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Inequality and creative destruction

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Inequality and Creative Destruction

by

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In this article we review recent evidence showing how market forces and policies shape the rate and direction of innovation, with various implications for inequality. First, we characterize several market mechanisms whereby higher rates of innovation lead to higher inequality. Second, we highlight channels whereby inequality acts as an impediment to innovation and growth. Third, we highlight policies that can help achieve better outcomes for both innovation and inequality. We show that two types of policies, which are not traditionally viewed as part of innovation policy, play a key role to achieve the goal of enhancing innovation while reducing inequality: education and competition policy.

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1. Introduction

The creative destruction paradigm developed by Philippe Aghion and Peter Howitt provides an enormously attractive way of looking at the role of incumbents and entrants and the balance of policies toward innovation, inequality, social mobility and growth. As can be seen from the string of high-profile empirical papers referenced in this volume, the increasing interplay between theory, data and policy is reaping returns, uncovering key relationships in the dynamics of innovation, growth and inequality.

Creative destruction generates inequality between the winners and losers from innovation. The Aghion-Howitt framework posits that this inequality will be concentrated at the top and largely temporary, with mobility driven by entry and imitation. There is a balance though, and the incumbent beneficiaries of innovation have an incentive to protect their position and restrict the entry of competitors. The resulting inequality can be 'too high and too persistent', eventually reducing innovation and restricting social mobility and growth. Some inequality may be required to provide incentives to innovate but there is evidence that the balance is getting worse, with incumbent firms, and wealthy families, gaining a stranglehold on entry and on upward mobility. In this survey article, we ask: how can we achieve a better outcome for innovation *and* inequality?

The impact of innovation on inequality will differ depending on the particular economic and social institutions in place. The empirical studies we discuss have shown us how the relationship between inequality and innovation depends on the share of higher educated workers and scientists, on the level of basic research, on the bargaining power of workers, on competition policy, patent law, the degree of globalization, the distribution of cognitive and noncognitive skills, the distribution of wealth and access to liquidity, the effective tax rates on rents and the overall progressivity of the tax and social insurance system. These empirical findings on Creative Destruction can help inform policy design in a way that maintains, even enhances, the level of innovation with lower levels of inequality and increased social mobility. We argue that judicious choices over competition policy and education, in particular, have great potential to achieve this goal.

We present our analysis of inequality and creative destruction in three parts. We begin in the next section by uncovering the key pathways from creative destruction to inequality. We review evidence showing that several groups are among the winners of creating destruction; that skills and bargaining power play an important role, as does geography; that, especially among those who are not lucky enough to be counted among the winners, the effects can be wider than just monetary (e.g., health); and that the mechanisms through which creative destruction affects individuals include prices and new goods. Then we examine how inequality can impact innovation. We pay special attention to market size effects, to unequal access to inventive careers (including entrepreneurship), and the role of financial incentives and taxes. Finally, we explore potential policy interventions and highlight the central role of education and competition policy.[4] The former is key to (potentially) providing a level playing field for all individuals capable of invention; the latter plays a central role in keeping in check the forces through which inequality, achieved through invention, may become (too) persistent.

2. From Creative Destruction to Inequality and Social Mobility

2.1 Conceptual framework: the winners and losers from creative destruction

2.1.1. The roles of the labor market, business ownership, and the product market

The winners from creative destruction include a wide range of individuals associated with innovation. These include business owners, managers and stockholders as well as the innovators, the development scientists and the owners of the innovation. Inequality can also be generated post-innovation from the skill complementarity of the specific innovation. The skill distribution and the degree of bargaining power of workers will also play a key role, with the lower educated workers typically among the losers.

The impact of creative destruction may also be geographically dispersed, generating regional inequality. Firms that are adversely impacted may lie in specific geographical areas resulting in pockets of deprivation and little local demand for managerial and scientific skills, or frontier firms. The impact on the individuals and the families within the adversely affected communities can have impacts that go well beyond income inequalities, exacerbating health inequalities and other social and economic inequalities more broadly. As Aghion, Akcigit, Deaton, and Roulet (2016) note, job destruction from innovation-led growth can have serious adverse impacts on well-being, the severity of which depends on, among other things, the generosity of social insurance policies.

There can be other important mechanisms that enhance the real incomes of those that have benefited from innovation. For example, recent evidence suggests that the relative price of the goods purchased by richer households has been falling in recent years in the United States, relative to goods purchased by lower-income households, which we discuss further in section 3.1.[5]

[4] For a recent overview of open policy questions related to the economics of innovation, see Bryan and Williams (2021).

[5] The bias of technological change in favor of higher-income consumers could stem from various sources, including skill-biased technological change if income-elastic goods have higher skill intensity.

2.1.2 Persistent inequality? The Balance between Entry and Market Power

Persistence in the inequality generated from creative destruction will be a central theme in our discussion. Persistent inequality has the potential to reduce opportunities for future innovators and adversely impact social mobility. The Aghion-Howitt framework recognises this but suggests that inequality will be concentrated at the top and largely temporary, with mobility driven by entry and imitation. As Aghion et al. (2021) put it 'in the short-term, innovation benefits those who generated or enabled it, in the long run innovation rents dissipate due to imitation and creative destruction. In other words, the inequality generated by innovation is temporary'. However, the dissipation of rents is not guaranteed. The winners from creative destruction will have every incentive to protect their winning position by preventing new entrants. The winners may also use any political power, generated by their winning position, to lobby for a change in tax policies, patent laws or competition policy that further protects their position. Incumbent innovators will have an incentive to increase the persistence of inequality thereby reducing social mobility. Indeed, the winners may choose to use the rents that flow to them to enhance the position of their offspring, thereby prolonging the persistence of inequality across generations. Those adversely impacted could thus face persistent disadvantage.

The standard creative destruction model has a trade-off that determines the degree of inequality and persistence at its heart: A balance between entry and market-power. Incumbents can have too much market power but there can also be too much competition, relative to the levels that would maximize innovation. Some market power may be needed to provide incentives for creative entry by new owners, managers and innovators. But 'too much' power in the hands of the incumbents can be used to deter new entrants and reduce innovation in the future. In the inverted-U framework of Aghion et al. (2005), this can be thought of as the 'wrong side' of the inverted-U. In terms of inequality, some inequality may be needed to provide incentives for the owners, managers and innovators. But the subsequent inequality can be 'too high and persistent' or bring 'too much power and influence' as the owners of the rents use their income and wealth to keep out new entrants and reduce social mobility, eventually reducing future innovation and growth.

2.1.3 The role of institutions

The impact of innovation on inequality will differ depending on the economic and social institutions in place. For example, Aghion and Griffith (2021) note that innovation that takes place in the public sector may be more pro-equality – possibly more likely to foster health innovations and green technologies. Aghion et al (2021) note 'The problem with established firms is not solely that they try to prevent the entry of new, innovative firms. There is another problem relating to their conservatism regarding innovation and technical progress.' The impact of innovation on inequality will therefore depend on the institutional setting in which the innovation takes place. It will depend on the type of innovation undertaken, on the patent law, on the degree of globalization, on the share of higher educated workers and scientists, on the distribution of vocational skills, on the effective tax rates on rents from innovation and on the overall progressivity of the tax system. Thus, we can ask how to design policy interventions that change the institutional setting toward one where the level of creativity is maintained while innovation results in lower levels of inequality and more social mobility.

In examining the impact of creative destruction on inequality in the remainder of this section, we begin with the impact of innovation on the top incomes and upward mobility. We then look at the impact of innovation on the skill premium and wage inequality, noting the role of frontier versus laggard firms and of the bargaining power of workers. We note that some low-educated workers appear to benefit from technology and innovation. We ask whether there are some skills among low educated workers that are valued by innovating firms – for these low educated workers innovative firms can act as a 'lever of social mobility'. We also look at the impact on the demand for the goods produced by the high skilled and on the prices of the good purchased by the rich. Finally, we note the potential impact on family incomes at the top and potential impact on the persistence of inequality across generations and on social mobility.

2.2 The Impact of Innovation on Incomes

2.2.1 Innovation and Top Incomes

Innovators and entrepreneurs certainly show up among top income earners. Using deidentified U.S. tax records including novel linked firm-owner-worker data, Smith et al. (2019) find 'a striking world of business owners who prevail at the top of the income distribution'. In every top income group and income definition, they find that entrepreneurial income rivals or exceeds both nonowner wage income and non-pass-through capital income. Not all entrepreneurs are innovators, nonetheless the authors argue that top earners are predominantly "human-capital rich" and that the majority of top income in the US accrues to the human capital of wage earners and entrepreneurs, not financial capital. Figure 1, taken from that study, plots the share of people by their majority income source in the US. It shows the strongly increasing share of business income in the top share, dominating wage income and income from interest, rents, royalties, estates and trusts, at the very top. Similar, although less strong, findings have been documented for the UK in Delestre et al. (2021).

Looking specifically at innovators and top incomes, Aghion et al. (2017), note that in a list of the wealthiest individuals per US state, 11 out of 50 are listed as inventors of a US patent and many more manage or own firms that patent. Supporting this finding, Forbes Magazine reports that 8 of the top ten innovators are US based and a large majority of the top 25 richest individuals in the US are first generation innovators. Germany too has a preponderance of innovators at the top. Figure 2, from Aghion et al. (2019) examines the correlation between innovation and the top 1% income share in the US over time. It shows that measures of innovation and top incomes share have also been found to be significantly correlated in the aggregate time series.

Figure 1: Share of People by Majority Income Source, Fiscal Income

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Figure 2: Innovation and the Top 1% Income Share over Time

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To address confounders that could be responsible for the time series relationship between innovation and top incomes displayed in Figure 2, Aghion et al. (2019) develop a state-level analysis, reported in Table 1. The analysis uses a state level panel to examine the dynamic relationship between top income inequality and innovation. State-level top 1% income shares form 1976 (Frank, 2009) and patents data from the United States Patent and Trademark Office. Using a number of alternative measures of innovation, the robustness of the effect of innovation of the top income share measure is clear. A long list of control variables are included and the potential endogeneity of patents is allowed for using an instrument that measures the composition of specific appropriation committees. The study also builds a second instrument for state innovation which relies on knowledge spill-overs from other states. The results are robust and show a positive and significant causal effect from innovation to top income shares.

Table 1: The Impact of Innovation on the Top 1% Income Share

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Digging deeper into the mechanism, Aghion et al. (2019) develop a simple extension of the Aghion-Howitt Schumpeterian framework. The derive five main predictions: (i) innovation by both entrants and incumbents increases top income inequality; (ii) the effect of innovation on income inequality is stronger on higher income brackets; (iii) innovation by entrants increases social mobility; (iv) entry barriers lower the positive effect of entrants' innovation on social mobility, and (v) national income shifts away from labor towards firm owners as innovation intensifies. We return to the importance of entrants and the impact on social mobility below. We first examine the distribution of innovation rents within and between firms.

2.2.2 Innovation and Wage Inequality

Van Reenen (1996) was the first to rigorously establish the positive effect of firm level innovation on firm level wages resulting in wage inequality between firms as firms become more dispersed. The distribution of these "innovation rents" across workers in the firm is also likely to increase within firm wage inequality. To understand some of the key mechanisms involved, Kline, Petkova, Williams and Zidar (2019) use a careful research design to look at who profits from patents within the firm. The analysis examines how patent-induced shocks to labor productivity propagate into worker earnings. They use linkages between patent applications with business and worker tax records. The results of this work highlight the role of skill complementarities, ownership and bargaining power. Panel A of Figure 3 presents the difference-in-differences estimates of the effect of initial patent allowances on *within firm* inequality measures. The results imply the largest earnings effects are concentrated among men and workers in the top half of the earnings distribution. This is paired with corresponding improvements in worker retention among these groups. The authors interpret these earnings responses as reflecting the capture of economic rents by senior workers, who are most costly for innovative firms to replace. Indeed, Panel B Figure 3, from the Aghion et al (2018) study of returns to invention within firms in Finland shows that by the by far the largest slice of returns to invention go to the entrepreneurs.

Figure 3: The distribution of innovation returns among different workers in the firm

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These findings suggest that separations of key personnel can be extremely costly to innovative firms, even when these employees are not themselves inventors. The fact that seniority appears to mediate the propagation of firm shocks into worker earnings suggests an important role for relationship-specific investments in the generation of labor market rents. More broadly, these results suggest that the influence of firm conditions on worker wages depends critically on their degree of replaceability. This work confirms earlier analyses of the impact of patent applications or patent grants on inventor wages, for example Toivanen and Vaananen (2012); Depalo and Di Addario (2014); Aghion et al. (2018); Bell et al. (2019). In general, inventor earnings are found to be more responsive to patent allowance decisions than are the earnings of non-inventors.

The impact of technology on task displacement and task replacement is a key idea underlying the task-based approach to inequality of Acemoglu and Restrepo (2021). They argue that when automation displaces unskilled labor from the tasks in which they used to specialize (which has been the modal impact so far), it increases the demand for skills and inequality. New tasks may or may not limit the increase in the demand for skills depending on whether they are mostly targeted at skilled workers. Replacement may be influenced by the duration of the relationship between the worker and firm and a worker's position within the firm hierarchy, issues emphasized in recent empirical studies of wage setting at European firms by Buhai et al. (2014), Jager (2015), and Garin and Silverio (2017).

The impact on top income shares and the distributional outcomes within firms paints a rather depressing picture for lower-educated workers and those not directly involved with the innovation. However, innovation may not always be bad for the outcomes of lower educated workers, at least if they have the right skills and are matched with 'good' firms. In a study of workers linked to firms and occupational tasks in the UK, Aghion et al.(2021), find that low educated workers engaged in soft skill tasks display, on average, higher wage progression. Figure 4, taken from shows the relationship between workers in occupations with high levels of soft skills and wage progression. Drilling down further into this finding the authors establish that innovating firms, and firms with larger shares of educated workers, value low educated workers with soft skills. These are skills that complement innovation. Note that this does not mean that cognitive skills do not matter, far from it, rather that soft skills can be an important dimension of the skill set for lower educated workers that is complementary to other firm assets, such as the share of educated workers and the intensity of R&D.

Figure 4: Soft skills and wage progression: low educated workers

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The impact of innovation will also depend on the impact on the size of the innovating firm, the impact on their costs and the impact on the prices of consumer products they produce. Using French data Aghion, et al. (2020) examine the impact of automation technologies on employment, wages, prices and profits. The estimated impact of automation on employment is positive, even for unskilled industrial workers, which suggests that the productivity effects of automation outweigh its potential displacement effects. They also find that automation leads to higher profits, lower consumer prices, and higher sales. They note that the industry-level employment response to automation is positive and significant only in industries that face international competition. The key mechanism they suggest is via the pass through of some of the productivity gains to consumers, inducing higher scale and higher employment. The results indicate that automation can increase labor demand and can generate productivity gains that are broadly shared across workers, consumers and firm owners. This suggests that to measure the full impact on inequality requires the study of the impact on product markets and consumer prices, a theme we return to in the next section.

2.3 Innovation and Between-firm Inequality

Technological innovation is also associated with the growing inequality between 'superstar' firms, reflecting a growing dispersion across firms in productivity, wages, markups, firm size and labour shares, see Van Reenen et al. (2021). These firms appear to exploit increased productivity from innovation and the rents in the product market not only to generate higher profits but sometimes to pay their workers better. Nonetheless, De Loecker, Eeckhout, and Unger (2020) argue that there is a direct, inverse relation between the firm's markup and the labor share. In general, firms that have higher markups spend less on labor. Gabaix et al. (2016) argue that the returns to new technologies accrue not only to innovators, scientists and owners but also to owners of capital in the form of higher capital incomes. Changing the capital income and wealth distribution as well as the balance of power in the product and the labour market.

Eeckhout (2021) notes that in addition to the split of output between profits and labor income, market power also affects labor income inequality between workers. He distinguishes two routes how market power affects between-worker inequality: profits sharing and monopsony. Market power tilts the split of output towards profits and away from wages. Now if the worker wage contains a share in profits, then wage inequality will in part be driven by profits. Therefore, an increase in market power leads to an increase in wage inequality. This is obviously the case for managers who get paid in stock options. There is also a positive correlation between a firm's markup and the executive's pay, indicating that market power drives profits and hence also compensation. But it is not only for managers: Those in positions with responsibility and who supervise other workers often get paid on performance and therefore share in the profits of the firm. Market power is not exclusive to the goods market. In the labor market, monopsony power arises when a firms with market power can affect the individual wages of workers in the firm. This leads to a markdown (equivalent to a markup) that drives a wedge between the worker's marginal revenue product and their wage. The higher the monopsony power, the higher the wage markdown.

Creative destruction can work by knocking out low productivity firms. Aghion et al. (2008) note that the threat of technologically advanced entry encourages incumbent innovation and productivity growth in sectors that are initially close to the technological frontier, whereas it may discourage incumbents in sectors further behind the frontier, see Figure 5. Laggard firms are likely to be geographically concentrated in low growth low wage areas. Creative destruction stimulating growth in firms in thriving areas with higher skilled workers, increasing top incomes and geographical inequality.

Figure 5: Reactions to entry in incumbents near and far from the technology frontier

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2.4 Creative Destruction, Social Mobility and Persistent Inequality

In the short-term, innovation benefits those who generated and enabled it. In the long run, we hope that more innovation will raise macro-growth reducing prices and raising equilibrium productivity and wages. Indeed, the theory of Creative Destruction predicts, rents will be dissipated through imitation and entry innovation by entrants increases social mobility. As Aghion et al. (2021) put it 'in the short-term, innovation benefits those who generated or enabled it, in the long run innovation rents dissipate due to imitation and creative destruction. In other words, the inequality generated by innovation is temporary'. However, Creative Destruction also predicts entry barriers lower the positive effect of entrants' innovation on social mobility, increasing the persistence of inequality.

Social mobility and the dissipation of rents are not guaranteed. The winners from creative destruction will have every incentive to protect their winning position by preventing new entrants of competitors and shielding their rents, e.g., lobbying for a change in tax policies, in patent laws or competition policy, in labour laws, in social insurance and in education policies. The reduced social mobility and restrictions on access eventually reducing innovation, further limiting opportunities for the losers and holding back general productivity.

Empirical results suggest innovation is positively associated with social mobility *but* lobbying is shown to dampen the impact of innovation on social mobility by reducing entry. Table 2, taken from Aghion et al. (2019), examines the impact of various innovation measures on social mobility, in which social mobility measures are taken when the child is 30 between 2011 and 2012 compared to his parents during the period 1996-2000. A comparison of the first two columns of results shows a stronger effect of entrants. The final column show that this impact is driven by entrants where there is lower levels of lobbying by incumbents.

Table 2: Innovation and social mobility: entry and lobbying

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Persistence inequality is equivalent to inequality with low social mobility**.** Reducing persistence inequality and enhancing social mobility while maintaining creative innovation is central to the policy implications of the creative destruction framework - encouraging new ideas and new innovation while preventing persistence and stagnation.

Many factors can impact the persistence of inequality following an innovation. Too little competition – poor patent design, poor competition policy, other entry barriers – lobbying for preferential treatment. Are there changes in policy and institutional reforms that can change the balance, reducing inequality while encouraging innovation and social mobility - changing institutions and incentives?

The key therefore is to get the skill-firm match right. Warehouse jobs maybe bad jobs, in terms of wage progression and career prospects, for low educated workers. Skills policy for the lower educated should go hand in hand with technology and innovation. Carefully chosen skills policy can mediate the impact of creative destruction on lower educated workers.

There is a parallel to the discussion of creative destruction and social mobility in the *parenting and education 'meritocracy' debate*. In the first round of meritocracy, starting from an equal opportunity initial condition, the 'more able' do best and earn more income. Assortative mating concentrates success in parents who invest in their kids and begin to undo the equal initial conditions for the next generation, reducing social mobility. Parents invest in schools, peers, neighborhoods, etc., deterring the 'entry' and the social mobility of kids whose parents are less advantaged.

Society wants to provide incentives for parents to invest in their children's education but also wants to get education directed toward (matched with) the most able children. Society can change the equilibrium by investing in subsidized/public education provision. Redistribution can help provide the resources for parents. Increased inequality in a winner takes all society and skill biased technological change increase the returns to education, and child investments more generally, providing further incentives for successful parents to invest in their own kids' success. But overall productive quality of 'labor' declines due to increasing mismatch.

3. From Inequality to Creative Destruction

Recent work characterizes the impact of several types of inequality on the rate and direction of creative destruction. Two main channels have been investigated: (i) how inequality in disposable income affects the direction of innovation; and (ii) how unequal access to careers in entrepreneurship and innovation across socio-demographic groups affects both the rate and the direction of innovation. Moreover, recent work shows that the impact of financial incentives and top tax rates on creative destruction is nuanced.

3.1 Due to market size effects, rising income inequality endogenously leads to "pro-rich" product innovations

A longstanding literature on endogenous innovation shows that market size creates incentives for innovation and entry (e.g., Aghion and Howitt 1996). Growing markets make it worthwhile to pay the fixed costs necessary to innovate, reduce marginal costs, and enter new markets. The idea that higher market size leads to endogenous productivity gains goes back to the seminal work of Linder (1961) and Schmookler (1926). However, it is only recently that the literature has examined the implications of increasing returns and the market size channel for inequality.

Jaravel (2019) estimates the causal relationship between market size and consumer prices, links changes in market size across product categories to changes in the (nominal) income distribution, and quantifies the implications for purchasing power inequality. The starting point of this analysis is that many product markets target different populations of consumers. For example, scotch and tobacco have very different income elasticities. In the context of economic growth and rising income inequality, for example in a country like the United States, demand grows faster for premium (income-elastic) products. Consequently, there are financial incentives for innovation and entry to occur primarily for income-elastic products. These dynamics have the potential to reduce prices for existing products in these fast-growing premium categories, which are predominantly consumed by high-income households. Jaravel (2019) conducts several empirical tests showing the relevance of these mechanisms, primarily by using barcode-level scanner data covering the U.S. retail sector between 2004 and 2015.

Figure 6 shows that higher-income households experienced a faster increase in product variety (panel A) and lower inflation in the U.S. retail sector (panel B) from 2004 to 2015. Consistent with these findings, in related work using national accounts data covering the entire US economy, Boppart and Weiss (2013) show that total factor productivity (TFP) growth is higher in more income-elastic sectors.

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Can the equilibrium response of innovation to faster growth in demand from high-income consumers explain the patterns of differential inflation and increase in product variety? It is well documented that in recent decades the share of U.S. national income accruing to high-income consumers has steadily increased. As a result, the relative demand for income-elastic goods increased. To estimate the causal effect of growing demand on product entry and equilibrium prices, Jaravel (2019) develops a shift-share research design. This design combines two components: (i) predetermined spending shares across the product space and various socio-demographic groups, and (ii) heterogeneity in the population growth rates for these various groups during the sample period. As age groups, education group, racial groups, and regional populations have different spending shares across products, variation in the size of these groups over time generates changes in demand.

Figure 7 reports the reduced-form specification of this IV, which draws out a downward-sloping supply curve. The IV estimate show that increases in demand lead to a large fall in prices and increases in product variety. In Figure 7, the CES price index accounts for changes in product variety and measures the change in welfare stemming both from product variety and from price changes for products available in consecutive years. When the growth rate of demand increases by 1 percentage point, the inflation rate for continued products falls by 0.42 percentage points (std. err. 0.139). With changes in product variety, inflation falls further, by 0.62 percentage points (std. err. 0.258).

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Based on the IV estimates, a calibration shows that changes in demand induced by shifts in the income distribution are large enough to explain much of the observed inflation inequality. The predicted inflation difference is about 70% of the observed inflation difference.

Thus, these results show that inequality in earned income, and hence in disposable income, can have an impact on the direction of innovation and lead to an amplification of inequality in purchasing power and welfare. These findings stand in contrast with a long tradition that emphasized the idea that all consumers benefit from innovation thanks to the "product cycle", the idea that high-income consumers may be targeted first but that the new products are soon brought to the mass market (e.g., Hayek 1931; Schumpeter 1942; Vernon 1966). In fact, the product cycle is not the only important force at play. Certain markets are clearly segmented, such that there is no product cycle between them (e.g., scotch and tobacco), and they cater to households with different income levels. In the context of rising inequality, the segmentation of product markets leads to a feedback loop between income inequality and purchasing power inequality through market size and the endogenous direction of product innovations.

3.2 The choice of entering a science or innovation career is largely influenced by social backgrounds, which affects both the rate and direction of innovation

3.2.1 Who becomes an inventor?

Career choice is another important channel whereby inequality shapes the rate and direction of innovation. A recent and rapidly growing strand of literature documents the social origins of individuals who contribute to economic growth by pursuing careers in science, entrepreneurship, or innovation. The literature to date has studied a large number of countries and proxies measure innovation, and delivers a consistent message: there is a large pool of untapped talent, individuals who could have contributed to raising economic growth but did not choose an innovator's career. Although this research agenda has only recently used large-scale datasets, its roots go to the 1950s, when Schmookler (1957) laid out the main research questions, and even to the 1930s when Rossman (1931) studied the motivations of inventors.

Figure 8 reports some of the key stylized facts from this recent literature. Panel A reports the key finding of Agarwal and Gaule (2020), who use data from the International Mathematical Olympiad (IMO) and show that talent students born in poorer countries are systematically less likely to enter a research career, as measured by the share getting a PhD in mathematics. IMO participants from low-income countries produce 34 percent fewer publications and 56 percent fewer citations than equally talented youth from high-income countries. Policies that can help talented youth from low-income countries to pursue scientific career could have a large impact on knowledge creation.

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The idea that there is untapped potential is also confirmed by country-specific studies. Panel B of Figure 8 examines the United States, reporting the propensity to become a patent inventor depending on parents' income percentiles. The patterns are very similar both using historical records, as in Akcigit, Grigsby and Nicholas (2019) who study the United States over the period 1880-1940, and modern administrative data, as in Bell et al.(2019) who study the United States after 1980. There is a strong convex relationship between parent income and patent innovation: children with parents in the top 1% of the income distribution are ten times more likely to become inventors than children with below-median-income parents. As shown on Panel C, Aghion et al. (2018) document a very similar relationship in Finland using data on men born between 1961 and 1984, with most parents born in the 1940s and 1950s.

Bell et al. (2019) also document large gaps by race and gender: White children are three times more likely to become inventors than Black children and only 18% of inventors are female. They show that the gender gap in innovation is shrinking gradually over time. However, at the current rate it would take another 118 years to reach gender parity.

Figure 9 shows that unequal access to innovation in the United States persists even conditional on test scores and for the most impactful innovations. Panel A shows that children at the top of their third-grade math class are much more likely to become inventors, but only if they come from high-income families.

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Panel B of Figure 9 examines the social origins of highly-cited "star inventors", who drive innovation and growth. Women, minorities, and individuals from low-income families are as underrepresented among star inventors as they are among average inventors. Given the findings from Panel A that innovation ability (as proxies by third-grade math test scores) does not vary much across these groups, this result implies there are many "lost Einsteins" among the under-represented groups – people who could have had high-impact inventions had they become inventors.

3.2.2 How large are the implications for aggregate innovation and long-run growth?

To assess the amount of lost innovation due to unequal access to innovation careers, Bell et al. (2019) carry out a simple reweighting exercise. If women, minorities, and children from low-income (bottom 80%) families invented at the same rate as white men from high-income (top 20%) families, there would be 4.04 times as many inventors in the United States as there are today. This simple calculation illustrates that leveraging the pool of untapped talent —the "extensive margin" of the supply of inventors— could be a powerful approach to increase aggregate innovation.

Is this conclusion robust to general equilibrium effects? Einio, Feng and Jaravel (2020) build a dynamic general equilibrium model with endogenous growth, in which a part of the population (called the "minority" group) is subject to barriers to access innovation. The model features many sectors, heterogeneity in research productivity and consumer tastes, entry barriers that vary across socio-demographic groups, and social interactions between groups that can alleviate these barriers. Calibrating the model to the U.S. economy, they find a large impact of reducing unequal access to innovation on the steady-state growth rate. As shown in Figure 10, eliminating completely the access barriers would lead to an increase in the long-run growth rates from 2 percent (in the current equilibrium) to about 4 percent (in the counterfactual equilibrium with no access barriers). Thus, misallocation of talent in the innovation sector can affect long-run growth rates: these results complement those of Hsieh et al. (2019), who quantify the impact of misallocation of talent allocation on welfare.

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Together, these results highlight the importance of a set of policies that can harness the under-utilized talent, both within countries and across countries. Targeting exposure programs to children from under-represented groups who excel in math and science at early ages is likely to maximize their impacts.

3.2.2 Implications for the direction of innovation

Recent work shows that the social environment influences not just whether a child grows up to become an inventor but also the types of inventions they produce, and the types of customers they target. Figure 11 reports these findings. As shown on panel A, Bell et al. (2019) find that children whose parents hold patents in a certain technology class (e.g., amplifiers) are more likely to patent in exactly that field themselves rather than in other closely related fields (e.g., antennas).

-- Figure 11 here –

Einio, Feng and Jaravel (2020) examine whether innovators' social backgrounds have an impact on the target markets they pursue, which in turn could affect welfare inequality through purchasing power. An individual's background and social experiences may affect the types of problems and customer needs they are familiar with, and thus the kinds of innovations they might bring to market. Indeed, the discovery of entrepreneurial opportunities depends on the distribution of information in society (Hayek, 1945) and often requires engagement with specific real-world problems and users (Von Hippel, 1986).

To assess the empirical relevant of this hypothesis, Einio, Feng and Jaravel. (2020) build a data set linking consumer characteristics to innovators' parental income, age, and gender. They find that innovators from a high-income family are more likely to create products purchased by high-income consumers. As shown on panel B of Figure 11, entrepreneurs from high-income families are less likely to get a patent or start a firm within a "necessity" industry (like food), but are more likely to do so in a "luxury" industry (like finance). Moreover, they find that female consumers are significantly more likely to purchase products from startups that were founded by female entrepreneurs. For example, panel C considers phone applications: female-founded phone applications startups have an 8.2pp higher female market share relative to their male counterparts, on a baseline of about 54%. Thus, there are clear homophily patterns between innovators and their consumers both across and within industries.

Einio, Feng and Jaravel (2020) also document that innovators' characteristics may affect the rate of "green innovations". As shown in Table 3, female inventors as well as young inventors are more likely to invent "green" patents (using the classifications of Acemoglu et al. 2012, Aghion et al. 2016), i.e. to have positive environmental externalities. 6.5% of inventors of clean patents are female, as opposed to 2.8% for dirty patents. Younger inventors are also more likely to patent in clean energy technologies, with a 0.1 percentage points decrease in the propensity to work on clean patents for one year's increase in age.

-- Table 3 here –

Similarly, Koning, Samila and Ferguson (2020) study biomedical patents and find that increasing the share of female inventors shifts the supply of inventions toward the needs of women. According to their estimates, moving a disease-technology area from the average (10 percent female-led) to gender parity would result in 23.4 percent of inventions being female focused. Relative to the average of 18.5 percent, this is a 25 percent increase.

Thus, inequality of opportunity may play a crucial role in shaping the direction of creative destruction and who benefits from product-market innovation.

3.3 Are high levels of income inequality necessary to incentivize innovators?

There is an active debate about the role of top income inequality in spurring creative destruction, with three contrasting views: low marginal tax rates at the top may be necessary to induce sufficient entrepreneurial effort; on the other hand, intrinsic motivation and career choices may not be responsive to such financial incentives; finally, the rate and direction of innovation depends more broadly on the entire structure of the tax system, not merely top tax rates.

3.4 Low marginal tax rates on top incomes create financial incentives for entrepreneurs

A large literature highlights that creating financial incentives for entrepreneurs may be necessary to induce entrepreneurial effort and spur creative destruction. According to this view, since entrepreneurs and innovators are typically at the very top of the earnings distribution, low marginal tax rates on top incomes may be necessary to sustain innovation and growth, implying lower redistribution and higher disposable income inequality. For example, Jones (2020) considers an optimal taxation model based on this channel.

He finds that this channel sharply reduces the optimal tax rate on top incomes. For this mechanism to operate, it should not be possible to target innovation with a separate research subsidy.

3.5 Intrinsic motivation and the choice to become an innovator appear to be largely responsive to marginal tax rates on top incomes

Another line of work suggests that high top income shares may not be necessary to sustain innovation. Indeed, innovators often have an "intrinsic motivation" to advance the knowledge frontier, rather than being led by financial motives alone. This idea is not new to the literature: already Rossman (1931) studied the motivation of inventors by surveying U.S. (patent) inventors: "Love of inventing" gained 193 (22%) mentions from the 710 responding inventors "most active and important in this country" (pp. 522), with an average of 39.3 patents. The second-most often mentioned motivation was "Desire to improve" with 189 (21%) mentions. "Financial gain" came third, among 9 active choices, with 167 (19%) mentions.

Recent studies have deepened our understanding of the relevance of this channel. For example, Stern (2004) shows empirically that scientists accept lower salaries to work in research labs that give them more freedom over the choice of their research agenda. From a related theoretical perspective, Lockwood, Nathanson, and Weyl (2017) study how taxation affects the allocation of talented individuals across professions. They show that, by blunting material incentives to enter high-paying occupations, high taxation magnifies the nonpecuniary incentives of pursuing a "calling." From that perspective, high marginal tax rates on top incomes may help direct the most talented toward careers promoting creativity, research, and innovation.

Standard neoclassical models of career choice deliver the same message: changes in marginal tax rates on top incomes appear to have a limited impact on the decision of becoming an innovator. Indeed, if the returns to innovation are forecastable at the point of career choice, tax policies would only induce inventors of marginal quality to enter the field rather than star inventors, who are responsible for most of innovation. Jaimovich and Rebelo (2017) establish this result in a neoclassical model of career choice with heterogeneous and known innovation abilities. Furthermore, Bell et al. (2019) show that, even when innovation abilities are heterogeneous and unknown at the point of career choice, the elasticity of innovation with respect to top income tax rates is likely to be small in a standard expected utility model. Indeed, top income tax changes only affect payouts when inventors have very high incomes and low marginal utility.

Figure 12 focuses on the case where heterogeneity in inventors' incomes is unknown. In this setting, as the skewness of stochastic shocks rises, both the elasticities of the number of inventors and quality-weighted innovation with respect to tax rates converge to zero if agents are risk averse. To illustrate the logic underlying this result, think of an example with two states of the world: a bad state in which innovation has zero return and a good state in which innovation has a large payoff, for example $10 million. In the bad state, taxes have no impact on utility. In the good state, a smaller payout (e.g., $9 million instead of $10 million) would not reduce an agent's incentive to become an inventor significantly, because the marginal utility of consumption is already low. Intuitively, when returns are very skewed, taxes only affect inventors' payoffs when they are very rich and are not sensitive to financial incentives, resulting in small behavioral responses. Put another way, when innovation has very risky payoffs, inventors must enter innovation partly because of its nonmonetary benefits and due to intrinsic motivation, making their behavior less sensitive to financial incentives.

-- Figure 12 here –

Thus, low taxes on top income may not be necessary to attract talented individuals into innovators' careers, both when heterogeneous abilities are known or uncertain. Although empirical evidence supporting these model-based predictions remains scant to date, these results call for a cautious assessment of the impacts of financial incentives and a greater focus on alternative policies to increase the supply of inventors, for example through education and mentorship.

3.3 Due to market size effects, the rate and direction of innovation depends on the entire tax system, not just to top tax rates

Because innovators are typically at the top of the income distribution, the debate on financial incentives and innovation often focuses on top tax rates. However, recent work highlights that the incentives to innovate depends more broadly on the entire tax system. Tax rates along the income distribution and the amount of redistribution change the relative market size of necessities and luxuries, which governs the financial incentives to innovate toward luxuries or necessities. Jaravel and Olivi (2021) study this channel in a model of optimal redistribution taxation à la Mirrlees (1971) with non-homotheticities, segmented markets, and increasing returns to scale consistent with empirical evidence (i.e., an increase in market size leads to a fall in the price index through endogenous innovation and entry). They show that endogenous innovations and price changes affect the marginal utility of disposable income and generate income effects such that it is optimal to increase redistribution toward households with a higher marginal propensity to spend on goods with falling relative prices. For example, an increase in redistribution to low-income households increases the market size of necessity products, whose price falls because of endogenous innovations targeting necessities. As a result, the social marginal utility of redistributing an additional dollar to low-income groups increases, because they face lower prices and therefore a larger utility increase from additional spending. This endogenous increase in the value of redistribution at the bottom leads to more redistribution, which amplifies the endogenous innovation reducing the costs of necessities, hence the value of further redistribution toward low-income groups, and so on. This channel shows that the relationship between income inequality and creative destruction is nuanced – more redistributive tax systems may re-direct innovation toward necessities and thus promote inclusive growth.

4. Innovation policies and inequality

The previous sections have highlighted how a variety of channels may affect both innovation and inequality. We now examine which policies have the most potential to achieve better outcomes for both innovation and inequality.

4.1 Broadening the toolkit of innovation policies

Any analysis of how innovation policies may affect not only innovation but also inequality necessitates that one defines what is meant by "innovation policies" and clearly delineates what types of inequality are taken into consideration. Traditionally, economists have viewed innovation policy to consist mostly of public funding of private R&D in one way or another, and intellectual property protection. Current practice is one justification for this view as other potential tools such as prizes and contests, public procurement and promotion of research joint ventures have largely played a secondary role.

The traditional approach is however unnecessarily narrow: a broader view considers any policy that has an impact on the innovative potential of an economy as part of innovation policy.[6] This approach brings into consideration education policy, basic research, taxation, competition policy, immigration rules, trade policy and potentially others, too. We argue that, especially when the attention is aimed at the effects of innovation on inequality, the emphasis should be on the indirect policies, and education and competition policy in particular. This argument rests partly on our view that the two most important dimensions of inequality one should consider when designing innovation policy are income inequality and inequality in market outcomes, i.e., the possibility that even those incumbents who rose to prominence on the strength of their innovativeness may over time become entrenched, at the expense of potential newcomers and thereby the

[6] Takalo and Toivanen (2016) make a distinction between direct (government funding of private R&D, intellectual property protection, …) and indirect innovation policies. Without making such a clear categorization, Bloom et al. (2019) also, in discussing a "toolkit" for innovation policy, consider a broader array of policies than the direct or traditional ones. They, too, point out that (certain) education policies improve innovation and reduce inequality.

society at large.[7] The latter dimension is important primarily as it eventually may feed into the first dimension.

Given this choice, we do not discuss direct innovation policies, but concentrate on the role of education and the role of competition policy.[8] In the next section we discuss the role of education before turning to competition policy in the following one.

4.2. Education and invention

4.2.1 The causal effect of access to education on innovation

There are several interlinked arguments that suggest that one should view education as part of innovation policy. The most important one is that the advances in technology notwithstanding, invention is still a human activity. The second one is that data strongly suggests that modern-day innovation requires specific training and human capital. The final one has to do with our emphasis on the effects of innovation and policy on inequality: the educational system plays an important role in enabling or hindering social mobility.[9]

At least since the late 19th century, inventors have been highly-educated (though not necessarily so earlier; see Khan and Sokoloff 2004). Modern data shows irrefutably that invention is to a large extent the prerogative of those with the right education. Giuri et al. (2007), using data from the European – wide PatVal – survey, document that 77% of inventors have at least a master's degree and 26% a PhD. Similar descriptive statistics have been reported also for non-European countries (e.g., Onishi and Nagaoka 2012). Toivanen and Väänänen (2016) find that in late 20th century Finland, engineers dominate patenting. Below we present a graph from Aghion et al. (2018) displaying how the probability of becoming an inventor is related to own education in Finland. What emerges strongly from the figure is that having a STEM education in general (the red bars), and a high STEM education, in particular, is highly associated with the probability of becoming an inventor.

[7] This is obviously a choice one may criticize. An obvious criticism is that with this choice we sidestep the important question of gender inequality in invention. It is well documented that women are badly underrepresented in invention. An emerging literature tackles both the challenges along the educational path (Kongstedt et al. 2020) as well as in research (Kim and Moser 2021) that women face. Toivanen and Väänänen (2016) find that once they control for (endogenous) education, there are no gender differences in the probability of becoming an inventor despite the fact that less than 10% of inventors in their data are female.

[8] Bloom et al. (2019) and Takalo and Toivanen (2016) are two recent surveys of the academic literature related to innovation policy widely defined. A distinction between them is that the latter authors discuss the differences between a large (closed) economy and a small open economy.

[9] In line with most of the literature, we mean inventors of patented inventions when we talk about inventors. This is an obvious limitation of the literature, this chapter included.

Figure 13. Own education and the probability to invent.

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The relation between STEM (or more narrowly engineering) education and invention has not gone unnoticed by policymakers. Developing countries, India and China in the vanguard, have invested heavily in engineering education in the last few decades; and a perennial worry in the US is that the drawing power of STEM studies is waning (e.g. Task Force on the Future of American Innovation).

A key question regarding the undisputed positive association between education and invention is whether there is a causal relationship or not. This is of first-order importance for policy: If the relationship is purely an association, it would imply that the role of (STEM / engineering) education is to act as a sieve, catching as many individuals as possible who possess the capacity to become inventors. If the relationship is causal, it opens the door for a potentially large improvement in the inventive capacity of a society as the number of inventors can be increased much more.

Toivanen and Väänänen (2016) provide the first evidence that the relationship may be causal. Using the distance to nearest (technical) university at the age of 19 as an instrument and leveraging the expansion of the Finnish university system in the 1950s and 1960s they find that obtaining a university (M.Sc) engineering education increases the probability of becoming an inventor by 5 percentage points. Compared to the share of inventors in the population at large which is round 1% (see Aghion et al. 2021), this is obviously a very large effect.

A related stylized fact is the relationship between parental education and invention. This is illustrated in Figure 14 (Aghion et al. 2018) which shows how the probability of becoming an inventor grows steeply with both maternal and paternal education, and in particular, with the STEM education of the parents.

Figure 14. Parental education status and becoming an inventor.

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There is thus evidence supporting the view that increasing the number of individuals who obtain a STEM / engineering degree will increase invention. There is also evidence that invention increases both the inventing individuals' income (see Toivanen and Väänänen 2012, Bell et al. 2019b), and that of their coworkers (van Reenen, 1996, Aghion et al. 2018, Klein et al. 2020, Aghion et al. 2021b). Regarding the relation between invention and income inequality, the key question then becomes access to education. From the point of view of invention and the point of view of enhancing intergenerational mobility, equal access to educational tracks that lead to a STEM education is key.[10]

The ongoing research of Aghion et al. (2021b), showing that parental STEM education has a large positive causal impact on the probability of children becoming inventors further raises the stakes regarding intergenerational mobility. If the education system is biased in favor of e.g. those with a high income, one may lose inventors not only in the immediate generation, but also the following ones as talented young from less privileged backgrounds do not obtain the education that would have raised the probability of both them and their offspring becoming inventors.

4.2.2 The importance of policies promoting exposure to innovation

There is mounting evidence that promoting innovation requires moving beyond general human capital policies to provide specific exposure to innovation careers. As we discussed in section 3, Bell et al. (2019) provide evidence that the proximity to inventors in childhood has a causal effect on the probability of becoming an inventor.

Recent randomized control trials have shown the importance of mentoring programs and role-model effects in shaping career choice, in particular for STEM fields and fields likely to promote innovation. For example, Breda et al. (2020) show that a brief exposure to female role models working in scientific fields affects high school students' perceptions and choice of undergraduate major. The intervention caused a significant 2.4-percentage-point increase in STEM undergraduate enrolment among girls in Grade 12, i.e. an increase of 8 percent over the baseline rate of 29 percent. As shown in Figure 15, the effects on educational choices are concentrated among high-achieving girls in Grade 12, who are more likely to enrol in selective and male-dominated STEM programs in college. In contrast, the effect for boys was negligible.

Figure 15. Role models and becoming an inventor

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Relying on rich survey data, Breda et al. (2020) distinguish between various potential mechanisms that could explain the large effects of role models. In principle, role models could (i) affect students' preferences by increasing their taste for science; (ii) change their expectations by modifying their beliefs regarding careers in science, in particular with respect to the place of women in those careers; and (iii) counteract the

[10] It may also be that providing equal access requires more than just the right education policies: There is evidence (see e.g. Figures 6 and 7 in UNESCO 2017). that in more developed countries, gender segregation in higher education regarding STEM education is increasing, i.e., young talented females choose other educational paths.

effects of gender norms on students' social identity. The authors find evidence supporting primarily the second and third of these mechanisms. They also show that the most impactful role model interventions are those that did not overemphasize women's underrepresentation in science.

In related work, Falk et al. (2020) estimate the causal effect of mentoring on schooling decisions in Germany. The find that children from an underprivileged background, who were randomly assigned to a mentor for one year, are 20 percent more likely to enter a "high track" program more likely to lead to high-skill jobs, i.e. with more potential for the creation and diffusion of innovations. Scaling-up such interventions should be a priority for policymakers going forward, with the potential to increase long run growth by mobilizing the pool of untapped talent (as discussed in Section 3).

4.3. Competition policy and innovation

Competition policy is an important arena of government decision-making that affects both the forms creative destruction may take as well as the effects creative destruction may have on society. Competition policy may affect creative destruction e.g. by removing restrictions that impede entry of new firms that are created either through mergers among the incumbents, through acquisition of small entrants by dominant incumbents, or by restricting other abusive practices of dominant players. Notwithstanding the fact that the relationship between competition policy is discussed in other articles in this volume (notably those by Rachel Griffiths and John van Reenen and by Richard Gilbert et al.), it is worth devoting it some space here as well as competition policy may directly affect inequality and social mobility with which this chapter is concerned.

It has long been understood that the rather static approach typically taken by competition authorities towards merges may be unsatisfactory. Recent development in several markets, online markets and pharmaceuticals being two prominent examples, suggest that incumbent firms may be engaging in "killer acquisitions" where the economic logic rests on reducing future competition more than on improving one's own productivity.

In a recent paper, Cunningham et al. (2021) provide a model for and find evidence of the phenomenon of killer acquisitions. Using data from the pharmaceutical industry on 16 000 drug projects and 4 000 companies, between 5 and 7% of acquisitions are killer acquisitions where the R&D project of the acquired firm is discontinued after the deal has been consummated. Importantly for policy purposes, such acquisitions happen below the antitrust intervention thresholds.

The relationship between market consolidation and innovation has also attracted the interest of theorists. Federico et al. (2018) find that in their model, merging parties always reduce their R&D investments whereas rivals increase them. Denicolo and Polo (2018), however, note that in the model of Federico et al., innovation may be spurred through the elimination of wasteful duplication.

Federico et al. (2020) provide a wide-ranging analysis of different types of mergers and how innovation would be impacted through them and accompany these with case analyses. They also point out the misplaced use of the existing evidence on the (inverted-U) relationship between competition and innovation in terms of antitrust policy. They summarize their view as follows (pp. 127): "innovation is best promoted when market leaders are allowed to exploit their competitive advantages while also facing pressure to perform coming from both conventional rivals and from disruptive entrants."

Thus, it is crucial to design competition policies that safeguard the entry of new ventures and put limits on the ability of entrenched (dominant) incumbents to buy out their future rivals. To do so, competition policy needs to balance two forces: (i) the need to provide successful innovators rents, and (ii) the need to disallow incumbents to use their financial strength and market power to solidify their position against innovative and more productive entrants. Developing such policies is an important direction for researchers and policymakers going forward, as it has the potential to both increase innovation and reduce inequality in the long run.

5. Conclusion: how to achieve better outcomes for both innovation and inequality

In this survey article, we have reviewed recent evidence characterizing how market forces and policies shape the rate and direction of innovation. Innovation policies can have a first order impact on inequality, both in the short and in the long run. A standard view highlights that policymakers may face a dilemma between increasing innovation and reducing inequality. Indeed, enhancing innovation may lead to increased inequality through various market mechanisms, which we reviewed in Section 2. Taking these market mechanisms as given, policymakers may have to tolerate increasing inequality to achieve higher rates of innovation, while at the same time ensuring that inequality does not increase to the extent that it would stifle innovation through endogenous entry barriers.

Notwithstanding the prevalence and empirical relevance of the traditional view, recent work characterizes several market and social mechanisms whereby inequality acts as an important determinant of the rate and direction of innovation, such that there is no tradeoff between innovation and inequality, as we discussed in Section 3. Recent findings on how the direction of innovation differentially affects different socio-economic groups, how social background affects the prospects of becoming an inventor, and whether and how the tax system affects incentives to invent all call for a holistic yet nuanced approach to policy.

Leveraging these mechanisms is an important direction for policy to achieve better outcomes for both innovation and inequality.

In Section 4, we argued that two policies, which are not traditionally viewed as part of innovation policy, play a key role to achieve the goal of increasing innovation while reducing inequality: education and competition policy. An educational system that enables individuals to pursue an education that leads to the possibility of becoming an inventor, irrespective of the social and financial background, is likely to lead to both more innovation and less inequality. Such policies would ensure that (i) all children, in particular from less privileged backgrounds, have the possibility of obtaining an education that matches their talents, (ii) all children are encouraged to pursue careers in science and innovation, especially when they are unlikely to have role models in these careers, for example due to their family background or because of gender norms. By creating incentives to displace incumbents through innovation, both by facilitating entry and by restricting the ability of incumbents to abusively exploit their position, competition policy also has the potential to simultaneously increase innovation and reduce inequality.

References

Acemoglu, Daron, "Technical Change, Inequality, and the Labor Market," *Journal of Economic Literature*, mar 2002, *40* (1), 7–72.

Acemoglu, D. and Restrepo (2021), Technology and Inequality, IFS Deaton Review.

Acemoglu and David H. Autor, "Skills, Tasks and Technologies: Implications for Employment and Earnings," in "Handbook of Labor Economics" number 4. In 'Orley Ashenfelter and David E. Card (eds.),.', Amsterdam: Elsevier, 2011, pp. 1043–1171.

Aghion, P. C. Antonin and S. Bunel, (2021) The Power of Creative Destruction, Princeton University Press.

Aghion, P., Akcigit, U., Bergeaud, A., Blundell, R., and Hemous, D (2019) "Innovation and Top Income Inequality", Review of Economic Studies, 86, 1-45.

Aghion, Akcigit, Deaton, and Roulet (2016) Creative Destruction and Subjective Well-Being, *American Economic Review*, 106(12), 3869-97

Aghion, P., Akcigit, U., and Howitt, P (2014), "What Do We Learn from Schumpeterian Growth Theory?", in *Handbook of Economic Growth*, ed. by P. Aghion and S. Durlauf, Vol 2B: 515-563.

Aghion, Philippe, Akcigit, Ufuk, Hyytinen, Ari and Otto Toivanen. 2018. The social origins of inventors. NBER working paper 24110.

Aghion, Philippe, Akcigit, Ufuk, Hyytinen, Ari and Otto Toivanen. 2018b. On the returns to invention within firms: Evidence from Finland. *American Economic Association, Papers&Proceedings*, 108, 208-212.

Aghion, Philippe, Akcigit, Ufuk, Hyytinen, Ari and Otto Toivanen. 2021. A Year Older, A Year Wiser (and Farther from Frontier): Invention Rents and Human Capital Depreciation. mimeo.

Aghion, Philippe, Akcigit, Ufuk, Hyytinen, Ari and Otto Toivanen. 2021b. Parental education and invention. Work in progress.

Aghion, P., Bergeaud, A., Blundell, R. and R. Griffith (2021), "Soft skills and the wage progression of low-educated workers", Working Paper.

Aghion, P., N. Bloom, R. Blundell, R.Griffith, and P.Howitt (2005) 'Competition and Innovation: An inverted U relationship', *The Quarterly Journal of Economics,*Vol.120, (2) May 2005.

Aghion, Philippe, Richard Blundell, Rachel Griffith, Peter Howitt and Susanne Prantl (2008) 'The effects of entry on incumbent innovation and productivity' (with *Review of Economics and Statistics*, MIT Press, vol. 91(1), pages 20-32, October.

Aghion, Philippe and Rachel Griffith (2021) Deaton Review

Autor, David, David Dorn, Lawrence F Katz, Christina Patterson, and John Van Reenen. 2020. "The fall of the labor share and the rise of superstar firms." *The Quarterly Journal of Economics* 135 (2):645–709.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova and John Van Reenen (2019) "Who become an investor in America? The importance of exposure to innovation" Quarterly Journal of Economics, 134: 2, May 2019, 647 – 713.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova and John Van Reenen. (2019b.) Do tax cuts produce more Einsteins? The impacts of financial incentives versus exposure to innovation on the supply of inventors. Journal of European Economic Association, 17, 3, 651-677.

Bertrand, Marianne, Matilde Bombardini, and Francesco Trebbi (2014) "Is it whom you know or what you know? an empirical assessment of the lobbying process" American Economic Review, 104 (12), December 2014, 3885 – 3920

Bloom, Nicholas, van Reenen, John, and Heidi Williams, 2019. Toolkit for policies to promote innovation. Journal of Economic Perspectives, 33, 3, 163-84.

Boppart and Weiss (2013)

Breda, Thomas, Grenet, Julien, Monnet, Marion and Clémentine van Effenterre, 2021. "**Do Female Role Models Reduce the Gender Gap in Science? Evidence from French High Schools**," PSE Working Papers halshs-01713068, HAL.

Bryan and Williams (2021). Innovation: Market failures and public policies. In Armstrong, Mark and Robert Porter (eds.) Handbook of Industrial Organization, 3rd edition. North Holland.

Buhai, I.S., Portela, M.A., Teulings, C.N. et van Vuuren, A. (2014), "Returns to Tenure or Seniority?", Econometrica, 82(2): 705–30.

Cunningham, C., Ederer, F., and S. Ma. 2021. Killer Acquisitions. Journal of Political Economy, 129, 3, 649-702.

Denicolo, V., and M. Polo, 2018. Duplicative Research, Mergers and Innovation. Economics Letters, 166, 56-59.

Falk, Armin, Kosse, Fabian and Pia Pinger. 2020. Mentoring and schooling decisions: Causal evidence. IZA DP13387.

Federico, G., Langus, G., and T. Valletti, 2017. A Simple Model of Mergers and Innovation. Economics Letters, 157, 136-140.

Federico, G., Scott Morton, F. and C. Shapiro, 2020. Antitrust and Innovation: Welcoming and Protecting Disruption. Innovation Policy and the Economy vol. 20.

Frank, Murray and Vidhan K. Goyal, 2009 Capital Structure Decisions: Which Factors Are Reliably Important? Financial Management, 38(1) , 1-37.

Chetty, R., Hendren, N., Kline, P., and Saez, E (2014), "Where Is the Land of Opportunity? The Geography of Intergenerational Mobility in the United States", *Quarterly Journal of Economics*, 129, 1553-1623.

De Loecker, Jan, Jan Eeckhout, and Gabriel Unger. 2020. "The rise of market power and the macroeconomic implications." *The Quarterly Journal of Economics* 135 (2):561–644.

De Loecker, Obermeier and Van Reenen, 2021 "Firms and inequality", Deaton Review, IFS, May

Deaton, A (2013), *The Great Escape: Health, Wealth, and the Origins of Inequality*, Princeton University Press

Delestre, A, H. Miller, K. Smith (2021) Taxation and Top Income Inequality, IFS Deaton Review, IFS, May.

Depalo, D., and S. Di Addario (2014), Inventors' Returns to Patents Domenico, Bank of Italy, January.

Eeckhout (2021) Market Power and Inequality, IFS Deaton Review, IFS, May.

Gabaix X, Lasry J-M, Lions P-L, Moll B. The Dynamics of Inequality. *Econometrica*. 2016;84 (6) :2071-2111.

Garin, A., and F Silverio (2018), How Responsive are Wages to Demand within the Firm? Evidence from Idiosyncratic Export Demand Shocks, NBER, November.

Giuri, P., M. Mariani, S. Brusoni, G. Crespi, D. Francoz, A. Gambardella, W. Garcia-Fontes, A. Geuna, R. Gonzales, D. Harhoff, et al. 2007. Inventors and Invention Processes in Europe: Results from the PatVal-EU Survey. Research Policy 36, 8, 1107–1127.

Goldin, Claudia and Lawrence F. Katz, *The Race between Education and Technology*, Belknap Press, 2010.

Griffith, Redding and Van Reenen (2004) "Mapping the two faces of R&D: productivity growth in a panel of OECD industries" *Review of Economics and Statistics*, 86(4), Nov 2004

Jager, S. and J Heining (2019) "How Substitutable are Workers? Evidence from Worker Deaths," mimeo MIT.

Jaravel, X. (2019) The Unequal Gains from Product Innovations: Evidence from the U.S. Retail Sector *Quarterly Journal of Economics*,

Khan, Zorina and Kenneth Sokoloff, 204. Institutions and democratic invention in 19th-century America: Evidence from "great inventors" 1790-1930. American Economic Review Papers and Proceedings, 94, 2, 395-401

Kim, Scott and Petra Moser. 2021. Women in science. Lessons from the baby boom. Mimeo.

Klein, P., Petkova, N., Williams, H., and Zidar, O., 2019. Who profits from patents ? Rent-sharing at innovative firms. Quarterly Journal of Economics, 1343-1404.

Hoisl, Karen, Kongsted, Hans-Christian and Myriam Mariani. 2020. Lost Marie Curies: Parental Impact on the Probability of Becoming an Inventor. Mimeo, Copenhagen Business School.

Krusell, Per, Lee E Ohanian, José-Víctor Ríos-Rull, and Giovanni L Violante, "Capital-skill complementarity and inequality: A macroeconomic analysis," *Econo- metrica*, 2000, *68* (5), 1029–1053

Linder (1961)

Onishi. Koichiro and Sadao Nagaoka. 2012. Life-cycle Productivity of Industrial Inventors: Education and other determinants. Mimeo.

Rossman, Joseph. 1931. The Motives of Inventors. Quarterly Journal of Economics, 45, 522–528.

Schmookler, Jacob. (1926). Inventors past and present. Review of Economics and Statistics, 39, 3, 321-333.

Stantcheva, S. (2021) The Effects of Taxes on Innovation: Theory and Empirical Evidence, this volume.

Takalo, Tuomas and Otto Toivanen. 2016. Economics of innovation policy. Nordic Economic Policy Review, 2, 65-90.

Toivanen, Otto and Lotta Väänänen. 2016. Education and Invention. Review of Economics and Statistics 98, 2, 382–396.

UNESCO, 2017. Cracking the code: Girls' and women's education in science, technology, engineering and mathematics. UNESCO 2017, ISBN 978-92-3-100233-5. https://unesdoc.unesco.org/ark:/48223/pf0000253479

Van Reenen, John. (1996). The Creation and Capture of Rents: Wages and Innovationin a Panel of U.K. Companies'. Quarterly Journal of Economics 111(1), 195–226.

Van Reenen (2021) Innovation and Human Capital Policy, in A. Goolsbee and B. Jones, eds., Handbook of Innovation and Public Policy, NBER, University of Chicago Press.

Table 1: Top 1% income share and innovation

Dependent variable	Log of Top 1% Income Share					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of innovation	Patents	Cit5	Claims	Generality	Top5	Top1
Innovation	0.031***	0.049***	0.017*	0.024**	0.026***	0.020***
	(0.011)	(0.009)	(0.009)	(0.010)	(0.005)	(0.004)
Gdppc	0.089**	0.063	0.096**	0.093**	0.074*	0.087**
	(0.043)	(0.044)	(0.045)	(0.043)	(0.043)	(0.043)
Popgrowth	0.943	1.089	0.943	0.934	0.990	1.074
	(0.654)	(0.700)	(0.651)	(0.647)	(0.690)	(0.685)
Finance	0.080**	0.109***	0.072**	0.078**	0.098***	0.094***
	(0.035)	(0.036)	(0.035)	(0.035)	(0.035)	(0.035)
Government	-0.018	-0.019*	-0.018	-0.018	-0.018	-0.016
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Unemployment	-0.006**	-0.006*	-0.005*	-0.006*	-0.006*	-0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
TaxK	-0.038***	-0.039***	-0.038***	-0.038***	-0.038***	-0.037***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
TaxL	0.017***	0.014**	0.017***	0.018***	0.013**	0.013**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
R^2	0.889	0.896	0.889	0.889	0.895	0.895
Observations	1734	1581	1734	1734	1581	1581

Notes: Variable description is given in Table 1. Innovation is taken in log and lagged by two years. The dependent variable is the log of the top 1% income share. Panel data OLS regressions with state and year fixed effects. Time span for innovation: 1976-2009 (columns 1, 3 and 4) and 1976-2006 (columns 2, 5 and 6). Autocorrelation and heteroskedasticity robust standard errors using the Newey-West variance estimator are presented in parentheses. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

Source: Aghion, Akcigit, Bergeaud, Blundell, and Hemous (2019)

Table 2: Top 1% income share, innovation and the role of lobbying intensity

Dependent variable	Log of Top 1% Income Share					
	(1)	(2)	(3)	(4)	(5)	(6)
Measure of innovation	Patents	Cit5	Claims	Patents	Cit5	Claims
Innovation						
by entrants	0.905***	0.527**	0.837***			
	(0.000)	(0.014)	(0.000)			
by incumbents				0.246	0.196	0.307*
				(0.172)	(0.312)	(0.091)
Lobbying×Innovation						
by entrants	-0.051***	-0.030**	-0.048***			
	(0.000)	(0.015)	(0.000)			
by incumbents				-0.016	-0.011	-0.019*
				(0.132)	(0.320)	(0.073)
Lobbying	-0.305	-0.151	-0.095	0.053	-0.100	0.079
	(0.245)	(0.468)	(0.683)	(0.813)	(0.631)	(0.707)
Gdppc	0.107	0.014	0.105	0.095	-0.013	0.091
	(0.384)	(0.924)	(0.397)	(0.473)	(0.929)	(0.482)
Popgrowth	0.401	-0.146	0.379	0.640	0.150	0.622
	(0.738)	(0.897)	(0.754)	(0.613)	(0.902)	(0.622)
Finance	-0.021	-0.062	-0.027	-0.019	-0.057	-0.018
	(0.726)	(0.326)	(0.663)	(0.749)	(0.348)	(0.754)
Government	-0.107*	-0.189***	-0.108*	-0.117*	-0.221***	-0.115*
	(0.085)	(0.006)	(0.086)	(0.066)	(0.001)	(0.064)
Unemployment	-0.010**	-0.022***	-0.010**	-0.011**	-0.023***	-0.011**
	(0.026)	(0.000)	(0.023)	(0.016)	(0.000)	(0.015)
TaxK	-0.013**	-0.014**	-0.012**	-0.013**	-0.015***	-0.013**
	(0.025)	(0.012)	(0.028)	(0.023)	(0.010)	(0.022)
TaxL	-0.002	0.003	-0.003	-0.002	0.003	-0.002
	(0.840)	(0.815)	(0.815)	(0.844)	(0.811)	(0.884)
R^2	0.684	0.739	0.685	0.678	0.734	0.677
Observations	714	561	714	714	561	714

Notes: Lobbying is measured as explained in subsection 4.4. Other variable description is given in Table 1. Innovation is taken in log and lagged by two years. Columns 1 to 3 consider entrant innovation whether columns 4 to 6 consider incumbent innovations. The dependent variable is taken in log. Panel data OLS regressions with state and year fixed effects. Time span for innovation: 1996-2009 (columns 1, 3, 4 and 6) and 1996-2005 (columns 2 and 5). Autocorrelation and heteroskedasticity robust standard errors using the Newey-West variance estimator are presented in parentheses. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

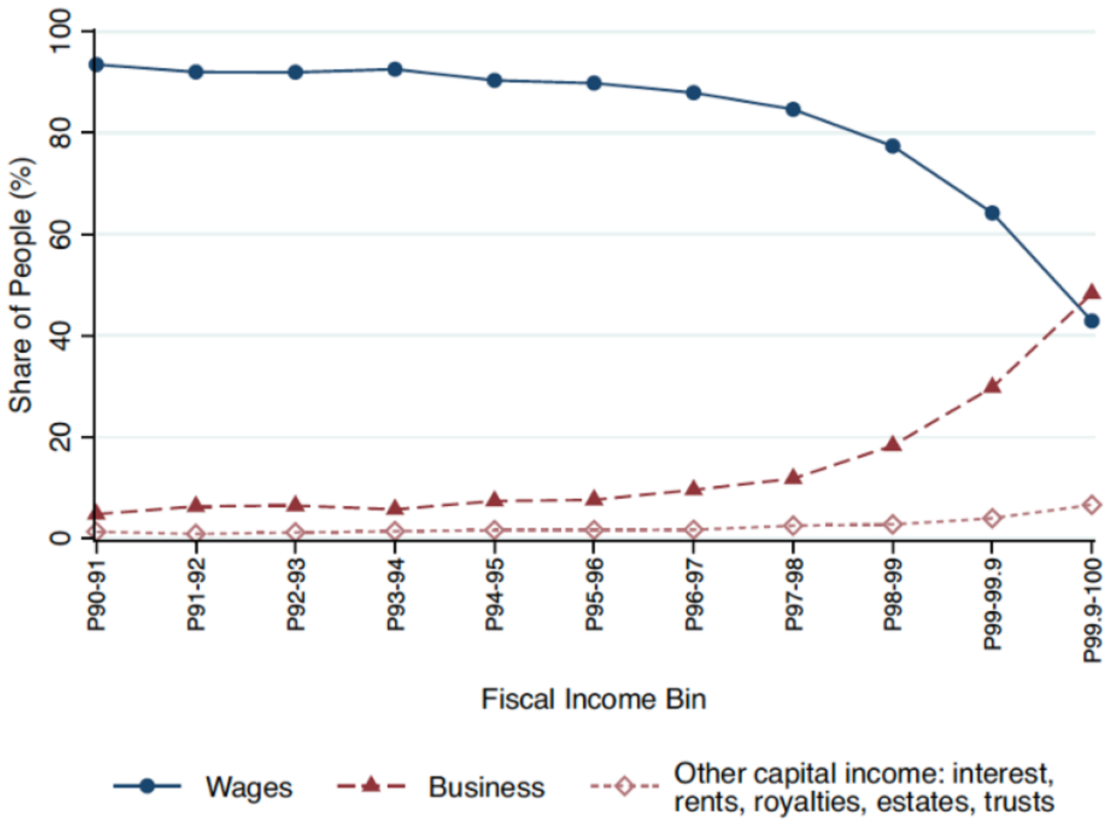
Source: Aghion, Akcigit, Bergeaud, Blundell, and Hemous (2019)

Table 3: Green Innovations are More Frequent for Female and Younger Inventors

	Clean Patent	
	(1)	(2)
Female Inventor	0.326***	
	(0.014)	
Average Inventor Age		-0.001*
		(0.0006)
Mean	0.286	0.132
N	53,984	1,243

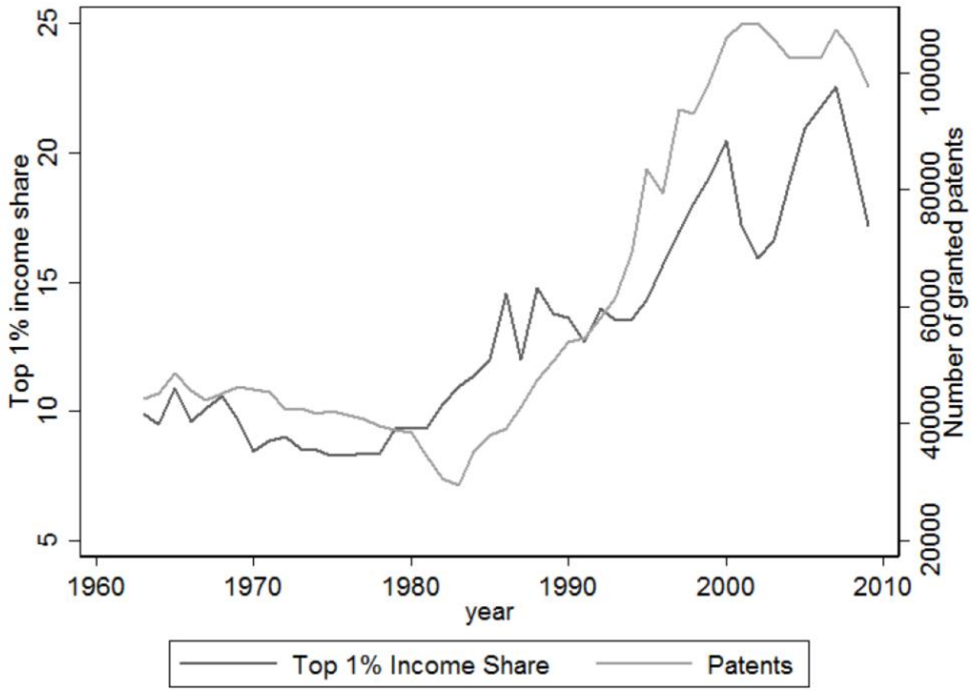
Source: Einio, Feng and Jaravel (2020).

Figure 1: Entrepreneurial income is a large portion of top incomes



Source: Smith, M., D. Yagan, O. Zidar, and E. Zwick (2019) 'Capitalists in the 21st Century'.

Figure 2: Innovation and Top 1% income share in the US. 1963-2010

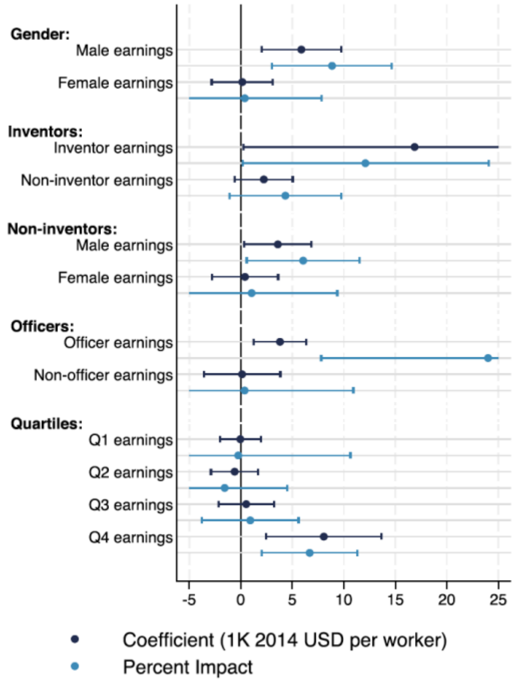


Source: Aghion, Akcigit, Bergeaud, Blundell, and Hemous (2019)

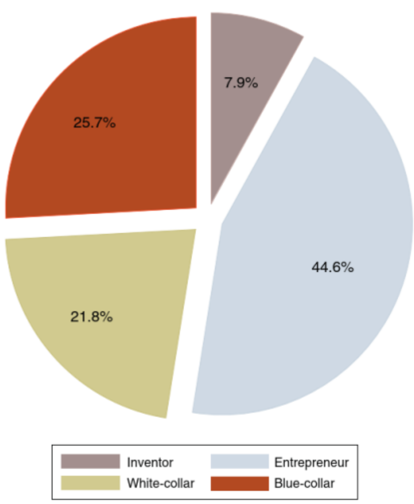
Notes: This figure plots the number of granted patents distributed by their year of application against the top 1% income share for the USA as a whole. Observations span the years 1963-2009. Top 1% income shares come from Frank (2009) and patent data come from the USPTO.

Figure 3: The Distributional Effects of Patents

Panel A: The Within Firm Distribution of Profits from Patents in the United States

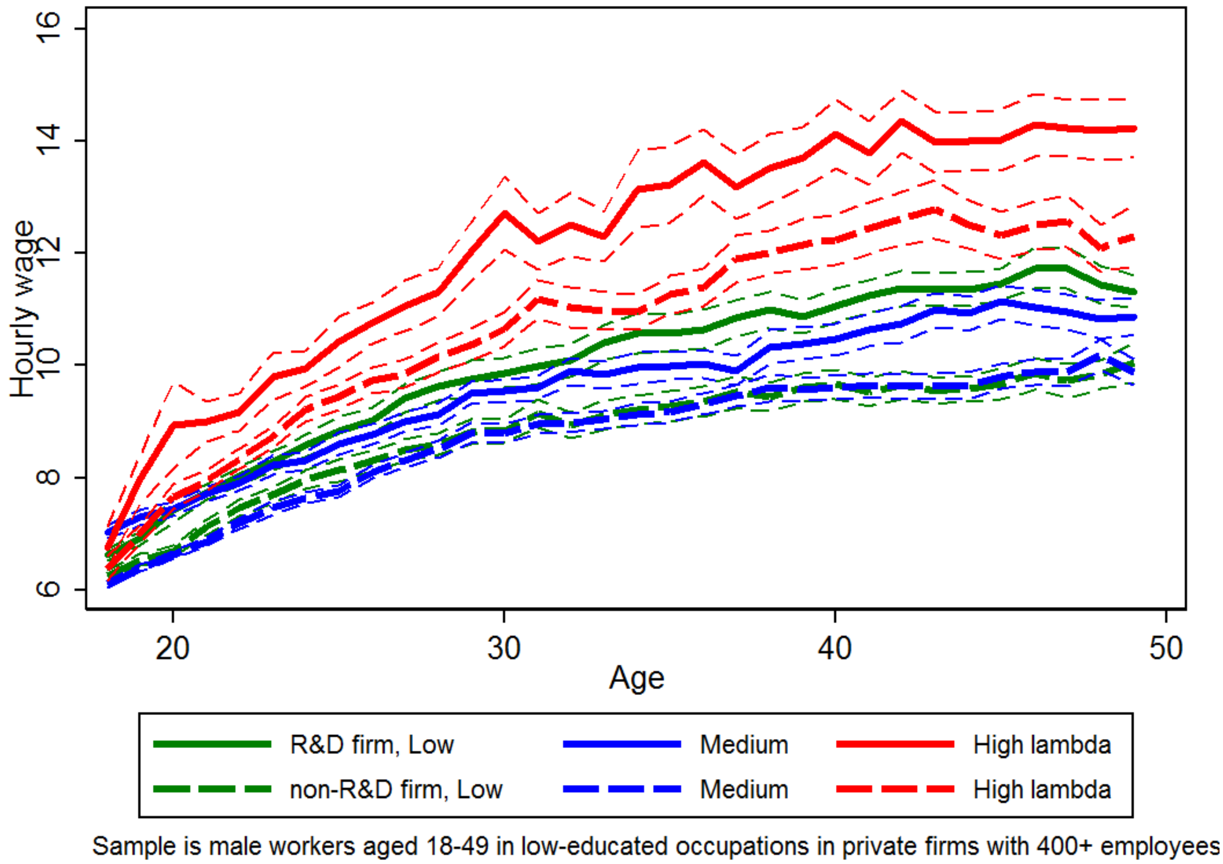


Panel B: Distribution of innovation returns among different workers in the firm in Finland



SourceS: Panel A: Kline, Petkova, Williams and Zidar (2019); Panel B: Aghion et al (2018).

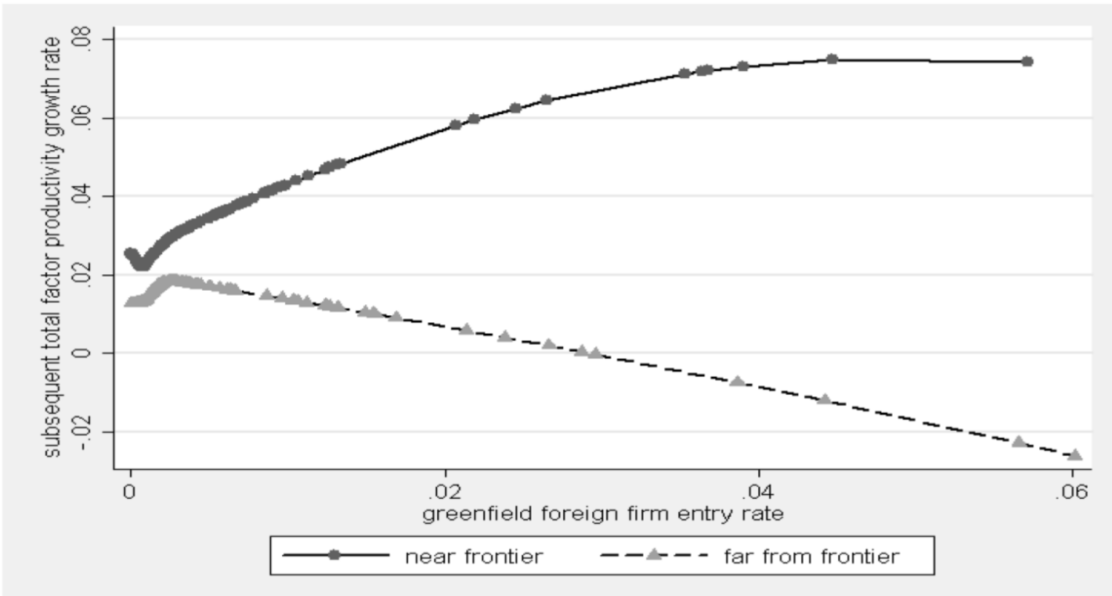
Fig 4 Soft skills and wage progression for low-educated workers



Source: Aghion, Bergeaud, Blundell and Griffith (2021)

Notes: matched employer-employee data for UK 2004-2016; average hourly wage for workers in low-skilled occupation in innovative and non-innovative firms, by degree of soft-skills (lambda).

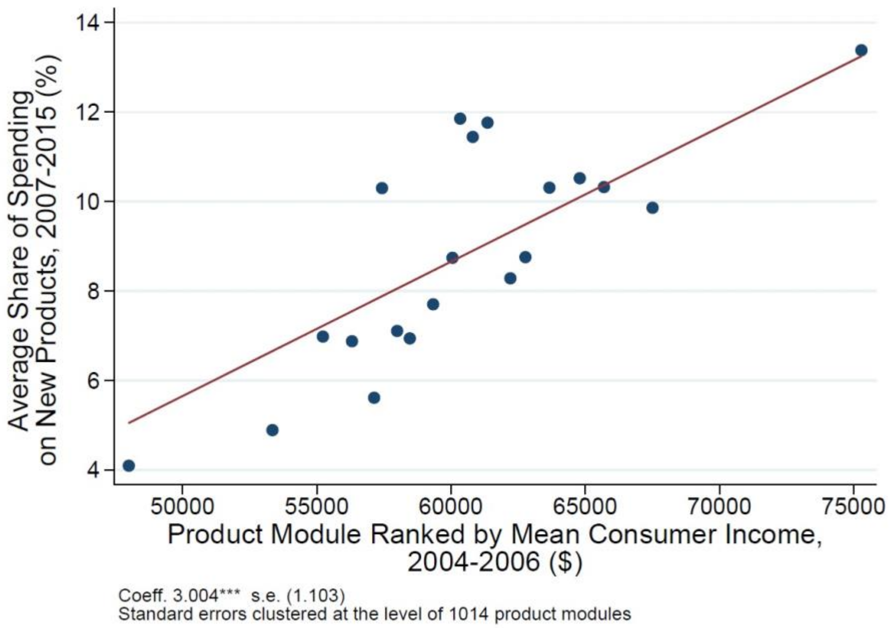
Fig5: Reactions to entry in incumbents near and far from the technology frontier



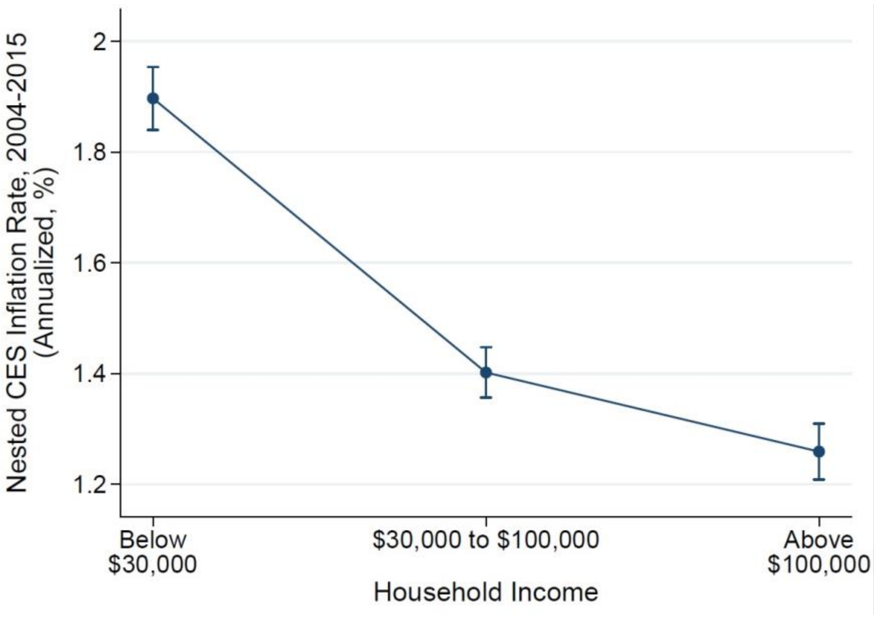
Source: Philippe Aghion, Richard Blundell, Rachel Griffith, Peter Howitt and Susanne Prantl (2008) "The effects of entry on incumbent innovation and productivity," *Review of Economics and Statistics, Vol. 91, No. 1, pp. 20-32*

Figure 6: High-income consumers benefit from a faster increase in product variety and lower inflation

Panel A: Household income and increase in product variety

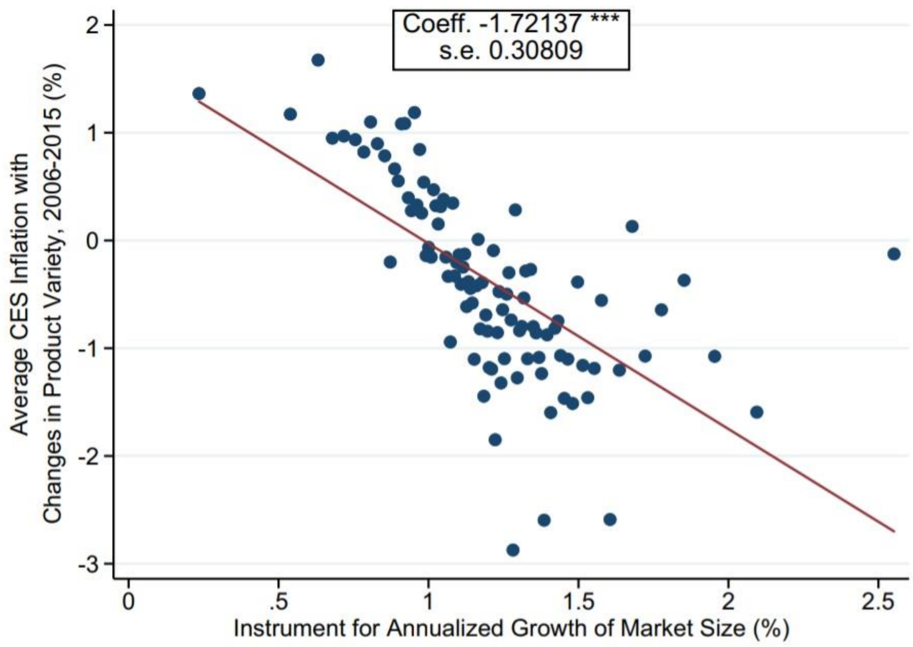


Panel B: Household income and inflation



Source: Jaravel (2019).

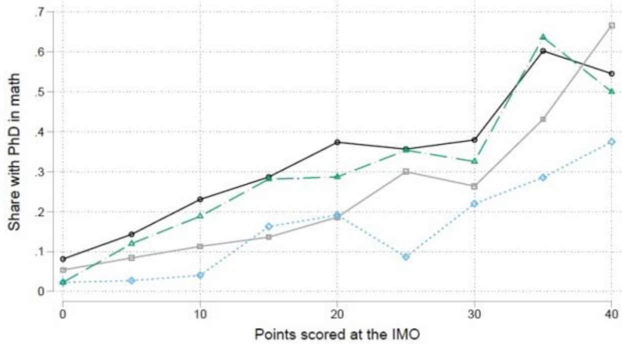
Figure 7: The effect of changes in demand on inflation and product variety



Source: Jaravel (2019).

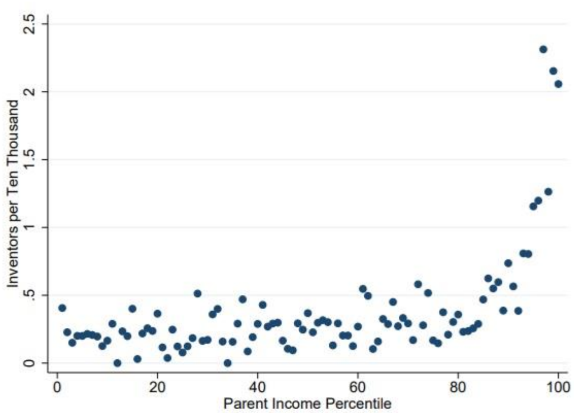
Figure 8: Unequal access to science and innovation careers around the world and over time

Panel A: Share getting a PhD in mathematics across country income groups depending on rank at the International Mathematical Olympiad

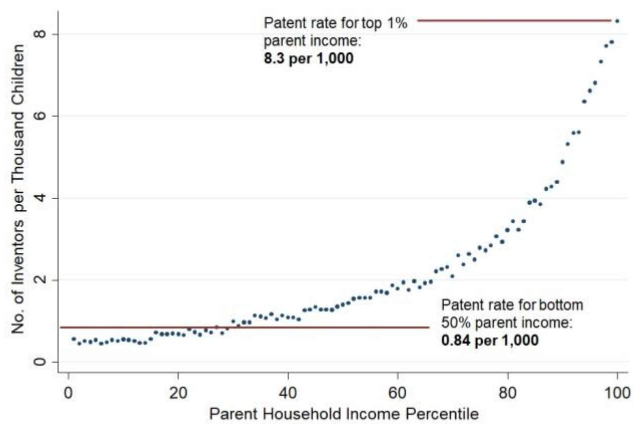


Panel B: Evidence from patent inventors in the United States

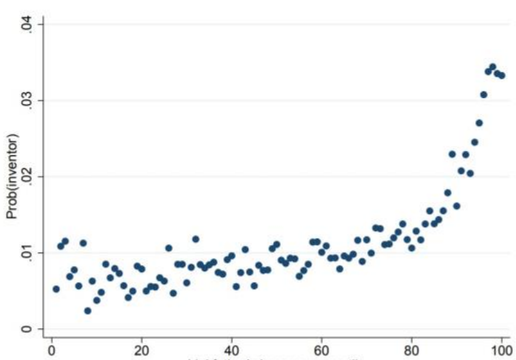
(i) United States in 1880-1940



(ii) United States post 1980



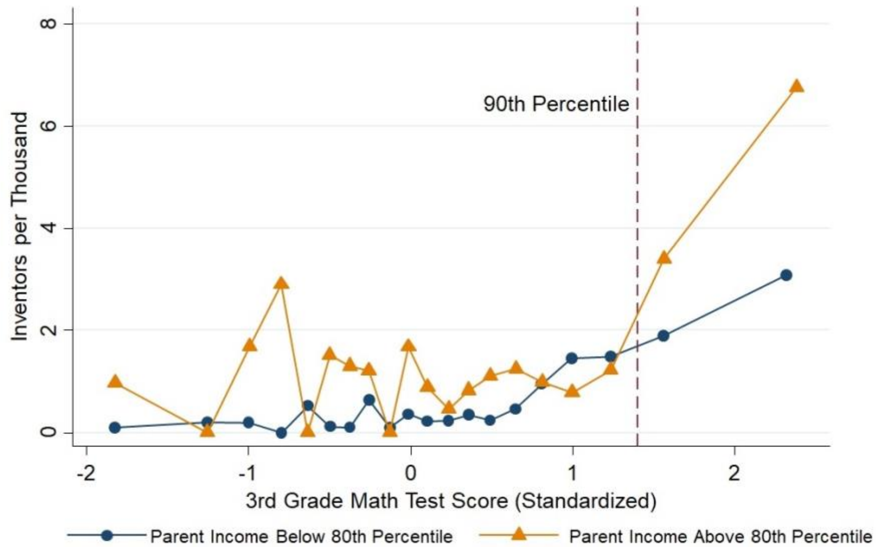
Panel C: Evidence from patent inventors in Finland



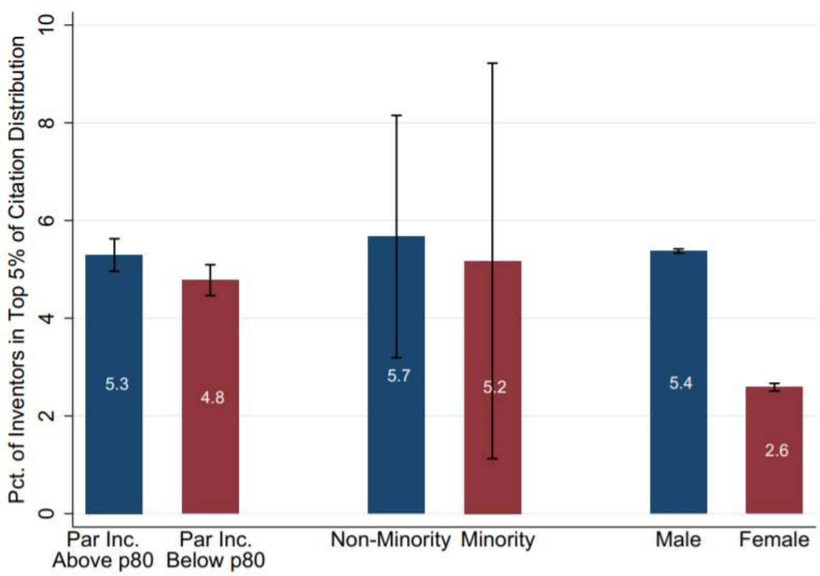
Source: Panel A: Agarwal and Gaule (2020); panel B(i): Akcigit, Grigsby and Nicholas (2019); panel B(ii): Bell, Chetty, Jaravel, Petkova and Van Reenen (2019); Panel C: Aghion et al. (2018).

Figure 9: Unequal access to innovation conditional on test scores and for the most impactful innovations

Panel A: 3rd-grade math tests scores and propensity to become a patent inventor

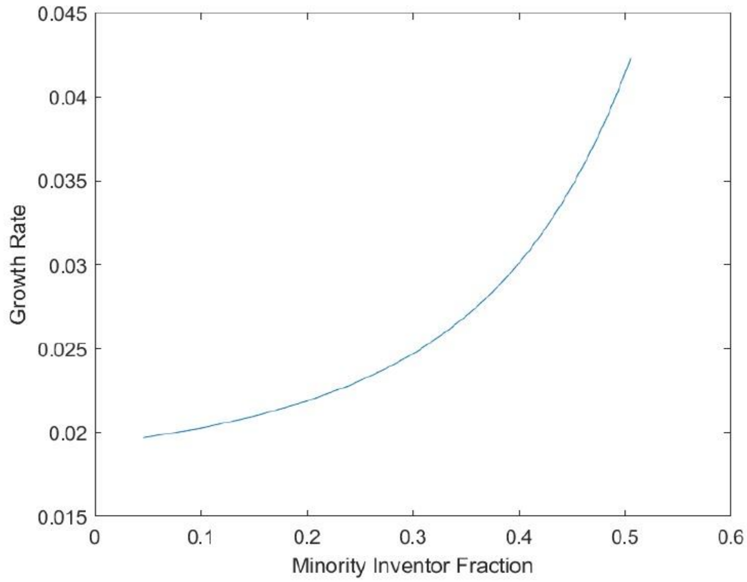


Panel B: Citations of inventors by characteristics at birth



Source: Bell, Chetty, Jaravel, Petkova and Van Reenen (2019).

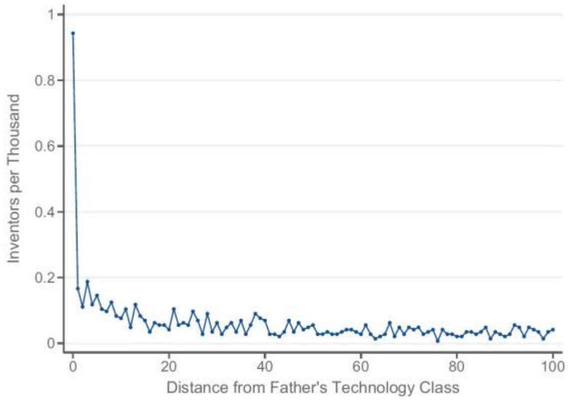
Figure 10: Predicted impact of equalizing access to innovation on the long-run growth rate in an endogenous growth model



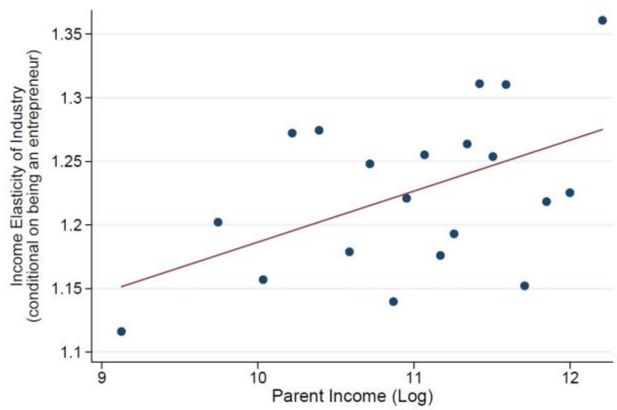
Source: Einio, Feng and Jaravel (2020).

Figure 11: Innovators' backgrounds and the direction of innovation in the United States

Panel A: Patent rates by distance from father's technology class for children of inventors

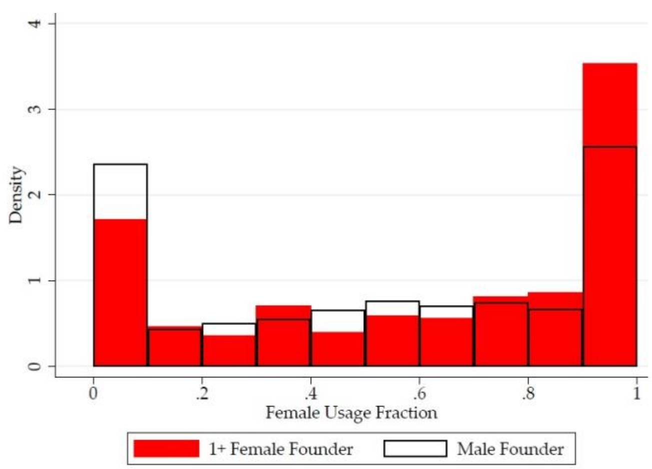


Panel B: Entrepreneur's parental income and industry income elasticity



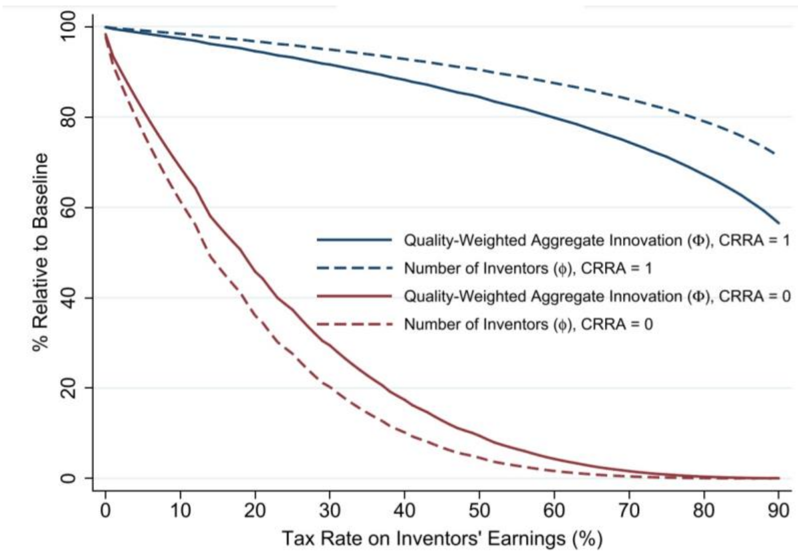
Coeff. = 0.04** (s.e. 0.0175). The sample includes entrepreneurs only (N=275).
Parent income is measured as the sum of father's income and mother's income.

Panel C: Female user fraction vs. founder gender for phone applications



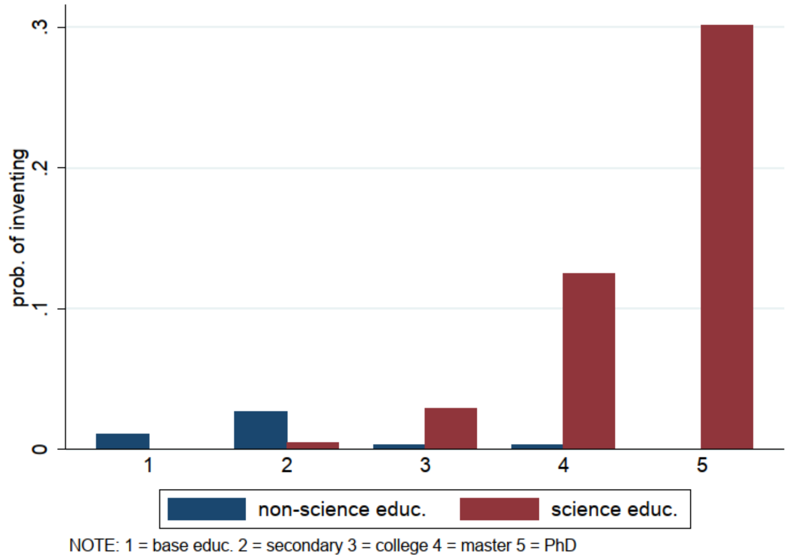
Sources: panel A: Bell, Chetty, Jaravel, Petkova and Van Reenen (2019); panels B and C: Einio, Feng and Jaravel (2020).

Figure 12: Predicted impact of tax rates on innovation in a neoclassical model of career choice



Source: Bell, Chetty, Jaravel, Petkova and Van Reenen (2019).

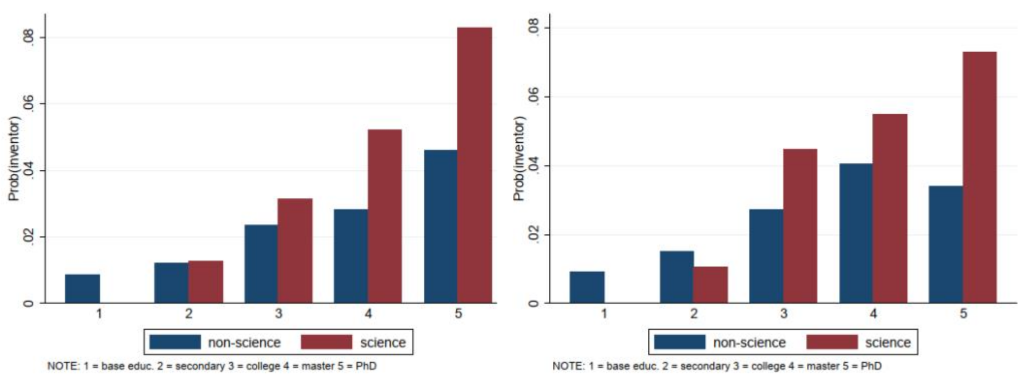
Figure 13: Own education and the probability to invent.



Notes: The figure displays the probability to invent conditional on the education of the individual. We divide education into five groups by level of education: base education (up to 9 years, depending on age of parent), secondary, tertiary, MSc, and PhD. We also condition all other levels of education but base education on a parent having a STEM education. A STEM base education does not exist. We measure education at age 35.

Source: Aghion et al. (2018).

Figure 14. Parental education status and becoming an inventor

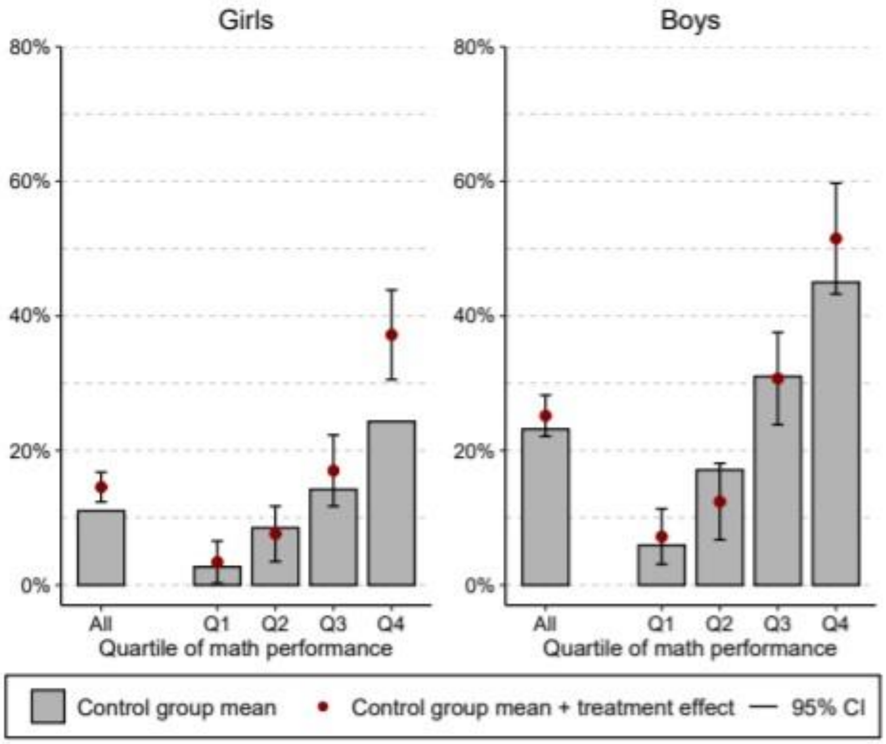


A. Father B. Mother

Notes: The figure displays the probability to invent conditional on the education of the father (A) and mother (B). We divide parents into five groups by level of education: base education (up to 9 years, depending on age of parent), secondary, tertiary, MSc, and PhD. We also condition all other levels of education but base education on a parent having a STEM education. A STEM base education does not exist. Parental education is measured in 1975 unless unavailable, in which case 1985 data used.

Source: Aghion et al. (2018).

Figure 15: Role models and becoming an inventor



Source: Breda et al. (2021).