

Financial Development and Wage Inequality: Theory and Evidence

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Abstract

We provide an explanation for the joint occurrence of widening wage inequality and changes in organizational form in response to financial market developments in the US economy in the last two decades. We present an endogenous growth model with imperfect credit markets and establish how improving the efficiency of these markets affects modes of production, innovation and wage dispersion between skilled and unskilled workers. We argue that financial market development is an independent source of the rise in the skill premium in the US since the 1980s, as well as a factor magnifying the effects of technological progress. The experience of US states following banking deregulation and the more recent surge in venture capital provide support for our hypothesis. Cross country evidence is also consistent with our model.

PRELIMINARY. PLEASE DO NOT CITE.

1 Introduction

In recent years the increase in wage inequality in the US has received a lot of attention from economists. Researchers have documented the rise since the 1980s in overall wage inequality, differentials between wages of college degree and high school diploma holders (between group inequality), as well as the increase in wage differentials measured within education and experience groups (residual or within group inequality).¹ The factors usually identified with the increase in wage inequality are trade, technological progress, and organizational change (itself brought about by technological progress). In this paper we explore the role of financial market development (in particular the rise in entrepreneurial finance) as an independent source of the increase in the skill premium, as well as a factor magnifying the effects of technological progress.

The interaction between entrepreneurial finance, organizational change, and technological progress has become an increasingly important component of the innovation process in the US in recent decades. Following the 1979 amendment to the Employee Retirement Income Security Act (ERISA), which permitted pension funds to invest in risky asset vehicles such as venture capital, the amount of capital flowing into venture capital firms increased substantially (Gompers & Lerner, 2004, Chapter 1). Subsequently, venture capital financing was found to have a positive impact on innovation (Kortum & Lerner, 2000). Dynan et al. (2006) document the greater ease with which firms and households can access credit markets in the US during this period thanks to financial innovation and changes in government policy. Associated with these developments was a change in organizational form in the US economy. Smaller firms employing workers of relatively similar skill levels rose in prominence, whereas the large scale corporations that mixed workers of differing skills declined. Kremer & Maskin (1996) document that the correlation between wages of US manufacturing workers in the same plant rose from 0.76 in 1975 to 0.80 in 1986 and argue that this “segregation by skill” contributed to the rise in wage inequality. The coincident timing of these

¹Autor, Katz and Kearney (2005).

developments suggests that venture capital firms, and more sophisticated financial markets in general, may have facilitated the change in organizational form (and thus the widening of the wage distribution) by promoting the emergence of smaller, innovative start-up firms.

We build on these insights and construct a model which demonstrates that an increase in financial market sophistication leads to organizational change, an acceleration in growth, and the widening of the wage distribution. Previous research has found that the bulk of the widening inequality has been concentrated in the upper tail of the distribution and that there is a similar pattern in terms of residual inequality.² We provide a link between the rise of entrepreneurial finance and widening upper tail residual inequality. The second part of the paper confronts these predictions with evidence from US states. We find that the states which experienced higher venture capital activity also experienced larger increases in residual inequality. Furthermore, using a measure of banking deregulation, we find that states which deregulated their banking sector earlier experienced a more rapid increase in the skill premium (measured as the return to education).

The paper is organized as follows. Section 2 summarizes the related literature and discusses the developments in the US economy over the last twenty years that have motivated our analysis. The model is presented in Section 3.

2 Explanations for rising wage inequality in the US

There exists an extensive literature documenting and attempting to explain the rise in wage inequality over the last 25 years in the US, the UK and several other countries. The sources usually identified with the increase in wage inequality in the US are trade, changes in labour market institutions such as the minimum wage and unionization, technological progress, and organizational change (itself brought about by technological progress). A number of studies have questioned the importance of trade as an explanation for the rise in inequality in the

²Autor, Katz and Kearney (2005) study wage data from the March CPS and the CPS Outgoing Rotation Group over the period 1963 - 2003. They find a “pronounced, secular rise in residual earnings inequality that, paralleling the rise in overall inequality, is concentrated above the median of the (residual) earnings distribution.”

US since the relative price of skill-intensive goods has not increased to the extent that would explain the rise in inequality (Acemoglu, 2002). Studies have also documented that the bulk of the increase in inequality has been in the upper tail of the wage distribution, which would not be directly affected by changes in the minimum wage or by de-unionization (Autor, Katz and Kearney, 2005).

Papers that study the role of technological change in causing the increased dispersion in wages often rely on the idea of skill-biased technology (Acemoglu, 1998; Krusell et al. 2000). The idea is that technological progress over the recent decades has disproportionately improved the productivity of skilled workers. There indeed appears to be substantial empirical evidence of skill-bias in the computing and telecommunications technologies that have been implemented in advanced industrial countries in recent times (Autor, Katz, and Krueger, 1998; Berman, Bound, and Machin, 1998; Machin and Van Reenen, 1998).

On the theoretical side, skill-biased technological change (SBTC) can be modelled as having a direct effect on the productivity of skilled workers through an increase in the number of intermediate goods designed to complement skilled labor, or an improvement in the quality of capital (assuming capital-skill complementarity). The rate at which these skill-complementary technologies are designed itself may be influenced by the pool of skilled workers available to use the technologies: the larger the relative supply of skilled workers, the more rapid will be the rate of skill-biased technological change (Acemoglu, 1998). Alternatively, technical change may be neutral with regard to inputs in the production of final goods and yet alter the relative productivity of skilled labor in other sectors. For example, Aghion and Howitt (1998) present a model where the arrival of a new general purpose technology (GPT) ushers in a period of diffusion and adoption. The adoption and learning of new and unfamiliar technology requires the use of skilled labor. As more firms adopt the new technology, skilled workers become scarce and their wages are pushed up, leading to an increase in wage inequality. In the long run, when all firms master the new technology, skilled and unskilled workers again become perfect substitutes and wage inequality falls.

The SBTC explanations do not address the high upfront costs of research faced by innovating firms, frictions in the financing of research, or the rationing of entrepreneurial finance. Changes in financial sophistication that ease the rationing of credit to research projects therefore play no role at all in these analyses. Our model incorporates imperfect capital markets and studies how improvements in their functioning (brought on, for example, by financial deregulation, new financial products that allow for great diversification of risk, improvements in monitoring technologies) affect organizational change, growth and inequality. The increased flow of entrepreneurial finance following improvements in the sophistication of financial markets facilitates the emergence of start-ups - small companies focused on innovation. In turn, the innovations delivered by the start-ups lead to a shift in production methods as high skilled workers cluster together and separate from low skilled workers. As high skilled workers get reallocated across firms, the skill premium increases.

Previous researchers have also studied organizational change as a factor driving inequality (Kremer and Maskin, 1996; Acemoglu, 1999). These papers emphasize that the quality of jobs created by firms (i.e. their hiring decisions) are driven by the supply of skills in the labor market. As the mean skill level rises, firms that previously hired both high and low skill workers now start focusing only on one or other type in their hiring decisions, and the composition of jobs changes. Garicano and Rossi-Hansberg (2006) develop a theory of hierarchical organizations with positive sorting of workers by skill and use to it explain the evolution of wage inequality in the US in the 1980s. They argue that the common underlying force driving the decline in firm size and the rise in inequality in the US is a reduction in the “costs of acquiring and communicating information” (p. 1412) that have come about due to the widespread adoption of e-mail, cellphones, and wireless networks. While these papers explain how the changing composition of jobs and sorting of workers across firms can lead to higher inequality, they do not address a potentially important contributor to organizational change - financial development. Our model makes explicit the connections between financial deregulation, changes in organization of production and more rapid technological progress,

and demonstrates how the interaction between these factors has led to the widening of the wage distribution in the US in the last 25 years.

3 A Model of Financial Development, Innovation, and Organizational Change

We present an endogenous growth model with imperfect credit markets and establish how improving the efficiency of these markets affects growth, organizational change and the dispersion in wages between skilled and unskilled workers. Unskilled workers are employed in manufacturing the final good. Skilled workers, on the other hand, either work in manufacturing or in research.³ Firms in the manufacturing sector produce final output using one of two production methods - one which combines skilled and unskilled workers (we refer to this as the “old economy”) and the other which combines skilled workers with an expanding variety of capital goods (we call this the “new economy”).

Technological progress takes place through the expansion in the number of intermediate capital goods, in the style of Romer (1990). When the variety of intermediate capital goods increases, the relative productivity of skilled workers rises and they get reallocated away from firms in the old economy that combine their services with unskilled labor input. As the number of skilled workers in the new economy firms decreases, the relative productivity of unskilled workers falls and the skill premium in wages increases.

Skilled workers are the only ones capable of innovation. We think of innovation in a broad sense as including invention of new and better intermediate goods, but also improvements in the production process of final goods. A reallocation of skilled workers from the manufacturing sector to the innovation sector can be thought of as another route through which un-pairing of skilled and unskilled workers in the production process takes place (as documented by the recent literature on changes in the organization of firms).⁴ The key

³Although the model emphasizes research devoted to producing new varieties of capital goods, we have in mind a broad range of innovative activities including problem-solving and cognitive tasks associated with implementing new business ideas, legal, accounting and strategy consulting.

⁴Kremer & Maskin (1996) argue that organizational change has contributed to widening inequality as higher skilled workers

point is unskilled workers' productivity in the final goods sector increases in the number of skilled workers in the old economy manufacturing firms, whereas when skilled workers work in manufacturing firms in the new economy they do not have an impact on the productivity of unskilled workers. As we discuss in more detail below, skilled workers in the innovation sector do contribute indirectly to unskilled workers' productivity through a spillover effect enjoyed by the old economy firms when the number of intermediate capital goods in the new economy expands. The total supply of skilled workers is allocated between the manufacturing and innovation sectors.

Furthermore, we assume that credit markets are imperfect. In particular, we assume that skilled workers are constrained from borrowing and cannot undertake their research projects without outside financing. However, significant frictions exist in the credit market because of potential asymmetric information between potential creditors / financiers and researchers. Households, in particular, cannot monitor the activities of researchers perfectly. This provides the rationale for the existence of specialized financial intermediaries capable of borrowing from households and financing innovation projects. Due to heterogeneity of projects as well as variation in prior expertise of financial intermediaries, not every intermediary is appropriate for every project. The appropriate financial intermediary can overcome the problems of asymmetric information and imperfect monitoring due to prior experience or expertise with research projects of a similar nature. Financial intermediaries therefore engage in costly search as they look for an appropriate project to finance. We model this process using a reduced form matching function approach borrowed from the labor literature (Wasmer and Weil, 2005; Jerzmanowski and Nabar, 2007). Due to credit market imperfections, not every researcher seeking finance will get matched with a financial intermediary. Entry into the innovation sector is restricted by the rationing of finance. This drives a wedge between the wages of skilled workers in manufacturing and the wages of researchers in the

match with other high skilled workers in smaller, specialized firms. Previously, the prevalence (and dominance) of large-scale companies ensured that high skilled workers mixed with low skilled workers. Low skill workers benefitted in these large corporations, since their productivity (and wages) were boosted by working along side high skill workers.

innovation sector. We demonstrate below that in this set-up a reduction in the degree of imperfections in the credit market will affect the allocation of skilled workers across sectors and drive up the skilled/unskilled wage differential (between group inequality) as well as the gap in wages between skilled manufacturing workers and researchers (within group inequality).⁵

3.1 The basic set-up

There is one final good produced by competitive firms with access to two types of production technologies - one which combines unskilled labor and skilled labor (the old economy) and the other which combines skilled labor with an expanding variety of intermediate goods (the new economy). This final good is used for consumption, investment (in R & D), and for manufacturing intermediate goods. Time is continuous and the economy is populated by infinitely lived agents of two types - skilled and unskilled. Unskilled workers can only be used in manufacturing of the final good, whereas skilled workers can also work in research. There are constant measures of both types of workers, L and H respectively.

Households

Households maximize present discounted value of linear utility with a discount rate ρ . This pins down the interest rate.

3.2 Production, Innovation and Growth

Final Goods Producers

The final good is manufactured by perfectly competitive firms with access to two types of production technologies. In the new economy technology, firms employ skilled labor together with an expanding variety of intermediate capital goods x_j , $j \in [0, A]$ according to

$$Y_{N,t} = H_{N,t}^{1-\alpha} \int_0^{A_t} x_{jt}^\alpha dj, \quad 0 < \alpha < 1.$$

⁵A change in the productivity of the innovation sector (brought about by the arrival of a new technological paradigm such as the internet) will also affect the allocation of skilled workers across sectors, the skill premium, and within group inequality in a similar way.

In the old economy technology, firms combine skilled and unskilled labour according to a CES production technology

$$Y_{O,t} = B_t \left[H_{O,t}^\rho + L^\rho \right]^{\frac{1}{\rho}}, \quad \rho < 1,$$

where $B_t (\leq A_t$ for all t) is a technology parameter which captures spillovers from innovation in the new economy sector.

Skilled labor is mobile between the old economy firms and the new economy firms. Skilled workers are allocated across sectors so that, in equilibrium, skilled wages are equalized across old and new economy firms.

Let $p_{j,t}$ represent the price of intermediate good j , $w_{L,t}$ denote the wage of unskilled workers and $w_{H,t}$ be the wage of skilled workers. Profit-maximization in the competitive final goods sector is consistent with the following conditions in factor markets:

$$p_{j,t} = \alpha H_{N,t}^{1-\alpha} x_{j,t}^{\alpha-1}, \quad (1)$$

$$w_{L,t} = B_t \left[H_{O,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} L^{\rho-1}, \quad (2)$$

$$w_{H,t} = (1 - \alpha) H_{N,t}^{-\alpha} \int_0^{A_t} x_{j,t}^\alpha dj \quad (\text{skilled wage in the new economy firms}), \quad (3)$$

$$= B_t \left[H_{O,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} H_{O,t}^{\rho-1} \quad (\text{skilled wage in the old economy firms}). \quad (4)$$

Intermediate Goods Producers

This component of the framework builds on the expanding variety endogenous growth model of Romer (1990). Each unit of intermediate goods costs one unit of final output to produce. Intermediate goods producers hold perpetual monopoly rights. At each point in time, they maximize the flow profit

$$\pi_{j,t} = (p_{j,t} - 1)x_{j,t} = \alpha H_{N,t}^{1-\alpha} x_{j,t}^\alpha - x_{j,t}.$$

The optimal choice of $x_{j,t}$ solves

$$\begin{aligned} \alpha^2 H_{N,t}^{1-\alpha} x_{j,t}^{\alpha-1} - 1 &= 0, \\ \Rightarrow x_{j,t} &= \alpha^{\frac{2}{1-\alpha}} H_{N,t}. \end{aligned} \quad (5)$$

In equilibrium, the amount of intermediate good produced is identical across all sectors. It follows that all intermediate goods are priced at the same mark-up over marginal cost

$$p_{j,t} = \frac{1}{\alpha},$$

and the flow profits

$$\pi_{j,t} = \frac{(1 - \alpha)}{\alpha} \alpha^{\frac{2}{1-\alpha}} H_{N,t}, \quad (6)$$

are also identical across all intermediate sectors in equilibrium.

Innovation and Growth

Skilled workers have ideas for new varieties of intermediate goods but they need to obtain finance to get started on their research projects. As described previously, the moral hazard problem that arises due to imperfect observability of research effort implies that this is not a frictionless process. The specialized financial intermediaries, venture capital firms, therefore incur costs in searching for the appropriate researcher to match with. If a successful match is formed, the skilled worker begins research and, with flow probability η , produces a measure δA of ideas for new intermediate goods. The parameter δ measures the productivity of skilled workers in the research sector and A captures the “giants’ shoulders” spillover from past research. Note that this implies that the model exhibits strong scale effects (Jones, 2005).

Let N be the number of researchers with financing. The aggregate growth in the number of varieties is given by

$$\dot{A}_t = \eta \delta A_t N = \eta \delta A_t (H - H_{O,t} - H_{N,t}), \quad (7)$$

where the second equality follows from the market clearing condition for skilled workers:

$$H = N + H_{O,t} + H_{N,t}.$$

As the number of intermediates A_t expands, the technology parameter for the old economy evolves according to

$$\frac{\dot{B}_t}{B_t} = \lambda \left(\frac{A_t}{B_t} \right)^{\frac{1}{\gamma}}, \quad 0 < \gamma < 1. \quad (8)$$

The growth rate of B is a function of the gap between the two technology indexes, A and B . As the gap gets larger, the bigger is the spillover effect and the growth rate of B increases exponentially. In the limit, with a very large gap, the spillover effect is infinite.⁶ We restrict λ to be such that

$$\lambda < \eta\delta N \text{ for all } N,$$

to ensure that

$$\frac{\dot{B}_t}{B_t} < \frac{\dot{A}_t}{A_t}$$

for the early time periods when B can be argued to be close to A . After the initial time periods, the gap widens until the steady state gap is reached. Figure (1) plots the growth rates of the two productivity parameters against their ratio. The growth rate of A is independent of the ratio $\frac{A}{B}$, whereas the growth rate of B increases exponentially with this ratio. Along the Balanced Growth Path (BGP), we will have

$$\frac{\dot{B}_t}{B_t} = \frac{\dot{A}_t}{A_t} = \eta\delta N,$$

and the steady state ratio $\frac{A_t}{B_t}$ follows as

$$\frac{A_t}{B_t} = \left(\frac{\eta\delta N}{\lambda} \right)^\gamma = Z \text{ (a constant)}. \quad (9)$$

3.3 The Capital Market

Ideas and Financing: the Matching Process

We assume that skilled workers can work in their current jobs in manufacturing while waiting to be matched with an appropriate financial intermediary. The number of new firms that are formed in each instant as a result of the search and matching process is given by the following matching function

$$M = \zeta F^\phi (H - N)^{1-\phi}, \quad (10)$$

⁶The formulation of the spillover effect is similar to the treatment of imitation costs in Barro and Sala-i-Martin's (1997) leader-follower model of cross-country technology diffusion. Also see Weil (2005, Chapter 8) for more discussion.

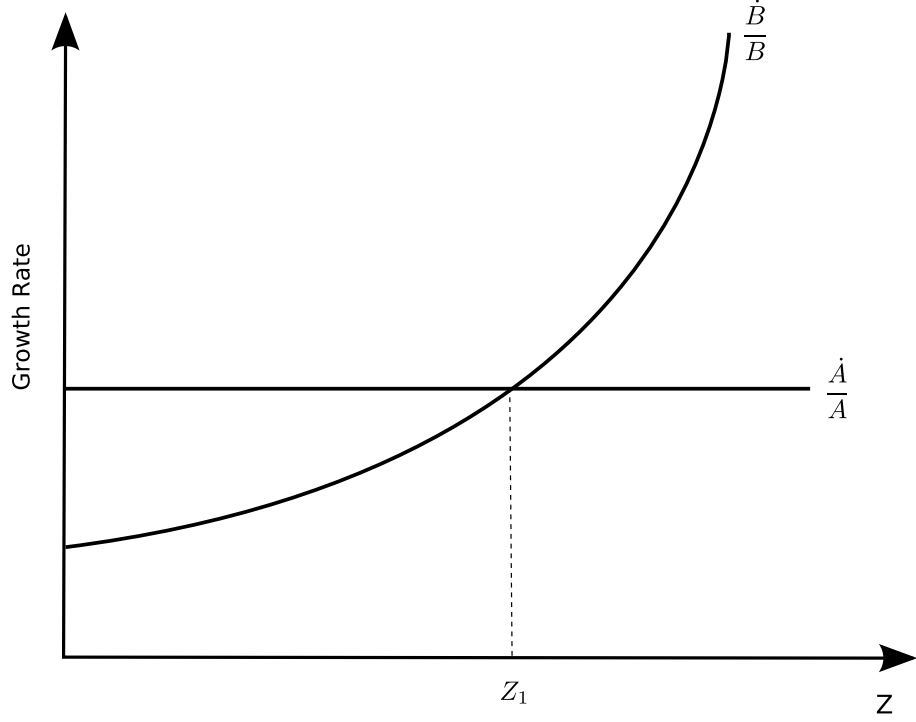


Figure 1: Determination of the steady state growth of productivity levels A and B and the productivity gap $Z \equiv A/B$.

where F is the number of financial intermediaries seeking researchers, $H - N$ is the total number of researchers seeking financing (i.e. all skilled workers in manufacturing), and $\zeta \geq 0$ indexes the efficiency of the matching process. An increase in ζ indicates an enhancement in the quality of financial intermediation. Note that with $\zeta = 0$, no matches are possible and no new research firms are formed. All skilled workers are employed in manufacturing and technological progress stalls.

Define $\theta = (H - N)/F$, i.e. the ratio of searching skilled workers to financial intermediaries. Then the probability of a financial intermediary being matched to a skilled worker is given by

$$\frac{M}{F} = \zeta \left(\frac{H - N}{F} \right)^{1-\phi} = \zeta \theta^{1-\phi} \equiv f(\theta), \quad (11)$$

and the probability of a skilled worker getting matched to a financial intermediary is

$$\frac{M}{H - N} = \frac{f(\theta)}{\theta}, \quad (12)$$

where $f' > 0$.

The number of research firms evolves according to

$$\dot{N} = M - \eta N, \quad (13)$$

where ηN is the measure of research firms that innovate.

3.4 The Labor Market

Our focus is on labor market outcomes. In particular, we are interested in how the skill premium responds to changes in financial markets.

Skilled Wages

Recall from (3) that the skilled wage in the new economy sector is

$$w_{H,t} = (1 - \alpha) H_{N,t}^{-\alpha} \int_0^{A_t} x_{j,t}^\alpha dj.$$

Substituting for $x_{j,t}$ from (5) we get

$$w_{H,t} = (1 - \alpha) H_{N,t}^{-\alpha} \int_0^{A_t} \alpha^{\frac{2\alpha}{1-\alpha}} H_{N,t}^\alpha dj = (1 - \alpha) \alpha^{\frac{2\alpha}{1-\alpha}} A_t. \quad (14)$$

In equilibrium, the wage of skilled labor is equalized across the old and new economy sectors.

Combining the expressions from (4) and (14), in equilibrium:

$$(1 - \alpha) \alpha^{\frac{2\alpha}{1-\alpha}} A_t = B_t \left[H_{O,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} H_{O,t}^{\rho-1}. \quad (15)$$

As A_t evolves, skilled labor is drawn out of the old economy by the higher wage. H_o declines and H_N increases. But there's a limit to how long this reallocation will continue. The labor market equilibrium condition in (15) defines H_o as a decreasing function of the ratio $\frac{A_t}{B_t}$. In steady state, for a given number of research firms N , from equation (9) we see that the ratio $\frac{A_t}{B_t}$ assumes the constant value Z . It follows that the allocation of skilled workers to the old and new economy sectors (H_o, H_N) will be stable in steady state.

Unskilled wages

The wage of unskilled workers is given by

$$w_{L,t} = B_t \left[H_{o,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} L^{\rho-1}, \quad (16)$$

which is increasing in H_o . As the number of skilled workers in the old economy declines, the wage of unskilled workers may initially fall, but in steady state (once H_o stabilizes) it will rise at the rate at which B increases. The model does not rule out an absolute decline in real wages of unskilled workers followed by a rebound (which is consistent with the pattern in the US data for wages at the 20th percentile and below over the last 25 years - Yellen 2006).

Skill premium

From (4) and (16), the skill premium is given by

$$\frac{w_H}{w_L} = \left(\frac{H_o}{L} \right)^{\rho-1}, \quad (17)$$

which is diminishing in the ratio $\frac{H_o}{L}$, and therefore increases as the ratio $\frac{H_o}{L}$ falls.

In the comparative statics below we will show that as financial markets improve, the steady state ratio $\frac{H_o}{L}$ declines. The intuition for this result is that as financial markets improve, more research firms are formed and the growth rate of A increases with the more rapid expansion of varieties of intermediate capital goods. Some of the skilled workers from the old economy firms get matched with financiers and move into the research sector. Furthermore, as the wage of skilled labor in the new economy rises (equation 14), skilled workers prefer to move to those firms. The number of skilled workers in the old economy firms declines on account of the combination of exit to the research sector and to the new economy firms.

Compensation of researchers

Consider now the determination of the wage in the innovation sector. As is standard in the search literature (see, for example, Pissarides, 1985), we assume that the wage ω that innovating firms pay to skilled workers is an outcome of a Nash bargaining process between the financial intermediary and the skilled worker, where β measures the bargaining power of financial intermediaries and $1 - \beta$ measures the bargaining power of workers.

Let S be the value of a financial intermediary without a skilled worker (i.e. in searching state), let J be the value of a financial intermediary with a skilled worker, let U be the value for a skilled worker of being in the unmatched state, and finally let Z be the value to the worker of being in a match. Let ω be the wage of innovative skilled workers. In addition, assume that if an innovation occurs the entire value (PDV of profits) goes to the financial intermediary.⁷ Let κA be the search cost incurred by a venture capital firm, which increases with the amount of intermediates since the level of expertise required to find the appropriate match rises with the level of productivity. This leads to the following arbitrage equations:

$$\rho J = -\omega + \eta \left(\frac{\delta A \pi}{\rho} - J \right) + \dot{J}, \quad (18)$$

$$\rho S = -\kappa A + f(\theta) (J - S) + \dot{S}, \quad (19)$$

$$\rho Z = \omega + \eta (U - Z) + \dot{Z}, \quad (20)$$

$$\rho U = w_H + f(\theta)/\theta (Z - U) + \dot{U}. \quad (21)$$

All these equations are simple arbitrage equations equating the flow return from holding an asset to the return from lending the asset's value at the interest rate ρ . For example, the flow return for an innovating firm is equal to the sum of the wage cost ($-\omega$), the expected capital gain (the gain of the perpetual stream of monopoly profits π/ρ from a measure δA of new blueprints), and the appreciation in the value of the asset (\dot{J}).

In order to obtain a closed form for the the wage we impose the balanced growth path assumption (we consider the off-BGP dynamics later). To find the wage, denote the total productivity-adjusted surplus⁸ from a match by $\tilde{D} = \tilde{J} - \tilde{S} + \tilde{Z} - \tilde{U}$. The solution to the

⁷This can be thought of as a risk-sharing arrangement, whereby the researcher gets paid a wage during the research process even when there is no tangible output to show for the work, but once the innovation is made, its entire profit stream gets captured by the financial intermediary.

⁸The productivity-adjusted surplus is simply the value normalized by productivity. For example

$$\tilde{J} = J/A$$

Nash bargaining process calls for the following division of the surplus

$$\tilde{Z} - \tilde{U} = (1 - \beta) \tilde{D}, \quad (22)$$

$$\tilde{J} = \beta \tilde{D}, \quad (23)$$

where, by free entry, we have $\tilde{S} = 0$.

Using the arbitrage equations and the solutions to the bargaining process, we get the following expression for the productivity-adjusted value of the researchers' wage $\tilde{\omega}$ (see Appendix A for details of the derivation):

$$\tilde{\omega} = (1 - \beta) \frac{\eta \delta \pi}{\rho} + \beta \frac{\tilde{w}_H(\rho + \eta - \eta \delta N) + (1 - \beta) f(\theta) / \theta \frac{\eta \delta \pi}{\rho}}{\rho + \eta - \eta \delta N + (1 - \beta) f(\theta) / \theta}. \quad (24)$$

Notice that if the bargaining power rests solely with the skilled workers (i.e. $\beta = 0$), then the researcher wage is simply the expected PDV of profits associated with a measure δA of ideas for new intermediate goods, $\eta \delta A \pi / \rho$. In productivity-adjusted terms, $\tilde{\omega} = \frac{\omega}{A} = \frac{\eta \delta \pi}{\rho}$. On the other hand, if skilled workers have no bargaining power (i.e. $\beta = 1$), then the researcher wage is simply equal to the wage of skilled workers in the intermediate sector \tilde{w}_H (in productivity-adjusted terms). In this case, research firms need only pay the reservation wage to satisfy the workers' incentive compatibility constraint. In general,

$$\tilde{w}_H < \tilde{\omega} < \frac{\eta \delta \pi}{\rho}.$$

The research wage and within-group inequality

Empirical studies of wage inequality in the US have argued that rising residual, or within-group, inequality is a major component of the increased dispersion in overall wage inequality (Autor, Katz and Kearney, 2005). These studies have also documented that the rise in residual inequality appears to be largely above the median of the residual wage distribution (i.e. in the upper tail of the distribution, among mainly college educated workers). In our model heterogeneity among skilled workers arises on account of the two different occupations that are open to them (manufacturing or research).

Our model generates predictions on conditions under which within-group inequality (the ratio of $\frac{\tilde{\omega}}{\tilde{w}_H}$) will increase when financial markets improve. Improvements in financial markets

lead to a higher number of successful matches (i.e. N increases). Recall that the productivity-adjusted wage of skilled workers in manufacturing \tilde{w}_H is constant regardless of the number of research firms. If the productivity-adjusted wage of researchers increases with N , within-group inequality (the ratio of $\frac{\tilde{\omega}}{\tilde{w}_H}$) will increase. Above we have established that when workers have some bargaining power, the research wage will lie between the PDV of the profit stream associated with ideas for new capital goods and the wage of skilled workers in manufacturing. If profits π are increasing in N , and if workers have some bargaining power, the research wage will also increase in the number of research firms N .

In Appendix C we show that there exists a certain threshold number H^* of skilled workers in the old economy such that

$$d\pi/dN > 0 \text{ only if } H_0 > H^* .$$

It follows that if the allocation of skilled labor across old and new economy firms is such that $H_0 > H^*$, the wage of researchers and within-group inequality increase in response to improvements in financial markets and an increase in the number of research firms.⁹

Since the share of corporate profits in GDP has been increasing in the US economy over the last several years (climbing from its historic average of roughly 6% in the late 1970s to close to 10% in recent years¹⁰), it is tempting to conclude that the US economy has had an allocation $H_0 > H^*$. Note however, that if the productivity of R&D δ increases, average profits $\eta\delta\pi$ may go up even if π falls. Either way, the model predicts an increase in the skill premium in response to financial development since skilled workers are drawn out of the old economy firms as the number of intermediate capital goods expands more rapidly with the improved functioning of financial markets. Furthermore, as long as profits increase with N , the model predicts that the wages of skilled workers in research also increase when their bargaining power is greater than zero. The skill premium calculated not just on the basis of

⁹An interesting implication is that continued improvements of financial markets (or acceleration of technological progress) may reduce profits.

¹⁰Source: Authors' calculations, based on data from the FRED database of the Federal Reserve Bank of St. Louis.

manufacturing wages but on the basis of wages of all skilled workers therefore also increases.

3.5 Balanced Growth Path

Along the balanced growth path, $\dot{N} = 0 \Rightarrow N = M/\eta$. Furthermore, the asset values grow at the same rate as productivity

$$\frac{\dot{J}}{J} = \frac{\dot{S}}{S} = \frac{\dot{Z}}{Z} = \frac{\dot{U}}{U} = \frac{\dot{A}}{A} = \eta\delta N.$$

Our hypothesis is that improvements in financial markets contribute to entry of more research firms, faster growth, and widening wage inequality. In order to demonstrate this, we first derive a two-equation system in (J, N) which will help us pin down the equilibrium value of N .

Free entry into financial intermediation implies $S = 0$ and, from (19), it follows that

$$\begin{aligned} -\kappa A + f(\theta)J &= 0, \\ \Rightarrow J &= \frac{\kappa A}{f(\theta)}. \end{aligned}$$

Dividing by A to convert the above value function into a productivity-adjusted value we get

$$\tilde{J} = \frac{\kappa}{f(\theta)} \quad (\text{FE}). \quad (25)$$

Similarly, dividing equation (18) by A and using $\dot{J} = \eta\delta NJ$ we obtain the following expression for \tilde{J}

$$\tilde{J} = \frac{\eta\delta\pi/\rho - \tilde{\omega}}{\rho + \eta - \eta\delta N} \quad (\text{JJ}). \quad (26)$$

As we make more explicit below, the two equations FE and JJ define a two equation system in (J, N) space which can be solved to get a value of N along the balanced growth path. Define

$$\vartheta \equiv \frac{f(\theta)}{\theta} = \frac{\eta N}{H - N}, \quad (27)$$

which is the probability of a skilled worker matching with a financial intermediary along the balanced growth path. Recall also that from equation (11) we have

$$f(\theta) = \zeta \theta^{1-\phi},$$

so that

$$\vartheta(N) = \zeta \theta^{-\phi}.$$

From this expression we see that $\theta(N) = \vartheta(N)^{-1/\phi} \zeta^{1/\phi}$, and therefore

$$f(\theta) = \zeta \theta^{1-\phi} = \zeta (\vartheta(N)^{-1/\phi} \zeta^{1/\phi})^{1-\phi} = \zeta^{1/\phi} \vartheta(N)^{-(1-\phi)/\phi}.$$

The equilibrium condition (25) becomes

$$\tilde{J} = \frac{\kappa}{f(\theta)} = \frac{\kappa}{\zeta^{1/\phi} \vartheta(N)^{-(1-\phi)/\phi}} = \kappa \vartheta(N)^{(1-\phi)/\phi} \zeta^{-1/\phi} \quad (\text{Free Entry}). \quad (28)$$

This relationship is upward sloping in the (J, N) space (from equation 27, $\vartheta'(N) > 0$). As the value of research firms increases, more financial intermediaries enter in search of a match until the value of a searching firm is driven back down to zero. Since the number of financial intermediaries increases, the number of matches (M) increases and so does the number of research firms in equilibrium ($N = M/\eta$).

As we show in Appendix B, combining condition (26) with the above expression for the wage of researchers (equation 24) yields

$$\tilde{J} = \frac{\beta \left(\frac{\eta \delta \pi(N)}{\rho} - \tilde{w}_H \right)}{\rho + \eta - \eta \delta N + (1 - \beta) \vartheta(N)} \quad (\text{JJ}). \quad (29)$$

The expression indicates that the value of a research firm increases in the bargaining power of financial intermediaries (β), the present value of future profits from an innovation, and the productivity of research effort δ . The value is decreasing in the discount rate ρ and the flow probability of innovation η (a higher η implies that a larger fraction of research firms will innovate in any given instant and therefore the value of an additional innovation is lower). The value is also decreasing in the probability of a skilled worker matching with

an intermediary along the BGP, $\vartheta(N)$. As this probability increases, the reservation value for workers of remaining in the searching state goes up because they have better prospects of matching with the appropriate intermediary and therefore they can continue to remain in the searching state until the right match is made. A consequence of this is that financial intermediaries have to concede a higher wage $\tilde{\omega}$ to researchers, which lowers the value of a research firm. The exception is when researchers have no bargaining power ($\beta = 1$) and, as a result, changes in the reservation value of skilled workers brought on by an increase in their matching probability have no effect on the value of a research firm.

The JJ-locus plots the productivity-adjusted value of a research firm (\tilde{J}) as an inverted-U shape function of the number of research firms (N). With an increase in the number of research firms, the growth rate of productivity in the new economy sector ($\frac{\dot{A}_t}{A_t}$) increases. The faster productivity growth of the new sector opens a larger productivity gap between it and the old sector, drawing skilled workers out of the old economy sector. At the same time, skilled workers also leave both the old and new economy sectors to work in the innovation sector.

Initially, starting from a low number of research firms, an increase in N is associated with a net inflow of skilled workers into the new economy sector. As the pool of skilled workers who use intermediate capital goods expands, the value of an additional intermediate good (i.e. of an innovation) increases. This causes \tilde{J} to increase. Beyond a certain threshold size of the innovation sector (number of research firms), a further expansion in the number of firms will be associated with a net outflow of skilled workers from the new economy sector. The innovation sector grows by drawing skilled workers out of both the old and new economy sectors. As the pool of skilled workers who use intermediate capital goods in the new economy sector shrinks, the value of an additional intermediate good and \tilde{J} fall.

We show in the Appendix (to be added) that the two curves JJ and FE must intersect as depicted in Figure 2 for plausible parameter values. Equations (28) and (29) are a system in J and N , which together determine the BGP equilibrium. In fact, there can be two steady

state equilibria. As discussed in the Appendix the steady state to the left of SS_1 is an unstable equilibrium and so we focus on SS_1 . Note that the intersection can occur in the either the upward or downward sloping part of the JJ curve.

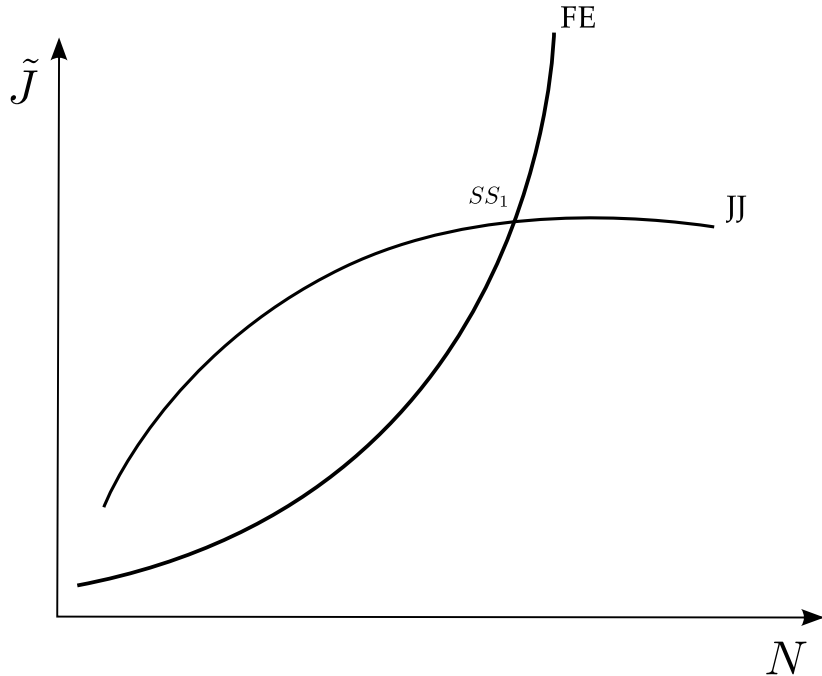


Figure 2: The determination of balanced growth path value of N and J .

Comparative Statics

Consider for example a reduction in financing frictions, illustrated in Figure 3 as a shift to the right in the FE curve. The probability of a successful match increases with the improvement in financial markets, drawing a larger number of skilled workers into research. At every level of \tilde{J} , there is a higher number of research firms in equilibrium. The increase in the number of researchers N leads to a faster expansion in the variety of intermediate capital goods ($\frac{A_t}{A_t}$ rises - Figure 4). Since the steady state ratio of relative productivity $\frac{A_t}{B_t}$ increases, this drives up the wages of skilled labor in the manufacturing sector. As N rises, H_O – the employment of skilled workers in the old sector – falls and the skill premium increases (Equation 17). In the long run, due to the spillover effect, the productivity of unskilled workers rises. Initially, however, their wages fall as the number of skilled workers in the old economy (H_O) declines. This increases wage inequality. In the long run all wages grow at a

faster steady state rate due to the accelerated pace of innovation (which results from greater financial sophistication and the employment of skilled workers in the innovation sector).

The wage of researchers in the innovation sector depends in an important way on what happens to profits. If the equilibrium occurs in the upward sloping part of the JJ curve (SS_2), profits increase with the reduction in financing frictions. When researchers have some bargaining power, with improvements in the functioning of financial markets their wage will increase relative to the wage of skilled workers in manufacturing. Within group inequality will therefore increase. Ultimately the model predicts that the equilibrium must move to the downward sloping part (SS_3), after which profits will begin to decline. As profits fall, the productivity-adjusted wage of researchers will also eventually decline relative to the productivity-adjusted wage of skilled workers in manufacturing and within group inequality will decrease.

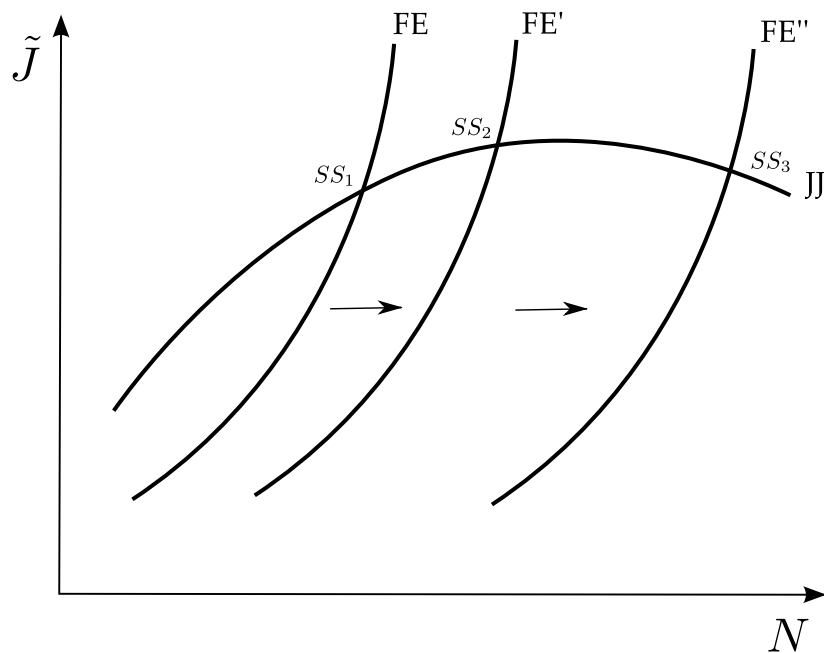


Figure 3: Improvement in matching efficiency of financial markets (increase in ζ) - comparative statics.

Figure 5 shows a numerical simulation of the model. The six subfigures plot how the steady state levels of several key model variables respond to greater financial development, i.e. an increase in ζ . As discussed above, the size of the innovation sector increases (Figure

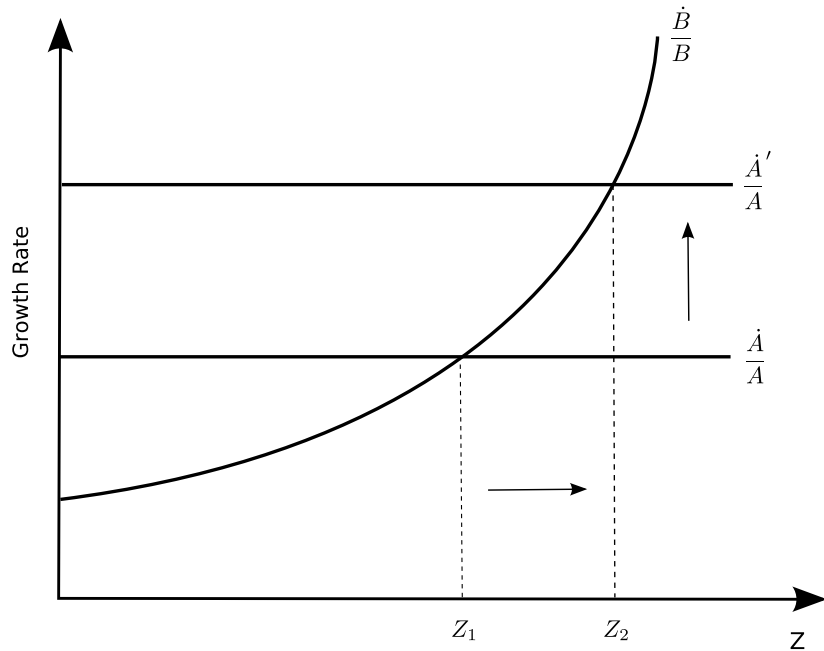


Figure 4: Financial development and changes in the steady state ratio $Z = \frac{A_t}{B_t}$.

5(a)) and the skilled employment in the old sector declines (Figure 5(b)). Skilled employment in the new sector increases initially but starts declining for higher values of ζ , reflecting the initial net inflow of skilled workers into the new economy sector and subsequently the net outflow as more skilled workers get matched with financial intermediaries. Profits follow the same pattern (Figures 5(c) and 5(d)). The skill premium, as measured by the ratio of manufacturing skilled wage relative to unskilled wage, increases uniformly (Figure 5(e)). Within group inequality initially rises but eventually starts to decline (Figure 5(f)). For the parameters used here, the decline in within group inequality sets in at a much higher value of financial development than the decline in profits does (compare Figures 5(d) and 5(f)), indicating that within group wage inequality can continue to increase for a while even with falling profits.

Finally, we want to consider the interaction between changes in the fundamentals of technological progress – the productivity of R&D δ – and the sophistication of financial markets. First, consider an improvement in the productivity of research (δ increases). The JJ curve shifts up – for every level of N the value of a research firm increases since each research

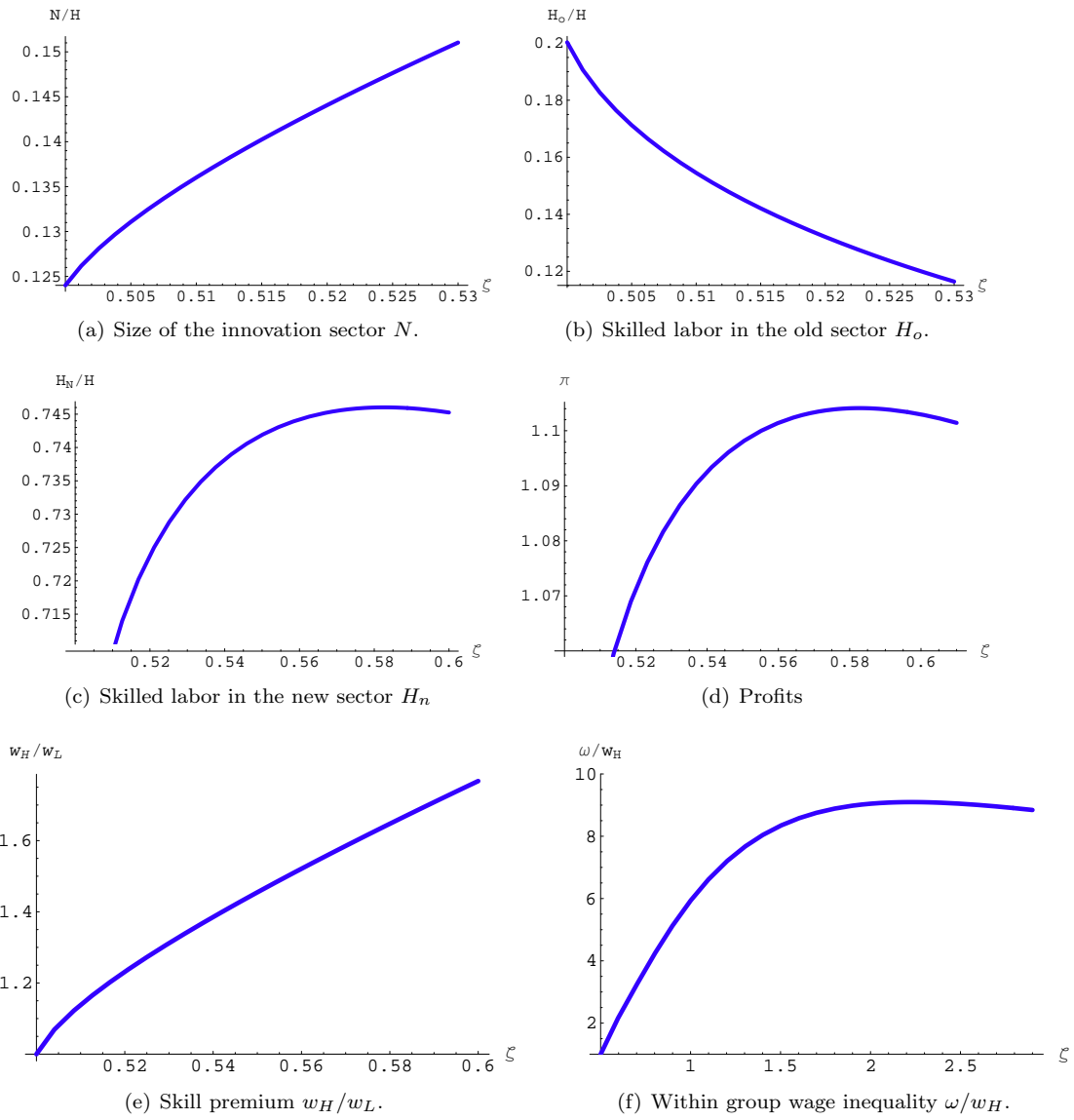


Figure 5: Numerical simulation of the model. The effect of financial innovation (increase in ζ) on key variables.

firm will generate a larger measure of ideas when it succeeds in innovating. As Figure 6 shows, the number of research firms and the value of a typical research firm increase irrespective of whether the intersection takes place in the upward or downward sloping portions of the JJ curve (we are simply moving up along the FE curve). As before the ratio of skilled to unskilled wages in manufacturing will rise. What happens to the compensation of researchers again depends on the allocation H_O relative to the threshold H^* , since this determines whether profit per new variety π goes up or down. As noted above, however, even if π falls, the total profit $\eta\delta A\pi$ may go up since higher productivity of research increases the measure δA of innovations that each start-up comes up with.

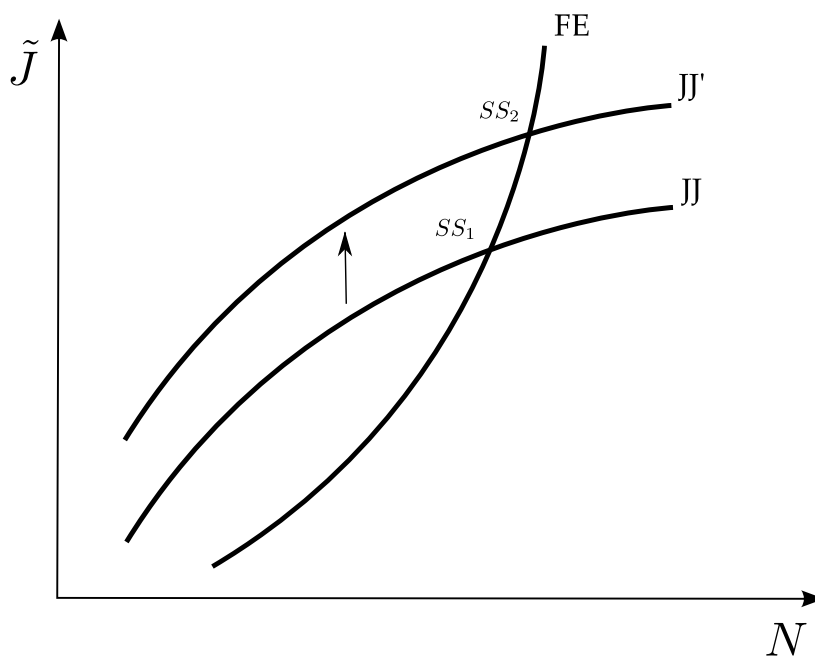


Figure 6: Effects of an acceleration of technological progress.

4 Empirical Evidence

The model presented above predicts that, *ceteris paribus*, the greater the degree of financial market development, the higher the ratio of skilled to unskilled wage (skill premium). It is also possible that the ratio of skilled wage in research ω to skilled wage in manufacturing increases (degree of within group inequality increases) in response to financial market development. This section presents an attempt to test this prediction. We concentrate on the evidence from US states and we also subsequently look at cross-country data.

4.1 State level evidence from U.S.

We study the relationship between financial development and inequality using two separate measures of each variable. First, we test the relationship between returns to education (skill premium) - calculated using both Census Data as well as March Current Population Surveys (CPS) - and financial deregulation using a panel over the period 1970-2000. We also do the same for residual (within group) inequality. Our measure of financial deregulation comes from Jayaratne and Strahan (1996), who document the timing of legal changes allowing for out-of-state bank branches to be established.¹¹ Second, we look at the relationship between returns to education calculated from the CPS data and NSF data on venture capital activity across states between 1995 and 2000. We repeat the exercise for residual inequality.

In the first stage of each exercise we estimate a Mincerian wage equation

$$w_{is} = \alpha + \alpha_s I_s + X_i \beta + \gamma E_i + \gamma_s E_i I_s + \epsilon_{is},$$

where w is the log of weekly wage, X is a vector of personal characteristics which includes experience, experience squared, sex and race, E is years of education and I_s is a dummy variable for state s . This specification allows for different rates of return to education across states. With the Census Data we run separate cross-sectional regressions for the four years

¹¹They show that financial deregulation leads to faster growth of state output per person, giving support to the hypothesis that state-level financial development matters for state-level economic growth and also suggesting that it might further affect outcomes in the labor market.

(1970, 1980, 1990, 2000) in the sample period. With the March CPS Data, we run cross-sectional regressions for two years (1995, 2000) for which we have venture capital finance data.¹² Prior to 1977, the March CPS Data do not contain state identifiers. We are therefore unable to estimate the first stage regression at the state level using this dataset before 1977. In the second stage of each exercise, we use these estimated rates of return as our estimate of the skill premium ($\widehat{\eta}_s \equiv \widehat{\gamma} + \widehat{\gamma}_s$) and the standard deviation of residuals for each state $\widehat{\sigma}_{\epsilon s}$ as our measure of residual inequality. The separate cross-sectional regressions conducted in the first stage allow us to construct a panel of skill premia and residual inequality to exploit within-state time variation in these measures of inequality in the second stage.

4.1.1 Banking Deregulation

The first measure of financial development we use is an indicator for banking deregulation compiled by Jayaratne and Strahan (1996). Starting from 1970, a number of states deregulated their banking sector by permitting out-of-state holding companies to consolidate their in-state subsidiaries into branches of one bank company, as well as by allowing intrastate expansion of branches. The authors demonstrate that these changes improved the quality of intermediation and had a positive impact on state-level growth rates. We conjecture that the changes in the banking industry improved the flow of finance to in-state businesses and possibly facilitated the widening of inequality through the channel discussed in the theory section. The specification used is

$$\widehat{\eta}_{st} = \delta_0 + \mu_s + \tau_t + \delta_1 D_{st} + \delta_2 E_{st} + \delta_3 g_{st} + v_{st},$$

where α_s is a state fixed effect that captures time-invariant state-specific attributes that affect the skill premium, τ_t is a time dummy that captures macroeconomic shocks affecting all states in year t , D_{st} is an indicator variable that takes on the value 1 if state s has deregulated its banking sector by time t , E_{st} is a measure of average years of education in state s at

¹²We also run the regression for 1990 and 1985 using the CPS data to obtain lagged values of RHS variables to be used as instruments in the dynamic panel data model.

time t .¹³ This measure of education proxies for shifts in the supply of educated workers. We also include the average growth rate of state-level output per worker g_{st} to control for demand side influences (for example, faster growing states may have experienced more rapid skill-biased technological change, which raised the relative importance of skilled workers in production).¹⁴ Recall that in our model an increase in the rate of technological progress will lead to a rise in the skill premium and, under some circumstances, this increase will be greater in more financially developed economies. The inclusion of growth rates also allows us to control for the influence of banking deregulation on growth and determine whether the financial changes had any impact on the skill premium over and above this indirect route.

While the banking deregulation can plausibly be thought of as exogenous (Jayaratne and Strahan argue that the timing of deregulation was not influenced by state-level economic indicators), both the growth rate and the measure of education are likely to be endogenous. It is plausible that returns to education affect schooling attainment and also that an omitted (and time-varying) variable is correlated with both growth of output and returns to education. In addition, the likely high degree of persistence in rates of return to education implies we should include a lagged level of the skill premium as one of the regressors. The inclusion of the lagged dependent variable invalidates the fixed effects approach. To deal with these two issues we estimate the model using the system GMM estimator of Blundell and Bond (1998).

Table 1 reports the estimates. The first column includes only the measure of financial deregulation. The second column adds the measure of average years of education, the third column includes growth in real output per worker, the fourth column adds both education and growth. The last column reports pooled OLS results. All regressions include time effects.

¹³This is calculated for the same sample as the one used in the first stage Mincerian regressions.

¹⁴The data on output per worker comes from Baier et al. (2007). For the regressions using ten year periods (Census data) we use the average growth over previous ten years. For the CPS data we use five year periods and so, accordingly, we use growth over previous five years. Since the data on output per worker are at decade frequencies, we interpolate the growth rate for the preceding five years using the growth rate of the nominal gross state product (GSP) from BEA data. For example, if growth of GSP between 1990 and 1995 was 45% of the growth between 1990 and 2000 we assign 45% of the real per worker 1990-2000 growth to the period 1990-95.

In all the specifications, banking deregulation enters with a positive sign and it is significant at the ten percent level in the first column, at the one percent level in the second column, and at the five percent level in the last two columns, indicating that states that have deregulated financial markets have seen faster increases in the rate of return to education than those states that have not. The magnitudes are also economically significant - as reported in column 3 for example, deregulation is associated with an increase in the return to education by 0.34 percentage points (or about 30% of the standard deviation of returns in 2000). This effect is over and above possible effects through the growth rate channel. In Column 4, we report results from a pooled OLS estimation. The effect of deregulation on the skill premium is statistically significant with this alternative estimation strategy as well.

	GMM	GMM	GMM	Pooled OLS
Fin.Dereg.	0.306* (0.175)	0.436*** (0.155)	0.337** (0.145)	0.314** (0.132)
Lagged Rets.	0.505*** (0.122)	0.715*** (0.093)	0.633*** (0.077)	0.599*** (0.064)
Education		-0.000 (0.003)	0.003 (0.003)	0.006*** (0.002)
Growth			0.046*** (0.009)	0.034** (0.014)
Constant	0.049*** (0.011)	0.036 (0.039)	-0.009 (0.037)	-0.052** (0.021)
R ²				0.780
N	153	153	153	153

Table 1: Return to education; Census data. System GMM treating education and income as endogenous variables (columns 1-3) and pooled OLS (column 4). Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

Tables 2 and 3 show the regressions for residual inequality. The specification used is

$$\widehat{\sigma}_{est} = \delta_0 + \mu_s + \tau_t + \delta_1 D_{st} + \delta_2 E_{st} + \delta_3 g_{st} + v_{st},$$

where $\widehat{\sigma}_{es}$ is the estimated state-level standard deviation of residuals in the Mincerian wage

regression (Table 2) and the (log) ratio of the 90th to 50th percentiles of these residuals (Table 3). The control variables are as described for the second stage regression using the skill premium. In all cases we find a positive and economically large coefficient on banking deregulation, but it is never estimated accurately enough to be significant at the 10% level.

	GMM	GMM	GMM	Pooled OLS
Fin.Dereg.	0.167 (0.403)	0.320 (0.343)	0.567 (0.350)	0.431 (0.393)
Lagged sd	0.369*** (0.079)	0.410*** (0.098)	0.631*** (0.052)	0.645*** (0.069)
Education		0.022*** (0.008)	0.024*** (0.006)	0.016*** (0.006)
Growth			0.101*** (0.019)	0.103*** (0.026)
Constant	0.357*** (0.041)	0.043 (0.079)	-0.121* (0.066)	-0.024 (0.064)
R ²				0.761
N	153	153	153	153

Table 2: Residual inequality (standard deviation of residuals); Census Data. System GMM treating education and income as endogenous variables (columns 1-3) and pooled OLS (column 4). Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

When using the March CPS data, we cannot identify some of the states prior to 1977. The benefit of using the CPS is that we can calculate our measures of wage inequality at a greater frequency. Table 4 shows the results of the full specification (with education and output growth) using all three measures of wage inequality in a 5-year non-overlapping panel (the years are 1978, 1983, 1988, 1993 and 1998). As with the inequality measures calculated from the Census data, all the coefficient estimates on banking deregulation are positive and economically meaningful – they are also significant at the 5% level for both regressions that employ measures of residual inequality (Columns 2 and 3).

	GMM	GMM	GMM	Pooled OLS
Fin.Dereg.	0.427 (0.417)	0.543 (0.409)	0.318 (0.387)	0.125 (0.554)
Lagged 90/50	0.498*** (0.174)	0.583*** (0.147)	0.508*** (0.101)	0.654*** (0.059)
Education		0.022** (0.010)	0.008 (0.009)	0.007 (0.008)
Growth			0.036 (0.028)	0.087*** (0.030)
Constant	0.337*** (0.101)	-0.010 (0.156)	0.224 (0.148)	0.116 (0.104)
R ²				0.736
Sargan p-value	0.45	0.49	0.04	
N	153	153	153	153

Table 3: Residual inequality (90/50 ratio); Census Data. System GMM treating education and income as endogenous variables (columns 1-3) and pooled OLS (column 4). Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

	Returns	Resid. Ineq.	90/50 ratio
Fin.Dereg.	0.243 (0.178)	0.446** (0.212)	0.802** (0.376)
Lag. Dep. Var.	0.167*** (0.057)	0.394*** (0.034)	0.128*** (0.038)
Education	0.022*** (0.003)	0.033*** (0.005)	-0.025*** (0.010)
Growth	0.068*** (0.007)	0.095*** (0.014)	-0.005 (0.028)
Sargan p-value	0.24	0.76	0.58
N	204	204	204

Table 4: March CPS Data; 5-year, non-overlapping panel. System GMM treating education and income as endogenous variables. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

4.1.2 Venture Capital

Our second test of the model's predictions employs data on venture capital (VC) activity across states. The enormous growth of this type of financing (especially for start-ups in the high tech business) during the latter part of the 1990s is well documented. We use data on the amount of VC disbursements per \$1000 of Gross State Product as our measure of financial development. The data come from the NSF's Science and Technology Indicators (2006). The venture capital data are for the years 1995 and 2000. We use March CPS data to construct our measures of inequality for these two years. The specification used is

$$\widehat{\eta}_{st} = \delta_0 + \mu_s + \tau_t + \delta_1 VC_{st} + \delta_2 E_{st} + \delta_3 g_{st} + v_{st},$$

Table 5 shows the results for specifications that parallel those used above for banking deregulation. Venture capital activity is not significantly associated with the skill premium in any of the specifications.

	GMM	GMM	GMM	Pooled OLS
Venture Capital	0.017 (0.025)	0.022 (0.026)	-0.008 (0.033)	-0.014 (0.035)
Lagged Rets.	0.418*** (0.114)	0.257** (0.128)	0.210* (0.114)	0.510*** (0.116)
Education		0.037*** (0.011)	0.031*** (0.010)	0.015*** (0.005)
Growth			0.092 (0.068)	0.129** (0.052)
Sargan p-value	0.44	0.70	0.53	
N	102	102	102	102

Table 5: Venture capital and returns to education. March CPS Data. System GMM treating education and income as endogenous variables. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

Tables 6 and 7 repeat the above exercise using the overall residual wage inequality (the standard deviation of residuals) and the upper-tail residual wage inequality (the log residual 90/50 percentile ratio), respectively as dependent variables. The specification used is

$$\widehat{\sigma}_{est} = \alpha_s + \tau_t + \beta VC_{st} + \gamma E_{st} + \delta g_{st} + v_{st}.$$

Here the results are both economically meaningful – a one standard deviation change in

venture capital activity explains about 40% of the standard deviation in residual wage inequality – as well as statistically significant, even when we control for education and state growth rates.

	GMM	GMM	GMM	Pooled OLS
Venture Capital	0.134*** (0.033)	0.161*** (0.035)	0.136** (0.054)	0.170*** (0.059)
Lagged Res.Ineq.	-0.094 (0.176)	-0.052 (0.149)	-0.028 (0.139)	0.447*** (0.117)
Education		-0.015 (0.017)	-0.005 (0.014)	-0.005 (0.006)
Growth			0.086 (0.110)	-0.036 (0.085)
Sargan p-value	0.73	0.40	0.71	
N	102	102	102	102

Table 6: Venture capital and residual inequality (standard deviation). March CPS Data. System GMM treating education and income as endogenous variables. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

	GMM	GMM	GMM	Pooled OLS
Venture Capital	0.209** (0.101)	0.242** (0.097)	0.279* (0.155)	0.297 (0.187)
Lagged 90/50 Ratio	-0.094 (0.155)	-0.138 (0.137)	-0.141 (0.132)	0.088 (0.132)
Education		-0.009 (0.048)	-0.015 (0.043)	-0.076*** (0.028)
Growth			-0.081 (0.306)	-0.122 (0.268)
Sargan p-value	0.65	0.53	0.71	
N	102	102	102	102

Table 7: Venture capital and residual inequality (90/50). March CPS Data. System GMM treating education and income as endogenous variables. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

We take the above results as highly suggestive of a relationship between financial development and wage inequality as predicted by our model. While our empirical analysis cannot pinpoint the exact channel of this effect, it is interesting to note the difference in results comparing our two measures of financial development - banking deregulation and venture capital activity. In our model, the quality of the financial market has a single dimension expressed by the efficiency of the the matching process. An improvement in this quality is

predicted to increase both the return to skill as well as within group inequality (if wages of workers in the research sector rise with the increase in H_N). In the data, however, we see evidence of banking deregulation associated with a rise in the skill premium, but not with residual inequality. Higher venture capital activity, on the other hand, is associated with an increase in residual inequality, but not in the skill premium. Since the issue is of statistical significance and not of the estimated direction of the effect, this may simply reflect noisy data. However, it may be the case that different types of financial innovation affect the two aspects of wage dispersion (overall and residual) in different ways. This is something we leave for future research to explore.

4.2 Cross-country Evidence

In this section we briefly examine the cross-country evidence. Van Aark and Monnikhof (1996) report that the distribution of firm size has shifted toward smaller and medium-sized businesses in recent decades across several OECD countries. Kremer and Maskin (1996) also report organizational change and sorting of workers by skill across firms in France in similar fashion to the US. At the same time, various studies have documented changes in inequality across OECD countries. Despite the widely held view that inequality in continental Europe has remained fairly stable, studies have found similarities between the trends in the 90-50 differential in Europe and the US.¹⁵ We therefore examine cross-country evidence to determine whether there are linkages between financial development and wage inequality in a broader sample of countries. This analysis has some obvious shortcomings. First, because the central mechanism in our story is innovation and the role of financial markets of facilitating skilled individuals' entry into the innovation sector, we feel that the theory applies more closely to developed countries. Moreover, considerable unobserved heterogeneity across countries is a challenge to any empirical work as is the likely low quality of cross-country data, especially that on wage differences and returns to skills. Nevertheless, we think it is

¹⁵Wage compression (on account of labor market institutions that ensure wages at the lower end of the distribution rise in step with the rest of the distribution) in Europe in the 50-10 range has however ensured that inequality has not changed as much as it has in the US (Acemoglu, 2002).

interesting to examine the evidence of the relationship between financial development and wage inequality in a cross section of counties.

We use two measures of skill premia – returns to education from a Mincerian regression (from Bils and Klenow 2000) and ratio of wages of skilled workers to unskilled workers (from UBS Price and Earnings Reports 2006). The Bils and Klenow data contains country level estimates of the Mincerian returns to education. The years vary from country to country but most are from the 1980s with a few from 1970s and 1990s. The UBS data reports wages of workers in several occupations for a cross section of cities from 40 countries – usually the largest city in the country is surveyed. We calculate the ratio of skilled to unskilled wage and average over cities whenever more than one city for a given country is included in the data. We define skilled workers, following Forbes (2001), as those grouped under categories of “engineers” and “skilled industrial workers”, and the unskilled as those in the “building labourers” category. We use the survey from 2006.¹⁶

In both cases we are interested in the relationship between the measure of skill premium and the development of financial markets. To measure the latter we use the Private Credit / GDP ratio from the World Bank. Since we are interested in identifying causality from financial development to skill premia, we use the credit measures from periods prior to the measurement of skill premia – 1970 for the returns to schooling data and 2000 for the wage data. In some specifications we also control for education as well as the capital stock and level of income. We get these measures from Barro and Lee (2000) and Penn World Tables (2002), respectively.

Figure 7 shows the simple OLS regression of the two measures of returns to skills on our measure of financial development estimated separately for the OECD and non-OECD subsamples.¹⁷ In both cases we observe a positive relationship in the OECD and non-OECD countries. The strength of the relationship appears similar, however, the intercept is not –

¹⁶The results are largely unchanged if we use averages of the credit variable over longer periods of time.

¹⁷We use log wages because the data in levels is highly skewed.

Returns to Skills and Financial Development: OECD vs. Non-OECD

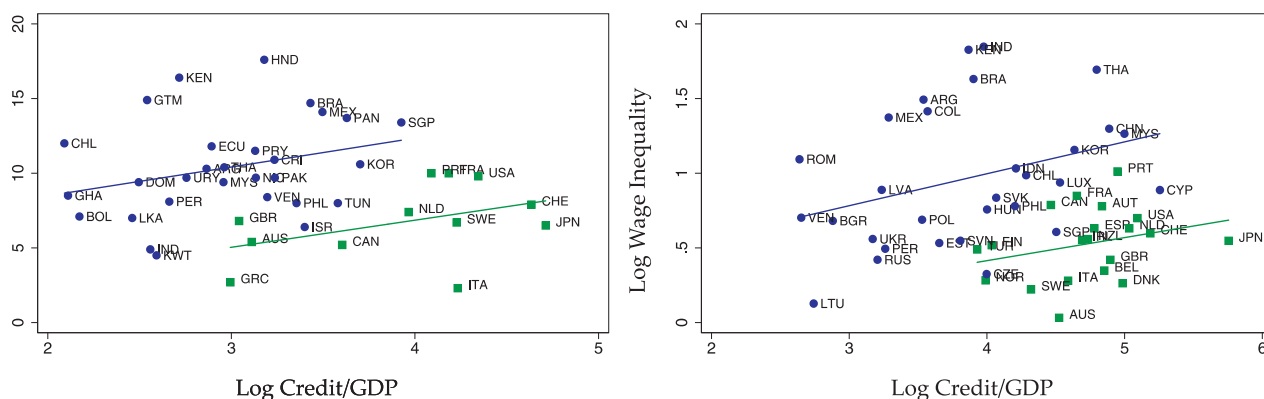


Figure 7: Financial development and wage inequality – Cross Country Evidence.

conditional on financial development, OECD countries have lower skill premia.¹⁸

To explore this relationship more formally we regress the skill premia on financial development while controlling for other covariances. The results are presented in Tables 8 and 9, for returns to schooling and wage ratios, respectively. In the first column of both tables, we control for the average level of educational attainment to account for the effect of the supply of skills on its price. We also include a squared term in the education measure to capture the possible nonlinearity of this relationship. As was clear from Figure 7, the intercept of the relationship differs between OECD and non-OECD countries. We therefore include a dummy for OECD membership. For both measures of skill premium we find that the development of financial markets, as measured by the credit/GDP ratio, has a positive and significant effect on the skill premium. We also note that, as should be expected, an increase in the supply of skills lowers the price of skills and this relationship appears to be nonlinear – but is only significant in the wage ratio regression.¹⁹

¹⁸This could be because the quality of unskilled workers varies a lot; for example, engineers in the US and India may be very similar in terms of skills while building laborers may not. Furthermore, it may be the case that many of the OECD countries have social insurance programs and labor market institutions that protect the wages of the less educated workers and ensure that they don't fall too far behind the wages of better educated workers.

¹⁹The nonlinearity is consistent with human capital externalities that are present at higher levels of human capital.

	Baseline		OECD	Non-OECD	
Credit	1.827** (0.875)	2.223*** (0.809)	2.265** (0.965)	2.053* (1.002)	2.204* (1.277)
Education	-1.202 (1.132)	-2.656** (1.009)	-2.625** (0.986)	-2.342 (1.264)	0.051 (1.842)
Education Sqr.	0.091 (0.094)	0.181** (0.079)	0.179** (0.079)	0.185 (0.106)	-0.072 (0.195)
OECD	-4.883*** (1.706)	-5.468*** (1.583)	-5.430*** (1.702)		Capital
Capital		1.182 (0.865)	1.244 (0.987)		Income
Income			-0.140 (1.199)		Constant
Constant	8.005** (3.517)	1.052 (6.892)	1.471 (8.227)	5.141 (4.514)	4.678 (5.477)
R ²	0.31	0.44	0.42	0.09	0.04
N	39	38	38	12	28

Table 8: Returns to education. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

In the next column of both tables, we include the capital-labor ratio to account for the possibility that capital-abundant countries have relatively higher skill premia because of complementarities between capital and skilled labor (Krusell et al., 2000). The inclusion of the capital stock also allows us to control for the indirect effect of financial development on the skill premium: countries with better developed financial systems will have more abundant capital and, due to the complementarity with skilled labor, higher returns to education. The effect of financial development on the skill premium is robust to the inclusion of the capital stock: in Table 8, the effect is significant at the 5% level while in Table 9 it is significant at the 10% level.

We also control for income (to proxy for the demand for skilled labor - countries with

	Baseline		OECD	Non-OECD	
Credit	0.222* (0.108)	0.223* (0.109)	0.218* (0.113)	0.215* (0.101)	0.159 (0.138)
Education	-0.436** (0.161)	-0.407** (0.182)	-0.413** (0.188)	-0.256 (0.164)	-0.517 (0.338)
Education Sqr.	0.023** (0.009)	0.021** (0.010)	0.022** (0.010)	0.013 (0.009)	0.026 (0.024)
OECD	-0.685*** (0.155)	-0.660*** (0.197)	-0.673*** (0.217)		Capital
Capital		-0.031 (0.120)	-0.065 (0.144)		Income
Income			0.056 (0.193)		Constant
Constant	2.148*** (0.560)	2.299** (0.934)	2.184* (1.127)	0.725 (0.630)	2.744** (0.937)
R ²	0.63	0.61	0.60	0.10	0.35
N	34	34	34	20	18

Table 9: Wage Inequality. Robust standard errors in parentheses; significance levels: * 10%, ** 5% and *** 1%.

higher levels of income may also experience more rapid skill biased technological change which raises the importance of skilled labor in production). The results are reported in the third column of both tables. The effect of financial development on the skill premium is robust to the inclusion of the proxy for demand for skilled labor: once again, in Table 8 the effect is significant at the 5% level while in Table 9 it is significant at the 10% level. Finally, we split the sample into OECD and non-OECD countries. The effect of financial development on the returns to education is significant at the 10% level in both sub-samples, while the effect on the skill premium is significant at the 10% level only in the OECD sub-sample (columns four and five of Table 9). This evidence suggests that the relationship between financial development and wage inequality is stronger in more developed (OECD)

countries, as our theory would predict.

5 Conclusion

Although considerable research has been done on the causes of widening wage inequality in the US in the last two decades, little attention has been paid to the role of financial markets in this process. This paper attempts to fill this gap in the literature. The last two decades have also been a time of increasing financial deregulation and the emergence of specialized financial intermediaries that focus on high risk investment, typically in the form of small, innovative start-ups. Kremer and Maskin (1996) have previously argued that the change in organizational form in the US has been a contributor to the widening wage gap between skilled and unskilled workers. In this paper, we argue for an independent role played by financial markets in facilitating this organizational change. Financial deregulation and alterations to labor laws that permit pension funds to invest in high risk assets have led to a reduction in financing frictions for new research projects and facilitated the entry of small firms that promote new ideas but had previously been constrained from doing so by a lack of investment funds. In our model, as high skilled workers leave manufacturing and enter the research sector in response to the ease of access to funds, the shortage of skilled manufacturing workers in the old economy firms, together with the rising productivity of skilled workers in the new economy firms drives up the wage of skilled workers. At the same time, since low skilled workers have fewer high skilled workers to work with, their productivity does not rise as fast and their relative wage falls. The model developed in this paper provides an explanation for the joint occurrence of the widening wage inequality and changes in organizational form in response to financial market developments in the US economy in the last two decades.

A Compensation of researchers

As is standard in the search literature, we assume that the wage ω that innovating firms pay to skilled workers is an outcome of a Nash bargaining process, where β measures the bargaining power of financial intermediaries and $1 - \beta$ measures the bargaining power of workers. Along the balanced growth path the productivity-adjusted asset values for a matched research firm, a searching firm, a matched researcher and an unmatched skilled worker are, respectively,

$$\rho \tilde{J} = -\tilde{\omega} + \eta \left(\frac{\delta \pi}{\rho} - \tilde{J} \right) + \eta \delta N \tilde{J} \quad (30)$$

$$\rho \tilde{S} = -\kappa + f(\theta) (\tilde{J} - \tilde{S}) + \eta \delta N \tilde{S} \quad (31)$$

$$\rho \tilde{Z} = \tilde{\omega} + \eta (\tilde{U} - \tilde{Z}) + \eta \delta N \tilde{Z} \quad (32)$$

$$\rho \tilde{U} = \tilde{w}_H + f(\theta)/\theta (\tilde{Z} - \tilde{U}) + \eta \delta N \tilde{U} \quad (33)$$

To find the wage, denote the total productivity-adjusted surplus from a match by $\tilde{D} = \tilde{J} - \tilde{S} + \tilde{Z} - \tilde{U}$. The solution to the Nash bargaining process calls for the following division of the surplus

$$\tilde{Z} - \tilde{U} = (1 - \beta) \tilde{D}, \quad (34)$$

$$\tilde{J} = \beta \tilde{D}, \quad (35)$$

where, by free entry, we have $\tilde{S} = 0$.

Adding equations (30) and (32) and rearranging we get

$$\tilde{J} + \tilde{Z} - \tilde{U} = \frac{\eta \delta \pi / \rho - (\rho - \eta \delta N) \tilde{U}}{\rho + \eta - \eta \delta N} = \tilde{D} \quad (36)$$

Similarly, rearranging the productivity-adjusted equation (32) we can obtain

$$\tilde{Z} - \tilde{U} = \frac{\tilde{\omega} - (\rho - \eta \delta N) \tilde{U}}{\rho + \eta - \eta \delta N} \quad (37)$$

Substitute (36) and (37) in (34) to get

$$\frac{\tilde{\omega} - (\rho - \eta\delta N)\tilde{U}}{\rho + \eta - \eta\delta N} = (1 - \beta) \left(\frac{\eta\delta\pi/\rho - (\rho - \eta\delta N)\tilde{U}}{\rho + \eta - \eta\delta N} \right)$$

which can be rearranged to get

$$\tilde{\omega} = (1 - \beta) \frac{\eta\delta\pi}{\rho} + \beta(\rho - \eta\delta N)\tilde{U} \quad (38)$$

Now consider equation (33). Rearrange to get

$$(\rho - \eta\delta N)\tilde{U} = \tilde{w}_H + f(\theta)/\theta (\tilde{Z} - \tilde{U})$$

Substitute from (34) to get

$$(\rho - \eta\delta N)\tilde{U} = \tilde{w}_H + (f(\theta)/\theta)(1 - \beta)\tilde{D},$$

and substitute further from (36) to get

$$(\rho - \eta\delta N)\tilde{U} = \tilde{w}_H + (f(\theta)/\theta)(1 - \beta) \left(\frac{\eta\delta\pi/\rho - (\rho - \eta\delta N)\tilde{U}}{\rho + \eta - \eta\delta N} \right),$$

which may be rearranged to get

$$\tilde{U} = \frac{\tilde{w}_H(\rho + \eta - \eta\delta N) + (1 - \beta)f(\theta)/\theta \frac{\eta\delta\pi}{\rho}}{(\rho - \eta\delta N)(\rho + \eta - \eta\delta N) + (1 - \beta)f(\theta)/\theta} \quad (39)$$

Finally, substituting for \tilde{U} in (38), the compensation of researchers, $\tilde{\omega}$, follows as:

$$\tilde{\omega} = (1 - \beta) \frac{\eta\delta\pi}{\rho} + \beta \frac{\tilde{w}_H(\rho + \eta - \eta\delta N) + (1 - \beta)f(\theta)/\theta \frac{\eta\delta\pi}{\rho}}{\rho + \eta - \eta\delta N + (1 - \beta)f(\theta)/\theta} \quad (40)$$

B The JJ Equation

Substitute for $\tilde{Z} - \tilde{U}$ from (37) into (36) to get

$$\tilde{J} + \frac{\tilde{\omega} - (\rho - \eta\delta N)\tilde{U}}{\rho + \eta - \eta\delta N} = \frac{\eta\delta\pi/\rho - (\rho - \eta\delta N)\tilde{U}}{\rho + \eta - \eta\delta N},$$

from where

$$\tilde{J} = \frac{\eta\delta\pi/\rho}{\rho + \eta - \eta\delta N} - \frac{\tilde{\omega}}{\rho + \eta - \eta\delta N}.$$

Substitute for $\tilde{\omega}$ from (40) and rearrange to get

$$\tilde{J} = \frac{\beta \left(\frac{\eta \delta \pi}{\rho} - \tilde{\omega}_H \right)}{\rho + \eta - \eta \delta N + (1 - \beta) f(\theta) / \theta},$$

which is the expression for the JJ locus (29).

C Financial development and within-group inequality

This section outlines conditions under which profits, and therefore the wage of researchers, increase in response to an increase in the number of research firms N . In particular, we show that there exists a threshold H^* allocation of skilled workers to the old economy firms such that

$$d\pi/dN, d\tilde{\omega}/dN \begin{cases} > 0 & \text{when } H_0 > H^* \\ = 0 & \text{when } H_0 = H^* \\ < 0 & \text{when } H_0 < H^* \end{cases}$$

Recall from equation (6) that profits π are proportional to H_N , implying that $d\pi/dN = dH_N/dN$. Furthermore, since

$$H_N = H - H_0 - N,$$

we have that

$$d\pi/dN = dH_N/dN = -dH_0/dN - 1.$$

This expression will be positive if $dH_0/dN < -1$.

To see the conditions under which $dH_0/dN < -1$, recall that the skilled labor market arbitrage condition (15) implicitly defines H_0 as a function of N . From (15) we have

$$\left[H_{O,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} H_{O,t}^{\rho-1} = (1 - \alpha) \left(\frac{1}{\alpha^2} \right)^{\frac{\alpha}{1-\alpha}} \frac{A_t}{B_t}. \quad (41)$$

From (9) we also have that in the steady state, the ratio $\frac{A_t}{B_t}$ is given by

$$Z = \left(\frac{n\delta N}{\lambda} \right)^\gamma.$$

Substitute for the steady state $\frac{A_t}{B_t}$ in (41) to get

$$\left[H_{O,t}^\rho + L^\rho \right]^{\frac{1-\rho}{\rho}} H_{O,t}^{\rho-1} = (1-\alpha) \left(\frac{1}{\alpha^2} \right)^{\frac{\alpha}{1-\alpha}} \left(\frac{n\delta N}{\lambda} \right)^\gamma. \quad (42)$$

Differentiating both sides of the expression with respect to N , it follows that

$$dH_O/dN = - \frac{(1-\alpha)\alpha^{2\alpha/(\alpha-1)} \frac{\gamma\eta\delta}{\lambda} \left(\frac{\eta\delta N}{\lambda} \right)^{\gamma-1}}{(1-\rho)(H_O^\rho + L^\rho)^{(1-\rho)/\rho} H_O^{\rho-2} \left(1 - \frac{1}{1+(L/H_O)^\rho} \right)}.$$

In order for $d\pi/dN > 0$, we need $dH_O/dN < -1$. In other words, we need

$$(1-\alpha)\alpha^{2\alpha/(\alpha-1)} \frac{\gamma\eta\delta}{\lambda} \left(\frac{\eta\delta N}{\lambda} \right)^{\gamma-1} > (1-\rho)(H_O^\rho + L^\rho)^{(1-\rho)/\rho} H_O^{\rho-2} \left(1 - \frac{1}{1+(L/H_O)^\rho} \right)$$

The RHS is decreasing in H_O , and it is infinite when $H_O = 0$. The LHS is decreasing in N , and it is therefore increasing in H_O . It is zero when H_O is zero. The two sides of the expression are graphed as shown below in Figure (8).

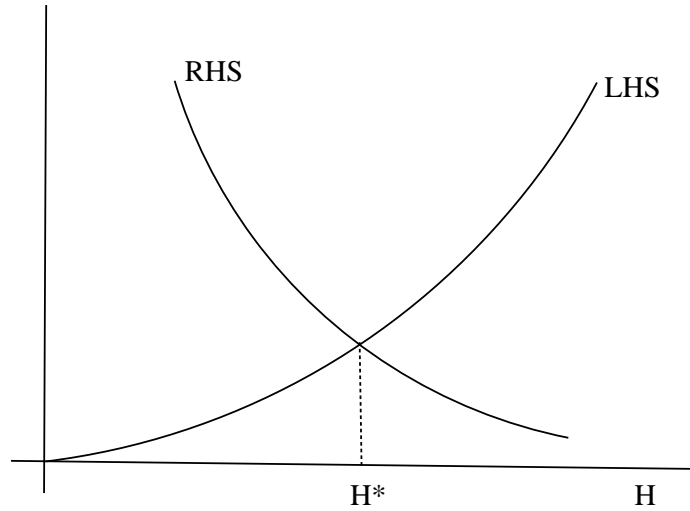


Figure 8: Threshold allocation of skilled workers to the old economy firms (when $H_O > H^*$, profits rise with an increase in N).

To the right of H^* , H_N and profits increase with N . As N goes up, skilled workers are reallocated away from old economy firms and the net inflow into the new economy firms is positive (H_N rises). In addition, if researchers have some bargaining power, as we have argued previously, research wage $\tilde{\omega}$ will also increase. Since $\tilde{\omega}_H$ is constant regardless of the number of research firms, as $\tilde{\omega}$ increases within group inequality (measured by the ratio $\frac{\tilde{\omega}}{\tilde{\omega}_H}$) will also increase.

However, we know that as N increases, the number of skilled workers in the old economy (H_o) falls. Starting from an initial allocation to the right of H^* , as financial markets improve and N increases, if N becomes sufficiently big (so that H_o becomes sufficiently small and is to the left of the threshold H^*), the economy eventually ends up in the region where H_N and profits decrease with N . As we have argued in the main text, data on profits / GDP for the US suggest that for the period of analysis, in terms of our model the economy has been operating to the right of H^* . The model therefore delivers the prediction that within-group inequality increases in response to an improvement in financial markets.

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