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Creative Destruction, Diffusion of Technology, and Differential Profit Rates : A Classical-Evolutionary Analysis

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Abstract

This paper develops an analytical microfoundation for the persistence of inter-sectoral profit rate differentials and the countervailing character of capital mobility, integrating the classical long-period method with an evolutionary framework of creative destruction and technology diffusion. The classical competition hypothesis posits that free capital mobility across sectors generates a long-run tendency toward a uniform profit rate. While this tendency has been extensively formalized in the modern classical tradition, the existing literature lacks a microfoundation linking the evolutionary dynamics of innovation to the structure of profit rate differentials.

We develop a two-sector model with heterogeneous, boundedly rational firms. Within the innovating sector, technology diffusion proceeds through differential profit rates, progressively reducing average production conditions and reducing the relative price of the capital good, thereby generating an inter-sectoral profit rate differential. The capital mobility response is structurally countervailing : adopters intensify investment in the innovating sector while non-adopters, whose returns are compressed by the price decline, exit or imitate. These opposing flows weaken the aggregate equalizing force relative to standard classical models.

Three findings follow. First, intra-sectoral diffusion generates inter-sectoral differentials even without barriers to capital mobility. Second, the mobility response is countervailing between adopter and non-adopter, rendering equalization strictly slower than the classical benchmark. Third, under continuous *innovations*, differentials are endogenously reproduced before preceding adjustments completion, so that profit rate equalization is a conditional tendency perpetually deferred by the dynamics of creative destruction.

Keywords : Bounded rationality ; Capital mobility ; Creative destruction ; Diffusion of technology ; Entry and exit ; Innovation
JEL code : B15, B51, O31, O33, Q55

1 Introduction

This paper provided an analytical microfoundation for the persistence of differential profit rates and the countervailing capital mobility, grounded in evolutionary framework of creative destruction and diffu-

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sion of technology.

The *Classical Competition Hypothesis*, originating with Smith, Ricardo, and Marx and then extending into the modern Sraffian tradition, holds that free capital mobility across sectors generates a long-run tendency for sectoral profit rates to gravitate toward a uniform profit rate. This hypothesis has been extensively formalized within long-period analysis (Sraffa, 1960 ; Kurz and Salvadori 1995). As Shaikh (2016) puts it, the mobility of capital across sectors is the movement from one terrain to another, the development and adoption of technology is the arms race, and the struggle for profit growth and market share is the battle itself. Yet the subsequent literature has shown that the conditions for uniform rates are restrictive and that differential profit rates can persist as long-period configurations under departures from this idealization (Nikaido, 1983 ; van Wegberg, 1990 ; D'Agata and Mori, 2017 ; Kurz, 2017). However, there is an explicit microfoundation remains missing from these literature which links the evolutionary dynamics of innovation to profit rate differentials. The evolutionary literature in the tradition of Nelson and Winter (1982), Metlfare (1994), and Montobbio (2002) has formalized intra-industry diffusion of technology through differential growth and selection but typically within one sector or partial equilibrium framework that does not engage with the inter-sectoral allocation problem central to classical theory. Conversely, the modern classical analysis of competition treats capital mobility as an aggregate response to sectoral differentials, abstracting from firm-level heterogeneity in techniques (Flaschel and Semmler 1987 ; Duménil and Lévy 1993 ; Boggio 1985). Shaikh (2016) offers the most systematic treatment of the intra- and inter-sector distinction within the classical tradition : within an sector, competition equalizes selling prices while disequalizing profit rates, as firms operating at different cost levels face the same market price ; across sectors, new investment gravitates toward sectors with the highest incremental returns on regulating capital, generating a turbulent equalization process characterized by a crossing-over pattern rather than monotonic convergence.

The mechanism we propose follows Shaikh's two-level analytical structure and complementary to D'Agata and Mori (2017) and Kurz (2008 ; 2017). D'Agata and Mori (2017) derive differential profit rates from heterogeneous subjective evaluation functions governing capital allocation ; Kurz (2017) examines how innovations generate temporary extra profits within a classical long-period framework. Our model derives intra-sectoral differentials from heterogeneous adoption of innovation under bounded rationality, providing a micro-level account of how diffusion of technology within a sector propagates to profit rate differentials across sectors. Firm-specific technical heterogeneity is taken as a primitive of the economy, consistent with the empirical evidence on intra-industry productivity dispersion (Dosi et al., 2010) and with the classical observation that "a whole population of firms exhibiting different efficiencies and yielding different profit rates" coexist in long-period configurations (Kurz, 2017).

Two research question organize the analysis. First, how the capital mobility associated with creative destruction and the diffusion of technology simultaneously generates a centripetal force toward profit rate equalization and centrifugal forces of differentials. Second, under what conditions one tendency dominates the other.

To address these questions, we develop a two-sector classical-evolutionary model with heterogeneous, boundedly rational firms that allocate capital across sectors. Within the innovating sector, diffu-

sion of technology proceeds through differential profit rates : adopters expand their market shares at the expense of non-adopters, progressively inducing the sectoral input coefficients. This intra-sectoral diffusion transmits to inter-sectoral capital mobility through the following mechanism. The improvement in production conditions in the innovating sector decreases the relative price, generating an inter-sectoral profit rate differential. Critically, the capital mobility response to this differential is structurally countervailing. Adopters, whose cost advantage survives the price decline, intensify investment within the innovating sector, while non-adopters, whose returns in the innovating sector are compressed by the same price fall, face a binary choice between exit to the other sector and imitation of the *innovation*. These opposing capital flows partially offset one another, weakening the aggregate equalizing force relative to the classical benchmark.

The remainder of the paper is organized as follows. Section 2 develops the basic model. Section 3 examines the capital mobility associated with creative destruction and the diffusion of technology. Section 4 concludes.

2 The model

This section establishes a two-sector classical-evolutionary model with boundedly rational heterogeneous firms. The model is organized in three layers : (i) firm-specific technique and capital-allocation decisions, (ii) sectoral aggregation through market shares into sectoral input coefficients, and (iii) the Sraffian price equations that determine prices and sectoral profit rates.

2.1 Firms, technology, and capital allocation

The economy consists of two sectors indexed $i=1,2$ and m firms indexed $h=1,2,...,m$. Sector 1 produces a capital good and Sector 2 produces a consumption good (the numéraire). Taking the wage rate w as exogenously given and under constant returns to scale, the sectoral price equations are :

$$p_1 = (1+r_1)(p_1 a_{11} + a_{21} + w l_1) \tag{2.1}$$

$$p_2 = (1+r_2)(p_1 a_{12} + a_{22} + w l_2) \tag{2.2}$$

where a_{ji} is the unit input of good j, $l_i(h)$ is the unit labour requirement, and r_i is the sectoral profit rate in sector i. We do not impose $r_1=r_2$ as a modeling identity--whether the two are equal is endogenously determined by the configuration of (a_{ji}, l_i) and w.

Assumption 2.1 (Productive Economy) The sectoral input coefficients matrix $A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$ has Frobenius root strictly less than unity, i.e., $\lambda(A)<1$.

This productivity condition guarantees that the price system admits a positive solution compatible with uniform positive profit rates.

Within the sector, firm h is a potentially cross-sectoral producer that operates in either or both sectors, $h=1,2,...,m$. Firms are heterogeneous in techniques :

$$(a_{1i}(h),a_{2i}(h),l_i(h)),a_{ji}(h)\geq 0,l_i(h)>0 \tag{2.3}$$

where $a_{ji}(h)$ is the unit input of good j and $l_i(h)$ is the unit labour requirement. Given firm-specific technique, the individual profit rate of firm h in sector i is given at prevailing prices :

$$r_i(h)=\frac{p_i}{p_1a_{1i}(h)+p_2a_{2i}(h)+wl_i(h)}-1 \tag{2.4}$$

Let $K(h)>0$ denote the total capital of firm h. Firm h allocates this capital across two sectors through the following allocation weights :

$$\theta_1(h)+\theta_2(h)=1,\theta_i(h)\in[0,1] \tag{2.5}$$

where $\theta_1(h)$ and $\theta_2(h)$ represents the shares of capital allocation in sector 1 and sector 2, respectively.

Given allocation weights and wage rate, firm h's output in sector i is determined by unit cost at prevailing prices :

$$x_i(h)=\frac{\theta_i(h)K(h)}{p_1a_{1i}(h)+p_2a_{2i}(h)+wl_i(h)} \tag{2.6}$$

Then the market share of firm h in sector i is

$$s_i(h)=\frac{x_i(h)}{x_i},\qquad \sum_{h=1}^{m}s_i(h)=1,\qquad s_i(h)\geq 0 \tag{2.7}$$

where x_i is the sectoral output.

And the sectoral input coefficients can be represented by the share-weighted aggregates of firm-level coefficients :

$$a_{ji}=\sum_{h=1}^{m}s_i(h)a_{ji}(h),i,j=1,2 \tag{2.8}$$

$$l_i=\sum_{h=1}^{m}s_i(h)l_i(h),\ \ i=1,2 \tag{2.9}$$

We connect the capital mobility to the evolutionary entry and exit by following definition and thus entry and exit are unified with capital reallocation as movements within the simplex of allocation weights (2.5).

Definition 2.1 (Entry and exit via capital allocation). The entry of firm h is defined by $\Delta\theta_i(h)>0$, that is firm h increases its capital in sector i, accompanied by $\Delta x_i(h)>0$ and $\Delta s_i(h)>0$. The exit of firm h is defined by $\Delta\theta_i(h)<0$, that is firm h decreases its capital in sector i, accompanied by $\Delta x_i(h)<0$ and $\Delta s_i(h)<0$. When $\theta_i(h)=0$, firm h directs no capital to sector i, so that $x_i(h)=0$ and $s_i(h)=0$. When $\theta_i(h)=1$, firm h is a specialized producer in sector i. For $\theta_i(h)\in(0,1)$, firm h operates in both sectors.

2.2 Selection pressure and firms' decision rules

This section introduces the operation of selection pressure on firms through the 'extra profit' and defines the principles that firms' decision rules are comparing among observables, based on their own technical conditions and the prevailing prices.

Firstly, the 'extra profit' of firm h in sector i, in the sense of Schumpeter, constitutes the carriers of selection pressure operating at the market level, independently of firms' decisions. It is defined as follows and the weighted sum of extra profits is zero.

Definition 2.2 (Extra profit). Given prevailing prices and wage rate, the 'extra profit' of firm h in sector i is defined as the deviation of its individual profit rate from the sectoral profit rate :

$$\rho_i(h) = r_i(h) - r_i \tag{2.10}$$

satisfying

$$\sum_{h=1}^{m} s_i(h)\rho_i(h) = 0 \tag{2.11}$$

Assumption 2.2 The market shares evolve following the replicator dynamics :

$$s_i^n(h) = s_i^o(h) \cdot \frac{1 + r_i(h)}{1 + r_i} \tag{2.12}$$

where $s_i^o(h)$ is the market share before adopting an *innovation*, $s_i^n(h)$ is the market share after adopting an *innovation*, and $r_i = \sum_{h=1}^{m} s_i^o(h) \cdot r_i(h)$.

The competition between firms acts as the selection mechanism represented by equation (2.12) : firms generating higher extra profits, systematically expand their market shares, whereas less profitable firms contract. Firms do not directly observe $\rho_i(h)$ nor optimize with respect to it. Instead, through the replicator-type equation (2.12), the differential extra profits are translated into the evolution of market shares. It is essential to distinguish the firm-level individual $r_i(h)$ from the sectoral profit rate r_i. Even if there is a uniform sectoral profit rate, i.e., $r_1 = r_2$, it is not necessarily to assume that individual profit rates are uniformity, i.e., $r_j(h) = r_i(h)$ for $h = 1,2, ..., m$. This enables to reconcile the determination of sectoral price equation and the persistence of firm-level dispersion. In Schumpeter (1934), extra profit is the entrepreneur's target--the prospective reward that motivates adoptive behavior. Further, in the model, we formalized the selection mechanism drive the firms without extra profit out of the market. The extra profit $\rho_i(h)$ is the measure of dispersion of techniques which is not observable to the firms.

Next, firms' decision rules follows assumptions below that introduces heterogeneity within the sector.

Assumption 2.2 (Bounded rationality). Firm h observes only (i) its own current technique ($a_{ji}(h)$, $l_i(h)$) and its potentially adoptable techniques and (ii) the prevailing prices (p_1, p_2). Firm h does not observe the individual techniques, sectoral techniques, capital allocations of other firms.

According to Assumption 2.2, firm h cannot observe the sectoral technical coefficients (a_{ji}, l_i) and thus cannot calculate the sectoral profit rates (r_1, r_2). Consequently, firm h's decisions are only formulated as comparisons that can be computed from the observable parameters. If there exists an *invention*, firm h will follows the principle as below.

Assumption 2.3 (Innovation Adoption). Firm h adopts an *invention* $(a_{ji}^n(h), l_i^n(h))$ available in sector i if and only if the *invention* yields a higher individual profit rate than the current one $(a_{ji}^o(h), l_i^o(h))$ at prevailing prices and wage rate :

$$r_i^n(h)(p_1, p_2, w) > r_i^o(h)(p_1, p_2, w) \tag{2.13}$$

Assumption 2.3 is equivalent to that firm h adopts if the *invention* reduces unit cost at (p_1, p_2, w). Note that this criterion is firm-level decision principle since it compares the new profit rate with the current profit rate.

Assumption 2.4 Firm h reinvests profits in the sectors in which they are earned, in proportion to its capital allocation weights $\theta_i(h)$. The growth rate of firm h's capital allocated to sector i is $g_i(h)=r_i(h)$.

Assumption 2.4 (Capital reallocation, entry and exit). Firm h increases its capital allocation $\theta_i(h)$ in the direction of the higher individual profit rate,

$$\Delta\theta_i(h) = \phi(r_i(h) - r_j(h)) \tag{2.14}$$

where $\frac{\partial \Delta\theta_i(h)}{\partial r_i(h)} > 0$ and $\frac{\partial \Delta\theta_i(h)}{\partial r_j(h)} < 0$. It is subject to the simplex constraint

$$\Delta\theta_i(h) \gtrless 0 \Leftrightarrow r_i(h)(p_1, p_2, w) \gtrless r_j(h)(p_1, p_2, w) \text{ and } \theta_i(h) \lesseqgtr 1 \tag{2.15}$$

Assumption 2.5 (Symmetric allocation). At the initial position, firm h allocates its capital symmetrically both sectors, that is, $\theta_1(h)=\theta_2(h)$.

Assumption 2.5 is technical. By imposing symmetric initial allocation, it ensures that all subsequent asymmetry in ($\theta_1(h)$, $\theta_2(h)$) is endogenously generated by the structural change rather than imposed as an initial condition. This contrasts with D'Agata and Mori (2017) that their model derives differential profit rates from heterogeneous subjective evaluation coefficients introduced as primitive while the model derives them from a homogeneous starting point with heterogeneity of capital reallocation arising as a consequence of diffusion of technology. Initial symmetric capital allocation at micro level does not necessarily imply $r_1=r_2$.

Example 2.1 (Exit as a corner solution) Consider firm h allocating a share $\theta_1(h) \in (0,1)$ of its activity to sector i with the remaining share $1-\theta_1(h)$ allocated to the other sector $j \neq i$. Suppose that firm h adjusts $\theta_1(h)$ according to the differential profit rates :

$$\Delta\theta_1(h) = \phi(r_1(h) - r_2(h)) \tag{2.16}$$

where $\frac{\partial \Delta\theta_1(h)}{\partial r_1(h)} > 0$ and $\frac{\partial \Delta\theta_1(h)}{\partial r_2(h)} < 0$. That is, a higher relative profitability in sector i reduces the share of capital allocated to sector i. Then, in this limiting case where the differential profit rate is persistently sustained, the corner cases $\theta_i(h)=0$ is attained, corresponding to firm h's exit from sector i.

Assumption 2.7 (Existence of a stationary market share distribution). Given wage rate, the firm-specific technical set $\mathcal{T} = \{(a_{ji}(h), l_i(h))\}_{h=1}^{m}$, and the capital $\{K(h)\}_{h=1}^{m}$, there exists a market share distribution $\{s_i^*(h)\}$ such that

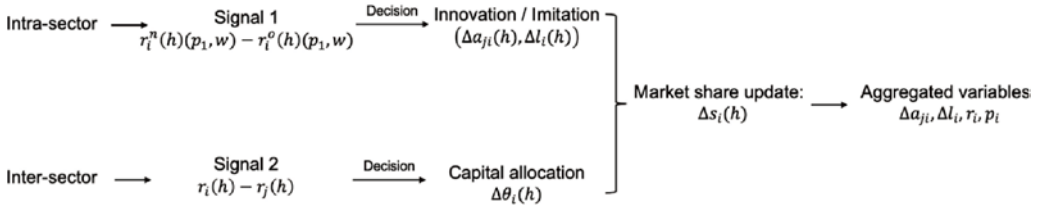
(i) For each interior firm with $\theta_i^*(h) \in (0,1)$, $r_1(h)=r_2(h)$, $i=1,2$;

(ii) For each specialized firm with $\theta_i^*(h) = 1$, $r_1(h)>r_2(h)$; and for $\theta_i^*(h) = 0$, $r_1(h)\leq r_2(h)$, $i=1,2$.

Definition 2.1 and Assumption 2.4 to 2.7 describe the firms' entry and exit through two behavioral rules (see Figure 1), which is determined by the change of market shares within sector and capital allocation across sectors. Each channel has its own observable signal, its own decision variable, and its firm-specific adjustment and eventually aggregates to sectoral outcomes. First, the intra-sectoral channel is triggered by signal 1, the difference between the new individual profit rate and the old one. When this signal is positive, firm h adopts the *invention*, realizing a change in its technique coefficients $(\Delta a_{ji}(h), \Delta l_i(h))$. This adoption decision alters the market shares of firm h in the intra-sectoral distribution without directly affecting its inter-sectoral capital allocation. Second, the inter-sectoral channel is triggered by signal 2, the difference between firm h's individual profit rates in two sectors, $r_i(h)-r_j(h)$. When this signal is non-zero, firm h adjusts its capital allocation weight $\Delta\theta_i(h)$ in the direction to the more profitable sector. This reallocation decision operates independently of whether firm h has adopted the *invention*.

The two channels converge at the market share update $\Delta s_i(h)$, which aggregates the combined effect of both decisions alongside the selection pressure of extra profits. Through this aggregation, micro-level heterogeneity in adoption and capital allocation propagates to the sectoral coefficients and ultimately determines the prevailing prices and sectoral profit rates.

Figure 1 It is illustrated two mutually independent channels at the intra- and inter-sectoral levels. Each rule operates through its own observable signals, decision-making process, and corresponding micro-level adjustments. This two decision rules remain distinct at the micro-level and ultimately aggregates structural change at sectoral-level.



3 Comparative analysis : Diffusion of Technology and Capital Mobility

Section 3 examines the effects of an *invention* in sector i by comparing three positions : (i) the long-period configuration prior to *invention* adopted, which serves as the analytical benchmark ; (ii) the post-diffusion pre-mobility position, in which intra-sectoral diffusion has changed sectoral input coefficients but inter-sectoral capital allocation remains unchanged ; and (iii) the capital mobility position, in which capital reallocation across sectors has been completed and a new LPC is established.

3.1 Benchmark : the long-period configuration

We begin the comparative analysis from a position in which no *innovation* has yet occurred. In this benchmark position, the economy has reached a state in which inter-sectoral capital mobility has been completed and the market share distribution within each sector has stabilized at the stationary distribution $\{s_i^*(h)\}$ of Assumption 2.7. This benchmark serves two analytical purposes. First, it establishes the initial conditions of all endogenous variables such as p_i^*, r^*, and $\{r_i^*(h)\}$. Second, it provides a precise characterization of the intra-sectoral heterogeneity that exists even in the absence of innovation : as Lemma 3.1 below establishes, the spectrum $\{r_i^*(h)\}$ is heterogeneous across firms, reflecting the technique dispersion of $\mathcal{T}$, even though the sectoral profit rates are equalized at r^*. This heterogeneity is a structural feature of the long-period position during competition process. We formalize this benchmark as follows.

Definition 3.1 (Long-period configuration) In the absence of *innovation*, given wage rate w and the sectoral input matrix $A=(a_{ji})$ generated by the stationary market share distribution $\{s_i^*(h)\}$ of Assumption 2.7, a long-period configuration (LPC) is a triple (p_1^*, p_2^*, r^*) with the distribution $\{r_i^*(h)\}$ such that :
(i) Sectoral profit rates are equalized, i.e., $r_1 = r_2 = r^* > 0$;
(ii) $p_i^* > 0$ together with r^* satisfies the sectoral price equations

$$p_1^* = (1+r^*)(p_1^* a_{11} + p_2^* a_{12} + w l_1) \tag{2.17}$$

$$p_2^* = (1+r^*)(p_1^* a_{21} + p_2^* a_{22} + w l_2) \tag{2.18}$$

(iii) Individual profit rate $r_i^*(h)$ is determined by the prevailing (p_1^*, p_2^*) and its own technique

$$r_i^*(h) = \frac{p_1^*}{p_1^* a_{1i}(h) + a_{2i}(h) + w l_i(h)} - 1 \tag{2.19}$$

Definition 3.1 (i) and (ii) jointly determine the triple (p_1^*, p_2^*, r^*) from the sectoral input coefficient matrix. Then condition (iii) assigns to each firm h an individual profit rate $r_i^*(h)$ computed from its owe technique and the prevailing prices (p_1^*, p_2^*). In general, the spectrum $\{r_i^*(h)\}_{h=1}^m$ are different from firms within each sector, reflecting the heterogeneous technique assumed in $\mathcal{T}$. Even though the sectoral profit rates $r_1 = r_2 = r^*$ are equalized at the long-period level, individual firms do not satisfy $r_i^*(h) = r^*$. LPC serves as the benchmark without innovation in which competition equalizes prices while generating

persistent dispersion in firm-level profit rates as firms compete for market share, thereby reproducing *competition* in the sense of Shaikh (2016) : *Competition* across sectors equalizes the prevailing prices and profit rates while *competition* within each sector generates persistent dispersion in firm-level profitability. The standard case in which all firms employ an identical technique is a degenerate special case of the LPC in which the spectrum collapses to a single point, $r_i^*(h)=r^*, h=1,2, ..., m$.

Thus, two consequences follows for Definition 3.1. First, the uniqueness established in Proposition 3.1 is conditional ; given a fixed distribution $\{s_i^*(h)\}$, the prevailing prices and sectoral profit rate is unique while the distribution itself is not. Different historical trajectories of firm-specific selection may yield different stationary distributions such that each generating a different sectoral input coefficient matrix A and hence a different LPC. Second, the LPC is the state in which firms survived prior competition process.

Proposition 3.1 (Existence and Uniqueness of LPC). Taking wage rate w given, there exist a unique long-period configuration $(p_1^*, p_2^*, r^*, \{r_i^*(h)\})$. Specifically, there exists a unique (p_1^*, p_2^*, r^*) with $p_1^*>0$ and $r^*\in(0,R)$, where $R:=\dfrac{1-\lambda(\bar{A})}{\lambda(\bar{A})}>0$ is the maximum profit rate, satisfying the sectoral price equations and the spectrum $\{r_i(h)\}$ is uniquely determined by (p_1^*, p_2^*, r^*) and the firm-specific technique set $\mathcal{T}$.

Proof. Under Assumption 2.1 and Frobenius theorem, the existence and uniqueness of (p_1^*, p_2^*, r^*) is trivial. At the LPC (p_1^*, p_2^*, r^*) with given wage rate w, each firm's individual profit rate is

$$r_i^*(h)=\frac{p_1^*}{p_1^* a_{1i}(h)+p_2^* a_{2i}(h)+w l_i(h)}-1 \tag{2.20}$$

Since (p_1^*, p_2^*, r^*) is uniquely determined and $\{a_{ji}(h), l_i(h)\}_{h=1}^m$ is given by $\mathcal{T}$, the spectrum $\{r_i(h)\}$ is uniquely determined. ■

Proposition 3.1 establishes that the LPC is analytically well-defined. The prices and sectoral profit rate of LPC are uniquely pinned down by the sectoral input coefficient matrix A while the spectrum $\{r_i^*(h)\}$ is determined residually by firms' heterogeneous techniques evaluated at the prevailing prices. Although the existence and uniqueness of the spectrum follow directly from this result, the internal structure of the spectrum--specifically, the extent of its dispersion and the geometry of its dispersion around r^*--remains to be characterized. Because according to equation (2.20), the individual profit rate is a strictly decreasing and strictly convex function of unit cost, symmetric deviations in unit cost around a reference point map generate asymmetric deviations in profit rates : the absolute gain enjoyed by a lower-cost firm exceeds the absolute loss incurred by a higher-cost firm. Lemma 3.1 formalizes this asymmetry and derives the spread of the spectrum as a function of the range of unit costs induced by the technical se $\mathcal{T}$.

Lemma 3.1 At the LPC of Proposition 3.1, define the unit cost of firm h in sector i as

$c_i(h) := p_1^* a_{1i}(h) + p_2^* a_{2i}(h) + w l_i(h)$. Let c_i^{min} and c_i^{max} denote the minimum and maximum unit costs across firms in sector i. Then

(i) The spread of the spectrum of individual profit rates is

$$r_i^{max} - r_i^{min} = c_i^{max} - c_i^{min} = p_1^* \frac{c_i^{max} - c_i^{min}}{c_i^{max} c_i^{min}} > 0 \tag{2.21}$$

where $r_i^{max} := r_i(c_i^{min})$ and $r_i^{min} := r_i(c_i^{max})$.

(ii) For any reference cost c and any $\varepsilon > 0$ such that $[c-\varepsilon, c+\varepsilon] \subset [c_i^{min}, c_i^{max}]$, the spectrum of individual techniques is therefore asymmetric, wider on the high profit side.

Proof. (i) is trivial. (ii) Since $r_i(c) = \frac{p_i^*}{c} - 1$ is strictly convex, i.e., $\frac{d^2 r_i}{dc^2} = 2\frac{p_i^*}{c^3} > 0$, the equal deviations $\pm\varepsilon$ around reference cost c generate unequal deviations around reference profit rates because $c_i^{max} \geq c + \varepsilon > c - \varepsilon \geq c_i^{min}$ implies $c(c+\varepsilon > c(c-\varepsilon)$ and hence

$$r_i(c-\varepsilon) - r_i(c) = \frac{p_i^* \varepsilon}{c(c-\varepsilon)} > \frac{p_i^* \varepsilon}{c(c+\varepsilon)} = r_i(c) - r_i(c+\varepsilon) \tag{2.22}$$

Consequently, for any symmetric cost distribution around a reference cost, the corresponding distribution of individual profit rate is right-skewed, that is, dispersion is on the side of higher profit rate (see Figure 2). ■

3.2 Intra-sectoral diffusion of technology

Definition 3.2 An *invention* in sector i is a pair (a_{j1}^n, l_1^n) with $a_{j1}^n \geq 0$ and $l_1^n > 0$, which has been con-

Figure 2 The (p_1^*, r^*) of LPC is illustrated by plotting in p-r plane (p_2^*, r^*). Line a and b represent the sectoral technique in each sector. The two lines intersect at the point (p_1^*, r^*) of LPC. The shaded area represents the range of the corresponding spectrum of individual profit rates. The part below Line a possess the higher profit rate while the part above Line b possess the lower profit rate.

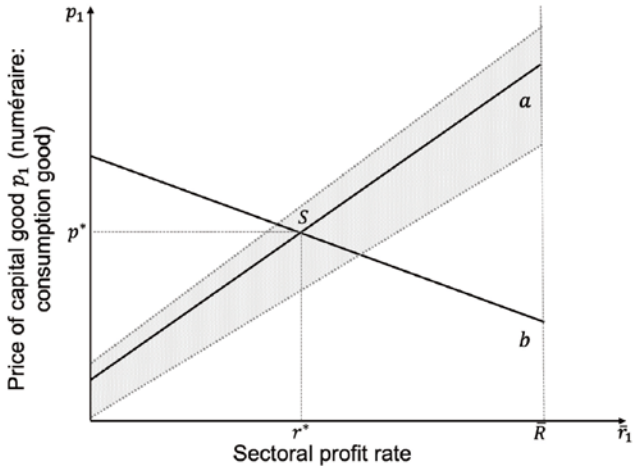
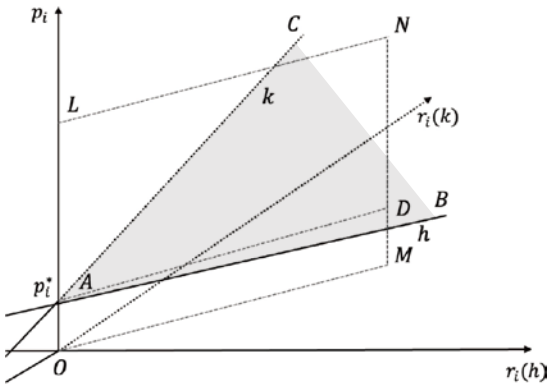


Figure 3 **The spectrum $\{r_i^*(h), r_i^*(k)\}$ of LPC within one sector is illustrated by plotting in a $(p_i, r_i(h), r_k(k))$ three-dimension space (assumed there are only two firms, h and k). Line h and k represent two techniques used by two firms. The plane ABC with shadow contains all combinations of price and different profit rates $\{r_i^*(h), r_i^*(k)\}$. The plane $OMNL$ contains the combinations of uniform profit rates $(r_i^*(h)=r_i^*(k))$. The line AD of intersection of the plane ABC and the plane $OMNL$ represents the combinations of price and uniform profit rate.**



ceived, technically available and distinctinguish from any technique currently in use by firms.

Definition 3.3 An *innovation* is an invention that has been actually adopted by at least one firm. Firms' decision of adoption follows Assumption 2.4.

Assumption 3.1 (Non-rivalrous availability) Once an *invention* is invented, it is non-rivalrous available to all firms, that is, each firm in sector i can employ the same *invention* at no cost.

Definition 3.4 (Adoption response). Let an *innovation* (a_{ji}^n, l_i^n) be available in sector i at prevailing price (p_1^*, p_2^*) and wage rate w. For each firm h, let r_i^n denote the profit rate of *innovation* and let $r_i^o(h)$ denote its current individual profit rate. The set of firms $\{1, 2, ..., m\}$ in sector i is partitioned into three pairwise disjoint subsets according to their adoption decisions :

(i) The adopter set $\mathcal{A} \subseteq \{1,2,\ldots,m\}$ comprises firms for which adoption strictly increases their individual profit rates, that is, $h \in \mathcal{A} \Leftrightarrow r_i^n > r_i^o(h)$;

(ii) The inertial non-adopter set $\mathcal{I}^{in} \subseteq \{1,2,\ldots,m\} \setminus \mathcal{A}$ comprises firms for which the adopted technique is economically viable yet fails to improve upon the firms' own current profit rate, that is, $h \in \mathcal{I}^{in} \Leftrightarrow r_i^o > r_i^n > r^*$, so-called *incumbent inertia* ;

(iii) The infeasible non-adopter set $\mathcal{I}^{inf} \subseteq \{1,2,\ldots,m\} \setminus \mathcal{A}$ comprises firms for which adoption would reduce the individual profit rate below the sectoral benchmark, that is, $h \in \mathcal{I}^{inf} \Leftrightarrow r^* > r_i^n$.

The three subsets satisfy $\mathcal{A} \cup \mathcal{I}^{in} \cup \mathcal{I}^{inf} = \{1,2,\ldots,m\}$ and the non-adopter set is defined as $\mathcal{I} := \mathcal{I}^{in} \cup \mathcal{I}^{inf}$ denotes.

According to Definition 3.4, Adopters $h \in \mathcal{A}$ implement the *innovation* to improve individual profit

rates, which is the bounded rational adoption criterion derived from Assumption 2.2 and 2.3. The firms of inertial non-adopters are those whose current techniques yields an individual profit rates exceeding the post-adoption rate. The innovation is socially viable—it raises profit rates for average-below firms and satisfies viable condition $r_i^n \geq r^*$. However, it is not privately advantageous for incumbents operating above a sufficient efficiency threshold, so-called 'incumbent advantage' phenomenon : technologically leading firms systematically face a higher adoption threshold, since any potential *invention* must improve upon a superior baseline. For those firms of infeasible non-adopters $\mathcal{I}^{inf}$, the distance between the current technique and the *innovation* is sufficiently large that the potential *invention* cannot sustain a profit rate at the prevailing prices.

Definition 3.5 (Firm-specific implementation). Let $h \in \mathcal{A}$ adopt an *innovation* (a_{ji}^n, l_i^n) in sector i. The realized technique of firm h is

$$(a_{ji}^n(h), l_i^n(h)) = \alpha(h) \cdot (a_{ji}^0, l_i^0) + (1-\alpha(h)) \cdot (a_{ji}^n, l_i^n) \tag{2.22}$$

Where the absorption coefficient $\alpha(h) \in [0,1]$ is firm-specific and exogenously given. It parameterizes heterogeneity in absorptive capacity which derives from organizational routines, complementary asset structures, and accumulated expertise of a firm (Cohen & Levinthal 1990). In the technological space, this coefficient is typically influenced by the distance between firm h's current technique and the *innovation* : firms whose techniques are technologically closer to the *innovation* can implement it more completely while firms with more distant technique achieve only partial absorption. If $\alpha(h)=1$, firm h completely absorbs the *innovation* so that its realized technique coincides with the *innovation*. When $\alpha(h)=0$, no absorption occurs and the firm retains its old technique entirely. For intermediate values $\alpha(h) \in (0,1)$, the *innovation* is a convex combination of the firm's old technique and the *innovation*.

Now we start to analysis the consequences of a single *innovation* through the long-period method. Intra-sectoral diffusion of technology is characterized at the prevailing LPC, establishing the conditions under which the adopter set $\mathcal{A}$ is non-empty and deriving the implied change in sectoral input coefficients.

Proposition 3.2 (Partial diffusion) Let the economy be at the long-period configuration $(p_1^*, r^*, \{r_i^*(h)\})$ with $r_1^o = r_2^o = r^*$, wage rate w fixed. Suppose an *invention* (a_{ji}^n, l_i^n) in sector i becomes an *innovation* if the adopter set $\mathcal{A}$ is non-empty. Then

(i) Each firm earns strictly positive extra profit and each non-adopter earns non-positive extra profit, that is, $\rho_i(h) > 0 \forall h \in \mathcal{A}$ and $\rho_i(h) \leq 0 \forall h \in \mathcal{I}$;

(ii) $a_{ji}^n \leq a_{ji}^o$, $l_i^n \leq l_i^o$ hold with at least one strict inequality and $\theta_i(h)$ is fixed ;

(iii) Inter-sectoral profit rates differential, that is, $r_i^n > r_j^o = r^*, j \neq i$.

Proof. (i) can be obtained directly from the Definition 3.4. (ii) By Assumption 2.6, the market share of firm h in sector i evolves following equation (2.12) such that $s_i^n(h) > s_i^o(h)$ if and only if $r_i^n(h) > r_i^o(h)$. Then adoption must shift the weighted sectoral input coefficients toward lower unit costs. Hence it is easily obtained that $a_{ji}^n \leq a_{ji}^o$, $l_i^n \leq l_i^o$ hold with at least one strict inequality. No firm enters or exits sec-

tor he sectoral coefficients of sector j, $j \neq i$ remain unchanged and thus $\theta_i(h)$ fixed. (iii) Substituting a_{ji}^n and l_i^n into price equations such that $(1+r_i^n) = \dfrac{p_i^*}{p_1^* a_{1i}^n + p_2^* a_{2i}^n + w l_i^n}$, by (ii), the denominator $p_1^* a_{1i}^n + p_2^* a_{2i}^n + w l_i^n < p_1^* a_{1i}^o + p_2^* a_{2i}^o + w l_i^o$, so $1+r_i^n > 1+r^* = 1+r_j^n$, i.e., $r_i^n > r_j^o = r^*, j \neq i$. ■

Proposition 3.2 illustrates the channel of diffusion of technology to intra-sectoral differential profit rates. The inter-sectoral differential profit rates in (iii) does not arise from the extra profits of adopters directly. Extra profits are intra-sectoral signals that does not carry direct implication for r_i instead govern the replicator dynamics in Equation 2.12 and its aggregate is zero in the capital-weighted sense (Haas, 2015, eq.12). The operating channel is : $\rho_i(h) > 0 \Rightarrow s_i^n(h) \uparrow$ for $h \in \mathcal{A} \Rightarrow a_{ji}^n \leq a_{ji}^o$, $l_i^n \leq l_i^o \Rightarrow r_i^n \uparrow$. The price p_i remains anchored at p_i^* because inter-sectoral capital allocation $\theta_i(h)$ is held fixed : no change in relative sectoral capacities occurs and hence no relative price adjustment is triggered.

The preceding proposition established that generates a strictly positive inter-sectoral profit rate differentials $r_i^n > r_j^o = r^*$ while inter-sectoral capital allocation remains fixed. We now examine how this differential triggers capital mobility. The response is structurally countervailing—adopters and non-adopters, observing different signals, move capital in opposite directions. For adopters, whose realized the *innovation* yields a sufficiently low unit cost, the compression of $r_1(h)$ is more than offset by the cost advantage of the *innovation*, so that $r_1(h) > r_2(h)$ is preserved. For non-adopters, operating on the incumbent technique with no such buffer, the price decline reverses the inter-sectoral capital mobility. Proposition 3.3 characterizes the first-order adopter-lead capital mobility. Lemma 3.2 establishes the price-sensitivity of individual profit rates required for Proposition 3.4 which drives the non-adopter reversal. Proposition 3.4 formalizes the second-order reversal and characterizes the resulting aggregate flow.

Proposition 3.3 (Adopter-lead capital mobility) Under the conditions of Proposition 3.2, with prevailing prices still at $(p_1^*, p_2^*, r^*, \{r_i^*(h)\})$ immediately following inter-sectoral diffusion :
(i) Each firm $h \in \mathcal{A}$ satisfies $r_i^n(h) > r_i^o(h), i \neq j$ and therefore, by Assumption 2.4, increases its capital allocation toward sector i, i.e., $\Delta\theta_i(h) > 0 \forall h \in \mathcal{A}$; the aggregate adopter capital flow into sector i is strictly positive, i.e., $\sum_{h \in \mathcal{A}} \Delta\theta_i(h) K(h) > 0$;
(ii) Each firm $h \in \mathcal{I}$, observing no change in its individual profit rates, does not reallocate, i.e., $\Delta\theta_j(h) = 0 \forall h \in \mathcal{I}$.

Proof. (i) By Assumption 5, it implies that $r_i^o(h) = r_j^o(h)$ for each interior firm. By Proposition 3.2 (i), each adopter satisfies $r_i^n(h) > r_i^o(h)$. Since prices remain unchanged and sector j has not been unaffected by the *innovation* yet, so $r_j^o(h) = r_i^o(h)$. Therefore $r_i^n(h) > r_j^o(h) = r_i^o(h)$ and Assumption 2.4 yields $\Delta\theta_i(h) > 0$ for $h \in \mathcal{A}$. Since $\mathcal{A}$ is non-empty and each $K(h) > 0$, the aggregate capital $\sum_{h \in \mathcal{A}} \Delta\theta_i(h) K(h) > 0$. (ii) Since each firm $h \in \mathcal{I}$ does not adopt, its technique remains unchanged and thus its individual $r_i^o(h)$ and $r_j^o(h)$ are both unchanged. By Assumption 2.4, $\Delta\theta_j(h) = \phi(r_i^o(h) - r_j^o(h)) = \phi(0) = 0$. ■

In the first-order flow, the initiation of inter-sectoral mobility does not require firms to observe the

sectoral differential $r_i^n(h) = r_j^n(h)$. Under Assumption 2.2, adopters respond exclusively to the comparison of their own individual profit rates $r_i^n(h)$ and $= r_j^n(h)$, both of which are computable from the prevailing prices and own techniques. Non-adopters who faces unchanged prevailing prices and unchanged own techniques, observe no signal and thus do not reallocate their capital. This implies that the first-order capital flow is driven entirely by the subset $\mathcal{A}$, whose aggregate capital weight determines the magnitude of the first-order reallocation.

Lemma 3.2 At any positive (p_i, p_j), the individual profit rate $r_i(h)$ satisfies $\frac{\partial r_i(h)}{\partial p_i} > 0$ and $\frac{\partial r_j(h)}{\partial p_j} < 0$.

Proof. Differentiating $r_i(h) = \frac{p_i}{c_i(h)} - 1$ with respective to p_i obtains $\frac{\partial r_i(h)}{\partial p_i} = \frac{a_{2i}(h) + wl_i(h)}{(c_i(h))^2}$ where $c_i(h) := p_1 a_{1i}(h) + p_2 a_{2i}(h) + wl_i(h)$. Since $a_{2i}(h) \geq 0$, $w \geq 0$, and $l_i(h) > 0$, the numerator $a_{2i}(h) + wl_i(h) > 0$. Hence $\frac{\partial r_i(h)}{\partial p_i} > 0$. Differentiating $r_j(h) = \frac{p_j}{c_j(h)} - 1$ where $c_j(h) := p_1 a_{1j}(h) + p_2 a_{2j}(h) + wl_j(h)$ with respective to p_j obtains $\frac{\partial r_j(h)}{\partial p_j} = -\frac{a_{1j}(h)}{(c_j(h))^2}$. Since $a_{1j} \geq 0$ and strict positivity holds, the derivative is strictly negative. ■

The two signs of Lemma 3.2 reflect the asymmetric role of p_i in both sectors. In sector i, p_i enters both as the revenue per unit output and as the unit cost of capital good input. A rise in p_i raises the value of each output more than it raises unit cost because not all cost of sector 1 is incurred in its own output--the wage component $wl_i(h)$ of sector i and the component $a_{ji}(h)$ of sector j are independent of p_i. Thus, the revenue effect strictly dominates in sector i. In sector j, p_i enters only through the cost $a_{ji}(h)$. Since sector j produces the numéraire, there is no offsetting revenue effect. A fall in p_i therefore unambiguously benefits sector j produces by reducing their input costs and raising $r_j(h)$.

Proposition 3.4 (Non-adopter reversal). Given wage rate w fixed. Following Proposition 3.3, there exists a new LPC $(p_1^{**}, r^{**}, \{r_i^{**}(h)\})$ such that the relative prices adjusts downward from p_1^* toward p_1^{**} with $r^{**} > r^*$. And then

(i) Each firm $h \in \mathcal{I}$, $\Delta\theta_i(h) < 0 \forall h \in \mathcal{I}$, $\sum_{h \in \mathcal{I}} \Delta\theta_i(h) K(h) < 0$;

(ii) The capital mobility into sector i decomposes into two opposing components,

$$\sum_{h=1}^{m} \Delta\theta_i(h) K(h) = \underbrace{\sum_{h \in \mathcal{A}} \Delta\theta_i(h) K(h)}_{>0} + \underbrace{\sum_{h \in \mathcal{I}} \Delta\theta_i(h) K(h)}_{<0} \tag{2.23}$$

whose sign depends on the relative size and capital weight of $\mathcal{A}$ and $\mathcal{T}$.

Proof. (i) By Lemma 3.1, $\Delta p_i^* < 0$ implies $\Delta r_i(h) < 0$ and $\Delta r_j(h) < 0$ for $h \in \mathcal{I}$. Therefore, by Assumption 2.4, a reversal is generated by $r_i(h) < r_j(h)$ such that $\Delta\theta_j(h) = \phi(r_i^o(h) - r_j^o(h)) < 0$. (ii) The decomposition directly derives from Definition 3.4. ■

The price decline ($p_i \downarrow$) acts on adopters and non-adopters. For adopters $h \in \mathcal{A}$, the *innovation* yields a unit cost strictly below the incumbent technique and provides the price decline is not so large as to eliminate the cost advantage entirely such that $r_1^n(h) > r_1^o(h) = r_2(h)$ their capital allocation remains directed toward sector i. For non-adopters $h \in \mathcal{I}$, who operates on the incumbent technique without such cost buffer, cannot maintain such profit rate differentials and therefore lead to the two-sided movement. That is, by Lemma 3.1, the price decline ($p_i \downarrow$) simultaneously compresses $r_i(h)$ (revenue effect in sector i) and raises $r_j(h)$ (cost-reduction effect in sector j) for $h \in \mathcal{I}$. It is the two-sided movement that drives $r_i(h) - r_j(h)$ from zero to strictly negative, triggering the outflow of Proposition 3.4 (i). The diffusion of the *innovation* operates as a selection buffer : although adopters induce the price decline through their own expansion, the resulting erosion of profitability falls disproportionately on non-adopters, whose higher unit costs leave them more exposed to competitive pressure.

And then non-adopters facing $r_i(h) < r_j(h)$ confront two responses under Assumption 2.3 and 2.4. On the one hand, firm h reallocates capital out of sector i and contract its capacity and thereby raising the market share of adopters. On the other hand, firm h adopts the *innovation* and transferring from $\mathcal{I}$ to $\mathcal{A}$ retaining $\theta_i(h)$. In both cases, the market share operating the *innovation* rises. And then diffusion is reinforced through the intra-sectoral imitation, which directly reduces sectoral input coefficients and the inter-sectoral exit, which reallocates surviving capacity toward lower-cost adopters.

It is implied that since the aggregate capital flow into the innovating sector i is the sum of two opposing flows, the net flow is strictly smaller than the gross flow from $\mathcal{A}$ alone, and smaller than the aggregate inflow that would be predicted by the model in which all firms respond uniformly to the sectoral difference $r_1 - r_2$. Consequently, the equalization between inter-sectoral profit rates is thus weaken by the opposing capital mobility of non-adopters. The closure of the differential $r_1 - r_2$ is retarded and convergence to a new LPC with uniform profit rates takes correspondingly longer, relative to the standard classical benchmark.

We now extend the analysis to an economy in which innovations arrive continuously. The preceding subsections examined a single *innovation* diffusing to completion. We here drop that the presumption of completion and examine what configuration the economy displays when *invention*s arrive before prior adjustments have closed. We do not track a trajectory but compare configurations associated with different conditions.

Definition 3.6 Let τ_I denote the inter-arrival time between successive *innovation*s and $\tau_M < \infty$ denote the finite interval required for capital mobility to drive the economy from the initial LPC $(p_1^*, r^*, \{r_i^*(h)\})$ to the new $(p_1^{**}, r^{**}, \{r_i^{**}(h)\})$ following a single completed innovation episode.

Proposition 3.5 Suppose successive innovations generate non-empty adopter sets and satisfy $\tau_I < \tau_M$. Then no admissible configuration of the economy is characterized by uniform sectoral profit rate : in each LPC, $\overline{r}_1 > \overline{r}_2$. The adopter set $\mathcal{A}$ remains perpetually non-empty and the partition $\{\mathcal{A}, \mathcal{I}\}$ never collapses into a homogeneous sectoral configuration.

Proof. Under Assumption 3.2, a single innovation episode requires an interval τ_M to complete the adjustment restoring $r_i=r_j$. Now consider a subsequent innovation arriving after an interval $\tau_I<\tau_M$. At the moment of arrival, the preceding adjustment remains incomplete by construction. Hence the standing differential generated by the previous episode has not yet been eliminated, that is, $r_i-r_j>0$. The new innovation then generates an additional differential before the previous one has closed. Since every new episode arrives prior to the completion of the preceding adjustment, no admissible comparison-sate belongs to the uniform profit subset. Consequently, the adopter set is continuously renewed and the equalizing movement generated by the capital mobility process is continuously interrupted by newly emerging innovation differentials.■

Proposition 3.5 illustrates a structural duality generated by the opposite movements. At the intra-sectoral level, diffusion of technology operates as a centripetal mechanism : The competitive process induces the progressive adoption of the *innovation* narrowing the dispersion of individual profit rates around the current LPC. However, at the inter-sectoral level, the same diffusion process operates as a centrifugal mechanism : reducing the sectoral input coefficients, it raises r_i relative to r_j and thereby generates the differential that capital mobility tends to close. These two tendencies are two expressions of competitive process viewed at different levels of aggregation. Under continuous *innovation*s satisfying $\tau_I<\tau_M$, neither movement reaches completion : intra-sectoral dispersion is repeatedly generated by successive technical differentiations while the inter-sectoral differential is continuously regenerated before the preceding adjustment closes. The competitive process is therefore characterized as a force of convergence within sectors and as a force of divergence between sectors.

4 Conclusions

This paper has developed a classical-evolutionary model to analyze the conditions under which sectoral profit rates equalize and the conditions under which they persistently diverge. The central result is a structural asymmetry between two levels of competitive dynamics. Within the innovating sector, diffusion of technology is convergent. As the *innovation* propagates, the dispersion of individual profit rates narrows toward the new LPC. Across sectors, the same diffusion process is divergent. By transforming the sectoral input coefficients of innovating sector, it generates the inter-sectoral differential profit rates that capital mobility fails to close. Thus, the persistence of profit rate differentials is the reinforced consequence of intra-sectoral dispersion that closes as diffusion completes and inter-sectoral differential sustained by capital mobility. Three principal findings follow.

First, the tendency for inter-sectoral profit rates to equalize is conditional. Since equalization proceeds exclusively through capital mobility, it is inherently a temporal process that depends on the completion of both intra-sectoral diffusion and inter-sectoral reallocation. During the competition process, inter-sectoral profit rate differentials remain operative and continue to guide capital movements. Shaikh's (2016) conception of turbulent equalization characterizes the regulating rate as a center of gravity around which actual profit rates fluctuate, rather than a magnitude continuously realized in observed

outcomes. We extend this insight that creative destruction and diffusion of technology, which narrow the intra-sectoral dispersion and reinforces inter-sectoral differentials, reconstitute the competitive processes towards the center of gravity. Therefore, the equalization of profit rates exists only as a tendency in a double sense--it is neither instantaneously realized nor directed toward the stationary state.

Second, with a single *innovation*, capital mobility generates structurally countervailing responses across the adopters and non-adopters. Adopters, who realized technique yields a cost advantage, intensify investment in the innovating sector. Non-adopters respond in the opposite direction that inducing capital outflow since adopters capital expands the capacity and depresses its relative price such that non-adopters' extra profit is compressed in innovating sector. The two flows partially offset each other so that the aggregate flow into the innovating sector is weaker than that in the classical benchmark.

Third, when *innovation*s occur at intervals shorter than the time required for capital mobility, the equalization of profit rates becomes systematically incomplete. Because the equalizing flow is already weakened by the adopter and non-adopter countervailing, the adjustment triggered by one *innovation* is liable to be interrupted by the arrival of the next. The observed differential is therefore not the residue of a single unfinished adjustment but the cumulative outcome of multiple overlapping adjustment processes.

Several limitations bound these conclusions. The analysis proceeds in comparative statics and therefore the persistence results should be considered as a statement between two processes instead of a tracked trajectory. The distribution of market shares underlying the benchmark is postulated rather than derived from a selection process or replicator dynamics equation, so that the firm-specific distribution remains path-dependent across multiple possible configurations. The firm-specific absorption coefficient is treated as exogenously given, leaving the determinants of absorptive capacity--organizational routines, accumulated expertise, and technological distance—outside the model. The analysis points to several directions for future research : (i) integrating imitation as an explicit dynamic process ; (ii) in the tradition of Cohen and Levinthal (1990), endogenizing the absorption coefficient by linking firm-specific implementation to observable measures of technological distance ; and (iii) empirically investigating countervailing capital flows in industries with heterogeneous adoption rates.

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