

My research interests focus on the economics of innovation, firm financing, and endogenous technological change. In my job market paper, I investigate the implications of venture capital finance on firm innovation and aggregate growth. My other research projects investigate the interplay between financial selection and firm entry, sudden stops and economic recovery, and the impact of R&D subsidies on international technology competition. With my experience and interest in topics such as finance of innovation, innovation policy, and productivity, I believe that, as a fellow, I would be a positive addition to the NBER Productivity, Innovation and Entrepreneurship Program.

My job market paper titled “Beyond Cash: Venture Capital, Firm Dynamics, and Economic Growth” presents a rigorous quantitative framework to explore the distinct mechanisms by which VC firms influence innovative firms and, through them, aggregate productivity. Investments by venture capital (VC) companies have a disproportionate impact on the US economy. In 2010, the revenues of firms that had ever received VC support accounted for 21% of GDP, and their employment share was 11% of total private sector employment, although VC investments to their portfolio companies amount to less than 0.2% of GDP.¹ VC financing is of particular relevance for firm creation and innovation because VC firms strive to find young and innovative firms that lack market experience. VC firms are unique in that they do not only provide financing: They also actively engage in management by bringing their *operational knowledge* to bear in their investments. Despite this distinctive structure, the contribution of operational knowledge to firm productivity and its implications for aggregate economic growth lack a thorough investigation. My study attempts to fill this gap.

Investing in a young company that needs to develop an innovative business idea entails considerable uncertainty and is subject to pervasive moral hazard problems (Gompers, 1995). In such environments, Casamatta (2003) shows that the *optimal contract* specifies a “dual role” for the VC firm. The optimal contract bundles financing and advice so that a VC firm’s financial stake in the company motivates it to provide valuable advice. By contrast, consulting firms are not preferred by young and innovative firms because they do not acquire stakes in the latter.² As a consequence of this lack of “skin in the game,” entrepreneurs have to pay a very high price in order to obtain valuable advice from the consultant. Therefore, young and innovative companies prefer VC advising to consulting advice.

Taking the structure of the optimal contract as given, I develop a structural model containing an explicit VC market. This model serves two main purposes: Firstly, I use the model to measure the importance of the VCs’ *operational expertise* to firm growth. To identify this channel, it is fundamental to separate it from the provision of financing and the overall selection of “portfolio” firms by VCs. Establishing a unified structure that accounts explicitly for different aspects of the VC market, the structural model is an effective tool to accomplish this task. Quantifying the operational knowledge channel is useful for evaluating the advantages commonly attributed to VC finance in fostering firm productivity and growth. To the extent that VC companies add valuable knowledge to their undertakings, they become a more efficient option for financing innovation than more traditional financing sources such as bank loans. Secondly, the model provides a suitable ground to shed light on various policy discussions such as the relationship between an active public equity market and VC financing.

To address these issues, I propose a new dynamic general equilibrium model of innovation with heterogeneous firms. In this model, entrepreneurs/private firms produce differentiated goods of heterogeneous quality which they can improve through risky research and development. The efficiency of this development process can only be increased with the help of a VC and is otherwise fixed. I introduce to this model a detailed venture capital market through (i) the feature of VC expertise and (ii) the endogenous matching market for firms and VCs. Every private firm that is not in a relationship with a VC can search for VCs and meet them in the

matching market. VCs improve the efficiency of product development through their operational knowledge. They also provide financing and relax the cost of inputs into the production of goods. This financial support to a priori unconstrained firms reflects the dual structure of the optimal contract for VC investment. The heterogeneity in the quality level of private firms determines the magnitude of the improvement that VC firms can potentially create. VC firms are subject to entry costs, which induce them to select firms for investment that present more room for growth. Thus, in addition to financing and operational knowledge channels, the VC setting also accounts for the effects of selection by VC firms. Because the preferred option for VC firms to exit their portfolio companies is to sell them via initial public offerings, the model also includes a public equity market. To complete the general equilibrium framework, the rest of the structure builds on the shoulders of endogenous technical change models in which entrepreneurs own intermediate product lines. The innovations generated by these intermediate good firms is the fundamental driving force of the endogenous rate of growth of the aggregate economy.

I estimate this model by the method of moments, using US data on the venture capital market, public equity issuances, and research and development expenditures. The model does a successful job in matching moments that pertain to venture capital and innovation aspects of the model, such as the duration of VC matches, firm age at the issuance of initial public equity, and aggregate share of R&D. Before using the estimated model for counterfactual analyses, I compare its auxiliary predictions to data moments in order to obtain out-of-sample validation. This comparison reveals that the model is very precise in capturing the high IPO frequency among VC-backed firms and the share of IPOs issued by VC-backed companies, both of which are definitive characteristics of the VC market in the US.

The first set of counterfactual experiments determines the relevance of VCs' operational knowledge to firm and aggregate growth. I create hypothetical economies in which I strengthen particular channels of VC finance in each experiment. Comparing the responses of the aggregate growth rate to these changes demonstrates that the knowledge channel accounts for 1/3 of VCs' impact. Hence, the conclusion is that VC support matters significantly beyond financing. Then I consider a 15% increase in the fixed cost of IPO to capture the average level of underwriting spreads in the US before their secular decline after the 1980s. Resulting in a smaller share of VC-backed private firms in the economy, this increase leads to a 1.5 basis point loss in long-run growth.

As an example for the policy implications of the model, I consider a recent regulation that the European Union introduced in 2013 regarding European VC firms. In order to decrease the fundraising costs of VC firms, this policy aims to harmonize the legislative environment these firms face when investing across the borders of European countries. I map this change into the model as lower entry costs for VC firms through lump-sum subsidies. I find that this policy can increase the long-run growth rate by 7 basis points at a cost of subsidies that corresponds to approximately 8% of the VC investment in the model. This increase in the growth rate hinges on the reallocation of private firms towards the VC market. Moreover, a rise in the median duration of the VC-firm relationship amplifies the effect of the operational knowledge. These results highlight the significance of the general equilibrium effects for the policy evaluation.

In a second paper, "Technology Dynamics, Innovation Policy and the Gains from Globalization" joint with Ufuk Akcigit and Giammario Impullitti, my coauthors and I are motivated by two strong observations on global innovative activity: First, there is a clear convergence in the number of patents (and also citations) issued by US and non-US based firms over the course of the 1970s until the mid- 1980s. Second, in the first half of the 1980s, R&D subsidies and tax credits were introduced both at the federal and state level in the US and a halt of the technological convergence followed. Motivated by these facts we build a trade model with endogenous technical change to analyze the effects of openness, foreign technological competition, and

the welfare consequences of innovation policies in this contest. We devise a two-country growth model with step-by-step innovation where firms invest in innovation to gain global leadership. Calibrated to match key innovation, growth, and trade statistics for the major innovating countries in the 1970s, the model is able to replicate the convergence observed in the data. We evaluate the welfare effects of foreign catching-up on the leading economy, the US, finding sizable short run and long-run losses. Moreover, feeding the model the increase in US R&D subsidies in the 1980s reproduces about 1/4 of the recovery of US leadership shown in the patent data since the mid-1980s.

In a third project titled “Fewer but Better: Sudden Stops, Firm Entry, and Financial Selection”, my coauthor Felipe E. Saffie and I combine the real business cycle small open economy framework with the endogenous growth literature to study the productivity cost of a sudden stop. In this economy, productivity growth is determined by successful implementation of business ideas, yet the quality of ideas is heterogeneous and good ideas are scarce. A representative financial intermediary screens and selects the most promising ideas, which gives rise to a trade-off between mass (quantity) and composition (quality) in the entrant cohort. Chilean plant-level data from the sudden stop triggered by the Russian sovereign default in 1998 confirms the main mechanism of the model, as firms born during the credit shortage are *fewer, but better*. A calibrated version of the economy shows the importance of accounting for heterogeneity and selection, as otherwise the permanent loss of output generated by the forgone entrants doubles, which increases the welfare cost by 30%.

As to my future research agenda, a potential extension that could have important policy implications is the comparison of the effects of R&D subsidies and the policies that affect the VC market. For instance, my paper with Ufuk Akcigit and Giammario Impullitti documents the expansion of R&D subsidies in the US over 1980s and analyze its implications for the position of the US in the international technological competition into 1990s. The US also witnessed a surge in the VC market in this era. Disentangling the influences of these events would be an ambitious but interesting research question. Another direction of research could be to extend the setting in my job market paper to include heterogeneity across VC firms and across innovation efficiencies of non-VC-backed private firms. A strand in the VC literature shows that the reputation and experience of VC firms matter for the success of their subsequent investments, as well as for private firms’ decisions of which VC firm to work with. Relating to these findings, I would like to introduce heterogeneity across VC firms and across the innovation efficiency of their potential undertakings in order to measure the relevance of these features for the impact of VC financing on firm and aggregate growth. In particular, I would like to see how the inclusion of these aspects would affect the findings of counterfactual and policy experiments in my job market paper. For instance, the expansion of the VC market might have an attenuated growth impact if the entering VC firms could not meet many private firms in need of operational expertise, such that the VC support cannot generate a large increase in the firm growth rate.

In a broader context, I would be interested in how VC business arose endogenously. The optimal provision of operational expertise by VC requires managers who possess both sufficient operational knowledge and financial wealth. Beyond being an interesting question by itself, explaining the factors that give rise to the emergence of venture capitalists can also help us understand an important cause of cross-country differences in the depth of VC markets. For example, one argument is that VC managers who were previous entrepreneurs are more successful. Therefore, the historically active market of entrepreneurial activity in the US and the expansion of VC business after 1980s may point to a deeper relationship which other regions such as continental Europe has lacked. To the extent that VC markets affect aggregate growth rate, which I argue to be significant, this line of research can shed light on the stagnating nature of European productivity in 1990s with respect to the US.

Notes

¹National Venture Capital Association (NVCA, 2013). Well-known examples include Amazon, Google, Starbucks, and FedEx.

²The result assumes that the entrepreneurial effort is cheaper and is key for the success of the project.

References

Casamatta, C. (2003). "Financing and Advising: Optimal Financial Contracts with Venture Capitalists". *The Journal of Finance* 58(5), 2059–2086.

Gompers, P. A. (1995). "Optimal Investment, Monitoring, and the Staging of Venture Capital". *The Journal of Finance* 50(5), 1461–1489.

NVCA (2013). "National Venture Capital Association Yearbook".