation could be relevant here?

Model: comments

2. So far no mention of foreign firms! The paper already has a standalone contribution without introducing foreign firms.
 - In the paper, some lines owned by foreign firms
 - Their innovation process is exogenous (but examined in Jo (2024))
 - Introduction of foreign firms motivated by empirical evidence
 - Perhaps, consider empirical evidence that does not rely in foreign firms. E.g:
 - competitive pressure due to NDA;
 - firms geographical expansion to proxy increased technological spillover (Chikis-Kleinman-Prato 2025). Do firms change innovation composition when a competitor opens an R&D establishment nearby?

Empirical analysis: summary

- Great data collection effort! (USPTO, LBD, LFTTD, CMF, NBER-CES, tariffs...)
- I liked using the number of new products added as a measure of creative destruction (closer to model interpretation wrt literature)
- The paper documents three pieces of evidence in support of the model:
 1. Citation gap (measure of time to learn) negatively correlated with self-citation share (measure of own-innovation)
 - creative destruction subject to imperfect spillovers
 2. Patent quality negative correlated with self-citation share
 - creative destruction leads to larger improvements
 3. Patenting positively associated with firm-level growth, but less so for own-innovation

Empirical analysis: summary

Empirical validation of market protection effect

increased competition from China (tariffs gap for WTO members and non-members):

$$\begin{aligned} \Delta y_{ijp} = & \beta_1 Post_p \times NTRGap_{ijp0} \times InnovIntens_{ijp0} + \beta_2 Post_p \times NTRGap_{ijp0} \\ & + \beta_3 Post_p \times InnovIntens_{ijp0} + \beta_4 NTRGap_{ijp0} \times InnovIntens_{ijp0} \\ & + \beta_5 NTRGap_{ijp0} + \beta_6 InnovIntens_{ijp0} + X_{ijp0} \gamma_1 + X_{jp0} \gamma_2 \\ & + \delta_j + \delta_p + \alpha + \varepsilon_{ijp}, \end{aligned}$$

- has no statistical effect on innovation
- increases self-citation ratio for firms with technological advantage, measure as lagged innovation intensity.

Table 4: Market-Protection Effect

	$\Delta Patents$	$\Delta Patents$	$\Delta Self-cite$	$\Delta Self-cite$
NTR gap \times Post	0.238 (0.237)	0.071 (0.283)	-0.075 (0.257)	-0.062 (0.291)
\times Innovation intensity	0.077 (0.231)	-0.054 (0.242)	0.732** (0.299)	0.795*** (0.277)
Observations	6,500	6,500	6,500	6,500
Fixed effects	j, p	j, p	j, p	j, p
Controls	no	baseline	no	baseline

Empirical analysis: comments

- Was the competition from China in this period primarily of technological nature? i.e. is this creative destruction or lower profits?
- Measure technological advantage directly wrt Chinese firms?
e.g. innovation intensity gap relative to patents registered in USPTO by Chinese firms
- Test the inverted U wrt technological advantage?

Quantitative analysis: summary

- Calibration: creative destruction contributes 1.88 times more to growth compared to own innovation
 - Here λ and η inferred indirectly. How do values compare to the literature? (e.g. Akcigit Kerr, Garcia-Macia et al)
- Main results, after rise in import penetration from 15% to 25%:
 - Own-innovation decreases by 0.4% at Δ^1 , increases by 0.2% at Δ^2
 - Effects vary depending on initial level of creative destruction

Quantitative analysis: comments

1. I would like to see the effects of increased creative destruction on the innovation portfolio composition of firms:
 - All domestic firms reduce creative destruction
 - Some increase own-innovation, others reduce it
 - Does the *share* of own-innovation increase for some firm types and decline for others? It would be nice to illustrate this
2. The quantitative model considers creative destruction proportional to the number of product lines. For quantitative results, it might be useful to introduce decreasing returns to scale at the firm level, as documented in the literature (Akcigit-Kerr 2018)

Conclusion

- Effect of imperfect technology spillovers and competition on firms' innovation composition
- Contributions with theory + data + quantitative analysis
- Key takeaway: an increase in competition has heterogeneous effects on firms' innovation composition, depending on technological gaps
- A recommended read!