

# Mergers, Innovation, and Inequality

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## Abstract

This paper presents a standard endogenous growth framework in which the source of growth is represented by vertical innovation. The crucial assumption we introduce is that there is a positive information gap concerning the discovery of innovation. The aim of reducing the information dissemination lag provides incentives for firms to decide to merge their research efforts. At the same time we find that the skilled/unskilled wage gap is strongly related to this phenomenon. We prove that changing antitrust attitudes toward efficiency-motivated mergers in contestable industries may simultaneously explain observed changes in the industry structure, in qualitative innovation, in wage inequality, and in labor supply composition.

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## 1 Introduction

Since the late seventies at least in the United States a relevant merger wave started contemporaneously with a broad pattern of other shifts, such as an increase of the overall wage inequality rose, returns to college education and product quality innovation<sup>1</sup>.

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<sup>1</sup>A striking example is the information and communication technology revolution.

The marked change ends with an intense debate on the role of acquisitions and takeovers: mergers are viewed as a mean to reallocate resources according to the most efficient criterion (Jovanovic and Rousseau 2001) being classified as either expansionary or contractionary (Andrade and Stafford 1999)<sup>2</sup> depending on whether firms are supposed to expand their productive capacity or rationalize their operations and remove duplication project risks (Jensen 1993, Mitchell and Mulherin 1996). Regardless of the motives for firms to merge, merger waves result associated to the environment's economic changes. The view that firms reallocate resources more effectively through mergers suggests a link between technological change and industry structure: when a new technology appears in a economic system, not all the firms would be easily able to run the technology and those firms having expertise in the newest technology can takeover the disadvantaged ones starting a merger wave and enhancing growth (Jovanovic and Rousseau 2001, Carol and Hanan 2000, Faria 2002)<sup>3</sup>. Several empirical approaches evaluating mergers' impacts on the economic context conclude for a positive relation between firms' economic performance and takeovers (Lichtenberg and Siegel 1990, Lichtenberg 1992), consistently with the "reallocation according efficiency" theoretical view. Moreover, it seems that those firms involved in an acquisitions process increase their R&D expenses above the sectoral average level and the increased R&D investment is likely associated with higher profitability (Mcdougall 1995).

Nevertheless, the radical shift in the distribution of wages that took place since the seventies has risen a significant interest in analyzing the potential explanations of this phenomenon. While there is a common consensus in the literature that wage inequality is due to the nature of technological change which, being skilled-biased has favored the skilled workers (Greenwood, Hercowitz and Krussel 1997, Greenwood and Yorucoglu 1997, Allen 2001), a strand of thought points its attention to a complex set of heterogeneous factors acting with the skilled-bias to explain wage inequality, namely labor market organization, institutional change and trade (Freeman 1995). Indeed, labor market has been reorganized in line with the pervasive recent technologies destroying several types of high pay-unskilled workers jobs (Kremer and Maskin 1999, Acemoglu 1999), institutional change has weakened the bargaining power of the skilled workers mainly through deunionization

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<sup>2</sup>Previous research sharing the same characteristics is by Bagwell and Shoven (1988).

<sup>3</sup>The argument had been introduced by Gort (1969).

process (Freeman and Kleiner 1990, Freeman 1991, Blau and Kahn 1996) and finally international trade with developing countries has significantly increased the number of less-skilled workers, depressing their marginal value product (Borjas Freeman Katz DiNardo and Abowd 1997, Acemoglu 2002).

Although these research lines represent a continuous advancement in understanding these issues, their reference frameworks are separate sets, each solely concerned with its own stylized fact. The aim of this paper is to suggest a way to fill this gap.

This paper presents a R&D-driven growth model sharing several features with the well-known Aghion and Howitt's (1992 and 1998) basic Schumpeterian model, in which the source of growth is represented by vertical (product quality improving) innovation. Our analysis takes two aspects of innovating explicitly into account: the discovery and the patenting of innovation. The crucial assumption of this model is precisely that the time when the discovery of innovation is made by a first firm is supposed to be unknown by the other firms. It becomes common knowledge when both the first step and the second one are concluded. Hence, there is a period of time when the firms do useless research effort. The realism of this assumption has been emphasized by Shapiro (2002, p.16): "since no disclosure is required when patent application is filed, companies introducing new products that incorporate state-of-the-art technology may find that they are unwittingly infringing on patents issued after their product design decisions were made and significant resources were sunk in developing the new product." Due to this information-gap negatively affecting research-effort, a form of congestion appears in the R&D sector.

Given these assumptions, our findings are twofold.

First of all, we show that the aim of reducing the information dissemination lag provides the incentives for R&D firms to decide to merge, and for R&D workers to cooperate with each others. This finding is consistent with the view according to which mergers can occur as a result of firms following efficiency criteria. Moreover, it seems to confirm the point that often firms decide to cooperate through a form of ex-ante R&D cooperation aimed at reducing the risk of duplicating projects. Indeed any agreement to eliminate the information dissemination lag makes R&D investment more efficient and enhances growth. Besides, we find that the skilled/unskilled wage gap is strongly related to the number of (cooperating groups of) firms in the economy: the higher the number of research-firms, the lower the probability of a firm winning the R&D race and the expected value of an hour in research;

the higher the number of firms in the market, the stronger the effects of the information-gap, the lower the skilled labor demand and the expected aggregate growth rate, and the lower the skilled/unskilled wage gap. So our model provides an additional explanation of the above mentioned stylized fact (Link, Paton and Siegel 2002)

Incidentally, our assumed information lag proves sufficient to purge a scale effect problem (Jones 1995 and 1999) suffered by the early generation endogenous growth models, such as Aghion and Howitt (1992), despite increasing returns in the production of ideas and a number of sectors that does not increase with population.

The remainder of this paper is organized as follow. Section 2 introduces the basic framework of the model. Section 3 presents the balanced growth properties of the market economy. Section 4 analyses the relationship between market structure, R&D activity, and economic growth. Section 5 endogenizes skilled labor supply. Finally some conclusions are drawn.

## 2 Basic Framework

In this section we will introduce a new ingredient - information lag - into the basic Schumpeterian model of Aghion and Howitt (1992 and 1998). We will derive the main consequences in the next sections. As we shall see this new element suffices in delivering strong implications about the relationship between concentration and growth - reviving some of Schumpeter's (1942) intuitions - as well about the growth properties of the model.

The economy is populated by a continuum of infinitely-lived individuals with linear intertemporal preferences

$$u(y) = \int_0^{\infty} y_t e^{-r\tau} d\tau$$

where  $r$  is a constant rate of time preference.

Due to perfect capital markets and linear preferences, the equilibrium interest rate will be constant and equal to  $r$ . There are three sectors, the final output, the intermediate, and the research and development (R&D) sector. The final output and the R&D sectors are supposed to be perfectly competitive while the intermediate good sector has monopolistic structure: the firm that is the successful innovator retains a temporary monopoly rent on the production of the intermediate good until replaced by the next innovator.

There are two categories of labor: skilled labor  $L$ , which is employed both in the manufacturing sector and in the R&D one, and unskilled labor  $M$ , which is used in producing the final output sector. In the final output sector the consumption good is produced by using a fixed amount  $M$  of unskilled labor -that can be employed only in the final output sector- normalized to 1, and intermediate goods  $x$  according to the following production function.

$$y_t = F(M, x) = A_t x_t^\alpha$$

Labor market equilibrium implies:

$$L_t = x_t + n_t$$

Let  $w$  and  $w^u$  the wage rate for skilled and unskilled labor respectively, and  $\omega_t \equiv w_t/A_t$  the productivity-adjusted skilled wage.

The intermediate monopolist's profit maximization problem yields the usual expression:

$$\pi_t = \left( \frac{1 - \alpha}{\alpha} \right) w_t x_t \equiv A_t \tilde{\pi}(\omega_t) \quad (1)$$

In the R&D sector the discovery of a better quality of intermediate goods comes in two steps - two phases of a single cycle-:

- a new intermediate good is discovered -first phase
- after the discovery the firms takes time to patent the new intermediate good -second phase

Innovations' use raises the technology parameter by a constant factor  $\gamma > 1$ .

We follow the standard Schumpeterian approach of modeling each R&D race as an inventing lottery: at the beginning of the R&D race each research-firm participates with equal likelihood to discover the highest quality intermediate good -first phase. The arrival rate of innovations  $\lambda n$  is governed by a Poisson process:  $\lambda$  represents the productivity of research technology and  $n$  the amount of labor employed in R&D. However once discovered the better quality of intermediate good, a *fixed* interval of time, say  $\delta$ , is needed to patent the innovation -second phase.

The time  $\tau$  when the discovery is made, namely the length of the first phase by a first firm, the winner of the R&D race, is supposed to be unknown

by the other firms. Moreover the winner starts to earn profits due to his discovery after a complete cycle<sup>4</sup>. The patent expires when a next intermediate good with higher quality is introduced in the economic system, namely when the following cycle is concluded.

However due both to the structure of the two phases needed to complete a whole cycle and to the fixed length of the second phase, the relevant time for a R&D firm to consider is that one after which an interval of length equal to  $\delta$  has not passed being a length of time  $\delta$  needed to patent the latest innovation.

In the R&D sector the winner earns the present value of the returns from discovering and patenting the higher quality intermediate goods:

$$V_{t+1} = [\pi_{t+1} - \lambda n_{t+1} (V_{t+1} - \bar{V}_{t+1})] / r \quad (2)$$

where the LHS represents the profit flow  $\pi_{t+1}$  due to the discovery of  $t + 1$  intermediate good minus the capital loss  $\lambda n_{t+1} (V_{t+1} - \bar{V}_{t+1})$  due to the finite length of monopoly rent.

The term  $\bar{V}_{t+1}$  is linked to the structure of a cycle: a delay is introduced in this asset equation since no research-firm is replaced by a new innovator until the second phase is closed. The present value disappears some time after the discovery of the next generation of intermediate good, when both the first phase and the second one are concluded.

Consistent with this assumption, it follows

$$r\bar{V}_{t+1} = \pi_{t+1} (1 - e^{-r\delta}) \quad (3)$$

By combining both (2) and (3), it follows

$$V_{t+1} = \frac{\pi_{t+1} + \lambda n_{t+1} \bar{V}_{t+1}}{r + \lambda n_{t+1}} = \frac{[r + \lambda n_{t+1} (1 - e^{-r\delta})] \pi_{t+1} / r}{r + \lambda n_{t+1}} \quad (4)$$

The denominator of the previous expression  $r + \lambda n_{t+1}$  represents the obsolescence-adjusted interest rate (see Aghion and Howitt 1992, Aghion and Howitt 1998, ch. 2): the second term  $\lambda n_{t+1}$  can be intended as a creative-destruction rate linked to the obsolescence affecting the innovation. The higher the research level in the next period the higher the creative-destruction rate the lower the present value of an innovation.

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<sup>4</sup>No profit is earned before a whole cycle is closed.

### 3 Balanced Growth

For brevity reasons we will here perform only balanced growth analysis. It is not too difficult to prove that explicitly incorporating transitional paths all quantities and prices tend to converge monotonically to the steady state values<sup>5</sup>.

The amount of labor to employ in the R&D sector is determined by the following arbitrage condition:

$$w_t = e^{-\lambda\delta \int_0^\delta n_t(s)ds} \lambda V_{t+1} e^{-r\delta} \quad (5)$$

according to which the value of an hour in manufacturing ( $w_t$ ) has to be equal to the expected value of an hour in research. The RHS representing precisely the expected value of an hour in research includes both terms  $e^{-\lambda\delta \int_0^\delta n_t(s)ds}$  and  $e^{-r\delta}$ . The first one refers to the probability that the highest quality intermediate good could have already been discovered<sup>6</sup> being the integral  $\int_0^\delta n_t(s)ds$  concerned with the uncertainty of the innovation process: since no firm knows the time of the discovery, the longer the time after the end of previous cycle, the less the success probability in the R&D race, the less the incentive to conduct research. The second term is linked to the timing of innovating. The present value of a higher quality intermediate good appear some time after its discovery: because of it,  $e^{-r\delta}$  has to be introduced in the arbitrage condition.

By combining (5) and (4), and given the relationship between  $\pi(w)$  and  $\tilde{\pi}(\omega)$ , the arbitrage condition can be re-written

$$\omega_t = e^{-\lambda\delta \int_0^\delta n_t(s)ds} e^{-r\delta} \lambda \frac{\gamma [r + \lambda n_{t+1} (1 - e^{-r\delta})] \tilde{\pi}_{t+1}/r}{r + \lambda n_{t+1}} \quad (6)$$

Similarly to Aghion and Howitt, the amount of research employment  $\bar{n}$  at a stationary equilibrium can be evaluated as follows

$$\frac{\omega}{e^{-\lambda\delta n} \lambda e^{-r\delta}} = \frac{\gamma [r + \lambda n (1 - e^{-r\delta})] \tilde{\pi}/r}{r + \lambda n} \quad (7)$$

It is higher the lower the interest rate  $r$ , the higher the size of innovation  $\gamma$ , the higher the arrival rate of innovation  $\lambda$ , the higher the total amount of

<sup>5</sup>See Tarola (2002, ch. 3) for detailed calculations.

<sup>6</sup>This probability is equal to 1 minus the probability that the higher quality intermediate good has been discovered, that is  $1 - (1 - e^{-\lambda\tau\delta \int_0^\delta n_t(s)ds})$

labor force  $L$

Besides, by manipulating the (7) it follows

$$\omega = e^{-\lambda\delta\bar{n}}\lambda\gamma e^{-r\delta} \frac{[r + \lambda\bar{n}(1 - e^{-r\delta})] \left(\frac{1-\alpha}{\alpha}\right) \omega x/r}{r + \lambda\bar{n}} \quad (8)$$

and hence

$$\frac{e^{\lambda\bar{n}\delta} e^{r\delta}}{\lambda\gamma\bar{n}} = \left(1 - \frac{e^{-r\delta}}{\frac{r}{\lambda\bar{n}} + 1}\right) \left(\frac{1-\alpha}{\alpha}\right) \left(\frac{L}{\bar{n}} - 1\right) / r$$

from which we get

$$\frac{\vartheta(L/\bar{n})}{\vartheta L} > 0$$

Hence an increase in  $L$  raises the ratio  $L/\bar{n}$ . Not too surprisingly any increase in the labor force, namely in the population size, does not raise proportionally the research labor. This is due to the fact that the R&D sector is supposed to be subject to a kind of congestion. The term  $e^{-\lambda\bar{n}\delta}$  refers precisely to this congestion: the higher the amount of labor devoted to research the lower the chance of winning the R&D race from an individual firm's perspective and the less profitable it is to invest in R&D activities.

As far as balanced growth is concerned, the final output good during the time interval  $t$  can be written as

$$y_t = A_t(L - \bar{n})^\alpha$$

hence it follows

$$y_{t+1} = \gamma y_t$$

As in Aghion and Howitt (1992 and 1998) we can write

$$\ln y(\tau + 1) = \ln y(\tau) + \varepsilon(\tau)$$

where  $\tau$  refers to real time and  $\varepsilon$  the number of innovations between  $\tau$  and  $\tau + 1$ .

The crucial point is represented by  $\varepsilon$ : in this framework the number of innovations is bounded above.

This is due to the timing of the model according to which on one hand research-firms need to see the previous innovation before anyone can think

of the new one, on the other hand an innovation becomes known just after both the first phase and the second one are closed.

During the second phase in spite of the discovery made in the first one no new innovation can be introduced in the system -regardless of the R&D effort- due to that no firm knows what has already happened. Hence the average growth rate of the economy is

$$g = \sum_{j=0}^{\kappa} \frac{(\lambda n \tau)^j e^{-\lambda n \tau \delta}}{j!} j \ln \gamma = \lambda m(n) \ln \gamma \quad (9)$$

where  $\lambda m(n) = \sum_{j=0}^{\kappa} \frac{(\lambda n \tau)^j e^{-\lambda n \tau \delta}}{j!} j$  which is bounded above by  $\kappa \equiv \frac{1}{\delta}$ . So regardless of the amount of skilled labor the information/dissemination lag puts an upper bound to percapita growth rate, thereby eliminating the well known scale effect property of Aghion and Howitt (1992) proved by Jones (1995) to be inconsistent with existing data.

## 4 Concentration and Cooperation in the R&D Sector

The main feature of the decentralized setting is the congestion phenomenon due to the information gap affecting negatively research-effort. This is rather realistic in an economy in which a large number of small firms undertake independent R&D projects. In the model of the previous section this was stylized by the assumption of zero-measure firms. Though in the real industrial world it is frequent for small firms to exchange some relevant information with each other, the character of a firm as an information barrier (Jovanovic and Rob 1989, Jovanovic and MacDonald 1994, Jovanovic and Rousseau 2001) provides strong incentives for firms to merge their R&D units or to let them cooperate (Cozzi 1999). In this model with free entry, tradable factors, and constant returns, homogeneous R&D workers extract all producers' surplus generated: so large firms can be equivalently seen as skilled workers' R&D associations. The aim of reducing the information dissemination lag provides a natural motivation for R&D firms to merge and/ for R&D workers to cooperate with each other. Of course, the antitrust authorities should worry that a cartel of R&D producers might refrain from innovation by internalizing the business stealing externality. Then it seems important to investigate

which firm size is the more adequate system to overcome this sort of congestion without discouraging aggressive innovative activity. The aim of this section is precisely to define the number of research-firms that maximizes growth, verifying the relationship between the number of research-firms and research-effort. We can assume that the antitrust authorities impose that each R&D firm size be not larger than one  $N^{\text{th}}$  of the market<sup>7</sup>. Since all researchers would want to work in the biggest R&D firms (because the duplication risk is smaller) exactly  $N$  research-firms participate in the R&D race. Each research-firm  $i$  devotes exactly  $n_t^i$  to R&D sector with

$$n_t^i \equiv \frac{n_t}{N}$$

where  $n_t$  is the total amount of labor employed in the research-sector.

In the determination of its R&D effort each firm cares about the probability of winning the R&D race. This is inversely related to R&D effort of the other research-firms.

Focusing on symmetric equilibria we can re-write the arbitrage condition for the firm  $i$  as follows:

$$\omega_t = e^{-\lambda \frac{(N-1)}{N} n_t \tau \delta} e^{-r\delta} \lambda \frac{\gamma [r + \lambda n_{t+1} (1 - e^{-r\delta})] \tilde{\pi}_{t+1}/r}{r + \lambda n_{t+1}} \quad (10)$$

where  $e^{-\lambda \frac{(N-1)}{N} n_t \tau \delta}$  refers to the probability of success for the firm  $i$ . It is expressed in terms of the number of research-firms working in the market and total amount of labor employed in R&D. It easy to see that RHS is a decreasing function of  $N$ . The following holds:

**Proposition 1** *The higher the number of non-cooperating research firms,  $N$ , the lower the probability of a firm's winning the R&D race, the lower the expected value of an hour in research. The higher the number of firms in the market the stronger the effects of the information-gap, the lower the expected aggregate growth rate, and the lower the skilled/unskilled wage gap.*

**Proof.** Let us rewrite the arbitrage condition as

$$\phi(n_t, N) \equiv e^{-\lambda \frac{(N-1)}{N} n_t \tau \delta} e^{-r\delta} \lambda \frac{\gamma [r + \lambda n_{t+1} (1 - e^{-r\delta})] \tilde{\pi}_{t+1}/r}{r + \lambda n_{t+1}} - \omega_t = 0$$

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<sup>7</sup>In the following analysis we assume  $N \geq 2$ .

Then according to the implicit function theorem we know that

$$\frac{\partial n_t}{\partial N} = -\frac{\partial \phi(\bullet) / \partial N}{\partial \phi(\bullet) / \partial n_t}$$

where

$$\frac{\partial \phi(\bullet)}{\partial N} = -\lambda n_t \delta N^{-2} e^{-\lambda \frac{(N-1)}{N} n_t \delta} e^{-r\delta} \gamma \frac{[r + \lambda n_{t+1} (1 - e^{-r\delta})] \tilde{\pi}_{t+1} / r}{r + \lambda n_{t+1}}$$

and

$$\frac{\partial \phi(\bullet)}{\partial n_t} = -\lambda \frac{(N-1)}{N} \delta e^{-\lambda \frac{(N-1)}{N} n_t \delta} e^{-r\delta} \gamma \frac{[r + \lambda n_{t+1} (1 - e^{-r\delta})] \tilde{\pi}_{t+1} / r}{r + \lambda n_{t+1}}$$

So it follows

$$\frac{\partial n_t}{\partial N} = -\frac{\partial \phi(\bullet) / \partial N}{\partial \phi(\bullet) / \partial n_t} < 0$$

since  $\frac{\partial \phi(\bullet)}{\partial N} < 0$  and  $\frac{\partial \phi(\bullet)}{\partial n_t} < 0$  that is the lower the number of research-firms the higher the equilibrium effort in R&D and the higher the average growth rate of the economy. The other statements follow straightforwardly. **Q.E.D.**

Hence due to that both the R&D effort is inversely related to the number of research-firms and the higher the research-effort the higher the average growth rate of the economy the best solution under laissez-faire is obtained when a minimum number of firms operate in the market that is when  $N = 2$ . Since skilled workers are always better off the relatively larger their R&D firm we can conclude:

**Corollary 2** *An antitrust policy that seeked to maximize growth would allow the formation of a non-collusive duopoly in the R&D sector, which would immediately form.*

Notice that here the duopoly emerges endogenously as R&D workers would tend to unify their effort, but the antitrust authorities can allow or ban it. Hence at the R&D stage every duopolist is under the constant threat of possible free entrants (defector groups of workers). Therefore all profits are dissipated into skilled wage.

## 4.1 Monopoly or Duopoly?

Should the antitrust authority allow R&D firms to join a unique firm, that will become the unique intermediate good monopolist<sup>8</sup>? We just need to compare (10) with  $N = 2$  to the following arbitrage condition of the monopolist:

$$\omega_t = \lambda \frac{(\gamma - 1) \tilde{\pi}_{t+1}}{r} \quad (11)$$

and conclude that the larger the information lag, the higher the quality jump, and the more populated the economy the more innovative the monopoly compared to the duopoly. Reminding the reader that in this representative sector model the monopoly should be correctly interpreted as belonging to an infimum sub-sector of the whole economy, it may be interesting to note that our analysis implies that - *ceteris paribus* - when a large area integrates economically it is more likely that antitrust authorities concerned with innovation would decide to allow more concentration than smaller areas. The reason is that with a large skilled labor mass working for the rival each duopolist would seriously fear that its potential discovery could already be - or will soon become - obsolete.

## 5 Endogenous Skills

Up to now we have been following Aghion and Howitt's (1992) assumption of a fixed composition of the labor supply between skilled and unskilled workers. In this section we show that our analysis allows to relate efficiency enhancing mergers to the endogenous composition of the labor force.

Indeed it is straightforward to endogenize the supply of skills in this economy, by adapting to the closed economy framework Dinopoulos and Segerstrom's (1999) methodology. We will assume that individuals are finitely lived members of infinitely lived households, being continuously born at rate  $\beta$ , and dying at rate  $d$ , with  $\beta - d > 0$ ;  $D > 0$  denotes the exogenously given duration of their life. People are altruistic in that they care

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<sup>8</sup>Taken literally in Aghion and Howitt's (1992) economy the monopolist would also have monopsonist power. However their macroeconomic focus - which is also ours - clarifies that it should be interpreted as a representative industry in a large set of industries.

about their household's total discounted utility according to the usual intertemporally additive functional. They choose to train and become skilled at the beginning of their lives, and the (positive) duration of their training period - in which the individual cannot work - is exogenously fixed as  $T < D$ .

Hence an individual with ability  $\theta \in [0, 1]$  uniformly distributed decides to train if and only if the following is satisfied:

$$E_\tau \left[ \int_\tau^{\tau+D} e^{-r(s-\tau)} w^u(s) ds \right] < E_\tau \left[ \int_{\tau+T}^{\tau+D} e^{-r(s-\tau)} \max(\theta - \gamma, 0) w(s) ds \right],$$

with  $0 < \gamma < 1/2$ , and with  $E_\tau$  denoting expectations as of time  $\tau$ . Notice that an individual of ability  $\theta > \gamma$  is postulated able to accumulate skill (human capital)  $\theta - \gamma$  after training, while individuals with too low ability ( $\theta < \gamma$ ) never get any skill from schooling.

As Dinopoulos and Segerstrom (1999) we focus on the steady state (balanced growth) analysis, in which all variables - and real wages in particular - are expected to grow at the same constant expected growth rate as  $A_t$ . Hence any individual will decide to get an education if and only if her ability level is no less than

$$\theta_0 = \sigma \frac{\omega^u}{\omega} + \gamma,$$

with  $\sigma > 0$  being a parameter dependent constant. Therefore the aggregate supply of unskilled labor at time  $t$  is

$$M(\tau) \equiv \theta_0 L(\tau) = \left( \sigma \frac{\omega^u}{\omega} + \gamma \right) L(\tau) \quad (12)$$

and the aggregate supply of skilled labor at time  $\tau$  is

$$L^s(\tau) = (\theta_0 + 1 - 2\gamma) (1 - \theta_0) \phi L(\tau) / 2 \quad (13)$$

with  $0 < \phi < 1$ .

Since the fraction of the population that decides to get skilled is only dependent on the productivity adjusted skilled/unskilled wage ratio and on parameters the results of the previous sections continue to hold and we can state:

**Proposition 3** *The lower the number of non-cooperating R&D firms,  $N$ , the higher expected aggregate growth rate, the higher the skilled/unskilled wage gap, and the larger the fraction of population that decides to get skilled.*

**Proof.** Just repeat the proof of Proposition 1 using (12) and (13) instead of  $M = 1$  and  $L$ . **Q.E.D.**

## 6 Conclusion

In this paper we have shown that due to the information gap between research firms a kind of congestion appears in the R&D sector. This phenomenon, reducing the research effort, affects growth negatively. Moreover as R&D effort is inversely related to the number of non-cooperating research firms, we conclude that the best growth-enhancing policy under *laissez-faire* is to allow at least a contestable duopoly for each innovative industry. It seems interesting that the information dissemination lag allows us to capture in a unified framework phenomena — such as wage inequality, mergers and their interplay — analyzed in often unrelated investigation, although with similar time pattern.

We can re-interpret some recent trends in the US and EU in light of our simple model's results. Since the mid 70's - also due to weaker international barriers and fierce competition by newly industrialized countries - US and EU authorities have relaxed their antitrust policy against either mergers or R&D cooperation in order to improve their competitiveness. This has stimulated R&D efforts, reduced innovation delay (see Agarwal and Gort, 2000), improved product qualities at a faster rate, and at the same time it has increased wage inequality and the fraction of the highly educated population.

Although our results seem consistent with some well known empirical evidence on interfirm barriers, the related incentives for firms to cooperate, and the plausible link between market structure, wage inequality, and growth, yet they have been obtained within the extremely stylized Aghion and Howitt's (1992) framework. It would be interesting to extend our logic to an explicitly more complex frameworks, such as for example Aghion et al. (2001). Moreover, by analyzing US data in the period 1985-1998 Link, Paton and Siegel (2002) find that authorities systematically allow R&D agreements more often when the country is losing international competitiveness in high technology sectors. This is consistent with our claim that policy changes are at the root of the observed consequence for innovation and income distribution, but at the same time suggests to endogenize industrial policy in an explicit international setting. These will be topics for further work.

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