

Valuing Innovation Options and Policy Flexibility under Uncertainty

Publishable Summary

Success in today's knowledge economy depends on the strategic use of intangible assets (such as R&D, patents and licensing) and on flexible innovative policies. The overall objective of this project was to contribute to Europe's efforts to enhance innovation and intangible investments by using real options analysis to address challenges posed by uncertainty and flexibility in innovation. Several specific issues were addressed: What makes innovation and policy design more valuable under uncertainty? What is the role of uncertainty and competition in innovation and policy? When should one compete or collaborate? How much is an innovation asset (e.g., a patent or licensing deal) worth at different stages? On what terms should one license a technology? Do these terms reflect fairly the development and commercialization options embedded in a licensing agreement? What evidence can support these valuations? How should one design flexible innovation policies and manage innovation and policy risks? What is the impact of uncertainty and ambiguity on macroeconomic outcomes and policies?

The project contributes to EC objectives and the literatures on real options, innovation and policy by developing novel ideas for the valuation, management and strategic use of intangible assets, innovation options and policy flexibility and examining the specific role of uncertainty on policy outcomes. Specific scientific objectives for the project focused on the following two areas:

(1) *Flexible innovation and policy under uncertainty*. This part focused on developing flexible policies for innovation under uncertainty and examined the impact of extreme market uncertainty on macroeconomic outcomes and policies. Real options analysis was used to provide a guide for flexible strategies and analyse innovation policy scenarios. Flexible policies presuppose a richer set of decision criteria, enabling conditional staged future decisions. We examined the strategic choice of when to pursue exclusionary strategies or cooperate in innovation, and traced empirically the impact of economic uncertainty on policy outcomes and real economic activity. We found that market uncertainty has adverse effects on important aspects of economic activity, including production, consumption, employment, productivity and overall economic output.

(2) *Multi-stage R&D and IP licensing*. The first part (theory) examined R&D and licensing as multi-stage compound options, focusing on how to design optimal and fair licensing terms and value sharing rules accounting for who controls innovation development and commercialization options. The second part (empirical) tested the theoretical predictions and analyzed licensing deals using the Medtrack and RECAP IQ databases on biotech/pharma licensing deals and terms (e.g. upfront payment, milestones, royalties). The analysis provided new insights on the factors that affect the value appropriation and sharing among the parties to a licensing deal accounting for the role of uncertainty and optionality.

In terms of main results, the project has shown how option-based analysis can provide a better understanding of the impact of economic uncertainty on macroeconomic policy outcomes, as well as in obtaining better valuation and management outcomes for multi-stage decision problems involving long horizons and high uncertainty, potentially involving competition or collaboration with other parties, as is the case with licensing agreements in the biopharma sector. In the design of licensing deals we have shown the importance in value share appropriation between the parties of the type of licensing scheme and which party controls the development option. Besides confirming the key roles of prior experience and negotiating power of the parties to a licensing deal, we also highlight an important adverse tradeoff for the innovator-licensor of negotiating a higher % royalty in terms of realizing lower fixed upfront and milestone payments, which gets more severe if the deal is signed at a later stage.

Project ideas and results help extend the state of the art on licensing, innovation and policy under uncertainty by properly accounting for the role of uncertainty, intangibles and flexibility in innovation activity. They underscore that value in innovation as well as business strategy and policy derives from tackling uncertainty in a forward-looking contingent manner and viewing it as an opportunity rather than a threat. Our novel framework allows researchers, firms and policy planners related to innovation to properly account for the role of uncertainty and the range of possible outcomes and staged decisions contingent on future economic scenarios and developments. The project synthesizes and extends ideas from the literature to new domains in innovation activity and economic/public policy.

The areas of intangibles appraisal, innovation management and policy decision making have been at a crossroads. Much has been done, but a lot of gaps remain. This project contributes by (1) using option-based analysis to properly account for the role of uncertainty and the value of flexibility on investment, economic outcomes and innovation activity, and (2) by testing the empirical implications of option-based predictions (e.g., of the role of uncertainty and flexibility) both at the level of the macro-economy (e.g., in terms of investment, productivity, employment and overall economic output), as well as at the firm level using a rich data set on biotech/pharma licensing deals to push the innovation licensing terms design and policy frontier forward.

The experiences, interactions and relationships developed at MIT and LUISS have helped advance the fellow's career and publication output and opened possibilities for collaboration. In terms of broader impact and implications, the work has the potential to enhance the innovation capability of an organization or the nation and might lead to new market opportunities concerning licensing deals design, as well as strengthen the competitiveness and growth of companies via licensing-in agreements to enhance and complement internally-generated organic growth. As such it may help address industrial and societal needs for a more holistic and collaborative growth and innovation activity. Although the work has the potential to result in exploitable innovation activities, the aim was to provide a conceptual economic framework for understanding and improving innovative activities, rather than to develop prototypes, processes or methods ready to be launched.

The work helps contribute towards European policy objectives and strategies regarding the knowledge economy and Europe's 2020 Strategy and may have a favourable impact on improving EU economic and innovation policy making, and in particular improving licensing activity and deal term design under conditions of uncertainty. The developed framework might be of value to European enterprises, IP managers, VCs and other funding providers, and EU policy makers as they strive to understand, evaluate and exploit innovation investments, growth and policy options.

The results on value sharing and design of licencing deal terms in the biomedical sciences should be of interest to pharmaceuticals (potential licensees) and innovating biotech firms (licensors).

More details about the project can be found at the action's public website at the address: <https://www.kcl.ac.uk/business/research/innovation-options.aspx>

