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*Poster*

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26<sup>th</sup> International Conference on Science and Technology Indicators | STI 2022

## “From Global Indicators to Local Applications”

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#STI22GRX

### Mapping technologies to business models: An application to clean technologies and entrepreneurship

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#### Introduction

Given anthropogenic climate change and the rapid depletion of the remaining carbon budget to limit global warming to a manageable level, the development and diffusion of clean, environmentally sound technologies plays an increasingly important role in managing the transition to a low-carbon economy. This has been acknowledged in the Paris Agreement of 2015 which stresses the ‘importance of [...] technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions’ (United Nations 2015, p. 14). According to the United Nations (2015), this technological shift needs to be accelerated by innovations and increased investment in more sustainable forms of production, consumption, mobility and housing. This clearly brings entrepreneurs as important source of innovation to the fore and has made sustainable entrepreneurship an important research direction to understand hurdles and incentives for the technological transition to decarbonization and dematerialization.

While research on sustainable entrepreneurship largely agrees that environmental innovations are inherent to both established companies and new market entrants (Hockerts & Wußtenhagen 2010; Schaltegger & Wagner 2011; Gast et al. 2017), there is relatively little empirical work that specifically analyzes the transitional impact of the latter group. Yet, from a theoretical standpoint market entrants are attributed a special role for the creation of new technological pathways to overcome transition inertia among incumbents. Unconstrained by previous investment decisions, new business ventures can introduce more radical environmental innovations than incumbent firms thereby acting as accelerators for the diffusion of clean technologies (Hockerts & Wußtenhagen 2010; Fichter & Clausen 2013). Empirically, firm-level indicators that reflect a company’s technological footprint are necessary to identify which role different types of companies play in the diffusion of new technologies. Typically, technology and innovation research relies on patent and R&D information to determine a firm’s technological profile (Archibugi & Pianta 1996; Aharonson & Schilling 2016).<sup>1</sup> In contrast to established companies, there exists no historical track record on R&D investments for new business ventures, and patent activities are also rare among start-ups (Graham & Sichelman

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<sup>1</sup> Of course, there are also innovation surveys which, apart from common survey problems such as cost intensity and non-response, appear impractical for measuring company-specific technology portfolios from a very broad spectrum of different technologies. Nonetheless, see Comin et al. (2020) for a recent attempt to survey companies across 287 distinct technologies.

2008; Helmers & Rogers 2011). The lack of such innovation-related data makes it inherently difficult to empirically narrow down new ventures' technology usage and innovation capability.

Moreover, existing classification statistics, such as industry affiliation, tend to be too broad to capture a subtle construct such as a firm's orientation towards environmentally-sound market solutions. For these reasons, research suggests that understanding the impact new ventures can have in accelerating sustainable market transformations is much more a question of 'predictive, modeling-based, ex-ante evaluation than of retrospective, experienced-based, ex-post evaluation which applies to established companies' (Trautwein 2021, p. 3). In other words, for companies that are new to the market, only information available at or shortly after the company's foundation can be used to predict its transformational capability with respect to the development and diffusion of sustainable market solutions.

This paper follows this predictive approach by focusing on new ventures' technological orientation towards clean technologies as ex-ante indicator of their contribution to the transition towards more sustainable market standards. For this purpose, the approach relies on observable and detailed business summaries that new ventures are typically obliged to report upon business registration.<sup>2</sup> The legal obligation to publish a business purpose provides researchers and policy makers not only with fine-grained information about a company's business activities at the time of business creation. It provides also a good indication whether specific types of technologies are relevant to a company's business model as the following example of a firm active in the geothermal energy sector demonstrates.

'Manufacture, sale, maintenance and repair of heat pumps and other technical equipment, in particular for generating thermal energy.'

Based on this textual source of firm-level information, this study shows that it is possible to construct an early indicator of a new venture's potential to contribute to the diffusion of a specific technology by mere virtue of its technological orientation. The paper leverages recent advances in the field of natural language modeling to create a mapping of a technological system and to use market entrants' business descriptions to determine their position within this system. In this way, it becomes possible to measure how 'closely' a firm is located towards a particular technology in order to derive a novel indicator of firm-specific technology orientation: a measure referred to as technological proximity in the remaining of the paper.

The scope of this study is twofold. First, to the best of my knowledge, the proposed measure of technological proximity is the first one which maps business models to a fine-grained level of distinct technologies. Most importantly, the indicator is applicable to market entrants which typically lack track record of alternative technology and innovation indicators. While in theory the approach is highly flexible and allows to position *any* kind of company within *any* kind of technology system, this study applies the approach to position market entrants within a system of well-defined clean technology fields. More specifically, as second contribution of this paper, the framework is applied to a representative survey of German start-up firms in order investigate the environmental innovation capability of clean technology oriented market entrants as well as the environmental impact of their products' and services'. Empirical results suggest that clean

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<sup>2</sup> In Germany, for example, limited liability companies are legally obliged to state their business purpose as part of the business registration process. See Limited Liability Companies Act (Section 3 (1) No. 2 GmbHG) and Stock Corporation Act (Section 23 (3) No. 2 AktG) for the legal basis of the obligation.

technology oriented firms' products and services have positive environmental effects for their customers in terms of emission reduction, energy efficiency and higher levels of recyclability.

Moreover, a higher cleantech orientation at founding predicts a higher propensity to introduce environmental innovations over the course of the new venture's lifetime. This suggests that cleantech ventures have a special role to play in the technological transition towards decarbonization and dematerialization: besides their existing products and services building on clean technological standards, they are also drivers of introducing new products and services with a superior environmental footprint that fundamentally differ from their existing product portfolio. These results are in line with theory on new technological path creation by market entrants.

### Discussion and conclusion

Current research suggests that increased investment in advanced low-carbon technologies not only allows to further decrease reduction costs of future emissions (Bistline & Blanford 2020) but also that many near-commercial technologies with substantial emission reduction potential already exist (Bataille et al. 2018). However, additional innovation and policy prioritization with a dedicated mix of policy instruments is required to accelerate the technological transition towards a deep industrial decarbonization (Bataille et al. 2018) and higher sustainability standards (Edmondson et al. 2019). Path dependence in incumbent technology regimes and market externalities for environmental innovations are two economic explanations that justify a policy-induced, directed technical change towards a desirable long-term equilibrium of green growth. In view of technological path dependencies, policymakers are, however, well advised to align their instruments to differences in companies' willingness to introduce sustainable innovations. Constrained by past technological investments, incumbent firms are typically locked into path-dependent trajectories of their existing technology portfolio with little incentive to stimulate disruptive environmental innovations. New ventures, in contrast, are technologically unconstrained in their innovation decisions seizing regulatory push and market pull effects for sustainable market solutions with more disruptive innovations (Hockerts & Wüstenhagen 2010).

This gives rise to consider new market entrants as enablers of a green technological transition. Following this theoretical consideration, this study has focused on entrepreneurs whose business models build on clean technology solutions such as renewables, carbon capture and storage or clean water solutions. It is shown that clean technology oriented market entrants have distinguishable characteristics that indeed suggest that they have an important role to play in the technological transition to higher levels of sustainability. Both by virtue of their business models that build on clean technology solutions as well as by a high propensity to adopt additional environmental innovations, they may act as accelerators in the transition to more sustainable forms of production, consumption, mobility, and housing. This motivates why policymakers should pay special attention to clean technology oriented market entrants for the design of optimal environmental policy.

First and foremost, policymakers must understand in which technological areas entrepreneurial activities are taking place and which challenges are hardly being addressed by entrepreneurs. While for incumbent firms detailed information through R&D investments and patenting activities allow to assess their contributions to the diffusion of sustainable technologies, data availability concerning new ventures is generally limited. In fact, assessing whether a new market entrant bears potential to contribute to the diffusion of clean technology solutions is fundamentally a measurement problem: at the time of founding, innovation related data that allows to effectively draw an entrant's technological orientation is scarce, if not non-existent. This is where the study's main contribution comes into play. With the technology

mapping framework presented in this study, it is possible to assess the technological orientation of new ventures at or close to the time of registration. For this purpose, the framework leverages observable business summaries that new ventures are obliged to report upon business registration. Transferring new entrants' business descriptions into technology space by means of state-of-the-art methods from the field of NLP, it is shown that entrants' technological orientation can be determined at a fine granular level of distinct technologies. On an aggregate level, this gives policymakers a first idea to what extent and in which technological areas, entrepreneurs are active in the development and diffusion of clean market solutions. Moreover, in the context of directed technical change, the framework provides a useful policy tool. Once a new venture registers, the proposed framework makes it possible to assess the ventures' technological orientation. Policymakers can use the framework to systematically scan business registries for clean technology oriented entrepreneurs. This can be an effective way to direct subsidies to companies with high potential to accelerate sustainable technological change or to pre-select potential candidates for government venture capital funding or public incubator programs.

The framework also opens up new gateways for economic research, particularly by providing a codified approach for identifying cleantech start-ups. Future research can benefit from this, especially for empirical assessments of start-ups' role in overcoming sustainability inertia among path-dependent incumbents. For this purpose, it requires empirical strategies that take a closer look at the interactions between cleantech start-ups and carbon-intensive incumbents. Different channels of innovation interaction exist that deserve closer investigation. In an alliance perspective on environmental innovation activities, established companies may act as funders for sustainable entrepreneurs. Besides a high willingness of new ventures to seize market opportunities of green growth by introducing radical environmental innovations, they typically lack capital to scale such innovations. In search for funding, corporate venture capital can be beneficial not only for the new venture but also for the corporate investor. It provides the corporate investor with a source for proof of concepts and allows for experimental learning which requires the investment target to have a certain distance from the investor's accumulated knowledge base (Hegeman & Sørheim 2021). At the same time, the incumbent does not need to leave its existing business model and technology pathway, but has some degree of control over the technological advancements which are developed outside its own organization. Once the new technology is mature enough, the incumbent may even decide to integrate it as complementary process or product line. In this alliance perspective, the funding of cleantech entrepreneurs through established companies, not only bears benefits for both parties, but more importantly, leads to advances in the transition to more sustainable forms of technology. There also exists a trading perspective in the green technological transition through innovation interactions between incumbents and new ventures. Under increased regulatory pressure, incumbent firms possibly see the need to innovate and adapt their business models more directly. This may incentivize them to pay license fees for the use of clean technologies developed by cleantech start-ups. Or it may even lead to the acquisition of cleantech start-ups by the regulated incumbent. In this scenario, incumbents would not make risky R&D investments themselves, but could continue to amortize their existing technology investments internally while beginning to build separate product and service lines based on the acquired clean technology solutions. This trading perspective on innovation interactions may yet again be an important channel of accelerating the green technological transition. Ultimately, there is a competition perspective in overcoming sustainability inertia among incumbents. In the search for new markets and market share, disruptive innovations from cleantech start-ups can force established companies to adapt their existing business model with more radical sustainability innovations. In this way, the incumbents may try to preempt future competition in its main product market. Despite their technological path dependence, they may feel forced to respond to increased competition with the introduction

of own environmental innovations that eventually disrupt their existing knowledge base. Presumably, these interaction dynamics are technology-specific and depend on the industry.

Fundamental to any empirical investigation of these interaction channels is a codified approach to identify cleantech start-ups, preferably at a fine level of distinct technology solutions. Future research could develop empirical strategies to examine these interaction effects and use the framework presented in this paper to identify relevant cleantech entrepreneurs in the first place.

There are limitations to the study. The distinguishable characteristics of cleantech entrants favoring a green technological change have been found by contrasting cleantech start-ups against non-cleantech start-ups. Theory suggest a special role for entrants by contrasting them against established firms' technological path dependence. Therefore, it would be more desirable to empirically determine entrants' environmental characteristics by contrasting cleantech ventures against incumbents. Unfortunately, the author does not have survey data that includes environmental information on both new and established companies. Furthermore, the technology mapping framework has been applied to company summaries, which can be brief and arguably provide little insight into a company's technology usage. While this can theoretically lead to false negatives in detecting companies that are relevant in a particular technology area, text embedding models precisely address this issue. They do not depend on exact word matches but place words in vector spaces signaling whether distinct words are close in semantic meaning or not. So even if a business description does not contain technology-specific words, it allows to place the description's words into the developed technology space capturing associative meaning between business model and technology. Moreover, the proposed framework has the advantage that it can be applied to any source of textual information about companies. Besides business summaries from business registries, corporate website content poses another promising source of textual data to conduct the technology mapping. It remains to future research to show how useful webdata is to map technologies to business models.

## References

- Aharonson, B. S., & Schilling, M. A. (2016). Mapping the technological landscape: Measuring technology distance, technological footprints, and technology evolution. *Research Policy*, 45(1), 81–96. <https://doi.org/10.1016/j.respol.2015.08.001>
- Archibugi, D., & Pianta, M. (1996). Measuring technological change through patents and innovation surveys. *Technovation*, 16(9), 451–468. [https://doi.org/10.1016/0166-4972\(96\)00031-4](https://doi.org/10.1016/0166-4972(96)00031-4)
- Bataille, C., Ahman, M., Neuhoﬀ, K., Nilsson, L. J., Fischedick, M., Lechtenböhmer, S., SolanoRodriquez, B., Denis-Ryan, A., Stiebert, S., Waisman, H., Sartor, O., & Rahbar, S. (2018). A review of technology and policy deep decarbonization pathway options for making energy-intensive industry production consistent with the Paris Agreement. *Journal of Cleaner Production*, 187, 960–973. <https://doi.org/10.1016/j.jclepro.2018.03.107>
- Bistline, J. E., & Blanford, G. J. (2020). Value of technology in the U.S. electric power sector: Impacts of full portfolios and technological change on the costs of meeting decarbonization goals. *Energy Economics*, 86, 104694. <https://doi.org/10.1016/j.eneco.2020.104694>
- Edmondson, D. L., Kern, F., & Rogge, K. S. (2019). The co-evolution of policy mixes and socio-technical systems: Towards a conceptual framework of policy mix feedback in sustainability transitions. *Research Policy*, 48(10), 103555. <https://doi.org/10.1016/j.respol.2018.03.010>
- Fichter, K., & Clausen, J. (2013). *Erfolg und Scheitern "grüner" Innovationen*. Metropolis.
- Gast, J., Gundolf, K., & Cesinger, B. (2017). Doing business in a green way: A systematic review of the ecological sustainability entrepreneurship literature and future research directions. *Journal of Cleaner Production*, 147, 44–56. <https://doi.org/10.1016/j.jclepro.2017.01.065>
- Graham, S. J., & Sichelman, T. (2008). Why Do Start-ups Patent? *Berkeley Technology Law*

*Journal*, 23(3), 1063–1097.

- Hegeman, P. D., & Sørheim, R. (2021). Why do they do it ? Corporate venture capital investments in cleantech startups. *Journal of Cleaner Production*, 294, 126315. <https://doi.org/10.1016/j.jclepro.2021.126315>
- Hockerts, K., & Wüstenhagen, R. (2010). Greening Goliaths versus emerging Davids - Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. *Journal of Business Venturing*, 25(5), 481–492. <https://doi.org/10.1016/j.jbusvent.2009.07.005>
- Schaltegger, S., Lüdeke-Freund, F., & Hansen, E. G. (2016). Business Models for Sustainability: A Co-Evolutionary Analysis of Sustainable Entrepreneurship, Innovation, and Transformation. *Organization and Environment*, 29(3), 264–289. <https://doi.org/10.1177/1086026616633272>
- Trautwein, C. (2021). Sustainability impact assessment of start-ups – Key insights on relevant assessment challenges and approaches based on an inclusive, systematic literature review. *Journal of Cleaner Production*, 281, 125330. <https://doi.org/10.1016/j.jclepro.2020.125330>
- United Nations Environment Program, & European Patent Office. (2015). Climate change mitigation technologies in Europe - evidence from patent and economic data. [https://personal.lse.ac.uk/dechezle/climate change mitigation technologies europe en.pdf](https://personal.lse.ac.uk/dechezle/climate%20change%20mitigation%20technologies%20europe%20en.pdf). Accessed September 30, 2020.