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Disseminar conhecimentos e estimular a reflexão e o debate, apoiando o desenvolvimento dos servidores, o seu compromisso com a cidadania e a consolidação de uma comunidade de praticantes, especialistas e interessados nos temas de políticas públicas e gestão governamental.

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Sumário

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Editorial

Caro(a) leitor(a),

Este número especial da Revista do Serviço Público reúne uma coleção de artigos apresentados no Seminário Internacional "Papel do Estado no Século XXI: Desafios para a Gestão Pública", organizado pela Escola Nacional de Administração Pública e pelo Ministério do Planejamento, Orçamento e Gestão e sediado em Brasília nos dias 3 e 4 de setembro de 2015. O Seminário contou com a participação de eminentes acadêmicos nacionais e internacionais no debate sobre a interação entre governo e iniciativa privada para a promoção do desenvolvimento econômico, os quais apresentaram seus trabalhos e foram convidados para a elaboração deste número especial.

O primeiro artigo, *Financial Governance After the Great Recession: What Changed and What Didn't?*, de Jan Kregel, trata das principais inovações em governança financeira em mercados desenvolvidos após a crise financeira internacional de 2008. O texto foca os requerimentos de capital e as regulações macro prudenciais, destacando que essas políticas não constituem novas provisões regulatórias, embora venham sendo adotadas há algum tempo sem grande sucesso. O autor argumenta que essas políticas não são capazes de proteger as economias em desenvolvimento, em virtude da instabilidade financeira provocada pela falha de governança nas economias mais desenvolvidas.

O segundo artigo, *Energizing Industrial Development: the Role of the State in 21st Century Greening Strategies*, de autoria de John Matthews, traz uma revisão das principais questões envolvidas na "estratégia industrial verde", discutindo as estratégias de instituições estatais que vêm sendo desenvolvidas na China, no Brasil, na Índia e na África do Sul. Segundo o autor, o estado desenvolvimentista do século XXI deve ser um praticante de estratégias industriais de energia limpa. O modelo brasileiro, com o envolvimento de instituições estatais com planos evolutivos de dez anos para energia renovável, investimento direcionado com exigências de conteúdo local por meio do Banco Nacional de Desenvolvimento Econômico e Social (BNDES) e a promoção da redução de custos por meio de leilões reversos mediados pelo Estado, é apresentado pelo autor como uma estratégia viável.

Mario Cimoli, Giovanni Dosi e Joseph Stiglitz escrevem o terceiro artigo deste número, intitulado *The Rationale for Industrial and Innovation Policies*. Segundo os autores, a evolução das indústrias nos últimos dois séculos em todos os países tem sido apoiada por uma série de políticas públicas dedicadas aos padrões de acumulação de capital, às regras de comércio, à organização dos mercados, aos esforços de inovação e ao processo de criação e difusão de conhecimento. Como destacam os autores,

instituições específicas foram criadas para apoiar esses progressos e tiveram um papel central para o crescimento econômico. A proteção de indústrias nascentes, as definições de regimes de comércio e de propriedade intelectual, a distribuição de rendas não laborais e a coerência com políticas macroeconômicas são elementos centrais dessas políticas. Os desafios atuais das políticas de indústria e de inovação são discutidos à luz de experiências recentes em países emergentes.

O quarto artigo, de Leonardo Burlamaqui, intitulado *Governing knowledge: Intellectual Property Management for Development and the Public Interest*, traz como hipótese central a ideia de que as últimas três décadas trouxeram uma grande mudança no campo de propriedades intelectuais e regulações. As fronteiras dos interesses privados foram, segundo o autor, hiperexpandidas enquanto as do domínio público foram significativamente reduzidas. O autor busca demonstrar que esse fenômeno é prejudicial para a difusão da inovação e para o aumento da produtividade. O artigo desenvolve o argumento teoricamente, apresentando algumas evidências empíricas e fornece algumas recomendações de política sobre como redesenhar as fronteiras entre os espaços público e privado para produzir um cenário institucional mais democrático e voltado para o desenvolvimento. A proposta analítica desenvolvida pelo autor, a "Governança do Conhecimento", busca fornecer uma estrutura na qual, no campo de criação e difusão do conhecimento, a linha divisória entre os interesses privados e o domínio público deve ser redesenhada. O objetivo central do artigo é fornecer um argumento para um conjunto de regras, redesenho regulatório e coordenação institucional que possa privilegiar o comprometimento com a distribuição em detrimento do direito de excluir.

O quinto e último artigo, *A Second Order Diffusion Model with Application in Capital Flow*, de autoria de Luiz Bevilacqua, introduz uma nova teoria acerca do processo de difusão. Essa nova teoria introduz uma abordagem de segunda ordem à dinâmica do espalhamento de partículas em um meio de apoio. A nova contribuição do artigo é a consideração de dois fluxos simultâneos no mesmo sistema dividindo a nuvem de difusão em duas frações. Segundo o autor, a possibilidade de trabalhar com dois fluxos simultâneos é muito mais adequada para modelar dinâmicas populacionais, doenças infecciosas com fluxos de pessoas em um determinado ambiente e, claramente, fluxo de capitais. Embora a teoria proposta pelo autor não tenha sua origem na economia, Bevilacqua destaca que os resultados apresentados pelo novo modelo são muito interessantes e aceitáveis pelo senso comum.

Boa leitura.

Gleisson Cardoso Rubin
Presidente da Enap

Editorial

Dear reader,

This special issue of the Public Service Review gathers a collection of articles presented at the International Seminar "The Role of the State in the 21st Century: Challenges for Public Management ", organized by the Brazilian National School of Public Administration and the Ministry of Planning, Budget and Management and held in Brasília on 3 and 4 September 2015. The seminar was attended by national and international eminent scholars in the debate about the interaction between government and private sector for the promotion of economic development, who presented their work and were invited to the preparation of this special issue.

The first article, *Financial Governance After the Great Recession: What Changed and What Didn't?*, by Jan Kregel, deals with the major innovations in financial governance in developed markets after the financial crisis of 2008. The text focuses on the requirements of capital and macroprudential regulations, highlighting that such policies are not new regulatory provisions, although they are being adopted for some time without much success. The author argues that these policies are not able to protect the developing economies, due to the financial instability caused by the failure of governance in the most developed economies.

The second article, *Energizing Industrial Development: the Role of the State in 21st Century Greening Strategies*, written by John Matthews, brings a review of the main issues involved in the "green industrial strategy", discussing the strategies of state institutions that are being developed in China, Brazil, India and South Africa. According to the author, the developmental state of the twenty-first century should be a practitioner of industrial strategies of clean energy. The Brazilian model, with the involvement of state institutions with rolling ten-year plans for renewable energy, targeted investment with local content requirements through the National Bank for Economic and Social Development (BNDES) and the promotion of costs reduction through reverse auctions mediated by the state, is presented by the author as a viable strategy.

Mario Cimoli, Giovanni Dosi and Joseph Stiglitz wrote the third article of this issue, titled *The Rationale for Industrial and Innovation Policies*. According to the authors, the evolution of industries in the last two centuries in all countries has been supported by a series of public policies devoted to the patterns of capital accumulation, the rules on trade, the organization of markets, the innovation efforts and the process of creation and dissemination of knowledge. As the authors point out, specific institutions were created for supporting these progresses and have played a central role in economic growth. The protection of infant industries, the

definitions of trade and intellectual property regimes, the distribution of rents and the coherence with macroeconomic policies are central elements of these policies. The current challenges of industry and innovation policies are discussed in the light of recent experiences in emerging countries.

The fourth article, by Leonardo Burlamaqui, titled *Governing knowledge: Intellectual Property Management for Development and the Public Interest*, brings as a central hypothesis the idea that the past three decades have brought a major change in the field of intellectual properties and regulations. The boundaries of private interests were, according to the author, hyperexpanded while those of the public domain were significantly reduced. The author seeks to show that this phenomenon is detrimental to the diffusion of innovation and to increase of productivity. The article develops the argument theoretically, presenting some empirical evidences and provides some policy recommendations on how to redraw the boundaries between public and private spaces for producing a more democratic and development-oriented institutional setting. The analytical proposal developed by the author, the "Governance of Knowledge", seeks to provide a framework in which, in the field of creation and diffusion of knowledge, the dividing line between private interests and the public domain shall be redesigned. The central objective of this article is to provide an argument for a set of rules, regulatory redesign and institutional coordination that can favor the commitment to the distribution over the right to excluding.

The fifth and final article, *A Second Order Diffusion Model with Application in Capital Flow*, authored by Luiz Bevilacqua, introduces a new theory about the diffusion process. This new theory introduces a second order approach to the dynamics of particles scattering in a supporting meaning. The new contribution of the article is the consideration of two simultaneous flows in the same system dividing the diffusion cloud into two fractions. According to the author, the possibility of working with two simultaneous flows is much more suitable for modeling population dynamics, infectious diseases with flows of people in a given environment and, obviously, capital flows. Although the theory proposed by the author does not have its origin in economics, Bevilacqua underscores that the results presented by the new model are very interesting and acceptable by common sense.

Enjoy your reading.

Gleisson Cardoso Rubin
President of Enap

Financial Governance After the Great Recession: What Changed and What Didn't?

Jan Kregel
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Abstract

Finance in general, and banking in particular, are probably the only areas of the economic system where there is widespread agreement on the necessity of formal governance. Most governments reserve for themselves the right to issue debt in the form of coins and currency; in addition private providers of means of payment have failed so frequently to provide a safe and secure means of payment, with disastrous consequences for the operation of the real economy that governments have sought to regulate financial to prevent financial crisis. However, in an open global economy the regulations of national governments have little impact on the operation of global financial markets which are regulated by the governments of developed countries. Thus the regulations determined in developed country markets, in particular the US are of crucial importance to the governance of finance in developing countries. This paper considers the main innovations of developed country governance in the aftermath of the recent crisis, in particular capital requirements and macro prudential regulations and suggests that they are in fact not new regulatory provisions, but have been employed for some time with little succeeds and are thus not likely to shield developing countries for the financial instability caused by the failure of governance in developed country markets.

Keywords: financial management, economic system, economic crisis, monetary policy, financial institution, regulation, governance

The Nature of Financial Institutions

The methods of financial governance depend on how financial services impact the pursuit of government's policy objectives. The traditional approach considers finance and financial services as equivalent to any other good or service provided in the economy; provision is thus subject to the operation of market forces and governance involves augmenting the operation and efficiency of those forces. Indeed, one of the major post-war criticisms of one of the most successful examples of financial governance, the New Deal Glass-Steagall Act, was that it created a monopoly for commercial banks in the provision of insured bank deposits which provided them zero cost funding. Like any monopoly these conditions were considered as market imperfections and thus considered as inefficient and a wasteful misallocation of resources. The wave of deregulation and liberalisation of US financial markets that occurred in the 1980s was based on this argument. In the context of the run up to the recent financial crisis this traditional approach was represented by the Chairman of the Board of Governors of the Federal Reserve System Alan Greenspan who based his approach to governance of the financial system on the idea that market forces limit leverage and risk: ''private regulation generally has proved far better at constraining excessive risk-taking than has government regulation.'' (Greenspan, 2008) An alternative approach, based on the contributions of Keynes, Schumpeter, Minsky and other analysts of monetary cycles argue that financial institutions and financial services are inherently different from produced real goods and services and the standard conditions for the existence of market supply and demand are not satisfied and are thus inapplicable. In particular, this relates to the absence of any constraints on the degree of leverage and financial innovation that is the basis of the creation of money, liquidity and near-money substitutes, requiring active governance of the process by government regulatory authorities.

It is important to note that representatives of the diverse approaches to governance both as Greenspan and Hyman Minsky agree that the driving force behind the instability of the financial system; they diverge on the most appropriate governance mechanism. For Greenspan "The very nature of finance is that it cannot be profitable unless it is significantly leveraged... and as long as there is debt, there can be failure and contagion." (Greenspan, 2013) This assessment is virtually identical to Minsky's view: "Banks are profit maximizing organizations. The return on owners' equity is P/B = (P/A) (A/B) where P is profits, B is the book value of owners' equity, and A is assets. Given this profit identity, bank management endeavors to increase profits per dollar of assets and assets per dollar of equity." (Minsky, 1977: 17) But, Minsky adds an additional factor, that innovation is an integral part of the creation of leverage: "During periods of banking and financial innovation, the supply schedule

of credit to business is virtually infinitely elastic. The availability of financing leads to increases in 1) capital asset prices relative to income, 2) the demand for investment goods, and 3) investment activity that is financed. The period in which a virtually infinitely elastic supply of credit exists is transitory, however, for the ever increasing amount of investment that is financed will lead to first an inflation in prices relative to wages and then to a wage inflation."(Minsky, 1977: 17-9) One of the most important innovations in the recent period has been the use of derivatives: And also here Greenspan's assessment is based on the application of market controls: The reason that growth has continued despite adversity, or perhaps because of it, is that these new financial instruments are an increasingly important vehicle for unbundling risks. These instruments enhance the ability to differentiate risk and allocate it to those investors most able and willing to take it. This unbundling improves the ability of the market to engender a set of product and asset prices far more calibrated to the value preferences of consumers than was possible before derivative markets were developed. The product and asset price signals enable entrepreneurs to finely allocate real capital facilities to produce those goods and services most valued by consumers, a process that has undoubtedly improved national productivity growth and standards of living. (Greenspan, 1999)

Thus both consider leverage (the excess of the institution's liabilities over owners' equity) as endemic and essential to the operation of the financial system. And both would have accepted Minsky's citation of Henry Simons: "Banking is a pervasive phenomenon, not something to be dealt with merely by legislation directed at what we call banks" The only difference is in how to reign in the operation of competitive innovation and the profit motive with the fact that leverage, which determined the supply of finance, is not subject to equilibration by any market forces. For Minsky "a fundamental flaw exists in an economy with capitalist financial institutions, for no matter how ingenious and perceptive Central Bankers may be, the speculative and innovative elements of capitalism will eventually lead to financial usages and relations that are conducive to instability."

Indeed, Greenspan also appeared to share this view for in the aftermath of the recent financial crisis he recognized the error of his belief in the limits on the creation of liquidity by means of leverage was subject to market forces: "I made a mistake in presuming that the self-interest of organizations, specifically banks, is such that they were best capable of protecting shareholders and equity in the firms." "Those of us who have looked to the self-interest of lending institutions to protect shareholders' equity, myself included, are in a state of shocked disbelief." "I've found a flaw. I don't know how significant or permanent it is. But I've been very distressed by that fact." (Greenspan, 2008)

As the greatest financial crisis since the Depression of 2007-8 morphed into the Great Recession of 2009-14 there appeared to be a consensus that the market was not capable of governing finance without a more rigorous set of regulations and supervision. This general agreement led to a series of Reports and measures proposing increased governance of financial institutions and in particular of banks issuing insured deposits serving as means of payment. In the United States the Dodd-Frank Act was introduced, in the United Kingdom the Vickers Report proposed ring-fencing commercial banking deposit taking activities, and the European Union Likannen Report, and the introduction of stronger central regulations in the form of the Single Rule book. Even international organisations were involved, in particular with the upgrading of the Financial Stability Forum, created in the aftermath of the Asian Crisis, to a Financial Stability Board, given broad powers by the Washington meeting of Heads of State and Government after the outbreak of the financial crisis in 2008.

Unfortunately, instead of focusing on the most appropriate measures to ensure stability of the economic system as a whole through enhanced and improved financial governance, much of the newly introduced governance legislation sought to respond to criticism that central banks and government agencies had allowed creditors to escape losses, bankers to escape prosecution and their insolvent financial institutions to be bailed out with government funding, rather than supporting the debtors, in the US households by writing down their underwater mortgages, and the Southern tier countries of the Euro zone by writing down government debts. Indeed, one of the major causes of the transformation of the financial crisis into generalized economic recession and growing unemployment was the asymmetric response to the crisis, supporting creditors and the value of impaired assets and imposing adjustment on the debtors without pursuing policies that eased their ability to service their debts.

Aside from a number of institutional provisions, such as the creation of numerous committees on the national and international level to monitor financial institution behavior and to warn of impending financial crises and to propose ex ante measures to avoid them, the main remedial measures have been:[1]

Regulations (in the US known as the Volcker rule) that restrict proprietary trading by regulated and insured subsidiaries of financial institutions. The intention is to reduce the subsidy to risk-taking created by provision of deposit insurance to the liabilities of these institutions.

[1] The measures have been proposed by a number of different bodies such as the Financial Stability Board, the Bank for International Settlements, national governments' regulatory agencies and in the case of the European Union the creation of a Single Rule Book which consolidates many of these measures under the authority of the European Central Bank (cf. Tonveronachi, 2015)

Rapid Resolution Authority, including "Living Wills" which provide a procedure for the bankruptcy of very large financial institutions according to a detailed plan of distribution of assets and liabilities (the living wills) to act as a substitute for government rescue and again to reduce the implicit subsidy to banks that are believed to be rescued in the event of insolvency.

Higher Capital ratios -- Enhanced Owners' Equity: to cover anticipated losses from excessive risk-taking and to avoid crisis. The idea is that bailouts can be avoided if PSI requires equity owners to absorb the losses from excessively risky behavior. Unfortunately this approach ignores the fact that a single case of equity write-down would be contagious to other institutions. Finally, the risk weighted capital asset ratios are supplemented with aggregate capital and liquidity ratios, with special supplements for large banks and rebasing the ratios on a more limited definition of capital limited to owners' equity or what is the context is called "loss absorbing" capital.

Liquidity buffers -- to ensure a higher share of liquid assets in portfolios to provide a first line of defence in meeting losses from excessive risk taking so that financial institutions can maintain funding by drawing on liquid marketable assets to meet a shortfall in funding in the case of portfolio losses and thus prevent a liquidity crisis from degrading into insolvency.

Stress Tests -- virtually all bank regulators have initiated stress tests to gauge the loss absorbing capacity of capital positions in event of an extreme crisis. The standard is that the bank should have enough capital to absorb losses in a severely adverse economic environment and continue to lend to households and businesses However, these event scenarios still do not assess the impact of interbank exposures and assume that existing balance sheet structure remains unchanged in response to a series of losses, yet it is precisely these responses to crisis that may well be the major contributing factor in crisis! As a result, these measures technically remain under the rubric of microprudential regulation. Many regulators also limit permission to grant dividends and increases in executive compensation to the successful completion of the stress tests.

It is perhaps unnecessary to note that the reliance on capital as a regulatory device depends on control of principals on their agents and the fact that this does not in general exist in Financial Markets as admitted by Alan Greenspan in "shocked disbelief": "The Agents (Management of Financial Institutions) have no self-interest to protect Principals' (the shareholders') equity".

Amongst the myriad of particular measures that have been proposed by governments in the countries worst impacted by the financial crisis (the Dodd-Frank Act comprises over 800 pages and calls for some 400 additional rules to be

written by various financial agencies, plus a series of studies and reports to be produced) the major innovations in financial governance introduced in response to the crisis are in the importance given to macroprudental regulation and enhanced capital ratios and liquidity buffers. The rest of this paper will provide an analysis of the effectiveness of these new approaches to financial governance as a means of enhancing the financial system stability and assess how they have improved the operation of the financial system.

The New Role for Bank Capital[2]

Concerns about bank capital ratios first arose in a special committee in the Bank for International Settlements to deal with risks in the clearing of international transactions following the failure of Herstatt Bank in 1974. It produced two Concordats that sought to allocate regulatory responsibility for banks operating internationally to their home regulatory agency and to provide for global consolidated balance sheet reporting. The rapid rise in international lending produced by the petroleum crisis later in the decade led the Committee to increase focus on the sharp decline in bank capital, and its inadequacy to meet Latin American defaults on syndicated lending. As will be discussed below, it was these concerns that led the Cooke Committee (which was to become the Basle Committee on Bank Supervision) to formulate what it called "macroprudential" regulations. (Clement, 2010)

In essence the Concordat was an international supervisory agreement designed to provide a substitute for an absent international lender of last resort, or better, for the assignment of international lender of last resort responsibility for banks operating internationally. It was the failure of the Concordats to achieve this latter objective that led to the push for international capital adequacy as a second-best substitute. It was given further impetus as a means of providing a "level playing field" for international banks when Japanese banks, with virtually non-existent equity capital, started to dominate the London Eurodollar markets to the detriment of US and European banks. The first formal proposal for capital ratios to be applied to banks operating internationally (Basle I), was issued by the BCBS in 1988 for formal approval by national regulatory bodies.

Minimum capital adequacy regulations in various forms in various jurisdictions had existed throughout US banking history, and after the creation of the Federal Reserve were frequently proposed, but never introduced in the post-war period. This was largely due to the dual regulatory structure of National and state chartered banking that characterized the US financial system. It was the rapid expansion of

[2] A more extensive discussion of the Basle proposals is in Kregel (2006)

bank lending in the aftermath of the sharp rise in oil prices and US inflation that led Paul Volcker in December 1981 to introduce the first numerical minimum capital adequacy ratio of 5 per cent for primary and 5.5 per cent for total capital.[3]

The motive behind Volcker's decision was the failure of money supply control to reduce bank lending (or inflation as had been promised by monetarist economists). Banks simply maintained lending margins by raising interest rates in step with inflation and continued to expand lending, irrespective of the level of policy rates, and without any need to raise bank equity. Thus, Wall Street analysts such as Henry Kaufman suggested that a more effective policy of regulatory capital ratios would force banks to raise equity to support their increased lending. If capital markets recognized the increased riskiness of the banks' loan portfolios they would reduce bank multiples pushing up the cost of capital to the point at which banks would no longer find it profitable to lend. The imposition of capital standards at that time was also in line with the trend toward deregulation and increasing the role of the market in determining interest rates.

For comparison with the current approach to capital ratios, it is important to recognize that capital adequacy ratios were initially viewed as a monetary policy measure, *not as a regulatory measure to ensure bank solvency*. The point had already been noted by Cooke (1949: 77) who concluded that "a required capital ratio may prove advantageous as a general credit control device."

Indeed, there seems to have been very little historical support for bank capital as a bulwark for bank solvency. A study of the bank statements of failed and successful Florida State Banks in the period 1922-1928 (the first Florida banking crisis that preceded the 1929 collapse) found that "A comparison of the statements of the groups of failed and successful banks discloses the interesting fact that … the net worth of the failed banks was a noticeably larger percentage of total liabilities than was the net worth of the successful banks. (12.9 % and 10.4% respectively)." The basic reason was "the larger and more rapid increase of the resources of the failed banks during the boom created problems of wisely investing the added funds." Rather than increasing their cash holdings, the banks rushed to invest the funds in increasingly doubtful real estate projects. The rapid increase in assets was rewarded by the stock market as an indication of increased future earnings, instead of representing an increase in the volatility of earnings due to the possible

[3] However, the seventeen largest banks operating in international markets were exempt. The official explanation was that they had access to superior liquidity and confidence and thus required less capital –however, as would become evident the following year, the real reason was that they were unable to meet the new minimum requirements, even before the Mexican default. In April 1985 the ratios were increased to 5.5 and 6.0 per cent, despite the fact that in the intervening period Continental Illinois Bank had collapsed with a 5.8 per cent ratio.

overinvestment in real estate in the area (much of which was still under swamp water). The capital market clearly provided no limit on the ability of these banks to expand their doubtful lending practices. A very similar episode took place in the 1980s as savings and loan institutions attempted to grow their way out of the difficulties created by the deregulation of the US financial system.

In theory, the imposition of capital ratios was to increase solvency by giving shareholders incentives to constrain bank management expansion into excessively risky lending to raise returns. If capital requirements have had scarce success as a constraint on bank lending, it is unlikely that they should have a positive influence on bank solvency. The already cited report of the 1920s Florida real estate crisis presented the traditional view of the role of bank capital noting that "net worth items not only disclose the volume of funds furnished the bank by stockholders, but also measure the amount of shrinkage and loss that can take place among the assets before any loss can fall upon the depositors." However, it goes on to note "The fact that the net worth was a greater percentage of total liabilities of the failed banks than of the successful, apparently disclosed a sounder and more favourable condition, for it indicated that the failed banks had a relatively larger amount of owners' investment with which to absorb shrinkages and losses among the assets before the losses could fall upon the depositors." Yet this did not turn out to be the case. And this is not a view that was limited to the historical experience of the 1920s.

Cooke (1949, 75) noted that "data compiled from the annual reports of the Comptroller of the Currency show that, although their surplus and reserves had been wiped out, national banks which failed during the twenty-five year period from 1920 to 1944 generally had only slightly lower capital-deposit ratios [from 10.6 per cent to 32.3 per cent] at the date of failure than active ones." She also notes that capital ratios shot up in 1934, as depositors withdrew funds the capital ratio would automatically rise.

A study published in 1995 (cited in Matten, 2000:34) comparing a retrospective assessment of American banks' capital adequacy measured under the original Basel Accord with the actual soundness of banks measured by the classification by US bank supervisors based on their "CAMEL" scores and actual insolvencies for the period between 1984-1989 showed that more than half of the failed banks in this period and about three quarters of the banks that were rated high risk problems by their supervisors would have been classified as either adequately or well capitalized under the risk-based capital regime introduced by the Basel Accord.

George Vojta states that "Levels of capitalization appear to have had no direct causal relationship to the incidence of bank failure." Nor is there evidence to suggest that increasing capital ratios provides increased protection against bank failures.

And there seems to be a number of good reasons for this. The first is the precise role to be played by capital in providing stability. Bankers have generally tended to argue that capital is not required to face general losses from their activities. These losses are to be met from current income. For example, a Citibank study covering the period 1962-72 showed that "in no year did after tax loan charge-offs exceed 13.1 per cent of after tax earnings, and that on average charge-offs in that period were 6 per cent of annual earnings. … Average chargeoffs as a percentage of the loan loss reserve were 3.5 per cent… After tax loan losses averaged less than 0.5 per cent of total capital accounts." Thus, on average bank losses will be covered through income flows, not met by capital. Indeed, most bankers would argue that capital is meant to protect the bank from abnormal conditions. However, Lucille Mayne (1972) notes "that it is not possible to devise a generally acceptable measure of capital adequacy since the essential function of capital is to serve as a defense against the occurrence of unpredictable events."

Vojta goes further and suggests that "[t]he capital account of a bank is not adequate to maintain solvency in the event of a major liquidity crisis… Effective defense against ultimate crisis comes from lenders of last resort" that is from the central bank. Finally, Vojta notes that "This does not mean that the government is expected to bail out mismanaged institutions; but neither should financial institutions be expected to be so overcapitalized as to bail out government's mismanagement of the economy. As a matter of fact and practicality, the economic disaster case should be excluded as a relevant scenario for capital adequacy purposes." The clear position of the financial industry is that capital is not an efficient means of providing a defence against abnormal conditions such as a systemic crisis – this is the role of lender of last resort, and is not the relevant factor in dealing with normal losses – these are best dealt with through provisioning out of income and chargeoffs.[4]

But, the current justification for capital ratios has nothing to do with their ability to constrain risky lending activity or to reinforce principals' monitoring of their agents. It is agnostic about the business model and operating mechanism of financial institutions and simply proposes to set bank capital at a level sufficiently large to cover any conceivable losses without incurring technical insolvency. It is thus also independent of any attempt to mitigate risky behavior or to provide an early warning market mechanism for impending instability.

However, it does rest on the ability to envisage the worst case scenario of systemic losses, supported by the stress tests. And not only is there no theoretical

[4] Vojta, op cit., p. 179. He gives as example the 1969 credit crunch in which "No level of capital would have been adequate to permit affected institutions to withstand general stress of this magnitude." And "It was only the intervention of the Federal Reserve that avoided collapse of the entire financial system." p. 173, note 10.

or practical way of measuring this magnitude (this is what value at risk (VAR) was supposed to provide) without being able to predict the innovations that the imposition of capital requirements will generate in financing practices as financial institutions compete for profit.

It has been argued that irrespective of efficiency, the imposition of higher capital ratios is a virtually costless means of reducing financial instability. In contrast to the arguments used in the 1970s when it was considered an instrument of monetary policy it is now argued, on the basis of the Modigliani-Miller theorem, that higher capital ratios will have no impact on bank lending rates (see Admati and Hellwell, 2013). The argument is that in perfect capital markets absent tax distortions, the composition of bank capital between equity and debt should have no impact on the cost of capital. Aside from the fact that the assumptions required for the validity of this result are never met in real financial markets, and there is no statistical evidence to support the claim (see Cline, 2015), more important it that the argument is based on a static equilibrium result applied to a dynamic disequilibrium adjustment process. In a crisis additional capital would have to be raised in distressed market conditions, and has J. Dimon (2015) has pointed out, in the last crisis "Banks continued to lend freely because effectively they are the "lender of last resort" to their clients as the Federal Reserve is to the banks". But in the event of a future crisis because of the higher capital requirements JPMChase would be unwilling to accept deposit transfers from weaker banks because of it would require higher capital since additional deposits would incur higher capital charges. In the next crisis "It will be harder for banks either as lenders of last resort or as market-makers to "stand against the tide."

The result of such procyclical behavior by stronger banks facing additional capital requirements would mean an overall decline in lending and an overall rise in capital costs and borrowing rates in response to crisis. The result of a static equilibrium adjustment process cannot be used to explain the dynamic adjustment of the system to distressed conditions.[5]

Finally, there is no method to adequately measure bank equity as "loss absorbing" capacity. First because capital is an accounting concept and bears no relation to the realizable value of bank assets financed with bank equity. And as both Greenspan and Minsky noted in quotations above, the viability of the financial sector depends on the existence of leverage to produce bank earnings. As noted by Vojta above, and shared by Minsky, the most important element in a financial institution's stability is the ability of its debtors to generate the cash flows to service their debt, and second

[5] He also notes the negative impact on dealer markets which depend on leverage to fund inventory: "Market depth … a precursor of liquidity … of 10-year Treasuries … today is $125 million, down from $500 million at its peak in 2007."

to be able to generate sufficient income to meet the market return to capital for it is the search for higher incomes that drives the innovation in financial practices which is at the basis of financial instability and the potential for systemic risk. It is in this sense that bank stability is a question of the operation of the broader macro economy and that has led to the interest in macroprudential regulations.

MacroPrudential Regulation

As noted above, "macroprudential" regulation is not really a new concept, having been implicitly proposed by Minsky in his early work in the 1960s and 1970s and then independently developed by the Cooke Committee of the Bank for International Settlements, largely under the influence of the work of its then Economic Adviser (subsequently Managing Director), Alexandre Lamfalussy, as he attempted to suggest measures to forestall what he considered to be the forthcoming Latin American debt crisis.

Minsky had early criticized the traditional "micro" approach to bank regulation, in which "The instability of banks and other financial institutions is usually described in term of runs and defaults at particular institutions without a clear explanation of why such strong assets substitution quite suddenly becomes the rule of the day. When conceived in terms of bank runs and defaults, a particular bank fails because of its own, idiosyncratic attributes. Its management has been incompetent or committed fraud. Such a failure may have repercussions on other banking institutions, in that for a time financial markets fail to work normally. This creates transitory refinancing problems for otherwise solvent banks, … idiosyncratic failures can trigger an epidemic of bank failures, imparting an adverse "depression-creating" shock to the economy." (H.P. Minsky and Claudia Campbell, 1987: 254-5). Thus "microprudential" regulation looks ideally at the structure and comportment of an individual bank, rather than its relations with the rest of the financial system or the overall macroeconomic environment.

In the US, there was a shift away from this approach after the crisis of the savings and loan banks in the 1980s towards a more "risk"-based approach, although the then Chairman of the Federal Deposit Insurance Corporation (FDIC) claimed that the changes "do not reflect a fundamental change in the FDIC's traditional approach to risk assessment". She nonetheless noted that examinations were "working to "bridge the gap" that currently separates the "macro" perspective of economics and market trends from the "micro" perspective of bank examinations in ways that will translate data into guidance that examiners can use in assessing and monitoring risks in institutions with differing levels and types of risk exposure. … The result will be a

more effective and accurate assessment of an institution's ability to manage its risks within a structured framework, which will enhance safety and soundness." (Helfer, 1996) Despite the clear recognition of impact of macro conditions on micro prudential regulation the approach still placed the emphasis on the examination of the individual institution, rather than on systemic impacts on the entire financial system.

AS noted above, the BIS and its Economic Adviser were stimulated by the sharp rise in bank lending relative to bank capital to push for higher capital standards, but also recognized that they would not be sufficient given the system nature of the forces that were propelling the increased international lending. They thus noted that "Prudential measures are primarily concerned with sound banking practice and the protection of depositors at the level of the individual bank. Much work has been done in this area – which could be described as the 'micro-prudential' aspect of banking supervision. […] However, this micro-prudential aspect may need to be matched by prudential considerations with a wider perspective. This 'macro-prudential' approach considers problems that bear upon the market as a whole as distinct from an individual bank, and which may not be obvious at the micro-prudential level." ("The use of prudential measures in the international banking markets", 24 October 1979, pp 1–2, in BISA 7.18(15) – Papers Lamfalussy, LAM25/F67. quoted in Clement, op. cit., p. 61).

According to Ivo Maes (2010), the broad Bank for International Settlements "approach to financial stability, "marrying" the micro and macro-prudential dimensions of financial stability with its emphasis on the macro-prudential dimension, first came to the fore in the Cross Report on innovations in international banking. … this was the first published official document that used the term "macro-prudential" The Cross Report defined the macro-prudential domain as "the safety and soundness of the broad financial system and payments mechanism" (Bis, 1986, p. 2). … it focuses on the financial system as a whole, paying attention to the macroeconomic dimension of financial crises. It treats aggregate risk in the financial system as dependent on the collective behaviour of the financial institutions (which contrasts with the microprudential view, where financial institutions are regarded as having no influence on the global situation).

Thus while both Minsky and Lamfalussy provide a similar critique of traditional micro regulation and suggest the importance of formulating regulations that deal with the systemic nature of financial crisis, and in particular, the role of financial innovations as an integral part of the systemic factors that should be covered in macroprudential regulation there is a basic difference in their approach. And that difference lies in the fact that Minsky argued that it was impossible to formulate a coherent approach to macro regulation without and underlying theory of systemic

crisis. If micro regulation was grounded in an explanation of the behavior of individual banks, macro regulation would require an explanation of the behaviour of the entire banking and financial system. It was the search for this groundwork theory that led to Minsky's Financial Instability Hypothesis, developing Keynes's "foundations of an investment theory of business cycles and a financial theory of investment in a capitalist economy" (Minsky, 1994:2) to provide the explanation of the cyclical behavior and the systemic interactions that could provide the basis for the formulation of "macroprudential" regulation.

The current approach to macro prudential regulation still lacks this fundamental theoretical grounding. For example, according to Haldane (2014:2) "Since the crisis, financial regulation has become explicitly macro-prudential. This is an expression much-used, but generally little-understood. In a nutshell, it means that policymakers have begun using prudential means to meet macro-economic ends. Those macro-economic ends include tempering swings in credit and leverage – the classic credit cycle. Or, put differently, curbing the credit cycle appears to be an important ingredient of broadly-based macro-economic stability. For Persaud (2009) "Prudential Regulations for the Macro Economy" can be characterized as "A growing consensus around three ideas: Capital requirements need a countercyclical element to "dampen rather than amplify the financial and economic cycle" by "requiring buffers of resources to be built up in good times." … Greater emphasis on rules rather than supervisory discretion to counterbalance the political pressures on supervisors. … rules should include leverage limits liquidity buffers."

The modern approach thus falls short of Minsky's view that any macro prudential regulation would require "A more complete description of the instability of an 'economy with banking'." Such an approach needs to look behind the runs and analyze the structure of balance sheets, payment commitments and position-making activities. Position-making for a bank consists of the transactions undertaken to bring the cash position to the level required by regulation or bank management. In the position-making view, bank failures do not arise simply because of incompetent or corrupt management. They occur mainly because of the interdependence of payment commitments and position-making transactions across institutions and units."(Minsky and Campbell, 1987: 255) Minsky thus went on to recommend and to make formal proposals for a Cash flow Examinations system to Support Macro Prudential Regulations: "Examination and analysis balance sheets based on the view that liquidity is not an innate attribute of an asset but rather that liquidity is a time related characteristic of an ongoing, continuing economic financial institution." Basic to the idea of liquidity as an attribute of an institution is the ability of the unit to fulfill its payment commitments. Any statement about a unit's liquidity, therefore

depends upon estimating how its normal activities will generate both cash and payments, as well as the conditions under which its assets (including its ability to borrow as an "honorary" asset) can be transformed into cash. . . . Any statement about the liquidity of an institution depends upon assumptions about the behavior of the economy and financial markets. As the assumptions are changed, the estimate of the liquidity of the institutions will vary.

But, in Minsky's view the error in Macroprudential regulation is the same as that noted above in applying enhanced capital ratios, it is based on an essential static supply and demand analysis when not only is supply and demand in appropriate, it is the static analysis which is an even greater cause of concern.

Dynamic Macro Prudential Regulation[6]

But Minsky's "new" approach was not only to recognize the cyclical nature of the interactions generated by financing relations within the economic system, it took a much broader approach to regulation: "The supervisory and regulating structure for banking and finance that is in place not only reflects institutional features of the economy stretching back over at least 150 years, it also reflects the understanding, i.e. the economic theory, of how our type of economy works that ruled at the time when the bits and pieces of this structure was first put in place." (Minsky, 1994:6) Indeed, this was one of the advantages of Minsky's proposed cash-flow approach: "The perspective underlying the suggestions was of a dynamic, evolving set of financial institutions and relations. All too often it seems as if the Federal Reserve authorities have been surprised by changes in financial practices. One aim in the design of the examination system was to establish a regular reporting procedure which would force the authorities to be aware of institutional changes that were ongoing, and which furthermore forced the authorities to inquire into how the ongoing developments can be expected to affect the stability of the financial system." In a subsequent note Minsky gave as example: "One byproduct of the cash flow examination procedure will be more precise knowledge of the relations between the examined institutions and fringe banks. Such a clarification will enable the Federal Reserve to better know what is emerging in financial relations and to be better prepared for contingencies that might dominate as the determinants of its behavior." (Minsky, 1975:2)

That is, regulation must be institution and theory specific, which is why it must be reassessed frequently in relation to the changes taking place in the financial system. Examination was thus intended to force the central bankers to become aware of

[6] This section draws on Kregel (2014)

ongoing institutional and operational changes in the financial system, something that was clearly lacking in the Fed's analysis of the recent crisis which has now been revealed to have ignored the mechanics of securitization of subprime mortgages and the role of credit default swaps in the interrelationships between banks and other (fringe or shadow) institutions operating in these markets.

One of the advantages of the use of Minsky's approach to regulation based on the FIH as the basis for macro prudential regulations is thus that it "explains why regulatory structures eventually become obsolete or perverse. The normal, profit-seeking activities of agents lead to innovation in order to create new sources of profits; innovation can be in products, process or finance. The search for profits also drives agnates to avoid, evade and adapt to the structure of regulation and intervention put in place to constrain incoherence. In time this undermines the effectiveness of a regime of intervention that "stabilizes the unstable system". Therefore if regulation is to remain effective, it must be reassessed frequently and made consistent with evolving market and financial structures." (Minsky and Campbell, 1988: 6) Minsky stressed the point that "As the monetary system, the financial system and the economy are always in the process of adapting to changing circumstances, the quest to get money and finance right may be a never ending struggle." because what is an appropriate structure at one time is not appropriate at another. Throughout our history the reaction to some 'unpleasant events' in banking or finance has been to reform the structure of banking and finance, as well as the structure of government chartering, regulation and supervision of financial institutions. Our predecessors were not fools: … they knew the institutions of their time well enough so that when legislation changes institution, the new structure succeeded in correcting the malfunctioning, for at least the time being. Such a new structure of payments and financing was apt enough, so that a 'better' performance of the economy followed. However the perennial quest for the profits that successful innovators earn, energizes entrepreneurs. New financial and banning institutions and new financing patterns for business, households and government units emerge and their users prosper. Over time the initially apt pattern of regulation and supervision becomes increasingly inept: the inherited structure of regulation and the supervision first becomes not quite right and later becomes perverse. A cumulative effect of the institutional and usage changes that occur is that the institutions which are supped to contain the endogenous disequilibrating forces of our economy lose much of their power to do so." (Minsky, 1994: 4-5)

As an example he noted "The shift in position-making from trading in liquid assets in the 1960s to transactions in liabilities in the 1970s" and the "decrease in the margins of safety used to cushion fluctuations in cash flows. As a result, payment

commitments have become more closely coordinated with payment receipts so that small changes in conditions can cause a large increase for units (households and businesses who are indebted to banks and banks that are indebted to depositors) to acquire cash by selling assets that may have thin markets." (Minsky and Campbell, 1987: 255) This leads to a need to sell assets to acquire liquidity which causes a decline in asset prices and a "process that leads to a deep depression". Minsky thus argued that "The problems today are the result of competition for profits that has transformed an initially robust financial structure into a fragile system and in so doing made obsolete the structure of deposit insurance established 50 years ago." (Minsky and Campbell, 1988:7)

From this point of view the greatest error committed in the run up to the recent crisis was to allow a major change in the institutional structure of the financial system in the 1999 Financial Services Modernisation Act without any accompanying changes in the regulatory or supervisory structures.

The conclusion , which is just as relevant today, is that "The introduction, in today's environment of … capital requirements and greater public disclosure of problem institutions … would make it more, not less, likely that insurance payoffs will be required. In addition, these reforms would increase system instability." (Ibid.: 253)

What Has Changed?

This paper has suggested that the two major changes that buttress the increased role of financial governance in the aftermath of the financial crisis and Great Recession are not really new. Both increased capital ratios and macroprudential regulation date back to the financial crisis of the 1970s and have been in continuous use since then. They do not seem to have been prophylactic in preventing the increasing number and virulence of financial crises since that time. The analysis of the operation of these measures suggests that there is ample reason to believe that they are not particular efficient in providing governance of the financial system capable of preventing financial instability. As noted, building on Minsky's work, one of the basic difficulties with these measures is that they are not grounded in a solid theoretical explanation of the way the economy with a financial system generates crisis.

One of the most important elements in the failure of these measures is the belief that they are supported by a governance mechanism based on market forces. This was the response to the crisis in the 1930s, as well as the crisis of the 1980s which produced the proposals for capital ratios and macroprudential regulations. The response to the current crisis is no different as can be seen from a recent statement from Alan Greenspan: "An important collateral pay-off for higher

equity in the years ahead could be a significant reduction in bank supervision and regulation. Lawmakers and regulators, need to be far less concerned about the quality of the banks' loan and equity portfolios since any losses would be absorbed by shareholders, not taxpayers. This would enable the Dodd-Frank Act on financial regulation of 2010 to be shelved, ending its potential to distort markets — a potential seen in the recent decline in market liquidity and flexibility." Basically the position is that sufficiently high capital ratios will allow the operation of market forces as the only governance mechanism. In this position, we can conclude that nothing has changed in the dominant approach that the most effective financial governance is through the market.

Addendum: An Alternative for Brazil?

Is there an alternative? Real changes in financial governance requires a change in financial structure in order to control leverage. This would involve prohibiting financial institutions from offering means of payment through transferable deposit account, and to have them operated by a government agency, much like the postal savings banks that at one time existed in most countries. This would eliminate the profit driven innovation in the creation of leverage and liquidity in the system. Further, Minsky suggested that "it is worth investigating whether a permanent government Investment bank, such as the Reconstruction Finance Corporation, is a desirable feature for an economy where solvency crises are likely to occur" (Minsky, 1994: 11) This would mean that the degree of liquidity in the system would be driven by the government's fiscal policy.

This is a real change that could be implemented quite easily in Brazil since it is one of the few countries that has retained a highly successful government development bank. It is perhaps ironic that the bank is currently under threat because it has recently received financing from the Federal budget when this is a major opportunity for increased financial governance and an element of stability in the financial system since it is the government that is levered, not the Bank. National governments can never default on debt issued in their own currency.

Part of the criticism is based on the idea that it provides a subsidy to the Bank's clients and distorts competition with private financial institutions since the Bank lends at an interest rate that is lower than the rate at which the government itself borrows to fund the Bank. But this is first, a problem of monetary policy and governance of the Central Bank. And secondly it overlooks the subsidies provided to the private banking system whose investment portfolio is dominated by holdings of government debt which allows them to earn returns on equity in excess of 20 per

cent, double the standard in the rest of the world. The reason is, that in addition to the high interest rates due to monetary policy, the government offers its debt with inflation, interest rate and exchange rate guarantees. That is, the debt includes options that cover all the risks of holding the debt, which is already in essence credit risk free, since the government cannot default on the debt. The value of these implicit "options" also represent subsidies to the private banks and a major contribution to the costs of financial stability in Brazil. Any clear comparison of subsidies to the development bank and the private banks must take these subsidies to the private sector into account.

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Energizing Industrial Development: The Role of the State in 21st Century Greening Strategies

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Abstract

Industrial development, as it diffuses globally to encompass the great emerging 21st century powers China, India and Brazil, increasingly has to place energy issues at the core – to move off the fossil fuels that worked in the past but are creating impossible tensions now and to move towards a new green growth model that promises to reduce or eliminate those tensions as it expands. In this paper I review the issues involved in the new 'green industrial strategy' and discuss the institutional state strategies being deployed in China, India, Brazil and South Africa – the BICS countries – to drive the transition that is under way. The argument goes that in the 21st century the developmental state has perforce to be a practitioner of green industrial strategies. The Brazilian model with its threefold involvement of state institutions in developing rolling ten-year plans for renewable energy deployment, targeted investment with local content requirements through the national development bank and promotion of cost reductions through state-mediated reverse auctions, is discussed as a viable strategy.

Keywords: industrialization, strategic planning, sustainable development, public policy, renewable energy, international cooperation, case study

Introduction

There was a time when industrial development and energy were discussed in separate categories. The prevailing orthodoxy, which governed the 'East Asian Miracle' of Japan's industrialization, followed by that of Korea, Taiwan and Singapore, was that integration with the world's fossil-fuel economy represented the optimal path forward. Grow rich with coal and oil, and then diversify – this was the formula. It worked because as a group, the East Asian 'tigers' could not put too much strain on global fossil fuel supplies. But in the 21st century, as giants like China and then India and Brazil and South Africa are moving along the industrialization pathway, their energy choices are becoming critical – for themselves and for the planet.

Let us call these the BICS countries, as opposed to the BRICS – leaving out Russia which is a special case through continued dependence on fossil fuels. The BICS countries have a population numbering 2.7 billion (around a third of world population of 7.3 billion), and at this scale the pathway to industrialization cannot ignore the means through which the process unfolds. If the BICS countries were to follow the 'Business as Usual' pathway, with its strategy of exploiting access to fossil fuels wherever they can be found and are politically/economically available, they would run into serious geopolitical tensions well before the fuels ran out.

The western countries as they industrialized were able to tap resources from around the world, via colonialism and imperialism, while they exploited their own coal and oil reserves without any sense that they might be finite. And carbon emissions with their deleterious planetary climatic impact were not considered a problem. Obviously enough, these conditions do not apply today.

The emerging industrial powers, led by the BICS countries, have to invent a new development model that will enable them to bring ten times as many people to the rising income levels enjoyed by industrialized countries, while having to respect much tighter constraints on resources and fossil fuel usage. Without a 'circuit breaker' this challenge does not add up – the BICS countries would be trying the square the circle. The result would be heightened geopolitical tensions leading to war, revolution and terror, quite apart from ecological damage of unimaginable proportions.

But there is a circuit breaker – and it is green development. Its core is green growth. In their various ways, the BICS countries are all pursuing some variant of green growth alongside the fossil-fuelled and resource profligate model of development. This is their feasible pathway to industrial development. When one reflects on the issues involved, what other pathway is there?

The positive future-oriented scenario is one in which these countries maintain their focus on and commitment to green development, because of their overwhelming national interests in doing so. It is an argument that starts with the interests of

the emerging industrial giants in finding a feasible pathway for completing their industrialization, rather than with international conferences on climate change. The sceptical view is that these countries are doing too little, too late to reverse their previous fossil fuelled trajectory. Our scepticism is reinforced by the carbon lock-in that still prevails in the West. The US for example (pace President Obama's 11th hour efforts) is fixated on its 'energy revolution' involving coal seam gas and shale oil – fossil fuels that have only become accessible in the past decade because of technological developments, and which as high cost businesses now appear to be doomed because of falling oil prices. Japan is still focused on nuclear, despite Fukushima – with all the cost over-runs and delays entailed. And the EU remains divided between the renewable energy optimism of Germany, with its remarkable *Energiewende*, and the fossil fuel/nuclear hard line of the UK, Poland et al.

Moreover the efforts of the BICS countries to promote renewables and low-carbon development are not supported internationally – even with all the rhetoric on carbon reductions emitted under the Kyoto process. In place of promoting diffusion of clean and low-carbon technology, the industrialized countries are actively seeking to impede it through trade sanctions. China for example has been 'punished' for promoting its solar PV industry by other countries, led by the US, the EU and Japan, in imposing counter-tariffs on solar PV imports and causing great disruption to China's PV industry. In India attempts to grow a solar PV industry in emulation of China, utilizing local content requirements, feed-in tariffs, tax breaks and other tools from the industrial strategy toolkit, are also being hindered by trade actions brought to the WTO.

Whether these international trade complications could derail current efforts by the BICS countries to green their industrial development is an important topic to be addressed in this paper. But the case for the success of their greening strategies is overwhelmingly based on the fact that renewables today offer the most cost-effective means of building energy systems. Whereas in previous decades the case that coal could provide the cheapest form of energy (and electric power in particular) was decisive in determining energy strategies, today the situation is reversed, with renewables providing the cheapest option – or being about to do so as the learning curve continues to drive down their costs. This is a truly world-historic change that can transform development possibilities, in the BICS countries and beyond.

Central to these developments and pathways is the role of state agencies and institutions. Price-guided mechanisms will not prove to be sufficiently robust and sufficiently rapid to effect the transition needed, to meet either the needs of the 21st century industrializing giants or of the world as a whole. Indeed, it is the role of public institutions and national governments in driving this new, green phase of world industrialization -- where Brazil, India and China are such key players -- that is proving to be fundamental. The issue is: what strategies are open to states as they seek to guide and shape the unfolding greening process which promises wealth and sustainability?

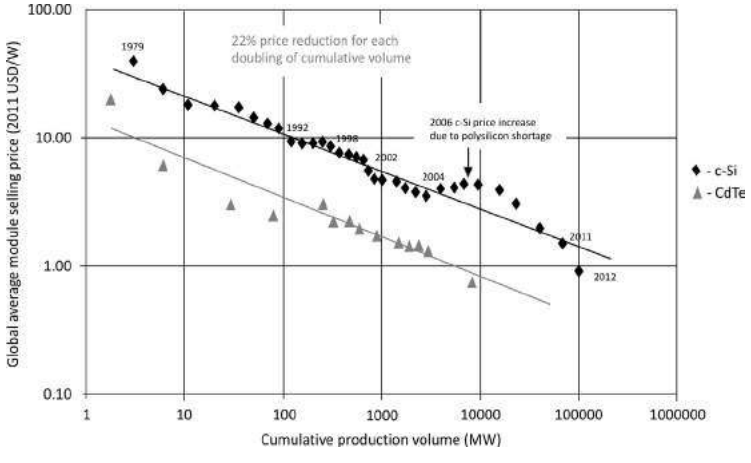
Development strategies in the 21st century: New roles for the state

Energy is not just any other commodity (oil, coal, gas) or any other process (conversion, transmission) or piece of infrastructure (grid, smart grid, high speed rail). It is in fact fundamental to modern industrialization; it lies at the core of the process of modernization that we call industrialization.[1]

Yet energy was conspicuous by its absence in the literature on conventional industrial development strategy. There was capital, and labor and land (e.g. land reform). But where was energy? It was just assumed that energy would be supplied by fossil fuels – as it had been in the west's industrialization. So in the 20th century Japan built a mighty energy system to power its manufacturing system, all based on fossil fuels and then nuclear. Likewise in the cases of Korea and Taiwan and, until recently, Singapore. All are locked into energy systems that prioritize fossil fuels and nuclear – although it is true that Korea is making efforts to liberate itself via its green growth strategy. All were locked into the incumbent energy system; but beyond this, they made leapfrogging progress in 'doing' fossil fuels better than the advanced countries. Singapore for example established itself as an indispensable hub for the oil industry – oil markets (the Singapore oil price index), oil refining, transport and petrochemicals.

It is falling costs which are the fundamental drivers of the global transition. The most recent analyses find that new solar PV installations are comparable in cost to fossil fuelled power plants, and falling at a rate of 16% for every doubling of capacity. The evidence is provided in Fig. 1.

Figure 1: PV module experience curve, 1976-2013

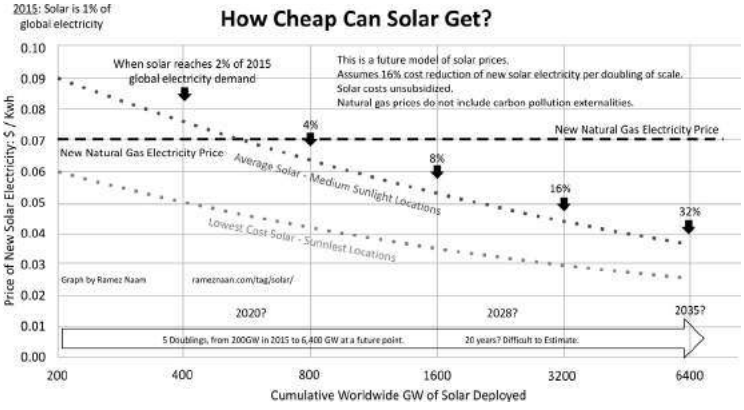


Source : IRENA

[1] See Rodrik (2014) for a recent statement of the case for greening of industrial strategies. My own contributions on these matters are listed in References, including Mathews (2007-2014; Mathews and Reinert 2014; Mathews and Tan 2011-2015; Mathews, Hu and Wu 2015.

As calculated in a recent blog posting by Naam (2015), the cost of solar PV power can be expected to continue its plunge, and to reach well below the costs associated with burning of fossil fuels for electric power by 2020 (Fig. 2).[2] At this point an industrializing country would be well advised to study closely its options regarding energy, and evaluate the costs of going with renewables as opposed to fossil fuels and nuclear.

Figure 2: Future trajectory of solar PV costs



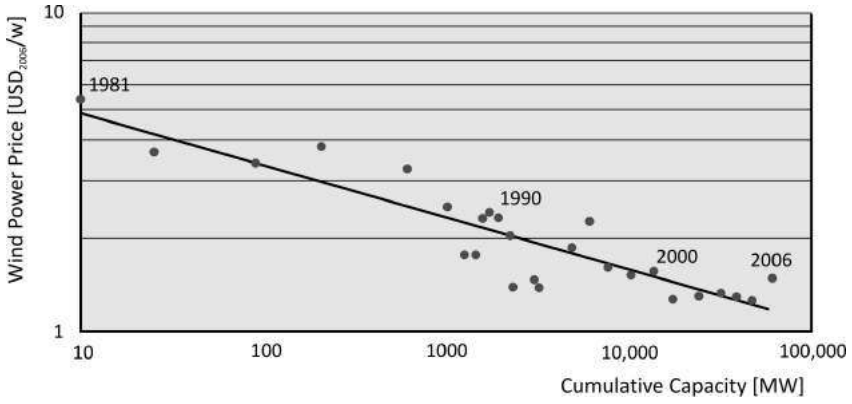
Source: Naam 2015

The chart indicates that the world could pass the 1000 GW mark of solar PV power (the first terawatt) in less than a decade from now, i.e. before 2025. This is entirely plausible. Already China has an official goal of 100 GW by 2020, and India has now matched that goal. There are extensive rooftop solar programs in Europe and the USA, and Japan seems poised to join the process. So the 1 TW mark is actually likely to be passed before 2020 – perhaps in just five years' time. By then the generating cost of new solar PV installations should be somewhere between 4 and 6 cents per kWh (or $40 to $60 per MWh) – cheaper than even the cheapest brown coal. This is how fast the renewables revolution is unfolding.

A similar story can be told for wind power. Consider the learning curve for wind power, which demonstrates a clear cost reduction potential out to 100,000 MW (or 100 GW – a level already achieved by China) – as shown in Fig. 3. The levelized cost of wind power has been falling at a rate of 14% per year as cumulative production experience and scale of market grows.

[2] See Ramez Naam, 'How cheap can solar get? Very cheap indeed', *Energy Post*, 21 August 2015, at: http://www.energypost.eu/cheap-can-solar-get-cheap-indeed/

Figure 3. Learning curve for wind power



Source: FISCHEDICK et al., 2011, p. 847

It is the rapidly falling costs of renewables that is the fundamental feature of the greening process. There can no longer be any doubt that clean and renewable energy technologies are now, or will shortly be, lower in cost than the fossil fuels that they replacing. This amounts to a fundamental sociotechnical shift (Mathews 2013) that will have widespread social, technical and economic repercussions. It challenges countries to revise their developmental strategies and challenges companies to craft new business models that take advantage of the plunging costs of renewables.

There are important reasons for this that go beyond the contingencies of one technology or another. All renewable energy devices – wind turbines, solar PV cells, CSP lenses and mirrors – share the characteristic that they are all the products of manufacturing. And this is what connects renewables fundamentally to industrial strategy. As Hao Tan and I put it in our article published last year in *Nature*:

> ' … unlike oil, coal and gas, the supplies of which are limited and subject to geopolitical tensions, renewable-energy devices can be built anywhere and implemented wherever there is sufficient water, wind and sun.' (2014: 166)

What we meant by this is that manufacturing is the very special process where increasing returns (reducing costs) can be generated: as the scale of production increases, so the unit costs decline. This has been understood by every mass production entrepreneur, from Henry Ford onwards.[3] It is now understood by Chinese, Indian and Brazilian entrepreneurs who are scaling up production of renewables devices and installing them at ever higher capacities, to reduce costs

[3] Between 1909 and 1916, Henry Ford reduced the cost of his Model T Ford from $950 to $360, a 266% drop over seven years. Each year, sales doubled – from just below 6,000 in 1908 to over 800,000 in 1917. The drop in prices was connected directly with the expansion of the market and the sales made by Ford himself.

and drive market expansion. In this way, *renewables are becoming central to the industrialization process*, because they involve manufacturing, learning curves and market expansion linked to cost reduction.

These features are not found in fossil fuel extraction and utilization. On the contrary, all fossil fuel extraction, from coal mining to oil and gas drilling and now right up to extraction of coal seam gas via hydraulic fracturing, involves a relentless process of diminishing returns (or long-run increasing costs). (Fossil fuels are going through a price deflation at the moment, but this is unlikely to continue indefinitely.)

Because renewables devices are always the products of manufacturing, they can in-principle be produced anywhere. This is fundamentally why renewables provide energy security – because a country can build its energy security through building manufacturing systems that can operate independently of the vagaries of supplies (and prices) of fossil fuels. No wonder China, India and Brazil are turning to renewables as fast as is technically and economically possible. And as they do so, they drive down costs even more, and provide further incentives for market expansion and entry by presently under-developed countries into the industrialization process.

This is a virtuous cycle. It was blocked by fossil fuels and their vast infrastructure controlled by the developed world, creating a barrier to industrial development for everyone else. But greening processes unblock the process. That is why it is so fruitful – and why green development is the culmination and likely next chapter in a process of global industrialization.

Let us now review how in their different ways all the BICS countries are participating in this vast energy transition – and through doing so, are raising their income levels to achieve their long-sought goal of becoming middle-income countries.

Renewable energy national strategies: the BICS countries

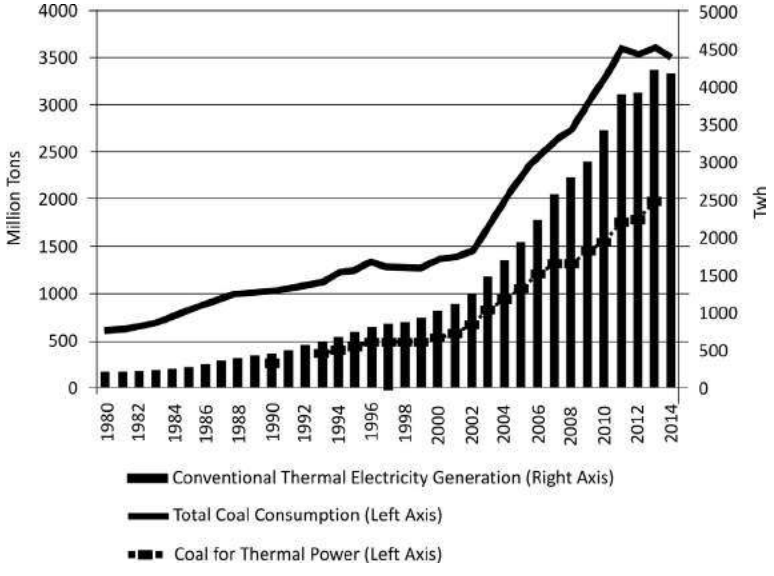
China

In just the past decade China has emerged as the world's renewable energy superpower – building up world class renewable energy industries (wind and solar farms in the vanguard) and renewable power manufacturing industries (wind turbines, solar modules and cells) as well as major infrastructure projects including a strong and smart grid, EV recharging networks and a national high speed rail network. All this as it has continued to expand its coal-fired energy system as engine of its vast manufacturing system – although it is true that China has been curbing its coal consumption over the past two years, not just in relative terms but in terms of

absolute levels. The peaking of China's coal consumption, followed by a peaking in its carbon emissions, could be about to occur much earlier in China than predicted.

Like rising industrial powers before it, China has initially relied on fossil fuels, and coal in particular, to drive its manufacturing engine. The rapid increase in coal consumption, that took off after China joined the WTO in 2001, is clearly seen in Fig. 4.

Figure 4. Chinese thermal power generation and rising coal consumption up to 2014



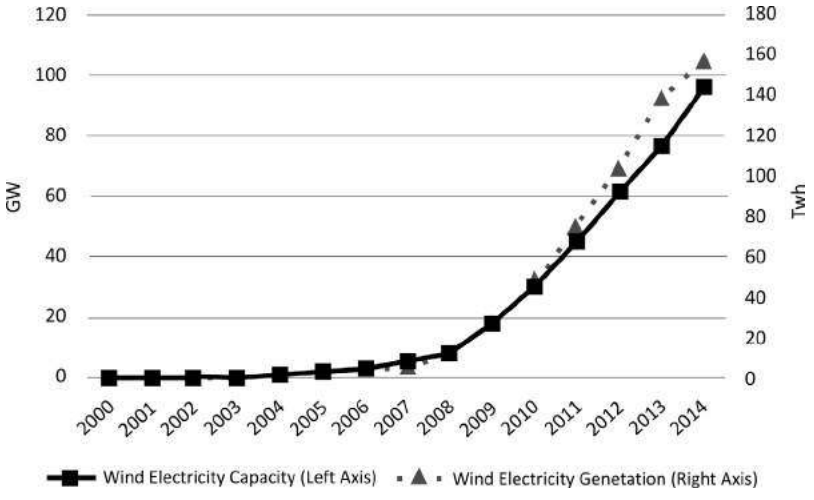
Source: Mathews and Tan (2015)

Fig. 4 also indicates that China is now taking active steps to curb coal consumption – as a step towards remedying the shocking air and water pollution that has struck Chinese cities. This is clearly visible in the flattening of the coal consumption curve after 2013.[4] The complementary actions taken by the Chinese government are that a new green energy system is being created, at a rate of advance that promises to eventually overtake the 'black' coal-fired energy system.[5] The results of actions taken to build a wind power industry are shown in Fig. 5.

[4] For a discussion of China's possible 'Great reversal' in terms of coal consumption, see the article from Hao Tan and myself posted to *Asia Pacific Journal: Japan Focus* on August 26 2015, at: http://japanfocus.org/-Hao-Tan/4365/article.html

[5] On China's expansion of its green power system, see in particular Hu (2006; 2011).

Figure 5. China's wind power generation, 2000-2014



Source: Mathews and Tan (2015)

It is China's building of wind power and solar PV systems at a scale never previously thought possible that is driving the cost reductions that are now making renewables accessible to all – including India, Brazil and South Africa.

China's judicious use of local content requirements was the key to its successful creation of a wind turbine manufacturing system – as widely acknowledged.[6] Some experience was generated by the *Ride the Winds* program of the late 1990s, and the formal LCR provisions were then imposed from 2003, both by the tendering system for nationally approved projects, where the scoring included clear LCR criteria, and by wind farm projects approved by the National Development and Reform Commission (ND&RC) and likewise contained a graduated LCR provision. Following complaints at the WTO by the US, the schemes were discontinued in 2009 – but only after they had done the job of helping Chinese firms to enter all the stages of the wind turbine manufacturing value chain, and ensuring that the leaders like Goldwind, Sinovel and MingYang were on the way to becoming global leaders. China backed these strategies with extensive financing, provided in the form of credit lines to Chinese renewable energy companies by the China Development Bank. In this way it demonstrated once again the power of development financial institutions – something very well understood in Brazil where the BNDES plays such an important role in the development of the Brazilian economy.[7]

[6] See discussions by Kuntze and Moerenhout (2013) and by Gandenberger et al (2015).

[7] See the discussion of the role played by the China Development Bank in Keidel and Burlamaqui (2015) and Sanderson and Forsythe (2013).

India

From a slow start, India is now determined to become a world leader in green energy and green development. It is doing so not just because of concerns over climate change, but for reasons to do with energy and resource security and the building of an energy platform that will supply both domestic markets and export business as well.[8] India is using a full panoply of industrial strategies to achieve these ambitious goals, from market promotion measures including tax breaks and feed-in tariffs to industrial promotion such as local content requirements being attached to foreign direct investments (albeit attracting some opposition at the WTO, particularly from the USA).

The most ambitious program is the National Solar Mission, which in July 2015 was upgraded with a new goal of seeing 100 GW of solar power installed in India by the earlier date of 2019 – where 40 GW would be rooftop solar and 60 GW would be medium- and large-scale grid-connected solar power projects. These are extremely ambitious targets, upgraded from the original target of 20 GW by 2021-22 that had been announced in 2008 and amended in 2010. Indeed it puts India on a par with China in terms of specific solar PV targets, where China has a well-known target for solar PV of 100 GW by 2020 (at the conclusion of the 13th FYP) – although there have been rumours floated in the press that China is about to double its 2020 target for solar to 200 GW as part of the 13th FYP (http://cleantechnica.com/2015/07/26/china-2020-solar-energy-target-200-gigawatts-rumor/).

With the election of the Narendra Modi government in 2014, the stage was set for further detailed promotion of renewables and greening of the Indian economy generally. Modi himself has reiterated the point that his government's central goal will be to ensure 24/7 power for all Indians – and since coal is subject to supply and price fluctuations, the best way of delivering on such a promise is through promotion of renewables. The fresh targets announced are backed by administrative and financial commitments. The July 2014 budget of the Modi government had a provision for a doubling of the tax on coal, which would raise an extra $1.1 billion to fund clean energy projects. Green energy companies were at the same time offered a 10-year tax holiday in order to get themselves firmly established.

The next anticipated move is for the Indian government to announce a National Wind Mission (NWM) to replicate the success so far of the National Solar Mission (NSM). Some reports indicate that the NWM will also set a target of 100 GW wind by 2022, and that it will be backed by comprehensive policy promotion encompassing tax breaks, facilitation in securing land and local permits, as well as promotion of

[8] For discussion of India's greening strategies, see for example Mattoo and Subramanian (2012) or Johnson (2015).

the wind power manufacturing value chain in India (at present largely dominated by Suzlon). The essence of these RE Mission programs (NSM and probable NWM) is that they provide investment certainty and real incentives for developers based on a clear understanding of what manufacturers and wind/solar farm developers need. The projects represent a substantial initiative on the part of the Ministry of New and Renewable Energy (MNRE), itself a major institutional innovation, designed to create fiscal and monetary space for RE development separated from the influence of fossil fuels.[9]

The LCR provisions of the NSM are quite explicit – and no doubt provide a template for what can also be expected under the probable NWM. The NSM was launched by the Singh administration with comprehensive national development goals being made clear (Johnson 2015). Three phases were envisaged, allowing for policy learning along the way. Phase 1 was the pilot phase, with a first batch of bids being commissioned in January 2012 and a second batch in January 2013. Phase 2 was designed to build on the achievements of Phase 1, when a more extensive value chain would be created in India, directly supporting a further 3 GW of solar development and leveraging a further anticipated 6 GW from the private sector. Phase 3 was envisaged as the final scaling-up of the program, with 10 GW being expected to be installed over five years. This aspect has been drastically upgraded to reach the new 100 GW target by 2019.

India has learned from China the power of local content requirements (LCRs) as a tool for domestic industry development. The provisions covering LCRs in the NSM were designed to avoid WTO entanglements, in particular having a state-owned entity being the purchaser of the solar energy generated and thereby being nominally in compliance with the WTO Government Procurement Agreement (GPA). Even the name of the program, namely the NSM Procurement Program, emphasized this aspect and signalled India's strategy if required to defend the program in Geneva. Nevertheless the United States has objected to the LCR provisions on grounds that they create trade barriers to exports of US RE products and technology (which is, after all, their goal). In fact the US has lodged two successive objections and the case is now moving through the WTO procedures. Indian observers were holding out hope that there could be a cooling off or even a settlement reached at the US-Indian Summit of Feb 2015 when President Obama visited the Indian capital with a strong trade retinue; the outcome (if any) has not yet been made public. But it

[9] Current levels of Renewable Energy (RE) capacity in India are (at March 2015): wind power capacity 23.4 GW; solar PV capacity 3.7 GW and total RE capacity 35.8 GW. The ambitious NSM and (probable) NWM targets would have to see an extra 10 GW of solar and 10 GW of wind capacity being added each year between now and 2020. This in itself can be viewed as a major industrialization effort.

is clear that India has not allowed this hiccup to curb further LCR provisions being inserted into Phase 2 batch 2 of the program, and there is open speculation that the anticipated NWM will likewise contain strong LCR provisions. India is clearly serious about building its RE industry and creating manufacturing industries to support both solar and wind power development on a large scale – and it is not about to let some scrapping at the WTO in Geneva block its ambitions.

Brazil

Brazil has been pursuing an industrialization strategy that is lifting tens of millions of its citizens out of poverty.[10] Brazil has been traditionally a green energy source country, with much more emphasis on hydro power than most, and greater emphasis on sustainably grown sugar cane-sourced ethanol as liquid fuel. But in the last five years it has been ramping up its renewable power sources generally, to enhance its energy security – e.g. making the country's industry less prone to brownouts and power rationing because of droughts that reduce hydro capacity (as in the worst drought on record in 2014/2015).

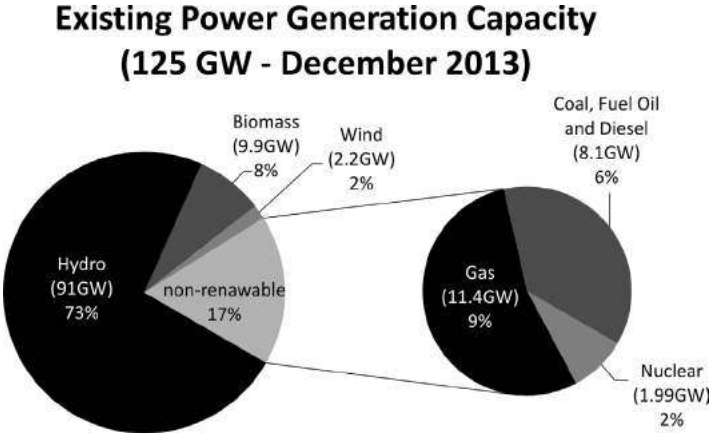
At the same time Brazil has been enhancing its energy security in terms of oil, through its offshore 'pre-salt' oil discoveries and the government's determined efforts to play a role in utilizing the exploitation of these offshore oil deposits to build an offshore oil industry – centered on state-owned Petrobras. Brazil became independent of oil imports in 2006, and since then has become a major oil and gas producer in its own right, earning export dollars and saving vast sums in terms of substitution of imports.

Brazil has one of the largest renewable energy components of its energy system of any country in the world – with renewables accounting for 83% of generating capacity, largely based on hydro (comparable to Norway). Since 2009 it has been ramping up wind and solar PV power as well, so that by 2015 wind power had grown to 6 GW (4.5% of generating capacity) and is expected to reach around 24 GW by 2023 (under the rolling 10-year energy plan maintained by the Ministry of Mines and Energy). Electric generating sources from water, wind and solar (WWS) are expected to grow from 103.2 GW in 2013 to 164 GW by 2023 – meaning that Brazil would be the world's fourth most significant deployer of renewable energy systems on the planet (after China, the US and Germany) and comparable to India. It is anticipated under the 10-year plan that wind will grow at an average of 2 GW per year, to reach 24 GW by 2023 (11% of the total) and solar to reach 3.5 GW (2%), which with hydro reaching 124 GW would mean WWS would account for 164

[10] On Brazil's strategies of industrialization generally, see for example Castro (2008) or Schutte (2012).

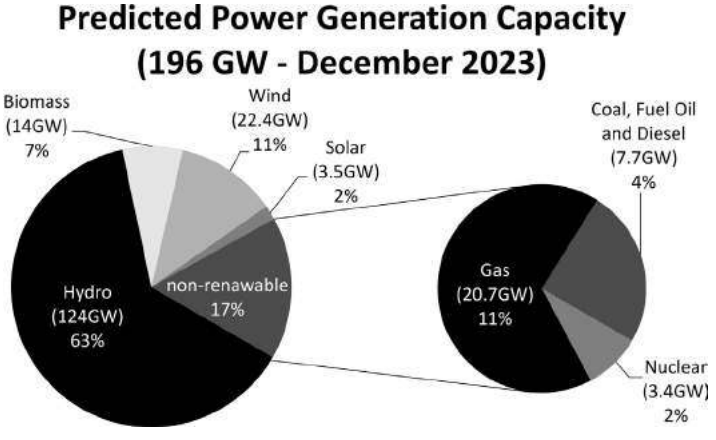
GW by 2023.[11] With biomass contributing 14 GW (7%), the 83% contribution from renewables is expected to be maintained (Figs. 6a and 6b).

Figure 6a. Brazil's existing electric generating capacity (2013)



Source: MME

Figure 6b. Brazil's anticipated electric generating capacity by 2023



Source: MME

Brazil maintains a 10-year rolling target for all energy sources, which in itself is an important institutional innovation and a measure reflecting strong state leadership in the renewable energy sector. The latest version is the 2023 plan, updating the

[11] Note that this projection assumes that hydro sources would grow from a capacity of 91 GW in 2013 to 124 GW by 2023, or a 33 GW increase over 10 years. Given the fact that present dams in Brazil are already highly controversial, and future construction could run up against social as well as environmental limits, particularly in Amazonia, these projections may be unrealistic. See Fearnside (2015) for a critique.

2013 energy mix. This 2023 target has Brazilian wind and solar accounting for 13% of all generation capacity, and hydro accounting for 65% -- i.e. WWS sources accounting for 78% of Brazil's generation capacity, and the balance (thermal, nuclear, and biomass) accounting for 22%.[12]

In June 2015 Brazil and the US issued a joint declaration on climate goals, with Brazil committing to protect forests and ramp up its use of renewable energy. Both Brazil and the US have committed to achieving 20% of their electricity from wind and solar by 2030 – i.e. from non-hydro sources.

The role of the state in creating this 21st century energy infrastructure in Brazil has been critical. The Ministry of Mines and Energy has maintained a strong emphasis on building up renewables capacity (with its foundation in manufacturing of wind turbines and solar cells and their value chains) even while supporting the country's existing minerals exploitation and export systems and the emerging offshore oil industry (despite problems of corruption that have surfaced at Petrobras). The series of New Energy Auctions have been responsible for creating wholly new wind power and now solar PV power contracts based on Power Purchase Agreements at costs amongst the lowest in the world.

Brazil has utilized a smart combination of strategies to enable it to catch up in renewables and build its own renewable power industries. These strategies include **guaranteed power purchase agreements** (PPAs) and **power-contract auctions** to boost the market for renewables, as well as the use of indirect local sourcing requirements not imposed through the trading system (where they would attract attention from trading partners, above all the US) but instead indirectly through the financing mechanism, operated by the National Development Bank BNDES. In 2011 the Brazilian (Lula) government took the important initiative of publishing a 10-year plan for energy development, creating targets that have underpinned investment certainty.

BNDES has been central to the renewable energy industry creation. The bank amended its approach to granting loans to the wind power industry in 2012, announcing that developers that utilize BNDES loans to build wind farms would have to source wind turbines and their components locally by the year 2016. In August 2014 BNDES announced similar plans for the solar PV industry. For dominant technology crystalline silicon PV panels, this program would proceed through three

[12] Hydro is expected to grow at an average rate of 3.3 GW per year, expanding from 91 GW in 2013 (73% of capacity) to 124 GW by 2023, and 63% of capacity. Wind is expected to expand at an average rate of 2 GW per year to reach 22.4 GW in 2023, up from 2.2 GW in 2013; while solar is expected to reach 3.5 GW by 2023, up from a negligible amount in 2013, and expanding at an average rate of 350 MW per year. Total WWS capacity in 2013 reached 93.2 GW (hydro 91; wind 2.2; solar PV negligible) while WWS sources are expected to reach 150 GW by 2023 (hydro 124, wind 22.4 and solar PV 3.5 GW).

phases, culminating in all cells being produced locally by 2020. For thin-film solar cells there are two phases with all module assembly having to be carried out in Brazil by 2018.[13] This strategy of attaching LCRs to development bank financing for project developers is a striking and effective aspect of Brazil's strategy – subject to the criticism that it would be better if there were time limits attached to the LCR provisions, ensuring that they do not become protectionist.

South Africa

While South Africa is not in the same league as the BIC countries in terms of its energy transition and its economic potential, there are good reasons for including it in this analysis because it is grouped with Brazil, India and China in Goldman Sachs-inspired analyses of emerging markets, and because it is party to the launch of the BRICS- countries' newly launched infrastructure investment bank (the New Development Bank, launched formally in Shanghai in July 2015: http://in.reuters.com/article/2015/07/21/emerging-brics-bank-idINKCN0PV07Z20150721). Moreover it is seriously addressing renewable energy issues from the perspective of industrial strategy, and utilizing the financing potential of the Development Bank of Southern Africa (DBSA).[14]

South Africa starts from the difficult position that it has traditionally been a highly energy-intensive industrial country with a strong dependence on coal. Its electricity generating system has been highly centralized and coal-fired; moreover the electric power market is dominated by a quasi-monopoly in the form of Eskom, responsible for more than 95% of the electricity generated in South Africa.

Against this backdrop the post-Apartheid ANC government (ascending to power in 1994) has been seeking to set a different direction. There were some false starts in promoting renewables, with the launch of a Renewable Energy Policy White Paper in 2003 that set modest targets for renewables for 2013 – but not including any solar PV or wind power. Next, following the Copenhagen Summit of 2009, the SA government issued a Renewable Energy feed-in tariff (REFITs) policy, but considerable uncertainty surrounded the commitments made and no contracts were actually signed. These could considered learning steps.

In August 2011, following a lengthy national debate, the South African government launched the Renewable Energy Independent Power Producer (REIPP) Procurement

[13] This extremely effective program is also quite transparent. In December 2014 BNDES published its *Perspectives on Investment* report for the next four years (2015 to 2018), outlining where it would be placing priority for investments. http://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/Institucional/Press/Noticias/2014/20141203_estudo.html

[14] On the role of the DBSA, see Mathews and Kidney (2012).

Program, which established a bidding process for renewable energy projects beyond the traditional thermal (coal-fired) generating sector. The new program was designed to encourage the emergence of independent power producers to break the Eskom monopoly, by providing a certain amount of protected market for the renewable sector. The principal target set under the program is for generation of 10 TWh of renewable energy. Complementary targets set under the REIPP included 3.7 GW of renewable energy capacity to be installed by 2016 – including 1.8 GW of onshore wind capacity, 1.5 GW of solar PV capacity and an initial 200 MW of concentrated solar power (CSP). The targets were raised in 2012, when the government called for an extra 3.2 GW of renewables capacity to be added by 2020. While small in comparison with thermal generating in South Africa, and tiny when compared with similar targets in China, India and Brazil, these goals nevertheless represent first steps towards a genuine transformation (greening) of the South African energy sector and pathway towards a new model of industrialization.

In November 2011 the South African government embarked on a public tendering process to accelerate uptake of renewable energy projects, in emulation of similar processes enacted by China, India and Brazil. This called for three rounds of tenders which attracted bids of nearly 4 GW of capacity sweetened by 20-year power purchase agreements (PPAs) with Eskom. The bids came from both domestic and foreign companies, and were backed by serious finance – Chinese bids backed by $2 billion in funding from the Industrial and Commercial Bank of China; US bids backed by $2 billion in funding from the Ex-Im Bank; and African bids backed by a loans facility of $1.1 billion provided by the DBSA, approved in 2012.

The public bidding process has achieved significant cost reductions in renewable energy, but has also enabled the SA government to impose LCRs that have been ratcheted up, from modest requirements in 2012 to 35% in the next round (much of which foreign investors were able to meet through construction costs) and rising to 40% in the most recent round (and 45% for CSP projects). Developers are in practice required to reach a 65% local content threshold in order to build a 'social and economic score' that can win contracts. So far there appears to be no international negative response at the WTO to these LCR provisions, which have a clear industry-building mandate rather than being protectionist. Some foreign countries have also been induced to sign financial assistance packages that clearly pave the way for involvement by their national firms – as in the case of a Danish loan that was followed by Vestas winning contracts. All this represents important activities on the part of the South African state.

In April 2015 the SA Dept of Energy announced the results of its fourth Request for Proposals under the REIPP procurement program (issued July 2014), which

resulted in 13 proposals being selected as preferred bidders, adding up to 1.2 GW of installed capacity and investment of R23 billion (US$ 1.7 billion). That brought total committed private sector investment under the program since 2011 to R168 billion (US$ 12.6 billion). The winning bids averaged R619/MWh (US$46.50/MWh, or 4.6 US cents per kWh) for onshore wind and R786/MWh (US$59/MWh) for solar PV – very much in line with the best results obtained in other parts of the world.[15]

Following initial acceptance of LCRs in Round 1, the bidders for Round 2 were asked to identify components of fulfilling their contracts that would involve local content – with a focus on manufacturing wind turbine blades and towers, PV modules and inverters and metal structures for PV plants. In Round 3 the definition of local content was further clarified, with as much emphasis on production of components along the value chain as on final product.[16]

Wind farms are now proliferating in South Africa, providing enhanced energy security and a growing market for wind turbine products as well as local employment for workers who would otherwise remain unskilled and unemployed. The Cookhouse wind farm for example is the largest built so far in Africa, with 66 2-MW turbines spinning to generate power at 138 MW; it started feeding power into the grid at the end of 2014. The wind farm is partially owned by a Community trust, which channels its profits from the farm to health and education projects. Wind energy costed at less than 5 US cents per kWh means that the farm generates power at around half the cost of coal. Eskom itself founded one of the first wind farms, the Darling farm located in the Western Cape; it was basically a pilot project founded in 2008 and involving just four turbines. Now there are farms like Sere and Dorper, both rated at 100 MW and under construction. (It needs to be pointed out that these 100 MW wind farms, impressive as they are, are only 1% the size and capacity of the giant 10 GW wind farms being built in China.)

The LCR provisions have been successful in creating components firms along the value chain. So far there is one final wind turbine producer, I-WEC, founded by two South African engineers in 2009. I-WEC (standing for Isivunguvungu Wind Energy Converter), offers a state-of-the-art 2.5 MW wind power system, with a design licensed

[15] The process of closing each bid involves negotiation of a Power Purchase Agreement between the bidding IPP and Eskom and finalization of an Implementation Agreement between the IPP and the Department of Energy. The contracted PPA involves a price that lasts for 20 years, indexed to the CPI. Foreign funding accounted for 28% of investment commitments, with local content rising to 65% (from 38% in the first round, 53% in the second and 54% in the third). The Department counts this as an economic success for the program, contributing significantly to SA's industrial development and greening. See South African Dept of Energy presentation on Bid window 4, Preferred Bidders' Announcement under the REIPP Procurement Program, 16 April 2015, at: http://www.ipprenewables.co.za/#page/2183

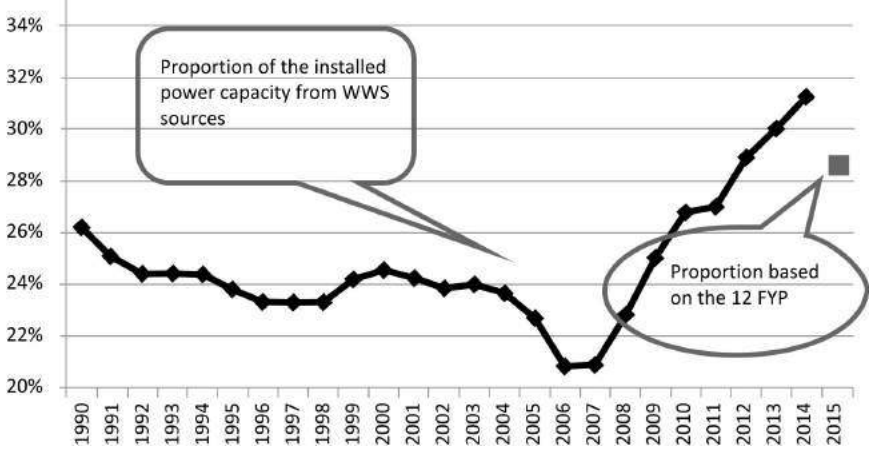
[16] See Moldvay et al (2013) as well as Eberhard et al (2015) for evaluations of these LCR provisions.

from the German wind turbine engineering firm Aerodyn Energiesysteme Gmbh. The company has partnered with the local heavy engineering firm DCD Dorbyl (now a shareholder in I-WEC) to boost its engineering capabilities and with the German wind turbine design company from which I-WEC has licensed its current 2.5 MW turbine. (The same German company has partnered with MingYang in China.) Note that I-WEC claims that its first energy converter already has 70% local content, while some critical components have to be sourced from foreign specialist suppliers.[17]

Global ramifications of integrating renewables into industrial development strategies

Evidently the BICS countries are all embarked on major transformations of their energy sectors with a clear target of raising their dependence on renewable sources, mainly water, wind and solar, and reducing their dependence on fossil fuels (and nuclear – not discussed here). The case of China will have to stand for all four major industrializing powers, in terms of its clear change of direction, as shown in Fig. 7.

Figure 7. Proportion of installed power capacity from renewable sources (hydro, wind and solar) in China: 1990 -2014, and 2015 target based on the 12th FYP



Source: Mathews and Tan 2015

[17] Complementing the wind power projects, South Africa's solar farms feature both solar PV and concentrated solar power projects located in desert areas. The Sishen solar energy facility came online in December 2014, rated at 94.3 MW peak; it can generate 216 GWh electrical energy in a year, from 320,000 solar PV modules. Complementing the solar PV projects are those based on mirrors and lenses – concentrated solar power (CSP) projects. The 100 MW Redstone CSP plant will be the first such facility in Africa, featuring Solar Reserve's molten salt energy storage technology allowing the plant to generate power day and night. Another CSP project is the 100 MW Kathu Solar Park which will be equipped with molten salt storage allowing power to be generated for 4.5 hours after sunset.

What then have been the international ramifications?[18] We have seen that local content requirements (LCR) provisions have been very successful in promoting BICS countries' green industries, and they have correspondingly become the focus of more and more acrimonious trade disputes, thus potentially curbing the global uptake of green technologies. In this way promotion of green industry and trade is coming to be viewed as a relevant 'industrial policy' in the 21st century – and demanding in turn a reform of trade rules to accommodate its specific character.[19]

The rash of current disputes over promotion of green industries and products dates back to the action taken against Ontario's Feed-in-Tariff (FiT) provisions coupled to Local Content Requirements (LCRs), which despite their success in helping to build an effective renewable energy system in the province and reducing carbon emissions, were made the subject of complaint by Japan and deemed WTO-incompatible by an Appeal Board in 2013.[20] There have been actions taken against China's promotion of both its wind turbine industry, through LCRs. and its solar PV industry through local subsidies and tax breaks (in separate actions brought by the US and the EU); and against India's National Solar Mission which was designed to bring India up from being a laggard to being a leader in transitioning to a clean energy future (an action brought by the US). Meanwhile China has itself brought cases at the WTO against US state-level LCRs and local subsidies; the US, in turn, has responded to domestic pressures and imposed anti-dumping and countervailing duties (AD and CVDs) on two occasions against Chinese PV imports, to which China has retaliated by imposing CVDs on US exports of such products as PV cell-making equipment and silicon exports.[21]

According to scholars of trends in world trade, this constitutes a serious outbreak of trade disputes that stem from the imposition of green industrial policies by both advanced and developing states, in a bid to accelerate the uptake of clean energy systems and reduce carbon emissions.[22] The impact is felt by the states targeted by these trade actions, and more widely by the warning sent out to other states that they too will be targeted if they proceed to impose green industrial policies.

Yet it has to be pointed out that if countries are going to seriously tackle the challenge of decarbonizing their energy systems, they will need to employ some

[18] See Gallagher (2014) for discussion.

[19] See Wu and Salzman (2014) and Bigdeli (2014) for reviews of the case law; Rodrik (2014) for the economic significance of the turn to 'green industrial policy'; and Pegels and Luetkenhorst (2014) for an analysis of the related industrial shift in Germany known as the *Energiewende* ('energy transformation').

[20] See WTO, Canada: Measures relating to the Feed-in Tariff program, Implementation notified by respondent, 15 June 2014, at: https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds426_e.htm

[21] See the discussion by Charnovitz and Fischer (2014); Bigdeli (2015); and on Indian implications, Kent and Jha (2014) and Johnson (2014).

[22] See in particular Asmelash (2015); Bigdeli (2014); Rubini (2012); Low, Marceau and Reinaud (2012); Kuntze and Moerenhout (2013); Cosbey and Mavroidis (2014); and Wu and Salzman (2014).

form of green industrial policy, and utilize one or more of the various industrial strategies involving subsidies, low-interest loans, tax breaks and above all FiTs and LCRs which have proven themselves to be powerful means, when employed judiciously, to build new cleantech value chains and producers of cleantech products. It is not a question of allowing newly industrializing countries like China and India to build renewable energy industries that will then destroy such industries in already developed countries. Rather, it is a question of promoting the diffusion of cleantech industries and encouraging the planting of such industries in countries around the world, subject to WTO oversight to ensure that competition remains reasonable and does not become predatory or overly protectionist.[23]

Short of comprehensive reform of world trade rules (unlikely under current conditions) there are promising ways forward. Governments interested in promoting their green interests and expanding trade could make local content requirements a subset of public procurement arrangements for green goods, utilizing government-owned entities for the purpose (as done by India). These arrangements stand a chance of surviving challenge at the WTO, and would have demonstrable ripple effects in the rest of the economy.

Countries that already possess the great public asset of a national development bank (like the CDB in China, the BNDES in Brazil and the DBSA in South Africa) have the option of pursuing local content requirements put in practice entirely through the domestic finance system, and by-passing the trade system altogether. Indeed the Brazilian model of building renewable energy industries through judicious use of targeted loans from the national development bank, offering lower interest rates for finance to domestic companies which meet local content requirements (and offering the same rates to foreign firms if they enter into joint ventures in Brazil, where the domestic partner is the one that applies for the green finance), combined with public (reverse) auctions that drive down costs of renewable energy as they enlarge the market, seems to be optimal for emerging/developing/industrializing countries in the second decade of the 21st century.[24]

Concluding remarks

Recognizing that promotion of green industries is already a major component of active state intervention in transforming fossil fueled-economies, and that trade promises to play a major role in the development of green industries around the

[23] The distinction here is that time-limited LCRs are clearly tools to promote new industry formation, not to protect existing industries from overseas competition -- but only become protectionist if they are allowed to run without limit. Brazil's LCRs attached to financing by the BNDES are ambiguous in this regard.

[24] With the proviso that the LCR conditions attached to the loans be time-limited.

world, the scope for a 'grand bargain' between the parties involved would seem to be clear. Yet recognizing that progress on these issues is slow (e.g. the UNFCCC has been hosting talks on developing a global accord on reducing carbon emissions for close on two decades) the prospects for resolution are not encouraging -- yet sentiment on these matters could shift rapidly, particularly if the Paris Conference of the Parties to be staged in December 2015 is successful. A possible line of advance would be for a set of products or processes to be identified as contributing to decarbonization of energy systems, and for which the WTO could provide exemption from the usual constraining rules of free competition. A candidate authority to make such an identification would be the United Nations Framework Convention on Climate Change (UNFCCC), which is calling the world to Paris in December 2015. The purpose of the exemption – the first to be recognized by the WTO since its inception – would be to allow countries to use such exemptions (for a designated period, say five years) and utilize provisions such as LCRs to build their own green industries. This would be a 21st century WTO-compatible green industrial policy.

There is an alternative way around WTO constraints, namely utilization of the provisions on government procurement combined with LCRs for renewable energy and green industry development, as applying to some nominated public entity or entities.[25] There is the Indian precedent, involving a government-owned energy company – but it is complicated by the action being taken against India's green LCRs by the United States.[26] This Indian experience provides a tentative model for other countries, because the public procurement provisions of the WTO are the ones that are least disciplined and subject to WTO case law.[27] The way this could be accomplished is that countries looking to promote their green industries in a forceful manner that is probably WTO-compliant would be advised to (1) create a public entity in the energy space that can act as driver of the green transformation (e.g. a public entity that purchases green electricity); and (2) ensure that the actions of the created

[25] On the international political economy of government procurement measures and the WTO, see Weiss (2005).

[26] One of the arguments used by the Indian government in defending its LCR scheme from the attack by the United States is that it has been administered by a public power producer, the National Thermal Power Corporation (NTPC). Now there are oddities here worth noting. India is utilizing the 'public procurement' defence – and yet it is not a signatory of the WTO Government Procurement Agreement, which nominally regulates public procurement between the parties. And the NTPC is a coal-burning entity, not a renewable power company.

[27] See Thurbon (2014) albeit without specific reference to the GPA. Resort to the public procurement provisions of the WTO as a means around interdiction of LCRs is also canvassed by Kuntze and Moerenhout (2013). Asmelash (2015) makes the point that the only cases brought to the WTO involve renewable energies – while leaving the subsidies paid directly and indirectly to fossil fuels unchallenged.

public entity comply with the provisions of the GPA, and perhaps set out exemptions for goods that are designated as 'green goods' where LCRs might be applied.[28]

In this author's opinion the best strategy of all, and the one that makes optimal use of state action in the 21st century, is the Brazilian threefold approach. First, investment uncertainty is reduced through the government creating and maintaining a rolling ten-year plan for the build-up of the renewables market; even if the individual forecasts turn out to be wrong (which they probably will) the important effect is to create a sense of direction. Second, the services of the state-owned development bank are utilized to provide green financing, with a preference for local content reflected in favourable interest rates, available to domestic firms either acting alone or in JVs with foreign partners (particularly technology partners). Such an arrangement where LCRs are effected entirely through the domestic finance system and not through trade or investment, stands the best chance of surviving any potential attack via the WTO. Third is a state-mediated (reverse) auction system where companies are allowed to bid for renewable energy contracts and costs are forced down through a competitive bidding scheme. This threefold approach combines finance with cost reduction and enhancement of investor certainty in an optimal manner – addressing the triple nexus of **market**, **finance** and **cost**. This approach provides a robust justification of a creative role for the state in the 21st century task of greening the world's industrial systems.

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[28] The Government Procurement Agreement of the WTO is a set of principles applying to procurement procedures by national and sub-national public entities. Many of the general principles of the WTO are subject to exemptions concerned with government procurement, provided the country concerned has signed up to the minimum principles outlined in the GPA – principles which are themselves also subject to exemptions. Israel for example is a signatory but specifically exempts many products that are purchased by public entities concerned with health and security matters. See Weiss (2005).

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The Rationale for Industrial and Innovation Policy

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Abstract

The evolution of industries in the last two centuries in all countries has been closely supported by a wide range of public policies addressing the patterns of capital accumulation, trade rules, the organisation of markets, innovative efforts and the process of knowledge creation and diffusion. Specific institutions have been created supporting such developments and have played a key role in economic growth. The protection of infant industries, the definition of trade and intellectual property regimes, the distribution of rents and the coherence with macroeconomic policies are key elements of such policies. The current challenges of industrial and innovation policies are discusses in the light of recent experiences in emerging countries.

Keywords: secondary sector, public policy, industrial policy, market/commercial policy, industrialization, international trade, intellectual property, macroeconomics

The evolution of industries[1]

A fundamental element in countries that successfully caught-up with the leaders during the 19th and 20th centuries was active government support of the catch-up process, involving various forms of protection and direct and indirect subsidy. The guiding policy argument has been the need of domestic industry in the industries of the day judged critical in the development process for some protection from advanced firms in the leading nations. Alexander Hamilton's argument (1791) for infant industry protection in the new United States was virtually identical to that put forth decades later by Friederich List (1841) regarding Germany's needs. Gershenkron's (1962) famous essay documents the policies and new institutions used in Continental Europe to enable catch-up with Britain. The same story also fits well with the case of Japan, and of Korea and Taiwan somewhat later. In many countries these policies engendered not successful catch-up but a protected inefficient home industry. However, they also were the hallmark during the 20th century of all the countries that have achieved their goals of catching-up.[2] We need to learn more about the circumstances under which infant industry protection leads to a strong indigenous industry: the project on which this work draws shed new light on the issue.

These policies obviously angered companies in the leading countries, and their governments, particularly if the supported industry not only supplied its home market but began to invade the world market. While the case made after World War II for free trade was mostly concerned with eliminating protection and subsidy among the rich countries, and at that time there was sympathy for the argument that some infant industry protection was often useful in developing countries, the more recent international treaties that have been made increasingly have been used against import protection and subsidy in countries seeking to catch-up from far behind.

Our belief is that Hamilton and List were and continue to be right that successful catch-up in industries where international trade is considerable requires some kind of infant industry protection or other modes of support.

Table 1. summarizes an exploratory taxonomy of policy interventions, measures and related institutions.

In the last resort, policies and other activities of "institutional engineering" affect together (i) the technological capabilities of individual and corporate organizations,

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[1] This paper draws upon M. Cimoli, G. Dosi and J. E. Stiglitz (eds.), *The Political Economy of Capabilities Accumulation: the Past and Future of Policies for Industrial Development*, Oxford University Press (2009) and on successive joint work by the authors. The research leading to this work has enjoyed the long-term backing of the Initiative for Policy dialogue (IPD), Columbia University.

[2] For a broad historical overview of the role of policies in some now-developed countries, see Reinert (2004).

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 (e.g. public agencies, development banks, training and research entities, etc.)

It happens that all major developed countries present indeed relatively high degrees of intervention – whether consciously conceived as industrial policies or not – that affect all the above variables. And this applies, even more so, to the period when today's developed countries were catching–up with the international leader. What primarily differentiate the various countries are the instruments, the institutional arrangements and the philosophy of intervention.

The case of of Japan is a paradigmatic example of catching-up policies (Dosi, 1984).

Interestingly, Japan appears to have acted comprehensively upon all the variables categorized in our taxonomy above. A heavy discretionary intervention upon the structure of signals (also involving formal and informal protection against imports and foreign investments) recreated the "vacuum environment" that is generally enjoyed only by the technological leader(s). However, this was matched by a pattern of fierce oligopolistic rivalry between Japanese companies and a heavy export orientation which fostered technological dynamism and prevented any exploitation of protection simply in terms of collusive monopolistic pricing.

It is tempting to measure this Japanese experience - notwithstanding, recent, mostly macroeconomic difficulties - with others, on average less successful, such as the European ones, which heavily relied upon one single instrument, financial transfers (especially R&D subsidies and transfers on capital account), leaving to the endogenous working of the international market both the determination of the patterns of signals and the response capabilities of individual firms. Certainly, there are country-specific features of the Japanese example which are hardly transferable. However, that case, in its striking outcome, points at a general possibility of reshaping the patterns of "comparative advantages" as they emerge from the endogenous evolution of national and international industries.

Table 1. Processes and institutions for policies on technological learning and industrial change

Domains of policy intervention	Policy measures	Related institutions
(i) Opportunities of scientific and technological innovation	Science policies, graduate education, "frontier" technological projects	Research universities, public research centers, medical institutes, space and military agencies, etc.

Domains of policy intervention	Policy measures	Related institutions
(ii) Socially distributed learning and technological capabilities	Broader education and training policies	From primary education to polytechnics, to US-type "land-grant colleges", etc.
(iii) Targeted Industrial Support Measures, affecting e.g. types of firms, etc. – *in primis* the structure, ownership, modes of governance of business firms (e.g. domestic *vs*. foreign, family *vs*. publicly owned companies, etc.)	From the formation of state-owned firms to their privatization, from "national champions" policies to policies affecting MNCs investments; all the way to the legislation affecting corporate governance	State-owned holdings, public merchant banks, public "venture capitalist", public utilities
(iv) The capabilities of economic agents (in the first instance business firms) in terms of the technological knowledge they embody, the effectiveness and speed with which they search for new technological and organizational advances, etc.	cf. especially points (ii), (iii) and also R&D policies; policies affecting the adoption of new equipment, etc.	
(v) The economic signals and incentives profit-motivated agents face (including actual and expected prices and profit rates, appropriability conditions for innovations, entry barriers, etc.)	Price regulations; tariffs and quotas in international trade; Intellectual Property Rights regimes, etc.	Related regulatory agencies, agencies governing research and production subsidies, trade controlling entities, agencies granting and controlling IPRs

Domains of policy intervention	Policy measures	Related institutions
(vi) Selection mechanisms (overlapping with the above)	Policies and legislation affecting Anti-trust and competition; entry and bankruptcy; allocation of finance; markets for corporate ownership; etc.	Anti-trust authorities, institutions governing bankruptcy procedures, etc.
(vii) Patterns of distribution of information and of interaction amongst different types of agents (e.g. customers, suppliers, banks, shareholders, managers, workers, etc.)	Governance of labor markets, product markets, bank-industry relationships, etc. all the way to collectively shared arrangements for within-firms information-sharing mobility and control, forms of cooperation and competition amongst rival firms, etc. (cf. for example the historical differences between Japanese *vs*. Anglo-Saxon firms)	

Certainly, the historical experience shows a great variety of country and sector-specific combinations between the types of policies illustrated above. Some subtle regularities nonetheless emerge.

First, a regularity, holding from 19th century Europe and US all the way to contemporary times, is the centrality of public agencies, such as universities, and public policies in the generation and establishment of new technological paradigms.[3]

Second, and relatedly, "incentives are often not enough". A crucial role of policies is to affect the capabilities of the actors, especially in the foregoing case of new technological paradigms, but also in all cases of catching-up whereby no reasonable incentive structure might be sufficient to motivate private actors to surmount big technological lags.

Third, market discipline is helpful in so far as it weeds out the low performers and rewards the high performers within particular populations of firms. However, nothing guarantees that too high selective shocks will not wipe out the entire populations themselves, thus also eliminating any future learning possibility.

Fourth, policies - especially those aimed at catching-up - generally face the need to balance measures aimed at capability building (and also at protecting the "infant learner") with mechanisms curbing inertia and rent-seeking. For example, the latter

[3] In particular on the serendipitous impact of public mission oriented programs after WWII see Mazzucato (2013).

are indeed one of the major elements missing in the old Latin American experience of import substitution while the former are what is lacking under many more recent "liberalization" policies.

Fifth, historically, a successful catching-up effort in terms of per capita income and wages has always been accompanied by catching-up in the new and most dynamic technological paradigms, irrespective of the initial patterns of comparative advantages, specialization and market-generated signals. Our conjecture is that, *ceteris paribus*, the structural need for policies affecting *also* the patterns of economic signals (including relative prices and relative profitabilities) as they emerge from the international market will be greater, the higher the distance of any one country from the technological frontier. This is what Amsden (1989) has provocatively called policies of deliberately "getting the prices wrong". Conversely, endogenous market mechanisms tend to behave in a "virtuous" manner for those countries that happen to be on the frontier, especially in the newest/most promising technologies. This is broadly confirmed by historical experience: unconditional free trade often happened to be advocated and fully exploited only by the technologically and politically leading countries.

The lessons from the past are useful in so far as they apply also to the future. Today, policy making ought to be acutely aware of the fact that future capabilities build upon, refine and modify incumbent ones: hence the policy goal of building *good path-dependencies* (see also Hausmann and Rodrick, 2006). Below is a list of feasible policies that go in this direction.

1. The necessity of nurturing infant industries

Safeguarding the possibility of learning, is indeed the first basic pillar of the *infant industry logic*.

On the incentive side, market signals left to themselves are often not enough and indeed frequently *discourage* the accumulation of technological capabilities in so far as they ought to occur in activities currently displaying significant comparative *disadvantages* and thus also unfavourable current profitabilities. Incidentally note, also, that the existence of financial markets are meagre instruments, if at all, for translating a future and uncertain potential for learning into current investment decisions (more in Stiglitz, 1994; and Stiglitz and Greenwald, 2014). Thus, there are sound learning-related reasons why historical evidence shows that, just prior to industrial catching-up, average industrial import tariffs are relatively low; they rise rapidly in the catching-up phase, and they fall after a mature industrialization. Indeed, it is during the catching-up phase that the requirement of distorting (international) market signals is more acute, precisely because there are young and still relatively fragile learning infants. Partly it has to do with the fact that many forms of protection entail the *possibility* of learning but not, in the language of Khan

and Blankenburg (2009), the 'compulsion' to innovate as distinct from the sheer incentive to just exploit a monopoly rent, no matter how inefficient and lazy is the potential 'learner' (more on this below). Partly, it has to do with the *conditions of capabilities accumulation and the characteristics of the actors involved*.

After all, even under the best intentions and incentives, industrialization might have rather little to do with the sheer award of property rights and with the establishment of firms as legal entities (cf. Hobday and Perini, 2009). Of course, the legal context does matter and is likely to be a conducive condition. However, this is far from sufficient. In fact, it is quite misleading to think that all over the world there are plenty of sources of technological knowledge just awaiting to be exploited – the lag being due mainly to institutional and incentive-related forces. In fact, irrespectively of the opportunities for the entrepreneurial exploitation of technological knowledge which the 'international knowledge frontier' *notionally* offer, the fundamental gap regards precisely the *lack of capabilities* in exploring and exploiting them. 'horizontal ' policies of education and training, together with the activities of technical support to firms by public institutions can go a long way in the capability-enhancing direction. But even that is not likely to be enough. In fact policies are often bound to get their hands *explicitly* dirty with respect to the nature, internal structure, strategies of few corporate agents themselves.

Fostering the emergence and in a few occasions explicitly building technologically and organizationally competent firms are indeed fundamental infant nurturing tasks.

Needless to say the absence/existence of mature technological capabilities and 'dynamic capabilities' for changing them (cf. Teece, Pisano, and Schuen,1997) in any one country is not a binary variable. However, the distribution is highly uneven. So, one could list several dozen countries which can hardly show any. Other countries do display some technologically progressive organizations in a bigger sea of less dynamic firms. In fact, even the most developed countries present only a fraction of technologically dynamic organizations within a much greater population of firms. (Note that all this applies to both 'high tech' and 'low tech sectors as conventionally defined). In a sense, industrialization has to do with the properties of changing distributions between 'progressive' and 'backward' firms. How do policies affect such dynamic? Dahlman, (2009) reports on China and India, but the historical lesson goes well beyond these two country cases. Policies happened to involve

(i) state ownership;

(ii) selective credit allocation;

(iii) favourable tax treatment to selective industries;

(iv) restrictions on foreign investment;

(v) local context requirements;

(vi) special IPR regimes;

(vii) government procurement;

(viii) promotion of large domestic firms.

In a nutshell, this is the full list of the capital sins which the market faithful are supposed to avoid!

There is here again a widespread misunderstanding to be dispelled, which goes under the heading of 'picking-the-winner' or 'national champion' fallacies. Why should governments foster national oligopolists or monopolists in the first place? And how could governments be more 'competent' than market in selecting who is technologically better or worse?

There certainly are unintentional or even counter-intentional outcomes of discretionary industrial policies. Of course, untainted pro-market advocates typically quote among OECD countries the failures of the computer support programmes and the Concord project in Europe as archetypes of such 'government failures' to be put down on the table against 'market failures'. Economists more sympathetic to the positive role of the public visible hand, including us, would find easy to offer the cases of Airbus or ST Microelectronics in Europe, Petrobras and Embraer in Brazil, etc., among many others, as good counterexamples. However, our point goes well beyond this. The 'picking the winner idea' basically builds on the unwarranted myth that there are many 'competitors out there' in the market, and the government has the arrogance of 'knowing better' than the market in their selection. This is often far away from reality in developed countries and, even more so, in catching-up ones. And in fact it happens that the major vehicles of learning and catching-up in all episodes of successful industrialization, with the possible exception of little Singapore, have been *domestic* firms – sometimes alone, sometimes in joint-venture with foreign MNCs -, but rarely MNCs themselves. This holds from German and American industrialization all the way to current China – possibly the case nearest to a two-pronged strategy, both fostering the development of domestic firms and trying to squeeze out of foreign MNCs as much technological knowledge as possible.

Historically, the 'infant learners' had to be shielded or helped in the domestic and international markets essentially in their interactions with the more efficient and more innovative firms from 'frontier' countries. In these interactions, there is no reason to give up the 'infant nurturing' philosophy. On the contrary, it adds to the reasons urging to push toward a more explicit use of the domestic or regional markets as venues of culture of an emerging national industry even when the latter tends to be squeezed on the international arena between 'advanced productions' and Chinese exports.[4]

[4] China quickly reduces its absolute disadvantages across the board, in both more traditional productions and in activities based on the newest technological paradigms. And it does so at rates higher than its catching-up in wages (notwithstanding the fast growth of the latter). The outcome is an absolute *cost* advantage in an expanding set of goods including those which were/are central to industrial production of many low and middle income countries.

2. Infant industries under the new international Trade Regime

There is another big novelty in the current organization of international economic relations, namely the regulatory regime stemming from the World Trade Organization (WTO) and the TRIPS agreements (more on them below). The latter ones have implied stronger constraints on what is admissible in terms of subsidies and other discretionary forms of support to firms and industries.

What can be done?

Quite a few things can be done also within the incumbent agreements, full as they are of loopholes and of provisions for exceptions generally put there by the negotiators of developed countries with an eye on their special interests – ranging from dubiously defined 'anti-dumping measures' to national safety and security considerations. Developed countries (in fact, frequently, *the very representatives of special industrial interests* in person*,* mostly from the U.S., EU and Japan), have been quick in exploiting these provisions. Developing countries have rarely done so, overwhelmed by the power of the money, the political clout, the lawyers' sophistication, the power of blackmail by stronger States. At least equally common has been so far the unawareness of these opportunities for pragmatic management, certainly thickened – we caricature on purpose – by Chicago-trained ministers of the economy truly believing that all problems come from the fact that trade liberalization has not gone far enough, and directors-general of the ministry of trade who had been taught that the Heckscher-Ohlin-Samuelson theorem on gains-from-trade is the last word on the subject. *There are other things that must be avoided at all costs:* among them*, shy away from 'bilateral' agreements.*

In brief, 'bilateral' agreements are WTO-plus, and, in terms of Intellectual Property Rights, 'TRIPS-plus' agreements, whose bottom line is to close the loopholes/exceptions/safeguard clauses of the original WTO and TRIPS agreements, freezing them in favour of the companies and industries from the developed world. So, a bilateral agreement, most often with the U.S., offers 'preferred country clauses', typically concerning textile exports and the like, which we know do not matter much, if at all, since Chinese exports are more competitive even if one takes away all tariff on the developing country's export. On the other more subtle side, the provisions of the bilateral agreement often involve the unconditional acceptance of the IPR regime imposed by the developed partner and curbs on imports from third countries of commodities produced under the various waivers still contemplated under the WTO. While there are significant and still largely unexploited degrees of freedom unintentionally provided by the current international trade institutions and rules, the straight jacket is likely to remain too tight. As Dahlman (2009) remarks, if China and India "had liberalized

from the beginning it is unlikely that they would be the strong economic powers that they have become. To a large extent, some of the strengths of both countries are that they developed strong capabilities before they liberalized". The point applies of course also to the countries which are beginning now their process of capability accumulation. But then the conclusion is that some trade re-negotiation is going to be necessary. It is reasonable for example to switch to a regime whereby the object of multilateral agreement are *average* industrial tariffs as distinct from tariffs that are line-by-line or apply to specific products and sectors.

The system is simpler than the current structure of tariff commitments and would also reconcile multilateral discipline with policy flexibility since countries would be able subject to an overall average ceiling while maintaining degrees of freedom for discretionary sectoral strategies. In practice it would have the effect of balancing tariff increases and reductions , since a country would need to lower its practised tariffs on some products in order to be able to raise them on others. This would encourage governments to view tariffs as temporary instruments and focus the efforts to ensure that they effectively serve the purpose they are designed for, that is to provide a breathing space for infant industries before they mature and catch up with their counterparts in more advanced countries.

Moreover, within such a logic, the average ceiling itself ought to depend on the levels of technological and economic development, raising as the catching up process is put in motion and falling as industrialization become ripe.

3. A management of the distribution of rents favourable to learning and industrialization

The other side of 'infant nurturing' policies discussed above regards the rent distribution profile that they entail. We have already emphasized that offering an opportunity of learning via, say, a temporary trade barrier, does not imply *per se* the incentive to do so rather simply exploiting the rents stemming from the protection. As outlined by Khan and Blankenburg (2009) , successful industrialization policies have all come with rent management strategies providing for *compulsions* for learning and accumulation of both technological capabilities and production capacity. There are three sides to such strategies.

First, on the 'carrot' side, policies must be able to transfer resources to the 'progressive actors' : fiscal policies, subsidies, preferential credits, grants are among the possible means. In fact, fiscal policies are particularly important in the transfer of resources from those activities which benefit from (cyclical or, even

more so, trend) improvements in the terms of trade of natural resources - in the form of export levies, royalties indexed on the final price of the commodities, fines and taxes discouraging environmental damage. Moreover, the construction of industrialization-friendly financial institutions is of paramount importance . Second, on the 'stick' side, governments must have the credibility to commit to developmental rents for periods that are sufficiently long but not too long (of course how long will depend on the sectors; the nature of the technologies; the distance from the international frontier; the initial capabilities of managers, technicians, workers, etc.). In that, of course, the critical requirement is the credible commitment to stop all rent-yielding measures after some time and, in any case, to withdraw them and impose sanctions on firms and industries failing to achieve technological investment or export targets. Third, the nurturing of domestic oligopolists has to be matched by measures fostering competition. There is a general lesson coming from the experiences of Korea, and some decades before Japan, whereby quasi-monopolistic or oligopolistic domestic firms were forced, quite early on, to compete fiercely on the international markets. And, together, above some threshold of industrial development, anti-trust policies are an important deterrent against the lazy exploitation of 'infant protection'.

Indeed, the management of rent distribution in its relation with industrial learning is one of the most difficult and most crucial tasks of any industrialization strategy, as it concerns the overall distribution of income, wealth and political power across economic and social groups.

4. Tight Intellectual Property Rights regimes never help industrialization and sometimes harm it

All catching-up countries – including, to repeat, at one time also the United States and Germany – have done so through a lot of imitation, reverse engineering, straightforward copying. But these activities are precisely what strong property right protection is meant to prevent. How effective IPR are in achieving this objective depends a lot on the technologies and the sectors but certainly when they are effective they are likely to represent an obstacle to domestic technological learning. Conversely, if IPR protection *may* represent an incentive to innovate in *frontier* countries – a claim indeed quite controversial, not supported by particularly robust evidence (cf. again Dosi et al., 2006, for a discussion) -, there is no evidence that they have any positive effect in spurring innovative activities in catching-up countries. Certainly, successful industrializers at some point start innovating and also patenting, but typically – a century ago as well as today –

they fill their patent claim in frontier countries where their strongest competitors are likely to be based. At the same time, the domestic IPR regime has been characteristically weak. The situation, however, has recently changed with TRIPS agreements which have basically extended the tightest IPRs rules of developed countries to all the signing countries, including developing ones, and has been made even worse by the already mentioned bilateral agreements. Further, TRIPS has taken away the possibility of differentiation the regime of protection across products and technologies.

First, it is to *be aware* and never buy the story that 'IPR are good for development because they are good for innovation'. On the contrary, in many technological areas they are largely irrelevant for both innovation and technological catching-up. In other areas like, in primis, *drugs*, they are definitely harmful for imitation and capability building in catching-up countries (while they have indeed a dubious effect on the rates of innovation in frontier countries). A consequence of such an awareness is also the need of greater efforts to build institutional capabilities and a clear 'technology acquisition strategy' to orient negotiations and dispute settlements.

Second, and relatedly, TRIPS agreements contain a series of loopholes, safeguard clauses and exceptional provisions – for example concerning compulsory licensing – which catching-up countries have still to learn how to exploit.

Third, the most advanced among catching-up countries ought to strive to offer relatively less developed ones appealing regional agreements which could be viable alternatives to the bilateral agreements with the U.S. (and the EU) generally containing IPR provisions even stricter than TRIPS.

Last but not least, also in this case, alike in the trade of goods –already discussed – a new wave of multilateral negotiations are likely to be needed aimed at

(i) reducing the breadth and width of IPR coverage;

(ii) expanding the domain of *unpatentability* – from scientific knowledge to algorithms to data -, and,

(iii) conditioning the degrees of IPR protection on the relative level of economic and technological development of each country.

After all, the current international IPR regime is largely the response to the special appropriability interest of a small *sub-set* of developed countries' firms – basically Big Pharma and biotech, Microsoft and Hollywood. A reform in the directions just indicated would benefit catching-up countries, but also the first-world consumers, without doing any harm to the overall rate of innovation.

5. The necessary consistency between macroeconomic and industrial policies

As extensively discussed in several chapters of Cimoli, Dosi and Stiglitz (2009) addressing the Latin American experience over the last two decades, there are macroeconomic policies which kill most learning efforts together with most forms carrying the related learning capabilities. Sudden and indiscriminate dismantling of trade barriers can easily do that, especially if it comes together with reckless (non) management of exchange rates, characterized by vicious cycles of appreciation followed by sudden devaluations. And the cycles have been only amplified by the stubborn refusal to utilize controls over capital movements, especially short-term movements. Blind trust in the 'magic of the market place' and the associated lack of fiscal policies and demand management increases output volatility. In turn, the latter, together with the endemic financial fragility of many developing countries' firms means induced waves of corporate mortality and with that also the disappearance of the capabilities of technological accumulation. And even among surviving firms, behaviours tend to become more short-term and the economy tends to respond more to financial signals than to long term learning opportunities (more on all that in Ocampo and Taylor, 1998; and Stiglitz et al., 2006). The comparative tales of Latin American countries as compared to e.g. Korea or Malaysia, tell the importance of the vicious feedbacks between macro policy shocks prescribed by orthodox recipes and micro dynamics (in Latin America) vs. the virtuous feedbacks between more interventionist and 'Keynesian' macro policies and the continuing industrial expansion even under severe financial crises (e.g. in Korea).

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Governing Knowledge: Intellectual Property Management for Development and the Public Interest

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Abstract

The core point of this paper is the hypothesis that in the field of intellectual property rights and regulations, the last three decades witnessed a big change. The boundaries of private (or corporate) interests have been hyper-expanded while the public domain has significantly contracted. It tries to show that this is detrimental to innovation diffusion and productivity growth. The paper develops the argument theoretically, fleshes it out with some empirical evidence and provides a few policy recommendations on how to redesign the frontiers between public and private spaces in order to produce a more democratic and development-oriented institutional landscape. The proposed analytical perspective developed here, "Knowledge Governance", aims to provide a framework within which, in the field of knowledge creation and diffusion, the dividing line between private interests and the public domain ought to be redrawn. The paper's key goal is to provide reasoning for a set of rules, regulatory redesign and institutional coordination that would favor the commitment to distribute (disseminate) over the right to exclude.

Keywords: knowledge management, intellectual property, patent, public interest, public sector, private sector, socioeconomic developmen

Introduction[1]

"The field of knowledge is the common property of mankind."
Thomas Jefferson

The core point of this paper is the hypothesis that in the field of intellectual property rights and regulations, the last three decades witnessed a big change. The boundaries of private (or corporate) interests have been hyper-expanded while the public domain has significantly contracted. The paper tries to show that this is detrimental to innovation diffusion and productivity growth. (cf. Brown-Keyder 2007; Boyle 2008; Rodrik 2011 and Burlamaqui and Cimoli 2014 for similar lines of reasoning).The paper develops the argument analytically, fleshes it out with some empirical evidence and provides a few policy recommendations on how to redesign the frontiers between public and private spaces. The result would be a more open, democratic and development-oriented institutional landscape in the fields of knowledge creation and appropriation. This "Knowledge Governance", analytical perspective developed here proposes a framework within which, in the field of knowledge creation, diffusion and appropriation, the dividing line between private interests and the public domain ought to be redrawn. The paper's key goal is to provide reasoning for a set of rules, regulatory redesign and institutional coordination that would favor the commitment to distribute (disseminate) over the right to exclude.

In 2005, Mark Blaug made a prescient, remark in that matter:

> "It never occurred to anyone before, say the 1980s, that such disparate phenomena as patents for mechanical inventions, industrial products and processes (now extended to biotechnology, algorithms and even business methods), copyrights for the expression of literacy and artistic expressions in fixed form and trademarks and trade names for distinctive services, could be generalized under the heading of property rights, all conferred by the legal system in relation to discrete items of information resulting from some sort of appropriate intellectual activity". (Blaug 2005, 71-72, italics added)

For the purposes of the arguments in this paper, there are two crucial elements implicit in Blaug's statement. First, that, as recently as in the seventies, the balance between private interests and the public domain was completely different from what it has become today. Second, that what became codified, and largely

[1] This paper is an outgrowth of recent papers published by the author (Burlamaqui: 2009b, 2014 and Burlamaqui and Cimoli: 2014).

accepted, as intellectual property rights was, until then, understood as a set of rules and regulations issued by the state, granting temporary monopolies to corporations in very specific cases. Recent history seems to back both Blaug's statement and my hypothesis. Until the 1970s, United States patents were seen as monopolies (a term with distinctly negative connotations at that time), not rights. In fact, in some areas of economic activity, it would have been possible to say that upholding the validity of IP was the exception rather than the rule (Brown-Keyder 2007, 159). This was reflected in IP law as well as in competition or antitrust law. In copyrights, the term under United States law was 28 years.

The early 1970s witnessed several dramatic changes. In 1974, a trade act allowed the Federal Trade Commission to bring sanctions directly against countries whose products were seen to hurt United States interests. In 1975, copyrights were expanded to over 70 years from the death of the author, and for corporate owners, to 95 and sometimes even 120 years (Brown-Keyder 2007, 158; Boyle 2008, ch. 1). In 1979, Section 301 of the United States trade law was amended to "allow private parties to take significant and public steps to enforce international trade agreements" (Brown-Keyder 2007, 160). In 1988, the Justice Department rescinded guidelines for antitrust prohibitions on certain kinds of licensing clauses. This removed IP licensing from antitrust scrutiny. Finally, with the enactment of the WTO in 1995, the TRIPs agreement quickly became the linchpin of United States trade strategy. By then, private corporations had vastly expanded their enforcement power and global outreach, while the public domain had significantly contracted.

From a knowledge governance perspective, the critical question is this: When does extended protection cease to work for generating Schumpeterian profits and become a base for rent-seeking and rent extraction.[2] There is no good theoretical answer to this, but recent data on declining R&D expenditures correlating with the maintenance of handsome profits in big pharma seems to emphasize its relevance (cf. "Supply Running Low." Financial Times 10 February 2011).As an alternative to the "strong IPRs" mainstream approach, new insights and evidence are beginning to appear. Besides the already cited studies, a few papers and books are laying the ground for a very different way to understand the complex interactions among knowledge production, appropriation and diffusion. Examples include Jerome Reichmann's work , the comparative and interdisciplinary research led by Richard Nelson, Akira Goto and Hiro Odagiri on intellectual property and catching-up and the collection of essays edited by Fred Block and Mathew Keller on the role of the US government in technology development (Reichmann et alii: 2014,Odagiri et alii:2010, Block and Keller eds: 2011).

[2] See Arnold Plant's point below on that matter.

However, notwithstanding the valuable contributions by this emerging body of research, the main analytical question remains largely untouched: How should government-issued intellectual property rules and regulations interact with publicly funded R&D research and competition policies[3], in order to help craft and govern socially inclusive development strategies? It appears there is no coherent analytical framework to address that interaction.[4] However, those links are central to any meaningful discussion of dynamic competition, knowledge accumulation and diffusion, and sustainable development in a global context today.[5]

This paper aims to contribute to answering that question. Section II lays the ground rules by linking knowledge production and dynamic competition with intellectual property issues from the perspective of the dynamic efficiencies and inefficiencies that are bound to appear. It will become clear that the existence of dynamic inefficiencies opens up a considerable space for public interest based "knowledge governance" policies and regulations. Section III further develops the previous framework by linking competition and technology policies with intellectual property. Special attention is given to how competition policies should link publicly funded R&D to intellectual property rules issues under a Knowledge governance approach.. Section IV concludes the paper by suggesting some broader theoretical and policy implications of that approach.

Knowledge production, dynamic inefficiencies and the role of knowledge governance

In the context of Schumpeterian competition, intellectual property rules and regulations (IPRs) – patents, trade secrets, confidentiality contracts, copyrights, trademarks and registered brand names – became powerful, strategic weapons for generating sustained competitive advantages and, especially, Ricardian rents (cf. Schumpeter: 1934, Plant 1934).[6]

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[3] A much less catchy label but one that reveals their real nature much better than "rights."

[4] This does not imply a shortage of work discussing specific issues in what is called "the economics of intellectual property rights." See Menell (1999) for an excellent survey on general theories of IP. A very interesting review acknowledging the under-researched nature of the theme can be found in Dixon and Greenlalgh (2002). The shortcomings of most of that work are, from my perspective, the result of its concentration on "data," "measures" and "testing," with little attention paid to the theoretical framework within which they are conducted.

[5] From an evolutionary perspective, evolution should not be confused with progress (a very common mistake), but as a process, it should definitively be understood as entailing increasing complexity.

[6] Having said that, it is striking how little has been written about the crucial and complex connection between Schumpeterian competition and IPRs. We include ourselves in that loophole. In that regard, legal theorists such as Landes and Posner and Benkler are clearly ahead, in the sense that they are already doing the reverse – using Schumpeterian concepts and insights to deal with IPRs (cf. Landes and Posner 2003, Benkler 2006).

From an entrepreneurial perspective, patents and other IPRs are extremely effective means to reduce uncertainties and therefore can contribute to igniting the animal spirits and long-term expectations through building temporary monopolies around products, processes, market niches and, eventually, whole markets (Nelson 1996; Burlamaqui and Proença 2003). However, the word temporary is crucial here because of creative destruction; as Schumpeter (1994, 102) stated long ago, "A monopoly position is in general no cushion to sleep on."[7]

The Chicago Law and Economics framework claims that in the absence of robust legal protection for an invention, the inventor either will have less incentive to innovate or will try to keep his invention secret, thus reducing, in both cases, the stock of knowledge to society as a whole (Landes and Posner 2003, 294). From that perspective, patent law itself supposedly internalizes the goal of promoting the diffusion of innovation.[8] It requires, as a condition of granting a patent, that the patent application disclose the steps constituting the invention in sufficient detail to enable readers of the application, if knowledgeable about the relevant technology, to manufacture the patented product themselves. Of course, anyone who wishes to replicate a patented product or process legally will have to negotiate a license with the patentee (Jolly and Philpott 2004, pt. 1; Landes and Posner 2003, 294-295).

Moreover, any reader of the patent application will be free to "invent around" it, to achieve the technological benefits of the patent by other means without infringing on the patent. Translated to evolutionary economics jargon, the requirement of public disclosure creates a situation of "incomplete appropriability" for the patent holder. That links directly to Schumpeter's insight on the temporary nature of monopolies: incomplete appropriability allows for the possibility of technological inventiveness and borrowing from publicized information, both of which foster creative-destruction processes that are the main challengers of established monopolistic positions. Thus, if carefully used, intellectual property rules can be sources of dynamic efficiencies that can help to ignite the Schumpeterian positive-sum game represented by falling costs, falling prices, positive margins (achieved through market power) and increased consumer welfare.[9]

Those are the basics, but the picture gets much more complicated as we examine the details. When we dive into the depths of the relationship between innovation and IP laws and regulations, considerable space opens up for dynamic inefficiencies to emerge and, therefore, for the introduction of governance considerations and

[7] However, a strong IP regime is precisely the kind of "institutional innovation" that can help to build that cushion. Addressing this problem is one of the core issues of the knowledge-governance approach.

[8] Reference here is to American patent law.

[9] From here on, I will label this "Schumpeterian positive-sum game" as the "Schumpeterian package."

for the emergence of a knowledge-governance approach. Consider the following six points.

First, as Sir Arnold Plant, an almost forgotten analyst in the field, observed in the early 1930s,

> "In the case of physical property, the institution of private property makes for the preservation of scarce goods. … In contrast, property rights in patents and copyrights make possible the creation of scarcity of the products appropriated. … the beneficiary is made the owner of the entire supply of a product for which there may be no easily obtainable substitute." (Plant 1934, 65-67, emphasis added)

In sum, intellectual property regulations can easily give rise to dynamic inefficiencies such as cumulative monopoly power to extract rents from a given consumer base, notwithstanding the fact that they can at the same time create the conditions for the expansion of productivity and wealth and the generation of Schumpeterian profits.[10] That in itself leaves ground for knowledge-governance-oriented initiatives to enter the scene[11], as we will see shortly.

Second, the broader – and stronger – the IPRs, generally, the less the patentee's competitors will be able to benefit from the patent by "inventing around," or innovating on the shoulders of, the patent (or copyright) holder. Broad IPRs are thus bound to exacerbate the dynamic inefficiencies that Plant and others have observed. Accordingly, especially given the complexity and diversity of patents and other IPRs, a one-size-fits-all prescription seems ill-advised. From an analytical point of view, the articulation between competition policies and IPRs is a much needed development[12], especially if the former's goal is innovation diffusion and delivering the Schumpeterian package, not innovators' protection per se.

Third, the practice of strategic patenting, that is, the proliferating business strategy of applying for patents that the company has no intention of using, or exploiting, solely to prevent others from profiting from the innovation (cf. Varian, Farrel and Shapiro 2004, pt. 2; Landes and Posner 2003, ch. 11). Obviously, this is a major source of dynamic inefficiency. It has the effect of shifting resources from true innovative activity to litigation (or from labs to courts). It drastically increases the costs of patent prosecution and litigation and, therefore, of innovation.

[10] Or, in a more technical way of saying it, the expected (negative) impact on future incentives for competitors to compete (innovate) and future consumer welfare (see Anthony 2000, sect. IV.)

[11] On policy prescriptions, institutional building, institutional coordination and regulatory redesign.

[12] We will use the term "competition policies" rather than "antitrust" here because of the outdated connotation of the latter. We will not discuss "trust-busting", but a much more subtle and complex set of behaviors, institutions and policy tools.

Such strategic patenting constitutes a paradigmatic example of what Baumol has called "unproductive entrepreneurship." Baumol notes:

> "… [a] variety of roles among which the entrepreneur's efforts can be reallocated … and some of those roles do not follow the constructive and innovative script conventionally attributed to that person. Indeed, at times the entrepreneur may even lead a parasitical existence that is actually damaging to the economy. (cf. Baumol 1993, ch. 2, 25; see also ch. 4)".

Evidently, this task of "reallocation of entrepreneurship" (from unproductive roles to productive ones) is a knowledge-governance matter and one that goes far beyond the common notions associated with industrial and technology policies.

Fourth, IPRs have a central role in the "digitally renewed economy", as Paul David would label it, (Cf. David in Brynjolfsson and Kahin 2002, 85). In so-called "new-economy industries", intellectual property, rather than the products and processes in and of themselves, is a firm's primary output or asset. Overlapping innovations, rapidly falling average total costs, zero marginal costs, strong network externalities and, therefore, fierce "standards battles" and "lock-in" situations are the hallmarks of new-economy industries (Shapiro and Varian 1999; Best 2001; De Long 2000; Brynjolfsson and McAfee: 2011). These industry-structure characteristics might be seen as generating speeding waves of creative destruction and, thus, potentially more (not less) fiercely competitive challenges to incumbents. Although there is an element of truth in that picture, creative destruction in a world of increasing returns of scale, fast learning and "winner-takes-all" markets does not mean anything close to some idealized form of "perfect competition" or perfectly contestable markets. Rather, it merely brings the replacement of one, or a few, dominant firms by others, such as the replacement of Fairchild by Intel, of Ciba and Geigy by Pfizer and Novartis, of Wang and Compaq by Dell and Samsung, of IBM by Microsoft and Lenovo and of Microsoft by Google and Apple.

In other words, in the new economy, firms' abilities to combine first-mover advantages with trade secrets, patents, copyrights, brand loyalties and network externalities may afford them secure long-lasting monopolistic positions despite their low rate of (radical) innovations and not because of it.[13] The outcome is,

[13] See Landes and Posner's (2003, 395-396) somewhat reluctant recognition of that point. The case of Microsoft itself can be used to illustrate the point. The lack of breakthroughs – technological innovations or radical quality/price improvements – is notoriously known in Microsoft. It is well known that the "Windows" model was copied from Apple's user interface – which itself was a second-hand theft from Xerox PARC – as well as the tremendous lack of perception, by the company, of the Internet potential until the success of Netscape became obvious. It is also known that the differences between the versions of Windows and Office that I am using right now, although "new", display very pale improvements in relation to their 1998 predecessors.

once more, the danger of replacing Schumpeterian profits with rent extraction and Schumpeterian competition with zero-sum game exclusionary practices. From the perspective of delivering the "Schumpeterian Package", there is an obvious role for knowledge governance here in restoring the balance between private interests and the public domain (cf. Boyle 2008, Ch. 8-10). However, the normative policy framework within which it should take place is far from certain. I will revisit it in the next section.

Fifth, if we understand knowledge production as a cumulative, and increasingly globalized[14], process in which cutting-edge knowledge and expertise rest on previous innovations, and if we conceive of patents and IPRs, in general, as fences erected to protect those previous innovations, we get a very different outcome. It is not difficult to perceive, depending on the institutional design within which IPRs are handled, the tension and potential trade-off between private interests and the conception of knowledge as a global public good. This is the so-called argument of the "second-enclosure movement" or "information feudalism," which is now the subject of intense debate (cf. Drahos and Braithwaite 2002, Boyle 2003 and 2008, Evans 2005, Technology Review 2005). According to Evans (discussing Boyle's ideas),

> "There are really two halves to the second-enclosure movement. The defensive side focuses on intensifying the enforcement of protected monopoly rights to exclude others from using information that has been defined as private property. The offensive side of the agenda involves taking information that has been considered part of "nature", or the common, cultural and informational heritage of humankind, and transforming it into "private property". If both halves are successful, the "second-enclosure movement" would constitute a global re-distribution of property comparable to the eradication of the commons that ushered in agrarian capitalism in Western Europe 300 years ago". (Evans 2005, 2; emphasis added)

Once more, we encounter strong forces of global dynamic inefficiencies, presenting an opportunity for knowledge-governance-oriented policies to step in.

Sixth, to the question "where do knowledge and innovations come from in the developed nations?" a very large part of the answer would include: publicly funded R&D, government contracting to buy things from the private sector that do not exist and using the WTO to help open up markets for those innovations abroad (Block 2008, Weiss 2008, 2009). In the case of the United States, armed with an annual procurement budget of US$450 billion – more than 1 trillion if states are included

[14] In the sense of its increasingly geographical dispersion, but not denoting any sign of broader inclusion or democratic orientation.

– the state plays a crucial role in governing the way knowledge and innovations prosper in the United States (Ruttan 2006; Weiss 2009). Furthermore, according to some recent studies, the United States government played a decisive part in the development of virtually all general-purpose technology, from interchangeable parts and mass production to DARPA and biotech (cf. Ruttan 2006, Weiss 2007, Block 2008, Block and Keller 2011).[15]

Let me rephrase this point: If we conceive R&D as "turning money into knowledge" and innovation as "turning knowledge into money," why should governments (i.e., public money) heavily subsidize the former and almost completely retreat from participating in the latter?

Last, the institutional structure – or institutional design – within which the knowledge-production appropriation and diffusion apparatus is enforced is central for understanding its performance. We refer here not to the rules, as such, but to their legal enforcement apparatuses, the state structures by which they are supported and the sort of public bureaucracies available to administer the R&D and IP systems. Jaffe and Lerner's (2002) thoughtful and provocative work on the recent changes in the United States patent system provides the background for our discussion, which will draw on the relationship between the institutional design of the United States patent system and the problems it creates for the promotion of innovation and "productive entrepreneurship" .

All six issues discussed above illustrate how the interaction between Schumpeterian competition and hyperextended intellectual property rules and regulations can give rise to dynamic inefficiencies that risk the delivery of the "Schumpeterian Package" and call for knowledge-governance interventions to restore the balance between private interests and the public good (or public interest.

Knowledge governance: Bringing the public domain back in

Knowledge governance (KG) is a broad concept embracing different forms of governance mechanisms influencing the production, dissemination and appropriability of knowledge. The "knowledge-governance approach" is an emerging approach that cuts across the fields of knowledge creation and management, innovation and competition policies and state capacities. KG deals with how the deployment of governance mechanisms influences knowledge processes, such as sharing, retaining and creating knowledge. As an analytical perspective, it encompasses intellectual property rules and regulations but supersedes it, drawing

[15] DARPA is the Defense Advanced Research Projects Agency, the central research organization of the United States Department of Defense. Its most radical innovation was the Internet (known first as ARPANET).

on those aforementioned fields and disciplines in order to design the contours of a new knowledge ecology. KG's main goal is to design, support and implement public interest oriented governance mechanisms, as well as organizational and business models which are alternatives to the instituted intellectual property regime we now have (Burlamaqui 2009b). Within the knowledge governance approach, the general rule should be the promotion of innovation (not the innovator) and the assurance of its widest diffusion. This implies, simultaneously, promoting and regulating entrepreneurial success. Promoting and regulating is a crucial link here. Together, they address both the private (profit seeking) and the public (innovation-diffusion and technological-upgrading) sides of competition policies and their respective institutional designs.

This policy and institutional-design package was, in fact, the core of the Asian state-centered developmental strategy. Nowadays, it remains alive and well in East Asia. In Singapore, it is evident in the country's twin government-sponsored initiatives. On "biomedical sciences" and on "work restructuring," where market-shaping and institutional coordination are the core elements (Pereira 2008). In China, it is clearly present in the 12th five-year plan for 2011 to 2015, finalized last April. The plan highlights the importance of the "magic seven" industries: (1) energy saving and environmental protection, (2) next-generation information technology, (3) biotechnology, (4) high-end manufacturing, (5) new energy, (6) new materials and (7) clean-energy vehicles. The plan's objective is to "shape" them in order to raise their share from 3 percent to 15 percent of the economy by 2020.

None of those countries labels their government-sponsored initiatives as knowledge governance, but it is quite clear that this is what they really are: going much beyond "industrial policy" or "intellectual property", they reach the key interactions between knowledge and markets … and shape them from a public-policy/public-interest perspective.

From a normative perspective, knowledge-governance policies should use market-shaping devices in order to design policies to manage creative-destruction processes. These policies would seek to shape markets in order to reduce dynamic inefficiencies and increase dynamic efficiencies coming from Schumpeterian competition, a form of competition that, now, overuses intellectual property rules as one of its core weapons. From the perspective of firms, knowledge-governance policies should not be about preventing "market power" but about curbing its excesses: "unproductive entrepreneurship" and "rent extraction".

Within a knowledge-governance framework, the main policy concerns should be to mitigate structural inefficiencies and to increase access. Plant argued that patents can make the beneficiary "the owner of the entire supply of a product for

which there may be no easily obtainable substitute", (1934, 30) a troubling claim. A clever, but not radical, innovation (for instance, market-niche dominance by Post It® notes from 3M) should not raise major concerns among policy-makers dealing with competition issues. However, what are the implications of a proprietary general-purpose technology cornering the market? For instance, a new genetic-engineering research tool or a particular DNA sequence)? Then Plant's point would hold completely, and the granting of a patent would create a substantial monopoly for the owner – and potentially prevent others from exploiting it – thus slowing the diffusion of a potentially radical innovation with obvious negative impacts on productivity growth.

In cases like those involving general-purpose technologies, IP rules and regulations should be much more rigorously examined and carefully constructed. A possible "tool" for dealing with them would be for the government to claim a golden share in the IPR system (especially patents and copyrights), by which it would be able to convert a property right previously granted into a general public license[16], as well as to profit from its dissemination[17].

In sum, radical innovations – and, especially, general-purpose technologies – should be subjected to a special IPR regime in which the government's golden share should be able, if needed, to "shape" the market toward a more competitive institutional design (away from too secure – or broad – monopolies).[18] A legitimate, and fair, reason to do so is that, as already mentioned above, according to some recent studies, the US government played a decisive part in the development of virtually all general-purpose technology, from interchangeable parts and mass production to DARPA and biotech (cf. Ruttan 2006; Weiss 2007 and 2014; Block 2008).

[16] That is, a legally enforced temporary monopoly.

[17] Meaning the ability to recover his costs, establish a robust competitive advantage and enjoy a sizable profit stream, but not the ability to exclude others from using and inventing around his innovation or protecting its diffusion. Taking as an example the Microsoft case, the battle should not be about "breaking" the company. The golden share would allow the government to force Microsoft to publish its source code. An open code would quickly get cleaned up and improved, consumers would benefit and new entrants would probably arise helping ignite the innovation race and dislodging Microsoft from its monopoly position while preserving the company's market power and ability to innovate.

[18] As a clever reader, you should, at this point, be asking "How can an innovation – or innovation cluster – be defined as radical before it 'matures' though a process that evidently takes time?" The answer is simple: it cannot. The proposal here is for public sources of funding and regulatory bodies, through the golden share or via special provisions similar to those behind the rationale for issuing compulsory licenses, to retain the option to classify an innovation cluster as a strategic general-purpose technology for potentially delivering "massive wealth creation." As such, those technologies would be treated similarly to weapons of mass destruction, but for inverse reasons. And that placement would happen ex-post, not ex-ante.

Given both the complexity and diversity of knowledge-production regimes and R&D funding, a one-size-fits-all prescription for knowledge appropriation (IPR rules) is not the best way to handle the matter. The 20-year length of a patent (or the terms of copyrights and registrations) is not a "scientifically established outcome" (Landes and Posner 2003). It is, rather, a convention – that is, a (lobby-based) institutional-legal construct that, as such, can very well be questioned and changed.[19] Alternatively, consider this broad guideline for knowledge-governance policies: the length and breadth of patent protection, as well as innovations protected by copyrights, such as software, should be directly linked to the expenditures in R&D, made by applicants in the development of a technology and inversely correlated with their market power.[20] Thus, big research budgets (in terms relative to the firm's size) would, in principle, qualify better than "historical accidents" to earn legitimate protection. Conversely, "global players" would enjoy less legal protection than "garage outfits", given that the same legal contract would grant cumulative and increasing returns in the former case – reinforcing dominance – and, often, the ability to serve debt in the latter. Instead of one size fitting all, we would have something like – paraphrasing Rodrik – "many recipes under the same rule".[21]

As for the source of dynamic inefficiencies referred to above as strategic patenting, it should be dealt with in the same way David Ricardo suggested landlords should be addressed[22]: earned but unused patents should be classified like fertile but uncultivated pieces of land in an environment structurally constrained by scarcity. They should be taxed, and progressively so. After an initial "launching period," each year of idleness in the commercialization of the patent should give rise to a severe

[19] As a matter of fact, a century ago, copyrights lasted for 14 years – and could be extended another 14 if the copyright holder petitioned for an extension. Today, corporate copyrights last for 95 years, and individuals retain copyrights for 70 years after their deaths. There was nothing "scientific" to back these changes but rather the powerful lobby of the entertainment industry. As for patents, the reader bear in mind that both in Switzerland (between 1850 and 1907) and in the Netherlands (between 1868 and 1912), industrialization occurred without enforcement of patent laws (cf. Schiff 1971).

[20] R&D expenses as a percentage of the applicant's sales or assets could become a metric. That would require a close monitoring of R&D evolution within firms. Assuming that those R&D-intensive industries are also the ones bearing more fixed and sunk costs, plus near-future planned expenses tied to the "birth" of an innovation or technology, should be in the contract granting the rights and their actual production of the enabling mechanism to conclude the exam. Otherwise, patent pending would be a sort of "reasonable doubt" proviso.

[21] A very difficult emerging theme here is the protection to be given to traditional knowledge: DOC (Denominacione de Origine Controllata certifications that grant monopolies based on regional know-how and capabilities, like champagne versus sparkling wines) issues and related others. I acknowledge its importance but do not deal with that in this paper.

[22] The parallel here would be between the example given by David Ricardo of the unique fertility of a piece of privately owned land, which would generate increasing revenues to its owner, regardless of efforts to improve the land's productivity, and the stream of revenue generated from a patent regardless of whether its owner keeps innovating.

fine, the exact amount of which should be left to specialists in the field but could very well be an increasing percentage of the patentee's sales or assets. Does this sound rigorous? Yes, it does, but patents and IPRs are legally conceded monopolies and matters of public interest.[23] They are too important to be left to private law firms to design and to corporations to govern.[24]

> Additionally, the kind of approach to the governance of knowledge I am pointing to should have as its core principle the discouragement of the sort of unproductive entrepreneurship that Baumol highlighted more than three decades: A type of legal entrepreneurship that turns law firms into very big and profitable corporations but with zero impact on the economy's real productivity. It would, in sum, help to trigger the "relocation of entrepreneurship" – from courts back to labs – as claimed by Baumol (1993 and 2002).

Another key point outlined in Section II above relates to the relationship between the "digitally renewed economy" and intellectual property issues, and particularly to the risk of winner-takes-all market outcomes (cf. Varian et al. 2004; Carlton and Gertner 2002). Knowledge-governance policies here should pursue, very aggressively if needed, public enforcement of standards development, cooperative-standards setting, the stimulation of (instead of restriction on) joint research ventures and other forms of research coordination and venture capital financing to multiple sources of experimentation (Block and Keller 2011). The aim should be a "less kind, less gentle patent system," as Jaffe and Lerner (2002) put it, in which patents are much harder to acquire and easier to share.

Also of concern is the recent wave of IPR expansion and its connection to a potential "information feudalism" or "second enclosure movement." This movement is analyzed by "progressive IP lawyers", software programmers and a sizable number of social and natural scientists of various extractions as a recipe for global monopoly, one that is likely to stifle innovation at the same time as it concentrates

[23] In that sense, they are very similar to the financial industry and especially to the banking sector.

[24] Google offers a striking example on that matter: it has just bid US$900 million for the patent portfolio of Nortel Networks, the Canadian telecom-equipment maker, as part of a strategy to defend itself against patent litigation. The amount of money involved signals how fierce the patent wars have become, particularly in Silicon Valley, where even the largest and most powerful companies, like Google, are besieged by dozens of patent-infringement suits. It also underscores Google's frustration with the state of the patent-reform legislation in Congress.

Though Google could potentially use some of the technology in the Nortel patents in future research, the company said it wanted to buy them to defend itself against patent litigation. By building a large portfolio of patents, Google keeps them out of competitors' hands. It also hopes to dissuade other companies from suing it, either because Google holds similar patents to the ones they might sue over or as deterrence – if you sue me, I will sue you (NYT 5 April 2011).

wealth (see Moglen 2003, Benkler 2003 and Burlamaqui and Cimoli: 2014). A number of commentators have called for an alternative to this second enclosure, an alternative they term "the new commons".[25] As Evans (2005, 3) has aptly put it, this alternative is "attractive both because of its distributional implications and because of its potential for raising the rate of innovation and value creation". From a knowledge-governance perspective, the basis of the new commons comes from a redefinition of "ownership": from the focus on the right to exclude to the focus on the commitment to distribute (disseminate).

The key idea here is that once property rights are redefined along the lines pioneered by the open-source software movement, a much more egalitarian redistribution of intangible assets and a more powerful rationale to foster innovations will be able to emerge. This rationale is one that unfolds from the characteristics of the networked information economy – an economy of information, knowledge and culture that flows over a ubiquitous, decentralized network.

In that environment, as Benkler remarks, productivity and growth can be sustained in a pattern that differs fundamentally from the industrial economies of the twentieth century in two crucial characteristics. First, network based knowledge creation can play a much more important role than it could in the physical economy. Individuals and teams working cooperatively alongside firms can make a difference in the creation of innovative solutions and productivity gains (Benkler 2003, 1 and 2006).[26] Second, decentralized production and distribution networks, whether market-based or not, can similarly play a much more important role by increasing the diversity of ways of organizing production and consumption and, therefore, by increasing the sources and possibilities for multiple forms of experimentation.

This is clearly a global issue and – because of its global scope, and also because of the under-theorized relationship between innovation, competition policies and intellectual property rights – a very difficult one to handle. It will certainly require the active involvement of governments in encouraging and assisting the development of open-source systems to move society toward more general-public-licenses-oriented IPR regimes. It will also require international cooperation – both very turbulent matters from a power-politics perspective. Nevertheless, the recent

[25] A "commons" is a piece of land over which people can exercise certain traditional rights in common, such as allowing their livestock to graze upon it. Older texts use the word "common" to denote any such right, but more modern usage is to refer to particular rights of common and to reserve the name "common" for the land over which the rights are exercised. By extension, the term "commons" has come to be applied to other resources that a community has rights or access to.

[26] And, he adds, one can clearly observe this behavior by noticing that most of what we do on the Internet runs on software produced by tens of thousands of volunteers, working together in a way that is fundamentally more closely related to a community than to a hierarchical big corporation standing alone.

decisions by IBM and Nokia, for example, to put part of their patents into the public domain suggests that there is perhaps more room to maneuver than the skeptical analyst might expect.

Conclusion

The knowledge-governance-oriented policy-institutions framework I have proposed would be flexible and pragmatic and have creative-destruction management and maximum expansion of access to knowledge as its main goals. In its innovation- and competition-policies dimension, it would not be anti-bigness per se, but anti-unproductive entrepreneurship (Baumol 1993 and 2002); pro-efficiency but not libertarian (in the "Chicago School" sense of letting the market, almost always, take care of its own problems); and, especially, pro-cooperation, leaving room for business networks to thrive and for state-sponsored administrative-guidance initiatives. It would also engineer policies toward the development of multiple sources of experimentation and allow room for industrial and technology policies without jeopardizing its own core theoretical foundations.

In its intellectual-property dimension, it should not point to a one-size-fits-all institutional design and should not pursue the maximum protection of monopolistic rents, as both the US PTO and the WTO seem to be doing. It should search, instead, for the minimal common denominator, allowing for institutional and technological diversity and space for distinctive developmental strategies (Boyle 2004, 2008; Rodrik 2011). It should take into account the asymmetries in the distance to the "development frontier" among countries and regions, echoing Joseph Stieglitz's wise remark that "Intellectual property is certainly important, but the appropriate IPR system for an emerging country is different than the IPR system best fitting already developed nations" (Stiglitz 2005).[27]

From an evolutionary perspective, the key issue to deal with is how to separate innovation-rooted profits, which should be rewarded but understood as temporary (their continuity dependent on continuous innovation), from legal monopoly-granted rents, which should be eliminated or, at least, closely monitored and curtailed.

None of these policy prescriptions will be achieved without a huge dose of "strategic state action"; and most of them will require a high degree of state capacity as well as international treaties redesign (such as the GATS[28] under the

[27] One of the main reasons for that, although certainly not the only one, is that the big pharmaceutical companies perform obscene price discrimination among nations (cf. Varian et al. 2004, 52) and almost always refuse to engage in poor and emerging countries' public policies oriented toward health care.

[28] General Agreement on Trade in Services.

WTO). This is an uneasy task; nonetheless, the expected result, to which this paper intends to make a small contribution, would be a theory/policy framework linking, conceptually, innovation and Schumpeterian competition to competition policies and intellectual-property-rights management, which will allow room for a more open, democratic and development oriented knowledge ecology.

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RSP

A Second Order Diffusion Model with Application in Capital Flow

A Brief Report on the Creation and the Academic Output of the Federal University of ABC

A Short Report on Role of EMBRAPA in the Brazilian Agribusiness

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Abstract

The initial project regarding the paper to be presented in the "***Seminário internacional Papel do Estado no Século XXI: desafios para a gestão pública***" promoted by the "*Escola Nacional de Administração Pública (ENAP) e o Ministério do Planejamento, Orçamento e Gestão do Brasil (MP)",* was restricted to the last two topics, that is the impact of public investment on the higher education system and on the technological advances fostering the Brazilian agribusiness. Instead of writing an overview regarding the general higher education system and the agribusiness complex we selected two emblematic enterprises proving that making the right choices public investments have a very high return rate.

However meanwhile we closed the basic concepts regarding a new theory dealing with diffusion process. This new theory introduces a second order approach to the dynamics of particles scattering in some supporting medium. The new contribution is the consideration of two simultaneous flows in the same system dividing the diffusion cloud into two fractions. The possibility to work with two simultaneous flows is much more adequate to model population dynamics, infectious diseases with people moving in and out some environment and clearly capital flux. Despite the fact that we have no expertise in economics we dare to present a first essay in

capital flux since the results obtained by the new model are quite interesting and acceptable by the common sense. We are also convinced that it is the obligation of the university to take risks and try to open new roads. The ultimate aim of a genuine research project is to present unexpected results. If in the research output there is no surprise something is missing.

Therefore we decided to make two short reports on the Federal University of ABC in São Paulo, a very successful new university and on EMBRAPA which is a paradigm in the agribusiness complex, following a relatively extended presentation of the second order diffusion theory to capital flux. Besides the economic turmoil affecting Brazil and the international community as well deserves at least some alternative model that could better explain what is going on.

Our apologize for that new orientation.

Keywords: agribusiness, theory, higher education, economy, economic crisis, capital, scientific method, research method, scientific education, education, methodology, scientific research, science and technology, environment, scientist, public company, agriculture

A Second Order Diffusion Model with Application in Capital Flow

Introduction

The extraordinary advance in computer technology in the last 30 years together with the demand for integration of several knowledge fields to solve new and challenging problems pushed forth the development of modeling techniques. Initially confined to physicochemical matters modeling was latter introduced to simulate population dynamics, environmental dynamics, epidemics and more recently diseases evolution and social behavior. Particularly the dynamics of economic systems and knowledge transfer belongs to this last theme. Not seldom the mathematical tools were taken from the models used in natural and engineering sciences and adapted to the new fields of knowledge. This type of adjustment works well for simple cases but may fail in more complex situations. Take for instance the classical diffusion equation in its original form to represent the evolution of contagious deceases or capital flow. The fundamental hypothesis of the classical diffusion theory rely on the assumption that the totality of the material contents, whatever it may be, particles, people, money, moves along a single flow trajectory in a given substratum. This is a rather restrictive hypothesis when we consider infected people moving in and out some environment or capital flow that may occur simultaneously in two opposite directions.

The difficulty is that while acknowledging the limitations of the mathematical tools the demands for new results forces the introduction of rather artificial modifications in the basic governing equation to match some experimental results and observations. The introduction of complementary sources and non-linear terms in the governing equations allows for tuning up the new parameters to match almost all possible observations. Therefore, the validation is restricted to a given circumstance but not concerning the phenomenon itself. If the model together with the parameters estimated for a given data set is applied to a similar problem but with a different input the theoretical prevision could deviate substantially from the real outcome. It is important to distinguish the validation of a particular event from the validation of the subjacent phenomenon. This observation is particularly important when dealing with social and economic modeling.

One of the purposes of this paper is to introduce a new diffusion formulation that admits the occurrence of two simultaneous fluxes of the same contents. That is, the same contents, let us say currency, may be into two different “excitation states”, income or outflow, earnings or expenditures, generating two simultaneous flows. Besides, they may change states along the process. The simulation of this

kind of phenomenon requires a new governing equation, a fourth order equation. A short presentation of the main steps to derive this new diffusion equation is given in the next section.

The classical diffusion framework

For purpose of completeness it is convenient to make a brief introduction to diffusion processes. The ordered scattering of particles in some supporting medium is called diffusion. Diffusion may happen in a physicochemical process, salt particles disperse in water;in public health problems, malaria spreading in an environment favorable for mosquito reproduction; in a social framework, knowledge transfer in a human population.

The theory associated with the diffusion process was settled in the beginning of the last century. The motivation was the spreading of gas molecules in a confined environment. That is the theory was developed to find out how the particle concentration would evolve in space and time. The basic conclusion was that the particles move from regions where the gas concentration is very high towards rarefied gas regions.

That is nature always tries to homogenize an initially uneven particle distribution provided that the system is free from external perturbations. The analytical formulation of this phenomenon assumes as fundamental hypothesis that the particles flow rate is proportional to the slope (gradient) of the concentration distribution. The direction is clearly from regions of high concentration to regions with low concentration. The modulus of the flow rate is therefore given by (Fick's law):

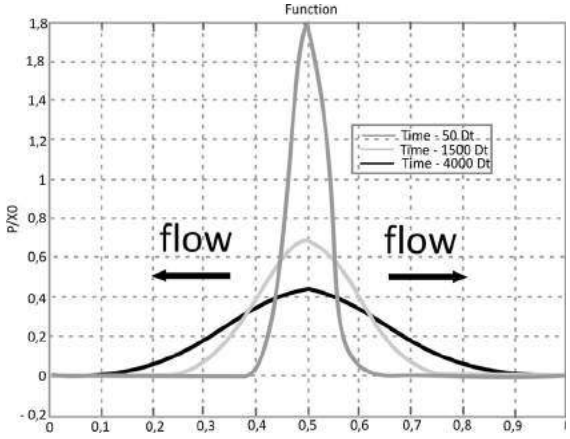
$$\left|\Psi_1\right| = D\left|\frac{\partial q}{\partial x}\right|$$

The parameter *D* is the diffusion coefficient and is the modulus of the concentration distribution gradient. This parameter is related to the interaction between the resistance of the supporting medium against the particles motion and the repulsive force exerted by the particles among themselves. Figure 1 illustrates the diffusion process profiles of particles initially concentrated in a small interval with center at x=0.5.

High values of the concentration gradient imply correspondingly high flow rates. Therefore as can be seen in the figure 1 as the process develops the flow rate decreases since the concentration distribution becomes smoother. Using the classical mass conservation principles and the flow rate law introduced above the following equation is obtained:

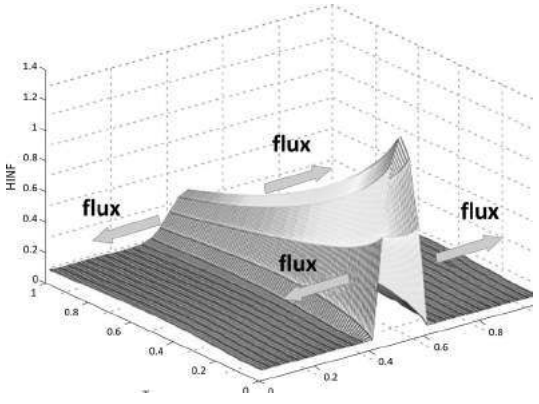
$$\frac{\partial q}{\partial t} = D\frac{\partial^2 q}{\partial x^2} \qquad (1)$$

Figure 1: Evolution of the particle concentration distribution in time and space. For t=0 particles are highly concentrated close to x=0.5. Particles spread laterally as time increases



Careful experimental observation have been made for several types of particle scattering in different substrata. For regular diffusion processes equation (1) has proved to be quite satisfactory. Figure 2 shows the evolution in time and space of a regular diffusion process. The problem arises when there are non expected phenomena taking place in the process, as time delay in particle motion. In these cases the classical equation does not provide a satisfactory solution. To solve the discrepancies between experimental observation and the prediction of the classical theory some extra terms are introduced to complete equation (1).

Figure 2: Evolution of the particle concentration distribution in time and space. For t=0 particles are highly concentrated close to x=0.5. Particles spread laterally as time increases

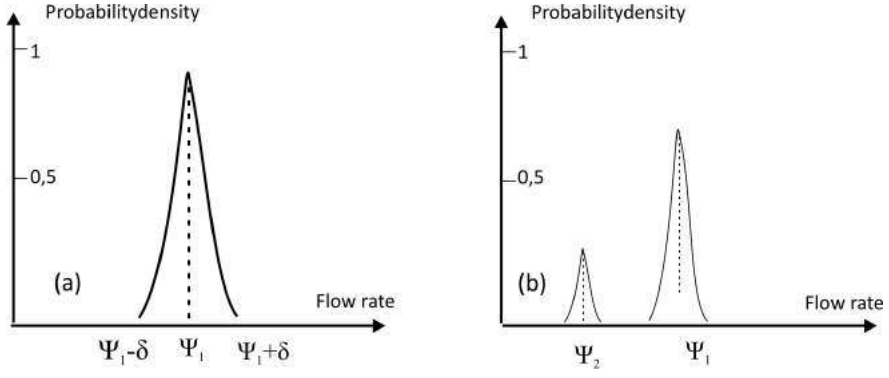


Now the hypothesis that all particles at a givencross-section of the particle cloud move with the same speed is a considerable simplification. What is physically consistent is that the flow rate given by the Fick´s law:

$$\mathbf{\Psi}_1 = -D\frac{\partial q}{\partial x}\mathbf{i}$$

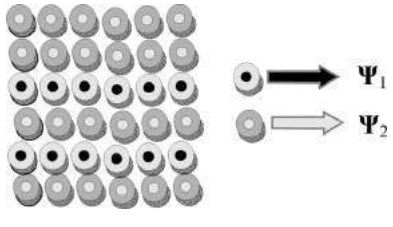
represents the mean value of a flux distribution with a very small deviation from the mean(fig.3a). So the diffusion equation (1) is an approximation that works out satisfactorily for very small values of δ.

Figure 3: Flow rateprobabilitydensity function for single flux diffusion (a). Flow rate probability density function for bi-flux diffusion (b). δ very small



It is not impossible that in some cases the same particle system is split into two sets scattering with different flow rates (Fig. 3b). Beware we are not saying that there are two different species in the same flow, but it is the same species excited into two different energy states. If there were two different species the problem could be solved with two equations of the same order as introduced above, equation (1), with two different diffusion coefficients D_1 and D_2 and possibly with the inclusion of coupling terms. Therefore, we need a new theory that would allow splitting the particles cloud in the system into two sets of the same nature diffusing with different flow rates. That is the mass flux is divided into two fractions, excited by two distinct flow potentials generating two flow rate vectors $\mathbf{\Psi}_1$ and $\mathbf{\Psi}_2$ as shown in the figure 4.

Figure 4: Similar particles scattering with different flow rates. Red cells correspond to 2/3and black cells to1/3 of the total mass

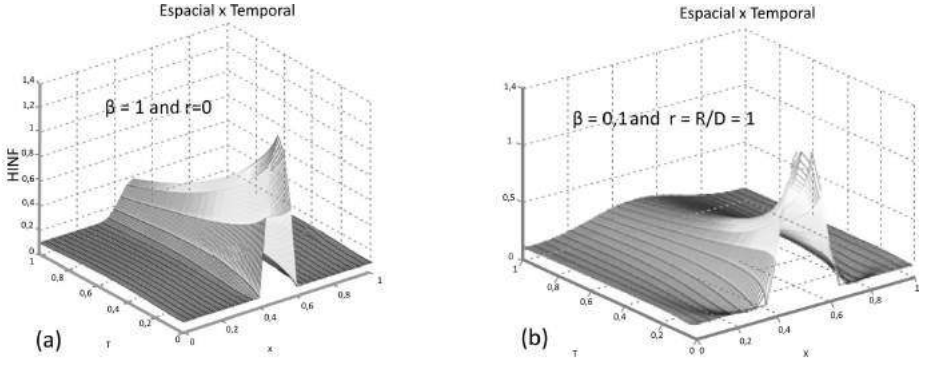


As presented in the next section if we introduce a delay on a certain fraction of the diffusing particles, say (1–β) with 0<β<1 allowing the complementary set *β* to scatter according to the classical theory, the following governing equation is obtained:

$$\frac{\partial q}{\partial t} = \beta D \frac{\partial^2 q}{\partial x^2} - (1-\beta)\beta R \frac{\partial^4 q}{\partial x^4}$$

What we have now is a unique concentration distribution where the particle flux is divided into two distinct portions. Figure 5 illustrates the difference in the response of the two diffusion approaches for a mass concentration input at t=0 at the center of the segment [0,1]. The presence of a secondary flux introduces acceleration on the concentration decay while spreading the solution along the x-axis. The behavior of the concentration for the bi-flux theory depends strongly on the parameters β and *R*.

Figure 5: Response to a concentrated distribution at x=0.5. (a) Single flux diffusion process, classical solution; (b) bi-flux diffusion process, fourth order PDE



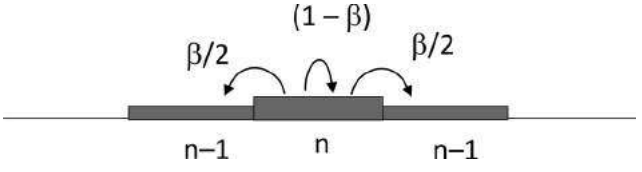
A clear example where this phenomenon is not only plausible but necessary is capital flow. Even in our small universe we all have income and expenses, that is, cash inflows and outflows. It is the same money flowing in two opposite directions possibly with different speeds. The ultimate purpose of this proposal is to show that it is worthwhile exploring the new approach introducing the bi-flux phenomenon in the context of capital flow. The behavior of the economy could be better estimated using the second order flux theory as presented here.

An overview of the Second Order Theory

The derivation of the second order theory can be obtained with a very simple discrete model. Indeed, consider a row of cells such that each cell can communicate with the neighboring ones. Let the contents of each cell be partly redistributed to the adjacent cells in equal portions and partly retained in the cell at each time step.

Figure 6 represents the distribution process for a characteristic time step Δ*t*. The fundamental idea is therefore, to assume that the contents of a cell *n* at a time *t* changes at each time interval Δ*t* such that a fraction *β* is equally redistributed to the right, n+1, and left, n−1, neighboring cells while the remaining portion (1−*β*) stays temporarily confined in the same cell n. The set of equations derived with the help of the discrete approach representing this distribution law reads:

Figure 6: Contents distribution considering partial retention



$$q_n^t = (1-\beta)q_n^{t-1} + \frac{1}{2}\beta q_{n-1}^{t-1} + \frac{1}{2}\beta q_{n+1}^{t-1}$$

$$q_n^{t+1} = (1-\beta)q_n^{t} + \frac{1}{2}\beta q_{n-1}^{t} + \frac{1}{2}\beta q_{n+1}^{t}$$

where $0 \le \beta \le 1$. Clearly with *β*=1 the above equations represent the discrete formulation scheme leading to the well-known second order classical diffusion equation. But with $\beta \neq 1$ a new equation is obtained. After the proper operations and assuming the continuity requirements for the function *q*(*x*,*t*) we get [1] [2].

$$\frac{\partial q}{\partial t} = \beta D \frac{\partial^2 q}{\partial x^2} - (1-\beta)\beta R \frac{\partial^4 q}{\partial x^4} \qquad (2)$$

The fourth order term with negative sign introduces the effect of retention. The coefficient *D* is the well-known diffusion coefficient and *R* is a new coefficient that we will call reactivity coefficient. The parameter β is a control parameter expressing the balance between diffusion and retention when both are activated simultaneously. The retention effect reaches its maximum for β=0.5. Clearly retention cannot be activated without diffusion, that is, while diffusion can take place without retention β=1, the complementary process, that is, retention without diffusion β=0 is not possible.

It is remarkable that the discrete approach shows that non-linear terms are not required to represent temporary retention at least for the case of homogeneous isotropic media. This means, as it should be expected, that temporary retention belongs to the class of primary phenomena and, in general, is not a secondary perturbation on the diffusion process as usually assumed for modeling anomalous diffusion.

Equation (2) shows clearly the existence of two different diffusion processes. The variable *q*(*x*,*t*) represents the mass concentration and it is not difficult to see that

two distinct velocity potentials come into play one of them corresponding to the second order differential term and the other one corresponding to the fourth order differential term. Particles belonging to the fraction β follow the classical Fick´s law, it is the primary flux that will be called $\mathbf{\Psi}_1$ and particles belonging to the fraction (1–β) follow a new law, it is the secondary flux that will be called $\mathbf{\Psi}_2$. Considering equation (1) and anticipating the mathematical structure of the integrand for the mass conservation principle it is not difficult to see that the fluxes are given respectively by:

$$\mathbf{\Psi}_1 = -D\frac{\partial q(x,t)}{\partial x}\mathbf{e}_1 \text{ and } \mathbf{\Psi}_2 = R\beta\frac{\partial^3 q(x,t)}{\partial x^3}\mathbf{e}_1$$

The physical meaning of the primary flux is well known, namely, the particle concentration distribution tends to smooth out along the x-axis. The particles move from higher concentration regions toward lower concentration regions. The secondary flux is concerned with the curvature variation of the concentration distribution. It grows with the increase in the curvature. Since increasing curvature means local accumulation, the secondary flux may be interpreted as a process that opposes the growth of local concentration. It is also remarkable that the intensity of the secondary flux increases linearly with the fraction β of particles belonging to the primary flux.

Applying the second order theory to simulate simple cases of capital flow.

In order to justify the presentation of this proposal it is convenient to show that some basic results match the common sense expectations for simple situations. The questions that certainly can be raised from the following examples could only be answered through a careful investigation effort organized through the convergence of different knowledge fields.

It is important to keep in mind that the present theory is intended to apply the second order or bi-flux theory to typical cases where the classical approach fails to represent the coupled flux. Capital flow is adequate to our purpose. Therefore, we will consider the economic behavior of a small social chain that is the overall response of a relatively restricted economic system.

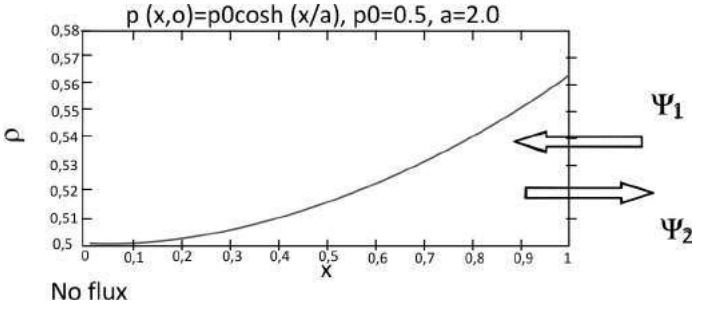
1. Inflow and outflow in a simple economic chain.

Preliminary analyses have shown that the use of the bi-flux theory leads to simulations that reproduce, at least qualitatively, some of the most important economic states.

Consider the case of some economic chain in the interval (0,1). The resources concentration, that we call $q(x,t)$, vary slightly from the initial point x=0, $q(0,0)$=0.5,

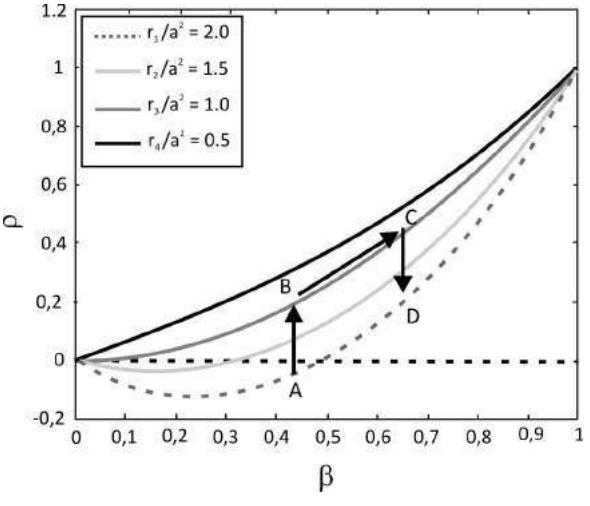
to the end of the chain, *x*=1,*q*(1,0)=0.56 for some reference initial time t=0. The boundary condition at x=0 prescribe no flow meaning that it is the end of the chain with no interaction with external agents. At x=1 the agents in the chain interact with the outer environment such that the primary flow Ψ1is directed inward and a secondary flow Ψ2outward (Fig.7). The solution to this problem with the initial condition q(x,0) given below is very simple.

Figure 7: Profile of aggregated money fluxin an economic chain



The parameter ρ controls the time evolution of the diffusion process. Figure 8 shows the variation of ρ with β *f*or some values of the parameter *r*. Clearly for $\rho>0$ the process evolves in the direction of assets accumulation $e^{\rho t}>1$, meaning that the volume of capital inflow exceeds the volume of capital outflow. For the opposite case, $\rho<0$ and $e^{\rho t}<1$ the process enters in a recession cycle accumulating losses progressively. Points combining β and *r* such that ρ vanishes represent stagnation points that may be considered in a different context points of equilibrium. We prefer call those points stagnation points, no gains no losses.

Figure 8: Variation of the evolution control parameter ρ with the mass fraction distribution β



Initialcondition:

$$q(x,0) = p_0 \cosh\left(\frac{x}{a}\right)$$

Boundary conditions:

at x=0 $\Psi_1 = \Psi_2 = 0$ no flux

at x=1

$$\Psi_2 = q_0 \left(\frac{1}{a}\right)^3 e^{\rho t} \sinh\left(\frac{1}{a}\right)$$

$$\Psi_1 = q_0 \left(\frac{1}{a}\right) e^{\rho t} \sinh\left(\frac{1}{a}\right)$$

The solution is

*p(x,t)=q*0e*ρt*cosh*(x/a)* where $\rho = \frac{D\beta}{a^2}\left(1-(1-\beta)\frac{r}{a^2}\right)$ *r=R/D*

Note that as stated before Ψ_1 corresponds to the primary flux that is, it is assumed to exist independently of Ψ_2. The subsidiary flux exists, if and only if Ψ_1 is active. This means that spending money is only possible if there is money coming in.

D, *R,* β and *a* maybe considered preliminary as defined below.

D: represent the tools to encourage (discourage) investments, high values of *D* correspond to intensification of the capital inflow rate

R: represents regulations to reduce (increase) the spending time rate, low values of *R* correspond to contention in the outflow rate that is it tends to decrease the cash outflow rate.

β: this is a very important parameter regulating the distribution between the volume of investments and expenditures. It also controls the outflow rate, if β is small the expenditure rate will fall in the same proportion. It means that if there is no money available payment becomes impossible.

a: may be considered as the length of the connected activities composing the economic chain.

It is important to introduce now the interpretation of the space variable representing the economic chain where the several agents are distributed. Recall that the first order driving force of any diffusion process is the difference between

the concentrations in two neighboring points of the economic string. Following this rule we will divide the economic chain into three segments. E_1 consisting of the economically dominant agents, in the following examples this group is closer to the external environment, x=1. E_3 consists of the economically weaker sector, close to x=0, and E_2 composed by agents with intermediate impact on the economy.

Just to give an example, suppose a certain economy following a contracting trajectory, that is ρ<0 as represented by point A, $r=r_1$, in the figure 8. Suppose that it is required by the economic authority that the ratio (capital inflow)/(capital outflow) remain constant that is β must be kept constant until the economy shows a positive evolution. This would be possible by reducing the value of $r=R/D$. If D is kept constant because presumably it depends more on fixed external factors the solution would be reducing R, that is, try to negotiate extension of payment terms. This would lead to a point B with $r= r_3$. At this position the economy presents concrete signs of expansion and then it would be possible to attract new capital, that is, increase the value of β to reach the point C. Now if it is convenient to increase R and accelerate the outflow for some reason it would be possible to return to r_1 and still keep the economy in a growing track, point D.

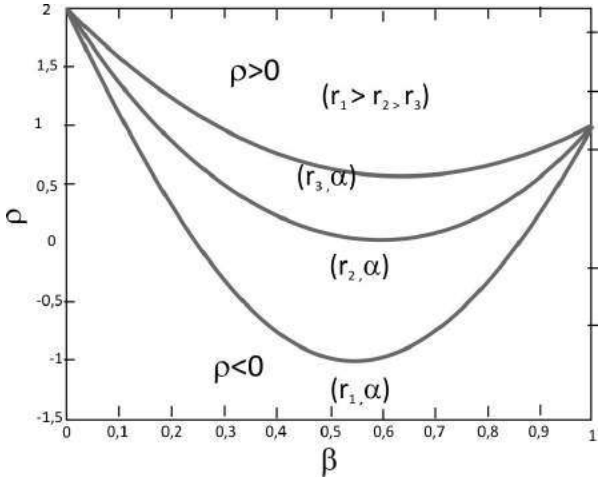
2. The influence of sources and sinks.

If there are sources and sinks the diffusion equation must be modified in order to incorporate these new factors. Consider a source proportional to the concentration fraction (1–β) which corresponds to the capital outflow and a sink proportional to the fraction β which corresponds to the capital inflow. The sources or sinks are not originated from business as usual but require some external agency that lend or borrow money in order to improve the economic output (sources) or to spare money for future applications (sinks). The new equationreads:

$$\frac{\partial q}{\partial t} = \beta D \frac{\partial^2 q}{\partial x^2} - \beta(1-\beta) R \frac{\partial^4 q}{\partial x^4} + A(1-\beta)q - C\beta q$$

The constants A and C define the intensity of the source and the sink respectively. With the same initial and boundary conditions as before we get $\rho=\rho(D,R,\alpha,\beta,A,C)$. With $r=Ra^2/D$, $\alpha=A/Da^2$, $\gamma=C/Da^2$ we obtain the qualitative results as shown in the figures 9, 10, 11 and 12. Figure 9 shows the effect of the inclusion of a source, $\alpha>0$ and $\gamma=0$. The theory suggests that there is a critical value of r that overturns the behavior from growth into loss. Therefore injection of capital only turns out to be favorable if the capital

Figure 9: Influence of the parameter r on the evolution of an economic chain for a given source α=2.0. $r_1 = 10$, $r_2 = 5.8$, $r_3 = 3.5$



outflow is relatively low. For high values of *r* the economy will be severely damaged. It is also interesting to notice that the action of the external source for α>1 is more effective when outflow concentration prevails over the inflow concentration, β relatively small. This means that injecting money in the economy is more effective if the economic activity is stimulated and people are spending moneyand taking loans.

Now if r is taken constant and the source intensity α is allowed to vary there are two typical cases. First if $\alpha > 1+ra^2$, figure 10-a, it is possible to have expressive growth in the economy provided that the source intensity is high enough $\alpha > 1$. For very high source intensity the more expressive growth is observed for low values of β. This scenario can be associate with a reduced outflow rate or credit expansion with more flexible rules. If the injection of money is modest it will cause more harm than benefits. For weak sources the economy will grow faster for high values of β, that is high inflow rates.

Now it is interesting to observe that for very modest sources $\alpha < 1+ra^2$there will always be growth although at very low increasing rate (Fig. 10-b). For this situation the best option is to stimulate capital inflow.

Now if we consider only a sink in the system, $\alpha = 0$ and $\gamma > 0$, that is we want to spare some money from an expanding economy the situation is much more critical. First for very large values of γ the economy will accumulate considerable losses. The whole system will enter a descendent trajectory. For modest capital subtraction from the system, that is γ small, it would be possible to preserve the growing process provided that *r* is small and the capital inflow keeps β sufficiently high as shown in

the figure 11. Subtraction of money from the economy inhibits the outflow that is spending money and taking loans.

Figure 10: Influence of the source intensity on the evolution of an economic chain for (a) r=4; α_1=5, α_2=2, α_3=1, α_4=0.1; (b) r=0.8; α_1=0.8, α_2=0.5, α_3=0.3. For this case α_i<1+r=1.8 for all i=1,2,3

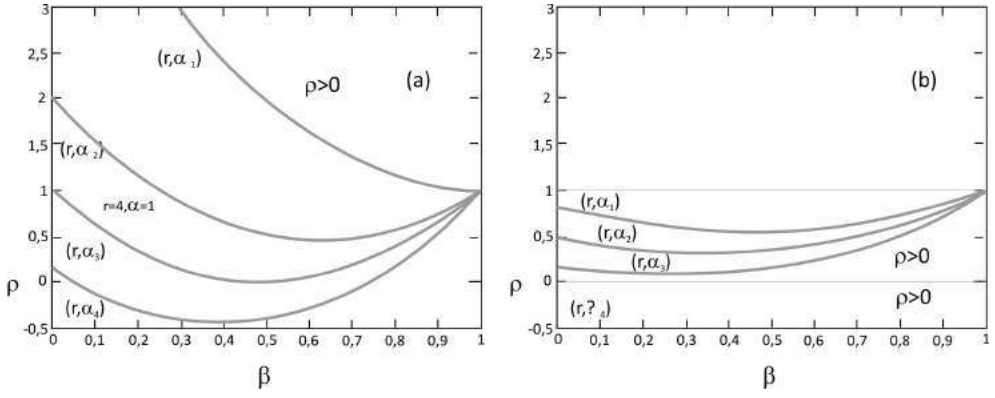
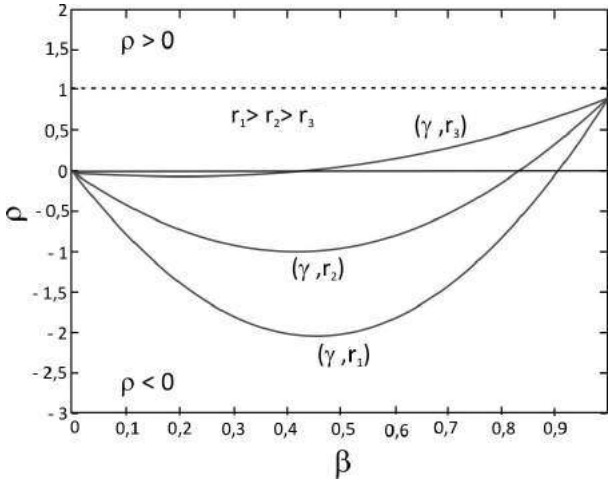
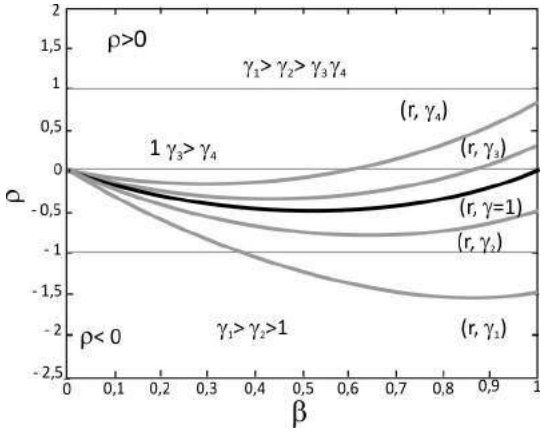


Figure 11: Influence of the parameter r on the evolution of an economic chain for a given sink γ=0.1; r_1 = 10, r_2 =5.8, r_3 =1.5



Now if we take a fixed value for r=2, the outcome is very critical. For very high extraction of resources from the economic system there will be degradation for all β. If the amount of assets subtracted from the system is modest only the regions where the influx prevails that is high values of β will be associated with growth (Fig. 12)

Figure 12: Influence of the parameter γ on the evolution of an economic chain for a given r=2; γ1=2.5,γ2=1.5,γ3=0.7,γ4=0.15



Although the interpretation of the variables advanced here may be subjected to strong criticisms, particularly the meaning of the x variable indentified with the structure of the economic chain, the overall response of the model may be identified with real cases observed in the several occasions of strong economic changes.

The results derived from the bi-flux approach are plausible and do not oppose the common sense. The above examples are encouraging. Therefore, it is worthwhile increasing research efforts to obtain an accurate interpretation of the different parameters and select appropriate data to validate the model.

3. Anomalies introduced by the boundary conditions

Different boundary conditions introduce considerable discrepancies on the capital concentration function $p(x,t)$ for small values of t. We show this behavior by using slightly different boundary conditions with the same initial condition. Consider that at x=0 there is no flux and at x=1 the flux bifurcates into two sections, inflow and outflow. The initial condition is $p(x,0) = p_0 \cosh\left(\frac{x}{a}\right)$ and the boundary conditions are:

(a) For time independent conditions:

$$\Psi_2 = p_0\left(\frac{1}{a}\right)^3 \sinh\left(\frac{1}{a}\right) \qquad \Psi_1 = p_0\left(\frac{1}{a}\right) \sinh\left(\frac{1}{a}\right)$$

(b) For time dependent conditions:

$$\Psi_2 = p_0\left(\frac{1}{a}\right)^3 e^{\rho t} \sinh\left(\frac{1}{a}\right) \qquad \Psi_1 = p_0\left(\frac{1}{a}\right) e^{\rho t} \sinh\left(\frac{1}{a}\right)$$

Figure 13-a shows the capital concentration variation for three different times. Clearly at the very begin t=50Dt the boundary conditions (a) induce a slight decrease in the capital concentration at the lower end of the economic chain and high concentration increase in the region close to *x*=1, where the in-and outflow are under control. Let us recall that the space variable *x* represents the economic chain, starting with the weaker economic agents E_3 , *x* close to zero and ending at *x*=1 E_1 representing economic segment with more decisive power. As shown in the figure 13-a except for the higher sections of the social or economic chain, there will be losses for the segment E_3 and very low economic growth for most of the agents in the segment E_2 just after the process starts. As time increases the economy enters a growing phase for all the sections of the chain.

Figure 13: Concentration distribution for 50Dt, 1500Dt and 4000Dt for time dependent (a) and time independent (b) time dependent boundary conditions

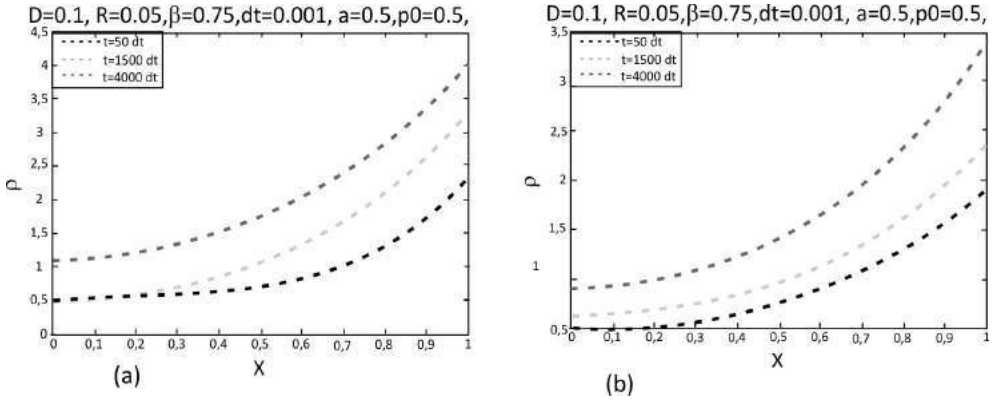
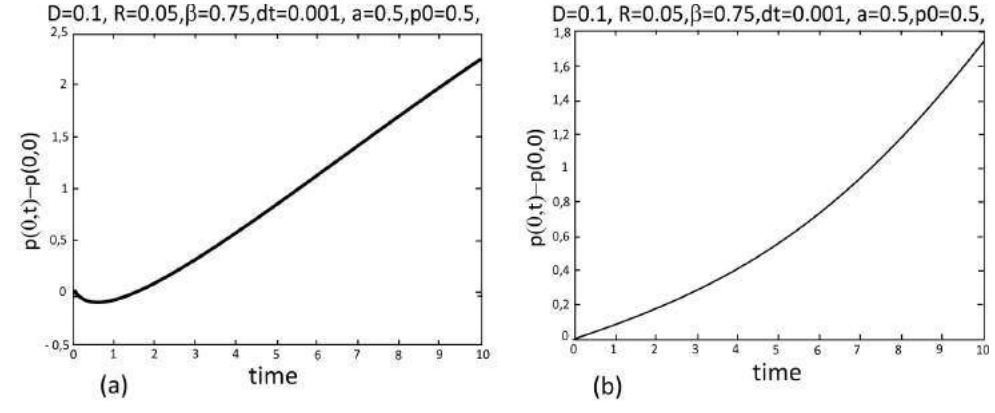


Figure 14: Concentration deviation from the initial conditions at x=0 as function of time, (a) fixed boundary condition, (b) time dependent boundary conditions



Therefore the fixed boundary conditions trigger a wrong signalization for the economic evolution if we consider the tendency shown by the initial steps. As shown in the figure 14-a the capital concentration at x=0 decreases initially before start growing. This situation could generate panic and social disruption.

Now, for time dependent boundary conditions, that is, if the in- and out flow at x=1 follow the evolution tendency signalized by the whole process, all sections of the social chain will benefit from the economic growth as shown in the figure 13-b with no drawback for any section of the social chain, even at x=0 as shown in the figure 14-b.

Figure 15: Evolution of the first derivative of q(x,t) for fixed boundary conditions (a) and time dependente boundary conditions(b)

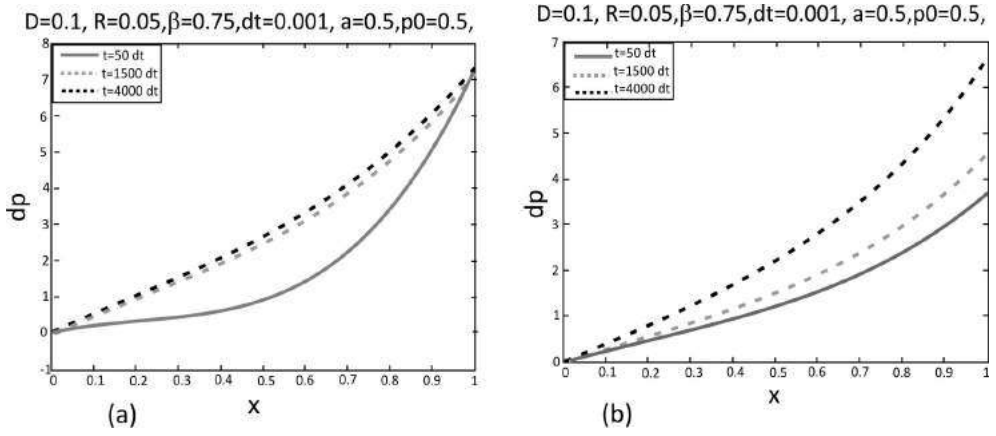
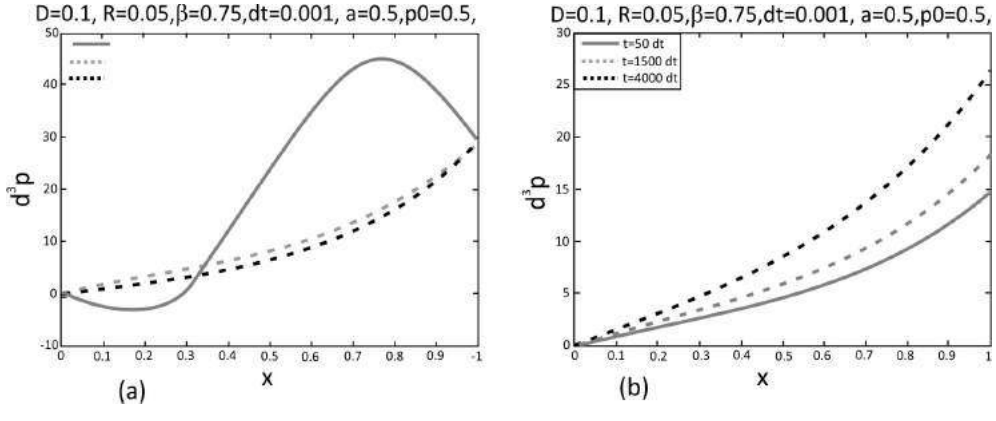


Figure 16: Evolution of the third derivative of q(x,t) for fixed boundary conditions (a) and time dependente boundary conditions(b)



The case of time dependent boundary conditions therefore follows a very regular time evolution as shown in the figures 13-b and 14-b. The first and third derivatives also are monotonic increasing function of x as expected. Recall that the

absolute value of the primary flux **Ψ1** is proportional to |dq/dx| and the absolute value of the secondary flux **Ψ2** is proportional to |d3q/dx3|. Therefore for the case of time dependent boundary conditions the flow rates **Ψ1** and **Ψ2** are well behaved monotonic increasingfunctions as shown in the figures 15-b and 16-b.

Now the fixed boundary conditions, that is, time independent boundary conditions induce a peculiar behavior that could hardly be anticipate at the very beginning of the diffusion process. The dynamics of the process is particularly intense for x> 0.5 that presumably corresponds to the agents with relatively high influence in the economic development. The inflow **Ψ1** intensity and particularly the outflow **Ψ2** intensity are both very high in this section of the chain. We believe that this parameter is difficult to be directly measured, except for the generalized "sensation" of accelerated capital gains and losses, but with modest impact on the economic growth if any.

The outflow under the conditions imposed in the diffusion process is so high for x > 0.5 that, in order to keep the segment E_3 still alive, that is with reduced but still positive resources, there is an inversion in the direction of the subsidiary flow at $x \approx 0.3$ (Fig. 16- a). Therefore for $0<x<0.3$, both fluxes, primary and secondary have the same direction. It is a kind of loan coming from the middle segment E_2 toward the lower segment E_3 in the economic scale.

After the impact at the beginning of the deflagration of the economic dynamics the process reaches the expected behavior with a smooth and monotonic increasing behavior as function of *x*. Despite the fact that this is only a very elementary model the qualitative divergence in the growth process for the two alternatives presented here are not incompatible with real cases reports. The model suggests that, if the in- and outflow conditions for the economic segment E_1, with the responsibility of negotiating with external agents – boundary conditions – do not allow for a flexible evolution in time to match the internal demands determined by the natural evolution path, at least in the very beginning, there will be unavoidable uneven economic growth distribution along the chain. Also, the initial signs do not match the forecast concerning the future economic behavior which presumably is much more positive and optimistic.

The ideas advanced here concerning the socio-economic significance of the new variables need to be carefully discussed. What we intended to show is that the new parameters introduced with the bi-flux theory allow for a much more flexible interpretation of the economic dynamics. The intensity of the secondary flow Ψ_2 for instance is proportional to the inverse of the radius of curvature of the wealth distribution. This means that the secondary flow is directed towards regions with high wealth concentration. This is not an unusual situation.

4. The next steps toward the validation of the theory.

It was shown that the classical theory, which is very useful for simulating simple diffusion processes, is not enough elaborated to deal with more complex processes. The introduction of the second order linear theory, fourth order partial differential equation, allowing for two simultaneous flows within the same diffusion process is adequate to model bi-flux processes as capital flow. This was shown in the preceding section through three particular simulations. The results indicated by the new theory, despite being primarily qualitative, very much agree with the common sense. Therefore we may advance the following statements:

1. The theory is adequate to deal with simultaneous fluxes within a same process.

2. The responses do not contradicts the observed and expected outcome.

In other words the results are encouraging and suggests an elaborated version of the model. We consider that future work should look into the following aspects:

Development of the capital flow model. The questions raised by the previous examples could only be answered through a deeper analysis of the significance of the coefficients D,R,β and a. Therefore it is necessary to select some cases, initially simple cases, to be reviewed under the light of the fourth order theory. Particular attention should be given to the following items:

1.1. Establish a methodology to associate concrete economic data basis with the variables and coefficients introduced in the theory.

1.2. Selection of some cases with reliable data, available and free to be used to test the model.

1.3. Perform a detailed analysis with β as function of time and examine the influence on the answers given by the solution of the equation.

1.4. A key question is to investigate the possibility of the resistivity R to be a function of β. If there is strong evidence supporting this hypothesis the behavior of the solution could be substantially modified to match real cases of economic evolution.

1.5. Explore the significance of sources and sinks, probably associated with loans and debts.

Mathematical analysis. Given that it is crucial to investigate the behavior of the fundamental equation with the parameters R,D and β as functions of x and t it is inevitable to devote part of the attention to mathematics. Also the addition of sinks and sources and the respective influence on the response is essential. Therefore we envisage the following topics to be considered:

2.1. Development of numerical methods for nonlinear equations of the form:

$$\frac{\partial q}{\partial t} = \frac{\partial}{\partial x}\left(\beta(x,t) D(x,t) \frac{\partial q}{\partial x} \right) - \frac{\partial}{\partial x}\left(\beta(x,t)(1-\beta(x,t)) R(x,t) \frac{\partial^3 q}{\partial x^3} \right) + \sum A_i(x,t) f_i(\beta)$$

2.2. Analysis of the behavior of the linear fourth order equation with $\beta=\beta(t)$, function of time. Particular attention should be given to the term $\beta(t)(1-\beta(t))$ that for some particular conditions could lead to chaotic behavior.

2.3. Analysis of the stability conditions of the solution for *D* and *R* functions of *x*. Anisotropic media. Influence of sinks and sources on the stability of the solutions.

2.4. Behavior of particular cases with $R=R(\beta)$ as suggested by the input from the research line 2 above.

2.5. Advanced elaboration of the inverse problem for the fourth order partial differential equation [4] [5].

2.6. If it is possible to associate capital inflow and outflow with two distinct "energy states" a new notion of "entropy" could be introduced in the economy dynamics.

Finally we would like to say that a country cannot remain captive of economic models and indicators that might not represent the dynamics of the real economy. At least some effort should be done to investigate more adequate models that would allow for more efficient economic policies. There are no unique solutions, particularly in socio-economic matters. This is the intention of the present paper.

References

We have restricted the references to those dealing directly with the subject of the proposal. Although there is a huge number of papers dealing with diffusion the case of bi-flux for a single particle species could not be found. There are of course several cases where fourth order equations come into play but in different contexts or dealing with non-linear diffusion approaches. References [1] and [2] below contain several citations on classical and anomalous diffusion processes. A representative example of modeling economic behavior with the help of the classical diffusion approach may be found in the famous Black &Sholes paper [6]. Certainly several scholars strongly criticizes the Black and Sholes theory while raising doubts about the efficacy of mathematical models in social sciences. This attitude however should not avoid a continuing effort to develop tools helping decision makers to accomplish their rules in society. The key point is not to use models as an infallible tool to take decisions.

[1] L.Bevilacqua., A.C.N.R Galeão, F.P.Costa, An. Acad. Bras. Ciênc.,*A new analytical formulation of retention effects on particle diffusion processes*, 83 (4) (2011) 1443-1464.

[2] L.Bevilacqua.,A.C.N.R.Galeão. J.G.Simas, A.P.R.Doce, *A new theory for anomalous diffusion with a bimodal flux distribution,* J Braz. Soc. Mech. Sci. Eng. 35 (2013) 431–440.

[3] Black, Fischer; Myron Scholes. *The Pricing of Options and Corporate Liabilities,* Journal of Political Economy 81(3): (1973) 637–654.

[4] Silva, L. G., Knupp, D. C., Bevilacqua, L., Galeão, A. C. N. R. e Silva Neto, A. J., *Formulação e Solução de um Problema Inverso de DifusãoAnômala com Técnicas Estocásticas*, Ciência e Natura. Artigo Aceito para Publicação, 2014.

[5] Silva, L. G., Knupp, D. C., Bevilacqua, L., Galeão, A. C. N. R., Simas, J. G., Vasconcellos, J. F. V. e Silva Neto, A. J., *Investigation of a New Model for Anomalous Diffusion Phenomena by Means of na Inverse Analysis*, Proc. 4th Inverse Problems, Design and Optimization Symposium (IPDO-2013), Albi, França, 2013.

[6] Black and Scholes*, The Pricing of Options and Corporate Liabilities*, JournalofPoliticalEconomy, **81**(3), 637-654, 1973.

A Brief Report on the Creation and the Academic Output of the Federal University of ABC

1. The new cultural environment

In the last 70 years the world was subjected to amazing changes encompassing the whole spectrum of human knowledge and our way of life. Among several issues we may consider:

1. Global climate changes and the environment
2. Science and Technology boom
3. Socio-political and economic issues
4. The open road to the Universe
5. Cultural differences and conflicts
6. What is life? How does our brain works? Who are we ?
7. Religion, myths and beliefs
8. A small world- IT
9. The planet earth and self-destruction?
10. Art, artist and mass culture industry
11. Rational and transcended knowledge

All these points are essentials to propose the identity of a university for the XXI century. Particularly the extraordinary progress in science and technology was made possible due to two main factors: advancement in observation: macro- and microcosms and advancement in computer technology and applications. An immediate consequence of these two factors together with the new challenges imposed by the needs of our society was the convergence of disciplines formerly isolated by strong barriers. The disciplinary convergence has strong impact in the university academic structure. It is necessary to consider, besides reshaping the scientific guidelines, the emerging of new technologies in all fields and the new professions and new options of higher education.

All these new initiatives are coming up very quickly. Then I would say that more than the knowledge era we are living an era of cultural shock. In addition, in times of cultural shock we need to change considerably our attitude towards education. The committee in charge of designing the UFABC project was well aware of these new conditions and the difficulties inherent to the creation of a University that would challenge the traditional academic structure. In any case one important obstacle was not present, namely the academic committees, the faculty senate and all the

organized groups that are the guardian of the traditional academic structure. The University would be created from scratch. The obstacles would come from outside. These are not so dangerous as the internal destructive forces.

2. The basic principles

So the Federal University of the ABC was planned considering the conditions imposed by the new cultural environment. The following basic principles were taken as essentials:

1. The traditional university organization is hopeless
2. There is no much time to think and take decisions
3. It is necessary to undertake risks
4. It is necessary to be prepared to make quick changes in orientation
5. It is necessary to challenge traditional rules and fight for new and more flexible statutes adequate to the present times
6. It is necessary to find a suitable "board" to rise above the cultural "shock wave"
7. Anyway it is necessary to be prepared to fall down and get to your feet again

Keeping in mind those challenges the committee started working on the basic academic principles, the cornerstones on which the new University would rest. Although not explicitly appearing in the texts of the implementation committees the academic structure of UFABC was supported by four very basic principles:

Learn rather than Teach

Against the teaching strategies prevailing in the Brazilian culture, it was acknowledged that the University must be a place intended primary to learn rather than teach. This may be apparently easy to implement but it is not. The primary attitude towards the students is that they would learn only what the teacher teaches. The student is considered a passive player in the learning process. The concrete expression of the new attitude was the limitation of number of class-hours per week. It was strongly recommended no more than 15 class-hours per week, 12 being the desirable charge. The students were encouraged to study by themselves and to look for the solutions of new problems autonomously. The education was centered on the following principles:

Fostering creativity – More individual work and less classes – Think.

Building self-confidence – To dare and to reduce aversion to risk.

Learning to take decisions and to stimulate entrepreneurship – Less complaints and more solutions.

Together with this new attitude, it was strongly recommended that the sharp boundaries separating the university community into very specific layers (professors, students, technicians, administrators) should be dissolved. It is crucial to build up a new academic community.

Do not pour new wine in old bottles

Interdisciplinary research has come to stay. It is already a successful approach to tackle complex problems. However courses, particularly undergraduate courses follow the classical organization. Departments remain as the fundamental academic units in the university structure. This kind of contradiction confuses the students. It is necessary to break up the departmental structure. Together with breaking down the departmental barriers a reshuffle of the main themes distributed among the classical disciplines, physics, chemist, mathematics, biology, computation should be done. New guidelines more adequate to the new science and new technology should be implemented substituting the old ones. The committee proposed that the new university should be organized with three schools, namely: Natural Sciences and Humanities, Mathematics, Computation and Cognition, Engineering and Social Sciences. The new guidelines would be: Structure of Matter, Energy, Transformation Processes, Communication and Information, Representation and Simulation (Mathematics), Humanities and Social Sciences. The student should have more freedom to select courses and professional options keeping credit requirements for basic courses at a minimum level.

First discover then publish

Advancement of knowledge rather than thickening the authors' CV should be the focus of publications. The contribution of a scientist is not measured by volume but by the scientific value of the new ideas. The pressure for quantity instead of appreciation for quality delay the advancement of science and technology. Also this fundamental idea should support the performance evaluation in the academic career.

Finally the UFABC ultimate declaration of identity was settled as follows

The main commitment of the UFABC toward society is to **recover the appreciation for scientific learning**, to show the beauty inherent in the mysteries of nature and hidden in a mathematical object. It was founded on the assumption that knowledge is not only a means to response to market demands but **above all to the enlightenment of the human spirit**.

The project of UFABC is sustained by the **freedom to explore new paths** that will lead the University closer to its **original and universal purpose**: to discover, to invent and to think critically. The education system, more than ever, should encourage students to make **their own choices, to take risks, to accept challenges and to think creatively.**

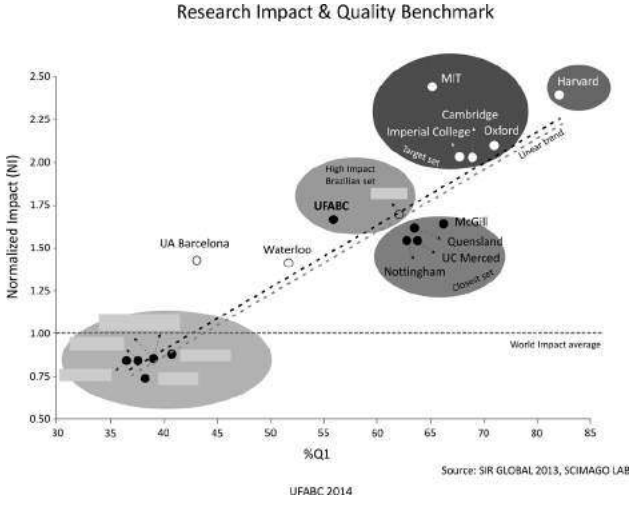
The UFABC is committed to the above principles that will guide the university to accomplish its mission contributing effectively for the educational enhancement of our Nation.

3. The implementation

The UFABC was founded according to the above principles. The first five years were difficult partly due to the resistance to accept a new education project. Our society is acquainted to follow well established educational paths. Any deviation rises suspicious attitudes most of the time assuming that education would deteriorate if the students would be free to make their own choices. High school teachers, parents and also most of the academic community did not approve the new educational project. The high school students were discouraged to apply for the new university. The local unions and community associations criticized strongly the new project. Newspapers independently from their ideological option opposed the basic educational principles and the orientation proposed by the university for the new professional careers.

So the first five years were very difficult for the faculty and the UFABC leaders. Fortunately the young professors joining the university were highly qualified and committed with the project. Graduate courses started simultaneously with undergraduate courses so that the professors joining the university could continue their research work. Collaborative agreement, frequently very informal, were established with other universities allowing for the continuation of research projects of the new faculty joining the university.

Figure 1: UFABC scientific production, quality of journals versus impact, SIR GLOBAL 2013, SCIMA GO LAB



After 10 years the UFABC is now showing that the effort was worthwhile. The academic output of the university is being recognized internationally as shown in the figure 1. It is the best Brazilian university considering the criteria of high-quality publications, normalized impact fator, overall excellence and internationalization. Certainly the volume of publication is still less than other older Brazilian universities.

According to the Ministry of Education evaluation process, the UFABC is distinguished as one of the 20th best universities in Brazil among 2000. The UFABC belongs to the select group with the highest possible score. In 2013 this recently founded University conquered the first place in the education performance for the bachelor courses: Chemistry and Mathematics and the engineering courses: Material Science and Engineering and Environmental Engineering.

The former UFABC student Thiago Alencar who obtained the undergraduate degree in Aerospace Engineering in 2011, was honored with the **"The Theodore W. Hissey Award"** sponsored by the IEEE. It was the second Brazilian to receive this prize. He wrote a letter to the UFABC faculty finishing with the following words:

"I would like to dedicate this prize to the (UFABC) professors and share my achievements accomplished in last few years expressing my high appreciation for the Bachelor degree project that I finished and has made a big difference not only my academic life but also in my education as a citizen, besides the several opportunities that this pioneering and audacious academic project has opened in my life. I owe a great deal for being what I am now to my former professors who even facing so many difficulties believed in the interdisciplinary pedagogical proposal of the Bachelor program and that fight constantly to keep the university mission faithful to its original principles, preparing courses, doing research, advising students to become highly qualified professionals with critical though concerning their role in society."

The ranking of Brazilian Universities organized by the newspaper "Folha da São Paulo" distinguishes the UFABC as the Brazilian university more involved in international cooperation. The UFABC leads the rank in the item "Internationalization".

In May 2015 the prestigious British newspaper "The Guardian " published an article under the title: The Federal University of ABC (UFABC).

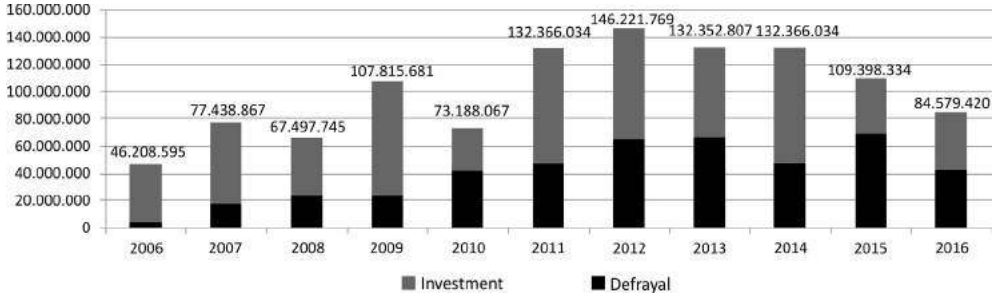
The first paragraph reads:

"President Lula may have drwn much of his power base from the unions he represented in local industry, but in the creation of the ABC region's Federal University he has paid back that loyalty. Shaking off the image of closed-off laboratories, conservative approaches and reluctance to change, UFABC is proving the shining example of what a public higher education in Brazil can become".

This is a remarkable recognition of the high level that Brazilian higher education can reach. Unfortunately our the Brazilian media do not emphasize the histories of success, the disaster and misconduct have the priority.

Finally the recent choice of the São Bernardo do Campo county as the headquarters of the Swedish aircraft factory SAAB to produce fighters for the Brazilian Air Force has closed the overall purpose of the UFABC. The UFABC certainly played an important role in the SAAB's decision process. The unions that 10 years ago had a suspicious attitude towards the UFABC role in the industrial enhancement of the region are now asking for more investments on education and training for the region. Even the fostering of graduate courses in the region entered the list of the union demands.

Figure 2: Evolution of the UFABC annual budget. The 2016 FY is estimated



So it is very clear the extraordinary benefits that this new university with a revolutionary academic project, at least for the Brazilian standards, has brought not only for the local society but also for the national education system. In fact, after the success of UFABC other Brazilian universities are trying to reorganize their curricula to be more effective in the modern world. Now how to measure the impact on the economy brought by the quality of higher education is not an easy task. In any case, it is commonly accept all over the world that education plays a key role in the economic and industrial development. The public investment in higher education has been severely cut in the last two years. The figure 2 shows the recourses allocation to UFABC since its creation. It is imperative to recover the initial investment pace. The UFABC is now living a very productive cycle. Discontinuation will severely damage the scientific production and education for the future. With 562 professors, 12000 students 23 undergraduate courses and 23 graduate courses, with high academic evaluation and honored with more than 100 academic awards the UFABC is still in expansion phase particularly regarding laboratories and infrastructure. It would be a disaster to abandon such a singular initiative, which is bringing a renovation wave for the national higher education, with unquestionable success recognized internationally.

We avoid introducing references. Complementary information can be obtained from the University homepage. Several dissertations have focused the UFABC project and evolution. We believe that a close follow up of the UFABC development will be extremely useful to analyze the factors that could influence the growth or the decay of a university in the Brazilian federal system. Finally it is important to mention that this August the number of graduate students in UFABC has reached the digit 1000.

A Short Report on Role of EMBRAPA in the Brazilian Agribusiness

This section is a short account on the EMBRAPA role in the Brazilian agricultural complex. It is only to remind how worth is State investments. EMBRAPA´s history and development trajectory has been well written by several authors [1] [2]. So it is not our purpose to summarize EMBRAPA´s history but to show in brief numbers how important this Institution has been to the Brazilian economy and agricultural science and technology.

EMBRAPA, Brazilian Agricultura Research Corporation,a research section of the Ministry of Agriculture, Livestock and Food Supply was created in 1973 as the govenment's response to the challenge of modernizing agriculture to face the new and challenging problems of the modern world. This institution was given the mission of coordinating the Brazilian Agricultural Research System, integrating the actions of several Brazilian institutions involved with agricultural research. It was also within the EMBRAPA's scope to promote a more effective international cooperation.

Although EMBRAPA has been playing an excellent role in the development of the Brazilian industrial complex I would like to remind the contribution of a scientist who migrated to Brazil in the fifties and is an example for all our academic community: **Dr. Johanna Döbereiner.** Against the opinion of several well recognized scientists who sustained that working with bacteria to fix nitrogen was good only for theoretical purposes, with no practical application, she pursued her research and proved that she was right. Their opponents sustained that only the nitrogen fertilization could be effective to improve soybeans production. After strong discussions, involving Brazilian and mainly foreign scientists who were skeptical about her theory, she proved that she was right. This was possible with her breakthrough contribution showing that nitrogen fixation could be done introducing *Azospirillum* and other bacteria that could be useful to Brazilian soil following the discovery of nitrogen fixation bacteria in different species of vegetables, mainly grasses as corn and sugar cane. Dr. Döbereiner contribution is an extraordinary example of self-confidence, intellectual independence, courage to face new and challenging problems and passion for scientific research. Her discovery played a decisive role in EMBRAPA effort to adapt soybeans in the northeast of Brazil. Dr. Döbereiner proved that science is extremely useful to push technological development. It is important to say that investing in science has always been one of the most important of the EMBRAPA's priorities. In an interview for BBC Brazil, researchers in the field of agriculture were unanimous to declare that the most important contribution of EMBRAPA was the development of technologies that allowed for the correction of the soil acidity in the Northeast Brazil making possible the adaptation of plants

coming from different biome. Before 1970 the Northeast region was irrelevant as a player in the agribusiness, nowadays this region contributes with almost 50% of the country's production.

- Among the main actions characterizing EMBAPA´s priorities we may quote [2}:
- The planning team includes people with economic and social sciences background that contribute decisively for the Institution's program. The Institution priorities are well defined and followed along the execution.
- The research is focused on the agribusiness as a whole. The purpose is to develop a system not a specific technology. The technology is part of the package.
- Departments were abolished and research units were created such that each unit could work out solutions more adequate to the requirements of the respective region.

It is also important to mention that EMBRAPA has an international outreach program.As stated in the EMBRAPA homepage the LABEX was created to " promote scientific and technological cooperation with other countries". To accomplish this target*," Embrapa* launched a program to set up virtual laboratories abroad*, which seek* to ensure Embrapa's *physical presence outside* of Brazil*.* The concept of virtual laboratoryentails sharing laboratory space and infrastructure with partner institutions*."*

EMBRAPA is a shining example that investing in technology is really worth it. As written in the Social Report 2014:

The Social ***Profit/Net Revenue ratio in 2014 was of 8.53****.* ***In order words, each Brazilian real invested was returned to Brazilian society multiplied by 8.53****. The returns from Embrapa's investment in the 106 technologies monitored and assessed since 1997, the year of the Social Report's inception, also indicate high yield and an average internal rate of return (IRR) of 39.4%.*

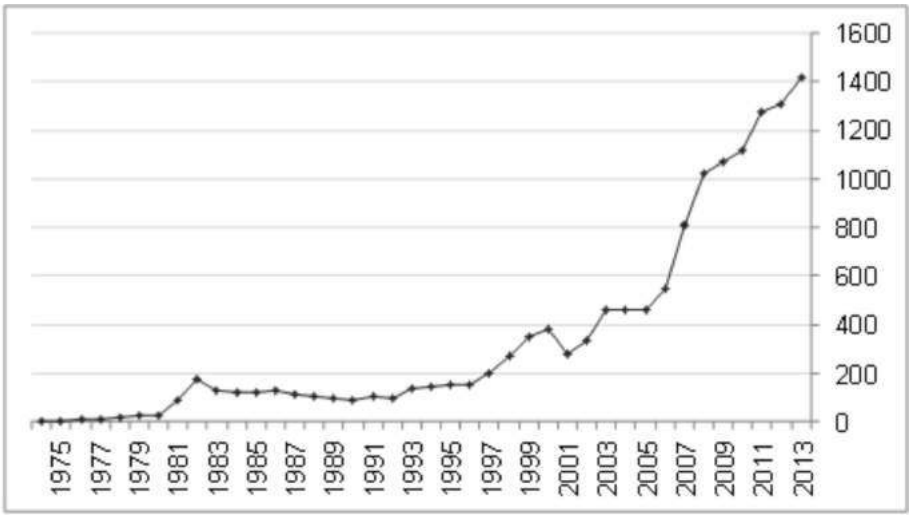
In 2014, 66,255 new jobs were created*. This is a baseline figure, as it refers to new jobs generated by the 106 technologies assessed in this report. Since Embrapa has developed and transferred thousands of technologies, products, and services to Brazilian society throughout the course of its history, such impact on the number of jobs created each year is certainly much higher.*

The ongoing research is contributing continuously to the growth of the country. We may highlight the following initiatives as stated in the Social Report 2014:

- Controle de Pesca do MatoGrosso do Sul -SCPesca/MS, which enabled the management and the conservation of fish stocks in Pantanal.
- Technology developed to reduce deforestation and to guarantee milk production in the Amazon region.
- App SuplementaCerto, a code which helps farmers decide on cattle feed during draughts.
- INPE-Embrapa Partnership in land monitoring in Amazonia extended to Cerrado.
- Booroola mutation program that expands sheep meat production in Southern Brazil.
- Draught-resistant cashew clone that generates wealth growth in Piauí semiarid.
- New gene bank that broadens Embrapa's contribution to food security in the planet.
- Embrapa's new website intended to increase the potential of technology transfer.

It is also important to mention that in 2014 EMBRAPA was distinguished with70 awards and honors. The growing contribution to scientific development is clear from figure 1.

Figure 1: Scientific publications in indexed journals according to Web of Science Period 1974 a 2013

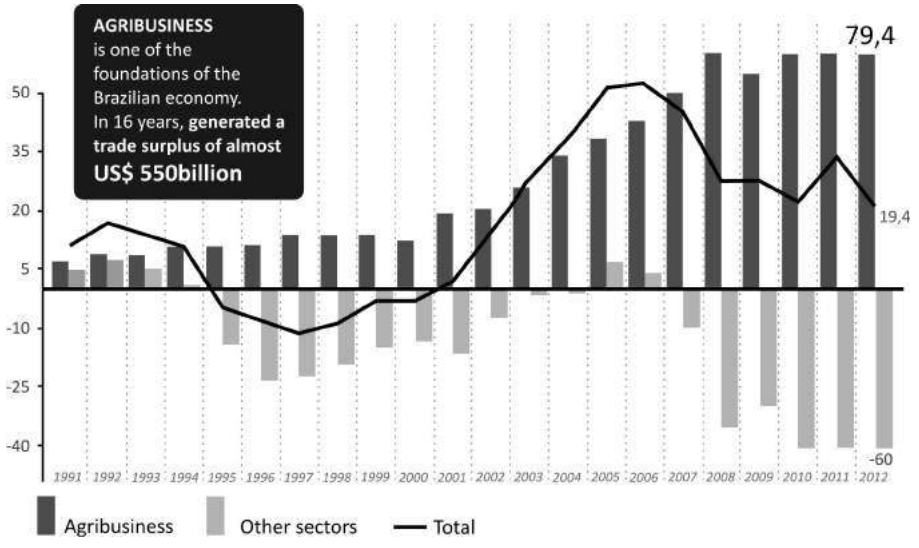


Among the new research topics the Amazon rain forest is attracting the attention of some of the researchers. The main focus is to invest in the adaptation of some

species to be introduced in the region keeping inviolate the sustained environment requirements. This initiative could enhance the production of typical fruits of the Amazon region and push forward the exportation to other Brazilian regions and to other countries. It is also to mention some initiatives in the field of genetic improvement, which fall outside of the investment priorities of the private sector. If EMBRAPA is successful in these projects it can raise the institution to a competitive status with the private sector and reach very good position in the market provided that it can create a business sector.

Among the several contributions that EMBRAPA has brought to the national development we would like to highlight two points. The first concerns the extraordinary impact in the economy. Between 2002 and 2012 the exports by the Brazilian agribusiness sector was multiplied by seven. The contribution of the agribusiness export is essential to keep positive the Brazilian commercial balance. As seen from the figure 2 in 2012 the Brazilian exports coming from agribusiness activities reached 79.4 billion USD overcoming several times other activities and keeping positive the commercial balance exports-imports.

Figure 2: Trade balance and contribution of the agribusiness



Source: Agrostat (MAPA)

The second point refers to the contribution of EMBRAPA to the increase of the Brazilian agricultural and cattle production. It is impressive as can be seen from the figure 3. Particularly remarkable is the increase in the soybeans production reaching the level of almost ten thousand percent in the period 1965/2005.

Figure 3: Performance of the Brazilian agribusiness 1965-2005 in tons

Ano	1965	1975	1985	1995	2005	Var.% 1965/2005
Cana-de-açúcar	75.852.864	91.524.560	247.199.472	303.699.488	420.120.992	453,9
Soja em grão	523.176	9.893.008	18.278.592	25.682.636	52.700.000	9.973,1
Milho em grão	12.111.921	16.334.516	22.018.176	36.266.952	34.859.600	187,8
Laranja	2.285.524	6.313.171	14.214.307	19.837.212	17.804.600	679,0
Arroz	7.579.649	7.781.538	9.024.555	11.226.064	13.140.900	73,4
Fumo	248.182	285.934	410.474	455.986	878.651	254,0
Trigo	585.384	1.788.180	4.320.267	1.533.871	5.200.840	788,4
Feijão	2.289.796	2.282.466	2.548.738	2.946.168	3.076.010	34,3
Carnes Total	2.420.782	3.589.592	5.898.738	12.807.517	19.919.135	722,8
Leite (mil litros)	6.857.813	10.054.500	12.572.830	17.126.100	23.455.000	242,0

In a recent report [4] the following guidelines were proposed to steer EMBRAPA's research effort. The following themes were selected following the input of the production chains that allowed the identification of the most important technological challenges in the several agribusiness activities. The selected topics are:

- Natural resources and climate changes
- New science: biotechnology, nanotechnology and geotechnology
- Automation, information technology, and precision agriculture
- Sanitary safety of agricultural products and productive chains
- Production systems
- Agro-industrial technologies of biomass and green chemistry
- Safety measures for food, nutrition and health.
- Markets, policies and rural development

Finally, we would like to call the attention about the evolution of EMBRAPA´s budget in the last 15 years [4]. After a critical phase encompassing the period 1995- 2003 when the institution budget decreased drastically from 1.38% to 0.73% of the gross domestic product (GDP) of the agribusiness sector there was a partial recovery to reach the level of approximately 1,0% of the agribusiness GDP (Fig. 4).

Figure 5 displays the institution budget in the last 15 years. Recently there was an increase in the amount allocated to EMBRAPA by the Federal Government. It is clear that this institution deserves the maximum support from governmental investment agents. The return of the investments to compensate the imbalance of the export-import relation justifies this policy. It is very important to sustain the effectiveness of institutions like EMBRAPA in the middle of temporary turmoil affecting the

national and global economies. We believe that it is one of the most important activities of the economic authority to define priorities in difficulty times. EMBRAPA has proved to bring unique contribution to Brazilian economy, agricultural science and agribusiness, it must be preserved.

Figure 4: Evolution of EMBRAPA´s budget as a fraction of the gross domestic product corresponding to the agribusiness activities

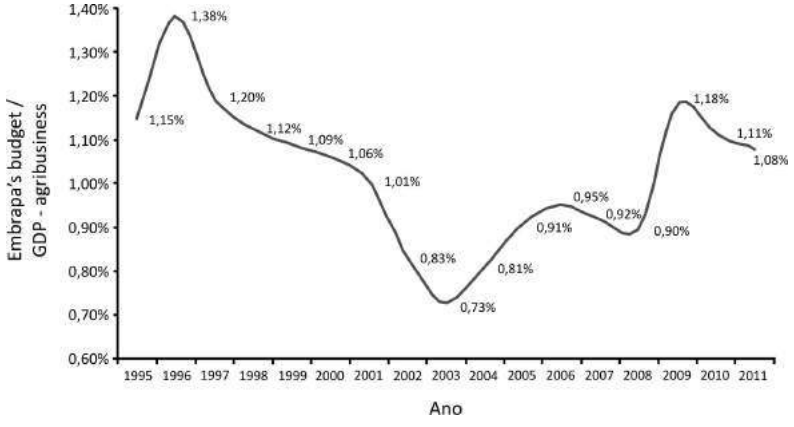
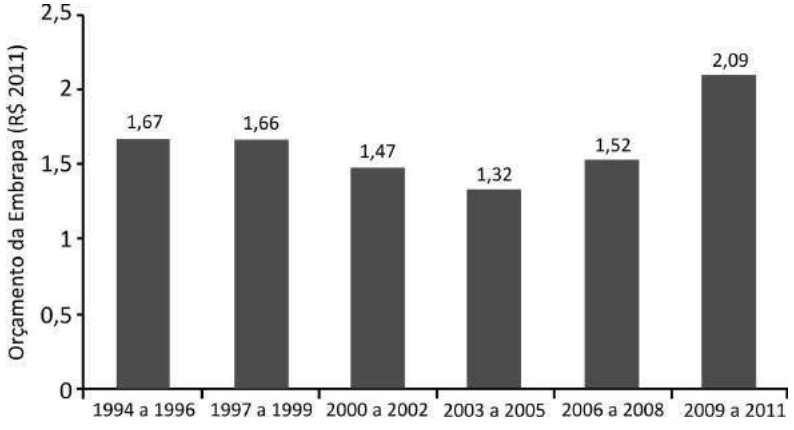


Figure 5: Evolution of EMBRAPA´s budget in R$ billions



This was a very short account on the EMBRAPA´s role in the Brazilian agribusiness industry. There are several papers and books on EMBRAPA`s history and role in Brazilian economy that the reader could easily access. The main conclusion is that public investment is worth, provided that, the people involved are competent and able to think independently, the problems are challenging, and the targets are well defined. EMBRAPA is one of these.

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