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RESUMO/ABSTRACT

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JEL Code: O4 - Economic Growth and Aggregate Productivity.
Keywords: Productivity Growth; Economic Fluctuations.

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Abstract

We analyze the productivity effects of shocks to the real interest rate and to demand and supply conditions in a world where productivity enhancing activities are disruptive. The model predicts that temporary demand downturns may have positive productivity effects if the real interest rate is not too countercyclical, and that supply shocks do not affect productivity growth. The model is used to derive refined novel empirical tests on the so-called Opportunity Cost View of recessions (Aghion and Saint-Paul (1998)) vis à vis the competing theories of learning-by-doing and capital market imperfections.

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1 Introduction

Recently, several papers in the endogenous growth literature have studied the effects of cyclical shocks on productivity growth. However, there is little empirical evidence on the matter (Aghion and Howitt (1998, Ch. 8)). This may owe to the difficulty of testing the existing competing theories. While, on the one hand, there are theories that predict that temporary demand downturns have deleterious effects on productivity growth, such as learning-by-doing (Staedler (1990)) and capital market imperfections (Stiglitz (1993)), on the other hand, theories in the spirit of the so-called Opportunity Cost View (Aghion and Saint-Paul (1998)) argue that temporary demand downturns have positive effects on productivity, since during the downturns the opportunity cost in terms of foregone output and profits of engaging in disruptive productivity enhancing activities is low, and therefore firms invest relatively more in such activities, which may include job reallocation, managerial reorganizations and training. Clearly, all the above mentioned theories are well rooted, and, thus, the effects of cyclical shocks on productivity growth is, to be pragmatic, an empirical question, which, in turn, calls for careful empirical work, with close guidance from theory.

By extending the work of Aghion and Saint-Paul (1998), we provide a novel set of theoretical results that can be used to narrowly assess the empirical importance of the Opportunity Cost View of downturns vis-à-vis the competing theories of learning-by-doing and capital market imperfections. In particular, we solve a model where firms invest in disruptive productivity enhancing activities and face shocks not only to demand conditions but also to supply conditions and to the real interest rate. We find that: (i) temporary demand downturns have positive effects on productivity growth if the real interest rate is not too countercyclical and (ii) supply shocks do not have effects on productivity growth. Both results are meaningful, at an empirical level, since they are useful in setting up empirical tests on the above mentioned competing theories. In particular, from result (i) we can study the joint behavior of shocks to demand conditions and to the real interest to test the unambiguous prediction that under the Opportunity Cost View productivity growth is stronger after temporary contractionary demand shocks associated with decreases in the real interest rate than after those associated with increases in the real interest rate. In addition, under the Opportunity Cost View, and by result (ii), supply shocks do not matter for productivity growth, unlike what is predicted by the competing theories of learning-by-doing and capital market imperfections, which are silent with respect to the nature of the shocks. Hence, this result provides one extra dimension to test these competing theories, and, concomitantly, to improve on the evidence gathered by, among others, Gali and Hammour (1992) and Saint-Paul (1993).

This paper is organized as follows. Section 2 solves a highly stylized model that extends Aghion and Saint-Paul (1998). Section 3 concludes.

2 The Model

The Goods Market and the Firm's Problem We consider an open economy that produces a variety of export goods indexed by i and consumes a homogeneous imported good. Demand for home good i, D_{it}, is a function of an index of nominal world demand, y_t, an aggregate price index for home goods, p_t, and good i's price, p_{it} and is written as:

$$D_{it} = (y_t/p_t) * (p_{it}/p_t)^{-\eta} \tag{1}$$

The aggregate price index for home goods is given by:

$$p_t = (\int_0^{N_t} p_{it}^{1-\eta} di)^{1/(1-\eta)} \tag{2}$$

where N_t is the number of varieties produced at home, and $\eta > 1$ is assumed.

Each home good i is produced by a monopolistic competitor of fixed size, characterized by its productivity level, x_{it}, which increases at rate $v_{it} \equiv \frac{dx_{it}}{dt}$: a choice variable involving a trade-off between a current cost and a higher future net present value of the firm. More specifically, to increase productivity by v_{it}, firm i must sacrifice a fraction $k(v_{it})$ of its current output, with $k^{'} \geq 0$, $k^{''} > 0$, and $k(0) = 0$. Let $\phi_{it} \equiv (1 - k(v_{it}))$ be the share of firm i's output not sacrificed by the implementation of the disruptive productivity enhancing activities. Hence, firm i's net output, z_{it}, reads:

$$z_{it} = e^{x_{it}} e_{it}^{\xi_i} \phi_{it}$$

where e_{it} is the level of an input, and ξ_i is a firm specific parameter between 0 and 1. The firm chooses e so as to maximize nominal profits π_{it}:[1]

$$\pi_{it} = p_{it} e^{x_{it}} e_{it}^{\xi_i} \phi_{it} - p_{et} e_{it}$$

where p_{it} is the exogenous price of the input e. In equilibrium, the marginal revenue product of the input equals its price and the goods markets clear. After imposing the goods market clearing condition ($z_{it} = D_{it}$), we determine the optimal e_{it}, e^*_{it}:

$$e^*_{it} = y_t^{1/a_i} p_t^{(\eta-1)/a_i} p_{et}^{-\eta/a_i} e^{x_{it}(\eta-1)/a_i} \phi_{it}^{(\eta-1)/a_i} b_i^{\eta/a_i}$$

where $a_i \equiv \eta(1-\xi_i) + \xi_i$, and $b_i \equiv \xi_i(\eta-1)/\eta$. We now evaluate nominal profits at the optimal input level, π^*_{it}:

$$\pi^*_{it} = p_{e_t}^{\frac{(a_i-\eta)}{a_i}} y_t^{\frac{1}{a_i}} p_t^{\frac{(\eta-1)}{a_i}} e^{x_{it}\frac{(\eta-1)}{a_i}} \phi_{it}^{\frac{(\eta-1)}{a_i}} (\eta - a_i)^{\frac{(\eta-a_i)}{a_i}} \frac{a_i}{\eta}$$

The optimal investment rate in productivity enhancing activities, v, solves the following recursive expression:

$$V_t[x_{it}] = \pi^*_{it} dt + (1 - rdt) E_t V_{t+dt}[x_{it} + v_{it} dt] \tag{3}$$

where $V_t[x_{it}]$ is the current value of the firm. The first-order condition for v is given by:

$$\tfrac{\eta-1}{a_i} \pi^*_{it} h(v_{it}) = E_t \frac{\partial V_{t+dt}}{\partial x_{it}} \tag{4}$$

where $h(.)$ is defined as $(k'/(1-k))$, or the absolute percentage change in the share of output that survives to a marginal productivity enhancing activity. Finally, we obtain an expression for the RHS of (4) by differentiating (3) with respect to x_{it}:

$$\frac{\partial V_t}{\partial x_{it}} = \tfrac{\eta-1}{a_i} \pi^*_{it} dt + (1 - rdt) E_t \frac{\partial V_{t+dt}}{\partial x_{it}} \tag{5}$$

Entry and Exit To close the model, we follow Aghion and Saint-Paul (1998) and assume that the liquidation value of exiting firms is given by $\theta C e^{\beta x_{it}} e^{-\beta x_t}$, where C is the entry cost, θ is a parameter between 0 and 1, β is a free parameter, and x_t is the average level of productivity. This ensures that entry and exit decisions do not influence the decision on v.

Goods Market Equilibrium We focus on the symmetric equilibrium where $v_{it} = v_t$, $x_{it} = x_t$, and $\phi_{it} = \phi_t$. From (2), (1), and the goods market clearing condition ($z_{it} = D_{it}$), we obtain:

$$p_t = y_t N_t^{-\eta/(\eta-1)} e^{-x_t} e_{it}^{-\gamma_i} \phi_t^{-1} \tag{6}$$

$$p_{it} = y_t e^{-x_t} e_{it}^{-\gamma_i} / (N_t \phi_t) \tag{7}$$

We use (6) and (7) to rewrite optimal purchases of the input, e^*_{it}, and nominal profits, π^*_{it}:

$$e^*_{it} = b_i y_t / (p_{et} N_t) \tag{8}$$

$$\pi^*_{it} = \frac{a_i}{\eta} \frac{y_t}{N_t} \tag{9}$$

[1] Supply shocks are shocks to the price of the input, p_{et}. We obtain the same results if we introduce supply shocks as exogenous productivity shocks to the net production function:

$$z_{it} = e^{x_{it}} e^{\lambda_{it}} \phi_{it}$$

where λ_{it} is the productivity shock.

Steady State In the steady state, profits, the number of firms, and the marginal value to the firm of an increase in x, $\frac{\partial V}{\partial x}$, are all constant. Using (5) and (9) we obtain an expression for $\frac{\partial V}{\partial x}$:

$$\frac{\partial V}{\partial x} = \frac{\eta - 1}{a}\frac{y}{rN} \tag{10}$$

Equations (4) and (10) determine the steady state value of v as follows:

$$rh(v) = 1 \tag{11}$$

To close the model, we assume that the economy is always on the margin of entry, i.e., $V = C$, which translates into the following free entry condition (using (3)):

$$\pi^* = rC \tag{12}$$

Finally, we use (9) and (12) to determine the number of firms in steady state (N):

$$N = \frac{a}{\eta}\frac{y}{rC} \tag{13}$$

Economic Fluctuations The economy can be in one of two regimes: in expansion, E, with (y^E, r^E, p_e^E), or in recession, R , with (y^R, r^R, p_e^R). While $y^E > y^R$ is naturally assumed, no relation between r^E and r^R and between p_e^E and p_e^R is assumed. The economy may switch from the E regime to the R regime with flow probability γ, and from the R regime to the E regime with flow probability ε.

Solution, Remarks and Interpretations Let u_j denote $\frac{\partial V_j}{\partial x}$ and d_j the demand that firms face $(d_j = \frac{y^j}{N^j} = \pi_j)$, $j = E$, R. Then, we write u_R and u_E as follows:

$$u_R = \frac{(\eta - 1)d_R/a + \varepsilon u_E}{r^R + \varepsilon} \tag{14}$$

$$u_E = \frac{(\eta - 1)d_E/a + \gamma[(N^R/N^E)u_R + (1 - N^R/N^E)\theta\beta C]}{r^E + \gamma} \tag{15}$$

The last expression in (15) reflects the existence of an exit effect: the expected capital gain includes the probability of exiting, $(1 - N^R/N^E)$, and associated value, $\theta\beta C$. It can be shown that if $\beta = (\eta - 1)/\eta$ then the exit effect vanishes and the above system reduces to:

$$\begin{cases} u_R = \frac{(\eta-1)d_R/a+\varepsilon u_E}{r^R+\varepsilon} \\ u_E = \frac{(\eta-1)d_E/a+\gamma u_R}{r^E+\gamma} \end{cases} \Longleftrightarrow \begin{cases} u_R = \frac{\eta-1}{a}\frac{(r^E+\gamma)d_R+\varepsilon d_E}{(r^R+\varepsilon)(r^E+\gamma)} \\ u_E = \frac{\eta-1}{a}\frac{(r^R+\varepsilon)d_E+\gamma d_R}{(r^R+\varepsilon)(r^E+\gamma)} \end{cases}$$

The first order conditions are given by:

$$\frac{\eta - 1}{a}d_j h(v_j) = u_j,\ j = E, R \tag{16}$$

Replacing the RHS of the first order conditions with the relevant expressions for u_j, we obtain:

$$h(v_R) = \frac{(r^E + \gamma) + \varepsilon d_E/d_R}{(r^R + \varepsilon)(r^E + \gamma)} \tag{17}$$

$$h(v_E) = \frac{(r^R + \varepsilon) + \gamma d_R/d_E}{(r^R + \varepsilon)(r^E + \gamma)} \tag{18}$$

Finally, to close the model, we use the free entry-exit conditions, together with the assumptions that in recessions there is exit ($V^R = \theta C$) and in expansions entry occurs ($V^E = C$). Hence, the following relations must hold in equilibrium (recall that $d_j = \pi_j$):

$$d_R = [r^R\theta + \varepsilon(\theta - 1)]C \tag{19}$$

$$d_E = [r^E + \gamma(1 - \theta)]C \tag{20}$$

We are finally in position to study the cyclical behavior of productivity growth, i.e., the relation between v_R and v_E. To do so, we only have to analyze the system of equations (14), (15), (19), and (20). We summarize the main implications of the model below, in form of remarks, accompanied by the relevant proofs, and followed by an interpretation at a rather intuitive level.

Remark 1 *Shocks to supply conditions have no productivity effects. Inspection of the system (14), (15), (19), and (20) reveals that* v_R *and* v_E *are determined without reference to the price of the input,* p_e*, the object through which supply shocks operate in the model.*

Remark 2 *If* $\theta < 1$ *and* $r^E \geq r^R$*, then* $v_R > v_E$*. Since* $h^{'} > 0$ *always obtains given the assumptions made on k, to compare* v_R *and* v_E *it suffices to compare the RHSs of (14), (15), (19), and (20).*

Remark 3 *If* $\theta < 1$ *and* $r^E < r^R$ *then there exists a* θ^* *such that if* $\theta \in (\frac{\varepsilon}{r^R+\varepsilon}, \theta^*)$*, then* $v_R > v_E$*, and if* $\theta \in (\theta^*, 1]$*, then* $v_R < v_E$*. From the above argument we know that* $v_R > v_E$ *obtains if and only if the following condition holds:*

$$\varepsilon(\frac{d_E}{d_R} - 1) + \gamma(1 - \frac{d_R}{d_E}) > r^R - r^E$$

When $\theta = \frac{\varepsilon}{r^R+\varepsilon}$*,* $\frac{d_E}{d_R}$ *becomes* $+\infty$ *and the above inequality will hold. Now consider* $\theta_0 = \frac{\varepsilon}{r^R+\varepsilon} + \delta$*. The above inequality will also hold as we make* δ *an arbitrarily small positive number, by a limit argument.*

The intuition for the above results is straightforward. Supply shocks affect an intra-temporal problem, but not the productivity investment problem, which is, of course, an inter-temporal problem. The productivity investment problem is affected, in turn, by the following two effects: an opportunity cost effect, associated with fluctuations in demand, and a real interest rate effect, as with any other investment problem. If the real interest rate is procyclical, then both effects reinforce each other and productivity unambiguously grows after a transitory demand downturn. If the real interest rate is countercyclical, then the opportunity cost effect and the real interest rate effect work in opposite directions. However, if the real interest rate is not too countercyclical and / or the opportunity cost effect is strong enough, then productivity may grow after a transitory demand downturn despite an increase in the real interest rate. Nevertheless, it is clear that the smaller the increase in the real interest rate during the transitory demand downturn, the stronger the productivity growth after the transitory demand downturn.

3 Final Remarks

We extend the work of Aghion and Saint-Paul (1998) and provide novel theoretical guidance to much needed tests of the empirical relevance of the Opportunity Cost View of downturns vis à vis the competing theories of learning-by-doing and capital market imperfections as empirically relevant theories on the relationship between cyclical shocks and productivity growth.

Future work should capitalize on the results we present here and seek to establish the empirical relevance of the surveyed competing theories on the relationship between cyclical shocks and productivity growth.

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