CHAPTER 2

Innovation, Public Policy and Growth: What the Data Say

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2.1 Introduction

Innovation and technological progress are the key determinants of long-run economic growth and welfare. For instance, in recent work, Akcigit et al. (2017) (henceforth AGN) show that those states in the US that have innovated more over the twentieth century grew much more rapidly than those that innovated less (see Fig. 2.1). Relatedly, more research effort has been devoted to understanding the social implications of innovation. Does higher GDP per capita or GDP growth increase happiness? The existing empirical literature on happiness and income looks at how various measures of subjective well-being relate to income or income growth. For instance, Aghion et al. (2016) analyze the relationship between creative destruction and subjective well-being. They show that: (i) the effect of creative destruction on expected individual welfare is unambiguously positive if the unemployment rate is controlled for, less so if it is not; (ii) job

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creation has a positive and job destruction a negative impact on well-being; (iii) job destruction has a less negative impact in US Metropolitan Statistical Areas (MSA) within states with more generous unemployment insurance policies; (iv) job creation has a more positive effect on individuals that are more forward-looking.

Given the tight link between innovation, economic growth, and well-being, designing the right public policies to achieve inclusive and sustainable growth requires a good understanding of what lies behind the innovation process. The mapping between innovation and economic growth can be described broadly as

Firms → Inventors → Ideas → Aggregate Growth

where firms hire inventors to produce new ideas/technologies which lead to economic growth. In line with this mapping, I will center my discussion in this chapter around three categories: (*i*) firm studies, (*ii*) inventor studies, and (*iii*) idea (patent) studies.

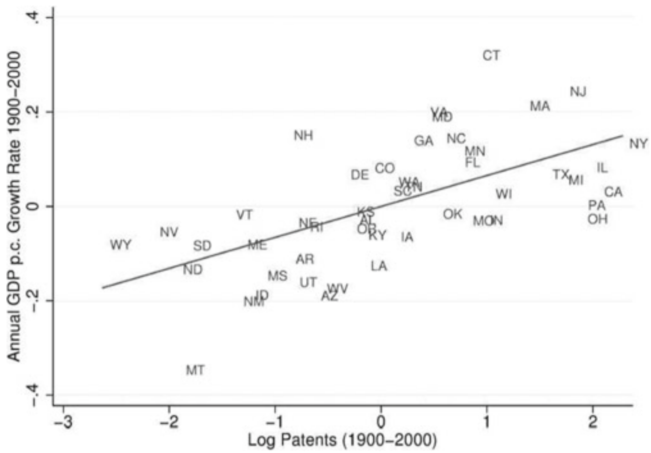

Fig. 2.1 100 Years of Innovation and Economic Growth (US States, 1900–2000) (*Source* Akcigit, Grigsby, and Nicholas [2017])

2.2 Firm Studies

Tax Credit and R&D Incentives of Firms Debates on public policy and economic growth cannot ignore the fact that innovations do not fall from the sky. They are created by firms and inventors who respond to economic incentives and, importantly, incentives are shaped by public policy. A large literature documents the important effects of tax incentives for R&D, thus justifying the detailed study of their optimal design.[1] A recent paper by Akcigit et al. (2017) (henceforth AAI) studies the role of R&D Tax Credit for innovation. In the US, the 1970s was a period of productivity slowdown that raised concerns about the declining international competitiveness of the US. At the time, John McTague of the Reagan White House said, "Foreign competition in the technology intensive industries poses a serious threat to our country's position in the international marketplace than ever before in our history." There are possible policies to deal with this "problem," the most discussed being import tariffs. The result of these debates was the introduction of the Federal R&D Tax Credit for the first time in 1981 (which has been in effect ever since).

Figure 2.2 shows the evolution of average firm-level R&D spending (normalized by firm sales) and the total share of patents at the US Patent Office filed by US firms. There are two facts worth mentioning. First, there had been a massive loss of technology leadership as documented by the rapid decline in the US patent share from 1975 to 1985. Second, US firms showed a large response to policy change. Starting from 1981, firms in the US increased their R&D spending which then translated into more patented innovations and brought international technology catch-up to a halt. How effective were these policies of the 1980s and how do tariffs affect innovation incentives?

Akcigit et al. (2017) assess the effects of import tariffs and R&D subsidies as possible policy responses to foreign technological competition in a dynamic general equilibrium growth model. Their quantitative investigation illustrates that, statically, globalization (defined as reduced trade barriers) has an ambiguous effect on welfare, while, dynamically, intensified globalization boosts domestic innovation through induced international competition. Accounting for transitional dynamics, they compute

[1] Among many others, see Goolsbee (1998), Bloom et al. (2002), Bloom and Griffith (2001), Bloom et al. (2002), and Serrano-Velarde (2009).

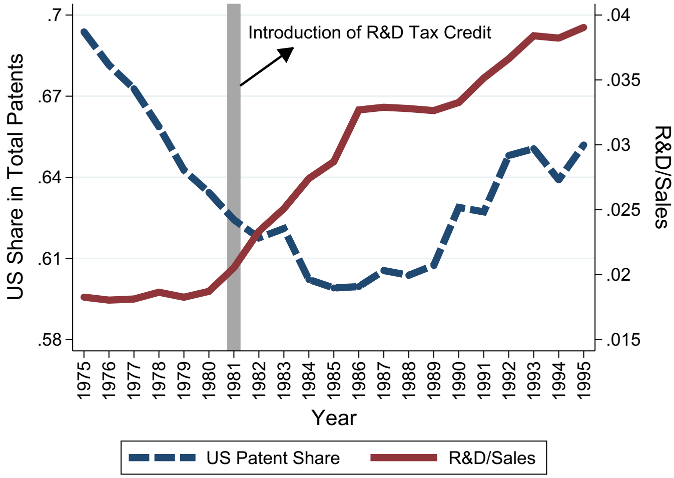

Fig. 2.2 Introduction of R&D Tax Credit, Firm R&D Spending and Innovation in the US (*Source* Akcigit, Ates, and Impullitti [2017])

optimal policies over different time horizons. Their model suggests that the introduction of the Research and Experimentation Tax Credit in 1981 was an effective policy response to foreign competition, generating substantial welfare gains in the long run. A counterfactual exercise shows that increasing trade barriers as an alternative policy response produces gains only in the very short run, and only when introduced unilaterally, while leading to large losses in the medium and long run. Protectionist measures generate large dynamic losses from trade, distorting the impact of openness on innovation incentives and productivity growth. Finally, they show that less government intervention is needed in a globalized world, thanks to intensified international competition as a result of lower trade barriers.

Key takeaway: An important policy message from this example is that tax policy, or specifically the R&D Tax Credit, could contribute to the attractiveness of a country for R&D and be a powerful tool for making firms more innovative and competitive.

Firm Selection and Public Policy The goal of R&D policies is to incentivize firms to undertake greater R&D investment, produce more innovations, increase productivity, and create more jobs. However, these policies do not affect every firm in the economy in the same way. For instance, Criscuolo et al. (2012) have shown that large incumbents are better at obtaining government subsidies. One can argue that R&D subsidies to incumbents might be inefficiently preventing the entry of new firms and therefore slowing down the replacement of inefficient incumbents by more productive new entrants. The turnover and factor reallocation between incumbents and entrants is an important source of productivity growth. Foster et al. (2001, 2006) have shown empirically that the reallocation of factors across firms accounts for more than 50% of productivity growth in the US. Given the empirical importance of this reallocation margin, it is necessary that R&D policy takes into account the interaction between innovation and factor reallocation. This is the focus in Acemoglu et al. (2018) (henceforth AAABK).

AAABK build a model with heterogeneous firm types where type is determined by innovative productivity. For instance, high-type firms produce more innovation for any given level of R&D input than low-type firms. The authors estimate the model by matching various empirical moments capturing key features of firm-level R&D behavior, shipment growth, employment growth, and exit, and the variation of these moments with size and age. They then use the estimated model as a lab to run counterfactual experiments and test the impacts of various observed R&D policies on economic growth and welfare. The policies that the authors consider include a subsidy to new entrants, a subsidy to R&D by incumbents, and a subsidy for the continued operation of incumbents.

The main findings are summarized as follows. Using 1% of the GDP to subsidize new entrants, R&D or continued operations of incumbents have small effects, and some of them even reduce welfare in the economy. This result might suggest that the decentralized equilibrium is already efficient and any subsidy in this environment is making the economy move away from its efficient level. To the contrary, the decentralized equilibrium may be highly inefficient due to the usual intertemporal R&D spillovers and competition (Schumpeterian) effects. However, in this model there is another important margin: *firm selection*.

In order to understand the role of selection, AAABK first solve for the economy's allocation from the viewpoint of a social planner who internalizes all the externalities of R&D spending. What they find is that the social planner forces low-type firms to exit the economy much more frequently, so that all their production resources are reallocated to the high-type firms. Then they turn to the *optimal* public policy experiments in which they assume that the policymaker cannot observe firm types but has access to the usual policy tools such as an R&D subsidy, an entry subsidy, and a subsidy/tax to firm operations. What they find is that the optimal policy requires a substantial tax on the operation of incumbents combined with an R&D subsidy to incumbents. The reason for this result is that taxing operations makes it harder for low-type firms to survive and forces them to exit. The freed-up factors of production are then reallocated to high-type firms, which make use of them much more effectively.

Their general equilibrium analysis, which incorporates both reallocation and selection effects, highlights the fact that the economy in equilibrium might contain too many low-type firms and policies that ignore the selection effect might help low-type firms survive. Another point that is highlighted is the fact that intertemporal spillovers are sizable and overall R&D investment is below the efficient level. Therefore a combination of R&D subsidies and taxes on firm operations could be an effective way of providing innovation incentives to firms, while also leveraging the selection margin in the economy.

Key takeaway: The authors conclude that (i) governments often subsidize industries, (ii) these subsidies typically go to all firms, regardless of performance, (iii) focused subsidies could be more effective since they could redistribute key resources by letting low-type firms exit, and hence exploit the selection of firms in the economy.

2.3 Inventor Studies

Who Becomes an Inventor? Inequality of opportunities to get proper education could prevent the citizens as well as society from realizing their full innovative potential. The strong complementarity between innovation and education is documented by AGN for the US and by Aghion et al. (2017) for Finland.

In Figure 2.3, AGN show that increased education makes it more likely for someone to become an inventor. Figure 2.4, on the other hand, shows that kids with rich parents are also more likely to become inventors. If parental income is the only resource to accessing education, Figures 2.3 and 2.4 suggest that financial constraints could be important impediments to inclusive growth whereby a broader fraction of the society participates in the innovation and growth process.

Key takeaway: An important takeaway from these findings is that public policy needs to ensure access to education for potential future inventors who could generate economic growth through their creative ideas.

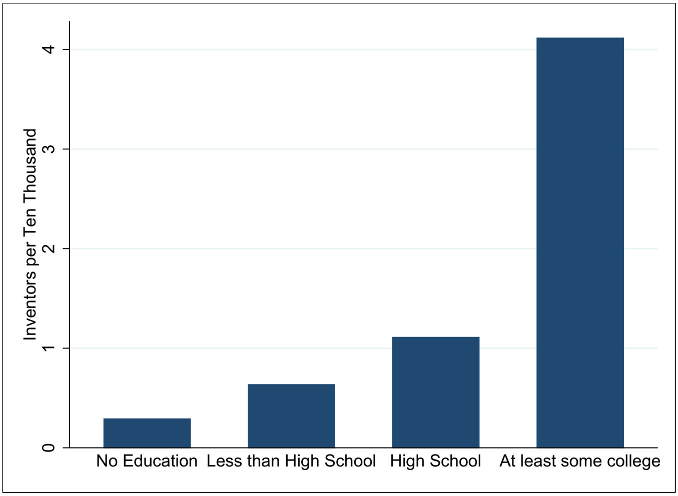

Fig. 2.3 Becoming Inventor and Education (*Source* Akcigit, Grigsby, and Nicholas [2017])

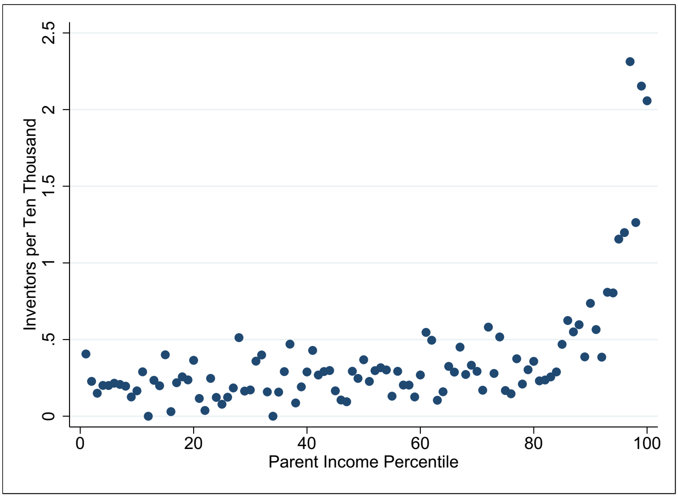

Fig. 2.4 Becoming Inventor and Parental Income (*Source* Akcigit, Grigsby, and Nicholas [2017])

Taxation and Inventor Mobility When it comes to policy debates, it is important to also take into account the disincentive effect of taxes on individuals and inventors in particular. Many of the prolific inventors around the world are international migrants and their location choice is affected by country-specific policies. In their work, Akcigit et al. (2016) (henceforth ABS) analyze the impact of top marginal income tax rates on the international mobility of inventors. Among many other things, they study the changes in tax codes in various countries, as illustrated in Figures 2.5 and 2.6.

Figure 2.5 shows the 1986 Policy Reform that reduced the top marginal tax rate in the US. The effect has been a rise in the number of foreign superstar (highest-quality) inventors who migrate to the US. Similarly, Figure 2.6 shows the policy change in Denmark in 1992 which lowered the top tax rate for high-income foreign researchers. The result of this change is again a significant rise in the number of foreign inventors in the country.

Key takeaway: The analysis by ABS shows the (dis)incentive effects of tax policies. Their findings suggest that some policies (top marginal tax rates, in this case) could impose significant costs on the society through their adverse effects on innovation incentives and economic growth.

Innovation, Inequality and Social Mobility Rising top-income share has been at the center stage of the current policy debates and many of the proposals to combat this trend focus on imposing heavy taxes on top-income groups. These discussions should also take into account

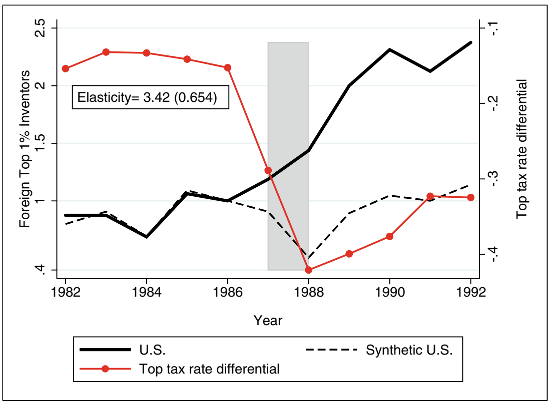

Fig. 2.5 Becoming Inventor and Education (*Source* Akcigit, Baslandze, and Stantcheva [2016])

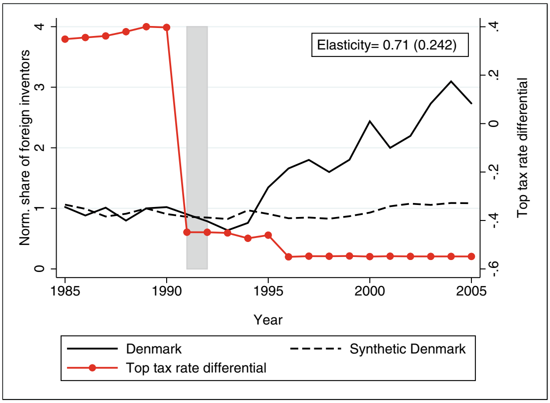

Fig. 2.6 Becoming Inventor and Parental Income (*Source* Akcigit, Baslandze, and Stantcheva [2016])

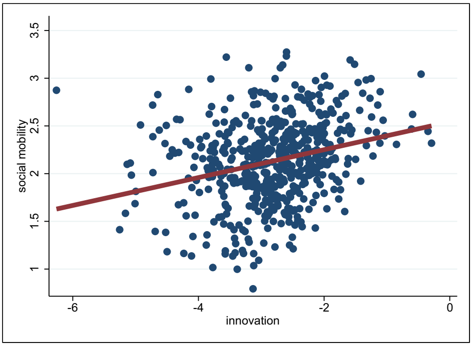

Fig. 2.7 Social Mobility and Patenting across the US Commuting Zones (*Source* Aghion, Akcigit, Bergeaud, Blundell, and Hémous [2018])

the link between top-income inequality and innovation, which has been studied by Aghion et al. (2018) (henceforth AABBH).

Innovation has important and nuanced implications for inequality and social mobility. On the positive side, AABBH show that those US regions (commuting zones) that produced more innovations have also experienced greater social mobility (see Figure 2.7).[2]

Innovation, however, comes with an important trade-off. In Figure 2.8, AABBH also show that the states which had an increase in

[2] Social mobility here is the expected percentile or "rank" (from 0 to 100) for someone aged 30 in 2011–2012 whose parents belonged to some percentile of the income in 1996 when the person was aged 16.

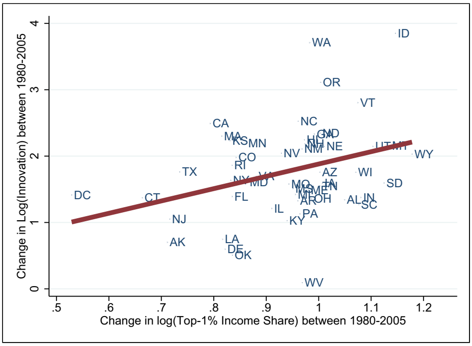

Fig. 2.8 Top-1% Income Share and Patenting across the US States 1980–2005 (*Source* Aghion, Akcigit, Bergeaud, Blundell, and Hémous [2018])

patented innovations also experienced, on average, a rise in top-income share between 1980 and 2005. These findings highlight the fact that while innovation is associated with faster growth and social mobility, it also comes with an increase in top-income inequality.

Key takeaway: Policies should take into account this tradeoff before leaping to conclusions for or against heavy taxation. In particular, high taxation may induce more equality but less social mobility.

2.4 Ideas

Market for Ideas New ideas are the seeds for economic growth. The rise in living standards depends not only on the production of new ideas (as it was discussed in Section 2.2), but also on the effectiveness of transforming new ideas into consumer products or production processes. Incarnating an idea into a product or a production process is by no means immediate. What happens to ideas and patents once they are produced? While a lot of the policy discussions center around increasing the number of ideas/patents/technologies produced, very little attempt is made at understanding how these new ideas are utilized after their invention. Akcigit et al. (2016) fill this gap by studying the secondary market for patents.

Ideas are not necessarily born to their best users and firms often develop patents that are not close to their primary business activity. This initial "mismatch" could potentially be mitigated in a secondary market where firms can buy and sell patents through patent agents (intermediaries). In Akcigit et al. (2016), the authors study the secondary market for ideas (patents) in the US. They build an endogenous growth model where firms invest in R&D to produce new ideas. An idea increases a firm's productivity. By how much depends on the technological distance between an idea and the firm's line of business. Ideas can be bought and sold on a market for patents. A firm can sell an idea that is not relevant to its business or buy one if it fails to innovate. The model is matched to stylized facts from the market for patents in the US. The analysis gauges how efficiency in the patent market affects growth. They find that the contribution of the secondary market for patents to the overall productivity is quantitatively significant.

Key takeaway: The immediate policy implication of this study is that strengthening the market for technologies could make economies use their scarce innovations and ideas better by allocating them to better users.

Patent Trolls The secondary market for patents suffers from various frictions and so-called "patent trolls" or non-practicing entities (NPEs) have emerged due to these frictions. Despite the attention on NPEs in the media and in policy circles, there is almost no systematic evidence on their business activities. How do NPEs impact innovation and technological progress? The question has enormous importance for industrial policy, with virtually no direct empirical evidence to start answering it.

A recent paper (Abrams et al., 2017) takes a major step in this direction by making use of some NPE-derived patent and financial data to answer this question. In doing so the authors inform the debate that has portrayed NPEs alternatively as benign middlemen that help to reallocate IP to where it is most productive or stick-up artists that exploit the patent system to extract rents, thereby hurting innovation. They find that NPEs target patents coming from small firms that are more litigation-prone, and patents from large firms that are not core to a company's business. When NPEs license patents, those that generate higher fees are closer to the licensee's business and more likely to be litigated. These findings suggest that NPEs could serve as middlemen in the market for technologies when frictions like high search costs or informational asymmetry between potential licensors and licensees are present.

Key takeaway: Taken together, the evidence in this paper is mixed and does not solely support the benign middleman or the stick-up artist theory. Rather it suggests that there are some aspects of NPEs that may increase innovation and some that may not. Therefore a more nuanced perspective on NPEs as well as additional empirical work is necessary before informed policy decisions can be made.

2.5 Conclusion

To sum up, innovation is good for society for at least three reasons: it leads to economic growth, social mobility, and happiness.

On the firm side, industrial policies could encourage more innovation, if we guide our innovation policy in an informed way, especially thinking about how the competition will have differential effects in different industries. The analysis on trade and innovation also shows that protectionist policies are detrimental for competition and growth, suggesting that the single-market policies of EU that remove trade barriers would stimulate more innovation and productivity growth. When it comes to individuals, a strong education policy could be a very influential innovation policy. High taxation could have significant disincentive effects for innovators, which could also harm social mobility in the society. Finally, having a well-functioning market for technologies could make economies utilize their scarce innovative ideas much more effectively.

Even though some of these studies use data from the US, their findings are much more general and relevant for all frontier countries that aim to grow through innovations. These findings show that public policy, innovation, market for ideas, and economic growth are tightly interlinked. Therefore any discussion on public policy and growth cannot be pursued in isolation from innovations and their effective use in practice, which are the main sources of long-run economic growth and prosperity.

The main lessons from these studies for Europe can be summarized as follows: First, international competition is healthy for innovation incentives. Second, innovation policies, such as R&D subsidies, require patience on the policymaker side, as these subsidies impact the economy in the medium-to-long run. Third, industrial policy needs to take into account the firm composition and factor reallocation in the economy. Bailing-out unproductive firms could slowdown factor reallocation from unproductive incumbents to more productive entrants. Fourth, education policy could be a very effective innovation policy in Europe. Providing as much equal opportunity for education as possible could improve the quality of the inventor pool and the overall innovation capacity. Fifth, the design of income tax policy has to take into account the fact that inventors do respond to incentives. Therefore one policy direction could be to couple income tax with tax breaks or research grants to inventors in order to undo the potential disincentive effects of taxes. Finally, the use of new technologies is at least as important as their inventions. Hence, Europe might also have to focus on its secondary market for technologies, in particular on technology sale and licensing, in order to improve its overall productivity.

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