

Looking for the right path : technology dynamics, inventive strategies and catching-up in the semiconductor industry

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9 VALORISATION

In accordance with article 23.5 of the Regulation governing the attainment of doctoral degrees at Maastricht University, this addendum discusses the valorization opportunities presented by this PhD thesis. I will first discuss the degree of innovativeness of the theories and methods presented here and then elaborate on the socio-economic relevance of this work for several target groups.

9.1 Degree of innovativeness

This thesis presented a number of novel insights about technology dynamics and latecomers' technological catching-up by developing a new theoretical and methodological framework to study the evolution of technology and firms' inventive strategies. The theoretical contribution of this thesis is the introduction of a new way of looking at catching up and technology dynamics that is grounded on the interaction between prevailing and emerging engineering problems and the variety of approaches to solve them. We also argued how changes in problem-solving approaches can lead to solve technical bottlenecks and spark the rise of new products. Ultimately, this can lead to the emergence of new engineering challenges that need to be tackled. In the thesis, we also developed a theoretical framework that links the level of technical knowledge modularity in an industry, the extent to which technical change is knowledge replacing and the urge of knowledge diversification for survival at the technological frontier.

This dissertation also contributes new methods to identify changes in engineering design trajectories, i.e. in the way engineering problems are solved and how their importance is perceived relative to other problems. We also introduced an algorithm to classify inventions, firms (and, potentially, regions and countries) with respect to the exploitation-exploration spectrum of problem-solving approaches and their focus on prevailing or emerging engineering problems. In addition, we designed a methodological framework to identify technology domains and assess their life cycle stage. Another main methodological contribution of this thesis lays in the creation of an index of specialization at the country level that provides a more realistic micro-founded picture of inventing activities by firms in a country than previously available indices. Finally, we also developed a model to predict a firm's probability of persisting innovating at the frontier given its level of knowledge breadth, depth and the extent to which past knowledge is useful today.

9.2 Socio-economic relevance

The theoretical and methodological framework presented in this thesis has important implications for several target groups. First and foremost, they are the first step of a rich research agenda whose ambitious goal is to quantitatively study technology evolution at the level of engineering problems and problem-solving approaches. We argued in the thesis how this may be the key to understand and, possibly, predict technology dynamics that lead to clustering of big innovations in time and contributes to the formation of economic cycles. This area of research is potentially very fertile and has been explored only partially. The rich admixture of concepts, theories and methods from evolutionary economics, complexity studies and strategy, which is found in this dissertation, also testifies how this new direction of theoretical thinking could affect several fields. For instance, one could use the same theoretical and methodological framework to analyse the knowledge evolution of specific scientific domains of interest, using publication instead of patent data. A unifying theory of knowledge evolution could be searched. Such theory would be based on the central notions defined in this thesis, namely that science and technology advance by solving problems and that problems are tackled by a variety of approaches. It would then need to be integrated with a sociological explanation of why the variety of approaches changes over time. Such theory could then be validated with data by applying the methods developed in this thesis.

Secondly, the theoretical and methodological contributions of this dissertation should be of interest to technology development practitioners. In fact, the research agenda that this thesis started can potentially lead to commercially viable and empirically grounded consultancy services in the field of strategy and business intelligence for technology development. A number of similar consultancy companies have been developed in the last few years attempting to consult firms about their location in the technology landscape. To the best of the author's knowledge (which is fairly limited in this area), none of these services are based on a dynamic perspective on technology. Rather, they take the technology space as given and consult firms on their current position. In contrast, the notions of a constantly evolving structure of the system of engineering problems and of the changing variety of existing problem solving approaches provide a much more accurate way of describing technology dynamics. This is enormously more appealing for business practitioners as it can provide detailed suggestions on the firm's position in the prevailing engineering trajectories and consult on the existence of alternative approaches. The core of such consultancy service could be based on the algorithms developed in this thesis to identify the main paths of engineering improvements in a given industry, detect technology domains, assess their life cycle stage, reveal companies' comparative advantage across technology domains and predict the probability that a company persist innovating at the technology frontier. Further refinement of these algorithms would focus on converting them in predictive tools to forecast the probability of an upcoming change in trajectory and assess how the firm is positioned in the technology space to take advantage or react to that. An additional service could address the problem of identifying useful external sources of knowledge. This could take the form of suggesting possible partners, acquisition targets, or individual inventors to hire, that have expertise in the new design trajectory or in emerging technology domains.

Similarly, the same kind of analysis could be of great interest to regional policy makers. The strength of a region's knowledge base in the industry of choice could be evaluated given the direction of technology evolution in terms of the current prevailing engineering problems and problem solving approaches, and the position of the region's firms or research lab in the technology space. High-resolution policy suggestions could be derived on how to steer the evolution

of the region's knowledge base toward the desired targets. Based on our analysis emerging areas of the technology space could be detected and targeted to build an early comparative advantage. Tailor-made subsidies to incentivize research and development effort and collaborations across firms in a given technology domain could be designed. For instance, if a region lacks any inventive activity in an emerging area of research in an industry that used to be strong in the region, one could identify possible external partners for collaborations based on knowledge complementarity. Alternatively, our method could also identify possible efficient research avenues, for firms that are currently in the region, to navigate the technology space until the desired emerging area is reached.

The pursuit of the commercialization avenues sketched above is not the author's current priority. However, being him a scholar interested in evolution, he recognizes that preferences, opportunities and paths can change in ways that are sometimes difficult to foresee. Yet, at the moment, the author intends to focus mostly on accomplishing the rich research agenda that started with this thesis and disseminating the results prevalently within academia. Perhaps this will actually lead to build a stronger recognition in this field that would facilitate future possible consultancies.