Volatility and Crisis in Catching-up Economies
Industrial Path-Through Under the Stickiness of Technological Capabilities
and “The Red Queen Effect”

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Introduction

It is well known in macroeconomics that the stickiness of prices may transform a negative shock of aggregate demand in unemployment. Barriers to adjust relative prices lead the economy to adjust in quantities. However, this kind of market imperfection is not supposed to last for a long period, and eventually prices will send the correct signals and resources will be reallocated. The more flexible the price system, the faster the adjustment will be. From this perspective, financial markets should adjust smoothly. These markets display high flexibility and are sufficiently well organized so as to spread information at light velocity among economic agents. Governments and policies are completely unnecessary in this case – at the end of the day, governments cannot know better than the myriad of rational agents who on average have the correct model of the economy in their minds. This is at least what is regularly taught in the economics departments. Still, the recent events in the financial markets, that have put the world at the verge (or in the middle) of an historical economic crisis, suggest that this view is completely flawed.

In recent days astronomic amounts of money have been dropped in the financial system to avoid its collapse while resources and assets evaporate. For many analysts, it is time to rethink the institutions and rules governing the financial markets. We argue in this paper that it is also urgent to rethink policies in the fields of technology and industrial diversification, particularly in catching-up economies. More specifically, we argue that all the reasons that impose the need of intervention in the financial system are as well present in the industrial system, and that the importance of adopting correct policies for the development of technological capabilities cannot be neglected in times of financial crisis – on the contrary, they are more necessary than ever. To discuss this point it is necessary to look more carefully at the microeconomics of learning and its relations with economic

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In effect, the impact of business cycles and crises on the real side has been frequently analyzed in terms of aggregate variables: output, employment and demand. However, there are as well microeconomic implications which influence economic development. This is the key point raised by the paper. Technological capabilities are the basis for the expansion of production and employment at the firm, sector and industrial levels, and building capabilities requires a continuous process of learning. At the beginning of 1970s it was recognized that economic development required borrowing, imitating, mastering and improving on the advanced technology used by countries that had reached the technological frontier. But this is not an easy task and the change and re-adaptation of technological capabilities are characterized by rigidities and uncertainty. This poses a major challenge to governments, which should be concerned with the long run process of technological accumulation, and with the risks of its destruction, both in normal times and in times of crisis. Until a few months ago it seemed as if the international economy would reward handsomely countries which have specialized in natural resources according with a static Ricardian view on comparative advantages, no matter their technological content. Nowadays these promises evaporated and the “Red Queen Effect”\footnote{The term is taken from the Red Queen's race in Lewis Carroll's Through the Looking-Glass, in which the Red Queen says "It takes all the running you can do, to keep in the same place".} is back as strong as ever: countries should keep running in the technological competition so as to avoid falling behind -- and the natural resources curse is certainly not a shortcut to Wonderland.

The way most policy-makers regard industrial policy hinders the design and implementation of development policies. In the past five years many Latin American countries experienced favorable terms of trade for their commodities. During these good times, very little was done to upgrade technology and human capital. Policy-makers looked at industrial policy suspiciously. Any step to promote an industry or to encourage learning had to be carefully explained and justified. Any industrial policy “picking (technology-based) winners” or protecting technological capabilities accumulated by generations had little support. Still, the stickiness of technological capabilities is certainly much more pervasive in industry than in the financial system. And although industry rarely experiences sudden collapse, it may experience chronic declination, a long run gradual loss in capabilities whose accumulated impacts on growth and welfare are not less devastating than a financial crisis. We believe that it is urgent to set aside this old view and discuss industrial policy taking into full consideration the stickiness of capabilities and its importance for long run growth.

The paper is organized in two sections besides the introduction and the conclusions. Section I address the endogenous determinants of business cycle and the interaction between financial and “productive” capital. It briefly mentions the importance of this theme in classical authors and then argues why one should be concerned with the influence of volatility on learning and capabilities in developing economies. The idea of stickiness in capabilities is referred to the evolutionary literature on the microeconomics of learning and industrial policy. Section II uses the literature discussed in Section I to shed light on the implications of instability for productivity growth and economic growth in the long run.
is shown that recurrent efforts for re-adaptation of technological capabilities compromise productivity growth at the firm and aggregate levels. At the same time, the loss of capabilities and complementary assets imply that the whole economic system becomes less competitive and less able to react to new shocks. Both effects combine and result in a persistent process of falling behind in the international economy, as has been observed in the case of several catching up economies and, particularly, in Latin American economies.

I. Business Cycles, Crisis and the real sector

In the last decades the classical analysis of business cycle and crisis has been forgotten in most economics departments at the top universities. They have been eliminated or placed in marginal positions, as part of the courses on economic thought and history of economic analysis. Policy-makers and managers (“practical men”) take decisions and formulate policies exclusively on the basis of the technicalities required to “build up” and “read” econometric models and statistical analysis. The underlying economic theory was not under discussion. It is assumed that markets behave efficiently and the expansion of the economic system would continue for ever in an equilibrium path. They can only be transitory affected by exogenous shocks.

Such foundations and trends in economics would have certainly alarmed classical authors. In the classical tradition, the endogenous nature of the business cycle, the importance of the real sector in the accumulation process, the problem of the proportionality between different sectors and between finance and production, are paramount in explaining the emergence of a crisis. Schumpeter put it clearly in the chapter dedicated to Marx and his explanation of the business cycles:

“Finally, we must try to collect Marx’s contribution to a fundamental or ‘causal’ explanation of the cycle, trying to find out, as so many others have tried before us, whether any definite theory of it can be attributed to Marx even though he never penned one explicitly. The first step is easy. Marx clearly visualized that the ‘decennial cycle’ that (‘interrupted by smaller oscillations’) runs along in a sequence of phases (or ‘periods’ he said) of average activities, prosperities, overproduction, crisis and stagnation is ‘characteristic of the modern industry’ and not merely the result of a series of incidents or accidents. And he definitely located its source in the process of accumulation. But beyond this, one thing only is certain, namely, that he treated this process, including the increase in productive capacity it brings about and the ‘industrial reserve army it creates’, as a movement away of equilibrium, and crisis as the catastrophes which periodically re-establish equilibrium and, by means of radical destruction of capital value, recreate the conditions for profitability of business. This is promising approach that avoids many possible errors and irrelevances and purposively leads up to the question that remains: why should the process of accumulation be essentially disequilibrating?” (Schumpeter, 1954, p. 749).

Subsequently, Hilferding placed the accent on the disproportionalities between sectors and between credit and production:
“We have seen how in the beginning of capitalist production the money of the banks comes from two sources. First, from the money of the non-producing classes; secondly, from the reserve capital of the industrial and commercial capitalists. We have seen, further, how the development of credit tends to place at the disposal of industry not only the whole reserve capital of the capitalist class, but also the greatest part of the money of the unproductive classes. Present-day industry, in other words, is carried on by means of a capital far larger than the total capital in the possession of the industrial capitalists. With capitalist development the sum of money constantly grows which is placed by the non-producing class at the disposal of the banks, and by these latter at the disposal of industry. The disposal over these sums, so indispensable to industry, belongs to the banks. With the development of capitalism and its credit organizations there thus grows the dependence of industry upon the banks. On the other hand, the banks can only draw the moneys of the non-productive classes, and keep the ever-increasing foundation stock of the same at their permanent disposal by paying interest on these moneys. This they could do, as long as these sums were not too extensive, by making use of them for speculation credit and circulation credit. With the growth of these sums on the one hand, and, on the other, with the decreasing importance of speculation and commerce, it became necessary to convert them more and more into industrial capital” (Hilferding, 1910, p. 166).

The lack of synchrony in the rate of growth of different sectors is the natural outcome of the strong redistribution of power in favor of financial capital. The monetary sector is never completely autonomous of the real sector; the disproportionally between them produces important transformations and convulsions which deeply affect the real sector (Harris 1983, Dibeh 2001)

Keynes was perhaps the author who best understood the importance of speculation in modern capitalism. The tension between investing in financial applications and investing in building new capital, the inherently speculative nature of capitalists’ decision as about how to allocate their wealth, are at the heart of the Keynesian tradition. Keynes himself wrote widely cited words in this respect, which could have been written yesterday:

“Speculators may do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation. When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done. The measure of success attained by Wall Street, regarded as an institution of which the proper social purpose is to direct new investment into the most profitable channels in terms of future yield, cannot be claimed as one of the outstanding triumphs of laissez-faire capitalism” (Keynes, 1936, p. 159).

Some Keynesian insights were subsequently refined by Hyman Minsky, who set forth a most interesting model of endogenous financial crises². He stressed that a capitalist system endowed with sophisticated financial markets is bound to generate crisis as the economy moves from hedge finance to speculative and eventually Ponzi finance (Kregel 2007, Kregel, 2008 and Hernandez, 2008). In Minsky’s words:

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² See also Foley (2003)
“There therefore are systemic conditions that need to be satisfied for a financial crisis to occur: the financial structure needs to be heavily indebted, involving a large element of either Ponzi finance or speculative finance which can become Ponzi. We can characterize a financial structure which is predominantly hedge financing as robust and a financial structure that is heavily speculative and Ponzi as fragile. The fundamental assertion of the financial instability hypothesis is that the financial structure evolves from being robust to being fragile over a period in which the economy does well.” (Minsky, 1991)

Such a perspective is extremely useful to understand why financial crises appear in a cyclical way and what governments (as lenders or last resort) can do to reduce their impact on the real economy. Particularly, financial capital over-expands on the assumption that the “imagination of the market” is so powerful in creating welfare that the real economy will have to follow suit and reinforce its expansive path. When a financial crisis materializes, the fact that finance, prices and production have not moved hand by hand becomes apparent. Minsky summarizes this in few words:

“The potential loss to society from a financial crisis will be great if it leads into a deep and long depression. If all that followed from a financial crisis is some redistribution of the wealth or a shift of production from investment to consumption economy, then some concerns goods within a full employment about equity and the impact upon the losers in this process may arise. But such concerns would not lead to the same willingness to intervene and taken possible efficiency losses as that which follows once policy is motivated by the possibility that the history, in which serious depressions are associated with financial crises, is a good guide to the consequences of a financial crises in our time. Intervention is ordained if it is believed that a free market resolution of a financial crisis requires doing time in a deep depression.” (Minsky, 1991)

But changes in the macroeconomic variables are part of the story. This paper addresses the implications of instability and crisis from a different perspective, which is the microeconomics of learning. The latter is central to the process of economic development. To the extent that instability and crisis affect the evolution of technological capabilities, then their effects go beyond the cyclical depression of production and employment. They may compromise economic and productivity growth for a long period, and thereby compromise development. This will be discussed in the following section, which focuses on the microeconomics of learning and capability building.

**Stickiness in capabilities**

We would like to add a new dimension to the analysis of the crisis, namely the idea that behind cycles of growth and depression there are as well significant changes in technological capabilities, particularly in catching up economies. We define catching up economies as those which are far from the technological frontier. In these economies the reduction of technological asymmetries, learning and diversification are the drivers of growth in the long run. Convergence in income per capita with the developed countries depends on the persistent accumulation of new technological capabilities and in the upgrading of the industrial structure (Cimoli, Dosi, Nelson and Stiglitz, 2006 and Cimoli, Dosi and Stiglitz 2008).
Clearly, stickiness is a feature which is more present in the construction of capabilities than in the financial sector. This implies that short term fluctuations in production may represent more than a temporary loss in the quantities produced (given the potential output); if fluctuations are recurrent, they may represent as well a loss of capabilities and therefore a loss of potential growth. Speculative shocks, price volatility in commodities and in the real exchange rate, and deep recessions left lasting marks in productivity and in the productive structure. The process of gradual but accumulated weakening of capabilities is less dramatic than a financial crisis, but it is not less costly in the long run for developing economies.

What do we mean by “stickiness” in capabilities? A first approach to this is the classical work by Atkinson and Stiglitz (1969), suggesting that the production function should be seen as “points” in the plane, and that learning is strongly localized around existing technologies – in other words, firms produce new knowledge just within a small interval of feasible technologies, concentrated in the vicinity of the technology they are actually using. Since the mid-eighties, the Schumpeterian evolutionary literature has steadily developed new microeconomic tools for analyzing learning (Cimoli and Porcile 2008). Basically, this literature gives strong theoretical and empirical basis to the idea that the expansion or contraction of the productive and technological capabilities is not a linear, reversible process. Technological learning features a set of inter-related regularities that cannot be ignored, namely:

i) Requires real time;
ii) It is strongly accumulative;
iii) It is subject to path-dependency, i.e. the evolution of capabilities strongly depends on the sectors and directions of past learning;
iv) There exists complementary between sectors and capabilities, in such a way that externalities and increasing returns are crucial at both the industrial and economy levels;
v) There is irreversibility in the accumulation of certain (physical and technological) assets, which cannot just be abandoned or replaced.
vi) There exists cumulativeness in learning, which implies that in a context of technological asymmetries, countries that are closer to the technological frontier will innovate at faster rates than the catching up economies.

These properties highlight the key role of technological and industrial policies, aimed at reducing the technology gap and diversifying the economic structure of the developing country towards sectors which are more technologically intensive. It happens that all the countries which are nowadays developed present high degrees of intervention to support the accumulation of technological capabilities; and this intervention was even more intensive during the period of the creation of their capabilities. Frontier countries differ in terms of prevailing instruments and institutional arrangements. However, they all share the “philosophy of intervention” and the recognition (although usually implicit) that the rationale for industrial policies is to induce the accumulation of technological capabilities in technologies already in use, and in those “strategic” and “uncertain” new technologies that
would drive productivity growth in the future. It should be stresses that the response that
developed countries has offered to the crisis, supplying funds not only to avoid the collapse
of credit but also to sustain firms in trouble, is a clear reminder of this philosophy to the
developing countries.

*Learning and policies in “normal times”*

Our discussion stresses the role of catching up with the technological leader. Imitation
drives this process, but this is far from being automatic. It is a costly, painstaking effort in
which imitation and diffusion are closely related to a stream of minor innovations on and
adaptations of foreign technology. Some stylized facts emerge from the empirical evidence
regarding the dynamics of learning and the policies that are necessary fro competitiveness
in normal times (Cimoli, Dosi, Nelson and Stiglitz, 2006 and Cimoli, Dosi and Stiglitz
2008), which can summarize as follows:

i) Catching up demands the emulation of production and technological activities that had
been successfully adopted or that will be diffused in the future -- as in the case of
information technologies, biotechnologies, nanotechnologies and new materials.3

Make an effort to equal or surpass others in any achievement or quality was the rationale of
development policies in the last 500 years. Countries that became rich have done so
through an emulation strategy, i.e. developing capacities in the areas where technological
progress was concentrated at that time (Reinert 2008). The emulation of a product requires
matching the abilities incorporated in firms and people that are already producing this good.
The first step is the efficacy to reproduce the characteristics and properties of that product.
Subsequently, the effort concentrates on reaching profitability and efficiency, measured in
terms of cost or time per units produced. In general, the accumulation of technological
capabilities is premised on efforts dedicated to emulate products and processes. This
principle, very well known to all skilled workers or engineers around the world, applies
also to the industrialization process. Indeed, in the past all countries chose to protect the
industry that used the “key” technology prevailing at that time and they all favored the
transfer of capabilities through direct interchange between “experts in the art”. England did
so at the time of the industrial revolution, and Korea did so in the 1960s. Indeed, England
protected her manufacturing industry for more than 350 years, the United States only for
about 100 years, Korea for 40 years, and China and India for the last 30 years.
Protectionism was never intended to be for ever (Dahlman 2008). Once a certain domestic
industrial capacity had been reached, firms should be able to move ahead and compete in
larger markets on their own. This has been the avenue to overcome the “Red Queen effect”

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3 In the Appendix a simple formal model is presented in which the technology gap and industrial and
technological policies are the key for convergence between developing and developed countries. The model
shows that international convergence requires a sustained effort to alter the structural parameters related to the
process of technological catching up. The historical evidence tends to confirm this view. The structural
parameters of the model are very stylized expressions of the specific features of the National System of
Innovation of different countries.
and reduce distances between developed and developing countries.

ii) It is necessary to acknowledge the complementarities between learning in technologies and the development of production capacity. Technological learning rests on the knowledge and resources required for generating and acquiring technologies (capital goods, know-how, capabilities embedded in human capital, and so forth), and for adapting them to local conditions. Production capacity concerns the stocks of resources, the nature of capital-embodied technologies, labor skills, product and input specification and the organizational routines in use.

In this respect, considerable evidence on micro-behavior highlights the mechanisms that stimulate and limit endogenous learning in developing countries. This mainly refers to microeconomic learning activities such as the use of equipment, the development of engineering skills and the adaptation of existing machines and final products to specific environmental and local conditions. Significant factors favoring this process include the quality of human capital, the skills and technical competences of engineers and designers in the mechanical artifacts and (increasingly) the existence of managers capable of efficiently running complex organizations.

The generation of technological and production capabilities requires time and is based on progressive learning in organizations. Historically, initial efforts concentrated on product design activities (most likely as a result of past incentives provided by import substitution policies) and, increasingly, on quality improvements and product differentiation. Attention has to be directed towards engineering, the organization of production and the mechanized production processes. The organization can thus move towards the development of managerial capacities, such as the scientific design of production processes, the search for a higher division of labor (deskilling jobs and separating mental and manual labor), the organization of fixed product lines and the implementation of vertical integration to improve learning.

In general, there is likely to be only one or, at most, very few "best practice" techniques of production which correspond to the technological frontier. In the case of developing economies, the process of industrialization is thus closely linked to the access of global knowledge (through trade, foreign direct investment, technology licensing, copying and reverse engineering, foreign education and training, and accessing foreign technical information in print, and now through the internet) and adapt and imitate the established technologies of the more advanced economies. R&D should be focused on indigenous innovation and on mission oriented programs on tracking, assessing, acquiring, and adapting foreign knowledge. This process of adoption and adaptation of technologies, in turn, are influenced by the specific capabilities accumulated in each economy. The capabilities already accumulated are the premise to design policies and implement them effectively.

iii) There should be compatibility between learning activities and the political economy, with particular emphasis on the institutional setting, openness of the economy, macroeconomic environment and competition policies (Akyüz 2008). Institutions can be seen as the social construct that govern the externalities, the interaction among agents and
the complementarities between learning patterns in different activities. Under this premise, policies and other activities of “institutional engineering” affect at the same time (i) the technological capabilities of firms and the rate at which they actually learn; (ii) the economic signals that they face (including of course profitability signals and perceived opportunity costs); (iii) the ways they interact with each other and with non-market institutions (like research agencies and universities)

Economic history shows that the average industrial tariffs were relatively low at the early stages of industrial development, rising rapidly in intermediate stages and falling with maturity. The evidence (Akyüz 2008 and Reinert 2008) indicates also that there was a strong correlation between protectionism and economic growth in the industrialized economies and in those that have managed to catch up recently. In that sense, successful catching up requires some kind of infant industry protection, which might take the form of tariff management, but which might also be achieved though different support mechanisms, like direct subsidies, a tailored IP regimes, etc.

In the early stages of economic development, production and exports consist largely of primary commodities while imports comprise mainly manufactures, both capital and labor-intensive products. How long a country can rely on the exploitation of natural resources before moving to industry depends, \textit{inter alia}, on the relative size of its resource endowments. However, evidence strongly suggests that abundant natural resources, even when combined with a well-developed human resource base, do not automatically lead to processing and diversification (Palma, 2008). Without active policies designed to promote and support such activities, being rich in natural resources can be detrimental to diversification out of unprocessed commodities.

On the other hand, even though commodity processing provides early industrialization opportunities, the possibilities of maintaining rapid development through deepening and diversification in the primary sector are limited. Industry offer better growth prospects not only because they allow for a more rapid productivity growth and expansion of production, but also because it avoids the declining terms of trade that have frustrated the growth prospects of many commodity-dependent economies. Countries rich in natural resources can delay industrialization, but in general they cannot reach high income levels without a strong industrial base.

iv) A key role is played by the management of rents that incentives and provide credible compulsions for learning and accumulation of technological capabilities (Khan and Blankenburg 2008). Institutions and policies for inducing learning have to provide the incentives for learning, and at the same time they need to have the credibility to impose costs and sanctions on industries and firms that fail to achieve the required rate of learning.

The structural need for policies that affect the pattern of economic signals (including relative prices, relative profitability of opportunities) as they emerge from the international market will be larger, the higher is the distance of the country from the technological frontier. Rent management requires institutional and political conditions that allow the effective implementation and complementarities of different strategies, as for example,
subsidies for the potentially dynamic infant industry and funds for the organizations dedicated to support research activities. Fiscal policy places a key role here: it must be capable of transferring rents form those sectors that benefit from the cyclical advantages of the terms of trade for natural resources (redistribution of part of the export revenue, royalties according to the profitability in natural resource and strategic sectors, tax on the environmental damage in the production of industries dismissed in developed countries).

Providing protection or subsidies for a very short period is just as problematic as providing it for too long. If the state does not have the credibility to withdraw a subsidy when there is underperformance then not only will there be a short-run cost, there will be a permanent cost because infant industries will never grow up. These conditions are particularly demanding because the optimal period of rent allocation for learning will vary from sector to sector, and across countries depending on the initial capacities of capitalists, managers, and worker. Moreover, if the government does not have the capabilities to monitor and withdraw subsidies in underperforming industries, the allocation of rent would represent a governmental failure.

The institutional conditions for compulsion (the rent management strategies) can themselves vary significantly given different internal political configurations of power, and their relative success depends on the “compatibility” of these institutions with the pre-existing distribution of power. Countries do not succeed when they tried to implement rent management strategies that appeared superficially similar to strategies in the successful countries, but which were incompatible with their specific internal political and social configurations. In these cases (of which there are numerous examples), rents that would theoretically create incentives for technology acquisition become in fact a burden, whose effects are in some cases much worse than the lack of intervention.

II. Volatility, price shocks, productivity and diversification

What are the implications for developing economies of the features of technological learning discussed in the previous section?

We will argue, firstly, that instability and uncertainty depresses the development of technological capabilities and the training of human resources, with a negative influence on productivity growth of the firm, industrial sector and the economy. Secondly, that they produce a loss of sectors and capabilities which reduce systemic learning and increasing returns at the industry and economy levels, compromising international competitiveness. Last but not least, both effects combine and reinforce each other, giving rise to virtuous or vicious cycles which hamper economic growth in the long run. These points will be discussed in more detail below.

Learning, adaptation and productivity slowdown

Real exchange rate instability, inflation and uncertainty have been very present in the
economic history of Latin America. In the past five years many Latin American economies (particularly those in the South of Latin America, like Argentina, Brazil, Chile and Uruguay) experienced substantial improvements in their terms of trade. This was in part due to real variables, namely the steady expansion of international demand for commodities and raw materials, arising from the rapidly industrializing Asian economies (among which China was a key player). But it also responded to the influence of heavy speculation in the commodity markets.

With the improvement in the terms of trade for commodities based on natural resources and the consequent appreciation of the exchange rate, the spaces for the diversification of technological capabilities and production were reduced. A process of concentration in fewer activities took place, while the incentives to learn and invest in other sectors and activities were reduced. The exploitation of natural resources and a falling exchange rate made the manufacturing sector less competitive and thus impacted negatively on growth. Sectors based on natural resources are capital-intensive and the stimulus to human capital formation is weak, impeding the emergence of knowledge intensive sectors and favoring polarization in income distribution.

The abundance of natural resources may sustain growth for a certain period, even without significant efforts for encouraging structural change. This is the case, in particular, when the terms of trade improve, exchange-rate appreciation is controlled and sectoral productivity is rising. However, in the long term, the promotion of unproductive activities and the failure to tackle income inequality tend to erode the economic benefits derived from these resources. Policies should be adopted to encourage a shift towards more sophisticated technological production stages and the diffusion of technological capabilities in other sectors when market signals are not in favor of the diversification of production and exports (Verspagen, 1990). When market incentives are adverse to endogenous capability generation, policies to promote the diversification of learning and the accumulation of technological capabilities need to be stronger and more pervasive.

As mentioned, improvement in the terms of trade has reflected not only the expansion of demand, but also speculative forces raising commodity prices to levels which could not be sustained (Kregel, 2008). The melting of these prices in recent months is suggestive of the importance of these forces. In addition, Latin America went through a period of remarkably volatility which has heightened uncertainty as regards the future scenario. A few months ago some observers expected a twenty-year positive cycle for commodities; nowadays the future is opaque, but most analysts believe that growth rates will be much reduced in the next years.

How does this combination of positive price shock followed by collapse affect productivity growth? How do firms adapt to changes in relative prices?

Here, we have two possible answers. The first, which could be given by a PhD from one top university now working in the government of a developing country, is the following: no problem, firms will adopt a new combination of techniques and efficient production process. Their assets are flexible enough and will find a new efficient equilibrium. And what will happen if prices change again? No problem again, firms will move from one
combination of factors to another combination, as the choice of techniques responds easily to relative prices.

The second answer is based on the evolutionary idea of stickiness of technological capabilities. A price shock obliges the firm to readapt and redefine its capabilities by reorganizing the production process, investing in R&D and moving towards a new mix of production. But these changes require time and resources; the velocity with which the firm responds is crucial to remain competitive in the market, and not all firms would be able to respond swiftly enough. Effects of re-adaptation on productivity will not be immediate. They take time and during this time there will necessarily be a slowdown in productivity growth. Clearly, the time for re-adaptation depends on many factors, such as the specificity of the assets of firms, routines and human capital (which define what we have called stickiness of the technological capabilities).

In addition, according to the Smith-Young-Kaldor perspective, output growth triggers increases in the division of labour and improves learning in each of the complementary activities, as well as the skills required in the use of equipment, the adaptation and transformation of machines tools and the management of complex organisations. Conversely, productivity growth falls when the expansion of production falls, and increasing returns are lost.

In the best scenario, after a slowdown in productivity growth (or even a transitory fall in productivity), this variable will grow again at the same or at higher rates than at the moment of the shock. But if shocks are recurrent and/or uncertainty persists, the firm would have to be constantly readapting its processes and the product mix, or will have to adjust at a slower pace (as it waits until the emerging structure of relative process becomes more transparent). At the end of the day, the evolution of the firm productivity with successive price or uncertainty shocks will look like as if productivity were stagnant (while it indeed fluctuates in such a way that firms are unable to find a stable path of productivity growth). Adding up the productivity slowdown across firms gives a lower rate of productivity growth in the aggregate (reinforced by systemic effects, as will be discussed below). Of course, some sectors and some firms will be able to respond faster and better than others to the shock, but to the extent that all firms will have to adapt, a slowdown in aggregate productivity is the most likely outcome of price volatility.

**Destruction of technological capabilities and losses in diversification**

But the aggregate impact of shocks on productivity is more than the sum of the effects on each individual firm. There are systemic effects related to externalities and changes in the share of the different industries in total value added.

A simple North (developed economy) – South (catching-up economy) model can be helpful to illustrate the interaction between the real exchange rate, the pattern of specialization and economic growth (see formal Appendix at the end of the paper). The model takes as a point
of departure the Balance-of-Payments constrained growth model\(^4\). A key assumption of this paper is that exports and imports do not only depend on relative prices, but evolve out of the processes of technological and structural change. A move towards high-tech sectors implies higher international competitiveness and entering into more dynamic markets, and therefore raises (reduces) the income elasticity of exports (imports).

The demand for exports and imports are specified as follows:

(1) \[ X = Y^*(N)^\alpha Q^\beta \]

(2) \[ M = Y(N)^{-\eta} Q^{-\gamma} \]

In equations (1) and (2) \(Y\) is the real GDP of the South, \(Y^*\) is the real GDP of the North, \(N\) represents the degree of diversification of the economic structure towards technology-intensive sectors in the South as compared to the North and \(Q = P^*E/P\) is the real exchange rate (\(P^*\) and \(P\) are domestic and foreign prices, respectively, and \(E\) is the nominal exchange rate). Current account equilibrium implies that:

(3) \[ \frac{Y}{Y^*} = Q^\mu N^\phi \]

In equation (3) \(\mu = \beta + \gamma\), which is supposed to be greater than one (Marshall-Lerner condition) and \(\phi = \alpha + \eta\). In other words, the relative South-North income depends on the degree of diversification of the economic structure in the South and on the real exchange rate.

Taking logs in (3) and differentiating with respect to time we have the relative rate of growth in North and South which keeps the current account in equilibrium. Relative income growth is a function of the rate of growth of the real exchange rate (\(q\)) and the rate of structural change in the South with respect to the North (\(n\)):

(4) \[ y - y^* = \mu q + \phi n \]

Finally, assuming that it is valid the dynamic version of the principle of purchasing power parity (\(q = 0\)) we have in equilibrium:

(5) \[ y - y^* = \phi n \]

In this simple case, in which the real exchange rate is stable, relative growth in equilibrium solely depends on structural change (\(n\)), which is a function of leads and lags in technology (see Appendix). On the other hand, an appreciation of the real exchange rate implies a lower South-North relative income in equilibrium. Inversely, an increase in the real exchange rate raises the income elasticity of exports and imports.

\(^4\) For a discussion of the external constraint on growth from the perspective of the Latin American structuralism see Prebisch (1950) and Rodriguez (1980). A static version of this model was originally set forth by Harrod (1936). The model was extended in several contributions, in particular Thirlwall (1979), Cimoli (1988), McCombie and Thirlwall (1994); Araujo and Lima (2007), Cimoli and Porcile (2007).
exchange rate would lead to temporary higher growth in the South (as compared to the North) and to a new (higher) South-North relative income ($Y/Y^*$, see equation (3)).

But we will now assume that a fall in the level of the real exchange rate alters the economic structure in a persistent way. As a result, when $Q$ returns to its initial level the value of $N$ in equilibrium (and hence $Y/Y^*$) will be lower than before. When price instability destroys capabilities, it also affects the basis for growth in the long run. The real sector will not recover its initial shape: a negative shock produces an irreversible change in relative incomes by changing the value of $N$ in equilibrium.

This process is described in Figure 2. There is a transitory fluctuation in the real exchange rate, which equals $Q_1$ at the initial moment, falls to $Q_2$ in a second moment and return to $Q_1$ in a third moment. How does this affect the relative income ($Y/Y^*$)? When $Q$ falls, the curve that plots the South-North relative income against the equilibrium economic structure of the South ($N$) shifts to the right. As a result, the relative income falls for all values of the Southern economic structure. If the economic structure is not affected, when the real exchange rate moves back to $Q_1$ the relative income will be the same and $N$ would not have changed (it will continue to be equal to $N_1$). This represents the ideal world of no stickiness in capabilities. The economy moves from A to B and it will return to A at the end of the fluctuation. There are no structural implications of short run fluctuations in $Q$, which are perfectly reversible.

But what does happen if some capabilities are destroyed in the process and cannot be recovered when the real exchange rate is back to its value of time zero? If some key sectors disappear during the period of currency appreciation, $N$ will decrease. Assume for instance that $N$ moves permanently to $N_2$ and remains there even when $Q$ is back to $Q_1$. In this case the destruction of capabilities is so extensive that the economy would not be able to recover after real devaluation. Of course, this is an extreme case, which is as unlikely as the case of no structural change (in which all capabilities are fully rebuilt after devaluation). An intermediate case, in which $N$ will adopt a value between $N_1$ and $N_2$ (with $Q = Q_1$) is the most likely outcome.
The previous results are a natural consequence of the features that characterizes technological learning – cumulativeness, path-dependency, complementary learning across sectors. It also reflects a world of fierce competition in terms of both prices and quality. Falling behind in terms of technological capabilities makes the process of catching-up increasingly difficult, as market shares are reduced and investment compromised. Calling back unused skills is not an easy challenge. Human capital is produced along with investment and production in high-tech industries, and it can be destroyed as much as financial assets. Engineers from Buenos Aires that lost their jobs during a protracted recession would not become psychologists the following day. More likely, they will find jobs selling pizzas in Puerto Madryn. And when a higher real exchange rate makes industrial production potentially profitable again, these engineers would not longer be available for the industry. They should have to be trained or retrained at a cost, and this implies less competitiveness, less industrial production and even less sectors than before.

Figure 2 summarizes this inter-relation between re-adaptation at the firm, loss of capabilities and systemic effects during a period of recurrent price shocks.
Figure 2 shows that each time there is a shock (in prices or in the real exchange rate) there will be as well a productivity slowdown during the adjustment process. But in addition, after the adjustment productivity growth will be lower than before. In other words, each shock depresses the rate of productivity growth after the adjustment. This will happen when the shock has an impact on the economic structure, to the extent that some sectors and capabilities are destroyed (R&D departments are closed, producer-user interactions ceased, public research agencies underfinanced, human capital lost and so on and so forth). The efforts of the firms to adjust to new shocks will become increasingly less effective, and the ability to learn and restore productivity growth will be undermined.
The evidence provided by Graphic 1 is rather clear regarding the effects of crisis and instability on productivity growth in Latin America. It shows the evolution of the ratio between labor productivity in Latin America and labor productivity in the USA. Clearly, the region was unable to overcome the “Red Queen effect”; more than that, it failed to keep pace with the technological leader and fell behind (labor productivity in Latin America was in 2006 half of the value observed in 1970). The effects of crises are well visible: a dramatic fall during the Latin American debt crisis of the eighties (the “lost decade”), a moderate improvement in the late eighties and the new fall of the second half of the nineties and early 2000s. Behind these fluctuations and the fall in relative productivity there are alternate periods of currency appreciation, trade liberalization and a mounting external debt, followed by major devaluations. The key assumption that guided policy-makers in the period of neoliberal reforms in Latin America -- that firms and sectors adapt and produce more efficiently when market are liberalized and resources move freely towards more competitive activities -- proved to be wrong. Technological capabilities were not promoted (Peres 2008). Unilateral trade and financial liberalization in economies with weak industrial polices failed to promote productivity growth (or did so at the expense of higher unemployment). While capabilities in sectors with medium or high technological intensity have been destroyed, there was no symmetric construction of new capabilities in sectors based on natural resources.
Concluding remarks: industrial path-through and policies in “turbulent times”

Crises are opportunities to challenge conventional forms of thinking. The taming of the ideological gales of the 1980s and 1990s give an opportunity to discuss industrial policy from a more pragmatic perspective. There is no lack of economic theory for that. Evolutionary economics has developed tools to discuss learning, and the theme is increasingly welcome by mainstream authors. There is a rich tradition of studies of endogenous crisis (from Marx to Keynes, from Hilferding to Minsky) providing valuable insights as regards how to act during the good times, so as to reduce the impact of the crisis and the duration of the bad times. Many analysts are now demanding a new look at the classical authors that wrote on endogenous crisis and the contradictions between speculation in financial assets and investment in building new assets. Keynes was declared officially dead in economic thinking many years ago. But like the Cid Campeador, he continues to win battles after death.

The focus of this paper is on the microeconomic consequences of volatility and instability in prices and how they interact with long run growth in production and productivity. Assume the case in which there is a price shock consisting of a temporary rise in the price of Latin American commodities. This may be due to the normal fluctuations in the market, or may by large reflect speculation in the commodity markets, spurred by increasing uncertainty. A shock of this type favors sectors which are less technology-intensive. If the shock persists for some time, many firms will leave the market and human capital will be reallocated to other, less technology-intensive activities. As a result the shock produces more than short-term fluctuations. When relative prices return to their pre-shock levels, the capabilities lost in the adjustment process would not be easily recovered. The economic structure that emerges after the adaptation process would not be easily recovered. The economic structure that emerges after the adaptation process will have in the aggregate less capabilities, less sectors (a loss of diversification) and less human capital than before. When the shock ends, the economy will be less able to respond to new challenges, or to increase productivity at the same rate as before. The region will be running at a slower pace than the rest of the world, being unable to “keep in the same place”.

The process described above is not a fatal outcome: it depends on policy decisions. During about 5-6 years some Latin American countries experienced very favorable international conditions. This could have represented an opportunity to vigorously adopt policies in favor of technological learning, human capital accumulation and economic diversification. However, such an opportunity was missed. Of course, improving terms of trade in commodities naturally led the economy to reallocate resources towards these sectors and made it more difficult to encourage diversification. But a significant part of the responsibility lies on the mental framework of policy makers who were in general very reluctant to embrace industrial and technological policies. There is a strong tendency in economic departments to teach that industrial policy is a bad thing, almost a fault in character, even when it is clear -- from both a theoretical and empirical point of view -- that stickiness is an outstanding feature of technological learning. The teachings of economic history in this field have been largely ignored. Moreover, we are taught that virtue is to tie your own hands while at the same time set free the invisible hand of the market. This kind
of ideological constraints has been stronger in developing countries, where ideas are in many cases copied uncritically. But virtue has not been rewarded. These policies avoided picking the winners, but produced loosers in almost every corner of the planet. In a tragicomic end, in some cases the idea of not interfering with the markets gave rise to the nationalization of most of the bank system.

Appendix: A simple Keynesian-Schumpeterian model

This appendix presents a model that highlights the role of technological learning and structural change in economic growth and also allows for discussing the impact of changes in relative prices. The international economy is formed by a small developing economy which is called South, while the rest of the world is the North. The South is structurally different from the North in the sense that it is a laggard economy with lower technological capabilities (i.e., there exists a North-South technology gap). We take as a point of departure the rate of economic growth compatible with the Balance-of-Payments constraint in the long run, given by equation (4).

\[ y - y^* = \mu q + \phi n \]

In equation (4) \( y \) is the equilibrium rate of growth of the South while \( y^* \) is the rate of economic growth of the North (assumed to be exogenous). We will develop the model assuming that purchasing power parity holds, \( q = 0 \).

The intensity of structural change (\( n \)) is an endogenous variable which requires to be explained. We will assume that two sets of variable shape structural change: North-South technological asymmetries and dynamic externalities related to the diversification of the economic structure.

The idea that relative rates of growth depend on technology and structural change is not a novel point in the literature. Several authors have already related demand-led Keynesian growth to international competitiveness based on Schumpeterian innovation and the international diffusion of technology (see for instance Dosi et al, 1990). In this strain of models, the efforts in the South for technological catching-up are crucial for defining the equilibrium rate of growth. Our specific contribution in this appendix is to include a new variable affecting the rate of catching up, namely the interaction between structural change and the technology gap. By doing so we intend to bring into the model the structuralist perception that structure and technology coevolves through time.

We will firstly focus on the dynamics of the technology gap, \( G \), defined as the ratio between technological capabilities in North and South, \( G = Tn/Ts \). What factors do influence this dynamics?

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5 See also Cimoli and Porcile (2007) in which this interaction is analyzed in the context of a Ricardian multigoods model.
First, it is affected by the initial level of the technology gap. Although most authors accept that this is an important factor, there is no agreement as about whether it has a positive or a negative effect (a topic already raised in the classical paper by Nelson and Phelps, 1966). From one hand, a high technology gap is an opportunity for imitation and thereby it boosts the potential rate of technical change in the South. On the other hand, if the technology gap is too high, the South will not possess the minimum capability levels required to learn and effectively become an imitator. We will assume that the influence of the technology gap on the rate of growth of the gap is negative, i.e. the South already has the minimum capabilities required to begin the imitation process. The gap represents an opportunity for technological spillovers and the higher the North-South gap the higher the rate of learning in the South, given the level of the South’s own efforts for catching-up. Subsequently, this assumption will be lifted and the possibility of a negative effect will be considered.

A second factor that contributes to define the rate of technological learning in the South as compared to the North is the technological-intensity of the economic structure. A more diversified and complex economic structure produces higher externalities and virtuous circles of innovation and diffusion (Bell and Pavitt, 1993; Cimoli, Porcile and Rovira, 2007; Peneder, 2002). As shown by Pavitt (1984) in his seminal work, science-based and specialized suppliers sectors are the main sources of innovation for the rest of the economy. This represents an avenue by which the economic structure affects the evolution of the gap. In effect, a larger share of these sectors in total industrial production will imply higher rates of innovation. Moreover, cultural and geographical proximity between industries facilitate the process of “learning by interacting” and therefore countries which have a more diversified structure will be more able to exploit this type of learning.

Still, the causality between the technology gap and the economic structure does not go just in one direction (from structure to technology): the technology gap does affect the rate of structural change. More specifically, countries which are more distant from the technological frontier would not be able to compete in new sectors and would be losing ground in those in which technological competition is fiercer. In particular, they will not be able to develop industries associated with the emergence of new technological paradigms nor promptly react to the rejuvenation of old industries (Freeman, 1994b).

This idea can be formally represented as follows:

\[
(A1) \quad g = a - bG - cN
\]

In the above equation \( g \) is the rate of change of the technology gap \( G \) \( (g = \dot{G}/\bar{G}) \), while \( N \) represents the degree of diversification of the Southern economic structure towards high-tech sectors. Higher values of \( G \) and \( N \) allow for Southern catching-up, leading to a fall in \( G \) \( (g < 0) \). Parameters \( b \) and \( c \) account for the intensity of technological spillovers and externalities, respectively, while the parameter \( a \) represents an autonomous component in the rate of growth of the gap.

The rate of structural change \( (n = \dot{N}/\bar{N}) \) depends on the level of the technology gap, according to the following equation:
(A2) \( n = h - jG \)

Clearly (A1) and (A2) form a system of two differential equations which yields a saddle point equilibrium, as shown by the following Jacobian (whose trace, \(-b\), and determinant, \(-jc\), are both negative numbers):

\[
\begin{vmatrix}
-b & -c \\
-j & 0
\end{vmatrix}
\]

In equilibrium we have:

(A4) \( G^e = \frac{h}{j} \)

(A5) \( N^e = \frac{aj - bh}{cj} \)

Equations (A4) and (A5) express the equilibrium values of the technology gap and the diversification of the economic structure as a function of parameters related to the technology gap and the intensity of dynamic increasing returns. Parameter values can be redefined by changes in economic policy – in particular by the industrial and technology policies, but also by macroeconomic policy.

The dynamics of the system is depicted in graph 1. The horizontal line \( G^* = h/j \) gives the equilibrium value of \( G \), for which the economic structure is stable (\( e = 0 \)). The curve GG gives the pair of values of \( G \) and \( E \) that makes \( g = 0 \).

We are particularly interested in the efforts each country deploys for technological learning, which are represented by the structural parameters \( a, c, h, \) and \( j \). These parameters reflect the institutional environment which coordinates and stimulates (or constrains) investments in formal and informal R&D (Nelson, 1993; Freeman, 1994a). They capture the extent to which institutions encourage or hinder cooperation and the exchange of knowledge among heterogeneous actors (firms, universities, public and private R&D centers), in such a way so as to give rise to dynamic increasing returns in the economy. Industrial and technological policies may shift these parameters by reshaping the institutional framework that coordinates learning.

A simple exercise of comparative dynamics can help to illustrate this point. We will assume that initially the South is in equilibrium at point \( H \) and there is an exogenous increase in the level of investment on the efforts for catching up with the technological frontier, giving rise to a fall in parameter \( b \). This shift the GG curve to the right (from GG1 to GG2) and defines a new equilibrium position in \( F \), featuring a more diversified, technology-intensive economic structure. The process of structural change is represented by the increase from \( N_1 \) to \( N_2 \). As a result, the North-South income gap falls along with the processes of structural change in the South, as represented in graphic 1B. It should be stressed that in equilibrium
the real income of the South is still lower than that of the North (perfect convergence implies \((Y/Y^*) = 1\)).

Another interesting point in graph1B is the effect of a more aggressive real exchange rate policy: a real devaluation shifts the curve RG1 to RG2 and reduces the North-South income gap (assuming as mentioned that Marshall-Lerner holds). Inversely, real appreciation produces the opposite results. Moreover, if the appreciation of the local currency persists for a long period, this may produce changes in the structure of the economy and the structural parameters vary. For instance, if a less diversified economic structure reduces complementarities and strengthens the negative effect of the gap (a rise in parameter \(j\)), periods of appreciation give rise to a new equilibrium with a higher technology gap and an economic structure concentrated in low-tech sectors. In this case the equilibrium value of the economic structure will be lower, even when the real exchange rate is back to its old value.

In sum, the simple Keynesian-Schumpeterian model presented above suggests that the key parameters for international convergence are related to the intensity of the processes of technological learning and structural change. In addition, it is shown that the exchange rate policy does affect the relative income in the long run equilibrium. If periods of real appreciation of the currency affect the rate of learning and the parameters of the model, they will give rise to a lower value of \(N\) in equilibrium. For instance, if complementary assets are destroyed reducing the value of \(a\), the rate of catching up will be reduced along with the degree of diversification in equilibrium.
Graph 1A and 1B. Structural change, the technology gap and the income gap: the effects of economic policy

Graph 1A shows how a fall in $b$ (the rate at which the South absorbs foreign technology) leads to a new equilibrium in which the economic structure is more technology-intensive (from H to F). This shift may be caused by a more vigorous technology policy. Graph 1B relates structural change to the relative North-South income. It can be seen that the income gap is reduced along with structural change in the South. Moreover, the graph also illustrates the effect of a change in macroeconomic policy: a real exchange rate devaluation shifts the RG1 curve to RG2 and reduces the income gap in equilibrium. Moreover, if this appreciation affects the structural parameters of the model, a new equilibrium value of $N$ will be obtained (not represented in the figure).
Bibliography


