Inequality and the Product Cycle

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Abstract

This paper builds an endogenous growth model whose purpose is to account for the recent rise of inequality.

Most papers interpret the inequality rise as the result of an increase of the skill-premium. Our paper departs from this literature. Inequality is the result of the existence of a dual labor market. Each firm offers two kind of jobs: "good jobs" and "bad jobs". "Good jobs" are located in the core activities of the firm, "bad jobs" are located in the secondary activities. "Good jobs" are paid efficiency wages whereas "bad jobs" are paid the market-clearing wage. The efficiency-wage premium is thus our measure of inequality.

The growth model is derived (loosely) from Grossman and Helpman (1991). Growth is driven by innovation. Each innovation triggers a two period product cycle. The key assumption is that new goods use (relatively) more core workers than old goods. This implies that the efficiency-wage premium is linked to the pace of innovation and the structure of the cycle (i.e. the relative length of two periods).

The main result of the model is to link the rise of inequality to the acceleration of the product cycle.

Eventually, we show that our framework can also account for the rise of the skill premium. This is done by introducing the reasonable assumption that the core activities are more skill-intensive than the secondary activities.

Keywords : inequality, product cycle, dual labor markets, efficiency wages.

1 Introduction

Wage inequality has markedly risen in the last 25 years in most countries of the OECD. For instance, in the U.S. the P90/P10 ratio rose from 3.497 in 1979 to 4.450 in 1996 (a 27% rise)[1] Many countries exhibit a similar pattern. Most of all the UK (a 20% increase in 7 years - from 2.53 in 1979 to 3.01 in 1986) [2]. The inequality rise has been much smaller in continental Europe, but seems to have started recently [3]. France and Germany, for instance,

[1]Source: Jared and Mishel (1997).

[2]But also Sweden : 10% in 11 years - from 2.1 in 1981 to 2.4 in 1992; Canada: 8.6% in 4 years (from 3.5 in 1987 to 3.8 in 1991: the Netherlands: 5,6% in for years (from 2.32 to 2.45). Source: the Luxembourg Income Study database (Gottschalk and Joyce, 1998).

[3]Data...

experienced no measurable increase in wage inequality in the 80s (Gottschalk and Smeeding, 1997), and some in the 90s. However, those countries generally experienced a concomitant rise of unemployment. According to Bertola and Ichino (1995), the institutional specificities of continental Europe (a high minimum wage, centralized wage setting and a very extensive social safety net) slowed the rise of inequality. But this came at a very high price : the explosion of structural unemployment.

The inequality rise has many dimensions. The first one, and the most widely reported, is the increase of the skill premium. It is, for example, well documented that: (a) the wage premium of College education rose dramatically in the U.S. from a low of 31% in 1979 to 53% in 1993 and (b) the experience premium (i.e. the wage premium given by ten years of labor experience) also rose markedly in the 1980s (Gottschalk, 1997). The increase of the skill premium is smaller in Europe, but the dramatic rise of the unemployment rate of the unskilled is good evidence of a fall of the relative demand of unskilled labor. This is all the more striking since the relative supply of skilled labor has, on average, risen throughout the OECD.

But one should not forget the other dimensions of the inequality rise. The attention put on the high-skill low-skill wage differential has led many economists to overlook two striking characteristics of the inequality shift :

- Inequality has increased not only among individuals with different observable traits (such as education, experience, race and gender) but also within groups of individuals with the same education, experience, race and gender [4]. Studies find that the increase of residual inequality represents between 50 and 60% of the total rise.

- Job stability and job security seem to have declined. This has long been debated. Many researchers still argue that job tenure and stability are stable and that all observed changes reflect changes in survey methods rather than real changes in the economy. However, a coordinated effort was made recently by several leading researchers to work out methodological differences. As a result, there is now a growing consensus on that matter (Neumark, 2000) [5].

The purpose of this paper is the build an endogenous growth model that can account for the rise of inequality. Why a growth model? Because, we think that technological change is a

[4]Gottschalk (1997) find that 50% of the rise of male wage inequality can't be accounted by observable traits ie. is residual (for the U.S., between 1973 and 1994). Note that the contribution of residual inequality is smaller for women (around 23%). This confirm an earlier study by Juhn et al. (1993), whose estimates of the contribution of residual inequality were even higher (around 60%). Gottschalk and Smeeding (1997) find similar shifts in the 80s for the UK, Sweden and Australia.

[5]Measuring job stability and job security is notoriously difficult. For instance, aggregate measures of job stability such as median job tenure are markedly stable. But this is misleading for two reasons: (i) demographic trends (the aging of the population) and sociological trends (the rising female labor participation) should have led, ceteris paribus, to an increase of aggregate median tenure; (ii) median tenure has markedly declined for male workers, older workers and more tenured workers. See the october 1999 special issue of *Journal of Labor Economics* for more data.

prime candidate to explain the inequality shift. (very) brief survey of related papers...

Most of these papers interpret the inequality rise as the result of an increase of the skill premium. They assume, implicitly or explicitly, that residual inequality is mostly the result of measurement errors and unobserved characteristics.

Our paper departs from this literature. We think that the residual component of the inequality rise (more than 50%) is too big to be ignored. Skill bias cannot be the sole explanation. A way to deal with residual inequality is to assume the existence of a dual labor market. Assume there is two kinds of jobs : primary and secondary. Primary jobs offer a wage premium : they are thus considered "good jobs", whereas secondary jobs pay the market clearing wage, hence the term "bad jobs". Efficiency-wage theory offers a simple and elegant way to model a dual labor market (Bulow and Summers, 1986). The trick is to assume that primary jobs have to be paid efficiency wages. [6]

A question arises. Do "good" and "bad" jobs coexist in the same firm? Or do they cluster in certain industries? Most studies report significant inter-industries wage differentials for very narrowly defined job classifications [7]. Indeed this is the evidence used originally by Katz to back-up the efficiency-wage hypothesis. However, Berman et al. (1994, 1998) show that the biggest contribution to the inequality rise came from the intra-industry and intra-firm component. Those studies have mostly been used as evidence of skill biased technological progress (against the rival trade hypothesis). But, given the importance of residual inequality, they may as well serve as evidence of the extent of dual labor markets *within* firms. There is another way to back-up this hypothesis. Many business studies divide the firm activities in two : core and secondary. Core activities are the essential activities that define the business the firm is in. All the other activities are considered secondary activities [8]. This division matters for the labor market, since workers employed in core activities are in some way essential to the firm. They have therefore more bargaining power than their counterparts working in secondary activities. It can thus be assumed that core activities offer on average more "good jobs" (high pay, high responsibility) than secondary activities. [9]

Since our prime focus is residual inequality, we will assume that all workers are identical but face a dual labor market. The efficiency-wage premium paid to core/primary workers will be the measure of residual inequality. This dual labor market structure will be embedded in

[6] It is also possible to choose a bargaining framework and assume that primary workers have a better bargaining position (or that secondary workers have none). Such a framework would be very similar to the insider-outsider framework introduced by Lindbeck (1992).

[7] For instance Krueger and Summers (1987) report that, in the US, after controlling for education, labor quality, sex, union status and a host of other variables, very large wage differences , of the order of 50%-70%, remain between the best-paying industries (petroleum, automobiles) and the worst-paying ones (various kinds of services)

[8] In theory, all secondary activities could and should be outsourced. But transaction costs limit the extent of outsourcing.

[9] Assuming a core-periphery structure is not incompatible with the existence of inter-industry wage differentials. Some industries may use relatively more core workers than others.

an endogenous growth model loosely derived from Grossman and Helpman (1991). Growth is driven by innovation. Each innovation triggers a two period product cycle. The key assumption is that new goods use (relatively) more core workers than old goods. This implies that the efficiency-wage premium is linked to the pace of innovation and the structure of the cycle (i.e. the relative length of two periods). [10]

The remainder of the paper proceeds as follows. Section 2 outlines the growth model. We specify the link between growth and residual inequality and show the existence of a unique long run steady state equilibrium growth path. This steady state equilibrium is represented as the intersection of two curves in the (innovation rate, efficiency–wage premium) plane: the TT curve, which summarizes the technology side of the model and the NS curve, which summarizes the efficiency-wage side of the model. Section 3 explains the slope of the NS and TT locus and studies the long run impact on growth and inequality of changes in the technology and efficiency-wage parameters of the models. Section 4 show that our framework may also account for the rise of the skill premium. This is done by introducing the reasonable assumption that core activities are more skill intensive than secondary activities. Section 5 concludes.

2 The model

Our model is a variety of the "vertical" growth model developed by Grossman and Helpman (1991). Perfectly competitive firms manufacture a final good using a set of horizontally intermediate goods. Intermediates are produced with labor. The final good may be either consumed or invested (i.e. used in the research lab). Process innovation reduces the manufacturing cost of existing products. Each innovation leads to the death of the incumbent firm and his replacement by a new monopoly. This is the so called "Creative Destruction" process. At the sectoral level, innovation is random. But the aggregate rate of innovation is deterministic. Therefore, the growth rate and all the aggregate variables are deterministic.

There are two main differences with the usual growth model.

- There is a dual labor market. Although labor is homogenous, workers face two kinds of jobs : primary and secondary jobs. Primary jobs have to be paid efficiency jobs in order to induce effort. They are thus considered as "good jobs" (high wage, high responsibility jobs). Workers that fail to get or retain a "good job" take a a secondary job (a "cashier job") where they receive the market clearing wage.

- Each firm lives a two-period cycle. Young firms use a lot of primary labor which is costlier. Over time they learn how to reduce the share in primary labor in production

[10] This model cannot account for the decline of job stability and security. This is done in a companion paper (Mendez, 2000) where we stress another possible implication of the dual labor market hypothesis. We assume that the efficiency wage is of the Shapiro and Stiglitz (1984) type. Then the efficiency wage premium - which is also our measure of inequality - is an increasing function of labor turnover. This allow us to link innovation and residual inequality since innovation increases labor turnover.

which reduces unit cost. When this arrives (we assume a random learning process), the firm enter the second period of her lifecycle. Old firms die with the arrival of a new process innovation.

Consumers

The economy has a constant population composed of a continuum of L identical agents. Each individual supplies one unit of labor and chooses savings so as to maximize, subject to the usual intertemporal budget constraint, the following intertemporal utility function:

$$U_t = \int_t^{\infty} \ln c(\tau) exp\left\{-\rho(\tau - t)\right\} \, d\tau$$

where c is consumption and ρ is the (constant) discount rate. Taking the consumption good as numéraire, it is straightforward to show that the consumption path must be such that:

$$g_c \equiv \frac{\dot{c}}{c} = r - \rho \tag{1}$$

where r is the real interest rate.

The final good sector

The production function of the final good is:

$$\ln Y = \int_0^1 \ln[x(i)] di$$

where Y is output, $x(i)$ is the quantity employed of the ith type of nondurable intermediate good.

We assume perfect competition between final good producers. The demand of intermediate i can be found using Shephard's lemma :

$$x(i) = \frac{PY}{p(i)} \tag{2}$$

where $p(i)$ is the price of intermediate i and P is the price of the final good (note that P can be considerated as an aggregate price index of the intermediates).

Cost minimization and the choice of the final good as numeraire implies that:

$$\ln P = \int_0^1 \ln[p(i)] \, di = 0 \tag{3}$$

The intermediate sector

Each intermediate firm lives a two period cycle. The firm is created when an innovator discovers new cost reducing process. This event arrives with poisson probability λ. The new firm takes the whole market, since we assume Bertrand competition. Over time, the firm learns to produce in a more efficient way. This is done by reducing the relative share of primary labor in production. This event, which is costless for the firm [11], happens with a poisson probability μ. The firm dies when a new cost reducing process is discovered.

This cycle is depicted in figure 1. Note that we assume that process innovation is impossible as long as the firm is young. This ensures that all firms complete their life cycle and considerably simplifies the problem.

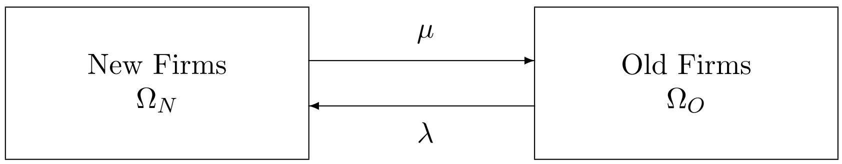

Figure1 : Intermediate firms life cycle

Intermediate firms use both kind of labor (primary and secondary) and state of the art technology. The lifecycle hypothesis means that we must distinguish two kind of firms : "new" and "old". The main difference between "new" and "old" firms is that the production of new goods requires more primary labor. [12]

$$\begin{cases} x(i) = \gamma^{j(i)} \min\left\{ \dfrac{(e/\overline{e})\, L_P(i)}{a(i)}, L_S(i) \right\} & & \gamma > 1 \\ a(i) = \overline{a} \qquad i \in \Omega_N & & \\ a(i) = \underline{a} \qquad i \in \Omega_O & & \overline{a} > \underline{a} \end{cases} \tag{4}$$

where $L_P(i)$ and $L_S(i)$ denote , respectively, the number of primary and secondary jobs. e denotes the effort spent by primary workers. $\overline{e}$ is a constant that will be specified later.$j(i) \in \{0, 1, 2, ...\}$ is the index of the technology applied in industry i. $\gamma > 1$ measures the impact of each innovation on labor productivity. $a(i)$ is the primary labor requirement. $a(i) = \overline{a}$ for new firms and $a(i) = \underline{a} < \overline{a}$ for old firms.

Intermediate goods producers choose w_P, $L_P(i)$, $L_S(i)$ to minimize cost and induce effort. To go further we must specify the effort function of a primary worker and the market structure of the manufacturing sector. This will be done in the following subsections.

The wage equation

The effort spent by a worker that holds a primary job is:

$$e(w_P, \overline{w}) = \begin{cases} \left(\frac{w_P - \overline{w}}{\overline{w}}\right)^{\beta} & if \quad w_P > \overline{w} \\ 0 & if \quad w_P \leq \overline{w} \end{cases} \tag{5}$$

[11] We assume a kind of learning by doing.

[12] We use a Leontief production function for convenience. The same results can be found using a C.E.S. production function, as long as the elasticity of substitution between the primary and secondary labor is strictly inferior to one.

where $\overline{w}$ is the wage reference. We choose as reference the average wage, thus $\overline{w} = w_P z + w_S(1-z)$ where $z \equiv \int_0^1 L_P(i)di/L$ denotes the share of primary workers.

Firm i choosse the primary wage w_P to minimize cost and induce effort.

$$\min \frac{a(i)w_P}{e(w_P, \overline{w})/\overline{e}} + w_S$$

The solution of this program is the well known Solow condition:

$$\frac{we_{w_P}(w_P, \overline{w})}{e(w_P, \overline{w})} = 1$$

Thus $w_P = (1+q)\overline{w}$ and $e = q^\beta \equiv \overline{e}$, where $q = \frac{\beta}{1-\beta}$. The efficiency wage premium is henceforth:

$$p_\omega \equiv \frac{w_P}{w_S} - 1 = \frac{q}{1-(1+q)z} \tag{6}$$

Our formulation is not the usual formulation of the efficiency wage hypothesis, but it has the highly desirable feature that the efficiency wage premium is an increasing function of primary labor demand z.

Pricing policy

Now we describe the pricing policy of the firm. The technology is such that there is always a technological leader (the firm that masters technology $j(i)$) and a multitude of (potential) followers (the firms that master technology $j \in \{0, 1, 2, \ldots, j(i)-1\}$). Assuming Bertrand competition, the technological leader maximizes her profit by using a limit price strategy that drives all followers out of the market. This is obtained by setting a price equal to the marginal cost of the most efficient follower (i.e. the old firm which is one step behind in the technology race). This means that new and old firms set the same price:

$$p(i) = \frac{w_P \underline{a} + w_S}{\gamma^{j(i)-1}} \tag{7}$$

First period profits are then, by (2), (3) and (7):

$$\begin{aligned} \Pi_N &= \left(p(i) - \frac{w_P \overline{a} + w_S}{\gamma^{j(i)}}\right) x(i) \\ &= \left(\frac{\left[\underline{a} - \frac{\overline{a}}{\gamma}\right](1+p_\omega) + 1 - \frac{1}{\gamma}}{\underline{a}(1+p_\omega)+1}\right) Y \end{aligned} \tag{8}$$

Whereas second period profits are, by (2), (3) and (7):

$$\begin{aligned} \Pi_O &= \left(p(i) - \frac{w_P \underline{a} + w_S}{\gamma^{j(i)}}\right) x(i) \\ &= \left(1 - \frac{1}{\gamma}\right) Y \end{aligned} \tag{9}$$

Research and Development

R&D firms use the final good to produce new blueprints. The discovery technology is Poisson with an arrival rate varying proportionately with R&D expenditures. A firm that uses one unit of final good during a time interval of length dt in any industry has a probability of $1/fQ\,dt$ to find a new process, where f is a fixed cost and $\ln Q = \int_0^1 \ln \gamma^{j(i)} di$ is a (geometric) average of total labor productivity. We assume thus that the unit cost of innovation fQ rises with labor productivity. Recall that λ be the poisson arrival rate in industry i.[13]

To fund their R&D investments, firms sell equity shares to consumers. Let V_N be the value of an R& D firm. Each firm lives a two period cycle. A young firm pays dividends at rate $\Pi_N\,dt$ and changes state with probability $\mu\,dt$. An old firm pays dividends at rate $\Pi_O\,dt$ and dies with probability $\lambda\,dt$. This gives the following arbitrage condition:

$$\begin{aligned} r\,V_N &= \Pi_N + \dot{V}_N + \mu\,(V_O - V_N) \qquad (10)\\ r\,V_O &= \Pi_O + \dot{V}_O + \lambda\,(0 - V_O) \qquad (11)\end{aligned}$$

where V_O is the value of an old firm. Free entry into R&D implies that the value of each innovation must not exceed its unit cost, so that :

$$V_N \begin{cases} \leq fQ & if \quad \lambda = 0 \\ = fQ & if \quad \lambda > 0 \end{cases} \qquad (12)$$

Labor Market Equilibrium

The model is closed with the labor market clearing condition. By (2), (4) and (7), primary and secondary labor demand function are:

$$\begin{cases} L_S(i) = \dfrac{E}{\gamma(w_P \underline{a} + w_S)} = L_S & \forall\, i \\ L_P(i) = \underline{a} L_S = L_P^O & i \in \Omega_O \\ L_P(i) = \overline{a} L_S = L_P^N & i \in \Omega_N \end{cases} \qquad (13)$$

All sectors employ the same amount of secondary labor (this is due to the pricing policy) whereas the new firms use more primary labor than the old. We now write labor equilibrium. Let s be the share of new firms (conversely $1-s$ is the share of old firms) and recall that z is the share of primary workers.

$$\int_0^1 L_S(i)\,di = L_S = (1-z)L \qquad and \qquad \int_0^1 L_P(i)\,di = sL_P^N + (1-s)L_P^O = zL \qquad (14)$$

This, and (13) implies that the share of primary labor z is an increasing function of the share of new firms s.

$$\frac{z}{1-z} = s\overline{a} + (1-s)\underline{a} \qquad (15)$$

[13] R&D effort is the same in all industries since the profit and the R&D technology are identical.

Innovation and the aggregate growth rate

Since all sectors demand secondary labor to the same extent aggregate production can be simplified to :

$$Y = (1 - z)LQ \tag{16}$$

where, as told before, Q is a geometric average of total labor productivity. This implies that the steady state growth rate of Y is $\dot{Y}/Y = \dot{Q}/Q = \lambda \ln \gamma$ [14], where λ is the poisson arrival rate of new innovations and $\gamma > 1$ is the productivity improvement brought by the innovation. It is easy to prove that this is also the growth rate of wages, consumption, aggregate profits and the lifetime utilities of all agents. Hence $g_c = \lambda \ln \gamma$.

3 The steady state growth path

It is easy to show that the steady state share of new firms s is an increasing function of the innovation-learning ration λ/μ. This is consequence of the lifecycle hypothesis, which is depicted in figure 1. Each new firm reaches maturity (ie learn how to reduce the primary labor content) with probability μ. Since s is the share of new firms, the outflow of the new firm group is $s\mu$. There are $(1 - s)$ old firms and each one dies with probability λ, the outflow of the old firm group is thus $(1 - s)\lambda$. Both flows must be equal at steady state, so:

$$s = \frac{\lambda/\mu}{1 + \lambda/\mu} \tag{17}$$

Now we show the existence and uniqueness of a steady state growth path. The steady state is such as the innovation rate λ and the efficiency wage premium p_ω are constant. It can be depicted as the intersection of two curves in the (λ, p_ω) plane.

Using (8)-(12), (15), (16) and (17) we write the TT equation which depict the technology side of the model:

$$\rho + \mu = \frac{1 + \frac{\lambda}{\mu}}{1 + \underline{a} + (1 + \overline{a})\frac{\lambda}{\mu}} \left\{ \frac{(1 + p_\omega)\left(\underline{a} - \frac{\overline{a}}{\gamma}\right) + 1 - \frac{1}{\gamma}}{1 + \underline{a}(1 + p_\omega)} + \frac{\mu}{\rho + \lambda}\left(1 - \frac{1}{\gamma}\right) \right\} \frac{L}{f} \tag{18}$$

Using (6), (15) and (17), we write NS equation, which depicts the efficiency wage side of the model:

$$p_\omega = q \frac{1 + \underline{a} + \dfrac{\lambda}{\mu}(1 + \overline{a})}{1 - \underline{a}q + \dfrac{\lambda}{\mu}(1 - \overline{a}q)} \tag{19}$$

The steady state innovation rate θ and efficiency wage premium p_ω are co-determined simultaneously by the equations TT (eq. (18)) and NS (eq.(19)). It is easy to check that this

[14] See Grossman and Helpman (1991, pg. 97).

system has a unique solution within the required bounds ($p_\omega > 0$ and $\lambda > 0$) as long as the following hypothesis are verified:

$$\begin{cases} H1 & \gamma > \overline{a}/\underline{a} \\ H2 & q < 1/\overline{a} \\ H3 & \left[\pi_N(\underline{p_w}) + \frac{\mu}{\rho}\left(1 - \frac{1}{\gamma}\right)\right]\frac{L}{f} > (\rho+\mu)(1+\underline{a}) \\ H4 & \pi_N(\underline{p_w})\frac{L}{f} < (\rho+\mu)(1+\overline{a}) \end{cases}$$

where $\underline{p_\omega} \equiv q\frac{1+\underline{a}}{1-\underline{a}q}$ and $\pi_N(\underline{p_w}) = \frac{(\underline{a}-\overline{a}/\gamma)(1+\underline{p_\omega})+1-1/\gamma}{\underline{a}(1+\underline{p_\omega})+1} = \frac{\left(\underline{a}-\frac{\overline{a}}{\gamma}\right)(1+q)+\left(1-\frac{1}{\gamma}\right)(1-\underline{a}q)}{1+\underline{a}}$.

Hypothesis H2 ensures that $\lambda_{NS}(\underline{p_\omega}) = 0$ and $\lambda_{NS}(\overline{p_\omega}) = \infty$ (where $\overline{p_\omega} \equiv q\frac{1+\overline{a}}{1-\overline{a}q}$). H2, H3 and H4 ensure that $\lambda_{TT}(\underline{p_\omega}) > 0$. This, and the fact that NS is increasing and TT decreasing imply that the two curves must cross within the required bonds.

The endogenous growth steady state equilibrium is depicted in figure 2 as the intersection of the NS and TT curves in the $\left(\frac{\lambda}{\mu}, p_\omega\right)$ plane.

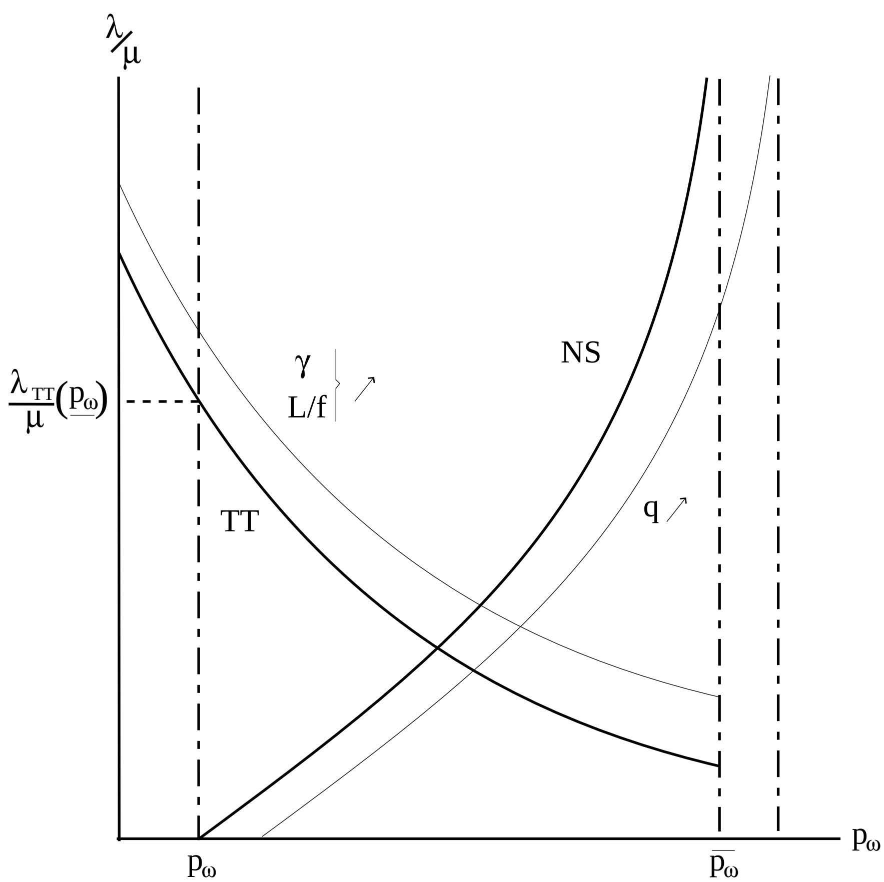

Figure 2: The steady state equilibrium under hypothesis H1-H4

4 Wage inequality and the product cycle

Efficiency wages create an endogenous linkage between the innovation-learning rate (λ) and the efficiency premium (p_ω). This link is embedded in the TT curve, which represents the technology side of the model, and the NS curve, which represents the efficiency-wage side of the model. The shape of those curve is critical to the analysis that follows. As depicted in figures 2 and 4, the TT curve always slopes downward, while the NS curve always slopes upward.

Let us explain the decreasing slope of the TT curve. The key determinant of innovation is the dividend rate Π_N/V_N paid by new firms. The steady state dividend rate of new firms is a decreasing function of the efficiency wage premium p_ω. This is easy to explain : the efficiency premium leads to a mis-allocation of labor (too much labor goes to the secondary sector). This static inefficiency reduces production, aggregate wages and profits. Any increase of the efficiency premium worsens this static efficiency which reduces the innovation rate.

Let us explain the slope of the NS curve. A rise of the innovation-learning ratio λ/μ increases the share of primary firms s. This entail a rise of primary labor demand z, which lead to an increase of the efficiency premium, since it increases the reference wage $\overline{w}$. Note that this means that the efficiency wage premium is directly linked to the structure of the product cycle since the relative average length of the cycle first period is : $\frac{1/\mu}{1/\mu+1/\lambda} = \frac{\lambda/\mu}{1+\lambda/\mu} = s$ (as depicted in figure 3, the average length of youth is $1/\mu$ whereas the average length of maturity is $1/\lambda$).

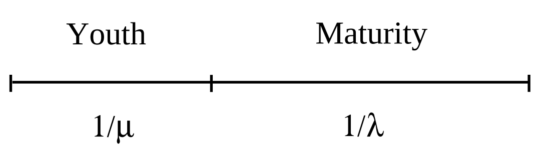

Figure 3 : average length of the two periods

We now turn to the analysis of the long run consequences of changes in some of the technology and efficiency-wage parameters of the model. We will study three variables : p_ω which is, as we said before, our measure of inequality, the rate of innovation λ and the innovation-learning ratio λ/μ. We separate the parameters in three groups.

- Labor supply L, R&D fixed costs $1/f$ and the size of innovation γ have the same impact on the innovation rate, inequality and the structure of the product cycle. They all lead to a rise of both dividend rates Π_N/V_N and Π_O/V_O. Profits rise with L through a market size effect. A fall of R&D fixed costs f leads to more entry into the research sector which brings a fall of the blueprint value. The TT curve shifts upward (as depicted in figure 2). This brings about a rise of the innovation-learning rate λ/μ. This means faster innovation (a higher λ) since the learning rate μ is constant and higher inequality due to the rise of the share of core activities.

- An increase of the efficiency wage parameter q [15] forces the firms to pay higher efficiency wage premium to primary workers. The NS curve shifts downward (as depicted in figure 2). This brings about a fall of the innovation-learning ratio which leads to a fall of the innovation rate. The mechanism behind the fall of the innovation rate is the one described in the discussion about the shape of the TT curve. The rise of the efficiency premium moves away the economy farther from the static optimum ($p_\omega = 0$). This leads to a fall of investment, through the reduction of the aggregate production and the profit rate.

- An increase learning rate μ always lead to rise of innovation but has ambiguous consequences on the innovation-learning rate and inequality. (...) This is depicted in figure 4. Proof is given in the appendix.

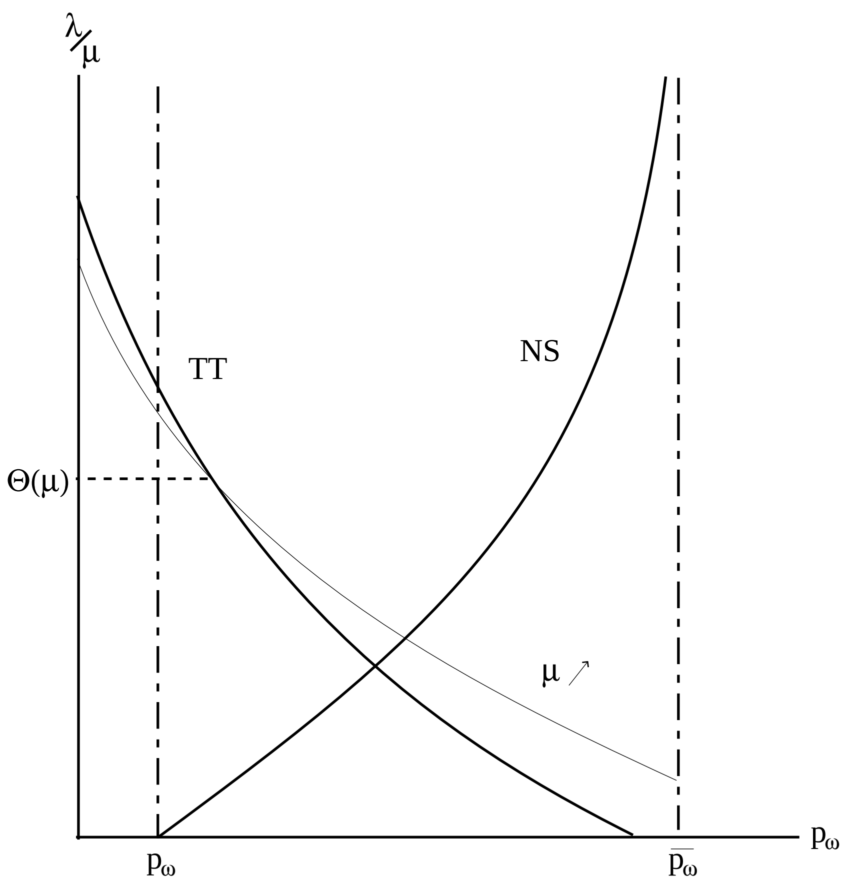

Figure 4: Consequences of a rise of μ, when $\lambda/\mu < \Theta$

5 The product cycle and the skill premium

This section will argue that the mechanism that links innovation and inequality through the product cycle may also explain the rise of the skill premium. To illustrate this point we present

[15] q rises with the elasticity of the effort function β. Recall that $q = \frac{\beta}{1-\beta}$.

here a simple extension of our model with two types of workers: skilled and unskilled. The key assumption is that primary jobs are more skill-intensive than secondary jobs. This means that the average skill premium will depend on the skilled and unskilled efficiency wage premia.

Since the general form (both kind of workers can hold both kind of jobs) is not very tractable we assume that primary jobs can only be hold by skilled workers whereas secondary jobs use both kind of workers. We conjecture that most of the following results apply in the general case (as long as primary jobs are more skill-intensive).

To be continued...

6 Summary and Conclusions

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A Appendix

Differentiation of the TT equation yields the following:

$$\Psi_{\lambda/\mu} d(\lambda/\mu) = \Psi_{p_\omega} dp_\omega + \Psi_\gamma d\gamma + \Psi_\mu d\mu$$

$$\text{where: } \left\{ \begin{array}{lcl} \Psi_{\lambda/\mu} & = & \frac{L/f}{1+\underline{a}+(1+\overline{a})\lambda/\mu} \left[\frac{\mu(1+\lambda/\mu)(1-1/\gamma)}{(\rho+\lambda)^2} + \frac{\overline{a}-\underline{a}}{1+\underline{a}+(1+\overline{a})\lambda/\mu} \left(\pi(p_\omega) + \frac{\mu(1-1/\gamma)}{\rho+\lambda} \right) \right] > 0 \\ \Psi_{p_\omega} & = & -\frac{1+\lambda/\mu}{1+\underline{a}+(1+\overline{a})\lambda/\mu} \frac{\overline{a}-\underline{a}}{\gamma(1+\underline{a}(1+p_\omega))^2} \frac{L}{f} < 0 \\ \Psi_\gamma & = & \frac{1}{\gamma^2} \frac{1+\lambda/\mu}{1+\underline{a}+(1+\overline{a})\lambda/\mu} \left[\frac{1+\overline{a}(1+p_\omega)}{1+\underline{a}(1+p_\omega)} + \frac{\mu}{\rho+\lambda} \right] > 0 \\ \Psi_\mu & = & \frac{1+\lambda/\mu}{1+\underline{a}+(1+\overline{a})\lambda/\mu} \frac{(1-1/\gamma)\rho/\mu^2}{(\rho/\mu+\lambda/\mu)^2} \frac{L}{f} - 1 \end{array} \right.$$

$$\text{This implies that:} \left\{ \begin{array}{l} \frac{\partial(\lambda/\mu)_{TT}}{\partial p_\omega} < 0 \\ \frac{\partial(\lambda/\mu)_{TT}}{\partial \gamma} > 0 \\ \frac{\partial(\lambda/\mu)_{TT}}{\partial \mu} > (<) 0 \qquad if \qquad \lambda/\mu < (>) \Theta \end{array} \right.$$

where $\Theta > 0$ (by H3) is such that $\Psi_\mu(\Theta) = 0$.
It is easy to show that $\frac{\partial \Theta}{\partial \gamma} > 0$, $\frac{\partial \Theta}{\partial L/f} > 0$ and $\frac{\partial \Theta}{\partial \mu} < 0$.

Differentiation of the NS equation yields the following:

$$dp_\omega = \Phi_{\lambda/\mu} d(\lambda/\mu) + \Phi_q dq$$

$$\text{where: } \left\{ \begin{array}{lcl} \Phi_{\lambda/\mu} & = & q \frac{\overline{a}-\underline{a}}{(1-\underline{a}q)+\lambda/\mu(1-\overline{a}q))^2} > 0 \\ \Phi_q & = & p_\omega \left\{ \frac{1}{q} + \frac{\overline{a}\lambda/\mu}{1-\underline{a}q+\lambda/\mu(1-\overline{a}q)} \right\} > 0 \end{array} \right.$$