Superstar Innovators and the Effect of Intellectual Property Rights on Innovation

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Abstract

This paper analyzes how the effect of intellectual property rights (IPRs) on innovation depends on the distribution of innovation rents across the population. This is done in a product-variety growth model with non-homothetic preferences and endogenous markups in which richer households consume a larger variety of goods than poorer ones. Innovation rents emerge because there are inframarginal superstar innovators who generate more valuable innovations than the marginal innovators do. It is shown that increasing IPR protection increases growth when innovation rents are widely distributed across the population but that it can reduce growth when innovation rents accrue to a minority of rich superstar innovators. The mechanism behind this result is the following: as rich (superstar) households are already satiated with the consumption of the existing innovative goods, they spend incremental income on non-innovative (service) goods. Because of that, an increase in IPR protection that increases the rents of superstar innovators by increasing the average markups of innovative goods decreases the market demand for marginal innovative goods. While reducing IP protection reduces the incentives to innovate when market demand is given, it can therefore increase them when it leads to a suffcient increase in the market demand for marginal (non-superstar) innovations. (JEL O34, O31, L16, D30, O41, E21)

Keywords: intellectual property rights, income inequality, endogenous growth, non-homothetic preferences, consumption pattern

1 Introduction

Income and wealth inequality have been rising in several countries (see https://wid.world/), and many people and policymakers are worried about this trend. It is therefore impor-

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tant to understand how inequality could be reduced and what implications this might have on the economy. Aghion et al. (2019) have identified innovation as a driver of top-income inequality. One might therefore wonder to which extent inequality is a necessary byproduct of a dynamic and growing economy.

Recent studies by Autor et al. (2020) and De Loecker et al. (2020) have found that there has been a rise in market power and a fall in the labor income share in the US economy over the last decades and that this trend was mainly driven by the rise of highly efficient superstar firms that charge large markups. This trend went along with a rise in the importance of the "intangible economy" in which intellectual property rights are important (see Haskel and Westlake, 2017). Given these trends, an interesting question is how reducing the market power of superstar firms - for example by reducting the strength of intellectual property protection - would affect inequality and innovation. As it seems likely that top income earners (like Silicon valley billionnaires) profit in a disproportional way from the rents earned by superstar firms, reducing these rents would probably decrease income inequality. Reducing the market power of innovative firms might, however, come at the cost of reduced innovation: when there is less reward in the form of monopoly profits for newly introduced "superstar" goods, the incentives to invent and to introduce such new goods might decrease[1].

This paper studies interactions between intellectual property protection, inequality, and innovation in a product-variety endogenous growth model with non-homothetic preferences. Due to the assumption of unit-consumption ($0-1$ consumption), richer households purchase a larger variety of goods than poorer ones, which is in line with empirical evidence (Jackson, 1984; Falkinger and Zweim\"uller, 1996, ...). The following mechanisms are at work in this model: the rents of (inframarginal) superstar innovators rise in the strength of intellectual property (IP) protection. When these innovation rents accrue to rich households, increasing IP protection increases inequality. A rise in inequality, however, reduces the demand for new goods and the incentives to innovate as innovation is only worthwhile in mass consumption markets.

The main result of the analysis is that in the case where a few rich superstar innovators obtain most innovation rents, decreasing IP protection can reduce inequality and at the same time increase growth. There is therefore no trade-off between inequality and innovation in this case.

The model builds on Föllmi and Zweimüller (2006, 2017), Föllmi, Würgler and Zweimüller (2014) and Kiedaisch (2021). These papers do not allow for innovation rents and only Kiedaisch (2021) analyzes the role of intellectual property rights. A detailed review of the related literature can be found in Kiedaisch (2021).

[1] This is less clear when innovation does not lead to the introduction of new goods (product innovation), but merely to the improvement of existing goods (process- or quality-increasing innovation). The current paper focuses on the case of product innovations in which the incentives to innovate normally increase when market power increases.

2 The model setup

2.1 Preferences and technology

There is a continuum of potentially producible differentiated goods indexed by $j \in [0, \infty)$. In a given period t, only one or zero units of any of these goods can be consumed by a household i: $c_i(j,t) \in \{0,1\}$. The quality level of good j is given by q_j (in equilibrium, only one quality level is available for each given good).

Households are infinitely lived and intertemporal utility is given by:

$$U_i(\tau) = \int_{t=\tau}^{\infty} ln \left(\int_{j=0}^{\infty} q_j c_i(j,t)\, dj \right) e^{-\rho(t-\tau)} dt \tag{1}$$

where $\rho > 0$ denotes the rate of time preference. While preferences are homothetic in the intertemporal dimension, the strong assumption of indivisibilities in the consumption of goods ("$0-1$ consumption") is made in order to introduce non-homothetic intra-temporal preferences in a simple and tractable way.

The factors of production are basic and high skilled labor and the stock of knowledge $N(t)$. Any good j ($j \epsilon [0; \infty)$) can be produced using a non-innovative, **traditional** technology. Goods produced with such a technology have quality $q_j = 1$. Producing one unit of a good using a traditional technology requires $\frac{\Omega}{N(t)}$ units of basic labor. Goods can also be produced with two types of innovative technologies, which have to be invented first: A **normal** innovation also gives quality $q_j = 1$, but allows to reduce production costs as it only requires $\frac{b}{N(t)}$ (with $b < \Omega$) units of basic labor to produce one unit of a good. A **superstar** innovation increases the quality of the good to $q > 1$ and at the same time leads to cost-reductions as it only requires $\frac{b}{N(t)}$ (with $b < \Omega$) units of basic labor to produce one unit of a good.

The stock of knowledge $N(t)$ is given by the the measure of sectors j in which innovative technologies have been invented. The measure of sectors in which superstar technologies are available is denoted by $S(t)$ ($\leq N(t)$) and the fraction of superstar innovations among the total innovations by $s(t) \equiv \frac{S(t)}{N(t)}$.

Obtaining a normal innovation in a sector j is associated with fixed R&D costs equal to $\frac{F}{N(t)} > 0$ units of basic labor, while obtaining a superstar innovation requires $\frac{F}{N(t)} > 0$ units of high-skilled labor. Accidental duplication of R&D is ruled out. In equilibrium, there is only one innovation per good as carrying out a normal and a superstar innovation for two different goods does not cost more than carrying both of them out for the same good j, and gives at least as much profits as no household consumes two versions of the same good. Consequently, each good j only has one unique level of quality. The assumption that labor productivity in both the production and the R&D sector increases in this multiplicative way in the stock of knowledge $N(t)$ is made in order to allow for continuous exponential growth[2].

2.2 Intellectual property protection and prices

The labor market is assumed to be competitive and every worker can freely choose to work in either the R&D or the production sector. Traditional technologies are in the public domain, implying that they can be supplied at marginal cost. An innovator who has come up with an innovation related to good j obtains intellectual property (IP) protection on it, which allows him to exclude others from producing this good with the protected technology. The intellectual property right, however, does not allow appropriating any of the spillovers, which increase the productivity of both firms that produce other goods and of future innovators, implying that there is a research exemption[3]. IP protection is assumed to expire with hazard rate γ (that means with probability γdt in time interval dt), implying that the expected length of protection is equal to $T \equiv \frac{1}{\gamma}$. IPRs are therefore infinitely lived ($T = \infty$) if $\gamma = 0$ and not protected at all ($T = 0$) if $\gamma \to \infty$[4].

After the IPR on a good j has expired, anyone can freely produce this good and it is supplied at marginal cost due to perfect competition[5]. The market-clearing wage for one unit of basic is denoted by $w_B(t)$. In order to obtain constant prices for the competitively supplied goods, the wage of a productivity-adjusted unit of basic labor is normalized to one, implying that the wage for one unit of basic labor is normalized to $w_B(t) = N(t)$. Due to this normalization, the price of a traditionally produced good is given by $p(j,t) = \Omega$ ($= w(t)\frac{\Omega}{N(t)}$, the marginal production costs) and the price of a goods on which IP protection has expired is given by $p(j,t) = b$. When R&D is undertaken by basic labor, the fixed R&D costs are also constant over time and given by F. The wage rate for one unit of high-skilled labor is endogenous and denoted by $w_H(t)$. It is assumed that a firm with IP protection in sector j cannot observe its customers´ income and therefore cannot price discriminate between households with different willingness to pay.

[2] Unlike in standard growth models, the productivity of the production sector needs to increase in $N(t)$ as the assumption of consumption indivisibilities precludes the possibility to consume and produce less of each good when the number of goods increases. Only in the special case of a "digital economy" where $b = 0$, these spillovers are not required. If there were no spillovers in the R&D sector, growth would be linear but the qualitative results would be the same.

[3] As R&D productivity increases in the stock of knowledge $N(t)$, future innovators benefit from the R&D undertaken by previous innovators. IP protection could therefore be broadened by granting innovators some blocking power over future inventions which would enable them to extract licensing fees from future innovators. Granting such extended IP protection would reduce the rate of growth along a balanced growth path (see Kiedaisch, 2021).

[4] In the following, T will often simply be referred to as the "length of IP protection".

[5] The analysis focuses on intellectual property rights as the only factor granting a monopoly position. If such a position can be obtained through other factors like trade secrecy or weak antitrust policies, the same analysis applies to these factors as long as there are the same spillovers and as long as the monopoly position can be lost due to imitation or stricter antitrust policies with hazard rate γ.

Households are not financially constrained and can borrow and lend at the interest rate $r(t)$.

2.3 Distribution

The size of the population is given by L, and the total labor endowment by $Y = B + H$,where B denotes the total endowment of basic labor, and H the total endowment of highly skilled labor. While all households have the same utility function, it is assumed that there are poor (P), middle class (M) and rich (R) households with population shares β, $1-\alpha-\beta$, and α (with $0 \leq \alpha+\beta < 1$). A poor household´s basic labor endowment is given by l_P, that of a middle class household by l_M, and that of a rich household by l_R, where $l_P < l_M < l_R$ is assumed to hold. The following condition must hold:

$$\beta L l_P + (1-\alpha-\beta) l_M + \alpha L l_R = B$$

A poor household´s high skilled labor endowment is given by h_P, that of a middle class household by h_M, and that of a rich household by h_R. The following condition must hold:

$$\beta L h_P + (1-\alpha-\beta) h_M + \alpha L h_R = H$$

In order to simplify the analysis, only two cases are considered:

1. $h_P = h_M = h_L$; all households have the same endowment of highly skilled labor
2. $h_P = h_M = 0$ and $h_R = \frac{H}{\alpha L}$; only rich households are endowed with highly skilled labor

At the initial date $t = \tau$, the economy is endowed with wealth V in the form of previously granted non-expired IPRs, the value of which is equal to the expected discounted profit income accruing to their owners. In order to simplify the analysis, the case is considered in which all income groups have the same level of initial wealth, i.e. in which $V_P(\tau) = V_M(\tau) = V_R(\tau)$. In Kiedaisch (2021) the case of a general distribution of initial wealth is analyzed, in which some additional effects arise that are not taken into account here.

2.4 Consumption choices

The intertemporal budget constraint of a household of type $i \in \{P; M; R\}$ is given by:

$$\int_{t=\tau}^{\infty} N(t) l_i e^{-R(t,\tau)} dt + \int_{t=\tau}^{\infty} w_H(t) h_i e^{-R(t,\tau)} dt + V_i(\tau) \geq \int_{t=\tau}^{\infty} \left(\int_{j=0}^{\infty} p(j,t) c_i(j,t)\, dj \right) e^{-R(t,\tau)} dt \tag{2}$$

where $R(t,\tau) = \int\limits_{s=\tau}^{t} r(s)ds$ is the cumulative discount rate between dates τ and t. The left hand side represents the discounted sums of basic labor income (note that $w_B(t) = N(t)$) and highly skilled labor income plus the value of initial wealth; the right hand side denotes the discounted sum of consumption expenditures. A household maximizes intertemporal utility (equation 1) subject to this budget constraint. As preferences are additively separable across periods, this maximization problem can be solved by applying two-stage budgeting: the household first maximizes instantaneous utility $u_i(t) = \int\limits_{j=0}^{\infty} q_j c_i(j,t)\, dj$ for given expenditures $E_i(t) = \int\limits_{j=0}^{\infty} p(j,t) c_i(j,t)\, dj$ in a period t and then optimally allocates expenditures across periods. The first problem is solved by purchasing one unit of each good for which the quality-adjusted price $\frac{p(j,t)}{q_j}$ lies below the household's willingness to pay $z_i(t)$, and by purchasing a non-negative measure of goods for which the quality-adjusted prices are equal to $z_i(t)$[6]. Then, a Lagrangian with the variables $u_i(E_i(t))$ and $E_i(t)$ can be set up and maximized with respect to $E_i(t)$ in order to derive $z_i(t)$. The resulting optimal consumption rule is given by:

$$c_i(j,t) = \begin{cases} 1 \;\; if & \frac{p(j,t)}{q_j} < \frac{e^{R(t,\tau)-\rho(t-\tau)}}{\lambda_i u_i(t)} \equiv z_i(t) \\ 1 \; or \; 0 \; if & \frac{p(j,t)}{q_j} = z_i(t) \\ 0 \;\; if & \frac{p(j,t)}{q_j} > z_i(t) \end{cases} \tag{3}$$

where λ_i is the Lagrange multiplier and represents the marginal utility of income at the initial date τ. The optimal consumption strategy consequently consists of exhausting the budget $E_i(t)$ by purchasing the goods with the lowest quality-adjusted prices. Consequently, a richer household (with a larger $E_i(t)$) purchases the same goods as a poorer one, plus some additional goods with higher (or equal) quality-adjusted prices, implying a higher (or equal) willingness to pay $z_i(t)$ of richer households. In equilibrium, the intertemporal budget constraints are satisfied with equality.

The variety (measure) of goods consumed by households of type i is denoted by $C_i(t) = \int\limits_{j=0}^{\infty} c_i(j,t)\, dj$. As rich households spend more on consumption in every given period, $C_R(t) > C_M(t) > C_P(t)$ holds. Normalizing the consumption varieties by the measure of available innovative goods gives the **consumption shares** $c_P(t) \equiv \frac{C_P(t)}{N(t)}$, $c_M(t) \equiv \frac{C_M(t)}{N(t)}$ and $c_R(t) \equiv \frac{C_R(t)}{N(t)}$.

The measure of goods on which IP protection has expired and that are sold at the marginal costs of b is denoted by $M(t)$. The fraction of the innovative toods on which IP protection has expired is denoted by $m(t) \equiv \frac{M(t)}{N(t)}$.

[6] There is always a positive measure of such goods in equilibrium, implying that $\frac{\partial u_i(t)}{\partial E_i(t)} = \frac{1}{z_i(t)}$ holds.

2.5 Equilibrium prices

For the rest of the analysis, the following assumption is made:

Assumption 1: The population share α of the rich is so small that it is not worthwhile to invent goods that are exclusively purchased by rich households.

The rich therefore represent an small minority of the population, like for example billionnaires. While these households are so rich that they consume all the existing innovative goods, there are just not enough of them to make it worthwhile to invent new goods that are exclusively purchased by them. Because of that, they spend incremental income on traditionally produced goods (like for example services like personal trainers, etc.). As traditionally produced goods are sold at the marginal cost of Ω and have quality level $q = 1$, the willingness to pay of a rich household for one unit of quality is given by $z_R = \Omega$.

Assumption 2: R&D is so profitable that all highly skilled labor is used to undertake superstar innovations and that in addition some basic labor is used for R&D, even in sectors the goods of which are only purchased by middle class and rich households.

Under this assumption, the measure $N(t)$ of sectors in which innovative technologies have been invented exceeds $S(t)$, the measure of sectors in which superstar technologies are available. Moreover, $N(t)$ is equal to $C_M(t)$, the measure of goods consumed by middle class households. Consequently, we have $C_P(t) < C_M(t) = N(t) < C_R(t)$.

A firm that has IP protection on good j sets the price $p(j,t)$ in order to maximize profits. In equilibrium, $z_R = \Omega > z_M > z_P$ holds (as will become clear later on), implying that market demand for any good j in period t is given by a step function: for a price higher than the quality-adjusted willingness to pay of a rich household ($p(j,t) > q_j z_R(t) = q_j \Omega$), there is no demand for the good (as households prefer to purchase traditionally produced goods); for a price equal to or below the quality-adjusted willingness to pay of a rich but above that of a middle class household ($p(j,t) \in (q_j z_M(t), q_j z_R(t)]$), demand is given by the number of rich households, αL; for a price equal to or below the quality-adjusted willingness to pay of a middle class household but above that of a poor household ($p(j,t) \in (q_j z_P(t), q_j z_M(t)]$), demand is given by the number of both rich and middle class households, $(1-\beta)L$; and for a price below or equal to the quality-adjusted willingness to pay of a poor household ($p(j,t) \leq q_j z_P(t)$) demand is equal to L (the size of the whole population). As it is due to Assumption 1 not worthwhile to sell exclusively to rich households, firms either charge a price $p_j = q_j z_M$ and sell exclusively to middle class and rich households, or they charge a price $p_j = q_j z_P$ and sell to all income groupe.

Assumption 3: poor households are sufficiently rich to purchase one unit of each good on which IP protection has expired and also one unit of each superstar innovation.

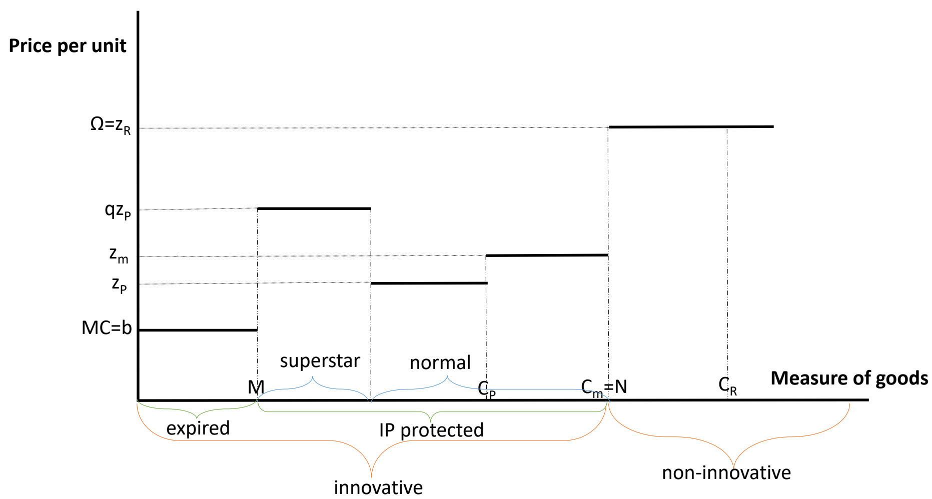
Under this condition, IP protected superstar goods are sold to all households (to be shown below), and we have $C_P(t) > M(t) + S(t)(1 - m(t))$. Some normal innovations are consequently sold to all households, while others are sold only to rich and middle class households. In the first case, per period profits derived from a normal innovation are given by $\pi_P(t) = L(z_P(t) - b)$, while they are given by $\pi_M(t) = (1-\beta)L(z_M(t) - b)$ in the second case (note that marginal production costs are equal to b). In equilibrium, firms must be indifferent between the two strategies, which is the case if $z_P(t) = (1-\beta)z_M(t) + \beta b$. Denoting the price at which normal innovations are exclusively sold to middle class and rich households by $p_M = p\ (= z_M)$, the normal innovations that are sold to all households are therefore sold at the following price:

$$p_P = (1-\beta)p + \beta b \tag{4}$$

Given these prices, superstar innovators can either sell to middle class and rich households at price qp, or sell to all households at price qp_P. As per period profits for superstar innovators are higher in the second case[7], they prefer to sell to all households at price $qp_P = q((1-\beta)p + \beta b)$.

Given the assumptions above, the following equilibrium price structure arises:

The measure $M(t)$ of goods on which IP protection has expired are sold at price b (marginal cost) to all households. The measure $S(t)(1-m(t))$ of IP protected superstar innovators are sold at price qp_P to all households. The measure $C_P(t) - M(t) - S(t)(1-m(t))$ of IP protected normal innovations are sold at price p_P to all households, while the measure $N(t) - C_P(t)$ of IP protected normal innovations are sold at price $p\ (> p_P)$ to middle class and rich households. The measure $C_R(t) - N(t)$ of traditionally produced goods are sold to rich households. A graphical presentation of the equilibrium price structure is given in Figure 1.



[7] In the first case, profits are equal to $\pi_P^S = L(q((1-\beta)p + \beta b) - b)$ and in the second case by $\pi_M^S = L(1-\beta)(qp - b)$. As $q > 1$, $\pi_P^S > \pi_M^S$ holds.

In the following sections the equilibrium of the dynamic model is derived and the endogenous variables $N(t)$, $M(t)$, $E_i(t)$, $C_i(t)$, $p_j(t)$, $\pi_j(t)$, $r(t)$ and $z_i(t)$ are derived as functions of the exogenous parameters.

3 The general equilibrium

This section studies the general equilibrium of the model.

3.1 The allocation of resources across sectors

The demand for production labor L_D in period t is given by

$$\begin{aligned} L_D(t) = L \int_{j=0}^{C_P(t)} \left(\frac{b}{N(t)}\right) dj + L(1-\beta) \int_{j=C_P(t)}^{N(t)} \left(\frac{b}{N(t)}\right) dj + L\alpha \int_{j=N(t)}^{C_R(t)} \left(\frac{\Omega}{N(t)}\right) dj \\ = L\left[c_P b + (1-\beta)(1-c_P) b + \alpha (c_R - 1)\Omega\right] \end{aligned}$$

The first term on the right in the first line denotes the labor that is needed to produce one unit of all the innovative goods that are consumed by all L households ($\frac{b}{N(t)}$ units of labor are needed in order to produce one unit of an innovative good). The second term denotes the labor needed to produce all innovative goods that are only bought by middle class and rich households, and the third term denotes the labor that is needed to produce traditionally produced goods that are only purchases by the αL rich households ($\frac{\Omega}{N(t)}$ units of labor are needed in order to produce one unit of a traditionally produced good).

The simplification in the second line arise because $c_i(t) \equiv \frac{C_i(t)}{N(t)}$ defines the consumption shares of the different groups.

The demand L_R for R&D workers depends on how much research is undertaken, meaning on $\dot{N}(t) \equiv \frac{\partial N(t)}{\partial t}$. As the invention of a new product requires $F/N(t)$ units of labor, the demand for R&D workers is given by: $L_R(t) = F\frac{\dot{N}(t)}{N(t)} = Fg(t)$, where $g(t)$ denotes the rate of growth of the stock of knowledge $N(t)$. Due to assumption 2, $Fg(t) > H$ must hold, so that all highly skilled labor H, plus the amount $Fg(t) - H$ of basic labor is used to undertake R&D. Equating supply and demand of labor in a given period yields $Y = L_D(t) + L_R(t)$. Plugging the corresponding values into this equation and solving for $g(t)$ gives the economy's **resource constraint**:

$$g(t) = \frac{1}{F}\left[Y - L\left[c_P b + (1-\beta)(1-c_P) b + \alpha (c_R - 1)\Omega\right]\right] \tag{5}$$

Given that $b > 0$, there is a negative relation between the rate of growth $g(t)$ and the consumption shares $c_p(t)$ and $c_R(t)$. The reason for this is that employing more workers in the R&D sector is only possible if fewer workers are used to produce goods for poor and rich households (note that $c_M = 1$ always holds as muddle class households always consume one of each innovative goods.).

3.2 Value of an innovation and interest rate along a balanced growth path

The expected value of a normal innovation $Z(t)$ is equal to the expected discounted sum of profit income that accrues to an IPR holder. Therefore, $Z(t) = \int\limits_{s=t}^{\infty} \pi(s) e^{-\tilde{R}(s,t)} ds$, with $\tilde{R}(s,t) = \int\limits_{q=t}^{s} (r(q) + \gamma) dq$ denoting the cumulative discount rate between dates t and s that depends on both the interest rates and the hazard rate γ at which profits are lost due to expiring IP protection. Deriving $z_i(t) = p_i = \frac{e^{R(t,\tau)-\rho(t-\tau)}}{u_i(t)\lambda_i}$ with respect to time gives: $\frac{\dot{u}_i(t)}{u_i(t)} = r(t) - \rho - \frac{\dot{p}_i(t)}{p_i(t)}$. Along a balanced growth path, the prices p_i and per period profits π_i for IP protected normal innovations are constant and $C_P(t)$, $C_M(t) = N(t)$, $N(t)$ and $S(t)$ grow at a constant rate $g(t)$. $u_M(t) = \int\limits_{j=0}^{N(t)} q_j c_i\,(j,t)\, dj = qS(t) + N(t) - S(t)$ and $u_P(t) = \int\limits_{j=0}^{C_P(t)} q_j c_i\,(j,t)\, dj = qS(t) + C_P(t) - S(t)$ therefore also grow at rate $g(t)$. Consequently, we obtain the following Euler equation:

$$r(t) = \rho + g(t) \tag{6}$$

The rate of interest is therefore constant along a BGP and positively related to the rate of growth and to the rate of time preference. Along a BGP, the expected value of a normal innovation that yields per period profits equal to $\pi = \pi_P = \pi_M$ is consequently given by

$$Z(t) = \frac{\pi}{r+\gamma} = \frac{L\,(1-\beta)\,(p-b)}{\rho+g+\gamma}$$

Due to free entry into R&D, the value Z of a normal innovation has to be equal to the (wage) costs of innovating, which are given by F. Therefore, the following **free entry condition** needs to hold along a BGP with positive growth:

$$Z = \frac{L\,(1-\beta)\,(p-b)}{\rho+g+\gamma} = F \tag{7}$$

As superstar innovators sell their goods at price qp_P (with $p_P = (1-\beta)\,p + \beta b$) and earn per period profits $L\,(qp_P - b)$, the value of a superstar innovation is given by $Z^S = \frac{L(qp_P-b)}{\rho+g+\gamma} > F$. This implies that highly skilled labor can earn a larger wage in the R&D than in the production sector (where productivity is the same for all types of labor).

Consequently, all skilled labor H is employed in the R&D sector. While the wage for one unit of basic labor is given by $w_B = N(t)$, a wage premium is paid to a unit of skilled labor due to the larger productivity in the R&D sector. The wage premium therefore reflects the differences in the values of innovations obtained by skilled and basic labor: $\frac{w_H}{w_B} = \frac{Z^S}{Z} = \frac{qp_P - b}{p_P - b}$. Consequently, the wage rate for one unit of skilled labor is given by:

$$w_H = N(t)\frac{qp_P - b}{p_P - b} \tag{8}$$

3.3 Solving for the balanced growth path

In the following, the balanced growth path (BGP) values of $m(t) \equiv \frac{M(t)}{N(t)}$, $s(t) = \frac{S(t)}{N(t)}$ and p are derived.

Multiplying the measure $(N(t) - M(t))$ of sectors in which IPRs are protected with the hazard rate γ with which IP protection expires, the absolute increase in the measure $M(t)$ of sectors in which IP protection has expired is given by $\dot{M}(t) = \gamma\,(N(t) - M(t))$. Taking into account that $g(t) = \frac{\dot{N}(t)}{N(t)}$, we can derive $\dot{m}(t) = \gamma\,(1 - m(t)) - m(t)g(t)$. Along a BGP, $\dot{M}(t) = \dot{N}(t)$, and therefore $\dot{m} = 0$ needs to hold, so that

$$m = \frac{\gamma}{g + \gamma} \tag{9}$$

As H units of highly skilled labor are used to invent superstar goods and as $\frac{F}{N(t)}$ units of highly skilled labor are needed to invent one of these goods, the number of superstar innovations at point in time t is given by $\dot{S}(t) = \frac{HN(t)}{F}$. Along a balanced growth path, $\frac{\dot{S}(t)}{S(t)} = \frac{HN(t)}{FS(t)} = g$ must hold, so that we obtain:

$$s(t) = \frac{S(t)}{N(t)} = \frac{H}{Fg} \tag{10}$$

Given that $C_P(t) > M(t) + S(t)(1 - m(t))$ holds (due to Assumption 3), the BGP consumption expenditures of a poor household in period t are given by (see the graphical presentatino in Figure 1):

$$\begin{aligned}\int_{j=0}^{\infty} p(j,t)c_P\,(j,t)\,dj &= M(t)b + S(t)(1-m(t))qp_P + (C_P(t) - M(t) - S(t)\,(1-m(t)))\,p_P \\ &= N(t)\,[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P]\end{aligned}$$

As middle class households purchase the same goods as poor household plus in addition the measure $N(t) - C_P(t)$ of goods sold at price $p_M = p$, their expenditures in period t

are given by:

$$\int_{j=0}^{\infty} p(j,t)c_M\,(j,t)\,dj = N(t)\left[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P + (1-c_P)\,p\right]$$

As rich households purchase the same goods as middle class household plus in addition the measure $C_R(t) - N(t)$ of traditionally produced goods sold at price Ω, their expenditures in period t are given by:

$$\int_{j=0}^{\infty} p(j,t)c_R\,(j,t)\,dj = N(t)\left[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P + (1-c_P)\,p + (c_R - 1)\,\Omega\right]$$

Inserting the above expressions, the relation $N(t) = N(\tau)e^{g(t-\tau)}$, and equation 8 into equation 2 allows to rewrite the intertemporal budget constraints at point of time $t = \tau$. Tor a poor household, the intertemporal budget constraint can be written as:

$$N(\tau)l_P + N(\tau)h_P\left(\frac{qp_P - b}{p_P - b}\right) + (r-g)\,V_P(\tau) = N(\tau)\left[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P\right] \tag{11}$$

For a middle class household, the intertemporal budget constraint can be written as:

$$N(\tau)l_M + N(\tau)h_M\left(\frac{qp_P - b}{p_P - b}\right) + (r-g)\,V_M(\tau) = N(\tau)\left[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P + (\right. \tag{12}$$

For a rich household, the intertemporal budget constraint can be written as:

$$N(\tau)l_R + N(\tau)h_R\left(\frac{qp_P - b}{p_P - b}\right) + (r-g)\,V_R(\tau) = N(\tau)\left[mb + s(1-m)qp_P + (c_P - m - s(1-m))\,p_P + (1\right. \tag{13}$$

The consumption expenditures in period τ (right hand sides) are therefore equal to wage incomes in this period (the two first terms on the left hand sides) plus $(r-g)\,V_i(\tau) = \rho V_i(\tau)$ (see equation 6), the consumption out of wealth. Expenditures $E_i(t)$ and individual wealth $V_i(t)$ therefore grow at rate g along a balanced growth path.

Subtracting equation 11 from equation 12 and taking into account that $V_P(\tau) = V_M(\tau)$ holds (by assumption), we can solve for p:

$$p = \frac{l_M - l_P + \left(\frac{qp_P - b}{p_P - b}\right)(h_M - h_P)}{1 - c_P} \tag{14}$$

Subtracting equation 12 from equation 13 and taking into account that $V_P(\tau) = V_M(\tau)$

holds (by assumption), we can solve for c_R:

$$c_R = 1 + \frac{1}{\Omega}\left[l_R - l_M + \left(\frac{qp_P - b}{p_P - b}\right)(h_R - h_M)\right] \tag{15}$$

3.4 Properties of the BGP

In the following, the case is considered in which poor and middle class households have the same endowment of highly skilled labor: $h_P = h_M$.

Plugging equation 14 into equation 7 and solving for g, the **free entry condition** can then be written as:

$$g = \left(\frac{l_M - l_P}{1 - c_P} - b\right)\frac{L(1-\beta)}{F} - \rho - \gamma \tag{16}$$

The free entry condition (equation 16) together with the resource constraint (equation 5) and equations 15 and 4 determine the BGP along which $C_R(t) > N(t)$, $C_P(t) > M(t) + S(t)(1-m)$, and $p < \Omega$ hold.

Given parameters are such that such a BGP exists, the following propositions hold:

Proposition 1. *Suppose that $h_P = h_m = h_R$, implying that innovation rents are equally distributed across the population. Then, an increase in IP protection (i.e. a reduction in γ) at point in time $t = \tau$ increases the rate of growth g, reduces the (current) consumption $C_P(\tau)$ of poor households and leaves the (current) consumption of rich households ($C_R(\tau)$) unchanged. There are no transitional dynamics (similar to Kiedaisch, 2021).*

Proof. To be added. □

Proposition 2. *Suppose that $h_P = h_m = 0$ and $h_R = \frac{H}{\alpha L}$, implying that rich households obtain all innovation rents.*

a) *When H and q are small (small innovation rents) and when β (population share of poor) is sufficiently large, an increase in IP protection at time $t = \tau$ increases the rate of growth, reduces the (current) consumption $C_P(\tau)$ of poor households and (slightly) increases that of rich households ($C_R(\tau)$).*

b) *When H and q are sufficiently large (large innovation rents) and/or when β is not too large, an increase in IP protection at time $t = \tau$ reduces growth, leads to a reduction in $C_P(\tau)$, and to a (relatively large) increase in $C_R(\tau)$.*

In both cases, there are no transitional dynamics.

Proof. To be added. □

What are the mechanisms at work? How can reducing IP protection increase growth (Proposition 2b)?

Reducing IP protection increases the fraction m of goods on which IPRs have expired and rises the markups of IP protected goods. On average, markups fall. Consequently, poor households can afford to consume more goods (C_P rises) and the willingness to pay of middle-class households for marginal innovations rises. Therefore, the incentives to innovate rise for marginal (normal) innovators. Reducing IP protection now reduces the innovation rents of superstar innovators and their consumption. The positive demand effect of weaker IP protection is stronger if innovation rents are larger (H or q larger) and if less resources are absorbed by the increased consumption of poor households (i.e. if β is smaller).

The analysis therefore shows that reducing the length of IP protection does not necessarily reduce innovation. If superstar firms are prevalent and if their rents are appropriated by a few rich households (think of Silicon valley entrepreneurs), reducing IP protection might actually increase innovation, while at the same time reducing inequality.

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Superstar Innovators and the Effect of Intellectual Property Rights on Innovation

Christian Kiedaisch (Université de Namur)

Introduction

- Concerns about rising levels of income and wealth inequality in many countries
- Innovation as a driver of top-income inequality (Aghion et al 2019)
- Rise in market power and a fall in the labor income share. Mainly driven by rise of highly efficient superstar firms charging large markups (Autor et al 2020, De Loecker et al 2020)
- Increasing importance of "intangible economy" in which intellectual property rights are important (Haskel and Westlake, 2017)

Policy Questions

- Would reducing inequality discourage innovation? (Jones, 2019).
- How would reducing the market power of superstar firms affect inequality and innovation?

Overview

This Paper

- Study interactions between **Intellectual Property** protection, inequality, and innovation in endogenous growth model
- Focus on the **role of demand**: in line with empirical evidence (Jackson, 1984; Falkinger and Zweimüller, 1996, ...), the variety of goods consumed rises in houehold income

Mechanisms at work:

- The rents of (inframarginal) superstar innovators rise in the strength of intellectual property (IP) protection
- When innovation rents accrue to rich households, increasing IP protection increases inequality
- A rise in inequality reduces the demand for new goods and the incentives to innovate

Main result: When a few superstar innovators get most innovation rents, decreasing IP protection can reduce inequality and increase growth

Related Literature

Standard product-variety models with **homothetic** CES preferences:

- Markups are constant and the effect of IP protection on growth does not depend on inequality (e.g. Cysne and Turchick, 2012)
- Saint-Paul (2004), Spinesi (2011), Bernal Uribe (2012): increasing IP protection increases the skill premium and wage inequality
- Chu (2010): increasing IP protection can increase consumption inequality by affecting the rate of interest and savings
- Gries and Naudé (2020): growth model with “Keynesian” frictions in which AI automation decreases the labor income share and reduces growth by reducing demand

Related paper:

- Kiedaisch (2021): similar setup with non-homothetic preferences, but no innovation rents.

Preferences

Setup related to Föllmi and Zweimüller (2006, 2017), Föllmi, Würgler and Zweimüller (2014) and Kiedaisch (2021)

- Continuum of differentiated goods indexed by $j \in [0, \infty)$
- Unit consumption: $c_i(j, t) \in \{0, 1\}$ units of good j consumed by household i at time t.
- Quality of good j: q_j
- Intertemporal utility at time τ is given by:

$$U_i(\tau) = \int_{t=\tau}^{\infty} ln \left(\int_{j=0}^{\infty} q_j c_i(j, t)) dj \right) e^{-\rho(t-\tau)} dt \qquad (1)$$

Production Technologies

Production factors: low- and high-skilled labor and "knowledge" $N(t)$

Technologies

- **Non-innovative (traditional) technologies**
  - available for all goods
  - low quality: $q_j = 1$
  - high per unit production costs: Ω ($\frac{\Omega}{N(t)}$ labor units per unit of good)
- **Innovative technologies**: have to be invented first and come in two versions:
  - **normal**: low quality: $q_j = 1$; low per unit production costs: $b < \Omega$ ($\frac{b}{N(t)}$ labor units per unit of good)
  - **superstar**: high quality: $q_j = q > 1$; low per unit production costs: b
- Measure of sectors with innovative technologies: $N(t)$
- Measure of sectors with superstar technologies: $S(t) \leq N(t)$

Innovation and Intellectual Property Rights

- Obtaining an innovation costs F ($\frac{F}{N(t)}$ units of labor)
- Only the subset H of labor is highly skilled and capable of achieving superstar innovations
  $\Rightarrow$ Can at most get $\dot{S}_{max}(t) = \frac{HN(t)}{F}$ superstar innovations in t (no restriction for normal innovations)
- Innovators obtain **IP protection** on their invented technologies that allows to exclude others from using these technologies
  - IP protection is assumed to expire with hazard rate γ. The expected length of IP protection is given by $T \equiv \frac{1}{\gamma}$.
  - When IP protection has expired, goods are supplied at marginal cost
  - The measure of goods on which IP protection has expired is given by $M(t)$ (with $m(t) \equiv \frac{M(t)}{N(t)}$)

Market structure and prices

- Competitive labor markets, free entry into R&D (for unskilled innovators)
- Households can borrow and lend at interest rate $r(t)$
- Monopoly pricing for IP protected goods
- Marginal cost pricing for non-innovative goods ($p_j = \Omega$) and for innovative goods with expired IPRs ($p_j = b$).

Optimal consumption

- Households follow a simple cut-off rule:

$$c_i(j,t) = \begin{cases} 1 \quad if & \frac{p(j,t)}{q_j} < z_i(t) \\ 1 \; or \; 0 \; if & \frac{p(j,t)}{q_j} = z_i(t) \\ 0 \quad if & \frac{p(j,t)}{q_j} > z_i(t) \end{cases}$$

  - $z_i(t)$ denotes household i's willingness to pay for a good
  - Richer households have a larger willingness to pay and purchase a larger variety $C_i(t)$ of goods

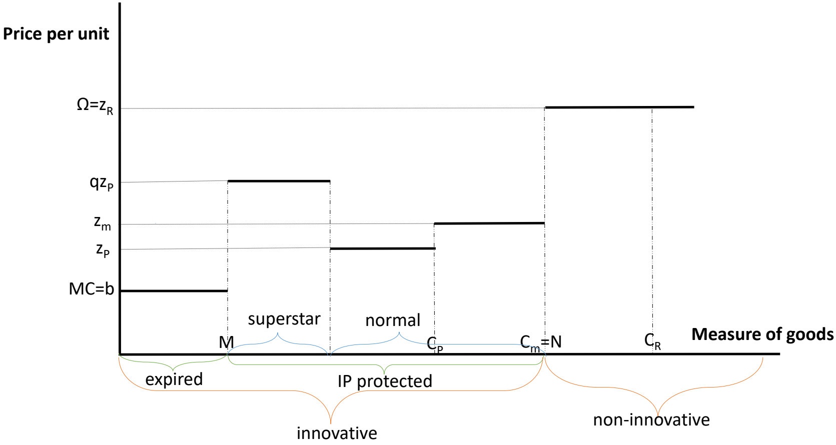
Distribution

- Total labor endowment: Y; population size: L
- Three income groups: poor, middle class, and rich
- Population shares: β (poor), $1-\alpha-\beta$ (middle class), α (rich)
- Per-capita endowments with **basic labor**: $l_P < l_m < l_R$
- Per-capita endowments with **highly skilled labor** ("creative genius"): $h_P \leq h_m \leq h_R$
  - compare two cases: 1) $h_P = h_m = h_R$; 2) $h_P = h_m = 0$ and $h_R = \frac{H}{\alpha L}$
- Per-capita **wealth** endowments: $V_P = V_m = V_R$ (general case analyzed in Kiedaisch, 2021)
- Wage for one unit of basic labor normalized to $N(t)$

Assumptions

- **Assumption 1**: The population share α of the rich is so small that it is not worthwhile to invent goods that are exclusively purchased by rich households (note that quality-adjusted prices cannot exceed Ω):
  - $C_P(t) < C_m(t) = N(t)$
  - Innovation is driven by demand from middle-class (and poor) households
- **Assumption 2 (technical)**: poor households are sufficiently rich (I_P is sufficiently large) to purchase one unit of each good on which IP protection has expired and also one unit of each superstar innovation:
  - $C_P(t) > M(t) + S(t)(1 - m(t))$

Equilibrium Price Structure



The Effect of IP Protection on Growth I

Suppose that $V_P = V_m = V_R$ and that parameters are such that a balanced growth path exists along which $C_R(t)$, $N(t)$, $C_P(t)$, $M(t)$ and $S(t)$ all grow at rate $g = \frac{\dot{N}}{N}$ and along which $C_R(t) > N(t)$, $C_P(t) > M(t) + S(t)(1 - m)$, and $p < \Omega$ hold.

Proposition 1

Suppose that $h_P = h_m = h_R$, implying that innovation rents are equally distributed across the population. Then, an increase in IP protection (i.e. a reduction in γ) at point in time $t = \tau$ increases the rate of growth g, reduces the (current) consumption $C_P(\tau)$ of poor households and leaves the (current) consumption of rich households ($C_R(\tau)$) unchanged. There are no transitional dynamics (similar to Kiedaisch, 2021).

The Effect of IP Protection on Growth II

Proposition 2

Suppose that $h_P = h_m = 0$ and $h_R = \frac{H}{\alpha L}$, implying that rich households obtain all innovation rents.

a) When H and q are small (small innovation rents) and when β (population share of poor) is sufficiently large, an increase in IP protection at time $t = \tau$ increases the rate of growth, reduces the (current) consumption $C_P(\tau)$ of poor households and (slightly) increases that of rich households ($C_R(\tau)$).

b) When H and q are sufficiently large (large innovation rents) and/or when β is not too large, an increase in IP protection at time $t = \tau$ reduces growth, leads to a reduction in $C_P(\tau)$, and to a (relatively large) increase in $C_R(\tau)$.

In both cases, there are no transitional dynamics.

The mechanisms at work

How can reducing IP protection increase growth (Proposition 2b)?

- Reducing IP protection increases the fraction m of goods on which IPRs have expired and rises the markups of IP protected goods
- On average, markups fall
- Poor households can afford to consume more goods (C_P rises)
- The willingness to pay of middle-class households for marginal innovations rises
- The incentives to innovate rise for marginal innovators
- Reducing IP protection reduces the innovation rents of superstar innovators and their consumption.
- The positive demand effect of weaker IP protection is stronger if innovation rents are larger (H or q larger) and if less resources are absorbed by the increased consumption of poor households (i.e. if β is smaller).

Conclusion

- Reducing the length of IP protection does not necessarily reduce innovation
  $\Rightarrow$ If superstar firms are prevalent and if their rents are appropriated by a few rich households (think of silicon valley entrepreneurs), reducing IP protection might actually increase innovation, while at the same time reducing inequality

Extension: network effects

- Suppose that the willingness to pay of a household for a good increases if more other households consume it
- $\Rightarrow$ The qualitative results stay the same in this case

Empirical Relevance?

- Dorn, Kiedaisch and Seliger (in progress) find indirect empirical evidence studying international patent applications
- More empirical evidence on the consumption pattern of rich households needed

Balanced Growth Conditions

- The following conditions need to hold along a balanced growth path:
- Euler equation: $r = \rho + g$ (rate of growth $g = \frac{\dot{N}}{N}$)
- Free entry condition: $Z = \frac{L(p-b)}{r+\gamma} = F$
  - Z is value of a normal innovation
  - $Z_S = \frac{L(qp-b)}{r+\gamma} > Z$ is the value of a superstar innovation
  - the skill premium ((wage of highy skilled)/(wage of low skilled)) is equal to $\frac{Z_S}{Z} = \frac{qp-b}{p-b}$ and falls in p
- Resource constraint:
  $g(t) = \frac{1}{F}\left[Y - L\left(\beta c_P b + (1-\beta)b + \alpha(c_R - 1)\Omega\right)\right]$
- From the intertemporal budget constraints, we can derive (assuming $h_P = h_m$ and $V_P = V_m = V_R$):
  - $p = b\beta + \frac{1-\beta}{1-c_P}(l_m - l_P)$
  - $c_R = 1 + \frac{1}{\Omega}\left[l_R - l_m + \left(\frac{qp-b}{p-b}\right)(h_R - h_m)\right]$