



F U N D A Ç Ã O
GETULIO VARGAS

EPGE

Escola de Pós-Graduação
em Economia

SEMINÁRIOS
DE PESQUISA
ECONÔMICA

“Formation and Destruction of Coalition Groups under Economic Growth”

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LOCAL

Fundação Getúlio Vargas
Praia de Botafogo, 190 - 10º andar - Auditório Eugênio Gudin

DATA

09/11/2000 (5ª feira)

HORÁRIO

16:00h

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Formation and Destruction of Coalition Groups under Economic Growth

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Comments are Welcome

November 7, 2000

Abstract

This paper introduces a model economy in which formation of coalition groups under technological progress is generated endogenously. The coalition formation depends crucially on the rate of arrival of new technologies. In the model, an agent working in the same technology for more than one period acquires skills, part of which is specific to this technology. These skills increase the agent productivity. In this case, if he has worked more than one period with the same technology he has incentives to construct a coalition to block the adoption of new technologies. Therefore, in every sector the workers have incentives to construct a coalition and to block the adoption of new technologies. They will block every time that a technology stay in use for more than one period.

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1 Introduction

The economic performance varies largely across countries and in the same country across time¹. Following Solow [10] and Solow [11], our assumption is that the engine of growth is the technological progress. Given the diversity of economic performance across countries our question is why the technological progress differs so much across countries or within a country over time.

In a world with closed countries, the success of a country in developing new technologies could explain its better economic performance. But, in a world where firms can use technologies developed in other countries, this explanation does not apply. The question to focus on is why countries resist to technological progress and how this resistance occurs.

The assumption of this paper is that “(technological) progress and growth, ..., involves costs that usually fell disproportionately on some groups”². In this case, those groups would resist to adopt new technologies. Moreover, “resistance almost always takes place through non-market mechanisms”³, principally through government intervention. These costs are not related with the production of the new technique (in fact, we are assuming an exogenous and cost-less technological progress). The costs come from the lost of skills or human capital, specific to the old technology, suffered by the workers of the sectors where the technological progress is happening (in the next section we will look in some estimative of this loss).

This paper follows the line of Parente and Prescott [7], Parente and Prescott [8], Krussel and Ríos-Rull [3], Holmes and Schimitz [2] and Teixeira [12], where the technological progress depends on the resistance of some groups to adopt new technologies. These papers stress the benefits of groups to resist to new technologies. In Parente and Prescott [8] some groups wanted to block technological progress fearing that technological progress in their sectors would reduce the relative price of this good. In this case, if the demand were price inelastic the technological progress would reduce the employment in their sectors. Holmes and Schimitz [2] and Teixeira [13] study how the international trade affect the decision to adopt new technologies. Particularly, Teixeira [13] studies the effects of the adoption of technology in the investment in physical capital. He shows that in closed economies (economies with

¹See Parente and Prescott [6], Prescott [9] and Chari, McGrattan and Kehoe [1].

²Mokyr [10, page 328]. See also Olson [5] for evidences of resistance to adopt new technologies.

³Mokyr [10, page 329].

Table 1: Predicted Growth Rate of Wages - By Years of Job Tenure

Years of Tenure	1	2	3	4	5	6	7	8	9	10
Rate of Growth	0.068	0.06	0.052	0.046	0.041	0.037	0.033	0.03	0.028	0.026

quota) the adoption of new technologies will be stopped for some periods, reducing investment and the capital labor ratio.

This paper is divided in.....

2 Wages and Accumulation of Skills

The basic point that we want to stress in this section is that the workers acquire skills or human capital in each passing year that they work in the same firm. Besides, part of these skills are specific to this technology. In this case, “workers with longer prior job tenures suffer substantially greater losses from displacement”⁴. In other words, with each passing year working with the same technology a worker acquires skills. Part of these skills are general and part are specific to this technology. The worker would loose the skills that are specific once he starts a new job. What Toppel [15] estimative indicates is that this loss is substantial.

Clearly, not every job lost by a worker can be used to support the above hypothesis. For example, a new match between a labor and a firm can have a problem of private information. The labor knows his skills, but the firm does not know. In this case, the labor can have less skills than he originally had. The firm, after realizing that, can fire the labor.

To eliminate this and other problems, Toppel [15] use a sample of men that have been displaced from a job because of layoffs or plant closing. He found that the wage loss varies from 9.5% for a worker with 5 years of seniority or tenure to 43.9% for workers with more than 20 years of tenure⁵.

The results of Toppel [15] are summarized in the Tables 1-3⁶. Table 1

⁴Toppel [15, page 148].

⁵See Toppel [15, page 149]. The sample consists of 4,367 men.

⁶The wage of a labor almost double during his career. Although, this growth is not linear and it is faster in the first years (Toppel [16]). But, Toppel [15] use workers with 10 years of seniority. In this case, this estimative could underestimate the accumulation of skills. In any case, they still give us a good indicative of the process of accumulation of

Table 2: Wage Index

Years of Tenure	0	1	2	3	4	5	6	7	8	9	10
Wage Index	1	1.068	1.132	1.191	1.246	1.297	1.345	1.389	1.43	1.47	1.509

Table 3: Wage Loss By Years of Job Tenure

Years of Tenure	5	10	15	20
Method 1	0.19	0.28	0.33	0.40
Method 2	0.26	0.35	0.38	0.42

shows the sample growth rate of the wage generated by accumulation of skills (general and specific). Table 2 is generated from Table 1, by constructing a wage index. Thus, in period zero the wage is 1. Then, we increase this wage following the growth rate given in Table 1. We see that the growth rate is higher in the beginning and it reduces over time.

Table 3 shows the estimated wage loss of a worker by years of job tenure. The estimation is based in two different procedures, that we call Method 1 and Method 2. Method 1 is the lower bound of the wage loss⁷.

From Tables 1-3 we can summarized the following conclusions:

- (i) Wages grow faster in the first periods of a new job than in the later periods. Thus, wages are concave in years of job tenure;
- (ii) The wage loss by job displacement is quite substantial, varying between 19% for a period of 5 years tenure to 42% for a 20 years tenure.

3 The Model

There are M goods at each date and a competitive firm producing each of those goods with a constant return to scale technology. There is no borrowing or lending and no physical capital accumulation. There are measure $\lambda > 0$

skills that take place in the job.

⁷Method 1 uses a two step procedure to estimate and separate the effects of experience and job tenure over the wage. Method 2 is the OLS estimator, that in this case is biased. See Toppel [15, pages 148–154].

of households that live forever. The period commodity space is $L = \mathbb{R}^{M+1}$, the space of M final goods and efficiency units of labor. A point of L is $x = (c_1, \dots, c_M, h)$.

We now turn to define the consumption set of a household i . To do that we need to specify the amount of labor that a household can supply in each period. In the first period, each household is endowed with one unit of time. We will call this unskilled labor. But, a household can accumulate skills. More specifically, after each period working in a firm (technology), the agent accumulates or acquires skills. We measure this new skills in units of time of the unskilled labor and we are assuming that the accumulation of skills follow some concave and bounded assumptions. That is, the marginal increase of skills for each period of work in the same technology reduces over time. Moreover, there is a maximum amount of skills for each technology. But, every time that a firm starts to use a new technology, an old employee loses part of his skills accumulated in the previous technology.

For example, suppose that in the first period, an agent starts to work with some technology. He can sell the services of one unit of unskilled labor. In the second period, for example, he would have 1.10 units of unskilled labor. In the third, he would have 1.15 and so on. Now, if in the fourth period he changes sectors or the technology that he is working with then he can supply only 1.07 units of labor. Thus, there is no external effects for other workers. The increase in his productivity comes only from his accumulation of skills in a “learning by doing” way. From the firm point of view, everything happens as if the agent was selling one unit of time in his first period, 1.10 in the second and so on.

Define H the space of functions $h : \mathcal{N} \times \mathcal{N} \times \mathcal{N} \rightarrow \mathbb{R}_+$ piecewise monotone increase, piecewise concave, piecewise continuous and $h'(a_j, a'_j, n_j) \geq 1$, where a_j is the current technology index for workers of sector j , a'_j is the next period technology index for workers of sector j , and n_j is the number of periods that worker i has been working with technology index a_j .

The consumption set of agent i is

$$X(h_i) = \{x \in L_+ : 1 \leq h \leq h_i, h_i \in H\} \quad (1)$$

• Preferences

All households admit a utility function of the form

$$\sum_{t=0}^{\infty} \beta^t \frac{(c_{1t}^{\alpha_1} \cdot \dots \cdot c_{Mt}^{\alpha_M})^{\rho}}{\rho} \quad (2)$$

where $\sum_{j=1}^M \alpha_j = 1$, $\rho \leq 1$ and $\beta \in (0, 1)$.

• Technologies

The technological set of a firm of sector j is

$$Y_j(a_j) = \{x \in L_+ : c_j \leq \gamma^{a_j} h, c_i = 0, \text{ if } i \neq m\} \quad (3)$$

where $\gamma > 1$ and a_j is an integer that indexes the technology in sector j and is determined by past policy decisions of workers of sector j .

We are assuming that there is an exogenous technological progress in every sector. The advance in technologies happens in the following way. There is a draw technology given by $\Phi(t)$. At each period t , $\Phi(t)$ is a M -vector that shows the sectors that will have a new technology available in the next period. That is, $\Phi_j(t) = 1$ if sector j will have a new technology in period $t + 1$ and $\Phi_j(t) = 0$ if not. Finally, the most advanced technology for sector j in period t , $A_j(t)$, and the technology used in sector j in period t , $a_j(t)$, are defined as

$$A_j(t) = \sum_{j=1}^t \Phi_j(j)$$

$$a_j(t) \in \{0, \dots, A_j(t)\}$$

For simplicity we will suppress time symbols from $A_j(t)$ and $a_j(t)$ leaving them implicit from now on.

The technology advance step by step. Besides, as we will see below, there is no uncertainty with respect to next period since the announcement of a new technology is made in the current period and known before the relevant decisions.

The last technology in this economy is a blocking technology. That is, there is a technology that blocks the adoption of new technologies, allowing workers of a sector to keep using an old one. But, this blocking is costly. We measure this cost in units of time that workers have to give up in order

to obtain the block of the new technology. This blocking technology is $G : \mathbb{N} \times \mathbb{N} \rightarrow \mathbb{R}_+$ that transforms technology index A in technology index a at a cost $d^\theta \kappa$, where κ is a positive constant, $d = A - a$

$$G(d) = d^\theta \kappa \quad (4)$$

where $\theta \geq 0$ and $a \leq A$.

• Policy Arrangement

The integers a_j indexes the technological set Y_j that produces good j . This integer belongs to the set $\{0, \dots, A_j\}$, and $A_j \leq t$.

In the beginning of period t , the workers of a sector $\Phi_j(t) = 1$ decide the technology that they will use next period. That is, workers of sector j such that $\Phi_j(t) = 1$ choose $a'_j \in \{a_j, \dots, A_j, A_j + 1\}$.

• Blocking

We will say that workers of sector j are blocking the adoption of new technologies if $a_j < A_j$.

• Timing

In the beginning of period t , the value of $\Phi(t)$ is known. Workers of each sector j such that $\Phi_j(t) = 1$ get together and decide if they will construct a coalition to block or not the new technology. That is, after $\Phi(t)$ is announced the workers of each sector that will have a new technology available get together. If they choose to block they divided the amount $G(\cdot)$ among themselves and use the blocking technology to create a barrier. The best technology will not be used in the subsequent period. After these decisions, the amount of labor that each agent can supply is known and markets are opened.

• Accumulation of Skills: an example

To make clear how an agent accumulates skills, let us write one example. Suppose that agent i works in a sector j . Define a function $h'_i : \mathbb{N} \rightarrow \mathbb{R}_+$ by

$$h'_i(a_j, a'_j, n'_j) = 2 - e^{-n'_j}$$

$$n'_j = \begin{cases} 0, & \text{if } a'_j > a_j \\ n_j + 1, & \text{if } a'_j = a_j \end{cases} \quad (5)$$

where h'_i is the amount of labor services that agent i can supply next period and n_j is the number of periods that agent i has been working with technology a_j .

Now, from Equation (5) we can see that, fixing a'_j and making $n_j \rightarrow \infty$ the marginal rate of accumulation of skills goes to 0. That is, $h'_i \rightarrow 2$.

3.1 Definition of Equilibrium

This is a discrete time infinite dynamic game with 2 stages in each period. In stage one, the draw technology $\Phi(t)$ chooses randomly which sectors will have a new technology available in the next period. This becomes a public knowledge. Given $\Phi(t)$, the workers of each sector j such that $\Phi_j(t) = 1$ get together and decide if they will construct a coalition and stop the adoption of the new technology available. In the second stage, price and allocations are determined competitively.

We will work with the Markov equilibrium⁸. But, we will restrict our analysis to the set of Markov equilibrium which is symmetric with respect to the workers of the same sector.

In each period we will analyze the game using backward induction from stage 2 to stage 1. In the second stage, the economy state variables are (s, H, s') where $s = (t, A_1, \dots, A_M, a_1, \dots, a_M, n_1, \dots, n_M)$, t indicates the current period, A_j is the index of the most advanced technology available for sector j in period t , a_j is the index of the technology in use in sector j in period t and n_j is the number of periods that technology indexed by a_j has been in use in sector j . $H = \sum_{i=1}^{\lambda} h_i$ is the aggregate stock of human capital in period t . For simplicity, we will write $s = (t, A, a, n)$. We are abusing notation, using n_j to represent the number of periods that a worker in sector j has been working with technology a_j as well as the number of periods that firms of sector j have been using technology a_j . For the set of symmetric Markov equilibrium that we are working here they are the same. In the second stage, consumers and firms solve their problem. That is, prices and allocations are determined competitively. The maximization problem of a consumers and firms are static.

In the first stage $\Phi(t)$ is announced and workers choose the technology that

⁸See Maskin and Tirole [4].

they will use next period. Once $\Phi(t)$ is known the economy state variables are (s, H) and A' . Let $S = \mathbb{N}^{3M+1}$ be the space of state variables and F the space of functions $g_j : S \rightarrow \mathbb{N}$. Let $D_j : F^{M-1} \rightarrow F$ be the best response correspondence (for workers of sector j). That is, if $g_j \in D_j(g_{-j})$ then

$$g_j \in \operatorname{argmax}_{a'_j \leq A'_j} E \left\{ \Phi \sum_{t=0}^{\infty} \beta^t \frac{(\gamma^{\alpha_1 a_1} \cdot \dots \cdot \gamma^{\alpha_M a_M} \hat{h}_i)^\rho}{\rho} \right\}$$

where $\Phi = \alpha_1^{\alpha_1} \cdot \dots \cdot \alpha_M^{\alpha_M}$

Finally, let $D(g)$ be a M vector of best response correspondence of all sectors.

• Dynamic Equilibrium

The equilibrium that we are working with is a Markov equilibrium⁹ with respect to the state variables (s, H) . We are restricting our attention to the Markov equilibrium which is symmetric with respect to workers of the same sector. An equilibrium is the following set of elements:

- (i) price functions $p(s, H) = \{p_1, \dots, p_m, w = 1\}$;
- (ii) households allocations $\{x_i(s, H)\}$ for all i ;
- (iii) firms allocations $\{x_j(s, H)\}$ for all j ;
- (iv) laws of motion $a' = g(s, H)$, $H' = G(s, H, s')$;
- 1) Given $p(s, H)$, and $a'_j = g_j(s, H)$, $\{x_i\}_{i=1}^\lambda$ solve the consumers' problem and $\{x_j\}$ solves the firms' problem;
- 3) Markets clear;
- 4) $g(s)$ is a fixed point of $D(g)$, That is, $g \in D(g)$.

3.2 Dynamic Equilibrium

In this section we will show that there exist conditions under which workers of any sector will block the adoption of new technologies, as long as (i) the technological index in use is not far from the technological frontier; (ii) the workers have been working with the same technology for some periods; and

⁹See Maskin and Tirole [4].

(iii) the arrival of new technologies is not frequently . The intuition is as follows. On the one hand, the further a sector is from the frontier more the workers of this sector have to pay to block the new technology that arrives. Since their income is bounded and the cost to block is unbounded then, there is a distance d^* from the frontier after which they will not block anymore. This happens because in this case their income is smaller than the cost to block. On the other hand, if the distance from the technological frontier is less than d^* it would be better for workers to pay the cost of blocking, as long as, the probability to be hitted every period with a new technology is very small. In this case, the workers avoid loose part of their income for many periods compesaning the cost of blocking.

In the next proposition, $\sigma = \frac{m}{M}$ is the probability that a sector will have a new technology available next period, λ_j is the number of workers in sector j . We should stress that in equilibrium λ_j is constant. The reason is the following. If a worker changes sector he looses part of his skills, reducing his income. In this case, he would change sector only when his sector changed technology. But, in this case he will be indifferent. Therefore, in the model there will have no movement of workers across sectors and λ_j will be constant.

Now, we will introduce the assumptions that we will use to prove the propositions below.

A1: $h(\cdot, \cdot, t+1) - h(\cdot, \cdot, t) > (1 - \sigma)^t \sigma$.

The intuition behind A1 is as follows. Suppose that we are in period T . The probability that until period $t + n$ our sector will not be hitted by a new technology reduces. Therefore, the increment in our income has to compensate this reduction in the probability, making our expected income nondecreasing over time.

Proposition 1 *If A1 holds then there exist a $n^* > 0$, $d^* > 1$ and $\epsilon^* > 0$ such that for $\beta \in (1 - \epsilon^*, 1)$, $\sigma \in (0, \epsilon^*)$ and $\rho \in (1 - \epsilon^*, 1)$*

- (i) *If $n > n^*$ and $d < d^*$ then a coalition will be constructed and $a'_j = a_j$.*
- (ii) *If $d > d^*$ then no coalition will be constructed and $A'_j = a'_j$*

Proof. From the utility function of a worker i from a sector j we can calculate the demand function of each good j .

$$c_j = \alpha_j \gamma^{a_j} \hat{h}_i \quad (6)$$

where $\hat{h}_i = h_i(\cdot)$ if there is no block or it is equal to $\hat{h}_i = h_i(\cdot) - \frac{G(d)}{\lambda_j}$ if there is block in sector j ; $\frac{G(d)}{\lambda_j}$ is the cost per worker of blocking since $G(d)$ is the total cost and λ_j is the number of workers in sector j .

$$\sum_{t=0}^{\infty} \beta^t \frac{(c_{1t}^{\alpha_1} \cdot \dots \cdot c_{Mt}^{\alpha_M})^\rho}{\rho} = \Phi \sum_{t=0}^{\infty} \beta^t \frac{(\gamma^{\alpha_1 a_1} \cdot \dots \cdot \gamma_{Mt}^{\alpha_M a_M} \hat{h}_i)^\rho}{\rho} \quad (7)$$

where $\Phi = \alpha_1^{\alpha_1} \cdot \dots \cdot \alpha_M^{\alpha_M}$.

Workers of sector j will choose n and d to maximize the last equation. Since we are looking for sufficient conditions, we will take the following steps. Suppose two strategies that are identical and without block in every period but period T . Suppose that in a period T a new technology for period $T + 1$ is announced. In strategy 1 there will be a block of the new technology and in the strategy 2 there will be no block. This will be the only difference between these two strategies. We will show that the above conditions are sufficient to guarantee that the block of the new technology will increase the utility (pay off) of this strategy. We generalize and show that the block will occur for some fix number of technologies and then the newest technology will be used. That is, if $d \leq d^*$ new technologies will be blocked and for $d > d^*$ no block will occur.

Again, suppose that in period T a new technology for period $T + 1$ is announced. If the workers decide to block this new technology, in the next period the amount of labor services that a worker of sector j can supply will increase to $h_i(\cdot, \cdot, n + 1)$ but each worker will pay an amount $\frac{G(d)}{\lambda_j}$ in period T . In period $T + 1$ another technology can be announced. If another technology is not announced then the amount of labor services that a worker of sector j can supply will increase to $h_i(\cdot, \cdot, n + 2)$ and so on. Here we will show just a sufficient condition to have a block of technology.

Call U_1 and U_2 the pay offs of the strategies 1 and 2 respectively. We will show that under the above hypothesis $U_1 - U_2 > 0$. Besides, we will show that for some d and n the block will occur. Basically, $\exists d^* \geq 1$ such that for $d \leq d^*$, $\exists n^* > 1$ such that for $n \geq n^*$ and $d \leq d^*$ they will block.

If we subtract U_1 and U_2 we get

$$U_1 - U_2 = \beta^T A_0 \left[\frac{(\gamma^{\alpha_j a_j} (h(\cdot, \cdot, n) - \frac{G(1)}{\lambda_j}))^\rho}{\rho} - \frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n))^\rho}{\rho} \right] +$$

$$\beta^{T+1} A_1 \left[\frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n+1))^\rho}{\rho} - \frac{(\gamma^{\alpha_j(a_j+1)} h(\cdot, \cdot, 0))^\rho}{\rho} \right] + \sum_{t=2}^{\infty} \beta^{T+t} A_t \left[\frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n+t))^\rho}{\rho} - \frac{(\gamma^{\alpha_j(a_j+1)} h(\cdot, \cdot, t-1))^\rho}{\rho} \right] (1-\sigma)^{t-1} \quad (8)$$

where the terms A_i come from Equation (7) once we isolate the expressions between brackets; $\sigma = \frac{m}{M}$ is the probability to have available a new technology in the next period and $(1-\sigma)^{t-1}$ is the probability in period T that no new technology will be available until period $T+t$, for $t \geq 2$.

As we can see from Equation (8), as $\sigma \rightarrow 1$ then $U_1 - U_2$ reduces. That is, the incentive to block a new technology reduces as the probability to be hit by a new technology increases.

Proof of (ii): From the first term of Equation (8) and since $h(\cdot, \cdot, \cdot)$ is bounded and $G(\cdot)$ is not bounded there is a d^* such that $\forall d > d^*$ there will be no blocking.

Proof of (i): Now, let us show that under the above assumptions for $\forall d < d^*$ and $n > n^*$ there there will be a block.

Looking at the second and third expressions of Equation (8) we see that if $\alpha_j \rightarrow 0$ then for any value of γ these two expressions are positive. Therefore, $\exists \alpha_j^*$ such that for $\alpha_j > \alpha_j^*$ the second and third expressions of Equation (8) are positive for any value of γ .

We have $A_0 \leq A_1 \leq A_t \leq A_{t+1}, \forall t \geq 2$ since technological index does not reduce. Taking limit in Equation (8) making $\rho \rightarrow 1$ and $\alpha_j \rightarrow 0$ we get

$$U_1 - U_2 \geq$$

$$\beta^T A_0 \left\{ -G(1) + \sum_{t=2}^{\infty} \beta^t [(h(\cdot, \cdot, n+t)) - h(\cdot, \cdot, t-1)] (1-\sigma)^{t-1} \right\} \quad (9)$$

We are looking for some properties for the difference $[(h(\cdot, \cdot, n+t)) - h(\cdot, \cdot, t-1)] (1-\sigma)^{t-1}$. That is, we will show that if this difference is greater than or equal to $\beta^t [(1-\sigma)^t - (1-\sigma)^{n+t+1}]$ then for $\kappa < n+1$ Equation (9) is positive. Define

$$h(\cdot, \cdot, n+t) = b + (1-\sigma)^{n+t} \quad (10)$$

Substitute Equation (10) into Equation (9) and use assumption 1 to get

$$U_1 - U_2 \geq \beta^T A_0 \left\{ -G(1) + \beta \frac{[1 - (1 - \sigma)^{n+1}]}{1 - \beta(1 - \sigma)} \right\} \quad (11)$$

Again, take limit in Equation (11), making $\beta \rightarrow 1$ and $\sigma \rightarrow 0$ we get

$$U_1 - U_2 \geq \beta^T A_0 \left\{ -G(1) + \beta \frac{[1 - (1 - \sigma)^{n+1}]}{1 - \beta(1 - \sigma)} \right\} \rightarrow \beta^T A_0 \{-\kappa + n + 1\}$$

Therefore, there exists $\epsilon^* > 0$ such that for $\beta \in (1 - \epsilon^*, 1)$, $\sigma \in (0, \epsilon^*)$ and for a given κ , then there exist a n^* such that for all $n > n^*$ we have $U_1 - U_2 > 0$. This concludes the proof. ■

Given Proposition 1, the next step is to prove the following result:

Proposition 2 *If all the assumptions of Proposition 1 hold then there exists a dynamic equilibrium such that for every sector j such that $n_j > n^*$ and $d_j < d^*$ workers will block the adoption of new technologies. Otherwise there the workers will allow the adoption of the new technologies available*

Looking at Equation (7) we see that the strategy of blocking is dominant. That is, the workers of one sector, will be better off if they block the adoption of new technologies, independent of what the workers of the other sectors are doing (once the conditions stabilised in Proposition 3 are satisfied).

This result has a resemblance with the Prisoner's Dilemma. That is, looking at Equation (7), we can see that workers of one sector are better off if the workers of the other sectors do not block the adoption of new technologies. But, if the workers of all other sectors are not blocking then it is better for workers of one sector to block. In this case, we can also conjecture that there exists another equilibrium. You do not block if workers of the other sectors do not block. If anybody deviates, then you return to your behaviour given by Proposition 2. In the line of the Folk Theorem, an equilibrium would be that nobody blocks.

In the next proposition we show that the incentive to block reduces if the probability of arriving a new technology (σ) increases and/or the cost of blocking increases (κ). The intuition for the cost of blocking is straightforward. Higher costs implies less benefits of blocking for the same number of years working with the same technology. Therefore, the higher is the cost of blocking a new technology, the higher is the required number of years working

with the same technology to make the workers choose to block. On the other hand, if σ increases the expected income of blocking decreases, reducing the incentive to block.

Proposition 3 *If all the assumptions of Proposition 1 hold then for every sector j ,*

- (i) $n_j^* = n(\kappa, \sigma)$ *is a decreasing function of κ and σ ;*
- (ii) $d_j^* = d(\kappa)$ *is a decreasing function of κ .*

Proof. To proof this proposition we will make use of expression (8). As before, to make things easier I will drop the subscript j from n and d . If all the assumptions of Proposition 1 hold then we know that in equilibrium $U_1 - U_2$ is a positive constant. Call it D that is, $D = U_1 - U_2 > 0$

$$D = \beta^T A_0 \left[\frac{\left(\gamma^{\alpha_j a_j} \left(h(\cdot, \cdot, n) - \frac{G(1)}{\lambda_j} \right) \right)^\rho}{\rho} - \frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n))^\rho}{\rho} \right] +$$

$$\beta^{T+1} A_1 \left[\frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n+1))^\rho}{\rho} - \frac{(\gamma^{\alpha_j (a_j+1)} h(\cdot, \cdot, 0))^\rho}{\rho} \right] +$$

$$\sum_{t=2}^{\infty} \beta^{T+t} A_t \left[\frac{(\gamma^{\alpha_j a_j} h(\cdot, \cdot, n+t))^\rho}{\rho} - \frac{(\gamma^{\alpha_j (a_j+1)} h(\cdot, \cdot, t-1))^\rho}{\rho} \right] (1-\sigma)^{t-1}$$

(i) The argument used here goes in the same line of the Implicit Function Theorem. Suppose that σ increases. Looking at last part of expression (8) we see that D decreases. Therefore, to compensate this reduction n has to increase. That is, since the arriving of new technology is independent and identically distributed, if σ the workers will require a longer period of experience to with a technology to block the adoption of new technology. That is, n_j^* is increasing in σ .

Now, let us analyze the effect of variations in κ over n^* . If κ increases, then the cost of blocking increases. that is, the function $G(\cdot)$ move up. From the first part of the above expression, we see that n has to increase to compensate the cost of blocking. That is, n_j^* is increasing in κ .

(ii) the effect of a variation on κ over d^* it is similar to the effect of κ over n^* as we can see in the first brackets of the above expression. ■

The above proposition show an important relation between the speed of technological progress or the rate of arrivival of new technologies and their

adoption. If the technological progress speed up, then the workers loose their incentive to construct coalitions and to block the adoption of the new technologies available. On the other hand, the slower is the technological progress the slower is the adoption of the new technology available. In the first case, I would say that the economy is a virtuous cycle. In the second case, I would say that the economy is in a vicious cycle.

An empirical implication of our model is that we should see less resistance to adopt new technologies among sectors where the technological progress is fast. On the other hand, the resistance to adopt new technologies should be higher among sectors where the technological progress is slow or we should see an increment in the resistance to adopt new technologies as the technological progress slow down¹⁰.

4 Conclusions

In this paper we study the relation between the speed of technological progress or the rate of arrival of new technologies and the level of resistance to adopt them. Our main conclusion is that resistance (and adoption of new technologies) and the speed of technological progress are inversely related. That is, the faster is the technological progress the smaller is the resistance to adopt new technologies. The reason is that workers acquire skills specific to a technology. The longer a worker has been working with a technology, the higher is the capital specific skills acquired. In this case, the worker has incentive to resist to adopt the new technology, keeping his skill level his productivity and his income.

A slow technological progress would generate this environment. Without the arrival of a new technology the worker would keep working for a long period with old one. In this case, once a newer technology arrive the worker would resist to adopt this new technology.

On the other hand, sector where the technology advances fast, we should see less resistance, more adoption and higher growth rates.

¹⁰We have not analyzed the effect of international competition on this behavior. We should mention that this result can be effected by the existence of international trade. See Teixeira [13], Teixeira [14] and Holmes and Schmitz [2].

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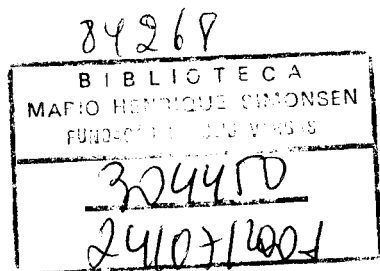
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