Science, Technology, and Inequalities in the Global Knowledge Economy: Policy Dimensions [1]

Preliminary Position Paper

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Contents:

Introduction

Two quotes set apart by nearly four decades may, through their opposite conceptions and extreme positions may be used to indicate the broader context within which ResIST defines its approach to exploring how science and technology (S&T), and S&T policy, may contribute to the reduction of poverty and inequality.

> *Whatever else in the world we know survives to the year 2000, [the disparity between rich and poor] won't. Once the trick of getting rich is known, as it now is, the world can't survive half rich and half poor. It's just not on.* [2]

> *Is Mode 2 likely to increase world inequalities?[...] Yes. There will be an increase in world inequalities in terms of access to and use of the results of scientific and technological activity. Even if Mode 2 knowledge production is more globally dispersed, its economic benefits will be disproportionately re-appropriated by rich countries and those of who are able to participate"* [3].

Read from within the context of the contemporary STI agenda, these quotes make, each in their own way, statements to which it is in some respects easy to subscribe, while appearing ostentatiously outdated and unacceptable in others. Many will readily support the strong general belief that S&T is "the trick of getting rich". We know – or are firmly convinced - that STI are key to alleviating poverty and extreme inequality: growth and development in developing countries and regions are contingent on the building up of qualified manpower and acquisition of technological capacity to exploit effectively S&T for economic growth and social development. In the hindsight of 50 years with limited and uneven achievements, it is impossible to embrace its unqualified optimism that the availability of S&T is in itself a guarantee that poverty and extreme inequality will inevitably, sooner or later, be abolished. If S&T have brought these goals within reach, then we must acknowledge that failure and ignorance on how to succeed still prevail. We do apparently not have sufficient knowledge, neither about the complex causalities that link STI and development, nor the extent of countervailing forces that have turned out to be far more numerous and powerful than the influence of myopic literary culture.

This qualified optimism conflicts squarely with the statement of the second quote, that the inherent dynamics of the new, "mode 2"-type of knowledge production which prevail in advanced societies at the turn of the century, will inevitably exacerbate inequalities and inequities. Its cynical and pessimist stance appears as unacceptable and already strangely outdated, despite taken from an oeuvre no more than a decade old, and with a pervasive – and still effective – influence on how we have been thinking about S&T during that decade. We identify with the assumption that active S&T policy to achieve development objectives, to reduce poverty and extreme inequalities, are, and must be, possible. That does not invalidate, however, the empirical observation of this analysis that contemporary knowledge production, research and innovation are

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[2] Snow, C.P. (1959) *The Two Cultures*.

[3] Gibbons, M et al (1994) *The New Production of Knowledge*, London: Sage Publications, p. 165-166

accompanied by increasing inequalities, and actually do appear to favour the already advantaged. This mode of knowledge production is apparently subject to dynamics and constraints which do pull towards increasing inequality, and which can be neglected only at the risk of underestimating the challenges, and of again falling into the trap of over-optimism. These constraints and dynamics may not, however, spring from the inherent nature and immutable laws of the "new" knowledge production, but are as much the effect of knowledge production taking place within a politically constructed configuration of institutional structures and power relationships, which may, we may hope, be amended and changed to help decrease rather than increase poverty and inequality.

Thus, ResIST takes it point of departure from the assumption that "making S&T work for the poor" is possible, worthwhile and necessary. But also from the awareness that that it is a difficult task, facing high risk of failure and powerful countervailing structures and forces.

The task is clearly enormous and pressing. The world's six billion people live in vastly different conditions. In Japan, a new mother can expect her baby to live 81 years, while in Botswana, she would expect only 37. Born in Europe, the child would have virtually no probability of being caught in armed civil conflict while growing up; but in Colombia or Sudan, that situation would be almost inevitable. In Europe or North America, the new mother could take basic sanitation facilities for granted, but half of her counterparts in developing countries could not.

Science and technology play dynamic roles in the world into which these children arrive. In what ways do science and technology make life better for all of them, and under what circumstances do they leave some or most behind?

The ResIST project analyzes the roles of science and technology in the dynamics of global inequality. This paper outlines the main concepts and approaches involved. On the one hand, our work is set against the backdrop of a rapidly changing global economy in which both established and rising nations seek economic growth through the production and application of knowledge. On the other hand, the background is the deep challenges of uneven development and persistent disadvantage for many communities and societal groups. We seek ways to use science, technology, and innovation to address both challenges at once, through socially sustainable development.

The paper is divided into two main sections. The first explores the central concepts of the ResIST project: the knowledge economy; inequalities; and science and technology policies. The second provides illustrations of the treatment of inequalities in S&T-related policies at three levels: national, European, and global. We conclude that there are many opportunities to seek equality through science and technology. In order to see them and take them up, however, we must adopt and apply broader concepts of innovation than the standard versions. We hope that ResIST's work will make such concepts visible and accessible to scholars and practitioners alike.

Section One: Basic Concepts

The Knowledge Economy

Introduction

The concept of the Knowledge based economy has been widely described in relation to successful fast-track development and is increasingly linked with innovation-driven competiveness and sustainability (knowledge-based bio-economy). The concept is used in both descriptive manner and as prescriptive tool. The success of USA, Europe, Japan and other developed economies has been attributed to significant strategic investments in R&D and in the framework conditions for wiring up the national system of innovation (including a range of both direct and indirect measures)[4]. These countries are now locked in a race to stay ahead in the wealth economies and global markets and might soon find themselves exhausted, as was the result of the race to colonialise the world. On the other hand these currently successful economies generally prescribe the same medicine to less developed economies. Investment in R&D has been touted as almost being the only way that poor countries may catch up with the developed world, or at least improving their living standards.

Most of the knowledge rich countries are still dependent on raw materials from poorer countries. Even though the prices of metals such as nickel, chromium, copper, zinc etc. have increased considerably over the last few years, the price of the finished product (raw material plus knowledge) has increased much more. Hence knowledge-based economies are buying low and selling high. Because of the dependence of the poor countries on several products of the rich countries (power generations, tools, medicine etc) the current situation may be view as one of neo-colonialism. To make matters worse developed countries welcome with open arms the best brains from the less developed ones and have incentives to retain them. So the less developed countries are prescribed to invest in R&D and the developed countries take a considerable part of the product. This is another ex-colonial trend.

Both national and various international bodies such as the World Bank, the IMF, the OECD and others subscribe to the concept of a ‘knowledge economy’, but may be seen to interpret it differently. Over the last decade, a general conviction has emerged that the concept has a relevant impact on the development policies adopted both by developed and underdeveloped nations. It is therefore important to study and understand the role that modern science and technology play in the creation of the divide between developing and developed countries. New, emerging technologies are recognized as having high potential for developing effective policies in developing countries related to poverty and education.

[4] http://ec.europa.eu/invest-in-research/annex/annex2_en.htm

Redressing bias in policy frameworks predicated on the knowledge economy concept

Current beliefs in the key role of science, technology and innovation as essential instruments for development, reduced poverty and inequality are, then, sustained by assumptions embedded in the pervasively used concepts of the 'knowledge economy' and 'knowledge society'. Ideas that knowledge is becoming increasingly important in modern societies have become pervasive, in public debate in general and in S&T policy discourse in particular. As knowledge is becoming an increasingly important 'strategic resource', the progress of societies and the success of their economies are seen to depend on the capability to develop and implement effective policies for the production, distribution and application of knowledge – education, research, R&D, technology. Such policies for knowledge have also been increasingly tightly integrated in the broader policy framework of knowledge-based or driven *innovation*, as it is recognized that effective harnessing of the socio-economic benefits of knowledge depends essentially on capacity to translate knowledge into products and services that are novel, useful and commercially viable.

'Knowledge' is, however, in this context not the generic, anthropological constant which constitutes human activity as such, but a concept which defines a hierarchy of forms, with advanced, research-based scientific and technological knowledge at the apex of the hierarchy, as the most important and effective source of innovation. "Scientific research, technological development and innovation are at the heart of the knowledge-based economy". [5] Innovation based on advanced scientific and technological research is seen as a main engine of economic growth, productivity and competitiveness. These forms of knowledge sustain the accelerating rates of innovation and technical change which characterize knowledge-based economies, where the most knowledge- and R&D-intensive industries and services are also the most fast-growing and profitable. The ever-increasing role of innovation based on advanced scientific and technological research has created "new rules of the game" [6], and learning how to master and play by these rules determines the divide between those who will become winners and losers, pioneers and laggards in the transition that is underway.

The knowledge-based economy is thus defined by the "fusion of science, technology and the economy" (Daniel Bell). Thus, science and science-based technologies have become immediate sources of innovation and growth. Knowledge is at the same time transformed into immediate economic entities through processes of commodification, by which knowledge is becoming an "intangible" capital asset in its own right. This is particularly evident in the rise of a specific type of knowledge-based firms which have much knowledge and intangible economic assets in-house, but few or no saleable products at the time when financing is required. The extension and stronger protection of property rights over intellectual assets, - patents, trademarks, designs, copyright – have thus become a hallmark of the knowledge economy.

While different version and definitions of the knowledge economy and society circulate, they have within STI policy contexts achieved some stability and coherence

[5] European Commission (2004) Science and technology, the key to Europe's future – Guidelines for future European Union policy to support research, (COM(2004) 353 final), p.2.
[6] UNESCO (2005) *UNESCO Science Report 2005*.

through the development and use of a core set of standard indicators of performance and progress in terms of developing into "knowledge economies". This set includes, as developed and disseminated by in particular the OECD [7] and the EU, indicators such as public and private investment in R&D; the R&D intensity of nations (R&D as proportion of GDB), and industries (R&D as proportion of sales); high tech export; output and employment in high- and medium-tech industries; patents, trademarks and designs; proportion of population with secondary and tertiary education; number of S&T graduates; new products to the market and the firms; level of ICT expenditures and several other ICT-related indicators (broadband penetration etc). These indicators sustain and guide policy formation by providing common conceptual frameworks and terminology, as well as common objectives and standardised quantitative measures of performance and progress.

These core elements in contemporary, mainstream policy conceptions of the 'knowledge economy' have shaped STI policy-making in developed economies and societies for a number of years. As their key ideas, arguments and indicators have been developed and disseminated under the auspices of, in particular, the OECD and the EU, they may have been developed in response to the opportunities, needs and conditions of already well-developed knowledge economies. It is far from given a priori that policy objectives and priorities, benchmarks and 'best practice' models which may be appropriate for well-developed economies and effective for ensuring their continued success, are adequate and appropriate for economies and societies beyond the North. [8] Another concern relates to the fact that developed economies are often unaware of and unwilling to admit to the shortcomings and less positive long-term effects of following these models in terms of knowledge failures and problems with social cohesion they generate.

There are growing concerns that the substantial public investments being made in research and innovation are often not being fully valorized by users because of policy failures in ensuring adequate absorption and take-up of research results. However even more worrying is that the fact research is often not relevant to end-users such as local communities and citizens but is driven by priorities of peer review and publication in international scientific journals. This is particularly the case in developing countries where scientists and researchers often return after studies in developed countries to work on research topics which are disconnected from their local context. In Europe there are also growing concerns that current investments in research and innovation are not gearing the economy and society sufficiently for the major transitions ahead towards the knowledge-based bio-economy.

Main tenets of these frameworks may, however, be questioned, even as applied to developed economies. Biases, inefficiencies and deficiencies may need to be addressed and redressed, as indications emerge that these framings have themselves become narrow, prejudiced and sources of policy lock-in, foreclosing alternative options and strategies. There may be more diversity in the knowledge economy, and more ways to

[7] See in particular, Godin, B (2005) Measurement and Statistics on Science and Technology: 1920 to the Present, London: Routledge

[8] See, e.g., Joakum Arendt: Building science, technology and innovation policies, http://www.scidev.net/dossiers/index.cfm?fuseaction=policybrief&policy=62&section=363&dossier=13 , and http://www.scidev.net/dossiers/index.cfm?fuseaction=dossierfulltext&Dossier=13

survive and succeed in it than prescribed by these frameworks. More importantly and fundamentally, however, is the disclosure of the political, conflictual underpinning of the rules of the game; they do not simply reflect the nature of new production of knowledge or of systemic innovation, but are disclosed as the hegemonic outcome of power and interest politics. Contestation and re-writing of the rules are becoming integral and essential parts of the competitive game itself.

Evidence indicates that prevalent knowledge economy framework do not adequately describe and explain performance even in developed economies. It is, e.g., a salient feature of many knowledge economy policy narratives that they struggle with a number of persistent "paradoxes", the most important being the "European paradox" itself. These paradoxes originate in weak, in some cases negative correlation, between performance as measured by knowledge/innovation indicators on the one hand, and actual competitiveness and growth performance on the other [9]. While cases of positive correlation are designated as best performers for others to emulate (US, Finland, Korea), the persistence of 'paradoxes' indicate that essential determinants of innovative performance are not taken into account, and – as a further consequence – that STI policy that mainly focus on the narrow set of options and objectives defined by these indicators, may remain restricted, ineffective and deceptive.

From high-tech to learning

Most standard indicators on the knowledge economy emphasize strongly the key importance of a few particularly R&D intensive manufacturing industries. These industries combine the key characteristics of the knowledge economy, - they are highly R&D intensive, scientific knowledge and research are immediate sources and drivers of innovation, and they are fast-growing. However, while high-tech manufacturing industries account for a growing share of value added in advanced economies (in particular in the US), they do still not account for more than 4 percent of GDP, even in the US [10]. Innovation in so-called low- and medium-tech industries remain essential to overall competitiveness and growth in all economies – and will remain so in the foreseeable future. While sophisticated knowledge and advanced technology may be essential in these industries, this is incompletely captured by R&D and high-tech indicators.

A narrow focus on R&D intensive, high-tech industries may thus be seen to build on a skewed representation of the overall basis of economic growth and employment. Even more importantly, it provides a narrow framework for addressing the ways which knowledge underpins innovation in the "knowledge economy". While knowledge in an immense variety of forms arguably does play increasingly important roles in the modern economy, it does so in the whole economy, drawing on widely diverse forms of knowledge, not only, nor primarily, in R&D-intensive and directly science-based industries. A less high-tech-focused notion of STI policy may be seen to emerge, as the role of Finland and the US as best performers in the knowledge economy is increasingly

[9] OECD (2005) Governance of innovations systems. Volume 1: Synthesis Report, OECD: Paris

[10] Hirsch-Kreinsen, H, D Jacobson, Steffan Laestadius (eds) (2005) Low-tech Innovation in the Knowledge Economy, Peter Lang: Frankfurt a M.

being matched by the strong performance of, e.g., Denmark, where growth is largely based on strong innovation performance in low- and medium-tech industries.

The high-tech bias of dominant knowledge economy framings of STI policies indicates that their concept of the knowledge economy is, more generally, predicated on narrow concepts of knowledge, and of a too narrow conception of how knowledge sustains innovation. Modern, innovative economies may be seen to be knowledge-based in a far more general sense. This is, in particular, a perspective phrased in terms of a conception of the knowledge economy as based on "learning", which emphasizes the role of knowledge as the most fundamental resource in the modern economy and the most important process as learning [11]. A wide variety of forms of knowledge and learning should be taken into account as a basis for and input to innovation processes, including tacit, experience-based, 'doing-using-interacting' (DUI) forms of knowledge. Foresight also constitute an important learning process through its open, participatory approaches to governance and its potential to create an open space for reflection on alternative futures and effective mobilization for future actions. While innovations originating in science-based forms of knowledge are common, particularly in R&D intensive industries as pharmaceuticals and ICT, even these forms of innovations depend on and are embedded in DUI-based forms of knowledge.

While R&D-biased innovation policies may thus be problematic and inadequate for developed economies, in particular as concerns small economies where low- and medium-tech industries are pre-dominant, this is a fortiori the case for developing economies: "A narrow innovation system concept focusing on the research and development system and on high tech and science-based innovations makes even less sense in the South" [12]. Appropriate and effective innovation policies for less developed economies, requires a broadening of the innovation policy framework to take into account the diverse ways by which the productive mobilisation and creative recombination of knowledge contribute to innovation.

The emphasis on the essential role in innovation for tacit knowledge, for DUI based forms of knowledge, and for the of the creative recombination of various forms of knowledge, also indicates how it may and should be part of innovation policies of less developed economies to identify, recognise and mobilise the unique innovative potential of so-called 'traditional knowledge'. These and other specific forms of context-bound, experience-based knowledge may be marginalised, neglected and suppressed in R&D-biased conceptions about how knowledge sustains innovation, with highly problematic social implications as to who are qualified to participate in and contribute to innovation processes. They may be mobilised as resources which enhance the distributive end assimilative capacities of these economies and societies. But mobilisation should be different from the appropriation and use of traditional knowledge by modern scientific research, as seen in cases of alleged 'biopiracy'. As in such cases neither the research nor

[11] Lundvall, B-Å (2005) *National innovation systems – analytical concept and development tool*, MS, <http://www.druid.dk/ocs/viewabstract.php?id=603&cf=3>, accessed Sept 2006.

[12] Lundvall, B A et al (2002) National systems of production, innovation and competence building, Research Policy 31, 226.

its benefits are controlled by these communities themselves, the carriers of knowledge are dispossessed, rather than empowered.

These biases may leave the impression that succeeding in the knowledge economy is all or primarily about success in a narrow range of particularly knowledge and R&D-intensive industries and services. Such narrow frames may be seen to load the dice in favour of advanced knowledge economies which are best placed to succeed in developing those industries, indicate that only a narrow range of strategies are available that adequately respond to the rules and conditions of the knowledge economy. The framework needs to be broadened to emphasize that innovation in the knowledge economy is about the creative mobilisation and productive recombination of knowledge generally, in the whole economy, including the less glamorous low-tech, traditional industries. This may open up searches for strategies which are better attuned to the needs and circumstances of economies where initial conditions are such that efforts to develop high-tech manufacturing will predictably be rewarded with meagre success.

Diversity and divergence in STI policy

Tensions and contradictions are built into narratives about the knowledge economy through the combination or amalgamation of ideas about the "knowledge economy" and about the "systemic" determinants of innovative performance, as embodied in particular in the concept of "systems of innovation". The marriage/fusion of knowledge economy and systems of innovation conceptions forms unstable conceptual amalgams. The shift from classical science, R&D and technology policy to modern, "systems"-based notions of innovation policy is based on the realisation that the persistent "paradoxes" of R&D and STI policy are in fact a symptom of overly narrow, implicit assumptions that underpin earlier conceptions of R&D policy. These are based on assumptions that investments in R&D will inevitably and quasi-automatically translate into actual innovations, productivity gain and growth. The concept of innovation policy grew out of the demise of the "linear models of innovation" that is seen to have sustained those assumptions. The scope of innovation policy must be extended far beyond R&D, in recognition that the effective commercial and social exploitation of the innovative potential of R&D and knowledge depends on the combination of complementary assets and competencies and on the configuration of a large number of factors, often with little or nothing to do with R&D as such, that influence innovative performance in complex ways. R&D is, hence, not a sufficient condition for innovation, and innovation policy must transcend R&D policy and address all these complementary assets, competencies and conditions. This requires a mix of policy measures and the synchronization of a range of policies (education, industrial, social, ICT..). Moreover, R&D is not even a necessary condition of innovation, at least not in an immediate sense. Highly effective forms of innovation involve knowledge in essential ways, without being immediately based on results from R&D, and such forms of innovation may be far more common and economically more important than suggested by R&D-focused and high-tech-biased conceptions of innovation.

The implication of "systemic" approaches to innovation policy is that innovative performance is contingent on the "systemic" interaction and complementarity of policies, resources, assets and conditions, not on specific strengths or weaknesses considered in

isolation. This dynamic at the "systemic" level is captured neither by single benchmarks, nor by their simple aggregation. While policy approaches predicated on benchmarks and best practice creates a dynamic of convergence pull on policy development and learning, systemic approaches also open up for the possible success of widely divergent configurations of assets, resources and conditions. Emphasizing diversity and divergence may open up the way for policies predicated on specific systemic qualities and assets that are not easily identified in single and/or aggregated benchmarks, nor effectively addressed through trans-systemic transfer of best practices.

If the innovative capacity of innovation systems is defined in terms of capacity to mobilise and recombine knowledge (with traditional knowledge or context-specific competencies or assets) in a productive way, that capacity is not only or primarily determined by the productive capacity that is primarily measured by capacity and output of research, or R&D. Innovative capacity is as much a function of the capacity of innovation systems in terms of knowledge distribution and absorptive capacity of the key actors (deriving from the particular local context within which they are operating). R&D contributes to innovation not only as immediate source of innovations, but also by expanding and enhancing the capacity of people, firms and institutions to assimilate knowledge and put it to productive use. This is why it is important that knowledge production is strongly connected to the needs and capacities of local communities through more open innovation systems and knowledge exchange strategies linking researchers and end-users. The more proactive universities in developed economies in cash-strapped situations are already mobilizing themselves in their strategies plans to develop knowledge exchanges strategies with local development agencies to meet local knowledge needs[13]. While this is an essential contribution by R&D to the innovative capacity and performance of any innovation system, it may be particularly important in the context of less developed economies, where innovation strategies may – according to conventional assumptions – to a larger extent build on imitation and adaptation rather than original inventions. However, phrasing the difference of innovation systems and strategies of developed and developing economies in these terms may, however, to overstate their differences. On the one hand, imitation, adaptation and incremental innovation may – in both developing and economies – be seen to involve innovation and novelty to a higher extent than the terms themselves suggest, while, on the other hand, imitative and adaptive forms of innovation remain, and will remain, a key and dominant feature of innovation even in developed economies.

Competitiveness and conflict

Thus, while it may appear from the overall trends as, i.a., captured by general statistics, that it is self-evidently true that "knowledge" in general, and science-and research-based knowledge in particular, is playing an increasingly central part in emergent "knowledge-based economy and society", it is far less self-evident how - and what – equally self-evident, specific policy implications may be inferred from and justified by this general evidence. In the short and longer term, any chosen line of action will benefit some actors and interests and harm others, depending on perceptions of available opportunities and viable options. It is, in particular, not evident how policy

[13] http://forera.jrc.es/fta/documents/anchor/HigherEdAnchorPaper.pdf pg 6

objectives to be achieved within zero-sum games of competition and competitiveness, can be generalized to apply to and benefit all: the success of policies to enhance the competitiveness of regions, nations, and of Europe itself, can only, at least in the immediate, short term, be achieved at the cost of competitors' loss of relative competitiveness and benefits, including developing economies. While such immediate conflicts of interests will, according to the ideology, be overcome in the longer terms, and all interests eventually benefit, it is not clear what mechanisms will sustain that future reconciliation, and empirical support is not strong that everybody benefits in the longer term. To the contrary, the pursuit of core competitiveness objectives within global contexts has rather been accompanied by increasing conflict.

This is for example, the case in relation to IPR protection. Linking IPR issues to trade, as was done for the first time in the Uruguay process of GATT, with TRIPS as the outcome, have made global IPR an issue in which tensions and conflict have become salient. The linking of IPR and trade as initiated by developed countries and the US in particular, has been seen as a move to create a "level" playing field, based on stronger harmonized IPR regulation, where the most developed knowledge economies are in a considerably stronger position to retain, consolidate and widen their competitive edge. The move towards stronger and more harmonized IPR protection has been seen by some as protectionism for the advanced knowledge economy: "Old protectionism was about keeping your rivals out of domestic markets. New protectionism in the knowledge economy is about securing a monopoly privilege in an intangible asset and keep your rivals out of world markets" [14]. Thus, IPR is one policy area which has assumed particular importance in the "knowledge economy", and where already conventional assumption and well-established positions, indicate how policies predicated on competitiveness cannot simply be extended to and adopted by all with equally beneficial results.

Another issue where creating "level" playing-fields may cement the competitive advantage of the already strong players of the game, is migration of high-skilled labour. As economic competitiveness is seen to depend increasingly on access to high-skilled work force, becoming a net beneficiary of these migration processes have become a key issue for gaining and retaining competitive advantage in the knowledge economy. Active policies are being developed by regions and nations to attract foreign students and researchers. Brain gain for the winners of this game is, however, brain drain for its losers. As only a few developed countries have been net beneficiaries of migration of high-skilled workers, these inequalities may easily be exacerbated by active policies to attract highly skilled personnel from abroad, as when countries and regions that are already well positioned to gain make specific efforts to extend and capitalize on that competitive edge. How migration policies are becoming core and integral parts of policies to sustain global competitive advantage and leadership, may e.g., be seen in the framing of US debate about the stakes involved in the new visa regulations and other post-9/11-barriers to the immigration of foreign scientists and engineers to the US: "We risk irreparable damage to

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[14] Drahos, Peter (with John Braitrhwaite) (2002) *Information Feudalism. Who Owns the Knowledge Economy*? Earthscan: London, p. 87

our competitive advantage in attracting international students, scholars, scientists and engineers, and ultimately to our nation's leadership" [15] .

Another closely associated issue of increasing importance for developing as well as developed countries where competition may be positioned in direct opposition to development is foreign direct investment (FDI) as a main avenue for sharing the benefits of the knowledge economy. This appears as a zero-sum game where policies of national governments may be limited to creating conducive conditions for the (re)location by MNCs of their R&D and innovation work. Each country may be under pressure to underbid each other in a game in which the fate of countries and regions in the knowledge economy depends on investment and (re)location decisions by a small number of MNCs which are becoming increasingly dominant in terms of share of private and total global R&D expenditure and innovation. [16] "Over the past eight years only 2% of global FDI has gone to Africa. And the financial losses because of changes in the terms of trade have been greater than all the aid and investment flows the continent has received." [17]

Thus, the flipside to STI policies framed in terms of competitiveness objectives is that the benefits of winners will be at the cost of losers. While policies framed in terms of competitiveness tend to emphasize "excellence", concentration and critical mass, they risk de-emphasizing the complementary and equally essential role of distribution, diffusion and spillover. These dimensions are not only key determinants of innovative performance, but also of prime importance if concerns with inclusion and participation, with wide distribution and general sharing of the benefits of innovation, assume a more central part of STI policy.

Market demand and social needs

An even more fundamental form of narrowness from a ResIST point of view is, however, the all-dominant role that purely economic policy objectives have played in policy-informing conceptions of the knowledge economy and of innovation systems (as well as their amalgams). Productivity, competitiveness and aggregate economic growth form core policy objectives. It is also the explicit basis for the EU adoption and adaptation of that framework as a core part of the Lisbon agenda, according to which Europe should become "the most innovative economy in the world". The primacy and predominance of economic objectives within the European STI policy agenda is also confirmed by the selection of indicators (European Indicator Scoreboard), benchmarks and review practices that have developed within the framework of the "open method of coordination" approach to research and innovation policy (TrendChart; European Innovation Scoreboard; Erawatch). Use in EU documents of the broader concept of 'knowledge society' address non-economic – social, cultural, political – dimensions of "knowledge society" in terms of the extent to which those dimensions may be seen to support or hamper economically relevant innovation. Thus, economic objectives have remained at the core of

[15] "Recommendations for enhancing the US Visa System to advance America's scientific and economic competitiveness and national security interests", 18. May 2005, http://www.aau.edu/homeland/05VisaStatement.pdf, accessed 29 Aug 2006.
[16] See *Monitoring Industrial Research: the 2005 EU Industrial R&D Investment Scoreboard*, EU/Research
[17] World Economic Forum

approaches to the role of 'social and cultural capital' issues on economic and innovative performance, including that of (in)equality as an issue of social cohesion/fragmentation.[18]

These developments have, no doubt, led to accelerated rates of technical change and innovation, as well as to increases in the aggregate growth and productivity of national, regional and global economies. Economic objectives and performance are primary, while the broader social and cultural preconditions, implications and effects of economic performance remain a marginal policy concern. Thus, while policy approaches that focus on market driven innovation have – at least for some economies - resulted in policies that are effective in terms of overall innovative performance and aggregate economic growth, they have remained too blind or tolerant to social costs and effects which these frameworks have not been designed to take into account.

Evidence indicates that the verso of the bright picture provided by economic indicators of a long period of strong, sustained growth, is increasing inequality, decreasing job quality and increasing insecurity. While some have enjoyed unequalled increase in wages, others have benefited less, and many have even suffered an absolute income decline. "[A] picture of simultaneous growth in wealth and poverty unprecedented in the twentieth century" (Paul Krugman) has emerged. This has taken place during a period of growth, at least partly explained by many by the success of policies to harness the potential for productivity increase of advanced technologies, in particular ICT. Assumptions based on the "trickle down" model of economic growth, that everybody will eventually benefit from overall growth, if not in equal measure, have proven false.

The unequal sharing of the benefits of technology-driven growth has become particularly salient on the global level. The issue of less developed countries' access to essential and affordable medicines has come to epitomize that gap. The issue of drugs for neglected diseases has become a case of "fatal imbalance" (Campaign for access to essential medicines) between needs and innovation tailored to market demand, and as such a strong symbol of structural imbalances and mismatches between social and economic objectives of contemporary STI policies. A "needs-driven research agenda" needs to be developed.

Thus, while "market failure" has for a long time been a core concern in STI policy, this is about concerns with the incomplete private appropriability of the benefits of knowledge, requiring correcting measures to balance total social investments in knowledge. Traditionally, the most important measures are the public funding of basic research and the protection of IPR. However, from a distributional point of view, a more fundamental "market failure" concern has not to the same extent been an integral core part of STI policy, i.e., the gap between social needs and market demand. Innovation has become increasingly market based. A shift has taken place in the relative roles of public and private R&D performers and funders. The proportion of total R&D performed by business has increased in most OECD economies, in some cases dramatically. Public STI policy is less framed in terms of initiative and of directing the R&D towards specific objectives, and more in terms of facilitation and support. "Increasingly, government must become a facilitator, enabling business and consumers to adapt to the demands and

[18] See e.g., Building the Knowledge Society: Social and Human Capital Interactions, SEC(2003) 652

opportunities of the new economy" [19]. Innovation policy remains firm-centered, about responding to "the needs of innovation" as perceived by these firms. Consequently, one standard objective of mainstream STI policy is to attract/retain high-growth, R&D intensive industrial activity. Hence, also, the increasingly important role of foreign direct investment as instrument in policies to develop national, regional knowledge economies, i.e., the creation of conditions and environments which are perceived by major, R&D-intensive companies as attractive locations for their core R&D and innovation activities. For firms whose intangible, intellectual economic assets are an increasingly important part of their capital base, FDI decisions may to a high extent depend on the level of IPR protection of hosting countries.

Competitiveness and social cohesion – aligning and fusing economic and social policy agendas

However, describing the contemporary STI policy agenda for the knowledge economy only in terms of its lopsided and myopic focus on economic objectives and performance only, inadequate. While the critical depiction of the dominant STI agenda as narrowly focused on economic objectives and STI indicators does arguably capture salient aspects of that agenda, it also leaves out important aspects and trends which make the overall picture far more complex and ambiguous. Criticism of the contemporary STI agenda as too narrowly focused on economic objectives has in fact become a salient aspect of that agenda itself. Another, balancing aspect of that agenda is also the proliferation and alignment of efforts to develop a framework for extending the framework beyond a narrow concern with competitiveness and growth only, and that a framework need to be developed which may accommodate and balance social and economic objectives.

These efforts are to a large extent initiated and supported by the EU itself within the framework of the Lisbon agenda. While economic objectives - competitiveness, productivity, growth – apparently remain firmly at the core of EU STI policy, the Lisbon agenda frames a broader, multidimensional agenda by incorporating social objectives – the quality of jobs, sustainability, quality of life, social cohesion – into the STI policy agenda on an equal footing with economic objectives. This agenda recognizes explicitly that economic and social objectives will often conflict, and will most often be in need of being balanced and bridged. It also envisages the possibility that these objectives may be balanced and made compatible in ways which open up for "win-win" and "mutually supportive" policies, by which everybody wins and nobody loses. The "eco-modernist" or "sustainable development" paradigm of win-win-type of policy ("prevention pays") is extended to encompass policy objectives which fall under the "social cohesion" category: "A high level of R&D spending and a good innovation performance contribute to more and better jobs. In addition research and innovation are needed to make the EU economy more sustainable, by finding win-win solutions for economic growth, social development and environmental protection" [20].

[19] OECD Policy Brief, sept. 2000.

[20] European Commission (2005) More research and innovation – investing for Growth and Employment: A Common Approach (COM(2005) 488 final, p. 4

This indicates the ambition of policy predicated on the "European model" for sustainable, economic growth; it is different and distinct from the "US model", where growth has been accompanied by increasing socio-economic inequality. The Nordic "sub-model" of economic development is increasingly held up as evidence of the viability of the European social model. These countries exhibit strong performance on R&D, innovation and growth, while retaining their distinctive features as welfare societies, with a high premium on social equality and security. The concept of the "learning economy" provides one rationale for social equality as an asset for innovation in the knowledge economy, as one essential part of the "social capital" on which innovative, interactive learning depends.[21]

These are significant shifts in the way the STI policy agenda is being framed, and the ResIST project acknowledges its origin in and its role as part of an emerging STI policy agenda guided by ambitions to develop a type of a less economy-dominated, more multi-objective STI policy framework. Within this framework, economic and social policy objectives, including equality and equity, may be seen as equally important, in need of being balanced, made compatible and – ideally - mutually supportive.

We also acknowledge, however, the difficulty of this task, requiring extensive policy innovation. Different and often manifestly conflicting policy objectives do not converge simply because it is highly desirable and politically urgent that they do. The idea of win-win-policy, and the idea that science, technology and innovation are important for development of innovative, win-win policy options, does not in itself go a long way in making such policies real. This talk may remain ideology and rhetoric, serving to defuse political conflict, rather than to emphasize the high degree of policy innovation required as well as the necessity of making difficult political choices for changing entrenched patterns of behaviour which are not compliant with "win-win" criteria. Despite statements that innovation policy predicated on the European model, must be a multi-objective, balanced, win-win type of policy, the primacy of economic objectives do apparently prevail: "So the challenge for European innovation policy is: first, to develop increased awareness of the significance of innovation across all policy

[21] The concept of mutually supportive, or "win-win" innovation policy has been elaborated by influential projects for the EU and OECD (Lengrand, L et al (2002) *Innovation Tomorrow: Innovation policy ad the regulatory framework: making innovation an integral part of the broader structural agenda*, Innovation papers no 28, DG Enterprise; OECD (2005) *Governance of innovations systems.Volume 1: Synthesis Report*, OECD: Paris). Here, it is introduced in terms of an emergent "3rd generation" innovation policy, which is an extension and re-articulation of the idea that has been strongly emphasized in notions of "systems of innovation": innovation policies must be *horizontal* in scope, cross-cutting traditional policy borders and encompass – in principle – all policies that impact on the conditions and performance of innovation. This idea is at the core of the Lisbon agenda, one implication of which is that "all policies at Member State and EU level should be tuned to support research and innovation, wherever possible" (EUC, 2005: 5). While putting "research and innovation at the heart of EU policies" (ibid) may be interpreted as a requirement that all non-economic policy domains and objectives should defer to the requirements of an economically oriented innovation. Horizontal policy must also be *coherent*, as coherent, overall innovation policy is essential for governments' capability to apply policies effectively, handle complex policy issues, reconcile policy objectives and achieve accountability. The concept of a 3rd generation horizontal innovation policy indicate that that while "1st and 2nd generation" policies for "innovation systems" were primarily focussing on the role of innovation policy for competitiveness and economic growth, 3rd generation innovation policy are *multi-objective*.

fields; and second to develop effective and efficient means of co-ordination through which we can ensure that conflicting policy aims are reconciled to the overall benefit of innovation and economic objectives". (Innovation and Technology Transfer, EUC, Sept 2003: 6). The concept of innovation and the conception of innovation policy may thus remain an instrument for achieving economic policy objectives, and thus hold back, rather than encompass and stimulate, the policy innovation required and called for by the terms of the Lisbon agenda and its call for a "balanced", "social model" of policy for innovation, development and growth.

How ResIST may contribute to reframing the STI policy agenda

This process of reassessment, extension and rearticulation of dominant STI policy framework is apparently, if ambiguously, underway. Criticism and reassessment of the narrowness of dominant framings of the STI agenda are becoming an integral part of that agenda itself, and the framing of the Lisbon agenda represents a key step in and a framework for that extension and rearticulation. The full development of that framework and agenda depends, however, on sustained, long-term work to develop new performance criteria, new objectives and different accountabilities. Different types of correlations and causalities need to be identified and exploited, a different set of learning-enhancing experiences and "best practices" should be selected, on the basis of different objectives and performance criteria than those that have been predominant in previous, narrow STI policy frameworks.

ResIST is itself the result of this process of extending and rearticulating the contemporary STI agenda. We aim to contribute to the further extension and deepening of a multi-objective STI policy framework. We hope to be able to, through our research, to bring new ideas and experiences to bear on the as yet incompletely developed and unfinished agenda for a comprehensive, multi-objective, balanced STI policy.

One initial assumption of the ResIST project is that this can be done by addressing, explicating and strengthening of interdependencies between what we have called the *structural, representational, and distributive* aspects of science, technology and innovation systems. The *structural* aspect reflects the organization of resources and capacities, for example, the dominance of men in science and engineering careers and the high concentrations of science-based businesses in the global North. The representational aspect refers to political power and voice, and therefore to the processes of accountability. Examples are the greater levels of political participation, both formal and informal, among middle-income Americans as compared with low-income Americans. At a global level, the greater voice of the U.S. Treasury in the decisions of the World Bank and International Monetary Fund, institutionalized in their voting rules, serves as an example. The distributional aspect refers to who gets the benefits and who bears the costs of science and technology, as for example, the benefits to consumers from lower production costs through automated production processes, as compared to the costs to workers who are displaced from old jobs by automation but do not have the higher skills needed to get new ones.

Inequalities

Concepts of Inequality

Inequality is the unequal distribution of something people value: some people have more of that valued object, some people less. This seemingly simple concept has complex applications when we use it to understand social, political, and economic dynamics on a global basis. This section of the paper calls attention to the most important dimensions of the concept of inequality for the work of ResIST, and defines some terms for referring to those dimensions in our work.

Even our initial definition raises the question: inequality of what? As hinted in the last section, STI policies tend to focus on two categories of things that people value: wealth and well-being. The wealth dimension includes the standard economic concepts of income and wages as well as wealth more narrowly defined as savings or ownership of capital. This is the valued object studied most often under the topic of inequality, usually by economists. However, ResIST could not achieve its goals without also considering the second dimension. The well-being dimension includes items whose worth is not usually pictured in monetary terms, such as health, education, and environmental quality. Both these dimensions are considered in ResIST in Work Package Four, which is developing a framework for distributional assessment of emerging technologies.

Work Packages Two and Three, furthermore, focus on inequalities of two other valued objects. Work Package Two considers inequalities in the distribution of science and engineering talent between countries, examining the role of researcher mobility in shaping it. In this case, it is countries that value the "object" of research personnel, while the individuals involved in mobility value career opportunities and the well-being they can achieve by moving. As foreshadowed in a later section of this paper, this work package explores the tension between individual freedoms and national goals. This angle on inequality begins to explore the structural aspect of S&T dynamics described in the last section.

Work Package Three studies inequalities in power, in the representational aspect. One set of cases examines participatory processes and their ability to embed re-distributional objectives in STI policies. These cases illustrate that if power were more equally distributed, the distribution of wealth and well-being would also be affected, and that STI policies are unlikely to change the distributions of wealth and well-being unless power is more equally distributed as well. This analysis intersects with structural inequality through the role of expertise in political processes. Communities that are structurally deprived of expertise will also be additionally disadvantaged politically in S&T intensive decision making processes.

The second set of cases in Work Package Three examines accountability, another political dynamic. How can accountability for outcomes be achieved in technological processes that extend widely across time and space? For example, if a worker is disadvantaged in a global production process, where can she or he find the political voice to change the situation? These questions intersect with the distributional issues, since it is the global ownership of capital that creates the production process, but perhaps global

communications through the Internet that gives the worker a chance at mobilizing broader support.

As these examples begin to illustrate, a second question is also generated from the simple definition: Inequality between whom? ResIST has not confined itself to one dimension of inequality, but attempts to illuminate the interactions among them. A dominant theme in the project is inequality between nations, commonly expressed by economists in terms of differences in GDP (Gross Domestic Product) per capita. Narrowing these differences is seen as the central problem of development economics, although this economically-focused concept competes in the development community with the broader human development concept we mentioned earlier. None of the ResIST work packages directly examines the factors that allow science and technology to contribute to economic growth, although the issue stands in the background of all the studies. This is particularly true for Work Package Two, which includes questions about national advantage and disadvantage.

Several of the work packages, however, examine inequality within countries. The participatory case studies of Work Package Three consider the dynamics of distribution within countries, by examining processes of choice involving local or national governments. Furthermore, the framework that Work Package Four is developing is intended to help policymakers understand how new technologies will interact with their local conditions to increase or decrease inequalities in both wealth and well-being dimensions within countries. The development community usually refers to the unequal distribution of incomes or wages as "vertical inequality," then uses the term "horizontal inequalities" to refer to differences by culturally-defined categories such as gender, ethnicity, religion, or region. Both vertical and horizontal inequalities will appear in the ResIST studies, characterizing a variety of contexts.

The term poverty brings to mind the kinds of unacceptable human conditions we called up in our introductory paragraph. As a technical term, however, poverty refers more dispassionately to the low end of the vertical income distribution. At the national level, poverty is often defined in relative terms; for example, the poverty level in the U.S. is … The global development community, however, most often addresses two measures of absolute poverty: people living on less than $1 per day, and those living on less than $2 per day. These are such low levels of cash income that we can assume that severe deprivations of others sorts follow, such as malnutrition and lack of access to clean water. Absolute poverty in this sense is very much a phenomenon of the developing world.

Eliminating global poverty at these absolute levels is an important international goal. Cutting the number of people living in poverty by half is the first of the United Nations' Millennium Development Goals, a list that also includes other objectives that focus on the conditions that accompany absolute poverty. Some of those goals call for contributions from science and technology. It is easy to picture reducing or eliminating poverty as the main route to reducing world inequality; but as worthy as the goal is, this conclusion does not follow. The unequal distribution of either wealth or well-being can increase even while absolute poverty is decreasing, as the experience of China has shown. ResIST will of course consider poverty-reducing, or for short "pro-poor," S&T policies in some of its work packages, in particular Work Package Four.

But the project will also include inequality itself in its scope and call attention to growing gaps in wealth, well-being, power, or capacity, where they appear in our analysis. Following Cozzens, Gatchair, and Thakur (2006), we will refer to policies that decrease vertical inequality as "equalizing" and those that decrease horizontal inequalities as "egalitarian." These join "pro-poor" policies in the set of policy options for reducing inequalities through science and technology, a set we refer to as "re-distributional."

Policies/ public interventions [22]

We have so far referred to "science and technology policies" rather generally in this paper, but it will be helpful as the project moves forward to define more carefully the scope of this policy area. For analytic purposes, we distinguish four main types of science and technology policies: innovation, research, human resource, and regulatory. In practice, the four angles are often intermingled in the same program or policy instrument, and of course their results interact strongly. It is possible to put most S&T policies and programs into one dominant type.

Innovation policies stimulate the introduction of new products and processes. They are usually aimed at the private sector, but in principle could be aimed at public sector or community innovation as well – both important possibilities when we want to consider broader concepts of innovation and look for re-distributional policy options. Common forms of innovation policies and programs are:

- Programs that require university-industry interaction, for example, Engineering Research Centers in the United States.
- Joint research programs aimed at moving particular technologies forward more quickly, for example, BRITE and EURAM in Europe.
- Policies that encourage invention, such as patent systems themselves and the policies that allow universities to own patents on their publicly-funded research results.
- Research and development tax credits.
- Science parks and other incubator programs to provide business help and infrastructure for high-technology start-up firms.
- Extension services that provide technical help to small businesses.

Since the 1990s, innovation policies have been designed and evaluated in relation to the concept of an innovation system, which can be national, regional, or sectoral. At the core of the innovation system are firms, which are engaged in learning and competence building for the sake of maintaining competitive edge in the marketplace for the goods or services they produce. (Competitiveness, the goal of innovation policy we discussed in an earlier section, refers to this ability to compete with other firms for market share.) The main other organizational actors in the innovation system are

[22] [Editor's note: input text from SC and TSP on policy dimensions overlap to a high degree; here, and so far, the text of SC has been used.]

government, which sets the "institutional context" or ground rules for business competition and innovative activity, and research institutions, which at their best provide ideas and trained people who help in the innovation process. The key to the vitality of the process is how these organizations interact, since innovation is seen as the process of combining ideas into something new.

The broader view of innovation we have argued for in this paper calls attention to other actors in the firm-centered innovation system, including worker-innovators with a direct view of the production process, and user-innovators. The latter have been receiving increasing attention recently. Less firm-centered innovation systems also exist, for example, community-based innovations or innovation in the public sector; but they are seldom studied, even by those who use broad definitions of innovation. While firm-centered innovation must be evaluated by whether it produces a profit, community-based or public-sector innovations can be evaluated in terms of the increased well-being they produce, a concept called "social productivity." Innovation systems that increase social productivity will be a special focus of ResIST. Almost nothing is known about the policies and programs that would encourage such innovation, so we expect to contribute significantly to this body of knowledge and practice.

Research policies stimulate the production of new formal knowledge. Typical research policies and programs include

- Funding for university research, whether it comes through the university's base of public support, through research council grants programs (e.g., the research programs of the South African National Research Foundation), or through sectoral project funding (e.g., from the U.S. Department of Energy for research on renewable energy sources)
- Support and management of government laboratories, such as the Councils for Scientific and Industrial Research in India and Australia, or the Centre National de la Recherche Scientifique (CNRS) in France.
- Strategic research programs, which provide funding for a specific theme, like the Citizens and Governance Programme under the European Union's Sixth Framework Programme – the source of support for ResIST research.
- Industry funding for research at either universities or government laboratories, with research in this case distinguished from product development by having knowledge as its result, rather than a prototype or product.
- Regulation of human subjects and laboratory safety, as well as national security concerns.

The key actors in research policy have been hinted in the preceding list. They include universities, research laboratories, and funding agencies in particular. While private industry likes to see government invest in research so that new knowledge becomes publicly available, public decision makers are the dominant force in research policy. This policy area is therefore permeable to the influence of civil society, and there is often considerable open negotiation over the research agenda. Particular groups care about whether their problems are being studied. For example, the Women's Health Initiative in the United States was brought into existence by a feminist political coalition

(Cozzens 2004). Institutions that operate on a global scale can also enter the arena of decision making in research. First, the international research community itself is a significant actor shaping the agenda, through publications and professional meetings. A frequent concern in the global South is that this international research agenda is too dominated by the intellectual problems of the global North. In addition to the research community's own institutions, new coalitions are forming around global research priorities, like the Global Health Forum, a consortium of public and private research funders with an interest in refocusing health research onto the neglected diseases of poor countries. Some international foundations also focus on research; the Gates Foundation's efforts in HIV and malaria serve as a prominent recent example.

Human resource policies work to ensure adequate supply of trained personnel within their jurisdictions. Most of these are national, but the European Union has developed its own human resource strategies, as a later section of this paper describes. Typical policies and programs in this area include

- Recruitment programmes to interest under-represented groups in science and engineering careers
- Provision of vocational technical training, e.g., for technicians and skilled operators.
- Student support for tertiary training
- Fellowships for science and engineering degrees, either domestically or on international exchanges
- Programmes to build institutional capacity for research at new institutions, so that they can provide a higher quality research training experience.

The coalition of actors interested in this issue is quite broad, with industry often playing a key advocacy role. Government agencies with S&T responsibilities may play some specialized role in the efforts, such as providing targeted fellowships. But ultimately educational institutions must produce the training, so Ministries of Education are essential partners in countries with national-level university systems, or sub-national units in other places. The investment in human resource development that meets national needs starts very early in the educational process, so primary schools can be involved in efforts to strengthen science and mathematics education among young students. Informal science education (museums, news coverage, television shows, etc.) would also be included in this area, since it is aimed at increasing the capacity of the general public to absorb and appreciate science and engineering.

Human resource policies are the home of egalitarian efforts to open science and engineering careers to under-represented groups, including women everywhere and disadvantaged ethnic groups in many places. ResIST's Work Package Two will give some attention to these groups and their role in international mobility. Trying to achieve re-distributional goals solely by changing the science and engineering workforce is a project probably doomed to failure (because of the interactions between recruitment and the other types of inequality we are studying), and surely doomed to take a very long time. Nonetheless, the role of differentially-distributed expertise is likely to appear in many places in the ResIST case studies.

Regulatory policies, those that set the ground rules for new technologies, are an area of overlap between science and technology policy and arenas focused on other goals, such as health, labor, and environmental policy. In addition to setting the ground rules for new technologies, regulatory processes are generally quite S&T intensive, calling for high levels of expertise and often for dedicated bodies of research knowledge. Examples of such policies include

- Approval of new drugs and medical devices after checking for safety and efficacy
- Environmental pollution standards, geared to public health goals
- Safety standards in food products, automobiles, telecommunication devices, workplaces, etc.
- Regulation of public utilities, including setting rates to assure broad access to basic services

The key actors in these areas are regulatory agencies, civil society groups with a focus on the regulatory area, regulated industries, and relevant portions of the research community. In principle, some of these policies are not distributional and are instead intended to protect health and safety of all citizens equally, although unequal power and participation can make the results unequal nonetheless. Some, however, are explicitly re-distributional, such as setting utility prices in ways that do not negatively affect low-income households, or that make sure that utilities extend to rural communities that are more expensive to serve. Some safety issues can have economic consequences for developing countries, such as the controversy over the safety of genetically modified foods, which has affected the market decisions of developing countries that cannot afford to lose European markets.

Science and technology policies thus represent a diverse but organized set of mechanisms, including many possibilities for re-distribution. We now turn to a set of examples where those objectives are being sought, in the context of illustrating the different levels of policy where ResIST could contribute.

Section Two: Illustrations

These types of S&T policies can be utilized by bodies at various levels of the political system, from sub-national to multi-national. In this section of the paper, we give examples of distributional issues that arise in S&T policies at three of the most important decision-making levels: national, European, and global. The section illustrates both the complexity of the issues and the variety of possible responses.

National policies

Introduction

Taking into account the different conceptions of 'inequality/inequity' as well as of 'knowledge economy/policy', discussed previously, we focus next on the how these different approaches emerge within policy discourse at national level. Are these, sometimes contradictory, visions taken into account within national S&T strategies? Are such contradictions acknowledged and placed in 'productive tension' or are these concepts used in ways which 'hide' the tensions? We focus on a selection of national cases, distributed across the focus regions of the ResIST project (i.e. Europe, Africa and Latin America) and covering different typologies of countries within these regions. We assume that discourse is a central tool for policy-making (cf. Fischer, 2003) and analyse the extent to which different national S&T policy strategy documents (or other macro-level information on S&T policies). recognise the potential impact of policies on inequality, and how do they entail their potential impact on mitigating existing inequalities. Particular attention is given to two factors: on the one hand the overall policy strategy, and on the other hand the innovative inclusion of policies that have a clear impact, even if indirectly, on the different forms of inequality identified above. The effectiveness of policy is here attributed to its delivery through discourse, and to how this initial stage in the policy process can contribute to the strategies of other actors and to their awareness of existing inequalities and the need to address these.

Focusing on national contexts allows an analysis based primarily on 'within country inequalities', even if global issues also emerge. National governments are the primary actors with regard to inequalities within countries. They face the political and economic challenges posed by both horizontal and vertical inequalities, and have the broadest set of options for action. The examples below illustrate ways that these issues are being addressed in the countries represented on the ResIST team.

Portugal[23]

The Portuguese government has recently approved a 'Technological Plan' which aggregates a variety of measures expected to promote economic growth and social cohesion, based on knowledge, technology and innovation, focusing mostly on the exploitation of S&T for competitiveness.

This plan is primarily concerned with contributing for economic growth, being hailed as the central piece in the national growth strategy. Besides traditional instruments proposed, the following aspects can be highlighted in this debate. Although this plan does not have a specific action line on S&T and inequality/inclusion, it includes several actions which largely frame a vision of inequality around two main issues.

Firstly, there is a strong focus on reducing *structural inequality*. This is framed primarily at the international level, and made evident by the use of international comparisons with main S&T indicators. "Overcoming the scientific and technological lag" is one of the central messages in the plan, as in recent other national S&T strategy documents. A typical portfolio of instruments are assigned to this objective (mostly 'research policies and programs') but 'human resource policies and programs' are taken as particularly instrumental to this objective. Several activities are proposed in this area, but particular attention is given to the impact of these policies on the improvement of the education and advanced qualification levels, rather than on potential sectoral impacts, for example, therefore reflecting the centrality of *structural inequalities*.

Secondly, particular attention is given to issues of inclusion, in particular through *access* to the 'Information Society'. This can be considered a form of *distributional inequality* as the use of knowledge, which depends on access to it, is likely to have a positive impact on its users. ICTs are given particular importance through their appropriation not only by the economic dimension but also through social actors.

Inclusiveness is also considered beyond the 'information society'. In particular through the improvement of education levels, portrayed not only in international comparative terms but also as a form of improving inclusion within society.

An additional form of inclusion is focused on access to S&T knowledge and is implemented through Public Understanding of Science programmes. Rather than focusing here on issues of *representational inequality*, there is a focus on a deficit model (*structural inequality*) and, eventually, on the relevance of greater understanding of science for day-to-day activities (some *distributional* impact).

[23] This section is based on the analysis of PT (2005), *Plano Tecnológico: Uma estratégia de crescimento com base no Conhecimento, Tecnologia e Inovação. Documento de apresentação*. Lisboa: Conselho Consultivo do Plano Tecnológico do XVII Governo Constitucional Português (http://www.planotecnologico.pt/Docs_PT_DS/OPlanoTecnologico.pdf)

UK[24]

In the UK the concern with science, technology and inequality is clearly less explicit. As a leading country in research, its 'Science and Innovation Ten-year Investment Framework', presented in 2004, is primarily concerned with the impacts of science on economic performance and international competitiveness. With the emphasis on keywords such as 'excellence', 'dynamic research base', 'collaboration', 'confidence', the explicit concern is on the impact of the system on innovation, and concerns with impacts on inequality, exclusion, or poverty are rather less clear.

Issues of *structural inequality* in science are clearly not a major concern in leading research countries. Nevertheless, these tend to emerge often as a consequence of regional political pressures. A good example of this in the US is the 'pork barrell', whereby congressmen try to influence regional allocation of large investments, including those in research. To avoid these tactics, and privilege both regional concerns and competitive allocation of resources, the National Science Foundation in the US developed the EPSCoR Program (Experimental Program to Support Competitive Research) with one of its objectives being explicitly "to avoid undue concentration of [science and engineering] research and education". In the UK, possibly as a result of the strengthening of the devolution process, the main structural inequalities identified are at the regional level, and a greater role to address these 'gaps' is recognized to the local development agencies.

Other forms of inequality explicitly identified are concerned with "women and other low participatory groups". Rather than being explicitly concerned with the potential *distributional* impact of these asymmetries, the concern is mostly with the functioning of the system, of guaranteeing participation (and in that sense, *structural*), rather than with the outcomes of such structure. Concerns with outcomes of other forms of inequality appear more directly in relation to performance (such as in involving younger applicants in the Highly Skilled Migrant Programme; in differential treatments to high-tech, fast-growth businesses).

Indirect concerns with impacts on inequality are more clear in what regards medical research, and its potential impact in the NHS, where "equality of access to high quality care for the entire" is a major concern. Issues of *distributional inequality* appear to be mostly ascribed to the role of science and research across government, rather that to science and research itself. The primacy of the concerns with economic impact is also reflected here.

Representational inequality is an emerging concern. The lay public is treated increasingly at *a par* with scientists, with 'public understanding' giving place to 'public engagement', 'public confidence'. Nevertheless, the locus of this concern is somehow tilted towards the protection of those already traditionally represented ("improve the promotion of science in society", "improve public confidence in the Government's use of science"), rather than otherwise (e.g. improving the participation of society in science, or providing new mechanisms of accountability on the Government's use of science).

[24] This section is based on the analysis of HMT (2006), *Science & Innovation Investment Framework 2004-2014: Next Steps*. London: HM Treasury (http://www.hm-treasury.gov.uk/media/D2E/4B/bud06_science_332v1.pdf)

The British case is therefore a clear example where concerns with the impacts of science and technology on inequality are essentially expected to filter down from primary concerns with excellence and economic impact of science.

Brazil[25]

The Brazilian case is clearly at an opposite extreme of the British case. The Strategic Plan for S&T in Brazil identifies as an horizontal axis of action the strengthening the national system of research and innovation and identifies three additional vertical axes. These include one on promoting innovation following the Industrial, Technological and Foreign Trade Policy, one on developing strategic programmes central to the country's sovereignty and one explicitly dedicated to 'Science, Technology and Innovation for Social Development and Inclusion'.

While the concerns with the economic impact of S&T are naturally central, this strategy does not leave to market and social forces the work of externalising the impacts on inequality, but rather internalises these objectives. In addition, this has been reflected at the organizational level of the system, with the implementation of a new Junior Ministry of Science and Technology for Social Inclusion (SECIS), created with the mission of promoting social inclusion through actions that improve the quality of life and stimulate the creation of jobs and income.

The areas of activity of this strategic objective include actions directly oriented towards addressing inequality (in general terms) through S&T, such as through actions on 'social technologies', 'assistive technologies', 'popular cooperative incubators', or more traditional initiatives on 'local productive arrangements', 'technological vocational centres' or 'digital inclusion'. The concern with distributional impacts is also explicit on including as priorities within this objective 'research on basic sanitation', as well as 'research on health, food nutrition and food safety', or 'S&T in the Northeast and Semi-Arid', reflecting some local primary concerns of the population, and not simply an international research agenda.

Specific actions are also directed at specific under privileged groups of the population. For example, there is an action to promote social technologies for traditional communities, recognizing how these have historically been excluded from policies for economic and social improvement, making therefore clear the existence of *representational inequalities* being addressed.

[25] This section is based primarily on the analysis of MCT (2004), "*Plano estratégico do Ministério da Ciência e Tecnologia 2005-2007"*. Brasília: Ministério da Ciência e Tecnologia do Governo Federal Brasileiro (http://www.mct.gov.br)

Mozambique[26]

The first paragraphs of the 'Science and Technology Policy' document from Mozambique illustrate well that S&T do not have a fully dominant position within knowledge systems as in some of the other countries analysed here. The identification of science as one among other forms of knowledge, in the national S&T policy, is both a recognition of a weaker S&T base in world terms as well as the recognition of the importance of other knowledge systems in local society. At the same time, this document makes clear that, at the global level, S&T has emerged not only as the dominant knowledge system, but also as central to an increasingly interlinked global economic system. The implicit acknowledgement of *structural inequalities* as well as of *representational inequalities* is therefore made clear. It is not only the fact that there are less S&T resources in the country, but also that other strong knowledge systems are weakly represented in the global system.

Within this background, the challenge for Mozambique's S&T policy is clearly intertwined with inequalities. While it includes actions directed towards the strengthening of the existing research institutions, of the relationship of the research system with civil society and the productive sector, of the advanced education system, or of technological innovations, it also includes explicit actions directed to different forms of inequality. These include:

- promoting the expansion of research institutions throughout the territory;
- promoting the participation of women and youth in research;
- promoting research and the use of local knowledges;
- promoting the integration of local knowledges in the formal system of education;
- promoting innovation in the production and use of local knowledges;
- creating conditions for the diffusion in the media of local knowledges.

By giving such emphasis to the importance of local knowledges the emphasis on *distributional* issues is made clear. The impacts of S&T can only be appropriated if it is not in competition with other knowledge systems, but rather part of the same *ensemble* of knowledges.

Taking account of the variety of initiatives, issues of *representational inequality* are acknowledged by making clear the need to work with a wide variety of actors in the implementation of this policy.

Finally, it is also relevant to note that S&T is included as one of the central horizontal issues relevant to the 'Action Plan for the Reduction of Absolute Poverty 2006-2009' (PARPA II). This identification is alongside other elements with a significant technical

[26] This section is based on the analysis of Conselho de Ministros da República de Moçambique (2003), "Política de ciência e tecnologia e a sua estratégia de implementação." Resolução nº 23/2003 de 22 de Julho. *Boletim da República*, I Série – nº 31: 349-355; Conselho de Ministros (2006), *Plano de acção para a redução da pobreza absoluta 2006-2009. (PARPA II).* Maputo: Conselho de Ministros da República de Moçambique (https://www.govnet.gov.mz/docs_gov/programa/fo_parpa_2/PARPA_II_aprovado.pdf).

component, such as HIV/AIDS, Environment or Food and Nutritional Safety, and the particular importance given to ICTs in this respect. The concern of the relationship between S&T and inequality is clear. It is not only driven from within the system, but it is drew upon to address specific social outcomes.

South Africa[27]

The South African research system underwent significant changes following the demise of the apartheid era. While specific sectors, such as the nuclear and defense industries, were targeted, there were wider impacts in the research system. After an initial phase when innovation took central ground, recently five key technology missions were identified. These are information technology, biotechnology, manufacturing technology, technologies to add value to natural resources and technologies to impact upon poverty reduction.

Also here distributional inequalities are of central concern within the national S&T policy. In particular, the strategic mission of impact upon poverty reduction has been identified as having "achieved some notable successes, particularly in the area of essential oil production, and new programmes in aquaculture show[ing] great promise" (DST, 2006: 2). Nevertheless, the application of 'social technologies' has had some drawbacks, partly resulting from higher expectations. The objective of developing "technologies to reduce the cost of housing, to enable low cost communication […] or practical sanitation" have not followed plans, and higher levels of funding are expected.

But in other areas the concerns with different forms of inequality also emerge. For example, in international partnerships, and following years of political isolation, the focus on themes interesting both parties is considered key. Examples given include the European Developing Countries Clinical Trials Partnership, for drugs targeting locally endemic diseases such as malaria, tuberculosis and HIV and AIDS.

Also at the level of human resource policies, particular concern is given to existing inequalities in access. A clear focus is to increase the number of women and people from previously disadvantaged communities entering the sciences and remaining in the system, while maintaining a strategy to maximise the pursuit of excellence in global terms.

While these objectives are being here highlighted other typical instruments of S&T policy are being implemented, focused on scientific excellence and economic impact, but the salience of the social impact initiatives, when compared to other countries is worth highlighting.

An additional feature worth highlighting in this analysis is also the concern with local knowledges (here framed as 'indigenous knowledges'). The development of an Indigenous Knowledge Systems (IKS) policy was led precisely by the Ministry of

[27] This section is based on the analysis of DST (2006), *Corporate Strategy 2005/6-2008/9.* Pretoria: Department of Science and Technology of the Republic of South Africa (http://www.dst.gov.za/publications/reports/corp_strategy.pdf); DST (2004), *Indigenous Knowledge System*. Pretoria: Department of Science and Technology of the Republic of South Africa (http://www.dst.gov.za/publications/reports/IKS_Policy%20PDF.pdf).

Science and Technology and adopted in November 2004. Besides the relevance of an inclusive approach to knowledge from the Ministry of Science and Technology, this policy is also particularly relevant as it links IKS directly with the S&T system. It does not limit itself to stating the need for the recognition of IKS. It includes a broad perspective on IKS in almost full parallel with general S&T policy concerns. For example it includes discussions of the IKS in the National System of Innovation of South Africa, a discussion of the role of research institutions within IKS, IPR issues, as well as an IKS information and research infrastructure. Furthermore, it clearly considers that "IKS development is a unique opportunity to recognise and redress inequities created by past policies in South Africa."

Regional policies: the European Union

Development of the European Research Area

European policy is unique in its strong supra-national decision making, at least in selected policy areas. Research, innovation, and S&T human resource policy are among those areas. EU S&T programs and policies fall under the general effort to build a European Research Area, a cooperative European-level focus to complement national S&T policies. The goal of the ERA is to make Europe more internationally competitive in research by reinforcing the highest standards. Among the ERA's goals are several re-distributive elements. The ERA seeks to give more prominence to the place and role of women in research. It also seeks greater European cohesion in research based on the best experiences of knowledge transfer at regional and local levels, and to bring together the scientific communities, companies, and researchers of Western and Eastern Europe. All these elements address horizontal inequalities within the European Union. Conspicuously missing in documents on the ERA is any mention of reducing the horizontal inequalities of Europe's growing disadvantaged ethnic minorities; this set of issues has not yet appeared prominently in STI policy discussions.

Initial structural inequalities create some of the challenges of reinforcing social cohesion through STI policies. The EU member states invest in research and development at very different rates, and while some established members are rapidly increasing their investments, some are experiencing declines (OECD Eurostat 2003-04). The top 15 research-intensive regions appear in five Northern European countries, and the EU's clustering policy is likely to reinforce the concentration of resources further.

The concentration of resources in turn has implications for where highly-educated scientists and engineers want to work. The distribution of R&D workers in the ERA is already heavily skewed; in 2003 54% of R&D personnel in the EU-25 were concentrated in Germany, France and the UK.[28] Mobility is central to the ERA strategy in two respects: first, increasing the *volume* of human capital through policies to retain researchers in and attract researchers into the ERA from other countries and, second, shaping the *distribution* of this human capital within the boundaries of the ERA. In many respects these two goals are linked as the development of research concentration and the emergence of specifically European Centres of Excellence play a critical role in maintaining the attractiveness of Europe to those scientists already located within the

[28] Gotzfried, A. (2005) 'Science, Technology and Innovation in Europe', Statistics in Focus, August 2005

ERA and acts as a magnet to those from outside. To support excellence, European researchers are expected to move to the places where excellence is strongest.

The expectation of mobility, however, can place the EU's ambitions for excellence in conflict with its re-distributional objectives. On the one hand, disadvantaged regions that are trying to develop their S&T capacity will not be helped by having their best and brightest move to the European centers of excellence. On the other, this goal may undermine efforts to bring women into science. European funds are distributed on the basis of scientific merit, but quotas have been set for the participation of women in projects. This requirement has been mainstreamed into the application process in even stronger ways than the earlier funds and initiatives for inclusion of less developed regions. Yet one of the reasons that women leave science is that they often do not want to be mobile, so meeting one goal may create challenges for the other.

There is also a strong tension between individual rights as these have been articulated in the European context and the broader objective of mobility. The broader ERA perspective promotes market liberalization, unfettered individual competition and mobility as the vehicles for the achievement of these goals. The 'free market' is the means by which to recruit and retain the 'brightest and the best' and to 'match' skills and resources optimizing scientific potential. Individual decision-making and the 'matching process' associated with it is central to the European Commission's commitment to meritocratic recruitment, competition and excellence and mobility, an important ' instrument for the transfer of scientific knowledge.' Mobility plays a critical role in the ERA strategy in terms of;

- Raising the scientific excellence of *individual researchers* and furthering the creation of internationally renowned centres of excellence attractive to researchers from all over the world
- Improving the quantity and quality of research training, by offering the best available opportunities *regardless of where this expertise is situated.* [29]

The wording of this text underlines the emphasis on individualism in the ERA; the whole thrust is to identify 'excellent' individuals and facilitate their mobility in order to maximize their scientific productivity.

The rationale for the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers[30] is also spelled out in clear economic terms as contributing to the Lisbon objectives of increasing the numbers of researchers in the EU through retention and increasing the attractiveness of the EU to researchers from abroad. In addition to its emphasis on mobility and the institutional integration of researchers, the code focuses on improving approaches to the recruitment, selection and evaluation of individual researchers encouraging greater transparency, openness and equality.

The Council Decision setting out the objectives of the European Commission's flagship mobility scheme (the Marie Curie Fellowship Scheme) places similar emphasis on the need 'to develop the Community's human research potential, making special

[29] The Communication, 'A Mobility Strategy for the European Research Area' COM (2001) 331, June 2001, para 2.
[30] Commission of the European Communities 11.3.2005 C(2005) 576, para 2.

efforts to ensure equality of access and a better balance between men and women.'[31] Equality of access, in this context, is not 'justified' on social or ethical grounds as such but rather as a means of overcoming the counterproductive 'underuse of the potential of female scientists'.[32] Although the emphasis here is on the leakage of women from science and the loss of potential this implies, the same argument could be made in relation to scientists working in countries with few opportunities for scientific research who are de-skilled, forced to take up other forms of work instead of or in addition to research or unemployed.

The careful fusion of economic and social goals reflected in recent ERA policy with social objectives essentially underpinning the competitive ethos is perhaps symptomatic of a new approach to the European Social Model. Rather than being presented as some kind of moral imperative with high social costs and potentially draining effects on competitiveness, equality objectives are now tield closely to the latter.

The language and approach adopted in many of the ERA policy instruments and the Researchers' Charter and the Marie Curie Fellowship Scheme illustrate what Barnard et al (2001)[33] refer to as the 'dynamic tension' that exists between the development of social rights and economic integration. For them, the year 2000 'saw an ever greater stress on the economic dimensions of social policy and in particular its links to the 'knowledge economy.' As evidence of this 'dynamic tension,' Barnard et al identify the emergence of a 'new conceptual language' linking social and economic objectives. In particular, they refer to the use of the concept of 'capabilities' in the *Supiot Report* which 'opened up a new front in the argument over the role of social policy'.[34] They explain the concept of capabilities as follows:

> *'The relevance of the concept of capabilities for the knowledge economy lies in the idea that mobilizing the economic potential of individuals is not simply a process of providing them with the necessary financial resources to exploit their endowments. Rather the institutional framework of the market has to be examined in order to establish how far it facilitates or constrains the potential of individuals to achieve their desired economic functionings.'* (p.468)

Viewed in this light, European social policy plays a critical role in supporting economic progress and ensuring optimal productivity or as the authors put it, 'European social law and policy can now be firmly regarded as a 'productive factor' which aids competition rather than hindering it (Barnard et al, 2001, p.476). In this context, the promotion of equality and quality (through competition) go hand-in-hand. Although Barnard et al's paper goes on to consider the value of this concept in the context of

[31] Excerpt from the Council Decision adopting the specific programe for research, ' Improving the human research potential and the socio-economic knowledge base (1998-2002).

[32] Add bit about differential opportunity here – the requirement of mobility generates its own inequalities as migrants are not 'individuals' as such but social actors. Raghuram (2003) refers to the neglect, in the brain drain literature, of attention to family and gender where the unit of analysis is 'inherently individualised'. Our research suggests that the ability to respond to these opportunities may be differential reflecting family status, life-course and gender dynamics (Ackers, 2001:2003).

[33] Catherine Barnard, Simon Deakin, Richard Hobbs, 'Capabilities and rights: An emerging agenda for social policy?', Industrial Relations Journal, 32 (5) pp 464-479

[34] Supiot, A. (ed) (2001) Beyond Employment. Changes in work and the future of labour law in Europe, Oxford: Oxford University Press.

employment law in general (and situations of maternity leave for example), it offers considerable potential in the current context in terms of understanding the 'balancing of equalities' within the ERA agenda.

Policy Tensions: Individual Equity versus Balanced Growth

The Lisbon objectives (cited above) refer explicitly to the idea of 'sustainable economic growth'. What is unclear, however, is the unit of analysis. If one takes the whole of the ERA as the appropriate level of analysis then one might argue, as many scientists indeed concur, that intra-EU mobility is effectively no different to internal mobility within an individual Member State.[35] On the other hand, if the aggregate effect of individual career and migration decisions, fuelled by policy and resource allocation decisions within the ERA, leads to serious imbalances in flows and significant losses to less developed countries then one might question the compatibility of free market economics with sustainability at Member State level.

The European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers36 explicitly recognizes these inherent policy tensions both in terms of researchers coming into the ERA from third countries and imbalances within the ERA:

*The development of a consistent career and **mobility policy** for researchers to and from the EU should be considered with regard to the situation in developing countries and regions within and outside Europe, so that building capacities within the EU does not occur at the expense of less developed countries or regions. (para 13)*

The Marie Curie Fellowship Programme is also responsive to the existence of these 'imbalances' and has developed a series of measures with the objective of, 'promoting scientific and technological cohesion of the Community, particularly with respect to its less favoured regions.'[37]

More recently, and following specific concerns around the impact of scientific mobility on capacity-building in developing countires (outside of the EU), the European Commission issued an 'EU Strategy for Action on the Crisis in Human Resources for Health in Developing Countries.'[38] Perhaps because of its specific focus on developing third countries outside of the ERA, the document identifies more clearly the 'risks' of highly skilled migration. The symbolic importance of being able to remain within 'ones own country' is rarely if ever seen in debates about EU Member States;

'The long term manageability of international migration hinges on making the option to remain in one's own country a viable one for all people. Sustainable economic

[35] Of course scientific investment and mobility within existing Member States is also highly contentious. The policy of augmenting already resource-rich 'golden triangle' of Oxford/Cambridge/London in the UK is severely criticized as reinforcing territorial injustice and regional inequalities within the UK (Millard 2005)

[36] Commission of the European Communities 11.3.2005 C(2005) 576.

[37] These include a return grant scheme supporting fellows from designated 'less favoured regions' to return. In practice, however, flows within the scheme remain highly skewed in favour of the research rich regions including the UK and Germany

[38]Communication to the Council and the European Parliament 'EU Strategy for Action on the Crisis in Human Resources for Health in Developing Countries' (COM(2005) 642 final dated Brussels 12.12.2005)

growth and equity and development strategies consistent with this aim are a necessary means to that end' (p5)

One of the development strategies under consideration, and building on policies developed in some countires (such as the UK for example) is the potential value of codes of practice governing 'ethical recruitment' which attempt to restrict specific recruitment initiatives in designated areas. The document explicitly recognizes the potential tension that such measures pose in terms of reconciling sustainability with individual equity:

'Regulation as a tool to limit migration, tends to increase the cost of migration to the individual and may be perceived as discriminatory' (p6)

The converse argument, that measures to lubricate mobility within the ERA might pose a risk to sustainable development is rarely expressed reflecting the importance attached to the principle of non-discrimination in European and international law.

Sustainable Development and Balanced Growth

We have already referred to the emphasis placed upon the identification and development of Centres of Excellence that lies at the heart of European R&D policy (mirroring that of most Member States) and to the role that mobility plays in 'matching' quality human resources with quality infrastructures. Mobility is the logical corollary of 'clustering' and the redistribution of human capital to support research infrastructures. How does this highly competitive form of capacity-building, which effectively augments existing resource-rich institutions and regions, sit alongside a commitment to building new capacity and maintaining sustainable R&D in less research intensive regions?

It could be argued that imbalanced flows of human capital, within the ERA, as a result of aggregate individual behaviour should not in themselves be interpreted as damaging provided that losses to the EU are contained or managed and European science, as a whole, is benefiting (and becoming more competitive in the process).

If one takes the view that the meaningful unit of analysis from an economic and political standpoint is the European Union as a whole and not individual Member States as such then imbalanced intra-EU flows, although not unproblematic, might be seen to benefit European science in general. Ultimately the benefits attached to this might 'trickle down' to the constituent sending regions.

Supporting Balanced Growth in the Context of EU Enlargement

EU enlargement creates a new dynamic in terms of migration flows within the ERA. The Communication, 'A Mobility Strategy for the European Research Area' acknowledges the 'regional dimension to mobility' in the context of EU enlargement. In particular, in designing its mobility strategy for researchers, the Communication seeks to promote forms of 'inter-regional mobility in order to avoid a brain drain from less developed regions'[39].

A recent report refers to 'the insufficient link between policies promoting balanced regional development and policies promoting geographic and occupational mobility'

[39] COM (2001) 331, June 2001, para 1.

(CEC 2002a p.3). The ERA strategy acknowledges the need to protect candidate countries from the consequences of 'increased competition for highly qualified researchers' (CEC, 2001d, p.6). It concludes that, 'special attention should be paid to prevent new forms of 'brain drain' from countries with less developed research capacity' through the introduction of new funding mechanisms designed to support a 'symbiotic collaboration' enabling them to build up their own research capacity.40

To conclude, we see a fundamental and pervasive tension in the European Research Area strategy between the pursuit of two different dimensions of equality, namely individual equity (and the individual human right not to be discriminated against on grounds of nationality) and sustainable development within the European Union (sometimes referred to as 'balanced growth'). Although they are often not expressed as such, concerns around 'brain drain' within the ERA – and policy responses to it - need to be understood as facets of this wider debate. Does EU enlargement and the logic of individual freedom (to physically move in response to scientific and other opportunities) necessarily imply a relatively permanent loss of knowledge to the sending country? Equally, does limited out-migration, imply retention and efficient use of capacity in those regions?

Global institutions and issues

A wide range of institutions with stakes in science, technology, and inequalities are operating at the global level. Some are inter-national entities, that is, multi-lateral arrangements among nation states to set the ground rules for security, trade, and finance. Some are part of global civil society, ranging from huge private foundations to groups organized by citizens to address issues that stretch across national boundaries. Each type shapes the global distribution of S&T resources and opportunities in its own way. In this section we give examples of how issues of science, technology, and inequalities arise in each of these two types.

Trade-relating intellectual property protection – from WIPO to WTO and back

Issues of IPR protection issues have within a time-span of just a couple of decades been transformed from a specialist, arcane issue of industry policy and law, into a highly contentious and strongly debated issue of innovation, industry and global trade policy. As knowledge has become an immediate economic resource, it has become a pressing issue to create effective and appropriate political and legal conditions for dealing with knowledge as such an immediate economic entity. Developments within the IPR domain have generally gone in the direction of stronger protection of the rights of "owners" of knowledge, thus contributing to a general shift towards the commodification of knowledge, as a prerequisite for ensuring the stronger private appropriability of knowledge qua economic resource. Thus, we have seen a fast change in IPR regimes, where a large number of separate changes in various domains have converged towards

[40] Specific Marie Curie Actions include new Host Fellowships for the Transfer of Knowledge (TOK) designed to encourage transfer of knowledge into less favoured regions. A compulsory return phase attached to out-going international fellowships encourages return as do 're-integration grants'.

what James Boyle has called a "maximalist" rights regime [41]. All major changes have contributed to the general extension and strengthening of the interests of right holders. These changes include the emergence of relaxed standards of patentability, in particular as concerns the criteria of inventive step and industrial use. The domain of patentable subject matter has been extended to include living entities, software programs, business methods and research tools. The protection period has been extended, and rights are more strongly enforced. Developments in the US have led the way forward. [42] Key stages of which have been the Bayh Dole Act and related Acts, the establishment of a more "patent holder friendly" federal court, CAFC, the US Supreme Court decision in the US vs Chakrabarty case, according to which "all subject matter made by man" may be patented. European Unions has followed suit, through new, highly controversial directives on the protection of IPR rights to biological inventions, software and databases, all contributing to the making of a stronger and more uniform IPR protection regime, seen to create as conducive conditions for performing knowledge-based innovation and business in Europe as in the US.

The shift towards stronger protection of IPR is both a sign of and an essential instrument for the transition towards the knowledge economy; stronger IPR protection has been instrumental in transforming an ever-increasing number of forms of knowledge into privately appropriable economic commodities and assets. Thus, extending IPR protection has become a main response to the "market failure" issues created by the non-rival nature of public knowledge, as private actors are now expected to take on a larger part of funding of research and innovation. In transforming knowledge more extensively into commodities whose economic value may be more fully appropriated in the market, R&D and innovation has become more strongly market driven. Strong IPR protection has become a key incentive to increase the role and proportion of private R&D, of market driven innovation and commercially motivated knowledge production. Extending the rights of IPR holders thus forms an essential stimulant to private investments in research and innovation, and public institutions such as universities have i.a. through the extended patentability of applicable research results and research tools redefined themselves as ("entrepreneurial") economic actors themselves. IPR indicators, such as patents and designs, have become a key indicator of economies' progress towards and competitiveness in the knowledge economy, where 'intangible' economic assets are becoming more important for the valuation of companies than physical stock.

Sustaining the emergence of the new "maximalist" IPR regime [43], characterised by the ever-increasing protection of IPR, has been an assumption that what is good for the innovating, knowledge/R&D-intensive firm is also, eo ipso, good for the economy and society in toto. While this maximalist trend in the IPR policy domain has been and still is dominant , however, become increasingly contested in a number of policy arenas. The extension of patentable subject matter, e.g. human genes, obfuscates the essential

[41] Boyle, James (2004) A manifesto on WIPO and the future of intellectual property.

[42] Coriat, B & F Orsi (2002) Establishing a new intellectual property rights regime in the Uniteds States. Origins, content and problems, *Research Policy* 31 (2002) 1491-1507

[43] Boyle James (2002) Fencing off ideas: enclosure & the disappearance of the public domain, *Daedalus,* Vol 131, Issue, 13(13)

discovery/invention distinction, and violates encroaches on human dignity. The "enclosure of the knowledge commons" may erode the essential role of the public domain and hinder rather than stimulate innovation [44]. The strong protection of competitive advantages of the already highly developed companies and nations will deprive developing nations of an essential policy instrument, i.e., the adaptation of IPR policy to their specific needs and circumstances, for entering the global knowledge economy.

The TRIPS agreement marks the end of a process initiated by the US by which issues of IPR protection had become more strongly connected to trade agreements. [45] The process originated within the US Generalized System of Preferences (GSP), under which designated beneficiary developing countries were allowed duty-free export of specific products into the US. The amendment of Section 301 of Trade and Tariff Act of 1984 gave the President authority to initiate trade sanctions against countries not seen to comply with the high standards of IPR protection which the US saw as a precondition for benefiting from GSF agreements.

A next step in the process and strategy of trade-relating IPR protection, was to bring these issues into the multilateral trade agenda, as part of the agenda of the Uruguay Round of GATT. Before this linking of international trade agreements and IPR issues took place in the Uruguay Round, multilateral negotiation on intellectual property had taken place within the World Intellectual Property Organization (WIPO) and its forerunners. Working through the WIPO to achieve higher of more harmonised IPR protection was, however, not seen as an option, as it was seen to take a permissive stance on rule diversity and to lack effective enforcement mechanisms. Trade-relating IPR issues by bringing them into the Uruguay Round of the GATT negotiations had many strategic and tactical advantages, including the possibility for high-tech industries in developed countries to trade stronger IPR protection for developing countries' access to agricultural markets of developed countries. In addition, enforcement mechanisms were available and could be effectively applied within the GATT/WTO context.

The immediate effect of TRIPS for developing countries was the eventual removal of an important basis for previous industry policies in important industries, particularly in the pharmaceutical industry, where Brazil and India had built up an extensive production of generics based upon national patent laws which exclude the patentability of pharmaceuticals. Given that acquiring technological capacity through copying, imitation and reverse engineering is an essential part of catching up strategies, TRIPS would place limitations, including higher licensing costs, on the use of that strategy.

Thus, TRIPS may be seen to offer few advantages to developing countries in terms of IPR; it was a trade-off where overall loss in IPR would be traded in for gains in trade, in particular export of agricultural products. It was also seen as an advantage that negotiations over intellectual property would be moved from bilateral to multilateral

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[44] Heller M & R. Eisenberg (1998) Can patent deter innovation? The anticommons in biomedical research, *Science*, Vol 280, 1 May 1998, 698-701

[45] Drahos, Peter with John Braithwaite (2002) *Information Feudalism. Who Owns the Knowledge Economy?* Earthscan: London.

trade negotiations. However, TRIPS has not led to the removal of IPR from bilateral and regional trade agreements. These bilateral agreements have been retained as a channel to enforce higher, "TRIPS Plus" standards of IPR protection, alongside and over those of the TRIPS itself.

Key IPR issues in the Doha Round have pertained to the relationship between the Biodioversity Convention and TRIPS. This concerns issues of "biopiracy", by which the "piracy" and "theft" discourse discourse that have been extensively used to drive the maximalist agenda have been turned around to apply to the IP right holders of developed countries. Issues concerning the compatibility between the TRIPS and the Biodiversity Convention, which regulates conditions of "access and benefit-sharing" between patent holders and providers, have been part of the Doha Round as a number of large, developing countries, including India, Brazil and China have pushed for a change in TRIPS to make it mandatory to include closure of origin of genetic resources in patent application. The Biodiversity Convention states the principle of national sovereignty of genetic resources, and the rights of origin countries to s fair share of the benefits of inventions based on biological resources. A closely related issue is work on the role of traditional knowledge in relation to IPR issues.

It seems, however, that multilateral IPR issues are now shifting back to the WIPO. Here, the WIPO 'patent agenda' is the basis for taking new steps beyond TRIPs towards the world-wide harmonisation of both substantive and procedural IPR regulation. This is, according to some, a process for developing harmonised TRIPS Plus standards, and even indicate the – still distant – possibility of the universal 'world patent'. At the same time, pressure has mounted for WIPO's adoption of an explicit "development agenda", by which the WIPO would, as a UN agency, become more committed to development goals. This agenda is sustained by the assumption that a "one size fits all" approach to global IPR protection, as may be seen to sustain the WIPO "patent agenda", is inappropriate from a development point of view: "The role of intellectual property is and its impact on development must be carefully assessed on a case-by-case basis. IP protection is a policy instrument the operation of which may, in actual practice, produce benefits as well as costs, which may vary in accordance with a country's level of development. Action is therefore needed to ensure, in all countries, that the costs do not outweigh the benefits of IP protection". [46]

International financial institutions

The role of international financial institutions in S&T for development and the rationales for their policies and programmes have undergone significant changes in recent years due to a number of factors, relating to shifts in policy thinking, the introduction of more strategic policy approaches as well as new understandings and partnerships. Policy learning in the form of open, healthy criticism, self-review and evaluation processes are also generating significant policy impacts. A major shift has occurred in their focus of activity from initial sole focus on economic development to also address more directly poverty alleviation and reduction in recognition of the fact that prior investments in infrastructure and physical assets, macro-economic and financial frameworks and foreign

[46] Proposal by Argentina and Brazil for the establishment of a development agenda for WIPO, WO/GA/31/11, 17. Aug. 2004,

exchange resources need to be complemented by more human-oriented and community-based development. These approaches were recently enshrined in the Millennium Development Goals and their primary emphasis on human and social dimensions.

The shift from R&D to Innovation policy approaches outlined earlier in this paper has impacted on the changing rationales of S&T for development reflected in the currently emerging role of international financial institutions and their S&T aid programme design. This has been complemented by the gradual replacement of old linear approaches by more systemic, integrated approaches to innovation. In the case of the World Bank, in particular, this policy transition process has been in response to various criticisms over the years of its one-size-fits-all policy approach based primarily on experiences garnered from developed country, without giving due attention to the particular policy context of the country in question. The assumption that S&T would inevitably provide the means for developing countries to break out of the vicious cycle of debt and poverty, highlights the fact that S&T for development challenges relate not only to limited resources but also to wrong approaches projecting S&T as "instant cures for deep-rooted economic and social problems" (Bezanson and Oldham,[47]). Key concern remains the limited exploration of alternative, more knowledge-based and sustainable approaches working in synergy with local culture, values, socio-economic patterns and ways of life.

S&T continues to occupy only a small part of the agenda of international institutions largely as a result of a legacy of past fragmented approaches, lack of strategic vision and limited investments. This is evident in the World Bank's lack of a consistent S&T capacity-building strategy except in the area of agricultural research and the fact that only 1 in 50 projects focused on improving S&T or had a significant S&T capacity-building component (Review48 of World Bank Lending for Science and Technology (1980-2004)). However, more recently there is evidence of a growing, enhanced role for S&T, with growing investments in S&T as a development objective per se as commitments to scientific understanding are perceived as critical to sustainable development.

A key driver of change in the approach and behaviour of international institutions in stimulating the use of S&T for development has been the use of reviews and evaluations of programme impacts and results. Based on learning from evaluations of its policies, the World Bank has invested more in community approaches and this has been reflected in the increased level of Bank lending from 5% to 25% [49]. Addressing concerns over corruption and poor use and distribution of resources, the Bank's Support for Community-based and driven development, responds to the need for communities to be empowered and directly involved in their own development and provides the "means for directly channelling assistance to the poor". Projects aim to improve the capacity for managing the environment better at community level or to improve the quality of life of rural communities. An evaluation of the scheme [50] has highlighted a number of positive

[47] Bezanson, K. And Oldham, G. (2005) Rethinking science aid (SciDevNet 10 January 2005)
[48] http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079975330/Review_WB_lending_ST_80-04.pdf
[49]Ms. Nalini Kumar, Task Manager for the Evaluation of the Effectiveness of the World Bank's Assistance for Community-Based and -Driven Development, Independent Evaluation Group, The World Bank http://www.worldbank.org/ieg/conference/human_social/docs/cbd_cdd_presentation.pdf
[50] http://www.worldbank.org/ieg/cbdcdd/

effects including a prime focus on the community's priority needs, and empowerment of the community and disadvantaged groups, together with access to service delivery on the part of remote communities. The challenges relate to reaching the poorest, sustaining infrastructure and services, shifting costs of service delivery infrastructure which may affect equity, and implementation arrangements hindering long-run enhancement of local government capacity.

A second driver of change in the behaviour of international financial institutions is the growing number of partnerships developing between international institutions which have lead to the common emergence of a more human and social face to development with an emphasis on poverty reduction as a major strategic goal complemented by efforts to reduce gender and ethnic inequalities in line with Millennium Development Goals.

In recent years, there is a growing awareness in international institutions of the fact that gender inequalities undermine the effective implementation of development policies and strategies and that they therefore need to be integrated into coherent policy approaches. Apart from evidence that gender affects development and growth, the World Development Report: Attacking Poverty (2000-1) highlights the fact that gender relations impact on all aspects of poverty, including income, opportunity, security, and empowerment. The inextricable relationship between gender inequalities and poverty reduction has been recognised, evidenced by the greater incidence of gender inequalities among the poor. Negative gender discrimination affects societies' ability to develop and reduce poverty (World Bank report 2001), whilst positive discrimination enhances the human resource /knowledge pool and creativity, as well as productivity and growth (Huyer and Mitter[51], ref missing).

However, the triple role of women in national and local STI-based development, namely productive, reproductive and community, has yet to be fully recognised and reflected holistically in the strategies and programmes of international institutions. For example, while gender equality and empowerment of women is an MDG goal, yet it is still only linked to social development (education, maternal mortality and HIV/AIDS) and the links to STI policies and economic and production strategies are not sufficiently emphasised. In terms of policy implications, this points to the need for the broader impacts of gender and ethnic inequalities on STI Policies and economic competitiveness to be made more explicit in the programmes and strategies of international institutions; more research and methodologically sound information for developing gender and ethnic-oriented STI policies; more integrated policy approaches and gender and ethnic mainstreaming.

[51] ICTs, Globalisation and Poverty Reduction: Gender Dimensions of the Knowledge Society Part I. Poverty Reduction, Gender Equality and the Knowledge Society: Digital Exclusion or Digital Opportunity? Sophia Huyer and Swasti Mitter

Conclusions

This rapid tour through the policy dimensions of ResIST's topic area has shown that there are many opportunities for working towards reducing inequalities through science and technology. Capacity-building efforts can be targeted to disadvantaged groups. Research and innovation can be better aligned with the needs, absorptive capacities and opportunities open to poor communities. Participation by women, disadvantaged ethnic groups, and the poor in the shaping of research and innovation agendas can help to build capacity at the same time and the development of more proactive approaches. By changing who is involved in research and what problems are addressed, both public and private sectors actions can have more positive distributional effects. In short, experience shows that a re-distributional S&T policy is possible. It remains for ResIST's partners in the policy world to put the concepts into action.