THE DETERMINANTS OF FIRM R&D INVESTMENT:
AN AUGMENTED TOBIN’S Q MODEL WITH KNOWLEDGE SPILLOVERS
(Supervisor team: Prof. Mehmet Ugru, Dr Paola Tubaro, Dr. Sara Gorgoni)

Abstract
This paper studies the effect of technological spillovers in the augmented Tobin’s Q model of firm R&D investment. The level of externalities has recently been considered to have strong effect on the optimal level of R&D investment at firm-level (Nieto and Quevedo, 2005; Bloom et al., 2013), due to its harmful influence on the profits of inventions and new products; and its positive effect in spreading knowledge and avoiding duplication of research. I argue that it can also contribute to the Tobin’s Q model of firm R&D investment using the change in Tobin’s average Q as my measure of expected profitability. Utilizing a dataset of 3,718 manufacturing firms from 15 OECD countries over the 2005-2013 period and the generalized method of moments estimator, I report several findings. First, the change in Tobin’s Q documents a positive and significant effect on firm R&D investment. Secondly, the results confirm the importance of controlling for both intra- and inter-industry spillovers. While the knowledge spilled over from firms in the same industry tend to increase firm’s innovative effort, the effect of spillovers from outside the industry has negative effect on firm’s investment decision. Overall, my results provide support for an augmented Tobin’s Q model, where not only the expectation from market signal determines the optimal level of firm R&D investment but also other factors such as knowledge spillovers, which affect the firm’s cost of investment, matter.

Literature review
- There has been a long-standing literature on Tobin’s Q – investment relationship. The most common theoretical model is (Abel, 1979; Hayashi, 1982):
  \[ \frac{L}{K} = \alpha + \beta Q + \varepsilon \]
  Which shows that the marginal Q can be the sole determinant of firm’s investment. Marginal Q: the shadow value of an additional unit of investment.
- Empirically, marginal Q is unobservable. The results of using average Q, as its measure with a set of strict assumptions: perfect market competition, constant returns to scale, and linear homogeneity in production and cost function have been disappointing. Average Q, even when it is significant, has very low level of explanatory power (Schiantarelli & Georgtouso, 1990; Salinger and Summers, 1983).
- Mairesse and Siu (1984) rely on the rational expectation hypothesis to suggest that managers could form the expected change in the investment opportunity based on the existing information.
- Reasons to test the effect of knowledge spillovers in an augmented Tobin’s Q model: + The “absorptive capacity” perspective from Cohen and Levinthal (1989) suggest that firms need to engage more in investment, in order to have what they call “absorptive capacity”, if they want to assimilate and exploit new knowledge spilled over from their competitors or from outside the industry. + The more common approach argues that high level of spillovers helps firms to avoid unnecessary duplication of research. Moreover, it can be harmful for firm’s incentives for R&D investment if firms cannot gain profits from its inventions because its competitors can imitate it too quickly.

Overall, Tobin’s Q and knowledge spillovers can be considered as not mutually exclusive, as the former reflects the market expectation that can influence managerial decision, while the latter affects the cost of investment. Therefore, it is necessary to test whether the level of knowledge spillovers can contribute significantly to my augmented Tobin’s Q model in explaining firm’s investment decision-making process.

Theoretical framework
- I propose using the change in average Q, as a measure of the expected change in investment opportunity. Basically, I believe there are 3 components in determining the level of firm R&D investment:
  - The information from the past investment, as R&D is long-term investment that understandably relate to the previous amount.
  - The expected profitability, reflected by the change in Tobin’s average Q.
  - The other factors: the level of knowledge spillovers, both at intra- and inter-industry level.
- My theoretical model:
  \[ R&D_i = \alpha + \beta Q_i + \gamma \left( Q_{i-1} - Q_{i-2} \right) + \delta C_{F,i-1} + \theta \left( C_{F,i-1} + C_{I,i-1} + C_{S,i-1} + C_{S,i-1} + C_{S,i-1} \right) + \epsilon_i \]
  (Due to the results of an autoregressive model of R&D intensity and its first 5 lags, the 2 first lags have significant effects on the contemporaneous value. Hence, I control for the first two lags of R&D intensity)

Data
- Financial data is first collected from Datastream.
- Patent citations data is collected from Patstat (EPO).
- These two datasets are merged using the IPC-SIC concordance from Silverman (2002). The inter-industry spillovers are constructed at 2-digit SIC industries.
- Data cleaning process:
  + Drop all firms with 0 or missing R&D expenditure for all 9 years of investigation
  + Apply the restriction of at least 5 consecutive years of data for main variables: R&D intensity, Tobin’s Q.
  + Specific variables: exclude 1% highest values of R&D intensity and leverage, and replace all value of Tobin’s Q bigger than 10 to missing (Gilchrist and Himmelberg, 1995).
- After cleaning, the dataset contains 31,493 firm-year observations of 3,718 manufacturing companies

Regression results
- Table of regression results for 2 main models with GMM estimator on two different measures of inter-industry spillovers: the unweighted measure where all other industries are treated the same, and the patent weighted measure where the weight is constructed based on the number of patent citations.
- The results show that:
  - The change in Tobin’s average Q, my measure of expected profitability has significant and positive effect on firm R&D investment.
  - Both intra- and inter-industry spillovers have significant effect, however in opposite sign. While intra-industry spillovers have positive but small effect, the inter-industry spillovers has consistently negative impact on firm’s innovative effort. It can be attributable to the fact that the knowledge spilled over from outside the industry often complementary to firm’s investment, hence it reduces the cost for duplicated research.

References