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Researching Inequality through Science and Technology

(ResIST)

Final Report: Volume 1

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These sentiments apply particularly to the members of our ResIST Advisory Group: Ahmed Ademoğlu, Jeff Dellimore, Marcelo Firpo Porto, Ricardo Thompson, and Dave Walwyn. Dave Walwyn in particular was a tower of critical strength.

None of these meetings would have taken place without great behind the scenes efforts by a host of people who supported our activity in work in finance, planning, editing and logistics. The list is too long to set out here, but they know who they are. Thank you.

Last but not least, this integrative report has three authors, but nearly fifty people contributed their research to ResIST. This is above all their work.

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June, 2009

Foreword

Many studies in science and technology studies have established that science and technology (S&T) do not merely cause or alleviate inequality, but that the most pervasive and obdurate sources of social distribution are enshrined and entrenched in S&T systems. Because of this, the development of a global knowledge economy, in which S&T play an increasing part, seems likely to increase inequality both within societies and between them. This makes it both important and urgent to understand processes that contribute to the increase in inequality through the role of S&T, but equally to understand S&T processes that can contribute to mitigating inequality. The task of our research project – *Researching Inequality through Science and Technology* (ResIST) – has been to address both these challenges, and produce research that would inform approaches to S&T policy for Europe, and for developing countries. In this way we hope to contribute to policy and practice that may achieve a better balance between S&T for economic growth and competitiveness, and S&T for social and economic inclusion, the complementary aims of the Lisbon agenda.

We focused on three forms of inequality – structural, covering capacities and resources in S&T; representational, covering the distribution of voice and power in determining direction for S&T and accountability for outcomes; and distributional, covering the ways in which the goods and harms S&T produced were spread across countries and groups. Our empirical cases and policy analysis took up four issues where these inequalities were most likely to be reflected, and thus where there was significant scope for remediation: policy frameworks; international migration of the highly skilled and its impacts on capacity building in disadvantaged locales; new accountability mechanisms; and the economic and social impact of emerging technologies.

The work on these four issues has been delivered through cross-national and cross-disciplinary teams, working in the familiar European format of work packages. The work of the project was also significantly shaped by the interchanges that each work package had with each other and, as importantly, with policymakers and practitioners in six world regional meetings during our research. It was the explicit task of a fifth work package – work package 0 (zero) – to organise the world regional meetings, and promote such interactions. The world regional meetings helped us frame issues, access cases for analysis, refine our products and significantly situate our work in relation to a current dominant policy framework in widespread use, national innovation systems.

Our work in ResIST is thus a co-production of researchers and practitioners, with a legacy in the form of proposals for further collaboration between researchers and practitioners in research, and in building networks of relevant expertise. The structure of our report also reflects these origins. Rather than simply setting out the results descriptively, work package by work package, we have constructed a broader narrative that puts the immediate four sets of research issues in a context that includes the historical origins of S&T, and their current policy context, and attempts to interlink them.

This is volume one of the five volume report. In volumes two, three, four and five the substantive work packages introduce their own work, and discuss it at more depth. (These later volumes are initially virtual, being reported on CD, but can take physical form.)

The third period deliverables from across the project are being submitted in parallel with the report, comprising over twenty papers of different kinds, with different purposes: reports of meetings, scholarly papers, policy briefs or more extended treatments of the issues which are still aimed at a policy audience. Much of this work will be reflected in the academic literature over the next few years, including in a couple of books, but we would also like our legacy to be reflected in policy and practice: in a lively debate, in some action to build S&T capacity for socially inclusive development for less advantaged areas of Europe and in the developing world, and in better analytic and policy capacity for the locales where that investment takes place.

Executive Summary

Science, technology and inequality

In ResIST we see science and technology as the social institution perhaps best embodying the survival in to the contemporary world of the Enlightenment. The nature of science, as of the Enlightenment itself, is of course ambiguous: both a symbol and instrument of emancipation and hope, and a perceived cause of repression, exploitation and injustice. Both a liberator from the constraints of nature, and a contribution to its rape. Policy bodies need to set a careful course in this environment of polarised opinion between ignorance and blind optimism.

They may be helped in doing so in taking the perspective that S&T's redemptive or diabolical possibilities are not essential, but contingent on context and circumstance. Acknowledgement of the roots of science and knowledge in Indian, Chinese, Islamic and African culture alongside the Western legacy will help a dialogic approach to science as being part of the heritage of mankind instead of being an export product of Western culture and society or, even worse, an ingredient for a clash of civilizations.

Seeing the range of possibilities of science as contingent and circumstantial also implies that the social, and the social sciences and the humanities are an integral part of the story. The development of science and technology are no longer entirely separable from other human endeavours and in principle can be enlisted in their service: science and technology policy and management make their appearance. The redefinition of issues of inequality between people and cultures has been at the heart of the Enlightenment project as much as the promotion of science and rationality (in parallel with the issues of human and civil rights and democracy).

Critics have pointed to the dark side of science throughout its modern history. The risks and danger of unrestrained commercialization of scientific findings is one theme. Science may be less innocent and neutral with respect to social, political and economic goals then science's acolytes occasionally claim. In so far as science promotes 'rationality' in economics, governance and the handling of human well-being, it represents, so it is argued by critics, a particular kind of rationality that is less universalistic and partial and restricted with respect to the definition of truth, beauty and good. These restrictions have been particularly strong in seeing what is seen to be beyond the bounds of 'Western' culture, and in restricted perspectives on what constitutes 'valid' S&T (along with modernity, rationality, civility, etc). Everywhere in the world, however, advanced contemporary knowledge and technology mix with traditions and cultural (sometimes religious) inspiration and commitments of a different nature. Commitments to knowledge development, human welfare, equality and rights are declared around the world, it is in their elaboration that we may differ, productively or in a more destructive way.

The connection between scientific and technologically based growth and inequality at large remains ambiguous. In the so-called BRIC countries[1], the newly emerging economies that rely heavily on the use, production and exploitation of advanced technology, there is a catch up going on vis-à-vis the economically advanced

[1] Brazil, Russia, India and China. Recently Indonesia and South Africa have been added to the list (i.e. BRIICS) by the OECD. (2008). *Globalisation and Emerging Economies; Brazil, Russia, India, Indonesia, China and South Africa*. Paris: OECD. It has also been suggested to drop Russia (BIICS) (Economist).

economies but at the same time internal inequality in countries like China has grown enormously[2] and a group of countries seems to emerge that remain behind constituting the 'bottom billion' (Collier, 2007).

All this raises the pertinent question if and how science and technology can be harnessed to promote equality and how the opposite (S&T leading to more instead of less equality, more poverty, increased marginalization etc.) might be counter-acted. This is the question that is at the heart of the ResIST project about which we report here (ResIST Description of Work, p.4).

Forms of inequality and their interconnections

At the most general level inequality refers to 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. Amartya Sen (1992)[3] notes that inequality is a multi-dimensional space, within which different political philosophies emphasize equality on different dimensions.

Economists, who tend to focus primarily on inequalities in income, distinguish between vertical inequalities (among individuals) and horizontal ones (between groups, such as between women and men or between ethnic or religious groups). The unequal distributions of other valued items also fall along these two dimensions, as may the distribution of harms which most wish to avoid.

In ResIST three types of inequalities have been distinguished: structural, representational and distributional:[4]

Structural inequalities refer to unequal distribution of human and institutional capacities inside as well as between countries.

Representational inequalities refer to differences in the permeability of decision making processes to inputs and influence from various groups. From the very beginning representational equality has been associated in the ResIST project with 'accountability'. In situations in which particular groups can be said to be represented this may actually be a dead letter because of their inability to hold officeholders to account. 'Representatives' that cannot be thrown out by those they claim to represent in some way are often not much help in addressing problems of inequality.

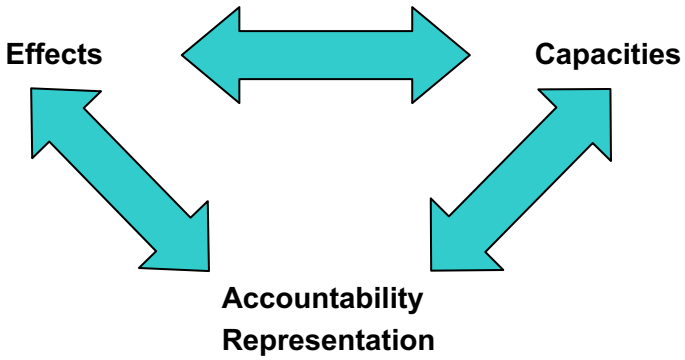
Distributional inequalities refer to unequal distributions of the benefits and costs of economic and other goods. The benefits and costs of science and technology, and of their policies, can be affect differently specific groups, either contributing to increase or mitigating inequalities.

Inequality in access to knowledge is characteristic of the uneven distribution of science across the globe. The migration of highly talented people towards the centres

[2] See Naughton, B. (2007). *The Chinese Economy; Transitions and Growth*. Cambridge, MA, USA: The MIT Press, 209-28. China now ranks amongst the countries where inequality is highest, but the data and methodology leave room for some reduction of the indices (220-1).
[3] Sen, A. (1992). *Inequality Reexamined*. Cambridge, MA, Harvard University Press.
[4] Cozzens, S. E., et al. (2007). 'A Framework for Analyzing Science, Technology and Inequalities: Preliminary Observations.' *ResIST Working Papers*. Oxford, UK: James Martin Institute, Oxford University.

of advanced learning in the US and Europe and the de-institutionalisation of science in, for example, Africa[5] reinforces that. A trend insufficiently countered by remigration or capacity building policies and 'brain-circulation' if it comes to effectively addressing the issue of inequality. Women and people with lower class backgrounds are *underrepresented* in science. So are 'neglected diseases' that are often of special importance to people in the 'Global South' and groups treated as 'marginal' in advanced societies. All this may be associated with *distributive* inequalities.

The cyclical effects of various types of inequality became iconically enshrined in what we in ResIST called the CARE cycle.



ResIST makes three key assumptions: a) that science and technology policy may counteract or reinforce inequality depending on choices made and their implementation; b) that various forms of inequality exist, including those associated with science and technology; c) that a better understanding of the connections between science, technology and inequality may lead to better innovation policies in terms of addressing issues of inequality, coherence, and social cohesion.

Given the complexity and multi-faceted nature of the concept of inequality just outlined, there is a very wide range of actions that could be taken in STI policy to reduce inequality. When the policy aims to reduce poverty or address conditions associated with poverty, it can be put it in the "pro-poor" category. When the policy is directed towards decreasing horizontal inequality, it belongs to the "fairness" category. When the policy works to decrease vertical inequality, we will put it in the "egalitarian" category. Each of the categories rests on a different rationale and calls for different kinds of actions.

Science, technology and development: actors, institutions, identities and ontologies

Within the discourse of STI policies, a tension exists between economic competitiveness as a goal on one hand and on the other social cohesion. According to many commentators the competitiveness goal is put into practice in a variety of ways, but the second often remains at the level of rhetoric. ResIST highlights the importance

[5] See Johann Mouton & Roland Waast, Study on National Research Systems. A Meta-Review, paper presented at the Symposium on Comparative Analysis of National Research Systems, 16-18 January 2008, UNESCO, Headquarters, Paris. See also section 9 below and Volume 3 of the ResIST project.

of a broad conception of the role of knowledge in the "knowledge economy" and associated actual and accountable implementation of such a conception, regardless of whether economies are more or less technically advanced. Such broader STI policies have inclusiveness and accountability (politically and administratively) as guiding, heuristic principles. Such inclusiveness and accountability refers to forms of knowledge, of technologies and of social groups and of issues of inequality and development that are targeted and mobilized in the framing of science, technology and innovation policies.

It is a technocrat's dream and a democrat's nightmare to assume that the political confusion and disagreements can be radically ended through research, that such research will provide hard and reliable universally applicable tools and that a decisive wall can be built between facts and values. Critical social science analysis can be helpful to discussions and decision making by analysing the positions actors adopt and how these merge and change, their interactions and networks, the way decisions are made and how these and the subsequent developments are accounted for. In social studies of science and technology this approach is generally coined in the dictum 'follow the actors'. Work along those lines over the last three decades has made clear how scientific facts and technological artefacts, values and social and physical arrangements in the world are 'co-produced'[6] in the interactions amongst scientists, engineers and the physical and social environments of which they are a part and on which they work. In ResIST we have looked at the ways in which key actors in the practices investigated frame the problems at hands, how they disagree, what they do and what results from their actions and interactions. We have looked at how issues and considerations of inequality are dealt with and where and how positive or negative examples and experiences emerge.

In all our case studies distinctions and relations between market and state, government and science and between citizens and government come into play. Where the lines are drawn and what this implies for the identities and capacities of citizens, politicians and entrepreneurs is at the same time conditioning the debate and struggles as well as at stake in the struggles and negotiations that are going on. A key recommendation is therefore that one should always include an analysis of what particular policies to mobilize science and technology against inequality imply for the interconnections and relations between state, economy, civil society, and citizens. Such analyses should be integrated in the public and political debates in order to clarify assumptions and commitments implied that would otherwise remain hidden.

International dependencies and transnational networks also play a key role in all this as the cases studies on transnational accountability and the negotiations about migration of high skilled labour demonstrate.[7] The struggle against inequality and its implications is an acknowledged international challenge. Environmental protection, sustainability, intellectual property protection, drug regulation, agricultural biotech are subject of – slowly – emerging international regimes. And so is development policy.

To question the connection between knowledge (science included) and policy-making means engaging with questions of what Mol and Law have called 'ontological

[6] Jasanoff, Sheila (Ed.) (2004), *States of Knowledge: The co-production of science and social order*. London: Routledge.
[7] See section 5 below.

politics'.[8] Ontological politics assumes that any given reality or object possesses multiple versions that are enacted, manipulated and built through the mediation of multiple instruments or resources during the course of a diversity of practices. In this sense reality does not precede practices or policy statements but is, on the contrary, the outcome of them. This means that whenever we argue about the use of science and technology to address issues of inequality ontological politics come into play.

Ontological politics also bears upon and is at stake where it comes to the relation between Western inspired scientific methods and traditions and what is often referred to as 'indigenous knowledge'. From the (non-)universality of Western rationality to the way in which local knowledges and local culture (i.e. indigenous knowledge) are dealt with economically, politically and in terms of rights in development discourse and science-oriented policies. In this respect 'indigenous knowledge' designates a key arena of struggle and ontological politics is the kitchen where cultural histories of interdependence and autonomy are made and mixed.

Development, cultural hegemony and indigenous knowledge

Indigenous knowledge (IK) presents us with four related challenges, which echo the issues explored in section 3. Ontologically, the forms of knowledge it produces are *sui generis*, each being incommensurable with other indigenous knowledges and with Western science, whose universalistic knowledge claims stand in direct contradiction to it. This in turn leads to an epistemological problem with indigenous knowledge, of how those outside its originating culture can assess its knowledge claims, or more fundamentally what meaning those claims have outside the immediate context of their production. Third, there are problems of rights – political, including political visibility and representation, and legal and economic – of traditional peoples and their products, and the way in which these may interplay or conflict in the way that any knowledge is developed or exploited. Lastly, ResIST's particular questions apply to indigenous knowledge as to all forms of knowledge in action: how does this play out in terms of the distribution of benefits and costs, as the knowledge becomes embodied in tangible or intangible products, and in what terms do we see wider social equity emerging?

IK's challenges are all framed by inequalities of power and voice. The very term 'indigenous knowledge' carries associations of 'the other', of being produced by those who are marginal, as being judged by an external framework. Studies have stressed indigenous knowledge as being traditional, in being culturally embedded and transmitted in a particular community; and local, in being derived from a particular environment.

The semantic associations of indigenous knowledge with tradition and deep cultural roots, together with the need for narratives of political legitimacy based on change, explain much about IK's constrained place in contemporary science and technology

[8] See Mol, A. (2004). Ontological Politics: A Word and Some Questions. In J. Law, & J. Hassard, *Actor Network Theory and After* (pp. 74-89). Oxfor IK's challenges are all framed by inequalities of power and voice. The very term 'indigenous knowledge' carries associations of 'the other', of being produced by those who are marginal, as being judged by an external framework. Studies have stressed indigenous knowledge as being traditional, in being culturally embedded and transmitted in a particular community; and local, in being derived from a particular environment. Blackwell/The Sociological Review. See section 5 below.

policies of developing countries. As Visvanathan explains (Visvanathan, quoted in Kraak, 1999[9]), for post-Colonial elites in these countries, many of whom had been western trained, western science was transformative knowledge, the base for a new order, the very counterpoint to the traditional.

Even many sympathetic attempts to convey the issues surrounding indigenous knowledges are framed in rationalist modernist terms, and apply modernist notions of rights and property. If the standards and reference points are not up for discussion, that shifts the entire issue of indigenous knowledge from the principled incommensurability of the systems to the question of finding common ground, translation between systems and compromise.

The political reassessment of the value of indigenous knowledge, from a distinctly modernist perspective, rests almost entirely on the discovery of the potential value of biodiversity. Its significance to the broadest remediation of inequality, rests in part on the fact that

> 'The world's biological diversity is distributed largely in inverse proportion to scientific and technological capacity' (Macilwain, 1998).[10]

That biodiversity has already been tapped once, in the late nineteenth and early twentieth centuries. Many of the products and processes which are currently globally traded were forms of indigenous knowledge that were commercialised before the beginning of the twentieth century, under European colonialism. From an STS perspective they represent embedded inequalities of power from that era, also still represented in the distribution of value from supply chains established at that time for products like tea, coffee[11] and chocolate. Thus some of the relationships between S&T capacity and biodiversity which Macilwain notes are not just circumstantial but rooted in the ability of European powers to build competitive advantage on the back of historic privileged access to the natural resources of the developing world.

As with the earlier stage of colonial exploitation, the principal equity question is whether biodiversity, undoubtedly a resource **of** the Global South, is also a resource **for** the Global South – that is, the extent to which the countries where these resources are found are able to appropriate their benefits. Our review of the various initiatives under international law and trade regimes to protect the intellectual property of gene rich states in this second round of exploitation of biodiversity, principally for new medicines, is not fully reassuring For example, the TRIPS agreements allow for local legal action to protect plant varieties and to exclude plants and animals from patenting, but like all TRIPS provisions for exceptions to trade related intellectual property provisions, considerable effort is required to provide alternative local

[9] Andre Kraak (1999). 'Western Science, Power and the Marginalisation of Indigenous Modes of Knowledge Production'. Interpretative minutes of the discussion held on 'Debates about Knowledge: Development Country Perspectives' co-hosted by CHET and CSD, Wednesday 7 April 1999. Available from reports archive at CHET (www.chet.org.za), accessed 24 April 2009.

[10] C. Macilwain (1998). 'When rhetoric hits reality in debate on bioprospecting', *Nature* vol 392, pp 535-540.

[11] In 2007, Ethiopia, where the Arabica coffee bean originated, tried to trademark three local varieties of coffee bean, but was allegedly blocked by Starbucks, although Starbucks claimed that the objection had come from the US National Coffee Association. Later a settlement was reached by which Ethiopia licensed the varieties to Starbucks. Oxfam, the development charity, welcomed the agreement as potentially fundamental for the 15 million Ethiopians whose livelihood, they said, depended on coffee.

protection arrangements. However, there have been recent advances, on paper: at the TRIPS Council meeting in October 2008 80 countries supported a new disclosure provision by which patent applicants are required to disclose the origin of genetic material or traditional knowledge used in their inventions (WTO, 2008).[12]

Some regard the whole process of international law regarding new medicines as essentially rigged against the providers of the basic genetic resources. Ikechi Mgbeoji believes that the problem of (foreign) appropriation is systemic and that

> '…the criteria of reproducibility, utility, specification and non-obviousness [standard tests of patentability] have been significantly watered down for the purposes of the pharmaceutical and biotechnology industries' (Mgbeoji, 2006: 193-4).[13]

His solution is that gene-rich states should use their sheer numbers to effect change.

The broader question of alternative reward systems for the creation of intellectual property, such as prizes, is under debate. This would not only transcend these problems of developed world appropriation of indigenous knowledge, but also counteract the tightening restrictions on the developing world's production of generic medicines. Visvanathan allies himself with this more radical approach, again inviting the economies emerging from the developing world to be more politically assertive in trying to remedy inequalities:

> '…knowledge as intellectual property violates the idea of cognitive justice and demands that we reject the institution of IPR. One is not merely suggesting a state of exception, arguing, for example, that during an epidemic that Aids medicines be considered outside the intellectual property frame. What one is advocating is a complete secession, a rejection of the IPR regime. If India, China, Brazil and South Africa reject IPR, the chances of such a regressive institution surviving are minimal' (Visvanathan, 2009).[14]

With these broader debates for reference, ResIST looked at a number of case studies of policies of policies for or use of indigenous knowledge in Mozambique, South Africa and Brazil. In the case of dengue in Brazil, in particular, the use of local knowledge combined with systematic social participation did suggest a new way of seeing and tackling the problem of disease control. Programmes of this type involve the articulation of a range of different disciplines and forms of knowledge, including, for instance, the collaboration between public health specialists and entomologists, but also local communities and their knowledge of local ecologies, construction materials and social organization. It also involves similarly broad based evaluation and assessment. It is therefore analogous to the same issues encountered with other forms of indigenous and local knowledges, as to how to assess its utilities in different contexts, and how to assess its use in combination with non-traditional knowledge. Cases on malaria presented at ResIST's Maputo meeting underlined the importance of sensitivity in establishing international technology projects in their local context.

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[12] WTO (2008). See http://www.wto.org/english/news_e/news08_e/trips_28oct08_e.htm, accessed 24 April 2008.
[13] Ikechi Mgbeoji (2006). *Global Biopiracy: Patents, Plants and Indigenous Knowledge*. Ithaca, New York: Cornell University Press.
[14] Shiv Visvanathan (2009). 'The Search for Cognitive Justice' in *Seminar,* no.597, 'Knowledge in Question', May ,2009. Available at www.india-seminar.com, accessed 24 April 2009.

Lessons learned included the need for a social science presence in all clinical trials, and active community participation in study design.

In a wider sense, our general STS perspective also stresses the importance of local and contingent knowledges in a broader sense as contexts for adaption and innovation (or the perceived failure to innovate). Local contexts, as Work Package 4 of ResIST emphasises, shape what innovation becomes, and shape the definition of what equity and other social values will mean and how they will be applied. It is not just that an equitable and inclusive science policy must include multiple forms of knowledge and expertise, including traditional situated knowledge (Cozzens et al., 2008: 9)[15] but that in this wider sense indigenous and local knowledges can contribute to the framing of all socio-technical change in processes of negotiation, heavily mediated by accommodation of different sources of power and legitimacy.

As the case of hoodia illustrates, adjudicating between local, national and international interests in developing indigenous knowledge for commercial exploitation to determine what exactly constitutes fairness is no easy matter, as Schuklenk and Kleinschmidt (2006b)[16] document. Hodia is an appetite suppressant traditionally used in the Kalahari by the San people, which the South African Council for Scientific and Industrial Research (CSIR) became aware of in 1937. CSIR went on to isolate and patent the active ingredient of the plant in 1980, and have since made two ultimately abortive attempts to licence it for development to pharmaceutical companies. There are a number of issues about the allocation of any benefits from these commercialisation efforts. At a level of principles and rights, should the benefits be at the level of the San peoples, or, as the CBD proposes, the state, which had, in this case, isolated and patented the active compound. As an issue of justice in administration, who exactly should benefit, given that the San people stretch over three jurisdictions, South Africa, Botswana and Namibia? And in what case could knowledge of hoodia be seen as the property of the San, given that some people from other ethnic groups traditionally shared the knowledge, and that not all the San people recognised or used hoodia's properties? Then, there is the question as to the distribution of benefits from the projects which the development trust might invest in: would these be more KEPP- or SCOPP-like in their distribution of benefits within the San community, and how would they affect the wider pattern of inequalities within South Africa? Finally, does a case like this leave any equitable developmental legacy in terms of the way in which issues of commercialisation of natural resources are to be dealt with in future?

Indigenous knowledge raises a number of issues for future research. We are still far short of the kind of understanding needed to frame policy and practice in a number of areas. First, it will be a sensitive task for research to tease out how pharmacological and social interactions between different routes of treatment based on different schemes of knowledge put the health and happiness of patients at risk in a variety of different ways. Second, in just one step further, how indigenous and other forms of knowledge interact forms a good basis for helping us understand knowledge accountability systems may be able to achieve a common framing so as to embrace

[15] Susan Cozzens, Rob Hagendijk, Peter Healey and Tiago Santos Pereira (2008). The CARE Cycle: *A Framework for Analyzing Science, Technology and Inequalities – Journal Article Submission.* ResIST Deliverable #3. Available from the ResIST website: www.resist-research.net, accessed 24 April 2009.
[16] Udo Schuklenk and Anita Kleinschmidt, (2006b). Presentation at the Innogen Annual Conference, September 2006.

equity as one of their core deliverables, even when starting with differences of approach verging on the incommensurable. Third, there are a number of 'ideal types' of local resource control which could repay study in relation to other models.

Finally, there are two aspects of the changing geopolitics of science-based innovation that need attention. One, is a relatively new development of 'market colonialism' as richer countries buy not just primary resources from developing countries, but large tracts of land from which it comes, in order to guarantee their future access to minerals, food or water (or even, as with island states threatened by climate change, a place to live). The acquisition of land in this way, and particularly on a large scale, raises some potentially strong ethical and legal issues about the scope for its use and the opportunity costs for the host country.

The second geopolitical issue for new research is the emergence of new global players with different needs and interests. The emerging BRICSAM[17] economies, for example, for the most part exhibit high ethnic diversity, and they are all struggling with large inequalities of wealth, in some cases overlapping with internal ethnic and geographical divides. In most cases they are decentralised states with sub-national systems of innovation. In most cases too their political discourse reflects the importance of extending social and economic inclusiveness, and favours a range of political approaches, with far from settled forms, that often lie outside conventional neo-liberal takes on the role of the market and on representative democracy. Their evolving versions of a knowledge society may embody quite different perspectives to local and traded knowledge and the distribution of opportunity and risk in science-based development.

This discussion of the incommensurability of indigenous and conventional knowledge tends to overestimate the extent to which scientific knowledge itself shares a single philosophical base. Further, there is within post-modernist perspectives a respect for pluralism even if some of the knowledge systems which are protected are at odds with earlier modernist views on what is best with respect to values like health and sustainable well-being.

What may be needed is a more symmetrical discourse (within modernizing catch up regimes and internationally) about various knowledges and techniques, i.e. minimal rules of discursive procedure in considering these. In such discursive procedures the following should be considered:

- is there ontological (in)compatibility of knowledge systems and world views and how can these be dealt with from the perspective of each of the systems considered?
- epistemological (in)compatibility in knowledge assessments and how to deal with it from the perspective of each of the systems considered?
- rights based perspectives – property, economic, collectivist and/or individualist – again for each system;
- rights based perspectives – human rights (health, food, water, etc.) – for each system;
- rights based perspective – how to deal with minority viewpoints – for each system.

[17] Brazil, Russia, India, China, South Africa and Mexico. A recent OECD study on the catch-up economies referred to BRIICS, with Indonesia substituting for Mexico. The arguments about internal diversity apply to Indonesia too.

At each of these levels it should be considered how the issue is defined in modernist and indigenous thought and where (if anywhere) there is minimal common ground.

More cognitively inclusive approaches also bring to centre stage the question of how potential conflicts are resolved politically, or the implications of less than total coherence in different parts of the system defining knowledge and social priorities; and they equally foreground issues of accountability.

Inclusiveness and accountability in development and globalisation

It follows from our definition of inequality that enhancing representation and participation should be an integral element as well as a goal of all STI policies that seek to redress inequality. To promote equality in the distribution of economic outcomes or with respect to access to key STI resources is obviously important but so is participation and inclusiveness. There are principled as well as functional arguments for this view. It refers to basic citizenship rights as such as well as to what is needed to define and implement policies that can be expected to be successful in delivering the goods. Participation and representation as an integral part of the struggle against inequality also concerns the connection to the development of knowledge, scientific and otherwise, and technological change. Accountability, however, refers not only to the fundamental right to participate, but also to the right as well as the plight to ask for and give accounts as a part of everyday discourse and its extensions into politics and spheres of specialized professional knowledge and expertise.

In Europe and the US policymakers have become increasingly aware of the importance of public participation for policies of technological innovation and economic growth. After the big turmoil about BSE or GM crops, and a wide-ranging crisis of trust about the capacity of regulatory agencies to deal with science-related technologies and practices, new formats of public consultation have been introduced and institutionalized. Work in STS has showed that the 'deficit hypothesis', based on the need for the popularisation of science, does not help to understand public conflict about new technology adequately. Lay citizens are very well able to appreciate how science may affect their personal life and well being and to respond and retaliate if provoked. Innovation policies fail unless people can be convinced that the new technologies help instead of harm their needs and that risks are under control. The question whether the new forms of engagement promoted in EU countries and beyond are a new form of political marketing or genuine attempts to engage with lay citizens' views on technological change is impossible to answer in general (Hagendijk and Irwin, 2006). Yet it is also known that people are inclined to comply with outcomes that do not reflect their own interests, provided they have the idea that the process was transparent and that they got a fair hearing.[18]

Alongside issues of participation questions regarding accountability should be studied closely if we want to understand how participation relates to equality of representation in decision making about science and technology and what effect this has. Yet, by attuning to the needs of the disadvantaged, systems of accountability can become focal points for reorienting scientific governance towards greater social inclusion in

[18] See Simon Joss and Arthur Brownlea, 'Considering the Concept of Procedural Justice for Public Policy – and Decision-Making in Science and Technology', Science and Public Policy, 26 (5), (1999), 321–331.

building S&T priorities and in distributing its products. To do so also implies however that we have to be attentive to differences between countries and political systems and that one has to address the specific constraints, needs and opportunities as they exist in different settings.

Accountability has recently become a fashionable buzzword in contemporary politics and in the media. Three main forms can be identified: 'accountability *to* the public', how politicians, bankers and other authorities should be held to account to things that have gone wrong to parliaments, media publics and the citizens at large; 'accountability *of* the public', referring to the accountability of citizens vis-à-vis their government and its representatives; and 'accountability *in* public', those forms of accounting or accountability that can be found in the everyday, mundane interactions of everyday life if one transgresses some unstated rule or convention.[19] All these forms of accountability can be easily observed in mixed forms in accountability processes in and around science and technology. Other institutionalized practices exist, such as legal, economic accountability and moral accountability.

Three concepts were central to our study of accountability and participation processes. The first important notion is that of 'ontological politics' (Mol and Law 2002; Mol 2004).[20] Ontological politics assumes that any given reality or object possesses multiple versions that are enacted, manipulated and built through the mediation of multiple instruments or resources during the course of a diversity of practices. This raises a question as to how to locate the places of decision, how to identify available options and possible development paths. Accountability systems are an essential part of such ontological politics. By engaging with accountability in terms of the people, processes, technologies and spaces involved, we can see how particular political realities emerge from accountability struggles, and arrangements. This provides a window on how this might be done in a different way to better address issues of inequality.

The second central concept for our study of accountability was that of 'double delegation' (Callon, Lascoumes, & Barthe, 2001). If decision-making comes to knowledge about the structure of the natural world the ultimate voice and authority rests with the sciences and those educated and disciplined in logic and experimenting after their image. At the same time for decisions about what to do about social and power relations and how to draw boundaries between public and private the ultimate authority lies with chosen representatives. This conception of twofold delegated decision making – to experts and political representatives – means that citizens are residual – largely excluded from decisions about issues that affect their well-being. Callon et al. argue that this double delegation model may work well for well-defined issues of limited reach, but also that recent history shows that there are many science and technology related problems that are difficult to handle under this system of double delegation given their complexity, novelty and wicked nature. For that reason Callon et al. and others argue in favour of more participation both with respect to experts and research as well as with respect to decision-making.

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[19] See for an extended presentation of this Neyland, D., et.al. (2007). *Articulating New Accountability Systems: Preliminary Integrated Framework*. Working Paper, Oxford: JMI Institute, Oxford University.

[20] See Mol, A. (2004). Ontological Politics: A Word and Some Questions. In J. Law, & J. Hassard, *Actor Network Theory and After* (pp. 74-89). Oxford: Blackwell/The Sociological Review; Law, J., & Mol, A. (2002). *Complexities: Social Studies of Knowledge Practices*. Durham, NC, USA: Duke University Press.

The third important notion is that of 'transnational accountability'. In discussions about participation and accountability the focus is often on national arenas of decision making, or even international. A lot more is going on associated with science and technology but which transgresses relations between states, even when the states are involved in some capacity. Where global and, in some cases, national issues are involved accountability tends to take the shape of 'accountability at a distance', people and agencies trying to hold others to account who are not physically present. This is of particular relevance when dealing with new emerging technologies as well as to dumping the remains of technical devices and processes.

This raises the question of how accountability could be better organized in such situations to give the people affected in non-Western contexts more say in the process. But to understand that we also need to understand better how accountability works in various settings today. The case studies undertaken in the second part of WP3 about electronic waste, fair trade and treatment for neglected diseases have a special bearing on this.

Looking at the formats of accountability that extend beyond purely face-to-face accountability, and that tie face-to-face accountability to wider contexts, two types may be distinguished. We have coined these respectively '*directive accountability'* and '*demonstrative accountability'. Directive accountability* refers to situations in which governments or agencies try to impose explicit instructions as to how particular situations and processes are to be designed, carried out and monitored, often through quantitative indicators. In situations of *demonstrative accountability* devices that are used pro-actively to demonstrate how seriously the firm or agency takes their public responsibility.

Alongside the formats of face-to-face, directive and demonstrative accountability the central issue in such practices is who decides on programmes and budgets, who is consulted and who holds whom or what to account. We have called such complex arrangements that are increasingly popular in some developing countries and are experimented with in Europe, participatory accountability. Consultative accountability is best seen as a weaker form of participatory accountability as institutionally and legally entrenched distinctions remain in place and decision-making remains in the hands of formally elected bodies and officials and agencies installed on their behalf. A summary table of the accountabilities discussed is given in an appendix to this report and in Volume 4 of the ResIST report. The empirical case studies in ResIST's work can be divided in those that focus on transnational accountability and those that study participatory accountability.

Case studies on participatory (and consultative) accountability deal with bottom-up and top-down initiatives in different settings. Two sets of case studies were selected. The first set of cases covered the participatory budgeting processes in Belo Horizonte (Brazil), Seville (Spain) and S. Brás de Alportel (Portugal), and enabled us to explore the areas of urban planning and information and communication technologies. The second set included cases on the creation of a public health system (including national and local levels of intervention) and the control of endemic diseases, both in Brazil, as well as the controversy between the European Union and the Brazilian environmental justice movement on the imports of used/retreated tyres.

There are three aspects setting some limits to accountability systems their capacity to become a challenge which may progressively shift the system:

a) Knowledge as a concept tends to focus on dominant forms of scientific and technical knowledge, and a broader understanding of what counts as knowledge is proposed;
b) Much social scientific work linking inequalities to formal institutions and policies and associated processes overlooking examples such as the case studies on Participatory Budgeting, of Health Municipal Councils in Brazil or of struggles over environmental justice;
c) Finally, the studies show the importance to be attributed to the ways in which inequalities are experienced by participants, and of a range of specific technical devices that have been developed for that purpose that contribute to the systems overall success.

For the case studies about transitional accountability three areas were initially defined: textile lifecycles, vaccines and e-waste.

Clothing, such as t-shirts, forms a ubiquitous aspect of consumer lifestyles in the developed world. However, often t-shirts are produced in developing countries, where questions are asked of labour conditions, safety and hours of work. Subsequent to use in the west, t-shirts are often donated to charities and shipped back to the developing world where they form the focus of emerging industries for accessing, distributing and owning such garments. The case-study report suggests that Fair Trade could get more involved in more sophisticated educational initiatives both in developing and developed countries. In terms of international accountability systems some Fair Traders advocate a change in import policies which might encourage the movement of more ethical or Fair Trade goods by, for example, lowering import duties or taxation on such goods. Finally there are Fair Traders who advocate a stronger role for Fair Trade organisations to build a more effective community of Fair Traders with greater opportunity to share information, interact on particular initiatives and develop co-operative rather than competitive trade.

Vaccines can form a pervasive, mundane and routine expectation within societies of the developed world (aside from questions of, for example, the availability of flu vaccines). Public-Private Partnerships with combinations of state, private and philanthropic funding were identified as key sites of intervention where different forms of accountability were played out.

With the growing use and disposal of IT equipment, questions are being asked of where waste should go, how IT should be dismantled and what impacts such e-waste is having on particular locales. Participants in the research suggested that more effort was required to harmonise the directives which held e-waste to account so that there were fewer interpretations of directives between EU members. Second, arguments were made that greater integration was required between the different accountability measures, so that design of new goods, packaging, transport, hazardous substances restrictions, the collection, disposal, re-use and recycling of e-waste formed a coherent package of measures. Third, it was suggested that consumers could be more effectively incorporated into e-waste initiatives. Developing country contexts were notably absent from many of the discussions.

The ResIST work on accountability brings out and stresses the importance of (a) a broad conception of accountability beyond a more limited political use of the term that focuses exclusively at political and business representatives; (b) the need to analyse how problems are analysed and handled in terms of 'ontological politics', i.e. processes in which realities, identities, devices and modes or organisation as well as

inequalities get (re)defined and eventually stabilized or black-boxed; (c) the inability of the system of 'double delegation' to deal adequately with contemporary complex problems of the social and natural world and the need to broaden the basis for decision-making on such constitutive matters.

In drawing general conclusions and lessons from this exercise (more detailed recommendations can be found in Volume 4), it is important to realize that the model of double delegation is not only inadequate, but also rather problematic as a model for governing the problems of societies with institutional (political, economic, civic) configurations that are different and less well-resourced than in high-tech, economically most advanced societies. Governmental and managerial accountability in such settings of delegates and experts is no less needed than anywhere else and may be even more required. Yet, at the same time it is also important to develop policies and forms of accountability that stress the role and responsibilities of lay citizens and their local leaders and to create spaces where such forms of responsibility can be articulated and mobilised in a constructive way.

By focussing on other examples of the organization of accountability than those that only concern the (lack of) responsibility of political leaders we have shown how this may be achieved in various situations if one draws on rather straightforward modalities of accountability *in* public, *of* the public and *to* the public. To make them work in other situations requires first and foremost experiments and learning from experiments. Such experiments, especially those with radical participatory formats are often opposed in the name of formal democratic procedures. Representative democracy would come under threat and would be restricted by the institutional innovation. Our research and that by many others shows that there is little basis for such fears. Obviously participatory or dialogic democracy (Callon, Lascoumes, & Barthe, 2001) is not an alternative for representative democracy but complements it and can be expected to improve the functioning of the formal system.[21]

The most general recommendation from the work of accountability is therefore that we need more controlled experiments with new formats of accountability and combinations of formats of accountability in order to develop new approaches to decision making that are especially suited to promoting equality with the help of science and technology. In such experiments institutional boundaries should not be treated as sacrosanct but should themselves be tested and interrogated.

STI policies in the face of global inequalities

Throughout the history of science and technology policy, discussions have always been informed by differences of opinion that were rooted in different views of the importance of economic goals and other goals like social security and social justice, environmental sustainability, health, disease and poverty. The EU discussions about the Lisbon agenda and its formulations illustrate this clearly. While the emphasis on knowledge, research and innovation takes a central role, the relevance of this fact is precisely because this is not dissociated from wider options therein on the European socio-economic model, with a parallel emphasis on social cohesion and sustainable development.

[21] See on this f.e. Fung, A., & Wright, E. O. (2008). Empowered participation for the UK; The Emerging Politics of Republican Democracy. In S. White, *Building a Citizen Society; The Emerging Politics of Republican Democracy* (pp. 83-92). London: Lawrence and Wishart.

It is important to note here that the discussion about science, technology and innovation is clearly an international one, at present focusing on international competitiveness, earlier on global geopolitics. The trend in the internationalisation of STI is increasing at different levels, actors, activities, policies. Governmental policies give greater attention to the foreign exchanges of their local research and innovation systems but also to the international flow of policy approaches. National policies are often developed in close collaboration with international STI partnerships. This is particularly clear at the EU level, where the proposal to develop a European Research Area, but international policy collaboration is not limited to the European arena, and has been developed, at different levels, by other countries and regions, such as in Africa.

In this context, it is clear that the national policy-maker has in fact a limited set of instruments and policy options with which to work with and implement policy. This is particularly so in less developed countries. Strongly dependent on foreign credit, on foreign donors and on foreign policy experiences, but as well and primarily on foreign competition, the roads left for experimenting with local policy are indeed limited. These constraints work at different levels. International organisations providing financial credit limit the types of public intervention that recipient countries can consider and promote market liberalisation. With weak bargaining power in the face of strong financial needs, less developed countries are left with only limited opportunities to promote endogenous technological capability building, and to develop more interventionist policies which were characteristic of earlier experiences of catching-up, and are largely ignored within the current neo-liberal policies framing these international organisations.

Similar unequal global relationships, where the experience from history counts less than the present discourse, are evident at multiple levels. Trade regulations or IPR regulations also provide strong examples of one size policies that give limited attention to the specific needs of Southern economies. While increasing appropriation of knowledge is guaranteed in the North, objections are raised to the protection of resources that are at the centre of knowledge activities in the South, such as the protection of traditional knowledge, or the full establishment of the Convention on Biological Diversity. The emphasis on the firm as central actor in the process, and the transfer of models focused on the firm to other areas of production and use of knowledge, overlooks the importance of other organisational forms in the Global South, such as local communities, the public sector, universities and research organisations. Scientific migration is one other example, extensively analysed in the ResIST project and further discussed below. The dominance of established macro-level indicators in the assessment of national performances of the STI systems also leads to further international pressures on the direction of policies.

The lack of success of most policies oriented towards the eradication of poverty in Africa has led to significant debates within development studies, and among the aid community. The strong role of donor agencies and countries also challenges principles of accountability, with less developed countries having greater incentives to be more accountable to external agencies rather than to the local population, questioning also principles of inclusiveness discussed earlier. While some of the most

controversial contributions to these debates, challenging the experience of foreign aid,[22] may be questionable, it is clear that new policies are required.

There is a need to go beyond the views of the State as a see-all planner, and to incorporate initiatives directly oriented towards addressing basic problems of the population, and to provide them with further knowledge resources in that process. This also means that STI policies should not be envisioned simply within the restricted definition of research and innovation activities, delivering responsibility to the competent Ministry. Instead, STI policies should encompass different activities, such as in health, sanitation, or agriculture, where some form of knowledge is essential to the solution of a specific relevant problem. The approach has not been tried in full as government policy and under appropriate conditions, but there is a lot of scattered evidence that suggests the plausibility and potential of such an approach. It is certainly justified and important to try to do so. Contesting and re-writing the "rules of the game" may be as integral and essential parts of that competitive game itself.

While, as discussed above, national policy actors have a limited role in implementing overall innovative strategies, they can play particularly strong roles in developing initiatives which address local conditions of inequality. They articulate STI issues with larger national values and set the agenda for attention to social cohesion by sub-national policy actors. As we concluded, it is difficult to find such STI policies which explicitly address inequality unless we focus on our integrated framework with three forms of inequality. STI policies have been less explicit about addressing vertical inequalities, other than in the international arena. In that sense, when one hears about STI policies that address inequality this mostly refers to global inequalities. Official policy papers that address questions of inequality through science and technology are not easy to find in Europe and other more developed countries. Take as an example European policies. As conveyed through the Lisbon Agenda, EU policy is expected to be more inclusive, with concerns with social cohesion on a par with those with economic growth. In practice, S&T enters this discourse essentially through the attribution of a greater priority to the importance of knowledge in contemporary society, largely as a fuel to future economic growth, rather than in the expectation that science and technology could contribute for a more effective identity of the European social model. In this way, science and technology and social cohesion appear as two goals that work more in parallel than effectively in tandem.

On the contrary, developing science and technology for strengthening industrial technological capabilities and for solving local problems related to development and to factors of exclusion has been a road taken increasingly by Southern countries. In fact, these countries appear to have no other choice, as the countries in the North do not seem to promote particular policies to improve the distributional impact of STI and to promote inclusion processes through STI.

While concerns with harnessing 'knowledge for development' or with achieving social cohesion alongside the development of competitive knowledge economies are voiced at different levels, there appears to be much less being effectively done to match discourse with practice. It is clear that unless the relationships between science

[22] Cf. William Easterly (2006) *The White Man's Burden: Why the West's efforts to aid the rest have done so much ill and so little good*, The Penguin Press: London. Moyo, D. (2009). *Dead Aid; Why aid is not working and how there is another way for Africa.* London: Allen Lane. Easterly, W. (Ed.) (2008). *Reinventing Foreign Aid.* Cambridge, MA, USA: MIT Press.

and technology and inequality are taken up explicitly up front, at the different arenas where policies are designed and negotiated, there are little resources left for the bottom billion to benefit from the promise of progress brought about by science and technology. Or in other words, a new approach to STI policy-making is needed.

National innovation systems approaches and the mobilisation of science and technology against inequality

For about two decades now the innovation systems approach has been an important framework with which to analyse how countries, regions and sectors perform with respect to technological change, science and economic performance. The innovation systems approach can be seen as an attempt to address the shortcomings of the neo-classical approach to assess the economic importance of innovation and the restrictions of unilinear conceptions of technological change.

An analysis in terms of innovation systems recommended itself as a result in which (a) innovation is central rather than treated as an exogenous variable, (b) a variety of factors (science, market, government policy, institutional architectures, culture) are proposed to be investigated and assessed in terms of their interactions and effects.

The attention and support from OECD and national governments and institutions may have promoted a certain emphasis on the study of so-called national innovation systems. Initially national innovation system studies focussed on the technologically most advanced countries, but later became generic, and it was claimed that it could also be used to support and discuss innovation and policies in economically less-developed regions and cultures and in the new nation-states of the Global South. National innovation systems have become a popular key buzzword, and members of our advisory board cautioned us that unless we would frame our recommendations in terms of national innovation systems, policy makers in southern countries would not listen.

The national innovation approach is certainly attractive as a framework to analyse and discuss the build up of capacities in science and technology in less-advanced economies and new nation states. To endorse it can be very helpful to get a comprehensive view of the problems and opportunities and to decide on priorities and consequences. To use the approach to address science and technology in the struggle for equality and against poverty and deprivation, however, requires inclusiveness and the political strength to overcome obstacles that stem from established powers in government, industry, the professional organisations and the science system as established. Apart from that, the approach itself also has a number of weaknesses when it comes to addressing problems of less developed economies and issues of inequality. Godin argues that the concept is essentially rhetorical and fuzzy.[23] Although this has not hampered its use, in empirical case studies it allows for ontological gerrymandering between broad and narrow definitions where situations are ambiguous.

[23] Godin, B. (2005). *Measurement and Statistics on Science and Technology:1920 to the Present*. London: Routledge. Godin, B. (2003). The emergence of S&T indicators: why did governments supplement statistics with indicators? *Research Policy , 32*, 679-691; Sharif, N. (2006). Emergence and development of the National Innovation Systems concept. *Research Policy 35 (2006) 745-766 , 35*, 745-66; Hagendijk, R., & Brouwer, R. *National innovation systems and development in the 'Global South'*. forthcoming.

One obvious limitation has to do with the extent to which the national governments, and especially those in developing countries, are actually in a position to do much about innovation and its consequences. Where governments with big bureaucracies to support them and advanced monitoring systems fail to address issues one cannot expect under-resourced governments in sub-Saharan Africa to be able to come to grips with issues that are clearly transnational in nature or that are mostly a matter to be dealt with at the level of villages, cities and provinces, like issues of water management, sustainability, pandemics and international financial crises. There is a danger that innovation systems approaches are too much endorsed as a part of building government bureaucracies rather than to actually address issues of inequality and poverty. This is not to say that such NIS approaches serve no purpose if it comes to addressing issues of inequality but the relevance should not be overestimated.

A final feature of the national innovation systems approach has to do with its seemingly a-political nature. This enhances a focus on the aspects of innovation systems and advice in politically neutral terms that avoids political sensitivities and political choices or addresses them indirectly at best.

On the basis of our work in the ResIST project we conclude that national innovation approaches certainly play a very important role in establishing, discussing and assessing institutions and policies to stimulate S&T and innovation in developing countries. Yet we also conclude that the contribution of the approach to actually implementing broad conceptions of innovation is ambiguous, and its relevance for the struggle against inequality, deprivation and poverty is questionable.

The positive contribution of the national innovation approach as well as its limitations are illustrated in the cases of South Africa and Mozambique, two countries that are economically rather different but which share a commitment to develop their economies and innovation systems so that all citizens will benefit.

Soon after the Mandela government came into office the new South African government embraced the national innovation system approach. It did so in the 1994 Green Paper on Science and Technology and in subsequent documents. The Green paper clearly states that it endorses a broad conception of innovation 'from high technology to the promotion of incremental technical changes in traditional activities' (DACST, 1994: 21). However, a particular and small rather than broad conception of innovation in actual fact emerged and it came in a format that shies away from addressing issues of inequality, poverty reduction, and making the available knowledge resources available to broader sections of the population.

Such an approach may be useful for the recovery and build up of the national state bureaucracies that are supposed to manage science and technology. It may help to re-arrange and intensify the relations between the economy and the science sector. And it may even be important for the benefit of the entire country to prepare for changes in technology, economy and society in the long run by preparing the ground for capacity building. But with respect to benefiting all citizens and addressing issues of inequality the plans formulate goals and visions whose delivery cannot but remain an open question. And this is inherent to the politically neutral and technical systems approach adopted and the focus on the existing knowledge institutions. In this respect the start of the redefinition of the South African innovation policies resembles the points and criticisms of the NIS approach formulated in general terms above.

The verdict in the most recent OECD review (OECD, 2007) can be summarized as 'satisfactory but not without problems'. Science and technology instruments have improved even if South Africa is not keeping up with other similar countries. The country is doing well in technology exports, but this is dependent on defence systems build up during the apartheid years. Between various departments and organizations there is overlap and tension about missions, ownership and performance. The most successful development signalled by the OECD has been the Nuclear Pebble Bed Reactor program. However, developing that facility was never part of the science and technology programs, but an independent activity of the Department of Energy. Furthermore, the Pebble Bed Reactor program is at the centre of the main problem of the system, the 'skills crunch'. It drains resources away from other priority areas where capacity shortages are threatening now that an older generation of scientists is about to retire. And while the priority programs introduced in the late 1990s are in part successful, the one on poverty alleviation, remarkably, has not been implemented at all according to the OECD. While a recently published new vision remains optimistic, it has been considered by critics as overly ambitious. Poverty alleviation is no longer a stated priority.

Poverty alleviation is often – but not always – not so much a matter of developing new science and technology but of actually getting it out and teach people how to use it. The question at the centre of tensions in this respect is whether such policies, e.g., connecting people to sewage systems and promoting sanitation, is a part of a broad conception of innovation or not. While the Green Paper points in the affirmative direction, strong forces point away from actually implementing such a broad conception and focus programs and policies towards a more limited set of indicators and international comparisons, in which the promotion of equality through science and technology does not get much space.

In Mozambique too attempts have been made to define a national innovation policy and to develop administrative and managerial provisions for government policies. And once again this is best seen as part of the build-up of capacities of the state to manage the country, its facilities for science and technology and its interface with industry, agriculture and other parts of the economy. Mozambique has not the resources and manpower to execute such a plan on its own. Whether and to what extent the plan will be implemented will depend on international support.

We believe a similar story can be told for other many other countries of the global south. The adoption of national innovation approaches serves key aspects of the reconstruction and build-up of science and technology systems in nation states that recently became independent or that are going through radical transformation after major and divisive conflicts and constitutional and economic renewal. In this context, national innovation systems approaches are best seen as discursive devices that allow representatives from government and from key stakeholders to deliberate policy issues.

What seems to be needed, i.e. what should be stressed much more explicitly instead of remaining merely reverential, is a conception of innovation policy that is directly and explicitly tied to a broad and inclusive conception of innovation and that explicitly includes social goals alongside strictly economic ones. Such a policy also needs to specify the basic formats of inclusion, consultation, deliberation and decision making to be adopted if one endorses such goals. Such a conception, to be outlined and contrasted with currently dominant conceptions in the next section, also implies the

build up of specific new indicators, participatory instruments and new forms of accountability towards broader segments of society.

Changing policy paradigms: from KEPP to SCoPP?

The discussion above of the application of one of the most widely disseminated STI policy approaches, based on the concept of the National Innovation Systems, suggests the need to reflect upon existing STI policy frameworks and their dissemination. This is, however, not simply a question associated with development policies, but it has to do more with the impacts of STI policies and not just in the Global South. It applies equally to Europe. We argue that STI policies can be distinguished according to the extent in which these take distributional objectives and impacts of policies explicitly and systematically into account on a par with economic growth and firm level objectives. Alternative policy approaches question, rearticulate and extend at a fundamental level the structure and limits of the existing economy-focussed frameworks. These new approaches may amount to a *paradigm shift* in STI policy, reflecting fundamental changes involved in policy objectives and priorities. Underneath most current policies for innovation there is in our view a basic logic that we call the "knowledge economy policy paradigm" (KEPP). We use this as a baseline to describe elements of an *alternative* policy paradigm, where the (un)equal social distribution of benefits and costs of STI policies are central. We call this alternative paradigm the "social cohesion policy paradigm" (SCoPP).

While the two policy paradigms are, as a whole, integrally different approaches, the differences between the two on specific points might well be less in actual practice. Yet we strongly believe this issue is not about shifting the balance a little in one aspect or dimension. To develop policies that really address issues of inequality in a consistent and adequate manner requires a more basic reformulation in terms of a comprehensive and coherent policy model or paradigm. It is not simply the degree of opposition on particular issues that is at stake but the overall view and its inherent concern with distributional impacts, access to resources and participation and representation in decision making process, the three dimensions of inequality which ResIST has been concerned with. We consider that the dimensions described below encapsulate central differences between the two.

Objectives

A central difference between the KEPP and SCoPP would lie in the extent to which economic growth and competitiveness are the overriding policy objectives. We argue that this is the case in KEPP. Its main focus is on improving competitiveness, fostering innovation in firms, raising productivity levels, and more generally a focus on aggregate economic performance. In SCoPP the ultimate objectives are not just economic ones but also include social objectives at the same level of importance and more generally aims at building a more sustainable and cohesive society. While improved economic performance of firms is certainly important, the SCoPP policy framework is not guided by this single objective but rather by achieving wider levels of progress and wellbeing in society, reflected also in terms of improved education, provision of health and social services, social cohesion, sustainable lifestyles and, not least, reduced inequality.

Capacities

The paradigms differ in the way in which they conceive of and treat agents, knowledge, and the concentration of resources. As a result structural inequalities will be handled differently under each paradigm.

Under KEPP private firms are clearly the key **agents** in innovation and as such the main target for public policies. Innovation is in this context a concept clearly embedded in firms and markets. For the policy-maker working under SCoPP, innovation is spanned more broadly across society. Other agents beyond firms have an important contribution to innovation processes that goes beyond their role as users of innovations. These include non-governmental organizations and policy bodies, but also communities, families and individuals. Innovation is not simply a process developed within private firms but is rather the result of the activity of a variety of innovative actors throughout society.

As a result, in the focus is on the type of **knowledge** chiefly produced within firms, within research and development (R&D) departments, as a direct contribution to their own innovation processes. The importance of R&D based knowledge is certainly not disputed in SCoPP, but there is a wider focus on learning processes and other forms of knowledge and experience beyond formal science. Innovation in low and medium-tech firms, and the use of other forms of knowledge, local, experience-based, traditional or indigenous knowledge, is also stressed. From the point of view of inequality, these policies are formally more inclusive by addressing a wider range of actors, and considering how other forms of knowledge are important to create and exploit distributed capacities of change among society.

In the KEPP discourse of economic growth and competiveness the **concentration** of resources to get critical mass has a prominent place. Such concentration, while implying some forms of exclusion in performance is argued to be in favour of greater collective prosperity. This would result from trickle-down effects. KEPP practitioners are thus likely to work towards the concentration of resources to support innovation in few institutions and places. Empirical evidence suggests that such trickle-down effects are quite limited in geographical scope, which is reflected in a variety of asymmetries in regional development. This is even more blatantly visible at the global level. A SCoPP approach would be more inclusive with respect to building distributed capacity geographically and otherwise. While maintaining the level of excellence at the top of the system, SCoPP would set as a specific objective raising the level of excellence across the system, including in particular disadvantaged groups.

Governance

A paradigm is reflected in both content and method. The two policy paradigms we are considering are reflected not only in their goals and innovation concepts, but also in how they make decisions. This is reflected in the processes used to take decisions, the extent to which the governance structure is accountable, and how, for such decisions, and the role of quantitative indicators in organizing decision-making processes.

KEPP governance relies heavily on elites to **make decisions**. If formal science is the privileged form of knowledge, it also defines who may be considered best positioned to make decisions on behalf of society. Policymaking under SCoPP must involve stronger forms of democracy if it is not to be self-contradictory. If many kinds of knowledge are valuable in the innovation process, those contributing to STI decision-

making should also be several. If innovation goes on in many places then decisions about it must be broadly participatory. Specialists need to share the power of knowledge with others. This has also implications for global governance and decision-making processes.

Under KEPP, **accountability** is expert based. This has traditionally been the case, as one would expect under guardianship. The widespread move to New Public Management has reinforcing an emphasis on efficiency and control, largely through performance indicators (a "science of science policy") and now constitutes an integral part of the KEPP approach. Under SCoPP, in contrast, accountability is achieved through direct public engagement and discourse. Available indicators should not simply reflect global performances, with a focus on competitiveness, but also reflect activity at the different levels of the system, and in particular with respect to multiple policy objectives. It is important that the indicators are not the single mode of accountability. There is no possibility of delegating the contextualization and interpretation of those indicators without involving the stakeholders the research or innovation activities were intended to serve.

The general characteristics as well as the relative stability and coherence of KEPP are reflected in the core set of **indicators** that has been developed within this framework for validating successes/failures, monitoring progress and guiding development of STI policies. They embed the corresponding approach to STI policy and therefore shaping and constraining policy formation. These standard indicators emphasize the salience in the KEPP framework of the most R&D intensive manufacturing industries. These industries epitomize the knowledge economy: they are extremely R&D intensive; scientific knowledge and research are immediate sources and drivers of innovation; they are fast growing and highly profitable. SCoPP needs to develop a remarkably different set of indicators. Inclusive governance processes themselves would be key indicators of the health of the system. More crucially, SCoPP would make a serious attempt to connect the development of innovations, and formal R&D activities, to outcomes in daily life, in a more sustainable and more cohesive world.

Outcomes

The two policy paradigms embrace different ways to understand, and to expect, outcomes of STI policies. While the mitigation of inequalities, for KEPP, is only expected as an indirect outcome, SCoPP considers that expected benefits in terms of social outcomes must be an integral concern of STI policies. These differences are reflected namely at the level of the drivers of innovation, on the role of IPRs and on the way the resulting benefits and costs of STI are shared.

The concept of market failure is central to both KEPP and SCoPP. Under KEPP, however, innovation has become increasingly **driven** by the market. A shift has taken place in the relative roles of public and private R&D performers and funders. The widely-debated issues of access to essential medicines issue may thus be the symbol of one type of "market failure" that has not been addressed in prevalent policies framed in terms of effective market-based STI policies. SCoPP would incorporate a needs-driven STI agenda to balance and supplement the dominant model of market-driven innovation. This is particularly important in developing countries as scientists and researchers who return after studies in developed countries continue to work on research topics which are often disconnected from their local context.

At the very heart of KEPP is the concept that knowledge is a form of capital that can and should be owned. It is of course the specialized, formal knowledge that is seen as valuable, forming the basis for new business opportunities and new industries in the global economy. Strong, standardized "one size fits all" protection for **intellectual property rights** becomes part of the KEPP. SCoPP makes a simple and subtle shift from this position. It maintains the basic idea that inventors should be rewarded for their inventions with a short period of temporary monopoly. But it eliminates all the dysfunctional extensions of this principle that have crept into the system over the years. SCoPP would need to take up the task of maximizing public benefit rather than private profit from the utilization of knowledge.

The various aspects of KEPP, as described, tend to give access to the **benefits** of new technologies to the affluent and central. By changing the dynamics of the system, SCoPP is designed to equalize these outcomes as well, in order to achieve its ultimate goal of shared prosperity, which is making daily life better for everyone. In doing so, it will probably be creating more sustainable conditions for the development of science, technology, and innovation in all their forms.

Role of public policy

KEPP and SCoPP also carry two different conceptions of the role of the state in the STI policy realm. In KEPP, the state is merely a facilitator of increasingly firm- and market-driven innovation dynamics. The state has a much higher level of responsibility under SCoPP, and it is now a facilitator of a dialogue between productive capacity and public need. As a consequence, these different paradigms have different success criteria. While KEPP looks primarily into the quantitative indicators, for SCoPP the success of the policy is not only assessed by what it directly achieves, in balancing economic growth and social cohesion, but also by the capacity for change it is able to induce across different actors.

The exposition in terms of two juxtaposed paradigms should not suggest that it is just a choice between two options. Nor is it a choice between two opposing alternatives, one focusing on economic impacts, the other on social impacts. The challenge, which SCoPP is placed to address, is to embrace a multi-objective framework rather than a unidimensional one. In this sense, while our primary concern here regards social inequalities, we have also highlighted the wider impact on other sectoral policies strongly tied to development options, such as planning policies and the impacts on the distribution of knowledge activities, or environmental policies and the objective of guaranteeing a sustainable development. These are also an integral part of a social cohesion approach.

Scientific mobility, knowledge transfer and capacity-building

In earlier debates on development, the priority of building a labour force highly skilled in S&T was controversial. Tertiary education has lower priority in some developing countries than primary and secondary education and this is due in part to the policies of the World Bank and other international agencies in the 1980s and 1990s. These policies were predicated on the belief that the returns to investments in higher and secondary education are greater, and equity arguments about the need to establish universal access to basic education. Nevertheless, for the purposes of

building and governing a modern state in the age of globalisation, especially in the light of the growing perceived contribution of knowledge to economic growth and social welfare, highly skilled and experienced S&T personnel are seen as essential.

Building and maintaining a highly skilled labour force is extremely sensitive to scientific migration, and globalisation has encouraged mobility. As a result many highly-skilled people leave their country of origin in search of better opportunities elsewhere. From the perspective of developing (sending) countries the collective impact of individual mobility presents significant, and inadequately understood, challenges to research policy. These individual decisions are shaped by a range of professional and personal factors including research policy in the 'receiving' countries and regions.

Growing concerns over the phenomenon of 'brain drain', implying a unilateral flow of human resources and knowledge (scientific capacity) are evident in the development agenda. In academic and policy discourse, overly simplistic notions of 'brain drain' have given way in recent years to those of 'brain circulation' emphasising the multidimensional movement of skilled personnel and the importance of return moves. More recent research has questioned not only the temporal assumptions underpinning the brain drain concept and the implied relationship between human mobility and knowledge transfer.

Our general aim in developing future options under ResIST is to try to balance continued economic growth with increased social equity; to reconcile a policy prescription emphasising the growth through the development of the knowledge economy, with one emphasising social cohesion – twin objectives at the heart of the Lisbon strategy.

Mobility of researchers is considered an "essential feature" of international cooperation but the context for this is that Europe is seeking to compete for the best researchers (CEC, 2008: 14). The need derived from the Lisbon strategy for Europe to recruit 700,000 new researchers in addition to those needed to respond to demographic concerns is likely to lead to Europe being seen as parasitic on the developing world. It is also likely that migration of scientific personnel within Europe, from south-east to north-west, will become an increasingly live political issue. International competition for expertise is increasing, and developing countries are starting to follow the developed in using selective immigration policies and incentive schemes.

The situation has prompted some researchers working in rather different geographical contexts to identify ways of restricting highly skilled mobility or, more positively, developing means of promoting return. The findings of the RESIST research do not support the institution of policies designed to impose restrictions on individuals' free movement rights, although increasing the opportunities remain and work effectively in the home countries and incentivising return is critical. Rather the research has identified the role that opaque and restrictive domestic employment policies play in encouraging people to leave (Ackers, 2008).[24] Mouton's thematic paper (Mouton et al., 2009, op. cit.) focuses on capacity building within the 'donor' regions with targeted funding for institutions rather than individuals. Esau and de Waal's thematic paper

[24] Louise Ackers (2008) *Ethical Dilemmas: Individual Human Rights versus Sustainable Development. Excellence, Migration and Equality Policy: Managing Unintended Consequences?* ResIST Thematic Paper, Deliverable # 11. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.

(Esau and de Waal, 2009: 17)[25] argues that restrictions on migration may be impractical and simply not work. Oliver's thematic paper argues that there is scope for policy development at European and national level to encourage a greater return on scientific mobility for sending region (Oliver, 2009).

One means of promoting sustainable scientific mobility in the development context is through effective harnessing of knowledge embodied in the scientific 'Diaspora' (Gill and Ackers, op. cit.). Lowell and Gerova (2004)[26] proposed a classification of interventions and initiatives to redress the brain drain, known as the six 'R's – reparation (the compensatory tax principle discussed above), restrictions, recruitment, return, retention and resourcing diaspora policies. To this list ResIST has added a seventh 'R' – remittances: the extent to which the highly skilled abroad can be mobilised to send home what Oliver has called 'knowledge remittances' as well as financial remittances (Oliver, op. cit.). Research suggests that highly skilled migrants actually send less money home than their unskilled compatriots (Khadria, 2002;[27] Ackers and Gill, 2008).[28] Of course, these kinds of remittances also increase the potential for forms of education-related mobility.

In countries or institutional contexts where there is capacity the 'brain circulation' thesis may apply and sending countries may realise certain returns on outward migration. Yet even in these more favourable circumstances Oliver's work suggests caution about the impact of such networks. Individually motivated and directed professional activities involving the sending country were more prevalent than involvement in formal networks/organisations. Policy makers need to consider ways of harnessing the potential in informal professional networks rather than generating new kinds of often artificial and unsustainable formal networking initiatives.

Supporting the professional contributions of researchers prior to return is important. This study found that those who anticipated returning to the sending country were less likely to seek to contribute at a distance – they anticipated that they would share their knowledge and skills upon return. However if return isn't realised these contributions are never made. Professional activities conducted at a distance ranged from informal knowledge exchange and sharing ideas to training doctoral candidates, delivering professional training, conferences and seminars through to joint collaborative projects.

Some of the smaller scale and 'more every day' contributions such as writing a paper, giving guest lectures or using professional contacts to bring researchers together, were overlooked by researchers who saw 'making a contribution' as something major or outstanding. A combination of formal and informal relationships bolstered by concrete activities was central to the success of many of the examples of cross national collaboration. A further key to success was maintaining research interests in

[25] Simone Esau and Liezal de Waal (2009) *Where have all the health scientists gone? : A South African question*. ResIST Thematic Paper, Deliverable # 10. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.
[26] Lowell, B.L. and Gerova, S.G. (2004). *Diasporas and Economic Development: State of Knowledge*. Institute for the Study of International Migration, Georgetown University. Prepared for the World Bank.
[27] Binod Khadria (2001) 'Shifting Paradigms of Globalisation: The Twenty-first Century Transition towards Generics in Skilled Migration from India' *International Migration*, 39, 5, pp.45-72
[28] Louise Ackers and Bryony Gill (2008) *Moving People and Knowledge: Scientific Mobility in an Enlarging European Union*. Cheltenham: Edward Elgar Publishing.

fields that were relevant to the sending countries. This supported the continued relevance and further development of existing social networks.

In order to throw light on the motivations of individual migrating scientists, the study included interviews with highly skilled people who had left less developed countries (South Africa, Turkey) to work in more developed countries (the UK, Germany), some half of whom had since returned home. For highly skilled South African health professionals, the 'pull' factors which increased their incentive to migrate included personal professional opportunities such as gaining international experience, or specific training or scholarship opportunities; access to human and non-human resources: technologies, networks and contacts; financial factors in terms of higher salaries and the opportunity to repay student debt; and the attractions of international travel.

The 'push' factors – the perceived home country negatives which propelled them towards emigration – were in many cases the direct reciprocal of these: international isolation and lack of 'broader horizons' and new approaches; poor resources for clinical research and lack of 'critical mass' in research environments; pay, hours and working conditions, and lack of job opportunities, including, for white (male) South Africans, the perceived limitations of opportunity for this social group resulting from affirmative action in favour of previously disadvantaged groups; and wider social and economic factors, including perceptions of crime rates, the economic downturn, and falling standards in public health care and education.

There was a third set of 'enabling factors', which facilitated the migration decision or choice of location. These included existing professional or personal links, skills or affiliations: the ease of registration with professional bodies; existing professional contacts; location of critical mass of academic or clinical expertise; common language; and colonial ties and dual citizenship.

An important finding for diasporal management is that taking the first step in international scientific migration may also lower the personal barriers to further moves.

As the diaspora management paradox set out above makes clear, the relatively poor state of research facilities in many African countries can be seen as both cause and consequence of the gradual erosion of human capital through the brain drain. The loss of highly skilled personnel in some African countries appears to be on such a scale as to be contributing to processes of de-institutionalisation of science and technology across much of sub-Saharan Africa. Many of the scientific institutions across Africa exhibit similar fragilities. They are susceptible to the vagaries of political and military events and are severely under-resourced and suffer also from a lack of clarity and articulation of science governance issues (demonstrated by constant shifts in ministerial responsibility for science). As well as the loss of highly skilled personnel, three other factors continue to shape and affect the (de) institutionalisation of science in these countries: the continuing legacy of colonial science in many countries; the destabilizing influence of political events and civil and regional wars; the role of international agencies in shaping African sciences.

Policy approaches to promoting migration and immigration in the European Research Area place an emphasis on individualism and migration between centres of excellence. This is in tension with other policy narratives stressing the importance of balanced growth and sustainability. EU policy does seek to address capacity building

within third countries (see Oliver, 2009). However, where international cooperation policies are tailored to developing countries the policy on migration is not. This tension is a familiar one in labour economics, and in many areas of labour market management relatively easily resolved. Countries that embrace many of the mechanisms characteristic of the social cohesion policy paradigm from ResIST's work often do so on the basis that higher social insurance arrangements will allow more flexible labour market regulation which in turn may help deliver greater growth. Balanced growth in these instances comprises a safety net beneath a higher risk, higher performing economy – in ResIST's terms, KEPP on the back of SCOPP.

One provocative thought that arises from this focus shift that international aid serves the function form of social insurance or compensation for developing countries which allows for international recruitment of their highly skilled or for free trade; another form of KEPP on the back of SCOPP. Similarly there might be resistance to the idea that the European structural funds are a compensation for the economic imbalances that result from the free movement of scientists and technologists within Europe. The point of these slightly perverse thought experiments is to emphasise the importance that migration policies, along with those for trade, aid, and intellectual property, are seen as linked and interdependent. A wider process of accountability would have involved detailed accounting for the pluses and minuses of these separate elements, so as to be sure that the total policy package is seen to deliver net benefits to developing regions and countries.

Special attention still needs to be applied to the creation and maintenance of internationally competitive S&T. This is a highly capital and skill intensive activity, and institutions in developing countries and regions whose intellectual capacities have been built up over decades can lose them rapidly. In the short term this loss for developing countries can threaten not just the science base as such, but a whole range of capacities essential to trade in and diffuse and regulate science-based products and services. At the same time, of course, such losses of highly skilled personnel undermine the longer-term strategic objectives of training the next generation and developing local knowledge economies. These considerations of course apply as much within Europe, in differences between countries and regions, as in Europe external policies, where Europe's hunger to suck in more scientists and technologists in order to compete in the premier league of international competition could be seen as a major contribution to the entrapment of many countries in the lower leagues.

Every effort should be made to support effective knowledge transfer and exchange. Supporting networking and circulatory migration patterns should supplement and not replace attempts to support return. International networking grants already exist (for example FP 7 International Staff Exchange Scheme or the UK Royal Society Networking Scheme). Consideration should be given to developing a specific 'Diaspora Grant' based on the principle of providing 'seed corn' funding to support migrant scientists based in the EU to develop or maintain professional networks within the sending country.

Policy makers should support migrant scientists to maintain contact with colleagues in the sending country even where stays are relatively short-term and migrants (or the mobility grant itself) anticipate return. Receiving countries should investigate the value of relatively small scale individual activities and support early career researchers to undertake them. Smaller scale Diaspora Networking grants could be used to promote the value of engaging with activities such as presenting research,

writing papers and planning grant applications. These could be targeted at early career researchers. Capacity building activities and funding could be targeted at teams with long term and established links in the sending country. The UK/South Africa Royal Society/National Research Foundation Joint Collaborative Programme could be a useful model here. Evaluative information is scant: there is need for a continuing effort to assess national and international policies in this area.

The most general policy implication here speaks to the relationship between brain drain from the South and the state of scientific institutions in these countries. Our analysis points to the key role of the institution and how the brain drain continues to erode institutional capacity and institutional research culture. Any attempt to reverse the brain drain will fail if it does not also consider interventions and initiatives that restore and eventual make these institutions sustainable research institutions.

Very few African universities (outside of South Africa) have well-established research management offices. Although some effort has been made in recent years to strengthen the local expertise in this field, this is simply not enough. Our experience shows that many research managers at these universities are recently appointed, have very little knowledge of how to manage the institutional research profile and how to access funding and support to do so. In addition research directors and managers of doctoral programmes require much more training and support across a wide range of skills and competencies. If capacity building is to replace de-institutionalisation, more ambitious and sustained efforts are required along these lines.

More broadly, we have seen it as one of our legacy responsibilities under ResIST to contribute to developing countries' capacity to undertake the kind of critical, independent policy study that Resist represents. Accordingly we have taken an initiative to set up a Science, Technology and Development Network to help focus work both on the issues and the analytic capacities needed – particularly in Sub-Saharan Africa – to engage with them, and to contribute to capacity building in this area.

Sending countries need to pay careful attention to the factors identified above to ensure that the positions and professional environment is as attractive as resources permit in order to discourage out-migration and ensure that excellence is allowed to flourish in science research.

Emerging technologies and inequality

Emerging technologies are new, science-based technologies that have a high potential to increase both economic growth and social inequality and appear as a strategic research site for examining the interactions of inequalities between countries and inequalities within countries. When technologies are already fully consolidated, public policies have limited tools for intervention. On the contrary, public intervention can make a difference through interventions with emerging technologies.

Because of the high research costs and skill requirements, emerging technologies can generate distributional consequences through high relative prices at both structural and distributional levels. For this reason, emerging technologies have a higher potential than older technologies for generating inequalities in access and employment. The distributional impact of new science-based technologies can be considered in terms of the business opportunities created, the employment generated,

and how the benefits and costs accrue to different actors. The benefits and costs of creating, producing, and using the new technology vary considerably across countries and people, a situation which is shaped by policy interventions.

The work developed in the present study analysed five technologies in eight countries. To capture the full impact of emerging technologies across different development levels, the analysis focused on technologies that emerged some time ago to be able to track actual effects rather than projecting them. The cases were information and telecommunications technologies and biotechnologies. The five cases studied are: genetically modified (GM) maize, mobile phones, open source software, plant tissue culture, and recombinant insulin.

We gathered data on the five technologies using a common data collection protocol in eight different national contexts, including four developed and four developing countries. The ResIST team studied their own countries in Europe and Africa (Germany, Malta, and Mozambique), and a companion grant from the U.S. National Science Foundation allowed our U.S. colleagues to study countries in the Americas: Argentina, Canada, Costa Rica, Jamaica, and the United States. The fact that these countries ranged widely in size, national wealth, and science and technology capability is a strong point under the case study approach, since the operation of the classic model was examined under a wide range of conditions.

The basic logic of the data gathering and analysis was that *technological projects* affect *inequalities* in *valued items* through pathways that are technology-specific, mediated by *national conditions*, and shaped by *public interventions*. We looked for distributional consequences of the technologies in four valued items: business opportunities, employment, benefits, and costs. Not every technology was relevant in every country, but in the end data was gathered for 34 country-technology pairs, leading to the analysis of results for each technology across the country examples and for each country across the technologies covered there.

The classic model of technology diffusion posits that after a new science-based technology is developed in the research and development department of a firm, it is typically introduced in a sophisticated, high-priced version that is marketed to a limited number of high-end users. As the market expands, the price of production falls and the firms producing the technology market simpler versions in order to reach broader markets. Eventually, the price drops far enough that the product reaches a mass market.

While the economic and technological conditions of countries where the use of these emerging technologies was studied are highly diverse, it is important to note that access to the technologies is not only mediated by the overall structural conditions. Other conditions, in particular the local existence of appropriate expertise and infrastructure were identified as central factors affecting the capacity of countries, firms, communities or individuals to benefit from these technologies.

Two major non-price constraints on the use of emerging technologies emerge – appropriate expertise and complementary infrastructure. A clear illustration is in the open source example. By definition, the product itself is free, which means that other factors shape the distributional patterns. However, in-house expertise to absorb and maintain the product is necessary and only available for some, typically large, firms. Similarly, private consumers rely on the existence of a computer. For those who do not have a computer, open source software still provides no benefit.

Recombinant insulin provides another appropriate example. In Argentina, Costa Rica, and Jamaica, there was a wide availability of recombinant insulin. This was largely through health insurance and public health services. However, where someone was not covered by this underlying social infrastructure, he or she did not have access to the technology. Access was not directly dependent on the technology, but rather on the wider supporting infrastructure.

Pockets of concentrated expertise can make a difference in whether a technology's benefits are accessible in a particular country. In the more affluent countries the distributional issues have to do with spreading the business opportunities around geographically, creating equal opportunity for traditionally marginalized groups, and subsidizing access in some cases. Without special policy efforts to distribute the benefits broadly, emerging technologies are absorbed through the existing relations of power and production and tend to increase the wealth and influence of those already at the top in those societies.

Because technologies do not take effect independently of wider, complementary, assets, services and capabilities, it is on this wider technological project, which some actor or set of actors (the "champion") tries to make happen, that we focused. The way the technology offer is packaged – with what services, with what price and payment plan, and with what accessories – is of the essence. Mobile phones are a good example of this. They are a product-service combination, which not only includes the hardware technology, but also the specific pricing options for the service itself. This was indeed a crucial factor in extending the market and the access to more poor population. Other technologies provide clear examples of the need to focus on the *technological project* itself, such as open source software.

These technologies emerged in a diversity of institutional environments, including international public laboratories (plant tissue culture), publicly-funded university research (recombinant insulin, GM maize), and private laboratories (mobile phones and open source software). The institutional context of discovery does not predefine its social impact and is not exclusively linked to public or private initiative.

However, there are important differences in the contexts of use and commercialisation of the technologies. Intellectual property rules, a traditional instrument of STI policy, are an example where the institutional context makes a significant difference, as we described earlier. In this way, the social benefits, in terms of reduced inequality, of each technology are dependent on such framework conditions. But the relevance of public intervention is not limited to traditional STI policy instruments, and other sectoral interventions can also be of significant relevance for the distributional impacts of emerging technologies. Five main categories of interventions that fall outside traditional STI policy emerged with particular relevance in the cases studied: public procurement; public utility oversight; anti-trust actions; health and safety regulations; and environmental protection.

The expected social benefits may justify forms of intervention without the use of direct subsidies, i.e. of an indirect nature. For example, public utilities are closely regulated because of the perception that they provide basic services that should be accessible to all citizens. Public utility oversight therefore plays a re-distributive role in some countries in the mobile phone example. The other sets of public interventions identified in the cases are health, safety, and environmental regulations. The different locations where the technology is produced and where it is used often requires that the corresponding different local regulatory processes have to be complied with.

The classic model of distribution of access to emerging technologies based on price does not fully characterize the potential impacts of emerging technologies on inequality. The assessment of the distributional consequences of emerging technologies must consider not simply the diffusion of technologies themselves, but also the business opportunities which these create, the wider employment effects and the overall benefits of costs derived from the actual use of, not simply viewed in terms of access to, emerging technologies.

We found that due to the science base of the emerging technologies studied, in three out of five technologies a strong role for intellectual property limited the business opportunities. IP protection has the tendency of concentrating assets and business opportunities. In contrast, in two of the studies IP is either not important (tissue culture) or used to disperse the business opportunities (open source, which enforces open IP). In these two cases, however, there were other barriers to entry for new businesses. In the open source example, an individual or company must have a high level of technical skills to get into the business.

The science base of the emerging technologies also implies that micro-enterprise is an unlikely beneficiary of the new development, and in three out of five stories, this hypothesis is confirmed. Nevertheless, opportunities arise for small business, such as in the open source project, which undermines the concentrating effects of the proprietary software business. And in the mobile phone story, micro-enterprise is a prominent feature, from local businesses that sell minutes on cell phones to those who do not own them to the ubiquitous pre-paid card vendors in Mozambique. Both these examples involve micro-enterprises based on re-selling small quantities of a product produced by another company.

While IP ownership strongly shapes the control of business opportunities, the employment associated with our five technologies remains, equally surprisingly, largely located in the affluent countries in the study. In some cases the new product does not produce new jobs, but is rather absorbed into an existing production process. New jobs in the new industries thus do not always displace older jobs, but may in fact retain them. What is at stake is not only the creation of new employment opportunities, but also the extent to which new technologies create unemployment in the old technology sectors. No major shifts in employment were visible in any of our case studies.

All the technological projects we studied provided benefits, so the diffusion of the technology itself is one important indicator of the distribution of those benefits. As expected, price is an important determinant of diffusion or penetration rate, but we were interested to find that it was definitely not the only one.

Each technology's history is different, making the findings complex. They illustrate both the benefits and limitations of distributional outcomes. All were conceived in pursuit of some general public benefit. One could not predict beforehand, based simply on the institutional context of discovery, which of the five would produce the broadest benefits. They all show, however, that public interventions throughout the process do make a difference, from commercialization environments to competition policies. Options are available to public decision makers for spreading the opportunities and benefits of emerging technologies more broadly.

This process can be developed collectively, along the process of development or of adoption of the technology, in much the same way that emerging technologies are

assessed by formal bodies in Europe and other countries. Technology assessment (TA) has become institutionalised in countries such as Denmark, the Netherlands, and the UK to reflect upon the social implications of new technologies. We propose that this process be specifically broadened with the view to consider the social implications of new technologies, both for the needs of countries in the Global South, as well as to the benefit of the less favoured groups in our societies.

Even if national contexts do frame the social impact of emerging technologies, it is clear that such process of distributional technology assessment (DTA) can be organised collectively to the benefit of the less developed countries, to contribute to the emergence of the appropriate complementary assets, where necessary, and to consider different forms of public intervention. There is much to be gained in this process through the sharing of global expertise. Such DTA process ought to be firmly grounded on networks of existing expertise, or more specifically, as we propose in the following section, on a *Science, Technology and Development Forum*. The different forms of public intervention, if considered beneficial, should then be decided at the national level. It will be the mix of local actors, in the business sector as well as in communities and in households, the corresponding complementary assets in terms of capabilities and infrastructures, and the public interventions that will dictate the distributional consequences of the new technology.

Clearly, there is no one-size-fits-all set of recommendations that can be made based on our analysis. National circumstances and political traditions differ but have in common the objective of spreading the benefits of emerging technologies more broadly. The real worlds of emerging technologies are diverse, but all carry within them the possibility of more equal outcomes for the world's households.

Building and responding to networks of expertise

ResIST seeks to throw light on and develop strategies to counter an obdurate social problem. Since it was clear that we see science and technology systems, policies and processes as embodying and reproducing the inequalities that constituted that problem, it was clear from the outset that we needed to engage with those undertaking and managing S&T. This was necessary in order to tap into their perspective on the distributional issues that were of key importance for study, to have some sense of how social, economic and S&T goals related in their own policy systems and, later, to refine our research results through dialogue with them. In this way we hoped to improve the relevance, utility and take-up of what we did, but we also saw it as a reflexive act, in following our own concerns, by tying ResIST into an accountability structure.

This can be seen as our first, short-term, objective – to 'establish effective links with policy and practice in the three selected representative geo-economic areas.'[29] The dialogue with policymakers and practitioners became one element of our second objective, to build about the capacities that would be needed on a continuing basis, after ResIST to support further academic and policy work on the issues we raised – establishing 'a basis for sustained mutual learning on issues, mechanisms and models.'[30] This second objective developed as the project progressed. Both objectives

[29] ResIST Description of Work, p. 23.
[30] Ibidem.

were in service of a wider aim 'of retaining focus on the overall objectives to support policy and practice which can support balanced growth.'[31]

There were two planned strands of dialogue under this immediate objective. The first was intended to be with the Commission. We sought to contribute to the growing dialogue between DG Research and DG Development, and we were looking forward for involvement of and communication with relevant people at the European Commission. Unfortunately this was not fully possible, but we believe that policy relevant research like ours can benefit if measures can be put in place to allow the boundaries between researcher, funder and policymakers to be managed in a more sensitive way, resulting in richer interactions. The potential of such interaction was evident at our final policy seminar in which staff of the Commission took a full active part.

The second strand of dialogue was with policymakers and practitioners in the selected geo-economic areas (Europe, Southern Africa, Latin America and the Caribbean). Initial dialogue at meetings in Maputo, Rio de Janeiro and Istanbul led to the formation of a ResIST Advisory Group whose members contributed to discussion in further meetings in Coimbra, Stellenbosch and Brussels. This was very fruitful, and what ResIST has achieved can be seen largely as co-production based in these exchanges. The Advisory Group provided clear suggestions that shaped our work and detailed feedback on individual work packages. With others they also contributed substantially to the idea of the follow-up action-research studies to ResIST, and to our reconsidering the disciplinary inputs and perspectives that should shape our future offerings of expertise on these issues.

We have also sought to contribute to research which seeks to counter inequalities within or between nations. Entirely on the basis of links with policymakers and practitioners made in the course of our research, we are in the course of working on a proposal to develop and apply ResIST's approach in four specific world regional contexts where we have worked:

- In support of the Turkish Programme of Local Innovation Platforms;
- In developing and applying a Caribbean Regional Policy Framework for S&T and Sustainable Development;
- In supporting a Public Health Initiative in Mozambique;
- In delivering a North-South Collaboration on Women's Health between the UK and Uganda.

A project proposal is expected to be put to funders in the last quarter of 2009. If successful, we expect such work to make a policy contribution in a local context, as well as making a methodological contribution in, for example, mapping and measuring the effects of different approaches to research development.

We also sought to re-think our contribution to expertise networks, despite ResIST already being a widely-based collaboration between sociologists, anthropologists, philosophers, economists and political scientists, whose work is broadly informed by the interdisciplinary enterprise, science and technology studies (STS). At the 2008 joint meeting in Rotterdam of two professional STS societies, the Society for Social Studies of Science (4S) and the European Association for the Study of Science and Technology (EASST), as well as presenting the work of ResIST over two sessions,

[31] Ibidem.

Rob Hagendijk organised a Development, Globalisation and STS Roundtable to consolidate and broaden such interdisciplinary collaborations in the context for development. The Roundtable was notable for bringing together Development Studies scholars ('sensitive to local contexts, blackbox-ing technology') with those specialising in STS ('sensitive to technology, blackbox-ing local contexts'), so as to combine their strengths, and compensate for weaknesses in intellectual perspectives/expertise[32]. It led to the establishment in September 2008 of a STS, Globalisation and Development network with a website (http://st-and-dev.net) and a programme of activity drawing on a range of funding sources, including a workshop in Amsterdam in June 2009 on *Technoscience and the transformation of the Global South.* It has been a specific goal of these initiatives to involve young researchers and practitioners from the South, who have the possibility of being central actors in this process. As this network develops we hope that it will contribute to a programme of meetings and researcher exchanges in and with the Global South that will help to strengthen the capacities for research and analysis there.

In our Second Review Report (deliverable #34), four specific proposals are set out which are aimed at supporting policy and practice which uses S&T for the 'social knowledge economy'. The first of these is discussed in the context of helping to bridge S&T capacity gaps in Europe; the other three are oriented primarily to international development contexts, but all can contribute to both purposes. They are:

- Establish a firm basis for the assessment of the outcomes of different forms of public participation in setting and delivering research priorities, either in their own right, or in contributing to the delivery of public goods or services; recognizing the diversity in needs and settings.
- Support knowledge remittances through the fostering of knowledge, business and investment networks between the knowledge diasporas in Europe and their originating countries in the developing world.
- Press for wider and fairer arrangements for knowledge ownership and contribute to a wider debate through support of a South-based Science, Technology and Development Forum.
- Develop a broader set of indicators of the social knowledge economy: the relationships between science, technology and innovation policies and social cohesion, applicable to states with diverging values and needs in development.

We recommend the formation of an international *Science, Technology and Development Forum*, with experts from around the world, that would explore investigate and assess the effects of technological and scientific change on culture and society in technologically less advanced societies and especially with the respect to the effects of such changes on the livelihoods of poor people and groups disadvantaged in terms of any of the three forms of inequality ResIST discusses: structural, representative or distributional. The experience in Europe (and other countries) with technology assessment could be extended to include the effects on other societies. Such a Forum would best be led from the Global South but with active support, participation from and accountability for the EU. Such an initiative would facilitate the discussion of these issues and the development of a comparative

[32] A notable collaboration of this kind has been established in the STEPS programme in the University of Sussex, bringing together researchers from two distinguished organisations, SPRU and the Institute of Development Studies.

knowledge base. A second task that could be pursued through the proposed *Science, Technology and Development Forum* would the development of a broader set of indicators of the social knowledge economy.

It is through the development of networks of expertise of the kind proposed here that the capacity to develop a more reflexive and inclusive science and technology policy can be established.

Recommendations

Our studies confirm the idea that science and technology can be important instruments in the fight against inequalities in contemporary societies but that they are often not systematically harnessed to that type of goals as a matter of self-conscious and reflexive policies across the branches of national government and transnational agencies and organizations for development collaboration. The inequalities that characterise the process of emergence of innovations – structural, representational and distributional – can as much be reduced as well as exacerbated unless full consideration is taken of the diverse actors and institutions, their identities and ontologies, and if STI policies does much more explicitly include considerations of inequality among their objectives. So, the ResIST project has important implications for policies at the national and global levels in countries in the Global South as well as inside the EU. It also raises questions and shows the need for further reflection on how dominant policy frameworks often travel from the North to the South, i.e. are transplanted and copied without being sufficiently taking into account how conditions differ and how lofty intentions may be marginalized by local institutional political and bureaucratic dynamics and interests as they are perceived by particular local stakeholders.

Broad conceptions of innovation and the importance to help the poorer parts of a country and its population are often endorsed in policy documents. Yet, there is reason to ask whether subsequent STI policy implementation in practice do not often diverge too much from such goals and approaches. Our work suggests that a divergence sometimes is threatening the policy approach chosen en its goals in favour of a focus on advanced internationally visible science and high tech as well as ideas about economic growth and competiveness expected to be dependent on developing these sectors. We do not deny the potential importance of such issues, but we believe that a broader innovation approach and the struggle against inequality with the help of science would benefit from a much more explicit articulation of goals of social cohesion and participation. The development and exposition on the differences between what we called a knowledge economy paradigm (KEPP) and a social cohesion paradigm (SCoPP) bring out these differences.

1. Introduction: Science, technology and inequality

The idea that science and technology may contribute to the elevation of mankind, the mastery of nature and the liberation from ills and evils is part and parcel of the emergence of modernity and modern science, as we know it today. Science and technology are part of the Enlightenment project, symbol and instrument of the emancipation of mankind vis-à-vis the dark forces of nature, societal oppression, political and economic exploitation, injustice and psychological repression. As a counter-current to this, critics from various corners have argued that the Enlightenment was itself an ideology serving repression, exploitation, injustice, destruction of the natural environment, promoting war instead of peace and once again a force of repression. In between these extremes there are those who argue that science and technology are forms of instrumental reasoning and technical means that may be associated with virtuous as well as diabolic goals depending on context and circumstance. The history of culture abounds with examples in literature, cinema and comedy that bring out science's ambiguous nature. Governments and international policy agencies that wish to mobilise science against inequality are well advised to be aware of these polarized assessments and to thread carefully between ignorance and blind optimism.

Steering such a careful course requires awareness of the contributions from other cultures to knowledge, science and technology as well as sensitivity to the long term history and conflict ridden institutionalisation of modern knowledge production. It also requires the adoption of a broad conception of science and technology which includes the humanities and social sciences, as well as forms of indigenous knowledge. Acknowledgement of the roots of science and knowledge in Indian, Chinese, Islamic and African culture alongside the Western legacy will help a dialogic approach to science as being part of the heritage of mankind instead of being an export product of Western culture and society or, even worse, an ingredient for a clash of civilizations. To do so does not have to stand in the way of a recognition of the achievements of modern science, its empirical turn and its institutionalisation as critical, politically and religiously independent way of promoting knowledge and rational argument. It is one thing to acknowledge the roots of the university in Madrassa schools, yet another to deny the development of the modern research universities as part of modern science and key to the education of emprical researchers and engineers. And finally a abroad conception of science that includes the humanities and social sciences and their history and practical involvements will stimulate us to appreciate the extent to which cultural and social knowledge is and has to be implicated in attempts to mobilize science and technology against inequality and underdevelopment.

The redefinition of issues of inequality between people and cultures has been at the heart of the Enlightenment project as much as the promotion of science and rationality. The same can be said with respect to issues of human and civil rights and democracy. Just think of the declarations that accompanied the alleged political expressions and milestones of the Enlightenment, like the US declaration of independence and the French *Déclaration des droits de l'Homme et du citoyen.* Especially in the course of the twentieth century (but also well before) governments and kings have tried to harness science and technology for political, economic,

cultural and social policies.[1] Science and science-based technology have been identified as key to development and economic growth. Socialists and other reformers have seen it as instruments to redress poverty, deprivation, marginalization and other ills. Today's globalization is also routinely associated with the introduction and spread of science and technology and more specifically with communicative and transport technologies. The key economic importance of science-based knowledge has led to the widely endorsed claim that we now live in or are moving towards "the knowledge society" or the 'knowledge economy'.[2] 'Knowledge society' is juxtaposed with industrial society, class-based society and in some case information society (UN, 2005).

'Knowledge societies' are as much about 'knowledge' as they are about 'risk' and 'uncertainty' and how to deal with the latter. Institutional reflexivity (the attempt to systematically review behaviour and policies for goal achievement, indirect consequences and re-adjustment) are seen as a systematic feature of such knowledge societies. This feature is demonstrated in the emergence and flourishing of departments, statistical and data gathering offices and think-tank organizations charged with reflexive review. Critics have pointed to the dark side of science throughout its modern history. The risks and danger of unrestrained commercialization of scientific findings is another theme. Science may be less innocent and neutral with respect to social, political and economic goals then science's acolytes occasionally claim. In so far as science promotes 'rationality' in economics, governance and the handling of human well-being, it represents, so it is argued by critics, a particular kind of rationality that is less universalistic and more partial and restricted with respect to the definition of truth, beauty and good than assumed by overly devoted modernists. The critique of modernity is a counterpoint to the marching melodies of modernity's progress since the late 18th century.

Both the debates and the societal developments just indicated are routinely situated in and associated with the European urban centres and their inhabitants from the 15th century onwards. Yet they are also associated with aggressive and benevolent forms of expanding 'Western' culture across the world. And from the very start they have been related to what is being made of 'The Other'[3], the cultures and societies that are nowadays, for lack of a better word often referred to as the Global South. Science, technology and a particular type of instrumental rationality have informed the ways in which people in the West conceive of natural and social evolution and the West's leading role in the World. And in line with that they have contributed to practices of colonization, imperialism, exploitation and social and technical 'progress' in dealing with 'traditional', 'classical', 'oriental' and otherwise labelled cultures. All this is echoed in the responses from the so labelled cultures and their populations themselves and their conceptions and performances of truth, morality and aesthetics. Here again

[1] Histories of the connections between science and its exploitation for economic and other goals abound as do studies of how the institutional configuration of science is changing in recent decades. For example, Ziman, J. (2000). *Real Science: What It Is, and What It Means*. Cambridge, UK: Cambridge University Press.; Gibbons, M., et al. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage; Nowotny, H. E. (2001). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge, UK: Polity Press. For a recent historical analysis see Steven Shapin (2008), *The Scientific Life; A Moral History of a late Modern Vocation*.Chicago: Chicago University Press.
[2] UNESCO (2005). *Towards Knowledge Societies*. Paris: Unesco Publishing.
[3] J. Fabian (2002). *Time and the Other*, New York: Columbia University Press, 1983.

the positions range from endorsement of 'Western' conceptions of modernity, rationality, civility, science and technology to an outright rejection of any or all of these.

As soon as we take these 'purist' articulations at the extreme poles for what they are what we actually see is an imbroglio or mixture of valences as well as practices in the middle. The middle ground so defined is the actual ground where distinct cultural traditions, forms of experience and knowledge as well as normative commitments meet, clash and cash in to recombine into elements and mixed configurations that serve situated goals and practices. Everywhere in the world advanced contemporary knowledge and technology mix with traditions and cultural (often religious) commitments of a different nature. Commitments to knowledge development, human welfare, equality and rights are almost universal, it is in their elaboration that we may differ, productively or in a more destructive way.

A closer look at this middle ground at the turn of the millennium also reveals that if anything inequality is a ubiquitous feature of the global knowledge society in which the relation of science and technology to the origins, current forms and consequences of inequality are unclear and – if only for that reason – contested.

A lot remains to be done if equality and democracy are universal and pertinent rights and if science and technology are supposed to support their achievement. As the work of the reflexive institutions now documents, the connection between scientific and technologically based growth and inequality at large remains ambiguous. In the so-called BRIC countries[4], the newly emerging economies that rely heavily on the use and exploitation of advanced technology, there is a catch up going on vis-à-vis the economically advanced economies but at the same time internal inequality in countries like China has grown enormously[5] and a group of countries seems to emerge that remain behind constituting the 'bottom billion'.[6]

All this raises the pertinent question if and how science and technology can be harnessed to promote equality and how the opposite (S&T leading to more instead of less equality, more poverty, increased marginalization etc.) might be avoided i.e. counter-acted.

This is the question that is at the heart of the ResIST project about which we currently report:

> "…whether and how science and technology are contributing to the production, reproduction, and reduction of inequalities today, and what scope there is for policy change." (ResIST Description of Work, p.4).

In the ResIST project which researchers from a variety of countries worked together with policy makers and representatives from academia and civic organizations to

[4] Brasil, Russia, India and China. Recently Indonesia and South Africa have been added to the list (i.e. BRIICS) by the OECD. (2008). *Globalisation and Emerging Economies; Brazil, Russia, India, Indonesia, China and South Africa.* Paris: OECD.
[5] See Naughton, B. (2007). *The Chinese Economy; Transitions and Growth*. Cambridge, MA, USA: The MIT Press, 209-28. China now ranks amongst the countries where inequality is highest, but the data and methodology leave room for some reduction of the indices (220-1).
[6] Collier, P. (2007). *The Bottom Billion; Why the Poorest Countries Are Failing and What Can Be Done About It*. Oxford, UK: Oxford U.P.

explore the questions just raised. Work focussed on four thematic areas or work packages:

- the framings of policies;
- intellectual migration of people and capacities;
- accountability;
- new emerging technologies and their distributional consequences.

The project was funded (FP6 Contract no. CIT5 – CT-2006 – 029052) by the EU reflecting the EU's stated ambitions with respect to its internal as well as global objectives. In line with these it was one of the explicit goals of the project to explore also the ways in which networks of expertise with respect to S&T policies in relation to inequality may be developed to promote integration of ambitions with respect to inequality reduction and mitigation in EU and international policy making.

2. Forms of inequality and their interconnections

From the very start the ResIST project endorsed a multi-faceted conception of inequality in which inequality in terms of access to resources, getting representation and the ability to participate in decision-making and deliberation were combined with a consideration of the inequalities at the level of distribution.

At the most general level inequality refers to 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. Amartya Sen (1992)[1] notes that inequality is a multi-dimensional space, within which different political philosophies emphasize equality on different dimensions. Some observers value equality in rights, others in power, and still others in income or the provision of basic needs like food and shelter. Decreasing inequality in one dimension almost always increases it in another.

Economists, who tend to focus primarily on inequalities in income, distinguish between vertical inequalities (among individuals) and horizontal ones (between groups, such as between women and men or between ethnic or religious groups). The unequal distributions of other valued items also fall along these two dimensions, as may happen with the distribution of harms which most wish to avoid. So, for example, a disadvantaged ethnic group may be disadvantaged in political power as well as income, and women may bear more than their share of the costs of technologies, as in the asymmetry in birth control devices. Horizontal inequalities are important limiting factors in social cohesion and inclusion.

Reducing inequalities in various dimensions goes on under a variety of names. Reducing inequalities between countries in national wealth is one way of describing the challenge of economic development. Reducing inequalities between countries in the extent to which the basic needs of their populations are met is a way of describing part of the human development challenge. Reducing absolute poverty is a central part of that challenge, which also has health, education, and environmental components. But inequalities between countries can also be seen in terms of power. When less affluent countries demand and achieve power, they reduce this type of inequality.

In ResIST three types of inequalities have been distinguished: structural, representational and distributional:[2]

Structural inequalities refer to unequal distribution of human and institutional capacities inside as well as between countries.

Representational inequalities refer to differences in the permeability of decision making processes to inputs and influence from various groups. From the very beginning representational equality has been associated in the ResIST project with 'accountability'. In situations in which particular groups can be said to be represented this may actually be a dead letter because of their inability to hold officeholders to

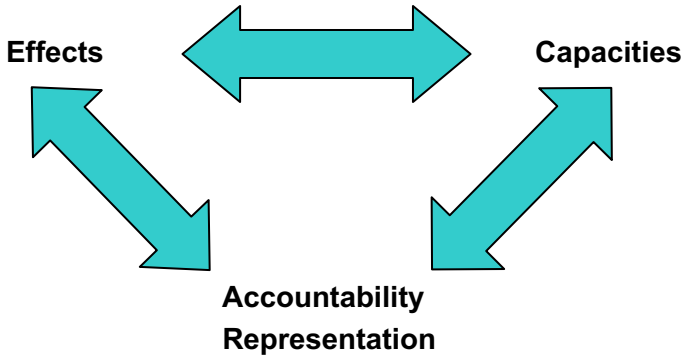
[1] Sen, A. (1992). *Inequality Reexamined*. Cambridge, MA, Harvard University Press.
[2] Cozzens, S. E., et al. (2007). 'A Framework for Analyzing Science, Technology and Inequalities: Preliminary Observations.' *ResIST Working Papers*. Oxford, UK: James Martin Institute, Oxford University.

account. 'Representatives' that cannot be thrown out by those they claim to represent in some way are often not much help in addressing problems of inequality.

Distributional inequalities refer to unequal distributions of the benefits and costs of economic and other goods.

If we look at science and technology and policies aiming to promote and use them for social goals one may think of examples of where and how they connect to issues of inequality and how to address them. *Inequality in access* to knowledge is characteristic of the uneven distribution of science across the globe. The migration of highly talented people towards the centres of advanced learning in the US and Europe and the de-institutionalisation of science in, for example, Africa[3] reinforce that. A trend insufficiently countered by remigration or capacity building policies and 'brain-circulation' if it comes to effectively addressing the issue of inequality. Women and people with lower class backgrounds are *underrepresented* in science. So are 'neglected diseases' that are often of special importance to people in the 'Global South' and groups treated as 'marginal' in advanced societies. All this may be associated with *distributive* inequalities. For example, those with health insurance are more likely to benefit from new drugs and therapies than those without; the affluent are less likely to live close to major sources of pollution; subsistence farmers are less likely to benefit from new seed strains if they are expensive; etc. The benefits and costs of public science, technology, and innovation programs are referred to as outcomes or results, as well as effects as we do here. Planning for and monitoring the achievement of outcomes has become a major part of the public management framework of many governments, and is therefore increasingly important in STI policies and programs.

The cyclical effects of various types of inequality became iconically enshrined in what we called the CARE cycle.



ResIST makes three key assumptions: a) that science and technology policy may counteract or reinforce inequality depending on choice made and their implementation; b) that various forms of inequality exist, including those associated with science and technology; c) that a better understanding of the connections between

[3] See Johann Mouton & Roland Waast (2008). Study on National Research Systems. A Meta-Review, paper presented at the Symposium on Comparative Analysis of National Research Systems, 16-18 January 2008, UNESCO, Headquarters, Paris. See also section 9 below and Volume 3 of the ResIST project.

science, technology and inequality may lead to better innovation policies in terms of addressing issues of inequality, coherence, and social cohesion.

Given the complexity and multi-faceted nature of the concept of inequality just outlined, there is a very wide range of actions that could be taken into account in STI policy to reduce inequality. It is important, therefore, to distinguish several basic approaches (Cozzens, Gatchair et al., 2006).[4] When the policy aims to reduce poverty or address conditions associated with poverty, it can be put it in the "pro-poor" category. When the policy is directed towards decreasing horizontal inequality, it belongs to the "fairness" category. When the policy works to decrease vertical inequality, we will put it in the "egalitarian" category. Each of the categories rests on a different rationale and calls for different kinds of actions.

The backdrop of the ResIST project is the deep challenges of uneven development and persistent disadvantage for many communities and societal groups. The project seeks to explore ways to use science, technology and innovation to address such challenges and create sustainable development both in social and physical terms. Research and development in general and in high-technological industries in particular are nowadays seen as key drivers of growth in modern globalized "knowledge economies". It is, however, also true that knowledge in a wide variety of forms and ways is essential for creating new ways of doing things throughout the economy, including in low and medium technology industries, and science-based knowledge and innovation may, and very often does, depend and draw on this variety and heterogeneity in knowledge. As will be argued in more detail below we suggest that contemporary STI policies are often focused too narrowly in terms of goals and targeted sectors to effectively address these issues of inequality. Although broad conceptions of innovation are regularly being mentioned in policy documents this often amounts to little more than lip service if one looks at what happens in actual implementation practice. Within the discourse of STI policies, a tension exists between economic competitiveness as a goal, on the one hand, and social cohesion, on the other hand. According to many commentators, the competitiveness goal is put into practice in a variety of ways, but the second often remains at the level of rhetoric. ResIST highlights the importance of a broad conception of the role of knowledge in the "knowledge economy" and associated actual and accountable implementation of such a conception, regardless of whether economies are more or less technically advanced. Such broader STI policies have inclusiveness and accountability (politically and administratively) as guiding, heuristic principles. Such inclusiveness and accountability refers to forms of knowledge, of technologies and of social groups and issues of inequality and development that are targeted and mobilized in the framing of science, technology and innovation policy agendas.

[4] Cozzens, S. E., S. Gatchair, et al. (2006). Distributional Assessment of Emerging Technologies: A framework for analysis. Globelics, 2006, Kerala, India.

3. Science, technology and development: actors, institutions, identities and ontologies

Regardless of the 'broad' or 'narrow' conception of innovation one adopts, differences of opinion and conflicts about choices and priorities will persist. This is quite understandable. And alongside 'innovation', categories like 'science' and 'technology' are also so broad that they encompass an endless variety of activities, forms and products.[1] The diversity of science and technology policies in terms of goals, focus, instruments, scope, and formats of engagement is enormous. Different political and ethical commitments, uncertainties about the facts of the matter and sheer or deliberately generated confusion cloud the issues as well as the debates as people and organizations try to influence research and development activities. Governments do this of course, but also entrepreneurs, NGOs, international organizations, consumers and scientists and engineers themselves. The same observations obviously apply to the notion of inequality. Assumptions and key concepts are often not explicated or debated. Nor are the levels of action or the corresponding central actors. Policy makers may be pre-disposed to think primarily of the nation-state if it comes to development policies and stimulating the role of science and technology. In regions, however, where national governments may be weak and where international regimes are prominent it would be wrong to assume such predominance a priori and without further ado. Transnational networks and local groups may be more relevant in various respects. Market fundamentalists may assume that markets can be self-regulating only to be interfered with in case of market failure, ignoring how much markets depend on provision and regulation by governments. It took a worldwide financial crisis to make everybody once again aware of the delicate interconnections required between market and state for markets to function properly.

The goal of ResIST under the contract is to explore possibilities to mobilize science and technology to enhance equality with respect to key social, economic and cultural issues and to maintain and protect social cohesion. It is therefore important to clarify how we have tried to deal with all these complexities and uncertainties.

The CARE cycle and pragmatic division of ResIST into various work packages focussing on policy frames (WP1), migration issues (WP2), accountability (WP3) and emerging technologies (WP4) provide in themselves already some further specification. Yet, that was not enough. In each of the case studies and analyses in the work-packages national and regional contexts and cultural differences between countries and regions come into play as well as transnational, i.e. cross-boundary configurations. ICT implementation is quite different from developing anti-malaria drugs. The science is different, applications require different elaborations, and marketing and regulation of products are different. But then again: How sweet potato research and new products derived from scientific research may enter Mozambican policies, markets and kitchens is a policy issue quite different from building a national system of innovation in, say, South Africa. In science and technology studies it has been extensively documented over the last century that no two laboratories are actually the same. Rather, it is in scientific discourse that the scientists involved decide or assume that they can be treated as the same with respect to the issues and questions at hand. Until there are good grounds to challenge this judgement. All this applies in the same way to the world beyond the laboratory, the world of politics and

[1] We generally use 'science' to denote the natural sciences as well as the social sciences and humanities.

social and cultural practice. Comparisons are important and instructive – and we will present them below – but their limitations and constructive nature should always be kept in view in making analysis, if not in employing them for rhetorical purposes.

Studies following the perspective indicated above are sometimes dismissed as merely reproducing actors' stories and perspectives. And as the policy makers are themselves part of the study the extra mileage available to policy studies would be limited. We disagree here and not just because it is silly to say that one does not learn from feedback, looking in mirrors and attending a recording of past practice. In the policy debates, in policy practice and in the ways in which attempts have been and are made (or sidelined) to mobilize science and technology to fight inequality some features, distinctions and arguments again and again come to the fore amounting to what one might call structural features of that discourse. This is the case even if the empirical case or debate seems to be about much more restricted issues, like whether farmers in A should get subsidies to grow particular crops. Or about freedom of movement around the world for highly skilled personnel urgently needed for technologically advanced multinational companies. Whatever the issue somewhere underneath assumptions are entertained about the role and power of the state, about economic liberties and about individual citizen and human rights.

Ideologically fuelled views are competing with one another in debates and decision making about specific issues concerning the ways in which science and technology may contribute to alleviate and address inequalities. And such debates are normally not very explicit about fundamental distinctions and assumptions. Social sciences and economics may support decision making about the issues at hand with quantitative analyses, but the limitations of such studies and their dependence on sometimes ambiguous or arbitrary operationalization of key variables should be kept in view. And apparently they often do not really end the confusion but rather shift it to new ground. It is a technocrat's dream and a democrat's nightmare to assume that the confusion can be radically ended through research, that it will provide hard and reliable universally applicable tools and that a wall can be built between facts and values once and for all. One of the potential weaknesses of government related policy institutions is that they may be under constraints to adopt a technical, i.e. apolitical definition and approach. This leads to the danger that political choices are unduly kept out of the analyses or reframed in technical terms suggesting that better policy is just a matter of improving regulatory regimes, governance systems, etc.

And yet, critical social science analysis can also be helpful to the discussions and decision making by analysing the positions actors adopt and how these merge and change, their interactions and networks, the way decisions are made and how these and the subsequent developments are accounted for and lead to further deliberations and actions. In social studies of science and technology this approach is generally coined in the dictum 'follow the actors'. Work along those lines over the last three decades has clarified what goes on in science and technology and has shown how scientific facts and technological artefacts, values and social and physical arrangements in the world are 'co-produced' in the interactions amongst scientists, engineers and the physical and social environments of which they are a part and on which they work. Overall the work in ResIST has been inspired by this general approach, often dubbed 'constructivist'. We have looked at the ways in which key actors in the practices and problems investigated frame the problems at hands, how they disagree, what they do and what their actions and interactions result in. We have looked at how issues and considerations of inequality are dealt with and where and

how encouraging or discouraging examples and experiences emerge. And in doing this we have included occasionally the way in which insights from the social sciences come into play in this discourse as well. This is the case in the case studies on participatory budgeting, but also in the analysis of emerging technologies, (transnational) accountability, international migration and obviously in the policy discussions themselves.

In all our case studies distinctions and relations between market and state, government and science and between citizens and government come into play, even when this is not explicitly mentioned as such in the actual discourse of the participants (but it often is). Where the lines are drawn and what this implies for the identities and capacities of citizens, politicians and entrepreneurs is at the same time conditioning the debate and struggles as well as at stake in the struggles and negotiations that are going on. A key recommendation is therefore that one should always include an analysis of what particular policies to mobilize science and technology against inequality imply for the interconnections and relations between state, economy, civil society, and citizens. Let's elaborate on this to show the importance at the empirical level.

In discussions about policy making and certainly with respect to policy making there is always the national government. What should the government do, what can they do, what do people and organizations want them to do? And related to that: What should they not do, abstain from, avoid? What is beyond their grasp? How are they are embedded in transnational networks and dependent on donor conditionalities? Policy analysts and commentators are inclined to think that governments make a difference for the better and that they are major actors when it comes to innovation policies to improve human fate. Anthropologists like Jim Scott and many others have warned against the effects of 'seeing like a state' (Scott, 1998)[2]. Economists, and especially those following the neo-liberal and neo-conservative approaches, are nowadays often sceptical about too large a role for the state as well. So are entrepreneurs, at least till the shit hits the fan. The arm of government is often much shorter than those in government like to believe. While some analysts may focus on national innovation systems and how to improve them through government intervention, others argue that the key agents of change are not necessarily in government. NGOs, local citizens groups, business networks might be as important or even more. Recommendations for inclusive policies and broad concepts of innovation often have to do with this, also in this report. The state has to play an important role but an overly state-centred approach may be less productive in mobilizing the research that is really important, but a more balanced approach steering away from the 'model of double delegation' (Callon, Lascoumes, & Barthe, 2001) that underpins most Western thinking about the roles of science and politics in dealing with social problems may be preferable.[3]

[2] James Scott (1998) *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven: Yale University Press.

[3] The double delegation model holds that for many problems in society decision-making by those affected has been delegated to political representatives, on the one hand, and scientific experts, on the other. Yet many contemporary problems appear difficult to deal with in this configuration and should be complemented, according to Callon et al. by alternative forms of creative deliberation and decision making. Callon, M.; Lascoumes, P.; & Barthe, Y. (2001). *Agir dans un monde incertain : essai sur la démocratie technique*. Paris: Éditions du Seuil. See also section 5 below for a more extensive discussion of the double delegation model.

Against those who plead for more government and more inclusiveness, we find those who argue that in the long run markets and entrepreneurs are essential for economic growth that will provide the resources needed to address the problems of inequality and poverty. Earlier experiences with too much involvement of politics and the state in development policies have proven to be disastrous according to many economists and economic liberals. Against this others will point out that the neo-liberal and neo-conservative policies summarized in the so-called Washington consensus have been dramatic as well. If one is interested in mobilizing science and technology to address issues of inequality and how policies to this end work, it is fruitful to explore the ways in which actors define the configuration, what this implies for the role of science and technology and what the effects are. Sometimes the debates about this are quite open and explicit as in some of the Mozambican debates about the role of governmental agencies and governmental regulation in the introduction of new products and crops. Sometimes complex public-private-partnership arrangements are introduced in which the actual strength of players will be dependent at least in part on reigning conceptions about the role of the state and the importance of private property and the interests of industry. The development of a new vaccine provides many examples.

Human and citizens rights also come in to play in some form in all these cases. Often this remains a sort of implicit assumption underneath or prior to the state-market nexus. In debates about migration, however, it becomes quite explicit. And likewise in debates about food or public health crises. In less dramatic situations the debate often is about the question between humanitarian support and relief and situations where one should proceed in accordance with rules that provide for economic liberalism, private enterprise and a limited role for government.

International dependencies and transnational networks also play a key role in all this as the cases studies on transnational accountability and the negotiations about migration of high skilled labour demonstrate.[4] The struggle against inequality and its implications is an acknowledged international challenge. The ideological debates and cleavages referred to above are fought in international arenas and organisations, as the reporting on WP1 will extensively document. Environmental protection, sustainability, intellectual property protection, drug regulation, agricultural biotech are subject of – slowly – emerging international regimes. And so is development policy. Especially since 9/11 and the emergence of 'security' as a key element in international relations development policies are being reorganized and the activities and funding of what NGOs and international agencies are changing and move towards tighter control and coordination between donors and governments of recipient countries.[5]The analysis of local relations between governments, citizens, entrepreneurs and scientist/engineers is necessarily incomplete if the extent to which they are part of emerging and changing international regimes is left out of consideration. The same goes for the analysis of transnational networks that do not consider how things play out 'on the ground' in the mundane interactions between people situated in villages (or government's local offices for that matter). In the various sections below and in extensive reports on case studies this issue will reappear regularly.

[4] See section 5 below.

[5] See Duffield, M. (2007). *Development, Security and Unending War; Governing the World of Peoples*. Cambridge, UK: Polity. For a recent book on the EUs external policies see Rodrigues, M. E. (2009). *Europe, Globalization and the Lisbon Agenda*. Cheltenham, Gloucester, UK: Edward Elgar.

A lot of what has been argued above may seem pretty straightforward and familiar. Working from a constructivist perspective one looks for the way actors define situations, what the main narratives are, how people and narratives, i.e. vision, clash and how the outcome of such clashed are determined by the relative strength of players involved. This relative strength will again depend on access to resources, the ability to harness the agency of others to the realisation of one's project or program and the ideological, normative and moral rules and categories one can bring to bear to convince others or to legitimate the use of force. Yet, things are always more complicated if one integrates the knowledge dimension and the role science and technology may play to address problems and issues of (in)equality. While it is possible to get a long way by treating the natural and social worlds as a given and restrict one's analyses to relations between people and their networks, things become more complicated once knowledge and scientific research come into play in framing and analysing the problem and to come up with scientific advice on what to do.

To question the connection between knowledge (science included) and policy-making means engaging with questions of what Mol and Law have called 'ontological politics'.[6] Ontological politics assumes that any given reality or object possesses multiple versions that are enacted, manipulated and built through the mediation of multiple instruments or resources during the course of a diversity of practices. In this sense reality does not precede practices or policy statements but is, on the contrary, the outcome of them. This means that whenever we argue about the use of science and technology to address issues of inequality ontological politics come into play.

This is easy to see if one thinks about the ways in which new technologies are developed and radically change the landscape of everyday life and the relations between people, animals and things that populate it. Think of how mobile telephones and the internet reshape the face of the African continent or the ability of citizens to challenge and interrogate their governments. Or think of advances in public health, birth control, sanitation, inoculation. The production of knowledge about the natural and social worlds has enormous implications for who and what we are and how we relate to one another and the world at large. Knowledge and society (culture included) can be said to be co-produced and designing, deliberating and using knowledge to change the world is a negotiated attempt to direct the course of such co-production (Jasanoff, 2004, 2005).[7] Actor's identities are not fixed under this perspective, nor are the features of the non-human world fixed or given. And the same holds for how entrenched interests will be associated to and respond to new experiences and insights resulting from filtering, categorizing and interpreting experience to generate knowledge.

Ontological politics also bears upon and is at stake where it comes to the relation between Western inspired scientific methods and traditions and what is often referred to as 'indigenous knowledge'. And that relation is obviously of key importance in innovation policies for development. It might be argued that there is a 'Western' modernist bias in the approach outlined above because of its stress on the relations

[6] See Mol, A. (2004). Ontological Politics: A Word and Some Questions. In J. Law, & J. Hassard, *Actor Network Theory and After* (pp. 74-89). Oxford: Blackwell/The Sociological Review. See section 5 below.

[7] Sheila Jasanoff, ed., (2004) *States of Knowledge: the Co-Production of Science and Social Order*. Cambridge, MA: MIT Press.
Sheila Jasanoff (2005) *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.

between state, market and citizenship and how conceptions of these relations come into play. A similar and associated concern might be the extent to which a Western conception of science and rationality is informing our analysis. Such criticisms are understandable but not justified in our view. The point is that in all discourse about science and development one finds ontologies that draw on such distinctions and on such conceptions of science and rationality. We argue that it is important to bring these features and commitments to the fore and to see how they relate to knowledge production and the ways in which science and technology affect the positions and identities of actors and entities given this basic divisioning in terms of states, markets and citizens and their boundary regions.

The way in which 'indigenous knowledge' is being discussed and handled in policies to mobilize science and technology for development is perhaps the best example where all the issues raised above come together. From the (non-)universality of Western rationality to the way in which local knowledges and local culture (i.e. indigenous knowledge) are dealt with economically, politically and in terms of rights in development discourse and science-oriented policies. In this respect 'indigenous knowledge' designates a key arena of struggle and ontological politics is the kitchen where cultural histories of interdependence and autonomy are made and mix.

4. Development, cultural hegemony and indigenous knowledge

The challenges of indigenous knowledge

Indigenous knowledge (IK) presents us with four related challenges, which echo the issues explored in section 3. Ontologically, the forms of knowledge it produces are *sui generis*, each being incommensurable with other indigenous knowledges and with Western science, whose universalistic knowledge claims stand in direct contradiction to it. This in turn leads to an epistemological problem with indigenous knowledge, of how those outside its originating culture can assess its knowledge claims, or more fundamentally what meaning those claims have outside the immediate context of their production. Third, there are problems of rights – political, including political visibility and representation, and legal and economic – of traditional peoples and their products, and the way in which these may interplay or conflict in the way that any knowledge is developed or exploited. Lastly, ResIST's particular questions apply to indigenous knowledge as to all forms of knowledge in action: how does this play out in terms of the distribution of benefits and costs, as the knowledge becomes embodied in tangible or intangible products, and in what terms do we see wider social equity emerging?

IK's challenges are all framed by inequalities of power and voice. The very term 'indigenous knowledge' carries associations of 'the other', of being produced by those who are marginal, as being judged by an external framework. Studies have stressed indigenous knowledge as being traditional, in being culturally embedded and transmitted in a particular community; and local, in being derived from a particular environment. In some science and technology studies readings, such as those of Helen Verran, indigenous knowledge may be considered as an intrinsic part of the ways in which a traditional people 'do', or enact, locality, as 'place as performed in knowledge production' (Verran and Christie, 2007).[1] Verran herself has acknowledged this distinctiveness of knowledge and perspective which result and sought to give them greater social expression, in ecological management for example.

The semantic associations of indigenous knowledge with tradition and deep cultural roots, together with the need for narratives of political legitimacy based on change, explain much about IK's constrained place in contemporary science and technology policies of developing countries. As Visvanathan explains (Visvanathan, quoted in Kraak, 1999[2]), for post-Colonial elites in these countries, many of whom had been western trained, some through socialist orthodoxies, western science was transformative knowledge, the base for a new order, symbolised in early modern narratives on the value of electrification: the very counterpoint to the traditional. Such elites could combine the expression of respect for indigenous knowledge with its effective marginalisation through 'museumising' it as traditional knowledge.

[1] Helen Verran and Michael Christie (2007). 'Digital Technologies and Aboriginal Knowledge Practices'. Paper given originally at the EASST Conference, Lausanne, 2006, and available online (with draft designation) at: www.cdu.edu.au/centres/ik/documents.html, accessed 21 April 2009.

[2] Andre Kraak (1999). 'Western Science, Power and the Marginalisation of Indigenous Modes of Knowledge Production'. Interpretative minutes of the discussion held on 'Debates about Knowledge: Development Country Perspectives' co-hosted by CHET and CSD, Wednesday 7 April 1999. Available from reports archive at CHET (www.chet.org.za), accessed 24 April 2009.

Elsewhere, he broadens this as an attack on museumising traditional lifestyles in general, as part of a broader political narrative of change under development (Visvanathan, 2009).[3]

Even many sympathetic attempts to convey the issues surrounding indigenous knowledges, including that in the opening paragraph above, are framed in rationalist modernist terms, and apply modernist notions of rights and property. As Hagendijk (2009)[4] points out, 'the standards and reference points are not up for discussion and that shifts the entire issue of indigenous knowledge from the principled incommensurability of the systems to the question of finding common ground, translation between systems and compromise.'

These issues of translation, and contestation, are very much to the fore in the exploitation of indigenous knowledge on the medicinal uses of plants, the next section of this chapter. It then draws on ResIST's work in showing how indigenous knowledge has featured in the policies of three countries with which ResIST has worked closely, Brazil, Mozambique and South Africa, and illustrates competition between conventional and indigenous knowledges from some project case studies. The last two sections offer suggestions of issues that need to be pursued in future research, and a view on how to approach the issue of differing knowledge perspectives as to what constitutes inequality, and how it may be remedied.

Biodiversity: Indigenous knowledge as exploitable resource

Indigenous knowledge carries the handicap in post-colonial administrations of standing outside their modernist narratives of progress and change. Philosophically, post-modernism may have helped to break that log-jam, but the political reassessment of the value of indigenous knowledge, from a distinctly modernist perspective, rests almost entirely on the discovery of the potential value of biodiversity. Biodiversity reverses our conventional expectations of knowledge inequalities, in that:

> 'The world's biological diversity is distributed largely in inverse proportion to scientific and technological capacity' (Macilwain, 1998).[5]

Given this distribution, biological diversity would therefore seem to represent a significant potential resource to the developing world. That biodiversity has already been tapped once, in the late nineteenth and early twentieth centuries. Many of the products and processes which are currently globally traded were forms of indigenous knowledge that were commercialised before the beginning of the twentieth century, under European colonialism. From an STS perspective they represent embedded inequalities of power from that era, also still represented in the distribution of value from supply chains established at that time for products like tea, coffee[6] and

[3] Shiv Visvanathan (2009). 'The Search for Cognitive Justice' in *Seminar*, no.597, 'Knowledge in Question', May,2009. Available online at www.india-seminar.com, accessed 24 April 2009.
[4] Rob Hagendijk (2009). Private communication, 6 May.
[5] C. Macilwain (1998). 'When rhetoric hits reality in debate on bioprospecting', *Nature* vol 392, pp 535-540.
[6] In 2007, Ethiopia, where the Arabica coffee bean originated, tried to trademark three local varieties of coffee bean, but was allegedly blocked by Starbucks, although Starbucks claimed that the objection had come from the US National Coffee Association. Later a settlement was reached by which Ethiopia licensed the varieties to Starbucks. Oxfam, the

chocolate. Thus some of the relationships between S&T capacity and biodiversity which Macilwain notes are not just circumstantial but rooted in the ability of European powers to build competitive advantage on the back of historic privileged access to the natural resources of the developing world.

The current second dip into the biodiversity of the developing world is of course predicated on its potential value to the production of new medicines. The terms of access to it by the developed world have been the subject of significant attention in S&T governance, echoing some of the issues of the nineteenth century about the distribution of global benefits, particularly in relation to the application of patent law. The appropriate UN regulatory framework is the Convention on Biological Diversity (CBD) (United Nations, 1992)[7] which recognises national sovereignty over all genetic resources, and prescribes 'prior informed consent' and access on 'mutually agreed terms'. Ikechi Mgbeoji, in a comprehensive review of all issues in the appropriation of plants and what he terms 'traditional knowledge of the uses of plants' (TKUP) argues against the view of a second important reference point in international governance of these issues, the World Intellectual Property Organisation (WIPO), that instances of the appropriation of plants are simply isolated cases of bad patents, but rather sees this as a fundamental problem:

> '…the problem of erosion and appropriation of plants and TKUP is systemic both juridically and institutionally'

and claims that

> '…the criteria of reproducibility, utility, specification and non-obviousness [standard tests of patentability] have been significantly watered down for the purposes of the pharmaceutical and biotechnology industries' (Mgbeoji, 2006: 193-4).[8]

His remedy is that

> 'gene-rich states should explore the option of restricting access to plant genetic material by those states with notoriously prejudicial and appropriating patent systems… Gene-rich states need not wait upon the powerful states before they assert themselves in this regard. Their sheer number already offers leverage and the potential for the creation of customary international law on the question of appropriation of plants and TKUP. Strategically, any such treaty should be effective with twenty to thirty ratifications' (Mgbeoji, 2006: 196).

Meanwhile the TRIPS agreements allow for local legal action to protect plant varieties and to exclude plants and animals from patenting, but like all TRIPS provisions for exceptions to trade related intellectual property provisions, considerable effort is required to provide alternative local protection arrangements. At the TRIPS Council meeting in October 2008 80 countries supported a new disclosure provision by which

development charity, welcomed the agreement as potentially fundamental for the 15 million Ethiopians whose livelihood, they said, depended on coffee.

[7] United Nations (1992). Convention on Biological Diversity. Available at: www.cbd.int/doc/legal/cbd-un-en.pdf, accessed 24 April 2009.

[8] Ikechi Mgbeoji (2006). *Global Biopiracy: Patents, Plants and Indigenous Knowledge*. Ithaca, New York: Cornell University Press.

patent applicants are required to disclose the origin of genetic material or traditional knowledge used in their inventions (WTO, 2008).[9]

The broader question of alternative reward systems for the creation of intellectual property, such as prizes, is under debate. This would not only transcend these problems of developed world appropriation of indigenous knowledge, but also counteract the tightening restrictions on the developing world's production of generic medicines. Visvanathan allies himself with this more radical approach, again inviting the economies emerging from the developing world to be more politically assertive in trying to remedy inequalities:

> '…knowledge as intellectual property violates the idea of cognitive justice and demands that we reject the institution of IPR. One is not merely suggesting a state of exception, arguing, for example, that during an epidemic that Aids medicines be considered outside the intellectual property frame. What one is advocating is a complete secession, a rejection of the IPR regime. If India, China, Brazil and South Africa reject IPR, the chances of such a regressive institution surviving are minimal' (Visvanathan, 2009).[10]

Indigenous knowledge in ResIST

Indigenous knowledge policy and practice: Mozambique, South Africa and Brazil

ResIST was organised around a framework which posited three forms of inequality: structural, representational and distributional. If we construe the notion of representational inequality broadly, to include subcultures being given differential attention by a dominant culture, this may be the form of inequality that is most frequently encountered by indigenous knowledge. More closely applicable still are the concepts of cognitive or cultural justice introduced by Shiv Visvanathan (2007).[11] Although we failed to incorporate cognitive justice or cognitive equality directly in our framework, issues of local and indigenous knowledge come to the fore both in our analyses of national, regional and global policies and regimes, and in the detail of our case-studies.

In the countries we have studied, we can see a strong concern with local or indigenous knowledge in the policies of Mozambique, South Africa and Brazil. In Mozambique, alongside strands of policy aimed at expanding research institutions throughout the country and promoting the participation of women and youth, there are policies which promote:

- research in, and the use of, local knowledges;
- the integration of local knowledges in formal education;
- innovation in the production and use of local knowledges;
- the diffusion of local knowledges through the media.

[9] WTO (2008). See http://www.wto.org/english/news_e/news08_e/trips_28oct08_e.htm, accessed 24 April 2008.
[10] Shiv Visvanathan (2009). 'The Search for Cognitive Justice' in *Seminar,* no.597, 'Knowledge in Question', May 2009. Available online at www.india-seminar.com, accessed 24 April 2009.
[11] Shiv Visvanathan (2007). 'An invitation to a science war' in Boaventura De Sousa Santos (ed.), *Cognitive Justice in a Global World*. Lanham, Maryland, USA: Lexington Books.

In South Africa, the development of an Indigenous Knowledge Systems (IKS) policy was led directly by the Department of Science and Technology (DST) and formally adopted in November 2004. It is potentially wide-ranging. 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 considers that "IKS development is a unique opportunity to recognise and redress inequities created by past policies in South Africa" (Cozzens et al., 2008).[12] The policy statement on indigenous knowledge presented to the World Intellectual Property Institute by South Africa portrays this very directly:

> 'Under apartheid, IKS in South Africa, as well as practitioners within such systems, were marginalized, suppressed and subjected to ridicule. This had profound negative effects on the development of South Africa's economy and society, resulting in the distortion of the social, cultural and economic development of the vast majority of its people. Across every measurement of socio-economic status and well-being, and across all age groups, geographical circumstances and both genders, indigenous people are severely disadvantaged. The disadvantages they face have the potential to increase and further entrench the disparity between indigenous and other sectors of society over the coming decades, unless greater effort is made now to redress the ongoing inequalities, not least of which is in respect of the knowledge systems of indigenous communities and specific knowledge traditions within these, such as guilds of traditional healers and specific knowledge traditions held by women within communities. Integrating and celebrating African perspectives in South Africa's knowledge systems is not only a matter of redress. It can help create new research paradigms and mental maps, as well as enrich existing ones' (Republic of South Africa, 2005).[13]

By the time the South African 10-year Innovation Plan was published in 2007, indigenous knowledge got a mention in two out of five Grand Challenges identified by the DST. It was coupled with South Africa's biodiversity and capabilities and infrastructure in genomics, bioinformatics and biotechnology in underpinning the country's ambition to become 'one of the top 3 emerging economies in the global pharmaceutical industry'; whilst in the human and social dynamics grand challenge, research on paleoanthropology, archeology and evolution genetics were seen as providing 'evidence-based support for interventions in learning processes and education, IKS and heritage literacy' (DST, 2007).[14]

A senior practitioner in the South African science and technology system has commented that indigenous knowledge promotion often has little to do with national innovation policies to produce new knowledge, and where it does innovation efforts are costly and slow to be realised. Further, there was in his view a distinction between

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[12] Susan Cozzens, Rob Hagendijk, Peter Healey and Tiago Santos Pereira (2008). The CARE Cycle: *A Framework for Analyzing Science, Technology and Inequalities – Journal Article Submission*. ResIST Deliverable #3. Available from the ResIST website, www.resist-research.net, accessed 24 April 2009.

[13] Republic of South Africa (2005): *Indigenous Knowledge Systems Policy*, submitted to the Intergovernmental Committee on Intellectual Property and Genetic Resources, World Intellectual Property Organization, November 2005.

[14] DST (2007), South African Department of Science and Technology, *Innovation Towards a Knowledge-Based Economy: Ten Year Plan for South Africa, 2008-2018*.

the use of indigenous knowledge in developing various kinds of 'cultural products' (which Visvanathan might see as another form of knowledge museumisation), and its use in medicine. In medicine, the knowledge claims and the world views which underpinned them were incommensurable. In these circumstances governments had to choose which knowledge system met the test of wider accountability to the public (Hagendijk, 2009).[15]

A main focus of ResIST's work on Brazil has been on the health system, which was fully expressed as an obligation of the state in the 1988 Constitution, after a long period of struggles and social movements through the twentieth century. Although there was no space for indigenous knowledge as such, the plurality of interests and the role of local knowledges have been recognised since the 1980s, and have included a recognition of the contribution of systematic social participation to reducing inequality in access to public health services. The characteristics of these changing policies are best seen in the changes in public responses to dengue, a viral disease transmitted to humans through mosquito bites (the full case is to be found in Nunes, Matias, Matos and Neves, 2008).[16]

In Brazil, efforts to eradicate dengue stumbled on the resilience of the vectors and lead, in the 1990s, to the widespread adoption of new strategies for the control of vector-borne pathologies. These new strategies were based on a move from trying to eradicate pathogens or vectors through chemical means, which had significant negative side-effects on the environment and on human health and were generally of limited effectiveness, to the design of place-based, collaborative and participatory approaches to the control of the vector by environmental interventions, so as to remove niches where mosquitoes could breed. Mobilisation through public participation in this case not only changed the nature of the attack on the disease, but also provided a health-conscious population to realise the new strategy.

Programmes of this type involve the articulation of a range of different disciplines and forms of knowledge, including, for instance, the collaboration between public health specialists and entomologists, but also local communities and their knowledge of local ecologies, construction materials and social organization. It also involves similarly broad based evaluation and assessment. It is therefore analogous to the same issues encountered with other forms of indigenous and local knowledges, as to how to assess its utilities in different contexts, and how to assess its use in combination with non-traditional knowledge.

Lost in translation? Issues of de- and re-contextualisation in bringing technology to the poor

In ResIST we have thought it instructive to think critically about the contingencies of the local and the social in all knowledge production and re-production, about seeing not the unity of western science but rather the diversity of priorities and practices embedded in it, and the variety of traditional political communities they serve. In this way, using the forms of indigenous knowledge as a sensitising notion, and with an anthropological eye, we can tease out the ways in which, whatever method of

[15] Rob Hagendijk (2009). Private communication, 6 May.
[16] João Arriscado Nunes, Marisa Matias, Ana Raquel Matos, and Daniel Neves (2008) (CES, University of Coimbra, Portugal). *New Accountability Systems: Experimental Initiatives and Inequalities in Public Policy and Health Care Domains.* James Martin Institute ResIST Working Paper 14; Contributory to ResIST Deliverable # 18.

knowledge production we are looking at, the cognitive, social and ontological are bound up together as socio-technological projects. We can then ask to whom and for what particular socio-technological projects are accountable, and how far they do link or could link with the objectives of the social cohesion S&T policies ResIST is advocating. If we see indigenous knowledge as another form of – albeit deeply culturally embedded – social technological project, we can also ask if the knowledge it embodies is so tightly bound to its context of origin to be incommensurable with other uses, or if instead, through processes of translation, it could provide a wider base for development.

By its nature, indigenous knowledge, its reproduction and the 'to whom and how' of its (usually face-to-face) accountability arrangements are nested together as a cultural package. This is particularly evident where indigenous knowledge comes up against conventional systems of science and technology assessment. For example, the process by which the local use of a plant by traditional peoples is transformed into a new chemical entity being tested for potential efficacy as a pharmaceutical product involves complex processes of stripping away contexts and meanings and attributing others: a process of translation of the cultural significance of an artefact which aligns it to the processes of legitimation, distribution and consumption of the developed world, including of course the property and more general economic relations which go along with that shift. Governments and agencies in developing countries can find themselves in a complex situation of managing the relationship between two virtually incommensurate worlds, for example, one in which health is one aspect of a holistic and community based concept of well-being, stressing cultural continuity, another in which it is individual, subject to disciplinary fragmentation and high rates of innovation and change in processes of largely chemical control.

These processes of decontextualisation – of 'translation out' of the originating context as indigenous knowledge becomes a candidate for wider markets – is paralleled by processes of local re-contextualisation: issues of cultural and economic 'translation in', which occur when knowledge products reach new markets (or are inhibited to do so by the transfer of marketing models from other contexts). Both processes can co-exist in competing knowledge claims which can get simplified under political and economic pressures. The case of HIV/AIDS in South Africa in the late 1990s and early 2000s, when the South African health ministry was under both resource and accountability pressures with the increasing burden of HIV/AIDS, illustrates the potential difficulties. For a period, although indigenous knowledge claims for such products as the African Potato were strongly challenged for their clinical efficacy, they constituted the only government response to meet popular clamour for action. The producers of anti-retroviral drugs at that time lacked a business model for distribution to the poor, and the government fell back on unsubstantiated indigenous knowledge claims to pursue independence and counter the crippling cost of treating its citizens. One unintended consequence of this was that many doctors characterised all traditional African healers as frauds, and there was a growing scepticism about traditional remedies. A study by Wreford (2008)[17] challenges this legacy, and calls for more collaboration between doctors and traditional healers in treating HIV/AIDS, and

[17] Joanne Wreford (2008). 'Myths, Masks and Stark Realities: Traditional African Healers, HIV/AIDS Narratives and Patterns of HIV/AIDS Avoidance.' University of Cape Town, Centre for Social Science Research, CSSR Working Paper No. 209.

this is echoed by Mbele-Khama (2008)[18] in an interesting analysis of some of the factors encouraging and inhibiting collaboration. Bessong (2008),[19] whilst in principle sympathetic to complementary roles for anti-retrovirals (ARVs) and traditional herbal therapies in the treatment of HIV/AIDS, points to clinical evidence of interactions between the two which can lead to treatment failures, drug resistance or drug toxicity and asks that the ethical issues be considered seriously, particularly in the majority of cases where clear evidence does not exist, and where the choice as to go for 'western' ARVs or more traditional treatments is thrown back to the patients.

The importance of sensitivity in establishing international technology projects in their local cultural and traditional knowledge context was illustrated by two contributions to ResIST's Maputo meeting, both concerning malaria. Ariel Nhacole (2006)[20] showed that cultural misunderstandings in translating knowledge into local contexts are not confined to international aid agencies and NCOs. The Health Research Centre in Manhiça in Mozambique (CISM) encountered initial resistance to the participation of children in clinical trials, with rumours circulating querying why the clinicians should take blood (samples) from children who were weak, or why they should measure the length of the children whilst they were lying down, a practice associated with measuring for coffins. Lessons learned included a social science presence in all clinical trials, and active community participation in study design.

Adelaide Agostinho (2006)[21], of the Traditional Medicine Department of the Mozambique National Health Institute, set out the recovery of traditional medicine following its suppression in the colonial period. This was a pan-African development: the Ouagadougou meeting in 2000 declared the Decade of Development of African Traditional Medicine, and Mozambique national policy set out in 2005 laid out arrangements for its regulation. Agostinho compared the efficacy of an established anti-malarial *Fansidar*, with a local herbal remedy, *Artemisia annua,* which suffered no IPR related restraints on use, improvement and research, and which required no highly qualified expertise and no pharmacies in its distribution and use. She concluded that although the direct efficacy of Artemisia is lower, because of the other advantages, both traditional and conventional medicines had complementary parts to play in a cost-effective anti-malarial strategy for Mozambique. How do we assess such policies – as giving some of the population second best, or expanding the population treated by using conventional medicines alongside traditional ones with lower production and administration costs?

In a wider sense, our general STS perspective also stresses the importance of local and contingent knowledges in a broader sense as contexts for adaption and innovation (or the perceived failure to innovate). Local contexts, as Work Package 4 of ResIST

[18] Sheila Fihliwe Mbele Khama (2008). 'Knowledge, Attitude and Practice in Traditional Health Practitioners in regard to HIV and AIDS in the Workplace', unpublished paper.
[19] Pascal Obong Bessong (2008). 'Issues surrounding the use of herbal remedies for AIDS in endemic regions.' *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 102, 209-210.
[20] Ariel Nhacole (2006). Community Involvement in Research Projects in Manhiça: the Case of a Malaria Intervention by CISM. Presentation to the ResIST Maputo meeting, November 2006. Available at http://www.resist-research.net/paperslibrary/southern-african-meeting.aspx, accessed 3 May 2009.
[21] Adelaide Bela Agostinho (2006). *Malaria and herbal therapies: where science and traditional knowledge meet*. Presentation to the ResIST Maputo meeting, November 2006. Available at: http://www.resist-research.net/paperslibrary/southern-african-meeting.aspx, accessed 3 May 2009.

emphasises, shape what innovation becomes, and shape the definition of what equity and other social values will mean and how they will be applied. It is not just that an equitable and inclusive science policy must include multiple forms of knowledge and expertise, including traditional situated knowledge (Cozzens et al., 2008: 9)[22] but that in this wider sense indigenous and local knowledges can contribute to the framing of all socio-technical change in processes of negotiation, heavily mediated by accommodation of different sources of power and legitimacy. In this sense, also indigenous knowledge can be seen as much broader, as global 'citizen science', supporting both continuity and change: the stuff of local and craft practice, of stock breeders and cheesemakers, science shops and social movements, in Europe (Sillitoe, 2002: 212).[23]

What remedies inequality? Issues of fairness in appropriating indigenous knowledge

Where products based on indigenous knowledge and technique are seen as efficacious, and can be pressed into commercial use, further complications can arise in determining the distribution of benefits. Schuklenk and Kleinschmidt (2006a)[24] analyse the ethical and legal issues involved in the attempted commercialisation of bioprospecting in three areas: in relation to the hoodia plant in the Kalahari, traditionally used as an appetite suppressant by the San people; an attempt to organise an international cooperative biodiversity program (ICBG) for the Maya people of Chiapas in Southern Mexico; and the use of a herb with anti-fatigue properties by the Kani people of southern Kerala in India.

The South African Council for Scientific and Industrial Research (CSIR) became aware of the appetite suppressing properties of hoodia in 1937 from a Dutch publication and from their San tracker guides. CSIR isolated and patented its active ingredient, P57, in 1980 and licensed it to a UK biotech company, Phytopharm. Its first choice, Pfizer, having earlier withdrawn, Phytopharm is now in its second licensing agreement for production to Unilever, which was expected to market an appetite reducing snack bar. Unilever has also recently announced that it too is abandoning hoodia on safety and efficacy grounds, but the issues involved in potential benefit sharing in this case are still of wider interest.

Schuklenk and Kleinschmidt (2006b)[25] document the long struggle by which, despite no prior revenue sharing agreement (the matter predated the CBD), CSIR and Phytopharm agreed compensation with the South Africa based San Council, which set up a trust fund to use the anticipated benefits for local development projects. Here and

[22] Susan Cozzens, Rob Hagendijk, Peter Healey and Tiago Santos Pereira (2008). The CARE Cycle: *A Framework for Analyzing Science, Technology and Inequalities – Journal Article Submission*. ResIST Deliverable #3. Available from the ResIST website, www.resist-research.net, accessed 24 April 2009.
[23] Paul Sillitoe (2002). 'Globalizing Indigenous Knowledge' in Paul Sillitoe, Alan Bicker and Johan Pottier (eds.), (2002), *Participating in Development: Approaches to Indigenous Knowledge*. London and New York: Routledge, Association of Social Anthopologists Monographs 39.
[24] Udo Schuklenk and Anita Kleinschmidt (2006a). 'North-South Benefit Sharing Arrangements in Bioprospecting and Genetic Research: A Critical Ethical and Legal Analysis'. *Developing World Bioethics*, ISSN 1471-8731 (print); 1471-8847 (online).
[25] Udo Schuklenk and Anita Kleinschmidt, (2006b). Presentation at the Innogen Annual Conference, September 2006.

elsewhere these authors also point out an irony and a number of ethical issues arising from this case. The irony that they see is that the San do not challenge the patent system which can be seen as having denied them access to medicines, but instead seek to benefit from it. The ethical issues concern the distribution of such benefits. At a level of principles and rights, should the benefits be at the level of the San peoples, or, as the CBD proposes, the state, which had, in this case, isolated and patented the active compound. As an issue of justice in administration, who exactly should benefit, given that the San people stretch over three jurisdictions, South Africa, Botswana and Namibia? And in what case could knowledge of hoodia be seen as the property of the San, given that some people from other ethnic groups traditionally shared the knowledge, and that not all the San people recognised or used hoodia's properties? Then, there is the question as to the distribution of benefits from the projects which the development trust might invest in: would these be more KEPP- or SCOPP-like in their distribution of benefits within the San community, and how would they affect the wider pattern of inequalities within South Africa? Finally, does a case like this leave any equitable developmental legacy in terms of the way in which issues of commercialisation of natural resources are to be dealt with in future?

Issues for policy and future research

We see the need for further research related to ResIST which focuses on indigenous knowledge. There is already a significant literature in which ResIST's interests on the relation between structural, representational and distributional inequalities interact with considerations of cognitive or cultural interest. Much of this focuses on attempts to implement IPR and other regimes that ensure a more equitable distribution of value, and community control or profit-sharing in the development and marketing of contemporary products based primarily on biodiversity and indigenous knowledge of its use. However, we are still far short of the kind of understanding needed to frame policy and practice in a number of areas.

First, as the examples in this chapter have made clear, the pharmacological and social interactions between different routes of treatment based on different schemes of knowledge put the health and happiness of patients at risk in a variety of different ways. Careful and sensitive multidisciplinary efforts in research and practice are required to bridge these.

Second, further analysis of these cases is likely to extend the scope of ResIST's work on new forms of accountability under WP3. WP3's work has already shown that public-private partnerships can be run in such a way as to share risks between partners, including the risks and costs associated with acknowledging and pursuing several routes towards a goal, which may turn out to be complementary or competing. Further case studies of efforts to secure alternative arrangements for control and the redistribution of benefits from research may help us understand how knowledge accountability systems may be able to achieve a common framing so as to embrace equity as one of their core deliverables, even when starting with differences of approach verging on the incommensurable.

Third, the more comprehensive proposals for community local discretion over the whole set of processes involved in research, identification, development and exploitation of new chemical entities – for example those proposed by the Kuna Yala

people in 1983 (Laird, 2002),[26] if fully achieved – represent an ideal type of local community-based determination which needs to be evaluated and against which other knowledge sharing arrangements it might be assessed.

Fourth, they provide the basis for a thought experiment on the modalities and impacts of a broader extension of the principles of local control and benefit which they attempt to enshrine upon the general negotiation of trade and aid, or the diffusion of innovation, where intellectual property is a key issue (issues of concern under WP1 and WP4). Would the wider application of these principles strengthen the hand of the communities holding indigenous knowledge in all circumstances, or provide consistent benefits to the poor?

The further reason to pursue these topics is the changing geopolitics of science-based innovation. There are two features here that merit attention. One is a relatively new development of 'market colonialism' as richer countries buy not just primary resources from developing countries, but large tracts of land from which it comes, in order to guarantee their future access to minerals, food or water (or even, as with island states threatened by climate change, a place to live). The acquisition of land in this way, and particularly on a large scale, raises some potentially strong ethical and legal issues about the scope for its use and the opportunity costs for the host country which result in developing its knowledge and natural resources.

Another interest for new research is the emergence of new global players with different needs and interests. The emerging BRICSAM[27] economies, for example, for the most part exhibit high ethnic diversity, and they are all struggling with large inequalities of wealth, in some cases overlapping with internal ethnic and geographical divides. In most cases they are decentralised states with sub-national systems of innovation. In most cases too their political discourse reflects the importance of extending social and economic inclusiveness, and favours a range of political approaches, with far from settled forms, that often lie outside conventional neo-liberal takes on the role of the market and on representative democracy. Their evolving versions of a knowledge society may embody quite different perspectives to local and traded knowledge and the distribution of opportunity and risk in science-based development.

As we have already seen above, such countries as South Africa and Brazil incorporate recognition of the importance of indigenous knowledges in their attempts to link science, cultural and development policies. To the extent that these policies are realised, they may bring new approaches to the negotiation of international order as they and other emerging economies gain in influence. However, there are reasons to doubt that the policies are being or will be realised in all cases. The Mbeki administration in South Africa was criticised from the left for its compliance within neo-liberal policies, although it will be some months before the complexion of the Zuma regime is known. Similarly, for all the rhetoric, Brazil remains one of the world's most unequal societies and NGOs at ResIST's Rio meeting were sceptical about the effectiveness of policies to change this.

[26] Sarah A. Laird (2002) (ed.). *Biodiversity and Traditional Knowledge: Sustainable Partnerships in Practice*. London: Earthscan.

[27] Brazil, Russia, India, China, South Africa and Mexico. A recent OECD study on the catch-up economies referred to BRIICS, with Indonesia substituting for Mexico. The arguments about internal diversity apply to Indonesia too.

Towards a more cognitively inclusive policy discourse

The discussion in this chapter of the incommensurability of indigenous and conventional knowledge tends to overestimate the extent to which scientific knowledge itself shares a single philosophical base. Further, there is within post-modernist perspectives a respect for pluralism even if some of the knowledge systems which are protected are at odds with earlier modernist views on what is best with respect to values like health and sustainable well-being.

What may be needed is a more symmetrical discourse (within modernizing catch up regimes and internationally) about various knowledges and techniques, i.e. minimal rules of discursive procedure in considering these. In such discursive procedures the following should be considered:

- is there ontological (in)compatibility of knowledge systems and world views and how can these be dealt with from the perspective of each of the systems considered?
- epistemological (in)compatibility in knowledge assessments and how to deal with it from the perspective of each of the systems considered?
- rights based perspectives – property, economic, collectivist and/or individualist – again for each system;
- rights based perspectives – human rights (health, food, water, etc) – for each system;
- rights based perspective – how to deal with minority viewpoints – for each system.
- At each of these levels it should be considered how the issue is defined in modernist and indigenous thought and where (if anywhere there is minimal common ground).

Of course such a debate or discourse is premised on 'openness' to other perspectives on what is problematic in the world and how to deal with it – carrying with it an idea that wider social, economic and environmental resilience may be served by a variety of approaches: the kind of resilience in factoring in Aboriginal understanding of Northern Territory wildfires that Verran points to (Verran, 2005)[28]. The endorsement – even at a rather general level – of the importance of considering indigenous knowledges as a part of policy frameworks is a step forward. As such, it should be recommended in general and as an element of ResIST type policy. It is representational justice comparable to cognitive justice.

But further steps are needed to get to full cognitive justice, and cognitive justice, as we have seen from some of the examples above, does not necessarily lead to wider distributional equality. Alternative views should not only be on the table but also be assessed with instrumental and broader cultural values and rights of groups, societies and individuals. That is why there is the need to bring ontological, epistemological and rights dimensions into consideration.

[28] Helen Verran (2005). "Knowledge Traditions of Aboriginal Australians: Questions and Answers arising in a Databasing Project". Draft Published by Making Collective Memory with Computers, School of Australian Indigenous Knowledge Systems, Charles Darwin University, Darwin, NT 0909, Australia. Available at: http://www.cdu.edu.au/centres/ik/pdf/knowledgeanddatabasing.pdf, accessed 24 April 2009.

Of course it cannot be assumed that decision rules can be specified to take the actual decisions. In that sense these recommendations are procedural and it is a procedural political and intellectual ethics that is being proposed. And indeed some may point out that it reflects a rather Western liberal view of the world. But such critique it itself also dependent on that same system!

Needless to say, more cognitively inclusive approaches also bring to centre stage the question of how potential conflicts are resolved politically, or the implications of less than total coherence in different parts of the system defining knowledge and social priorities; and they equally foreground issues of accountability, which are the focus of the next section of this report.

5. Inclusiveness and accountability in development and globalisation

If follows from our definition of inequality (see above, section 2) that enhancing representation and participation should be an integral element as well as a goal of all STI policies that seek to redress inequality. To promote equality in the distribution of economic outcomes or with respect to access to key STI resources is obviously important but so is participation and inclusiveness. There are principled as well as functional arguments for this view. It refers to basic citizenship rights as such as well as to what is needed to define and implement policies that can be expected to be successful in delivering the goods. Participation and representation as an integral part of the struggle against inequality also concerns the connection to the development of knowledge, scientific and otherwise, and technological change.

For participation to work in that way we have to look at it in terms of accountability and how accountability is organized and actually realised in policies to promote inclusiveness. Accountability, however, refers not only to the fundamental right to participate, but also to the right as well as the plight to ask for and give accounts as a part of everyday discourse and its extensions into politics and spheres of specialized professional knowledge and expertise.

In Europe and the US policymakers have become increasingly more aware of the importance of public participation for policies of technological innovation and economic growth. In the late twentieth century new emerging technologies like genetic modification of food, and medical genetics coincided with a wide-ranging crisis of trust about the capacity of regulatory agencies to deal with science-related technologies and practices in all possible areas. After the big turmoil about BSE, GM crops and so on new formats of public consultation have been introduced and institutionalized. Already existing policies for the popularisation of science stressed the need to educate the public about new science and risk and tended to focus on the public's alleged deficiency with respect to scientific knowledge. As representatives of the STS community pointed out at great length the 'deficit hypothesis' would not hold up nor help to understand public conflict about new technology adequately. Lay citizens may find it difficult to reproduce or understand abstract laws and principles of science, but they are very well able to appreciate how science may affect their personal life and well being and to respond and retaliate if provoked.

Innovation policies fail unless people can be convinced that the new technologies help instead of harm their needs and that risks are under control. Participatory engagement is important for that reason and from the late 1990s onwards formats of engagements that were first developed in countries like Denmark, Germany, Austria, the USA, Australia and The Netherlands started to spread across the entire world. These attempts to deal with public interest quickly met with new suspicions. NGO's and critics of modern government pointed out that participatory formats often seemed more designed to fend off criticism rather than to listen to public needs and concerns and to translate these in 'upstream' engagement. They looked like a new form of political marketing.

The question whether the new forms of engagement promoted in EU countries and beyond are indeed a new form of political marketing or genuine attempts to engage

with lay citizens' views on technological change is impossible to answer in general (Hagendijk and Irwin, 2006). On a case by case basis answers will differ depending on positions, interest and perspective of who one asks. A general point that can be made, however, is that the answer will depend on how accountability for the exercise is organized and whether this is convincingly implemented. Here the dictum applies that participation without accountability for inclusiveness, process and fairness of procedure and outcomes will open the door to accusations of manipulation and malice. This principle also applies to how the decision-makers handle the outcomes of the exercise. The threat of manipulative use becomes bigger if (1) there is no a priori commitment of the government to adopting the outcome as the compass for subsequent decision making; and (2) if the process of consultation and decision making is not organized transparently and arranged a priori.

All this is closely related to the issue of accountability of the government and politicians as well as citizens and their organizations. If participatory exercises are manipulated it is not only by the government. Nor is it limited to NGO's or industry. It is in the nature of the political debate to try to influence peoples' views and behaviour and it is to be expected that somebody at some point may start accusing others of misrepresenting what is at stake and to attempt to influence others in unacceptable ways. Yet it is also known that people are inclined to comply with outcomes that do not reflect their own interests, provided they have the idea that the process was transparent and that they got a fair hearing.[1]

In the literature about participation and extending citizenship there is ample attention to how participation may be extended without compromising the model of delegated decision-making in which chosen representatives in formally elected bodies have the last say and citizens vote and are consulted. Yet their voices should not compromise the ultimate responsibility of the representative for decision-making. Protagonists for radical democracy may argue that more participation complements representative democracy but does not replace it. It cannot do that and it should not. Others, starting from a more agonistic conception of democracy may argue that the goal of radical participation formats is to promote self-governance i.e. a blurring of the opposition between elected representatives and citizens. Not consultation but deciding and taking responsibility becomes the goal, or at least the goal becomes to test the boundaries of the system with respect to the definition of problems, solutions and who is in charge of what.

From the above it follows that alongside issues of participation questions regarding accountability should be studied closely if we want to understand how participation relates to equality of representation in decision making about science and technology and what effect this has. Yet, by attuning to the needs of the disadvantaged, systems of accountability can become focal points for reorienting scientific governance towards greater social inclusion in building S&T priorities and in distributing its products. To do so also implies however that we have to be attentive to differences between countries and political systems and that one has to address the specific constraints, needs and opportunities as they exist in different settings.

Accountability has recently become a fashionable buzzword in contemporary politics and in the media. It relates to how politicians, bankers and other authorities should be

[1] See Simon Joss and Arthur Brownlea (1999). 'Considering the Concept of Procedural Justice for Public Policy – and Decision-Making in Science and Technology', Science and Public Policy, 26 (5), 321–331.

held to account to things that have gone wrong to parliaments, media publics and the citizens at large who will cast their vote every few years. This is 'accountability to the public'. In social theory accountability however also refers to the accountability of citizens vis-à-vis their government and its representatives (accountability *of* the public instead of *to* the public). Most (post) Foucauldian literature is associated with this form of accountability and how it operates. And then there are, pace the philosopher Schutz and the ethnomethodologist Garfinkel, those forms of accounting or accountability that can be found in the everyday, mundane interactions of everyday life if one transgresses some unstated rule or convention (accountability *in* public). Examples like greeting behaviour, ignoring a good friend on the street or being very inquisitive at a family gathering will bring out the normally implicit rules governing interaction as one is taken to account for one's behaviour.[2] As we will see all these forms of accountability can be easily observed in mixed forms in accountability processes in and around science and technology. If one, furthermore, attends the institutional differentiation of Western liberal democracies it is also possible to speak of legal, economic accountability and moral accountability. This suggests that some forms of accountability may vary across institutionalized practices while others do not. Accounts to justify ones behaviour or deeds may have to fulfil specific formats or requirements to be acceptable for particular audiences.

Keeping all these distinctions and considerations in mind it is important to be clear how we think these forms of accountability come into play in the relations between scientific and technological change and inequality. It would be a mistake to believe that the relations between science and its environment are governed by and can be reduced to some unique set of rules and principles.[3] To understand how one may change processes of accountability with an eye to better address issues of inequality as defined we aim to develop a more fundamental understanding of the relation between these issues through conceptual reflection and empirical study.

Ontological politics

A good starting point for clarification is the notion of 'ontological politics' (Mol and Law 2002, Mol 2004).[4] Ontological politics assumes that any given reality or object possesses multiple versions that are enacted, manipulated and built through the mediation of multiple instruments or resources during the course of a diversity of practices. In this sense reality does not precede practices or policy statements but is, on the contrary, the outcome of them. Law and Mol (2002) argue that the concept of ontological politics draws our attention to the "enacted nature of reality and to the multiplicity of realities as they are historically, culturally and materially located" (Mol, 2004: 75). Reality and objects thus emerge as situated, as the effects or consequences of practices bringing together human actors, devices and non-human

[2] See for an extended presentation of this Neyland, D. et.al. (2007). *Articulating New Accountability Systems: Preliminary Integrated Framework* . Working Paper, Oxford: JMI Institute, Oxford University.

[3] For a recent review and critique as well as extension to the current interconnections between venture capital and high tech science see Shapin, S. (2008). *The Scientific Life; A Moral History of a late Modern Vocation.* Chicago: Chicago University Press.

[4] See Mol, A. (2004). Ontological Politics: A Word and Some Questions. In J. Law, & J. Hassard, *Actor Network Theory and After* (pp. 74-89). Oxford: Blackwell/The Sociological Review; Law, J., & Mol, A. (2002). *Complexities: Social Studies of Knowledge Practices.* Durham, NC, USA: Duke University Press.

entities located in spaces such as laboratories, work places, legislative bodies, administrations and public forums. Each of these practices or assemblages of practice enacts a reality. As Mol argues, the composite term of ontological politics points, first, to the multiplicity of conditions of possibility of objects and reality and, secondly, to their active shaping and, consequently to their open and contested character (*Ibidem*: 75).

This understanding of politics in terms of deliberation or choices that make a difference in the world and constitute reality is especially attractive and plausible if we think of science-based new technology that radically changes the world of everyday life. It raises the question of how to locate the places of decision, how to identify available options and possible paths of development. How are these spaces organized? Which actors are allowed to participate and deliberate in these spaces? How are they recognized? How are options defined, and how are choices made between them? How is the effectiveness of actions evaluated and fed back into subsequent developments?

Ontological politics also affect the identities of people, devices and objects involved and the processes in which knowledge is produced and assessed for its potential value and limitations and how they affect the order and power relations in society. This concerns both the side of knowledge production as such as well as the politics and decision-making.

Accountability systems are an essential part of such ontological politics. By engaging with accountability in terms of the people, processes, technologies and spaces involved, we can see how particular political realities emerge from accountability struggles, deliberations and arrangements. This provides a window on how this might be done in a different way to better address issues of inequality.

Double delegation

These political and scientific and technical deliberation processes as they occur in Western representative democracies have been described as a form of "double delegation" (Callon, Lascoumes, & Barthe, 2001). This notion seeks to catch the phenomenon that in Western societies decision-making about the world and what to do about it is organized in a rather particular way. If it comes to knowledge about the structure of the natural world the ultimate voice and authority rests with the sciences and those educated and disciplined in logic and experimenting after their image. At the same time decisions about what to do about social and power relations and how to draw boundaries between public and private the ultimate authority lies with chosen representatives. So nature is the terrain in which scientists and experts have priority while politics is about power relations and who gets what. This conception of twofold delegated decision making – to experts and political representatives – means that citizens are most of the time excluded from decision-making about issues that affect their well-being. They may cast their votes every couple of years, but beyond that they do not decide themselves about the organization of society. Callon et al. argue that this double delegation model may work well for well-defined issues of limited reach, but also that recent history shows that there are many science and technology related problems that are difficult to handle under this system of double delegation given their complexity, novelty and wicked nature. For that reason Callon et al. and others argue in favour of more participation both with respect to experts and research as well as with respect to decision-making. Such broader participation would not necessarily threaten representative democracy but is better seen as complementing it. There is also

no reason to fear that rational argument would give way to mob psychology if one looks at the experience with civic participation. To follow this road would imply that the boundary between consultation and decision-making is maintained but becomes more flexible and open. What this amounts to or might amount to can be studied empirically by analysing experiments that seek to harness citizens and expert knowledge to deal with public problems.

The consultative form of representation (and accountability) is nowadays more common in most European science and technology policy. In some Latin American countries, forms of participatory budgeting introduced in the last two decades amount to strong participatory procedures i.e. formats in which citizens and civic organizations become part of decision-making procedures. Our research on these formats show that the more radical forms of participatory decision-making can also be seen as a way of exploring and testing the institutional boundaries and the way in which they define and constrain approaches and how shifting such boundaries and definitions allows the exploration of alternative and productive solutions in which issues of inequality may be better addressed.

Transnational accountability

In discussions about participation and accountability the focus is often on national arenas of decision making. This is even the case when the issues clearly escape and go beyond national boundaries, for example in bio-banking, GM food, medical genetics etc. This focus is reinforced by agencies that seek to gauge public attitudes, the Eurobarometer surveys included. As decision-making is often still perceived to be about national preferences and legal frameworks much applied research also attaches much value to nation-based statistics over other forms of categorization. And yet other forms of accountability that go beyond national boundaries in various ways should be considered. Among these are intergovernmental or international political accountabilities but it is important to see that transnational accountability is not and has never been restricted to relations between states. Just think of the plethora of people and organizations and agencies involved in developing and implementing new medical treatments and vaccines. A lot more is going on that is associated to science and technology but transgresses relations between states even when the states are involved in some capacity somewhere.

Where global and, in some cases, national issues are involved accountability tends to take the shape of 'accountability at a distance', people and agencies trying to hold others to account who are not physically present. This is of particular relevance when dealing with new emerging technologies as well as with dumping the remains of technical devices and processes. New vaccines often originate in places where the patients are not, the initial research is carried out in European or US with development units and implementation teams on 'Southern' locations being incorporated at later stages or as ancillary contributors. New technologies are also often "dropped" on to regions of the Southern hemisphere (as was the case with some forms of biotechnology) without an assessment according to Western standards regarding possible impacts on pre-existing forms of land use, farming and local production, or possible environmental and health impacts.

This raises the question how accountability could be better organized in such situations and to give the people affected in non-Western contexts more say in the process. But to understand that we also need to understand better how it works in

various settings today. The case studies undertaken in the second part of the work package about electronic waste, fair trade and treatment for neglected diseases have a special bearing on this.

Empirical case studies

It quickly became obvious from our conceptual discussions and from preliminary empirical work that various composite formats of accountability would surface in the qualitative empirical case studies. Their variations turn around social and physical distances between key people and agencies on the one hand and the direction of the accountability connection on the other hand. In some chains, for example instances of certifying supply chains for Fair Trade clothing, the distance between beginning (cotton farming) and end of chain (European retailers) may be quite large and accountability will target the relation between farmers and certification organisations. In others, for example holding to account the production, distribution, retailing and disposal of electronic goods, distances can be short (with all players sometimes even in the same country) and number of parties involved can be small (depending on successfully delegating responsibility for goods to particular organisations). But in both cases there will be episodes or moments in which face-to-face encounters about accountability become prominent. Just think of the public hearings of bankers about the global financial crises by parliamentary committees to get a sense how face-to-face accountability comes into play and has an impact in extended chains of a global nature.

Looking at the formats of accountability that extend beyond purely face-to-face accountability and that tie face-to-face accountability to wider contexts two types may be distinguished. We have coined these respectively '*directive accountability'* and '*demonstrative accountability'.* Each of these could be identified in the case studies of transnational accountability that we carried out research and each brings with it its own dynamics as can be seen in the report below and the full reports on the case studies in Volume # 4 of the ResIST Report. *Directive accountability* refers to situations in which governments or agencies try to impose explicit instructions as to how particular situations and processes are to be designed, carried out and monitored. This may include reporting on outcomes and indirect effects. Directive accountability often relies on what might be called a 'metric of accountability' as standardized often quantitative indicators, measurements and benchmarking exercises often play a dominant role. They require a person or organization to make oneself or itself accountable. Most commonly the accountability is towards a government agency, inspector or other representative with the possibility that one has to make accounts publicly available. In situations of *demonstrative accountability* devices that are used pro-actively to demonstrate how serious the firm or agency takes their public responsibility are at the centre. Firms, NGOs and governmental agencies have an interest in building and maintaining relations of trust with their environments. Formats of demonstrative accountability help them to accomplish this. Externally provided instructions and benchmarks are not of overriding importance, but combinations of demonstrative and directive accountability do occur. Alongside situations of facing publics and stakeholders directly demonstrative accountability works through reports and PR material created by the agency seeking accountability i.e. trust. Fung et al. have shown for a range of cases in the US that demonstrative forms of accountability – frequently enhanced or demanded by the US government only lead to changing

company practices if this publicly available information is actively used by civic groups to monitor events and to challenge existing practices. Otherwise it is no more than PR.

The difference between the latter two formats of accountability (directive and demonstrative) on the one hand and face-to-face accountability on the other is that the former facilitate accountability at a distance i.e. outside situations of co-presence. As we will see, however, in all case studies face-to-face meetings are interconnected through arrangements that allow for accountability at a distance and representations of widely extending chains in such situations of co-presence where they can be checked, interrogated and endorsed or rejected. It is through this mixing and interconnecting that various forms of transnational accountability get their special character in every individual case.

In the formats of accountability just discussed issues of distance and direction were prominent. Not much was made of the divide between consultation and decision-making presented above in the double delegation model. If we do this the situation becomes more complex. The case studies about participatory budgeting illustrate this. Alongside the formats of accountability of face-to-face, directive and demonstrative the central issue in such practices is who decides on programmes and budgets, who is consulted and who holds whom or what to account. We have coined such complex arrangements increasingly popular in some developing countries and currently being experimented with in Europe, participatory accountability. Consultative accountability is best seen as a weaker form of participatory accountability as institutionally and legally entrenched distinctions remain in place and decision-making remains in the hands of formally elected bodies and officials and agencies installed on their behalf. A summary table of the accountabilities discussed is given in an appendix to this report and in Volume 4 of the ResIST report.

The empirical case studies ResIST work can be divided in those that focus on transnational accountability and those that study participatory accountability. We will deal with the results of each separately below, starting with participatory account-ability, and return to more general observations and recommendations after that.

Case studies: Consultative and participatory accountability

The case studies on participatory (and consultative) accountability deal with bottom-up and top-down initiatives in different settings (councils and other forms of heterogeneous fora involving citizens and stakeholders; coalitions of interest and resources promoting the recognition of problems or actors ignored or marginalized in the domain of health policy; forms of collaborative research involving scientists and experts and citizens and their organizations; local initiatives in agenda building for research and technological development, and budget allocation; initiatives for the involvement and empowerment of citizens for public debate and participation in deliberative fora, such as participatory budgeting processes, citizen juries and panels, among others). The areas initially identified for analysis on these initiatives were health policy and delivery, agriculture and environmental issues, information and communication technologies, urban planning or energy policies.

During an initial stage of the project a wide range of initiatives in several parts of the world was explored. After a comprehensive review of the experiences identified, two sets of case studies were selected. The first set of cases covered the participatory

budgeting processes in Belo Horizonte (Brazil), Seville (Spain) and S. Brás de Alportel (Portugal), and enabled us to explore the areas of urban planning and information and communication technologies. The second set included cases on the creation of a public health system (including national and local levels of intervention) and the control of endemic diseases, both in Brazil, as well as the controversy between the European Union and the Brazilian environmental justice movement on the imports of used/retreated tyres. The first two cases enabled us to deal with the area of health policy and delivery, while the third case was oriented towards environmental and health issues associated with international trade.

For the first set of cases, the research carried out had the following results: different characteristics of deliberative processes or initiatives organized around democratic debate were found to contribute, to a greater or lesser extent, to the capacity building of different actors in a variety of settings, with redistributive outcomes as a key dimension. The research also found that access to resources and to decision-making processes and the co-sharing of responsibilities in a variety of domains may also have important consequences for people's lives and well-being.

This particular form of accountability requires that the existence of different and conflicting interests in society is acknowledged; that "channels" and spaces allowing the expression and confrontation of these interests are created; and that these different interests engage in an exercise of negotiation or composition of adequate solutions to the problems. In short, participatory accountability is based on the idea of social control as redistributive responsibility for action from the State to new configurations of State and civil society and it is against this background that participatory accountability may be considered a "strong" or "high intensity" form of accountability. Within this general framework, we might describe our approach as dealing, first, with initiatives addressing representational and distributional inequality. But under some political conditions, they may also become, second, challenges to structural inequality. There are, however, at least, three aspects setting some limits to their capacity to become such a challenge and to progressively shift the system:

a) Knowledge as a concept tends to focus on dominant forms of scientific and technical knowledge. Therefore, a broader understanding of what counts as knowledge is proposed, so that "other" forms of knowledge, and in particular those associated with the poor and with "lay" citizens, are contemplated. The same remarks could be made on the privilege accorded to so-called "material" technologies, while ignoring what we call social or political technologies. The participatory budgeting processes studied in this project are examples of social technologies which address both the redistribution of resources in order to address inequalities, and the empowerment of citizens to participate in deliberation and decision-making. These processes are particularly relevant since, traditionally, the elaboration, implementation, monitoring and assessment of budgets have been conceived as specialized activities, requiring a type and degree of expertise which is beyond the capabilities of non-experts or "ordinary" citizens. As the examples studied show, these processes can be organized in such a way that they become more inclusive and accountabilities and responsibilities can be redistributed and redefined to allow citizens to fully participate in decision-making and to cross the expert/non-export divide in constructive and productive ways.

b) There is a tendency within much social scientific work to link inequalities to formal institutions and policies and associated processes, neglecting processes of knowledge production and policymaking which take place in other settings and are likely, under certain conditions, to influence formal processes of decision-making, and knowledge-making (as is the case of Participatory Budgeting, of Health Municipal Councils in Brazil or of struggles over environmental justice). The Municipal Health Council of Belo Horizonte offers an instance of social control related to "upstream" decision-making within the Health System. The case on the control of endemic diseases – focused on dengue – offers an interesting entry point into how a health system works under an emergency, and how it responds (or fails to respond) to address unequal vulnerabilities. The case of imported tyres also displays the complex configurations of actions addressed of a threat to environmental health associated with international trade.

c) Finally, the studies show the importance to be attributed to the ways in which inequalities are experienced by participants. Participatory budgeting in Seville and in Belo Horizonte are processes in which the way inequalities are experienced by populations are central matters. The aim of the processes is to promote a broader participation in decision-making related to the investment of public resources, and as a consequence, actions involved in city planning through the identification and proposal of means to address needs as they are identified and ranked by participants. A range of specific technical devices have been developed in relation with the need to provide sharable means to define and rank proposals for the redistribution of public investments taking into account the characterization of specific needs and vulnerabilities in different parts of urban territory. The Quality of Urban Life Index created within the participatory budgeting process in Belo Horizonte is an exemplary instance of these devices. It provides a major resource for the work of defining "needs" and "priorities", how they are assessed, what types of inequalities should be addressed, how to describe and compare them and how to address them to the redistribution of resources. As the research documents such devices can indeed be created and do contribute to the systems overall success.

Case studies: Transnational forms of accountability

For the case studies about transitional accountability three areas were initially defined: textile lifecycles, vaccines and e-waste.

Textile lifecycles. Clothing, such as t-shirts, forms a ubiquitous aspect of consumer lifestyles in the developed world. However, often t-shirts are produced in developing countries, where questions are asked of labour conditions, safety and hours of work. Subsequent to use in the west, t-shirts are often donated to charities and shipped back to the developing world where they form the focus of emerging industries for accessing, distributing and owning such garments. The work package developed an intensive piece of research into textiles, identifying two central modes of textile accountability with inequality issues. First, textile import and export quotas were analysed in order to under their redistributional consequences. Second, fair trade textile initiatives were investigated as an accountability system which held out the promise of poverty alleviation. To this end we analysed the possibilities of altering the

Fair Trade accountability system through the certification or monitoring process so that it was more closely attuned to the interests of Fair Traders or more varied and able to cover more developing country contexts. The case-study report suggests that Fair Trade could get more involved in more sophisticated educational initiatives both in developing and developed countries. In terms of international accountability systems some Fair Traders advocate a change in import policies which might encourage the movement of more ethical or Fair Trade goods by, for example, lowering import duties or taxation on such goods. Finally there are Fair Traders who advocate a stronger role for Fair Trade organisations to build a more effective community of Fair Traders with greater opportunity to share information, interact on particular initiatives and develop co-operative rather than competitive trade.

Vaccines. Vaccines can form a pervasive, mundane and routine expectation within societies of the developed world (aside from questions of, for example, the availability of flu vaccines). However, the absence of, and political controversies pertaining to, vaccines in the developing world require that many aspects of day to day routine are organised around attempts (and failures) to gain access to vaccines in appropriate settings, within appropriate time frames, for appropriate sections of a population. The work package particularly focused on the case of malaria as a neglected disease and analysed attempts to produce a vaccine within a broad suite of interventions (from policy initiatives through to the distribution of bed nets). Public-Private Partnerships with combinations of state, private and philanthropic funding were identified as key sites of intervention where different forms of accountability were played out.

In our study of *neglected diseases*, particularly focusing on malaria, Public Private Partnerships (PPPs) appeared to offer the principle way forward. They attract the most funding, are a focal point for drawing together organisations and manage to engage across the complexities of neglected diseases. In the specific case of malaria, there are complexities around availability issues (developing a vaccine and drugs, getting existing treatments or bed-nets to people), infrastructural issues (having the transport and medical infrastructure in place to deliver treatments and, at some point in the future, vaccines, and figuring out ways to initiate environmental controls) and educational issues (around, for example, diagnosis, bed-net use and insecticidal spraying). This has led to suggestions that PPPs offer the most suitable way forward as they are able to manage varied risks: *Financial risk* – PPPs can be focal points for drawing together and managing a range of different financial sources (from state funding, philanthropic sources and contributions from pharmaceutical firms, even if those contributions are in kind). *Reputational risk* – for vaccine and drug development, it has been suggested in this research that pharmaceutical firms might be put off engaging in neglected disease research due to concerns about their reputation and PPPs offer an opportunity to spread the reputational burden across several organisations. *Opportunity risk* – PPPs can be developed to tackle a disease from multiple angles simultaneously.

E-waste. With the growing use and disposal of IT equipment, questions are being asked of where waste should go, how IT should be dismantled and what impacts such e-waste is having on particular locales. Currently it appears that the Far-East provides the context for the development of IT, the western world provides the context for much IT use and the developing world (particularly China, India and Africa) has provided the context for IT disposal. In ResIST this case was used to analyse the development of European Directives aimed at tackling e-waste and preventing movement of waste to developing countries. In this case, the subjects of accountability

were producers, retailers, take-back schemes, recycling schemes, waste itself and consumers. The study considered the difficulties involved in attempting to alleviate issues of global poverty (such as stark differences in the experience of computers as a workplace tool or a focus for scavenging) and accounting for the success or failure of these policies.

Various possible future directions for e-waste management emerge from the analysis. First, participants in the research suggested that more effort was required to harmonise the directives which held e-waste to account so that there were fewer interpretations of directives between EU members. Second, arguments were made that greater integration was required between the different accountability measures, so that design of new goods, packaging, transport, hazardous substances restrictions, the collection, disposal, re-use and recycling of e-waste formed a coherent package of measures. Third, it was suggested that consumers could be more effectively incorporated into e-waste initiatives. Developing country contexts were notably absent from many of the discussions, although many of the participants (NGO, producer and government) recognised that some e-waste still ended up in developing country contexts despite attempts at prevention. Compliance with e-waste accountability systems was noted by many participants to be extremely low. More experimenting and investment is needed to organize sustainable, convincing and reliable accountability formats.

Experimenting with new forms of accountability: Policy recommendations and suggestions for further research

The ResIST work on accountability brings out and stresses the importance of (a) a broad conception of accountability beyond a more limited political use of the term that focuses exclusively at political and business representatives; (b) the need to analyse how problems are analysed and handled in terms of 'ontological politics', i.e. processes in which realities, identities, devices and modes or organisation as well as inequalities get (re)defined and eventually stabilized or black-boxed; (c) the inability of the system of 'double delegation' to deal adequately with contemporary complex problems of the social and natural world and the need to broaden the basis for decision-making on such constitutive matters. Both transnational chains of accountability as well as localized attempts to deal with accountability in everyday life offer lessons to see how accountability works and how it can be developed to address issues of inequality and the mobilization of science to address such issues.

Our analysis shows how accountability is organized and continuously discussed and adjusted in one direction or another in various mundane settings. Attempts to create new configurations of modes of accountability i.e. challenge exiting ones are going on continuously allowing us to learn how we may enhance representative equality and to better address key issues that have to do with all three forms of inequality (structural, distributional and representation).

In drawing general conclusions and lessons from this exercise (more detailed recommendations can be found in Volume 4), it is important to realize that the model of double delegation is not only inadequate, but also rather problematic as a model for governing the problems of societies with institutional (political, economic, civic) configurations that are different and less well-resourced than in high-tech, economically most advanced societies. The division between problems of nature and problems of society is not drawn in the same way as in Western culture, accountable

governments are in short supply, expertise is lacking and many of the problems are imported and/or stretch well beyond the power of the national governments. Governments and the limited number of scientific experts do neither have the power, nor the knowledge required to adequately deal with the problems outside the governmental centres in capital cities i.e. in the countryside or the slums. And yet out there and especially among local populations there often exists an enormous reserve of knowledge and experience that could well be exploited in combination with other Western sources of scientific and administrative capability to better address the problems. To stress governmental and managerial accountability in such settings of delegates and experts is no less needed than anywhere else and may be even more. Yet, at the same time it is also important to develop policies and forms of accountability that stress the role and responsibilities of lay citizens and their local leaders and to create spaces where such forms of responsibility can be articulated and mobilised in a constructive way.

The mobilization of people in such endeavours, which do not have to be restricted to a local issue but may also be concerned with transnational accountability issues is not only itself a contribution to the reduction of inequalities, but may also help to address other forms of inequality and progress. To achieve that it is important not just to consult people and to tap into their knowledge and experience from a government-centred perspective, but the let them participate and to make them accountable for helping to solve their own problems. Such initiatives should not come in place of scientific and administrative capacity building as promoted by international agencies and Western scientific institutions, but it is a necessary complement to such efforts. And without them capacity building in science and technology will turn out to be ineffective if not straightforward counterproductive.

By focussing on other examples of the organization of accountability than those that only concern the (lack of) responsibility of political leaders we have shown how this may be achieved in various situations if one draws on rather straightforward modalities of accountability *in* public, *of* the public and *to* the public. To make them work in other situations requires first and foremost experiments and learning from experiments. Such experiments, especially those with radical participatory formats are often opposed in the name of formal democratic procedures. Representative democracy would become under threat and would be restricted that way. Our research, and that by many others, shows that there is little basis for such fears. Obviously participatory or dialogic democracy (Callon, Lascoumes, & Barthe, 2001) is not an alternative for representative democracy but complements it and can be expected to improve the functioning of the formal system.[5]

The most general recommendation from the work of accountability is therefore that we need more controlled experiments with new formats of accountability and combinations of formats of accountability in order to develop new approaches to decision making that are especially suited to promoting equality with the help of science and technology. In such experiments institutional boundaries should not be treated as sacrosanct but should themselves be tested and interrogated.

[5] See on this f.e. Fung, A., & Wright, E. O. (2008). Empowered participation for the UK;The Emerging Politics of Republican Democracy. In S. White, *Building a Citizen Society; The Emerging Politics of Republican Democracy* (pp. 83-92). London: Lawrence and Wishart.

More specifically, the ResIST work on accountability resulted in a wide variety of recommendations that can be found in the specific volume of the ResIST report. Some highlights:

- A broader conception of "policy maker" therefore needs to be adopted, based on the articulation of several actors in policy development, including technical staff, citizens, civic organizations or social movements.
- Specific training procedures, such as the citizenship schools implemented in some experiences of participatory budgeting, should be organized to enhance citizen participation.
- If one integrates participatory procedures in development policies the relation with formal-decision-making should be made explicit up front.
- Too much stress prevalent directive forms of accountability may easily blind those involved to a range of unanticipated consequences. Combined use of directive with other forms of accountability helps to check that and may also control distributive effects.
- Drawing forms of accountability together can be useful for managing financial, reputational and opportunity risks in multi-partner pro-poor projects.
- Accountability processes don't guarantee outcomes – these still require scrutiny.

6. STI policies in the face of global inequalities

In previous sections we looked at the problem of inequality and science and technology with respect to its underlying concepts. Different conceptions of inequality, knowledge, actors and institutional configurations come into play, along with different views on accountability and inclusiveness and on the historical and cultural roots of the problem. The general question of ResIST was how to harness science and technology to address issues of inequality. The question regarding what policies with respect to science, technology and innovation (STI) amount to in that respect is a derivative of that general question. And so is the further question of what policy reframing would support the implied goal. In this and subsequent sections of the general report we will report on our findings with respect to those questions.

Policies with respect to STI are often linked to and rooted in broad conceptions that seek to diagnose the contemporary world, the role of science and technology and how if differs from the world we had before. Based on such conceptions remedies and policies are suggested or outlined. Nowadays a lot is written about the *Knowledge-Based Economy* that is supposed to be emerging. Others speak of the emerging *Knowledge Society* or the *Learning Economy*. The *Network Society*, the *Internet Society*, the *Risk Society*, the *Information Society* and the *Post-Industrial Society* have been previously popular conversation topics. In the 1990s the analysis of the emergence of the Mode 2 stimulated debates about the new way in which the production of knowledge would be organized.

Before our discussion of policy frames we want to point out that such general visions may help to keep policy discussions going but may be of limited value when it comes to accomplishing goals like advancing equality with the help of science and technology. Often underneath fashionable discussions about grand visions, politics go on as before and changes are marginal in relation to actual policy implementation in practice.

Another effect of a focus on fashionable debates might be that substantial conflicts and differences in interest, as these determine actual practices, do not get the attention they need in order to introduce changes on the ground. Visions may help to direct our attention, but they may also distract and cloud what needs to be brought out.

Throughout the history of science and technology policy, innovation policies and public policy writ large the discussions have always been informed by differences of opinion that were rooted in different views of the importance of economic goals (like growth and competitiveness) and other goals like social security and social justice, environmental sustainability, health, disease and poverty. As such the options regarding the future avenues for STI policies are tightly connected to economic policy and development policy debates. The EU discussions about the Lisbon agenda and its formulations illustrate this clearly. While the emphasis on knowledge, research and innovation takes a central role, the relevance of this fact is precisely because this is not dissociated from wider options therein on the European socio-economic model, with a parallel emphasis on social cohesion and sustainable development. Obviously the discussion about the Lisbon Agenda clearly refers to the place of Europe in the

international world and the global economy and what Europe should strive for and it should fear.[1]

The Internationalisation of STI Policy-Making

As the previous discussion already suggests, the discussion about science, technology and innovation is clearly an international one. This is of course implied in framings that stress economic growth and competitiveness, or – in an earlier phase – the competition between the West and the socialist bloc led by the USSR. Nowadays the international character of STI policies is also evident from phenomena of globalization and the emergence of Asian economies as prominent players in the international high tech markets.

Even if R&D was considered to be one of the least internationalised activities of multinational corporations (MNCs), particularly when compared with foreign-based production and marketing[2], there has been a significant increase in the globalisation of research activities. Innovation networks are becoming more global and global competition is inducing business firms to develop a variety of strategies which go beyond national markets. Joint research ventures, technology alliances, delocalisation of research activities, or greater presence in international technology markets have all be more characteristic of the global innovation processes. Governmental policies follow similarly by giving greater attention to the foreign exchanges of their local research and innovation systems. These include specific policies that target, for example, technology based foreign direct investment (FDI), or that attempt to attract international talent, by facilitating the mobility of advanced human resources. But the internationalisation of policies goes beyond specific instruments, as they tend to be highly interconnected with those of their counterparts. National policies are often developed in close collaboration with international STI partnerships. This is particularly clear at the EU level, where the proposal to develop an European Research Area has extended the coordination of EU research and innovation policy with those of the now 27 Member-States one step further beyond the already strong collaboration. But international collaboration is not limited to the European arena, but has been developed, at different levels, by other countries and regions, such as in Africa. Partly in response to being largely left out of the technology globalisation processes led by business firms, African countries have joined together through the New Partnership for Africa's Development (NEPAD) and the African Union (AU) to develop a series of initiatives and a plan of action under the African Ministerial Council on Science and Technology (AMCOST).

The interconnectedness of policies is not simply a matter of coordination. As will be further discussed below, in section 7, besides the flow of technologies, human resources or products, through these processes there also flow policy approaches spanning national borders. Paradoxically, a dominant framework in these international fora, originating from work at the OECD and which has then circulated well beyond it,

[1] Conclusions from the European Council and Communications from the European Commission are the typical source here. Maria João Rodrigues (2009), *Europe, Globalization and the Lisbon Agenda*, Cheltenham, UK: Edward Elgar, provides an overview of European policy implications of the Lisbon Agenda in the context of globalisation and include a series of reference documents.
[2] OECD (2006) *OECD Science, Technology and Industry Outlook*. Paris: OECD.

is the National Innovation Systems framework (NIS). While emphasising the strengths of national linkages in the innovation process, the NIS framework clearly emerges in relation to the creation of national identities in face of the strong international dimension of science and technology. While the next section will further elaborate on this, suffices it say here that this is another, important although paradoxical, example of the strong international interweaving of science and technology policies, operating at different levels, in different arenas and reflected in different issues. As will be illustrated below, it is clear that the national policy-maker has in fact a limited set of instruments and policy options with which to work with and implement policy. Strongly dependent on foreign credit, on foreign donors and on foreign policy experiences, but as well and primarily on foreign competition, the roads left for experimenting with local policy are indeed limited. Some examples of those different arenas and issues where such constraints are visible are discussed below.

Issues and Arenas

As Chang[3] and Fagerberg and Godinho[4] point out, the room of manoeuvre by catching-up countries is largely limited by their own dependence on foreign partners. These constraints work at different levels. At the overall level of macro-economic policies, international organisations, such as the World Bank and the IMF, who have a central role in lending funds to the less developed economies, limit the types of public intervention that recipient countries can consider. Having been largely imposed strategies based on structural adjustments and market liberalisation, Southern countries have had limited conditions to promote endogenous technological capacity building and to allow local firms and industries to develop their competitiveness, under the pressure of more productive international markets. With weak bargaining power in the face of strong financial needs and weak credibility in the international financial markets, less developed countries are left with only limited opportunities for intervention, which inhibit their capacity to create appropriate environments for the improvement of the local productivity levels or the building of technological capabilities. Chang's argument is not only important in contesting the extent of the role of policies based on market liberalisation in recent processes of catch-up. He also points out that those arguing that success cases were based on market liberalisation are at the same time imposing greater restraints on the role of interventionism in current development policies in less advanced countries. In this way, instruments that were successfully used in the past in similar processes, are now becoming unavailable due to the strong role that international organizations such as the World Bank, the IMF, and the WTO, can have on national policies.

While the weak bargaining power is particularly evident in such bilateral relationships, other multi-lateral international governance regimes also impose strong constraints on the role of individual states. Trade regulations, led by the WTO, or IPR regulations, led by the WIPO, also provide strong examples of one size policies that give limited attention to the specific needs of Southern economies, as several authors have recently

[3] Chang, H.-J. (2007), *Bad Samaritans: The guilty secrets of rich nations and the threat to global prosperity*. London: Random House Business Books.
[4] Fagerberg, J. and Godinho, M.M. (2005), "Innovation and Catching-Up", in J. Fagerberg et al. (eds.). *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

argued[5]. As discussed below, in doing so, they are often overlooking historical experience of catch-up, by the currently more developed countries, for whom interventionist and protectionist policies were of central importance in their convergence process, and are applying a principle of 'one policy fits all' which does not take into account the different contexts and needs in the South, and which favours the protection of the assets owned in the North against those in the South. One case where such open conflicts of interests have emerged is, for example, the issue of protection of intellectual property rights (IPR). The linking of 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. That linkage, as initiated by developed countries and the US in particular, has been seen as a move towards the development of global "level" playing field in IPR regulation, based on stronger protection and more extensive harmonisation of IPR regulations, seen to primarily sustain the interests of the most developed knowledge economies. While increasing appropriation of knowledge is guaranteed in the North, objections are raised to the protection of resources that are at the centre of knowledge activities in the South, such as the protection of traditional knowledge (see section 5),[6] or the full establishment of the Convention on Biological Diversity. While this goes on at the table of global negotiations, with the increasing focus on the commercialisation of public research new barriers are being built around knowledge which was previously more easily accessible, and thought of primarily as a public good. In a world where all, countries and institutions, increasingly focus on the appropriation of the public research results, it is difficult for a country to individually take an opposite strategy, where the emphasis on commercialisation and entrepreneurship does not take precedence to its public use.[7] The emphasis on the firm as central actor in the process, and the transfer of models focused on the firm to other areas of production and use of knowledge, overlook the importance of other organisational forms in the Global South, such as local communities or the public sector, namely universities and research organisations.

The constraints of national policy-makers regarding policy implementation is evident in the development of their own sectoral policies. In countries, such as Mozambique, where the implementation of STI policy strongly depends on the willingness of donor countries, these have an important say in how these policies are developed. While donor countries and donor agencies act in strong interaction with local governments in the support to existing strategies, they contribute to specific projects rather than in a more integrated way to the overall strategy. As such, they take an important role in indirectly influencing local priorities by supporting specific projects rather than others.

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[5] E.g. Chang, H.J. (2007), *idem*; Collier, P. (2008), *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It*. Oxford: Oxford University Press; Stiglitz, J. (2006), *Making Globalization Work*. London: Penguin Books.

[6] While countries in the North have not been willing to accept the protection of traditional knowledge, on the grounds of its long standing public availability, even if its public character is locally limited, these have been increasingly expanding the protection of scientific knowledge to areas not previously throught possible (such as in genomics) and to practices previously excluded (such as academic patenting). Cf. Adam B. Jaffe and Josh Lerner (2004), *Innovation and Its Discontents*, Princeton: Princeton University Press.

[7] Precisely because of this difficulty to act individually, central agricultural research organisations have collectively taken initiatives to counter this move towards appropriation, by collectively retaining the rights to their public research results (cf. Atkinson et al. (2003), "Public Sector Collaboration for Agricultural IP Management", *Science*, vol. 301: 174-5).

An overview of STI policies in African countries found that the actual priorities implemented, and reflected in research output profiles, was closer to the priorities of donor agencies than to those previously defined in governmental policy documents.[8] Local strategies may be developed in unbalanced ways rather than being able to fully develop the previously delineated integrated strategies, therefore limiting its success.

This leads to an additional tension in the relation between donors and local governments[9]. As put forward by Moss et al.: "[i]f donors are providing the majority of public finance and governments are primarily accountable to those external agencies, then it may simply not be possible to also expect a credible social contract to develop between the state and its citizens. Using the current terminology, aid may undercut the very principles the aid industry intends to promote: ownership, accountability, and participation."[10] As discussed in the previous section, accountability is essential to induce inclusive processes where the different stakeholders are involved. This, in turn, is important to guarantee that decisions on different projects respond to the needs of local populations and of the implementation processes local populations are often better placed to assess.

While the above reflects differentials of bargaining power in direct interactions in policy-making, other limitations develop from the interconnected nature of the global STI system. Another example where the creation of "level" playing fields may cement the competitive advantage of the already strong players of the game is migration of high-skilled labour, including scientific migration. While specific protectionist policies can be developed to limit the 'overflow' of local human resources, the STI system also depends on its openness and its capacity for the exchange of knowledge. As such, it is clear that there is a strong interconnection between local and external public decision-making processes, and in the decisions of researchers who opt to stay in or to leave less advanced countries in search of better individual opportunities. Besides individual incentives, local policy-makers also have to consider the impact of external policies, which at the same time work to, often explicitly, attract foreign advanced human resources. As economic competitiveness is seen to depend increasingly on access to a high-skilled work force, becoming a net beneficiary of these migration processes has become a key issue for gaining and retaining competitive advantage in the knowledge economy. Regions and nations are now developing specific policies to attract foreign students and researchers. As only a few developed countries have been net beneficiaries of migration of high-skilled workers, these inequalities may easily be exacerbated by such active policies to attract highly skilled personnel from abroad, as countries and regions that are already in advanced positions may extend and capitalize on that competitive edge. The discussion in section 9 clearly exemplifies this and the tensions faced by national policy-makers in the face of international STI policy-making processes.

[8] Mouton, J. et al. (2008) "A Baseline study on Science and Technology and Higher Education in the SADC Region", Science & Technology Studies Series, Southern African Regional Universities Association, SARUA, Wits, South Africa.
[9] These are discussed by different authors, not always in agreement, in Easterly, W. (Ed.) (2008). *Reinventing Foreign Aid.* Cambridge, MA, USA: MIT Press.
[10] Moss, T., Pettersson, G. and van de Walle, N. (2008), "An Aid-Institutions Paradox? A Review Essay on Aid Dependency and State Building in Sub-Saharan Africa Dysfunctional donors and how to reform them", in Easterly, W. (Ed.) (2008). *Reinventing Foreign Aid.* Cambridge, MA, USA: MIT Press.

Similar examples abound. Competition between developing as well as developed countries for foreign direct investment (FDI) may be positioned in direct opposition to development as a main avenue for sharing the benefits of the knowledge economy. 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.[11] The consequences are clear. The bottom billion, to use the phrase coined by Collier[12], appears to be increasingly out of this game, competing not only with those most successful in knowledge resources, but also with those that join such performance with low labour costs: "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." [13]

Furthermore, the internationalisation of STI policies does not only increase the pressures faced in the design of new policies, but also in its assessment. Widely driven by the use of established macro-level indicators, the assessment of national performances of the STI systems has created a global lens through which individual countries are analysed and internationally compared. Policy-makers at large want to see these indicators reflect improved performance, and know that these are the benchmarks used by their international counterparts. This can create additional external pressures on the direction of policies, towards greater focus on short-term impact on the established STI indicators, and not necessarily towards greater long-term impact. The two are not necessarily exclusive, but mainstream indicators, as will be further discussed in the following sections of this report, emphasise performance indicators which reflect more the structure of industrial innovative activities in the North rather than improved distributional impacts policy-makers in the South may also expect to achieve. While the extent to which these indicators may be the most appropriate to characterize the development of local knowledge systems and of STI policies in less advanced countries is subject to question from an academic perspective,[14] it is not easily questionable from within the global STI policy arena, with whom governments have to interact.

What happens nationally in terms of STI policy making is heavily influenced by the international discussions and negotiations as well as analyses and monitoring schemes that make policies and performances of various nations comparable. A consideration of how science and technology can be harnessed to address issues of equality and inequality should thus explore how such an endeavour relates to these contested general policy framings. But we also need to look at the more concrete level of specific policies and specific arenas in which specific policies are discussed and negotiated. At this level the same tensions come although sometimes indirectly also into play. And again the question is what this has to do with issues of inequality.

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[11] See *Monitoring Industrial Research: the 2005 EU Industrial R&D Investment Scoreboard*, EU/Research.

[12] Paul Collier (2008), *The Bottom Billion: Why the Poorest Countries Are Failing and What Can Be Done About It*. Oxford: Oxford University Press.

[13] World Economic Forum.

[14] As an example, STI policy experts in Latin America have joined forces to develop a new Manual for Innovation Surveys, the Bogotá Manual, to replace the Oslo Manual, which they consider not to be adequate to the context of the innovation process in the intermediate economies of Latin America (*Bogota Manual: Standardisation of Indicators of Technological Innovation in Latin American and Caribbean Countries*, RICYT/OAS/CYTED, March 2001).

Global policies within these contested policy areas need to be balanced and designed with more explicit consideration of how they may specifically benefit less advantaged economies, nations and social groups. For any of these specific policy issues, a broader agenda and alternative options are being sought and developed: in response to stronger and ever-increasing global harmonisation of IPR protection, a 'development agenda' for IPR is under development, emphasizing the need for flexible IPR policies according to the needs and circumstances of developing countries; in scientific migration issues, opportunities are sought, not to stop migration, but to make it benefit sending regions and countries [15] and awareness is developed for how the terms for FDI may ensure spillover and virtuous circles of wider growth and development.

This lies largely with the overall governance mechanisms of STI policies. From the start, the acronym used here of 'STI' already refers to a particular approach, albeit common, i.e. to the organisation of policies for science and technology (S&T) in the frame of innovation policies. As Borras and Lundvall[16] argue, this focus on innovation policies corresponds to the current model of policies in this area. In earlier periods the focus was initially on policies for the organisation of the research system more strictly, or science policies, and then on policies focusing on technology development, technology policies. Innovation policies appear as embracing a wider approach, which integrates science, technology as well as other forms of production of innovations, such as at the organizational level. However, in less advanced countries, where formal innovation processes are not widespread, and where science and technology is strongly linked to the higher education sector, on the one hand, and to civil society, on the other, it is questionable whether framing S&T policies fully in view of innovation at the level of the firm may be the best organizational arrangement. Indeed, such governance mechanisms can have an important effect in how capabilities, and their development, are understood.

STI Policy-making and Inequality

We have looked in section 2 into the different forms of inequality. Inter- and intra-country inequalities, vertical and horizontal inequalities, or the structural, representational and distributional inequalities that ResIST takes as its central framework. Broadly, we chose the characterisation in terms of structural, representational and distributional inequality as it reflects the impacts of science and technology on inequality *throughout* the process. Hence we have the CARE *cycle*. The different forms are important and if we expect to focus on the relationship with policies we cannot simply focus downstream, on the impacts, because well before that, upstream in that process, science and technology were already being shaped. This framework also allows us to more clearly think of the implications for STI policy-making. As we saw in section 5, policies which embrace representational inequalities, embracing wide participation in decision-making, for example in matters of public health, can better reflect local forms of knowledge on public decision-making processes. And as will be illustrated below, other policies can be described in relation

[15] Lucas Luchilo: Trends, policies and impacts of international mobility of the highly skilled on developing countries, http://www.resist-research.net/cms/site/docs/resistwrm_programme_rc.pdf.
[16] Borras, S. and Lundvall, B.-A. (2005), "Science, Technology, and Innovation Policy", in J. Fagerberg et al. (eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

to these forms of inequality. In fact, we will have some difficulty to find STI policies which explicitly address inequality unless we focus on our integrated framework with three forms of inequality. In one of the ResIST working papers[17] we have analysed policy documents to see whether and how issues of inequality figured in such documents. This leads to the overall picture described below.

STI policies have been less explicit about addressing vertical inequalities, other than in the international arena. In that sense, when one hears about STI policies that address inequality this mostly refers to global inequalities. In fact, the attempts to improve social wellbeing in the less developed countries, and to improve their economic growth towards convergence with more developed countries have increasingly been concerned with harnessing knowledge for development. Initiatives with this objective have been plentiful in recent years following two decades where S&T had largely fallen out of the agenda of development.

Official policy papers that address questions of inequality through science and technology are not easy to find in the Europe and other more developed countries. There seems to be two types of division of labour here at place. STI policies in the Global North focus on problems of economic growth, innovation in firms, and high-technology, while issues that deal with social challenges, such as inequality, are expected to be addressed through social policies. Secondly, addressing inequality through STI appears to be left to the South.

Take as an example European policies. As conveyed through the Lisbon Agenda, EU policy is expected to be more inclusive, with concerns with social cohesion on a par with those with economic growth. In practice, S&T enters this discourse essentially through the attribution of a greater priority to the importance of knowledge in contemporary society, largely as a fuel to future economic growth. Concerns with sustainable development are also an important component of this agenda, and certainly have implications both in terms of S&T policies, as well as for social cohesion. Nevertheless, at present the focus in this arena on science and innovation for social cohesion goes more in the direction of defending investment in longer-term goals, in supporting the training of a new generation of researchers, on guaranteeing future economic competitiveness[18], rather than in the expectation that science and technology could contribute for a more effective identity of the European social model. In this way, science and technology and social cohesion appear as two goals that work more in parallel than effectively in tandem.

Harnessing science and technology for strengthening industrial technological capabilities and for solving local problems related to development and to factors of exclusion has been a road taken increasingly by Southern countries. In fact, these countries appear to have no other choice, as the countries in the North do not seem to promote particular policies to improve the distributional impact of STI and to promote inclusion processes through STI.[19] As will be further discussed below in section 8,

[17] Cozzens, S. et al. (2007), "Problems of inequality in science, technology, and innovation policy", James Martin Institute Working Paper 5, Oxford: Oxford University.
[18] The much quoted statement from the Conclusions on the Lisbon European Council, in 2000, emphasises the goal of turning Europe "the most competitive knowledge-based economy by 2010".
[19] As stated by Rasigan Maharajh at the World Regional Meeting of ResIST organised in Stellenbosch, South Africa, concerns with poverty and inequality have for long been at the centre of policies in the South. Bringing STI in to this debate is the novelty. The reverse may

STI policies address mostly the high-technology sectors, with greater potential for growth, but also where new products often target the wealthier markets. This is also reflected in addressing global issues. The diseases which pose the major public health challenges, predominant in the South, have received much less funding through R&D than those more characteristic of the North.[20]

In the less developed countries policies promoted largely in the 1970s for the promotion of science and technology activities for development have not been successful, generally speaking.[21] In fact, the most notorious success in economic convergence, in East Asia, has led the World Bank to name this process as a miracle[22]. While the process of economic catch-up was difficult then, this is even more difficult now, for those from the 'bottom billion', who have increasingly limited options in upgrading their endogenous capabilities. As Collier shows,[23] while export markets are crucial for improving firm productivity, less developed countries have fewer instruments to be able to address the local underlying conditions in order to be minimally competitive in foreign markets. They face a dilemma regarding the contribution of science and technology towards this process of development. On the one hand the effectiveness of investments in science and technology capabilities depends on the ability to sustain such investments through long periods of time, without the ability to recover these in the short-term, and requiring some forms of protection for the local industries, which are increasingly limited through international trade and debt agreements.[24] As others have argued,[25] this depends strongly on the existence of institutional complementarities that can target and support the growth of the local technology sector. Recent examples of catch-up in East-Asia present diversified experiences, where the skills base, government intervention, protectionist

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be starting to happen in the North, with inequality having been left out of STI policy debates, but starting to make its appearance.

[20] Daniele Archibugi and Kim Bizzarri (2004), "Committing to vaccine R&D: a global science policy priority", *Research Policy*, 33(10): 1657-1671.

[21] For a review on science, technology and development from the perspective of STS, see W. Shrum and Y. Shenhav (1995), "Science and Technology in Less Developed Countries", in S. Jasanoff et al., *Handbook of Science and Technology Studies*, Sage: Thousand Oaks; and S. Cozzens, S. Gatchair, K. Kim, G. Ordóñez and A. Supnithadnaporn (2007), "Knowledge and Development", in E. Hackett et al., *Handbook of Science and Technology Studies*, Cambridge, USA: MIT Press.

[22] This was the title of a World Bank report on the economic growth in the so called East-Asian tigers (World Bank (1993) *The East Asian Miracle: Economic Growth and Public Policy*, World Bank: Washington, D.C.). While the World Bank study emphasises the role of institutional stabilisation, market governance and general education policies, the sources of this 'miracle' have been contested by other authors, who have emphasised the importance of policies that contributed to capability building, by select S&T support, trade protection, and active involvement of the State in industrial policies (cf. Lall, S. (1994), "'The East Asian Miracle' Study: Does the bell toll for industrial strategy?", *World Development*, 22(4): 645-654).

[23] Collier, P. (2008), *idem*.

[24] Chang, H.-J. (2007), *idem*.

[25] The work of Chris Freeman and Carlota Perez (Freeman, C. and Perez, C. (1988) "Structural Crises of Adjustment, Business Cycles and Investment Behaviour", in G.Dosi et al. (eds.) *Technical Change and Economic Theory*. London: Francis Pinter) on the importance of techno-economic paradigms is a case at hand. This has been more widely explored by Freeman, C. and Louçã, F. (2001), *As Time Goes By: From the Industrial Revolutions to the Industrial Revolution*. Oxford: Oxford University Press. An important early work in this line was that of Gershenkeron, A. (1962), *Economic Backwardness in Historical Perspective*. Cambridge: Harvard University Press.

policies or the importance of foreign direct investment have had different degrees of centrality on the strengthening of local technological capabilities.[26]

However, on the other hand, while they are not technologically competitive, their higher competitiveness on the basis of low labour costs still faces strong competition from countries in South East Asia, which maintain low labour costs but have already upgraded significantly their technological capabilities. As such, the opportunities presented by typical processes of upgrading and catch-up, with a mixture of imitation and innovation, protectionist policies and promotion of exports, seem to be rather limited. While these can take different forms, targeting the skills base, the financial institutions or the information infrastructure, it is clear that these need to focus on the wider local development strategy, and that these depend strongly on the public policies to that effect.

The lack of success of most policies oriented towards the eradication of poverty in Africa has led to significant debates within development studies, and among the aid community. The work of William Easterly,[27] in particular, has been controversial. Highly critical of recent experiences of foreign aid, based on extensive public spending programmes, proposed by those he calls the *planners*, he defends more piecemeal interventions, responding to specific needs and based on the responses to incentives, and developed by those he calls the *searchers*. Some have criticized his work for not being concrete enough in terms of solutions,[28] but have recognized his criticisms as partially valid. While his dichotomised view of public intervention in aid may be too simplistic, and overly optimistic regarding the ease of developing search based initiatives, it is clear that new policies are required.

There is a parallel to be taken here with the history of STI policies. The creation of formal R&D institutes in Africa at the image of those in the North, for example, which characterised earlier modernisation policies in the 1970s, had little success. Creation appears to be easier than maintaining and successfully exploiting these institutes. Institutions are, of course, needed, and there lays a trap of such dichotomised views. However, as also discussed in section 3, there is a need to go beyond the views of the State as a see-all planner, and to incorporate initiatives directly oriented towards addressing basic problems of the population, and to provide them with further knowledge resources in that process. Although that is much less the case in the North, STI policies in some of the countries studied, in the South, have increasingly developed initiatives where the impact of science and technology on development is not simply framed in terms of its impact on economic competitiveness but also on the reduction of internal inequalities and on improving the potential of science and technology to address local problems. This also means that STI policies should not be envisioned simply within the restricted definition of research and innovation activities, delivering responsibility to the competent Ministry. Instead, STI policies should

[26] Cf. Bell, M. and Pavitt, K. (1993), "Technological Accumulation and Industrial Growth: Contrasts Between Developed and Developing Countries", *Industrial and Corporate Change*, 2(1): 157-210.
[27] William Easterly (2006) *The White Man's Burden: Why the West's efforts to aid the rest have done so much ill and so little good*. London: The Penguin Press. A more recent controversial book formulating a similar message is Moyo, D. (2009). *Dead Aid; Why aid is not working and how there is another way for Africa*. London: Allen Lane. On alternatives, see Easterly, W. (Ed.) (2008). *Reinventing Foreign Aid*. Cambridge, MA, USA: MIT Press.
[28] E.g. Birdsall, N. (2007) "Foreign Aid: Diagnosis without Direction", *SAIS Review*, 27(2): 215-218.

encompass different activities, such as in health, sanitation, or agriculture, where some form of knowledge is essential to the solution of a specific relevant problem.

The approach has not been tried in full as government policy and under appropriate conditions, but there is a lot of scattered evidence that suggests the plausibility and potential of such an approach. It is certainly justified and important to try to do so. As Collier argues,[29] time goes against those at the bottom. For example, countries in Africa do not have to compete internationally only with the more advanced countries, highly technologically developed but with high labour costs. They also have to compete with countries for example in Asia, which have been able to climb the ladder of technological capabilities, but who add low labour costs to their high technological competitiveness. It is clear that the board in this game is tilted against those at the bottom and requires STI policies that recognise this and that work *from* the bottom.

Policies addressing inequality

The framing of STI policies cannot be seen as simple translations into policies of insights and knowledge about the 'nature' of knowledge as economical entity, of 'new production of knowledge' or of 'systemic innovation'. These framing processes are core parts of the politics of the contemporary global knowledge economy, where interests often conflict and the role of power is pervasive. Thus, developing effective STI policies is not only about learning to play by the "new rules of the game"; contesting and re-writing of those rules may be as integral and essential parts of that competitive game itself.

While, as discussed above, national policy actors have a limited role in implementing overall innovative strategies, they can play particularly strong roles in developing initiatives which address local conditions of inequality. They articulate STI issues with larger national values and set the agenda for attention to social cohesion by sub-national policy actors. While there is an established wide range of instruments available for national policy actors to use, in following dominant policy approaches, other possibilities, identified in the course of our research, which have been developed by local governments and actors to specifically address local inequalities through the role of S&T. From our study of policy strategies in different countries, we identified specific policy initiatives which go against the dominant approach focused on the knowledge economy. The initiatives that we discuss below, on the contrary, address problems at the heart of inequality processes in science and technology, at the structural, representational, or distributional levels. Although different in form and other respect they illustrate what is argued above.

Concern with building institutional capacity in disadvantaged communities for both science education and research is an example. In the United States, institutional development programs have been directed to historically black colleges and universities, and similar steps are underway in South Africa. In Mozambique, an example is the Centro de Investigação em Saúde da Manhiça (CISM, the Manhiça Health Research Centre), a regional health centre which is training health care workers for the whole country, while increasing capacity by doing clinical trials as part of international research efforts.

[29] Collier, P. (2008), *idem*.

The need to consider local and global forms of structural inequalities is particularly evident in human resource policies. Similar tensions also appear between countries. They are perhaps most visible in the context of the international mobility of scientists and engineers. As discussed above, setting up initiatives based on competition between countries for trained personnel requires greater attention to global outcomes of international mobility, but the extent to which the latter is taken into account is very limited. Section 9 below provides more extensive evidence on these issues.

While Europe and the United States are struggling to try to overcome their internal inequalities and over the long run recruit women and members of ethnic minorities into such careers, they are adopting policies designed to attract scientists and engineers from other countries.[30] In developing countries, these professionals are crucial for addressing both economic development and human development challenges like agricultural productivity and tropical disease. Policies on recruitment of immigrant talent can run directly counter to the same government's international development plans for capacity building.[31] In this way, the challenge for policies is to create the conditions for effective domestic recruitment everywhere, and to address the differential outcomes of mobility policies, both in receiving and in sending countries.

Public research institutions can build the knowledge base over the long term in directions that serve public goals, like research on issues such as public health or affordable housing. But the instruments available go beyond the typical, academic based research project to the role of 'extension'. Public research organisations can also provide technical consulting for community-based innovation processes, as the science shops do in the Netherlands.[32] Universities are also the site for spreading capacity through the education process, and their connections to the broader community are crucial in keeping them culturally attuned to this task.

While local initiatives are gaining relevance, the importance of the global role is particularly evident in research policies. International research efforts can contribute to poverty reduction, as is the goal with new national programs in the UK[33] or through international partnership arrangements, such as research on vaccines for the diseases of poverty.[34] As different national cases exemplify, public research institutions can also support broad, societal innovation processes that focus on collective goods, in addition to the current emphasis towards commercial applications.

With public decision makers being a more dominant force in research policy, and private industry less directly involved, this policy area can therefore be more influenced by civil society. There are several examples of considerable open negotiation over the research agenda, with diverse stakeholders. Particular groups care about whether their problems are being studied. Inclusive governance processes can

[30] Lucas Luchilo, "Trends, policies and impacts of international mobility of the highly skilled on developing countries". Available at: http://www.resist-research.net/cms/site/docs/resistwrm_programme_ll.pdf, accessed April 22, 2007
[31] For example, the UK's work in four development centres (see http://www.dfid.gov.uk/pubs/files/researchframework/research-framework-2005.pdf, accessed April 28, 2007), including attention to "how citizens can hold states accountable".
[32] Wachelder, J. (2003), "Democratizing Science: Various Routes and Visions of Dutch Science Shops", Science, Technology & Human Values, 28(2): 244-273.
[33] See: http://www.nerc.ac.uk/research/programmes/espa/events/ao1.asp, accessed April 28, 2007.
[34] Woolgar, S. et al. (2008), "Articulating New Accountability Systems: Integrated Framework", James Martin Institute ResIST Working Paper 13, Oxford University, Oxford.

have important contributions to mitigate inequalities. For example, the Women's Health Initiative in the United States was brought into existence by a feminist political coalition.[35] The priority-setting processes have been a central locus of accountability of the research policy process, through expanded representation. In addition, these processes are also expected to contribute to reduce both structural inequality (by putting in place programs to recruit these groups into science and engineering careers) and to address major health problems for these groups on a targeted basis (reducing inequalities in effects).

Inclusion processes in research policy can take other forms. For example, informal science education takes places in museums, newspapers, television, and other venues outside the classroom. These often provide the opportunity to reach out horizontally. In Brazil, a Junior Minister for Science and Technology for Inclusion carries science to the countryside in travelling exhibits.[36] While these initiatives are often seen as a tool for recruiting more young people into science and engineering careers or to improve public 'confidence' in science, emphasising mostly unidirectional communication, they are, nevertheless a first step in efforts of dialogue between science and society. More advanced engagement processes have moved beyond the "deficit model," which assumes that participants need to know more, to assuming that participants can also bring different kinds of knowledge to issues at stake, in which they are, or will be, partners as citizens/users/consumers. Spreading the capacity for many people in society to participate in decision making involving science and technology is a step towards reducing representational inequalities and increasing accountability, although we still need to understand much about what is needed to make participatory exercises truly re-distributive.

There are, however, examples of initiatives that can also be specifically directed in inclusive directions, on the basis of social outcomes. For example, Brazil's social inclusion effort through STI policies, includes work on "social technologies," "assistive technologies," and "popular cooperative incubators." In these initiatives, the focus on collective innovations, through local actors, is paramount. Similarly, the micro-finance movement includes support for grass-roots entrepreneurs who develop simple technologies that can be produced locally and solve local problems. Likewise, policies that affect diffusion of innovations can facilitate or prevent such inventive uses as small businesses started by "mobile phone ladies." A similar example from South Africa illustrates how the use of local knowledge for innovation can create export-oriented industries in ways that build local communities. BP1, a compound extracted from a local plant, is being developed as a mosquito-repellent product collaboratively between local community healers and a large government laboratory. If the business is successful, it will generate local jobs in growing the plant and in

[35] Cozzens, S. (2008), "Gender Issues in US Science and Technology Policy: Equality of What?", *Science and Engineering Ethics*, 14(3): 345-356.
[36] Information on Brazil in 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), as well as the presentation from the Ministry for Science and Technology for Social Development and Inclusion at the ResIST World Regional Meeting in Rio, Ildeu de Castro, "S&T and social inclusion". Available at: http://www.resist-research.net/paperslibrary/rio.aspx, accessed April 25, 2007.

producing the repellent candles.[37] The current effort in Mozambique to develop malaria-treatment tea based on a local plant also illustrates such an effort. If successful the tea will require "no dependence on highly qualified expertise, no dependence on imported medicine, no dependence on pharmacies (Green Pharmacies), no intellectual property rights related restraints on use, improvement and research."[38] Thus the community gains not only a solution to a problem – it also frees up resources to address other challenges.

Innovation policies can also address inequalities through their governance processes, depending on the extent to which private firms get 'all' the attention in the definition of innovation policies, or whether other actors in the innovation system are also considered. Worker-innovators, with a direct view of the production process, and user-innovators, along with community-based innovations or innovation in the public sector are examples of actors that are involved in the definition of certain innovation policy instruments.

Institution-building is also a key element in technology-based regional development, an effort that aims at reducing rural/urban and other sub-national structural inequalities. The UK science strategy, for example, points to reducing regional inequalities in capacity. And the Brazilian social inclusion effort extends to "local productive arrangements," "technological vocational centres," and "digital inclusion". The proximity between a variety of actors active in innovative processes becomes of particular importance.

While there is a tension regarding the level of agglomeration and the clustering of related activities, it is clear that there are important initiatives directed at different forms of innovation in the economy, and at different actors beyond those private firms in the most high-growth sectors. National policies can thus reinforce centre-periphery and urban/rural differences, in pursuit of national economic growth, unless the diverse types of innovation are addressed and institution-building does not focus only on specific technology centres.

Regulatory processes are often quite S&T intensive, calling for high levels of expertise and often for dedicated bodies of research knowledge. Formal knowledge tends to be given more weight than situated, local knowledge in such processes. This is relevant regarding public responsibility in consultation processes, but particularly regarding other actors. While industry relies on the mobilization of scientific experts, with appropriate credentials, civil society groups tend to mobilize a wider range of actors with specific knowledge, who must also be fully considered in such processes. In certain cases this results from wider international movements.

In fact, regulatory policy is often of particular importance to address questions of governance at the international level. It is a central site of dispute, often following citizen action, to enhance accountability processes, sometimes extending well beyond health and safety to economic justice. The environmental justice movement in Brazil, for example, has addressed the social as well as environmental consequences of large-

[37] Vinesh Maharaj, "Bioprospecting Research: a case study". Available at: http://www.resist-research.net/cms/site/docs/Vinesh_Maharaj.pdf, accessed April 22, 2007.
[38] Adelaide Bela Agostinho, "Malaria and herbal therapies: where science and traditional knowledge meet," slide 10. Available at: http://www.resist-research.net/cms/site/docs/Adelaide_Agostinho.pdf, accessed April 22, 2007.

scale soy production, including the closing of thousands of small farms.[39] This social movement has criticized the shipment of toxic waste from the rich state of São Paulo to the poor state of Bahia, and tried to prevent Europe from sending its used tires to Brazil, where these have serious impacts on public health. In these cases and other cases, for example regarding e-waste[40] the formal regulatory regime may not be sufficient, and new forms of accountability, such as partnership based, are often needed to address such international regulatory issues.

Overcoming inequality through STI requires new policies, at the global and national levels

While concerns with harnessing 'knowledge for development' or with achieving social cohesion alongside the development of competitive knowledge economies are voiced at different levels, there appears to be much less being effectively done to match discourse with practice. Either issues that are central to the effectiveness of STI policies that expect to develop local technological capabilities are negotiated elsewhere, outside its scope and privileging other discourses, or those concerns that broaden the scope of STI policies to a more inclusive approach, where distributional impacts are part and parcel of these policies, are not taken up and left for future steps, typically under the remit of other policies.

The dilemmas faced are multiple, and it is clear that the interlinkages between systems and between policies require new approaches to different issues and arenas where science, technology and inequality interact. While STI policies in the South appear to address, at least in the corresponding policy strategies, initiatives that address issues of inequality, global dominant STI policy discourses strongly permeate these policy-making processes and do little to consider the local importance of inequality in these processes. It is clear that unless the relationships between science and technology and inequality are taken up explicitly up front, at the different arenas where policies are designed and negotiated, there are little resources left for the bottom billion to benefit from the promise of progress brought about by science and technology. Or in other words, a new approach to STI policy-making is needed. The following section, through an analysis of the use of the concept of National Innovation Systems in the South, illustrates how the policy-making process in the South is often captured without being able to adapt to its own needs.

[39] Juliana Malerba, "Environmental Justice Network". Available at: http://www.resist-research.net/cms/site/docs/resistwrm_programme_jm.pdf, accessed April 22, 2007.
[40] Woolgar, S. et al. (2008), "Articulating New Accountability Systems: Integrated Framework", James Martin Institute ResIST Working Paper 13, Oxford: Oxford University.

7. National innovation systems approaches and the mobilisation of science and technology against inequality

For about two decades now the innovation systems approach has been an important framework with which to analyse how countries, regions and sectors perform with respect to technological change, science and economic performance. The innovation systems approach can be seen as an attempt to address the shortcomings of the neo-classical approach to assess the economic importance of innovation and the restrictedness of unilinear conceptions of technological change.

In the neo-classical approach to markets and economic growth technological progress is analyzed as a residual factor to be assessed by comparing the growth rates for capital and labour costs with overall growth in GDP. The extent to which the latter is higher than the weighted growth rates for capital and wages is referred to as total productivity growth and that is assumed to be caused by technological progress, better education and the like.[1] This form of growth accounting lacks a well-articulated theory or conception about innovation and technological change. It is against this 'residualism' that innovation systems theorists seek to develop an approach in which the role of institutions, the state and the development of knowledge as such are integral parts and studied in their own right.

Unilinear models come in two formats, 'technology push' models and 'market pull'. The 'technology push' model assumes that technological change occurs when scientific and technological discoveries lead to product invention after which markets for the new product come into existence. 'Demand pull' views follow the opposite course: a problem is acknowledged and it seems probable that consumers are willing to pay for products to deal with it. In response inventors and researchers will pick up on the lead and search for an innovative product. Although both 'push' and 'pull' models have a prima facie plausibility, reality is normally more complex. Detailed economic and especially historical and sociological studies of technical change have documented that the interactions between various factors and contexts are much more complex than the unilinear and neo-classical approaches suggest. An analysis in terms of innovation systems recommended itself as a result in which (a) innovation is central rather than treated as an exogenous variable, (b) a variety of factors (science, market, government policy, institutional architectures, culture) are proposed to be investigated and assessed in terms of their interactions and effects.

From the start innovation systems analysis was stimulated by the increasing interest in technological change as a major factor determining economic growth and international competitiveness. Major science policy actors such as the OECD, the US National Science Foundation – through the definitions used in its influential *Science and Engineering Indicators* series – played an important role in stimulating innovation systems analysis. Available official statistics on national economies, existing science

[1] Other economists starting from a neoclassical assumption have tried to turn technology into an endogenous factor in their models through other forms of growth accounting, but the result remained unsatisfactory in the eyes of their innovation systems critics. See Bart Verspagen, "Innovation and Economic growth," in Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.), *The Oxford Handbook of Innovation*. Oxford: Oxford Universtity Press, 487-514.

indicators and other relevant statistics (e.g. education) proved useful but additional indicator development was required which led, among other things, to innovation surveys and the so-called Oslo Manual. The attention and support from OECD and national governments and institutions may have promoted a certain emphasis on the study of so-called national innovation systems. Sectoral studies and regional studies have been done but seem to have got less attention from the innovation systems analysts in the early years. More recently there is more attention to regional systems echoing perhaps the growing interest in regional development in the international political system.

Initially national innovation system studies focussed on the technologically most advanced countries. Quickly research expanded to include studies of the so-called catch-up economies. Subsequently the approach become generic as it was claimed that the approach could also be used to support and discuss innovation and policies in economically less-developed regions and cultures and in the new nation-states of the Global South. The work of Lundvall[2] and the Globelics[3] initiative and also the OECD activities have been especially instrumental in the export of the innovation systems approach to the Global South. At several of our meetings it surfaced that the national innovations approach has become a popular key buzzword. Members of our advisory board cautioned us that unless we would frame our recommendations in terms of national innovation systems policy makers in southern countries would not listen to us. One wonders how to interpret such popularity.

The national innovation approach is certainly attractive as a framework to analyse and discuss the build up of capacities in science and technology in less-advanced economies and new nation states. To endorse it can be very helpful to get a comprehensive view of the problems and opportunities and to decide on priorities and posteriorities. To use the approach to address science and technology in the struggle for equality and against poverty and deprivation, however, requires inclusiveness and the political strength to overcome obstacles that stem from established powers in government, industry, the professional organisations and the science system as established. The history of the use of the approach in developed as well as underdeveloped countries documents this. And apart from that the approach itself also has a number of general conceptual, analytic and methodological weaknesses and also specific limitations when it comes to addressing problems of less developed economies and issues of inequality.

From the beginning different conceptions and definitions of the national innovation system have been entertained by the various leading protagonists of the approach[4]. Godin argues that the concept is essentially rhetorical and fuzzy.[5] Although this has not hampered its use in empirical case studies it allows for ontological gerrymandering between broad and narrow definitions where situations are ambiguous. When used for

[2] Lundvall, B. A., Johnson, B., Andersen, S. E., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy, 31*, 213-231.
[3] See: http://www.globelics.org.
[4] Godin, B. (2005). *Measurement and Statistics on Science and Technology:1920 to the Present*. London: Routledge; Godin, B. (2003). The emergence of S&T indicators: why did governments supplement statistics with indicators? *Research Policy, 32*, 679-691; Sharif, N. (2006). Emergence and development of the National Innovation Systems concept. *Research Policy, 35*, 745-66; Hagendijk, R., & Brouwer, R. *National innovation systems and development in the 'Global South'*. forthcoming.
[5] See note 4.

policy purposes the actual operational demarcation of what does and what does not belong to the innovation systems policies discussed becomes rather important, both in terms of the goals set as well as in terms of instruments, regulation and funding. Lundvall has always been the one amongst the founding fathers entertaining a broad definition of innovation and he has been particularly active in promoting the use of the approach to deal with issues of development. As we will see below, however, the use of the national innovation system approach in developing countries (and not just there) seems to meander between broad and narrow conceptions. Broad ones for public consumption and to mobilize support and a much narrower one depicting first and foremost the organizations of the local science system, public research organizations, major industries, branches of government and education as an input channel.

Analytically speaking a particular definition of the innovation system and its components implies or suggests particular hypotheses about its performance and how the performance might be boosted. If for example there is a complete lack of communication between those involved in knowledge production in the science and engineering components and industry one may expect that industrial innovation will be affected and as a result the structure and performance of the national economy. But this does not in itself logically lead to the conclusion that given more contacts industry and the economy will profit. That will still depend on a host of other factors of which policy making by the local government is only one. And obviously, even if such policies are demonstratively having effects the relation of such policies on issues of (in)equality is still an open question. If one would assume that the policies followed by catch-up economies have distinctive features that contributed to their success it should also be noted that in economically astonishing successes like contemporary China and India, regional and income inequality has been increasing fast over the last two decades (Naughton, 2007: 217-27; Borooah, Gustafsson and Li, 2006)[6].

Because of the integrative nature of the national innovation systems concept it would be a major achievement if it would be possible to show empirically and conclusively that some set of policies is clearly and unquestionably better than another. This seems to be difficult if not impossible which is not surprising given our comments on the fuzziness of the basic concept of national innovation system, the limited available statistics and their proxy character. Even if one restricts oneself to strictly economic indicators and to countries that are more or less equal in development, history and economic structure, it is not possible. It will become even more complicated if one seeks to include issues of (in)equality and if local situations and histories differ widely from the well-known examples of Western countries and Asian success stories. Amongst policymakers this leads analysts and consultants to the recognition that there may be more than one way to achieve the goal of promoting innovation:

> 'Even amongst the OECD member countries participating in this study – which are relatively homogenous in terms of income per capita – NIS vary greatly in their structural features and modes of governance. Accordingly there is no single "optimal" policy in terms of the design of either individual instruments or the mix of policies readily transferable to different contexts' (OECD, 2005).[7]

[6] Vani K. Borooah, Björn Gustafsson and Shi Li (2006) 'Income inequality and poverty north and south of the Himalayas' *Journal of Asian Economics*, 17, 5, pp 797-817.
[7] OECD. (2005). *Innovation Policy and Performance: A Cross-Country Comparison*. Paris: OECD.

The observation just quoted comes from a report about OECD member countries with highly developed economies and elaborated statistical agencies to collect information about key variable. Even in such countries one may doubt the adequacy of available indicators and how they are related to the dimensions of the innovation system in which one is interested. In less developed countries the available statistical data are obviously much more limited. Attempts to come up with reasonable and agreed upon indicators for international technological and scientific cooperation f or sustainable development at a special OECD conference in South Africa on Integrating Science and Technology into Development Policies Cooperation demonstrated the difficulties. The expert group failed despite extra efforts (OECD, 2007: 107-13)[8]. For policy makers and applied researchers the alternative to rigid and empirically hardnosed analysis is to resort to examples and bench-marking exercises to build upon the actual experiences and best guesses. This is perfectly acceptable as long as one keeps an eye open for the limitations and does not overestimate what can be achieved in this way.

On obvious limitation has to do with the extent to which the national governments, and especially those in developing countries, are actually in a position to do much about innovation and its consequences. Where governments with big bureaucracies to support them and advanced monitoring systems fail to address issues one cannot expect under-resourced governments in sub-Saharan Africa to be able to come to grips with issues that are clearly transnational in nature or that are mostly a matter to be dealt with at the level of villages, cites and provinces. Many of the problems that require action often go beyond what a national government can do. They are regional in character like issues of water management, sustainability, pandemics and international financial crises or they are local, urban or provincial in nature. That Western governments once embraced the national innovations concept in attempts to understand and redefine policies is no guarantee a similar move will be a panacea for the developing world. We at least have the impression that there is danger that innovation systems approaches are too much endorsed as a part of building government bureaucracies rather than to actually address issues of inequality and poverty. This is not to say that such NIS approaches serve no purpose if it comes to addressing issues of inequality but the relevance should not be overestimated.[9]

A final feature of the national innovation systems approach has to do with its seemingly a-political nature. The approach has become popular for policy makers through the efforts of the OECD and other policy institutions. The OECD is an international organisation in which many countries work together and that gives advice to the governments of its member countries as well as more generally. Apart from the endorsement of an economically liberal and politically formal democratic perspective, it is part of their political architecture to frame their work and advice in politically neutral terms that avoids political sensitivities and political choices or addresses them indirectly at best. This enhances a focus on the aspects of innovation systems that lend themselves to such an approach.

On the basis of our working in the ResIST project we conclude that national innovation approaches certainly play a very important role in establishing, discussing and assessing institutions and policies to stimulate science, technology and innovation in developing countries. Yet we also conclude that the contribution of the approach to

[8] OECD. (2007). *Integrating Science and Technology into Development Policies; An international perspective*. Paris: OECD.
[9] The following is based on Hagendijk and Brouwer, forthcoming.

actually implementing broad conceptions of innovation is ambiguous. Its relevance for the struggle against inequality, deprivation and poverty is questionable. The popularity of the approach in development policy making can in part be explained better in terms of the popularity of the approach among donor institutions (including policy think tanks like OECD), development economists and the ideals, ambitions and strategies of elites, old and new, in developing countries.

The positive contribution of the national innovation approach as well as its limitations can be illustrated by looking at South Africa and Mozambique, two countries that are economically rather different but who share a commitment to develop their economies and innovation systems so that all citizens will benefit.

Quickly after the Mandela government came into office the new South African government embraced the national innovation system approach. It did so in the 1994 Green Paper on Science and Technology and in subsequent documents. The Green paper illustrates some of the problems mentioned above with the broad and the narrow conceptions of the national innovation system. The Green paper clearly states that it endorses a broad conception of innovation 'from high technology to the promotion of incremental technical changes in traditional activities' (DACST, 1994: 21).[10] This is understandable given the political goal of the government to overcome the apartheid legacy and to create a future 'where all South Africans will enjoy an improved and sustainable quality of life; participate in a competitive economy… and share in a democratic culture' (p. 6). The new policy framework 'should enable all South Africans' to direct the science, engineering and technology system' to promote these general goals (p. 8).

Yet, most of the document, prepared with the help of the Canadian IDRC that had also supported the ANC during the struggle against apartheid, focuses on issues of the organisation and coordination of the science and technology system in a rather restricted sense. The second part of the report is mainly about functions the national innovation should fulfil and these are formulated in a technical managerial vocabulary that does not seem to be related to a broad conception of innovation or the broad goals of the governments plan for Reconstruction and Development. Rather the images emerges that the national innovation system is seen as an organizational network of institutions and stakeholders that should be re-arranged to do away with the opaque, secretive and chaotic situation of the past in order to function for whatever political and social goals might emerge in the new democratic South Africa. A similar impression emerges from the White paper published in 1996, which marks the end of the period of consultation. The main reminders of the broad conception of innovation here are the composition of the newly established National Council for Innovation and the Innovation Fund. In the formulations of the goals and the composition there are references to a broader conception of innovation. One might also think of the proposal for the regulation of post-graduate education in terms of a broad view of innovation, but overall there is little 'broad' operationalization of the broad conception of innovation. Although there was reference to existing knowledge that would be part of the innovation system the implications from that view for the organization of the policy domain remain opaque in these documents. In hindsight one of the people involved in the exercise explains that the perspective of the authors was that the government should facilitate various options for new developments rather than

[10] DACST (1994). *South Africa's Green Paper on Science and Technology; Preparing for the 21st Century*. Pretoria.

formulating more directive and selective policies.[11] Another insider explains that with the exception of legislation to establish the NACI, the White paper served more as a statement of intent and a broad framework than as a sharp instrument of policy. This confirms our view about the function of the approach in building up new systems of government in developing countries.

The point here is not to criticize the plans just referred to. It is quite understandable that the responsible authorities saw it as their first responsibility to map existing structures and to make the sectors more coherent, more accountable and open to steering by the new government in the post-apartheid period. As noted in the documents the South African position with respect to science and technology was deteriorating in international comparisons and there was a sense that action was urgently needed. The point here, however, is that a particular and small rather than broad conception of innovation in actual fact emerged and that it came in a format that shies away from addressing issues of inequality, poverty reduction, and making the available knowledge resources available to broader sections of the population. Such an approach may be useful for the recovery and build up of the national state bureaucracies that are supposed to manage science and technology. It may help to re-arrange and intensify the relations between the economy and the science sector. And it may even be important for the benefit of the entire country to prepare for changes in technology, economy and society in the long run by preparing the ground for capacity building. But with respect to benefiting all citizens and addressing issues of inequality the plans formulate goals and visions that may help to legitimize expenditures politically but whether it will deliver cannot but remain an open question. And this is inherent to the politically neutral and technical systems approach adopted and the focus on the existing knowledge institutions. In this respect the start of the redefinition of the South African innovation policies resembles the points and criticisms of the NIS approach formulated in general terms above.

As already indicated South Africa's new science and technology policies came about with support from the IDRC and people firmly committed to the NIS view. In subsequent years the relations with the OECD became particularly strong. In 2007 South Africa was one of a small number of countries invited by OECD to take part in 'enhanced engagement, with a view to possible membership'. OECD now reviews South African policy making on a regular basis.

The verdict in the most recent OECD assessment (OECD, 2007)[12] can be summarized as 'satisfactory but not without problems'. Both funding and science and technology instruments have been improved but South Africa's is not keeping up with other countries in more or less the same situation in terms of publication output. The country is doing well in technology exports, but this is dependent on exporting defence systems build up during the apartheid years, so hard to claim as the result of the new NIS policies. Between various departments and organization reckoned as part of the innovation system there is overlap and tension about missions, ownership and performance. The most successful development signalled by the OECD, however has been the Nuclear Pebble Bed Reactor program. Developing that facility was, however, never part of the science and technology programs, but an independent activity of the Department of Energy. The priority programs introduced in the late 1990s are in part

[11] This is in part based on interviews with Dave Walwyn, Johann Mouton, and Michael Kahn conducted in November 2008.
[12] OECD. (2007). *South Africa; OECD Reviews of Innovation Policy*. Paris: OECD.

successful but remarkably the one on poverty alleviation has not been implemented at all according to the OECD.

A central problem signalled by the OECD concerns the skills crunch. The Pebble Bed Reactor program drains resources away from other priority areas where capacity shortages are threatening now that an older generation of scientists that started before the regime change is about to retire. This 'skills crunch' is identified as one of the major problems of the South African NIS. The overthrow up of the Apartheid system has led to an enormous growth in the demand for higher education, a demand that the higher education system can hardly manage and that endangers the possibilities for academic staff to do research. Apart from this problem as such there is the associated problem that higher education policies are not under the remit of the Department for Science and Technology but belong to the domain of the Department of Education. According to insiders these ministry are engaged in boundary negotiations and struggles. Something that should not occur under a broad conception of innovation and that a national innovation system approach should avoid.

The 'skills crunch', the lack of success in the area of poverty alleviation and the heavy constraints have not deterred the agencies in charge of science and technology policy to remain optimistic and to endorse wide ranging agenda's. In 2008 the Department of Science and Technology published its new vision 'Innovation towards a Knowledge-Based Economy. Ten-Year Plan for South Africa (2008-2018).' This plan certainly radiates ambition. According to critics this plan is far too ambitious given the constraints indicated by the OECD and the NACI.[13] Resources seemed to be spread too thin and the plan lacks selectivity, but poverty alleviation is no longer a stated priority. Activities in this area are announced but not specified.

In conversations with some South African experts it has been pointed out to us that poverty alleviation is often – but not always – not so much a matter of developing new science and technology but of actually getting it out and teach people how to use it. The question then is whether such policies, e.g. connecting people to sewage systems and promoting sanitation, is a part of a broad conception of innovation or not. Those adhering to a broad conception of innovation and learning what answer that question in the affirmative and the conception of innovation endorsed in the Green Paper points in the same direction.[14] But apparently there are strong forces pointing away from actually implementing such a broad conception and overcoming the pressures that drive towards a much smaller definition of the system and that focus programs and policies towards a more limited set of indicators and international comparisons. A much narrower conception in which the promotion of equality is pursued through science and technology does not get much space.

Our diagnosis about national innovation systems approaches in South Africa is confirmed if we look at other countries. For example, Mozambique.[15] Obviously the

[13] For example Kaplan, D. (2008). Science and Technology Policy in South Africa: Past Performance and Proposals for the Future. *Science, Technology & Society, 13* (1), 95–122. See also Kaplan, D. (2004). South Africa's National Research and Development Strategy: A Review. *Science, Technology and Society, 9* (2), 273-294.

[14] See Lundvall, B. A., Johnson, B., Andersen, S. E., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research policy, 31*, 213-231.

[15] The following is based on input by project members Roland Brouwer and Lidia Britto, conversations with ResIST advisory council member Ricardo Thompson, and interviews with Carlos Lucas, Antonio José Leão, Carlos Nuno Castel-Branco and Antoni Francesco in November 2008. A fuller account will be given in Hagendijk and Brouwer, forthcoming.

economic and political situation in Mozambique is quite different compared to Africa as it is one of the poorest countries in sub-Saharan Africa and heavily dependent on donor support. The situation with respect to science, technology and higher education is also radically different. Yet, some problems are similar: enormous problems in the universities as the demand for higher education is exploding, erosion of the research opportunities for the academic staff, lack of resources and more priorities requiring research and development than one can master and afford. Yet, also in Mozambique attempts have been made to define a national innovation policy and to develop administrative and managerial provisions for government policies. And once again this is best seen as part of the build up of capacities of the state to manage the country, its facilities for science and technology and its interfacing with industry, agriculture and other parts of the economy.

A Ministry for Higher Education, Science and Technology was first established in Mozambique in 2000. In 2003, this ministry produced the country's first S&T policy paper after studies and consultations with stakeholders. This policy explicitly assumes the NIS approach while recognizing the importance of knowledge outside formal S&T and the international nexus for innovation in Mozambique. The document clearly states the role of S&T in poverty alleviation.[16] In the same year, the ministry published the first science and technology indicators for Mozambique, as an attempt to provide a starting point for the monitoring of the system.[17] In 2005, the Ministry of Higher Education, Science and Technology was dissolved and an independent Ministry for Science and Technology was established. Higher education became part of a Ministry of Education and Culture in this reshuffling. However, the new division of responsibilities was still a contested issue in 2008. After a process of study and consultation the new Ministry for Science and Technology published the Mozambique Science, Technology and Innovation Strategy (MOSTIS) in 2006.[18] Once again there are broad ambitions and inclusive goals. They are quite similar to those of the South African innovation policy approach. Advisors from South Africa and Brazil played a role in drafting the document and the needed financial support was given by international aid agencies.

The MOSTIS plan is very specific and ambitious in the actions that will be undertaken. It distinguishes nine general priority areas and five cross cutting issues as areas on which research will be a priority. For these 14 priorities 10 key ambitions are defined. The level of detail and the comprehensive nature of the document are impressive. For example, 12 research lines are identified for agriculture; for fishing and marine sciences 14 and so on. For each domain and crosscutting program short, medium and long term objectives are listed in a table. Yet, the document also makes clear that the amount of money available for each activity will be very small. A separate chapter of the report describes the actual organization of the national science and technology system (p. 61-76). For the seventeen sorts of organizations and sectors their functions and responsibilities are once again spelled out systematically and in detail.

[16] Conselho de Ministros (2003). Política da Ciência e Tecnologia. Resolução n.º 23/2003 de 22 de Julho.
[17] MESCT (2003). *Indicadores de Ciência e Tecnologia em Moçambique 2002-2003*. Maputo: Ministério do Ensino Superior, Ciência e Tecnologia.
[18] Council of Ministers (2006). Mozambique Science, Technology and Innocation Strategy (MOSTIS). Approved by the Council of Ministers in the 15th Regular Session on 27 June 2006.

Mozambique obviously has not the resources and manpower to execute such a plan on its own. Whether and to what extent the plan will be implemented will depend on international support. Apart from financial constraints there are others. The report itself identifies eight major implementation problems that require urgent attention. Among them not only the need to develop a performance indicator scheme to measure performance and output, but also a description of the Ministry's own limits, as many of the research institutions are responsible to other ministry or are part of universities that fall under the ministry for education (p. 89).

Given the financial and managerial constraints as well as the relatively weak position of the ministry for science and technology vis-à-vis other departments one wonders about the operational feasibility of the plan. It very much reads as if the wishes and priorities of all sorts of stakeholders and departments have been tabled together without much selectivity. Given the obvious importance of the priorities stated one may wonder how to expect selectivity. The consultative process allows i.e. stimulates all sorts of stakeholders to articulate plans with no firm coordinating ministry that can legitimately cut down the priorities in accordance with expectations about available funding. Given the lack of resources it once again and tragically seems to be the case that too little will have to be spread too thin. As in the South African Green and White Paper the plan may well be a success in providing a map of the organization of science and technology and of the research plans for various departments and institutes in the future. It is clearly functional in building up government capacities to develop and manages policies in this sector. And it may well be successful in convincing funding agencies that executing even a small part of the plan depends on what extra money will be mobilized with external help.

As the plan lacks argued for specificity it is not clear to what extent the mobilization of science to eradicate poverty and to enhance equality has been a criterion in the decision making process

We believe a similar story can be told for other many other countries of the global south. The adoption of national innovation approaches serves key aspects of the reconstruction and build-up of science and technology systems in nation states that recently became independent or that are going through radical transformation after major and divisive conflicts and constitutional and economic renewal. In this context, national innovation systems approaches are best seen as discursive devices that allow government representatives and representatives from key stakeholder groups to deliberate policy issues.

Given the highly technical and often bureaucratic nature of such debates, however, the attempts at broad consultation are important and harbour the risk of quickly becoming restricted to a small group of established institutions, ministries, industries and their representatives. Another feature may be that even within this more limited group various interests have to be accommodated without clear justification in terms of widening the processes of innovation beyond very small gestures towards groups and goals so far excluded. Associated with this is the risk that debates and the resulting choices do in actual fact reflect a narrow conception of the innovation system rather than the broad visions that surface in introductory paragraphs of plans for science and technology.

What seems to be needed, i.e. what should be stressed much more explicitly instead of remaining merely reverential, is a conception of innovation policy that is directly and explicitly tied to a broad and inclusive conception of innovation and that explicitly

includes social goals alongside strictly economic ones. Such a policy also needs to specify the basic formats of inclusion, consultation, deliberation and decision making to be adopted if one endorses such goals. Such a conception, to be outlined and contrasted with currently dominant conceptions in the next section, also implies the build up of specific new indicators, participatory instruments and new forms of accountability towards broader segments of society.

8. Changing policy paradigms: from KEPP to SCoPP?

The discussion above of the application of one of the most widely disseminated STI policy approaches, based on the concept of the National Innovation Systems, suggests the need to reflect upon existing STI policy frameworks and their dissemination. The popularity of the concept of the NIS has now travelled widely to less developed regions and countries, from its initial formulation, and application, in the global North. While its emphasis on the need to strengthen national institutional links may be welcomed by many policy-makers, and applied to national political projects, its adequacy for the context of certain countries, namely in Sub-Saharan Africa, raises questions. In countries where local conditions vary significantly, the institutional setup is often still being developed and the role of formal scientific and technical institutions is marginal to the overall socio-economic dynamics, a policy framework that focuses on the established formal science system and its links to major industries will be of limited value in addressing issues of inequality. Alternative policies which give greater attention to the diversity in the institutional setup, local conditions and knowledge resources, seem to be required in view of the high levels of poverty and inequality that exist.

This is, however, not simply a question associated with development policies, but it has to do more with the impacts of STI policies and not just in the Global South. It applies equally to the European context. We argue that STI policies can be distinguished according to the extent in which these take distributional objectives and impacts of policies explicitly and systematically into account on a par with economic growth and firm level objectives. Alternative policy approaches question, rearticulate and extend at a fundamental level the structure and limits of the existing economy-focussed frameworks. These new approaches may amount to a *paradigm shift* in STI policy, reflecting fundamental changes involved in policy objectives and priorities[1]. Such a paradigm shift would imply a redefinition of STI policymaking at a very *fundamental* level. Underneath most current policies for innovation there is in our view a basic logic that we call the "knowledge economy policy paradigm" (KEPP).[2] We will use this as a baseline to describe elements of an *alternative* policy paradigm, where the (un)equal social distribution of benefits and costs of STI policies are central. We call this alternative paradigm the "social cohesion policy paradigm" (SCoPP).

The way we present the two policy paradigms below is in terms of their overall opposition and as integrally different approaches. As will become clear the differences between the two on specific points might well be less in actual practice. Yet we strongly believe this issue is not about shifting the balance a little in one aspect or

[1] Cf. Ruivo, B. (1994), "'Phases' or '*paradigms*' of *science policy*?", *Science and Public Policy*, 21(3): 157-164; Biegelbauer, P. and S. Borras (eds.) (2003), "Introduction: Ideas and the Transition from Technology to Innovation Policy", in P. Biegelbauer, P. and S. Borras (eds.), *Innovation Policies in Europe and the US: The new agenda*. Aldershot, UK: Ashgate.

[2] We want to stress the KEPP as we discuss it here should not be equated in a linear way with national innovation systems approaches discussed in the previous section. KEPP is the common denominator of actual policies as we have deduced it on the basis of our analysis (section 6, see also Cozzens, S. et al. (2007), "Problems of Inequality in Science, Technology and Innovation Policy", James Martin Institute Working Paper 5, Oxford: Oxford University). The NIS approach started as an analytical exercise that subsequently informed policy advice and policy formulations but not necessarily policies as implemented.

dimension. To develop policies that really address issues of inequality in a consistent and adequate manner requires a more basic reformulation in terms of a comprehensive and coherent policy model or paradigm. The presentation below in terms of juxtaposed paradigms is intended to bring out the logic and consistency of the shift we advocate. However, not so much the degree of opposition on particular issues is at stake but the overall view and its inherent concern with the distributional impacts, access to resources and participation and representation in decision making process (see section 2), the three dimensions of inequality which ResIST has been concerned.

We have seen in earlier sections the importance of wider approaches to the governance of knowledge, focusing on accountability, or encompassing indigenous forms of knowledge, regarding its social impact.

What might a move from KEPP to SCoPP entail? How would it be different in terms of policy objectives, instruments, institutional organization, monitoring, indicators, inclusion policies and consultation and decision making? In our analysis we consider the dimensions described below to encapsulate central differences between the two, which are also more broadly reflected in the underlying objectives of each policy paradigm, and on the broader conception of the role of public policy represented by each approach. We present the distinctions between these approaches in the following sections.

Objectives

A central difference between the two paradigms, i.e. KEPP and SCoPP, would lie in the extent to which economic growth and competitiveness, and firms as the main economic agents are the overriding policy objectives. We argue that this is the case in KEPP. Its main focus is on improving competitiveness at the corresponding level of action (e.g. regional, national, European), fostering innovation in firms, raising productivity levels, and more generally a focus on aggregate economic performance. In SCoPP the ultimate objectives are not just economic ones but also include social objectives at the same level of importance and more generally aims at building a more sustainable and cohesive society. While improved economic performance of firms is certainly important, the SCoPP policy framework is not guided by this single objective but rather by achieving wider levels of progress and wellbeing in society, reflected also in terms of improved education, provision of health and social services, social cohesion, sustainable lifestyles and, not least, reduced inequality. As discussed in section 6, countries in the Global South such as South Africa, Mozambique, and Brazil have developed policies that explicitly entertain such goals.

Capacities

The paradigms differ in the way in which they conceive of and treat agents, knowledge, and the concentration of resources. As a result structural inequalities will be handled differently under each paradigm.

Agents

Are private firms the primary agents of innovation? The answer given by a policy-maker to this question is likely to be a good indicator of whether he or she is operating

under a KEPP or SCoPP approach. For the former, private firms are clearly the key agents in innovation and as such the main target for public policies. Innovation is in this context a concept clearly embedded in firms and markets. A traditional definition of innovation, which by distinguishing it from invention clearly places it in the realm of the market, induces the logic of markets and of those organizations operating primarily under 'market rules'. Even in analyses that reframe the role of the firm in the innovation process in a more open manner, the innovation process is still mostly seen to spread to more processes within the firm, or the firm in interaction with users of its products[3] (Von Hippel, 2005).

For the policy-maker working under SCoPP, innovation is spanned more broadly across society. Other agents beyond firms have an important contribution to innovation processes that goes beyond their role as users of innovations. Non-governmental organizations may play a leading role in developing and spreading new ideas. Policy bodies themselves need to innovate, taking new approaches to making and implementing decisions[4]. Communities, families and individuals also innovate, seeking new solutions to the challenges they face. Innovation is not simply a process developed within private firms but is rather the result of the activity of a variety of innovative actors throughout society.

Knowledge

The different ways of framing the locus of innovation is associated with the conceptualisation of the knowledge used in the innovation process under each paradigm. In KEPP the knowledge economy is firmly based on the firm level, and on the type of knowledge chiefly produced within firms as a direct contribution to their own innovation processes. Central is the type of knowledge produced in research and development (R&D) departments, where a core of technical people is engaged in finding new ways use and develop scientific knowledge for product development. This is defined by the "fusion of science, technology and the economy" as put by Daniel Bell, through which science and science-based technologies have become immediate sources of innovation and growth: "Scientific research, technological development and innovation are at the heart of the knowledge-based economy".[5]

The importance of R&D based knowledge is certainly not disputed in SCoPP. A wider focus on learning processes and other forms of knowledge and experience than formal science is also important, however, in promoting innovation in low and medium-tech firms and sectors.[6] And alongside this, there are a range of other examples of policy

[3] Von Hippel, E. (2005) *Democratizing Innovation*. Cambridge, MA: MIT Press.
[4] Koch, Per; Cunningham, Paul; Schwabski, Nitza; Hauknes, Johan (2006) *Innovation in the public sector: Summary and policy recommendations*, Public Report No. D24. NIFU STEP, Oslo.
[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] Work by Arundel et al. shows the importance of organisational factors in contributing to the way people work and learn, and how this has an effect on the innovation performance of firms. Policies that address this and consider the importance of the contributions of all workers for the creative process, and not simply that from formal R&D departments, are likely to have an effect on innovation performance. Cf. Arundel, A., E. Lorenz, B. A. Lundvall and A. Valeyre (2007), "How Europe's economies learn: a comparison of work organization and innovation mode for the EU-15", *Industrial and Corporate Change*, 10(1), 1-36.

initiatives which not only consider other forms of knowledge, local, experience-based, traditional or indigenous knowledge, but actually also target these. While they may be piecemeal examples within the national strategies rather than characteristic of the global national approach, they exemplify the possible success of such initiatives. The bioprospecting strategy from CSIR in South Africa mobilized community owned mosquito repellent candle making. Another example is the use of *Artemisia annue* infusion against malaria in Mozambique. A third one is the popular involvement of Brazilian citizens in the struggle against Dengue. All this is of particular relevance from the point of view of inequality, not only because these policies are formally inclusive by addressing a wider range of actors, but, particularly, because other forms of knowledge are important to create and exploit distributed capacities of change among society.

Concentration/dispersion

In the discourse of economic growth and competiveness the concentration of resources to get critical mass has a prominent place. Financial efficiencies are not the single argument; knowledge efficiencies are also argued for, leading to the emphasis on "centres of excellence", mobility, concentration of resources and critical mass and the role of a few particularly R&D intensive or technology industrial sectors as main attractors of human resources and 'technological activity'. Such concentration, while implying some forms of exclusion in performance is argued to be in favour of greater collective prosperity. This would result from trickle-down effects. KEPP practitioners are thus likely to work towards the concentration of resources to support innovation in few institutions and places.

But do such trickle-down effects actually occur and for whom? Empirical evidence suggests that such effects are quite limited in geographical scope, which is reflected in a variety of asymmetries in regional development.[7] This is even more blatantly visible at the global level. Here, it is not simply a matter of the distributional impact of such concentration policies, but largely their opportunity cost. The same policies that require concentration of resources also require large public investments. The overall opportunity cost of such initiatives are often high, namely in view of its reduced geographical impact.

A SCoPP approach would be more inclusive with respect to building distributed capacity geographically and otherwise. While maintaining the level of excellence at the top of the system, SCoPP would set as a specific objective raising the level of excellence across the system. This approach would be particularly important for places at the margins – smaller cities or rural economies, for example. The broad concept of innovation may help to make life better in these places without transforming them into industrial centres. Likewise, disadvantaged groups would get particular attention in SCoPP STI policy, which would make sure everyone gets excellent education and equal opportunity, in culturally appropriate ways.

[7] Cf. Labour Asociados (2003), "Analysis of the Impact of Community Policies on Regional Cohesion", Final Report, October.

Governance

A paradigm is reflected in both content and method. The two policy paradigms we are considering are reflected not only in their goals and innovation concepts, but also in how they make decisions. This is reflected in the processes used to take decisions, the extent to which the governance structure is accountable, and how, for such decisions, and the role of quantitative indicators in organizing decision-making processes.

Decision processes

KEPP governance relies heavily on elites to make decisions. This form flows directly from the values inherent in the concepts of innovation we have already discussed. If formal science is the privileged form of knowledge and high-technology industry the privileged form of economic growth, then the people with special skills in these areas may be expected to be best positioned to make decisions on behalf of society. In political theory, this governance principle is called "guardianship." Democratically elected governments often delegate guardian powers to elites with specialized knowledge. Organized in specific expert committees, their power has been compared to a *Fifth Branch* of government[8].

However, the extent to which these forms of *double delegation*[9] are an effective form of governance in controversies has been questioned, with several case studies showing the important contribution of knowledge inputs from a variety of stakeholders in decision-making processes. In this way, policymaking under SCoPP must involve stronger forms of democracy if it is not to be self-contradictory. If many kinds of knowledge are valuable in the innovation process, those contributing to STI decision-making should also be several. If innovation goes on in many places, not just technology-intensive firms, then decisions about it must be broadly participatory. Specialists need to share the power of knowledge with others.

A SCoPP STI policy therefore incorporates stakeholders as participants. Workers help shape the agenda in occupational safety and health; patients contribute to biomedical research agendas; poor communities choose their technological upgrades. They do not need to undertake these tasks in isolation. In fact the multiple objectives of SCoPP leave ample room for technical experts to collaborate with experts in daily life in inventing, designing, and implementing improvements. Even at the highest decision levels, however, people who represent broader visions of progress rooted in the lives of all citizens must be at the table.

What is being said here has also implications for global governance and decision-making processes. International organisations also need to take into particular account the voices of populations and governments from less developed countries on a more

[8] Sheila Jasanoff (1990), *The Fifth Branch: Science Advisers as Policymakers*. Cambridge, MA, USA: Harvard University Press.

[9] Following the work by Michel Callon, Pierre Lascoumes, Yannick Barthe (2001), *Agir dans un monde incertain: Essai sur la démocratie technique*. Paris: Le Seuil. See also section 5 in this report for a discussion of the double delegation model, and for reference on further case studies on stakeholder participation in decision-making processes developed under ResIST. The work by Steven Epstein (1996) *Impure Science: AIDS, Activism and the Politics of Knowledge*, Berkeley: University of California Press, is a classic example where AIDS patients, organised under activist movements, had a central contribution to the research process.

equitable way and with a view to improve impacts on the local populations, rather than being based on tacit enforcement of predetermined policies.

Accountability

Accountability is an essential element of democratic governance. Who answers to whom for results is a key issue. Under KEPP, accountability is expert based. This has traditionally been the case, as one would expect under guardianship. For example, in research policy peer review has been not only the main mode of allocation of project resources, but also of evaluation of results. Industry stakeholders have taken a larger role in these processes in the last few decades, but this is in line with strengthening a KEPP approach. The widespread move to New Public Management has reinforcing an emphasis on efficiency and control, largely through performance indicators (a "science of science policy") and now constitutes an integral part of the KEPP approach.

Under SCoPP, in contrast, accountability is achieved through direct public engagement and discourse. Again, there is no contradiction between this approach and gathering performance indicators. But it is important that the available indicators do not simply reflect global performances, with a focus on competitiveness, but that also reflect activity at the different levels of the system, and in particular with respect to multiple policy objectives (see below). In any case, it is important that the indicators are not the single mode of accountability. There is no possibility of delegating the contextualization and interpretation of those indicators without involving the stakeholders the research or innovation activities were intended to serve. This requirement is only weakly reflected in any current STI policy practices (see for example the experiences with PPPs, described in section 5 of the report), and thus would lead in time to a radical restructuring of assessment processes.

Indicators

The general characteristics as well as the relative stability and coherence of KEPP may, e.g., be seen in the core set of indicators that has been developed within this framework for validating successes/failures, monitoring progress and guiding development of STI policies. These sets include the broad categories used in the European Indicator Scoreboard (EIS), such as public and private investment in R&D; national or sectoral R&D intensity; high-tech exports, output and employment; innovation levels; IPRs; (S&T) education; ICT-related indicators. Organisations such as the OECD and the EU have devoted significant time to produce manuals for the production of such indicators (e.g. Frascati Manual, Oslo Innovation Manual). While an important contribution, when they become embedded they also become largely immutable[10] and bring with them the corresponding wider approach to STI policy, where innovation is based on firms, corresponding activities classified, and therefore shaping and constraining policy formation.

These standard indicators emphasize the salience in the KEPP framework of the most R&D intensive manufacturing industries. These industries epitomize the knowledge

[10] Latour, B. (1991). Technology is Society Made Durable. In J. Law (Ed.) *A Sociology of Monsters? Essays on Power, Technology and Domination, Sociological Review Monograph*, 38: 103-131. London: Routledge.

economy: they are extremely R&D intensive; scientific knowledge and research are immediate sources and drivers of innovation; they are fast growing and highly profitable, even if high-tech manufacturing industries still account for a very small share of the economy, even in the US [11]. Innovation in so-called low- and medium-tech industries remains 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 less high-tech-focused notion of STI policy may be seen to emerge, reflected on changes in national performances (e.g. Denmark, where growth is largely based on strong innovation performance in low- and medium-tech industries).

Reflecting global inadequacy of dominant indicator systems characterizing KEPP, others have been developing an innovation manual better able to address the forms of innovation found in countries in Latin America.[12] This goes in line with SCoPP needs to develop a remarkably different set of indicators. Inclusive governance processes themselves would be key indicators of the health of the system. For example, they might address the constitution of advisory and project selection committees of funding agencies; the inclusion of both men and women and all the relevant ethnic groups in a national context; the involvement of various publics in decisions processes around innovation; or the extent to which the system supports its own institutional renewal.

More crucially, SCoPP would make a serious attempt to connect the development of innovations, and formal R&D activities, to outcomes in daily life, in a more sustainable and more cohesive world. SCoPP therefore needs to consider a richer set of indicators of employment, health, education or environment and tracking their connections to formal STI policies and programs.

Outcomes

The two policy paradigms embrace different ways to understand, and to expect, outcomes of STI policies. This is particularly reflected in the way in which the mitigation of inequalities is expected to be an outcome of STI policies. While for KEPP this is only expected as an indirect outcome, resulting from the expected impacts on economic growth, SCoPP does not directly infer that relationship. On the contrary, it considers that expected benefits in terms of social outcomes must be an integral concern of STI policies. These differences are reflected namely at the level of the drivers of innovation, on the role of IPRs and on the way the resulting benefits and costs of STI are shared.

Drivers

The concept of market failure is central to both KEPP and SCoPP. If all the benefits to the public that R&D can produce were generated by the market, there would be no rationale for government intervention. We know that this is not the case, so governments do intervene.

[11] Hirsch-Kreinsen, H, D Jacobson, Steffan Laestadius (eds.) (2005). Low-tech Innovation in the Knowledge Economy, Frankfurt a M: Peter Lang.
[12] RICYT (2001). *Standardisation of Indicators of Technological Innovation in Latin American and Caribbean Countries: Bogota Manual*, RICYT/OAS/CYTED.

Under KEPP, however, 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. In some crucial basic needs areas, like agriculture, funding for the public research activities that underpin farm-based and community-based innovation has decreased dramatically.

The widely debated issues of access to essential medicines issue may thus be the symbol of one type of "market failure" that has not been addressed in prevalent policies framed in terms of effective market-based STI policies, viz. gaps that have widened between social needs and market demand. While the 'market failure' approach to public intervention in STI policy has been largely on the basis of the general underinvestment on R&D by private agents, on the basis of difficulty in appropriating results, this has largely left unquestioned the market institution itself, and how different markets are created, developed and consolidated. Work in the sociology of markets[13] has shown how markets rely on a variety of materialities and practices which define them and how they are constructed. In that sense, a SCoPP approach would need to give particular attention to other forms of consolidation of markets in which research is an important resource, besides the role of R&D funding, by looking at ways to materialize social needs. The extent to which future benefits and costs, for example in social cohesion or environmental impacts, can be framed within current market institutions is a case in point. SCoPP would incorporate a needs-driven STI agenda to balance and supplement the dominant model of market-driven innovation[14].

Needs-driven research policies may be essential for ensuring that substantial public investments in research and innovation are fully valorised by users, by redressing inadequate absorption and take-up of research results and fostering social innovation[15]. They may ensure that research becomes tailored to the needs of end-users such as local communities and citizens, and not driven, as it now often is, by priorities of peer review and publication in international scientific journals. This is particularly the case in developing countries as scientists and researchers who return after studies in developed countries continue to work on research topics which are often disconnected from their local context (see section 9 below).

Intellectual Property Rights

At the very heart of KEPP is the concept that knowledge is a form of capital that can and should be owned. It is of course the specialized, formal knowledge created in high-technology firms that is seen as valuable, forming the basis for new business opportunities and new industries in the global economy. A place that is home to such industries will prosper, according to KEPP, by turning its knowledge into products to sell at high prices in the rest of the world. Thus patents move into place as the central indicators of the innovation process under KEPP. Strong, standardized "one size fits all" protection for intellectual property rights becomes part of the KEPP agenda,

[13] Cf. Callon, M. (1999), *The Laws of the Markets*. London: Wiley-Blackwell.
[14] Roger Cortbaoui: Science and Technology for and by the Developing World. Available at: http://www.resist-research.net/cms/site/docs/resistwrm_programme_rc.pdf.
[15] Hämäläinen, T.J. and R. Heiskala (eds.) (2007), *Social Innovations, Institutional Change and Economic Performance*. Cheltenham: Edward Elgar.

whether it appears in international negotiations, in public sector research, or in the discourse of local KEPP-based elites, which may appear anywhere in the world.

SCoPP makes a simple and subtle shift from this position. It maintains the basic idea that inventors should be rewarded for their inventions with a short period of temporary monopoly. But it eliminates all the dysfunctional extensions of this principle that have crept into the system over the years that exploit community knowledge and prevent the benefits of inventions from reaching the broadest public as soon as possible after the expiration of IPR protection. The first is illustrated with controversies over private appropriation of traditional knowledge. The second is illustrated by the patent thickets that keep basic medicines from being produced generically after the expiration of the original patent, as in the case of recombinant insulin.[16] A third is illustrated by methodologies, tools and materials, appropriated through IPRs, which limit the research capacity in specific areas, namely in agricultural research. SCoPP would need to take up the task of maximizing public benefit rather than private profit from the utilization of knowledge. IPRs are a central institution in the current approach to markets and technology. This proposed change follows the discussion above on the need to change public policy approaches to market failures and to the institutions governing markets and how these frame technological development.

Sharing benefits and costs

The ultimate goal implied in the SCoPP paradigm is shared prosperity, which is, making daily life better for everyone. There is no question that new, science-based technologies can help with that goal and that expert communities and high technology industries are essential to the effort. However, the various aspects of KEPP that we have described add up to a different outcome. Concentration rather than dispersion of expertise; closed rather than open governance processes; tightly controlled business opportunities; and a market-driven research agenda – all these elements of KEPP tend to give access to the benefits of new technologies to the affluent and central. Expert-based regulatory processes give a further boost to this accumulation of privilege by allowing the powerful to avoid the risks of new technologies, while the disempowered have no escape.

By changing the dynamics of the system, SCoPP is designed to equalize these outcomes as well. Illustrating and implementing equal respect for various kinds of knowledge, STI policy can help open regulatory processes to producing more equitable distributions of risks and dangers. By creating new forms of accountability and encouraging broader innovation, SCoPP can help the benefits of new knowledge reach the poor and disadvantaged. In doing so, it will probably be creating more sustainable conditions for the development of science, technology, and innovation in all their forms.

Role of public policy

KEPP and SCoPP also carry two different conceptions of the role of the state in the STI policy realm. In KEPP, the state is merely a facilitator of increasingly firm- and market-driven innovation dynamics. The pace of innovation is the major outcome of

[16] See WP4 recombinant insulin case.

interest; direction means much less. The state intervenes to prevent distortions and keep markets open and competitive.

The state has a much higher level of responsibility under SCoPP. It is still a facilitator, but now a facilitator of a dialogue between productive capacity and public need. Keeping a watchful eye on outcome measures that monitor quality of life, the state opens a set of decision processes to the voices of people who live with the consequences of technological change. And it provides opportunities for many kinds of innovation, including a variety of processes both inside and outside of firms. It is particularly concerned with the direction of innovation, because its central responsibility is prosperity, not just growth. It guarantees that market institutions, such as IPRs, are not captured by the few, but that they work to provide increased social benefit, in the long term, and with a view to promote social cohesion.

As a consequence, these different paradigms have different success criteria. While KEPP looks primarily into the quantitative indicators described above, and the dominant economic indicators, SCoPP goes beyond such simple quantification (and as seen above, in this regard, with a wider portfolio of indicators). But for SCoPP the success of the policy is not only assessed by what it directly achieves, in balancing economic growth and social cohesion, but also by the capacity for change it is able to induce across different actors.

Conclusion

The discussion above of two distinct policy paradigms – the 'Knowledge Economy Policy Paradigm' and the 'Social Cohesion Policy Paradigm' – highlights that the current dominant policy discourse, which focuses on the economic impact of STI policies, and on the role of formal R&D, particularly in the more advanced high-tech sectors, is not the single approach to design STI policies. We have deduced the KEPP paradigm from the policies and policy documents that are currently dominant and achieving almost hegemonic status. We have articulated an alternative paradigm SCoPP as an alternative to better address the goals and concerns that otherwise may get mentioned for political reasons but are insufficiently addressed, partly as a result of the underlying paradigm and its architecture.

While we see an internal coherence that leads us to frame it as a 'policy paradigm', KEPP does not fully reflect changes in our current understanding of the innovative process. In particular, it does not fully consider the potential wider social outcomes of science and technology, beyond those resulting indirectly from improved economic growth. We propose that a shift towards an alternative policy paradigm (SCoPP) may be seriously considered and tried in practice as it more clearly and explicitly recognizes the potential direct impact of STI developments on social cohesion, and the capacity of a multitude of actors to participate and contribute actively in this process, in producing and using knowledge, and in contributing to the overall governance processes of the system.

The exposition in terms of two juxtaposed paradigms should not suggest that it is just a choice between two options. Nor is it a choice between two opposing alternatives, one focusing on economic impacts, the other on social impacts. The challenge, which SCoPP is placed to address, is to embrace a multi-objective framework rather than a unidimensional one. In this sense, while our primary concern here regards social inequalities, we have also highlighted the wider impact on other sectoral policies

strongly tied to development options, such as planning policies and the impacts on the distribution of knowledge activities, or environmental policies and the objective of guaranteeing a sustainable development. These are also an integral part of a social cohesion approach. The proposal for the development of SCoPP does not wish to provide a blueprint for STI policies across regions and nations. The policy paradigm does not depend on specific instruments – these should be tailored locally, reflecting local needs and concerns –, but on the overall coherence and rationale in relation to the above mentioned dimensions. Necessarily, the weight of different initiatives will differ across countries, depending on the local inequality concerns and needs, and global impacts, but the overall approach, and a change in focus into a diverse set of actors, processes and objectives should be a common trait to policies embracing a SCoPP approach.

What is discussed above has important implications beyond those directly entailed in the required change in policy approaches. It is important to note two central issues in implementing such changes. Firstly, these changes are not limited to the typical scope of action of Ministries of Science and Technology (or their different institutional forms). Rather, they not only can benefit from synergies between different sectoral policies, but, more importantly they require that sectoral policies, such as social policies, planning policies or environmental policies, encompassing a knowledge component whereby concerns with the 'capacitation' of different actors are an integral part of the policies. Not only knowledge policies should be considering their distributional impact; sectoral policies should address their knowledge distribution impact also (see a more detailed analysis of distributional effects in section 10 below). As documented in a quickly growing assessment literature it is apparently extremely difficult to implement broad innovation policies in national polities with strongly developed sectoral ministries and associated bureaucracies. This will be a major challenge for the articulation and implementation of SCoPP type policies. How to meet that challenge is an open question that deserves more research and experimentation.

Secondly, it should be obvious that SCoPP policies are not just a matter of national policy making. Nor is it a matter that does not affect local and regional policies and sectoral policies in a country. We already pointed out the increasing international character of STI and the various transnational arenas in which policies are shaped. The international dimension has been an intrinsic part of the KEPP approach, through the networks of performing actors and through the policy networks. The SCoPP approach cannot, and should not, avoid this. It has indeed a greater challenge at both ends. It must provide greater attention to the development of innovation at the local level, of the community, with local actors than hereto. Social innovation is becoming a dynamic factor of change in contemporary societies. However, it is also increasingly important to address the international arena. As we have seen in previous sections, processes of accountability, processes of policy formation, span and cross boundaries. The same happens with SCoPP. Some policy changes will require collective international action, and social innovations can also be developed at the international level. The move by central agricultural research agencies in several countries to guarantee full public access to public research organisations is an example (see section 6).

Two other topics that are of special relevance in this regard and the ResIST projected investigated in separate Work Packages are international migration and building national capacities for innovation and science (WP2) and how to deal with new emerging technologies under a 'SCoPP' (WP4)? This will be discussed in more detail in the following sections.

9. Scientific mobility, knowledge transfer and capacity-building

The importance of building and maintaining scientific capacity

The discussion of KEPP and SCoPP bring to the fore the full range of policy choices that in principle are available to governments seeking to develop S&T in the service of economic growth and social equity – choices within the bounds of the national system of innovation. In practice, the effective realisation of any of those policies depends on managing the boundary between the national system and the wider environment. Highly skilled personnel are one of the resources that cross that boundary most easily, in search of education or work in other countries, and it is because of this relative ease of scientific mobility that building and maintaining scientific and technological capacity is so central and so challenging.

In earlier debates on development, the priority of building a labour force highly skilled in S&T was not always quite so central. Tertiary education has lower priority in some developing countries than primary and secondary education and this is due in part to the policies of the World Bank policies and other international agencies in the 1980s and 1990s. These policies were predicated on the belief that the returns to investments in higher and secondary education are greater, and equity arguments about the need to establish universal access to basic education (see Mouton, Boshoff and Waast, 2009: 7).[1] Nevertheless, for the purposes of building and governing a modern state in the age of globalisation, especially in the light of the growing perceived contribution of knowledge to economic growth and social welfare, highly skilled and experienced S&T personnel are seen as essential, in particular in relation to the development of indigenous resources, as a basis for attracting FDI, to allow host countries to assess efficacy and safety of science-based technologies, and to lay a base for their diffusion. It is for these reasons that developing S&T capacity has been seen increasingly as one essential leg of strengthening development: 'an inseparable segment of national technology and economic development policies'... in which 'competition for highly skilled labour will continue to be fierce' (Mahroum, 2001, cited by Oliver, 2009).[2]

Building and maintaining a highly skilled labour force is extremely sensitive to scientific migration, and globalisation has encouraged mobility. As a result many highly-skilled people leave their country of origin in search of better opportunities elsewhere (Mouton et al., 2007).[3] [4] From the perspective of developing (sending) countries the collective impact of individual mobility presents significant, and inadequately understood, challenges to research policy. These individual decisions are shaped by a range of professional and personal factors including research policy in the

[1] Johann Mouton, Nelius Boshoff and Roland Waast, (2009) *Scientific mobility and institution building in science in developing countries*. ResIST Thematic Paper, Deliverable # 12. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.
[2] Mahroum, S. (2001) 'Europe and the Immigration of Highly Skilled Labour' *International Migration, 39*, (5), 27-43.
[3] Johann Mouton, Nelius Boshoff, , Tembile Kulati and Frank Teng Zeng, (2007) *Scientific Mobility and the African Diaspora*. ResIST Paper 6, Project Deliverable # 4. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.
[4] Liz Oliver (2009) *Legal Regulatory Frameworks and Scientific Mobility. Giving Something Back: Exploring Making a Contribution at a Distance to Policy and Practice*. ResIST Thematic Paper, Deliverable # 9. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.

'receiving' countries and regions. The EU and its Member States have actively developed policies designed to encourage and facilitate in-coming scientific mobility (Gill and Ackers, 2007: 5).[5]

Brain drain, brain gain and brain circulation

Growing concerns over the phenomenon of 'brain drain', implying a unilateral flow of human resources and knowledge (scientific capacity) are evident in the development agenda. In academic and policy discourse, overly simplistic notions of 'brain drain' have given way in recent years to those of 'brain circulation' emphasising the multidimensional movement of skilled personnel and the importance of return moves. More recent research has questioned not only the temporal assumptions underpinning the brain drain concept (that people move in one direction and on a more or less permanent basis) and the implied relationship between human mobility and knowledge transfer. Williams (2006)[6] identifies an important distinction between 'embodied' and 'disembodied' modes of knowledge transfer. Gill and Ackers (op. cit) further develop this concept identifying critical ways in which compensatory flows of knowledge can support the sending countries. This emerging literature also takes a more detailed analysis of the notion of 'investment'. Previously it was assumed that the sending countries were playing the primary (and often sole) role of investors in the training and expertise of scientists. Research in the European context has shown that this investment continues over the early career stage with many receiving countries making major contributions to training and development of foreign researchers. indeed, their analysis of scientific mobility in the Polish and Bulgarian context indicates the critical role that opportunities for outward mobility play in rendering science viable, effective and 'excellent' in the sending countries.

Understanding the nature and impact of scientific mobility (and identifying effective policy responses) demands careful and acute attention to context. The situation in a country like Poland is quite different to that in Bulgaria. Although the RESIST study has focused on the development context, it is important to acknowledge the distinctive position and role of South Africa and ensure that the insight gained in that specific geographical context is not taken as in any way representative of other developing countries in sub-Saharan Africa.

The policy objectives: 'Balanced growth'

These circumstances raise important if complex challenges for policy-makers faced with key policy 'tensions' between fostering internationalisation and the mobility it often implies and the free movement rights of the individuals concerned, on the one hand, and promoting 'balanced growth' and an effective return on investment in human resources on the other.

Our general aim in developing future options under ResIST is to try to balance continued economic growth with increased social equity; to reconcile a policy prescription emphasising the growth through the development of the knowledge

[5] Bryony Gill and Louise Ackers (2007). *Researchers in the European Research Area*. ResIST Working Paper, Deliverable # 4. Available at http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.
[6] Williams, A. (2006). 'Lost in translation? International migration, learning and knowledge', *Progress in Human Geography*, 30 (5), 588–560.

economy, with one emphasising social cohesion – twin objectives at the heart of the Lisbon strategy. The question is whether such a balance effectively currently exists, or whether a discourse about individual rights, which is particularly strong within the EU, and which is line with a recent neo-liberal economic framing of much policy, effectively unbalances it. Thus EU policy seeks to promote a 'symbiotic' relationship with sending countries and individual member states, for example the UK, have imposed limits on recruitment of personnel in fields like health. A dual approach is emerging within EU policy entailing the use of funding streams made available under the Framework Programmes to aggressively promote mobility on the one hand and the capacity building and cooperation activities developed through the framework programmes and specific cooperation agreements and conventions on the other (CEC, 2008).[7] In September 2008 the Commission published a Communication on 'a strategic European framework for international science and technology cooperation' (CEC, 2008). The Communication asserts the importance of developing scientific cooperation internationally with initiatives targeted at certain scientific issues or at countries determined by either their proximity to the EU or the level of their economic development. (Oliver, op. cit., p.10)

Mobility of researchers is considered an "essential feature" of international cooperation but the context for this is that Europe is seeking to compete for the best researchers (CEC, 2008: 14). The need derived from the Lisbon strategy for Europe to recruit 700,000 new researchers in addition to those needed to respond to demographic concerns is likely to lead to Europe being seen as parasitic on the developing world. It is also likely that migration of scientific personnel within Europe, from south-east to north-west, will become an increasingly live political issue, especially as European expansion makes for a more economically heterogeneous Union, with issues of fairness and equity coming more to the fore in the light of the economic crisis, and with traditional neoliberal solutions being questioned, if not actually discredited.[8] International competition for expertise is increasing, and developing countries are starting to follow the developed in using selective immigration policies and incentive schemes.

The situation has prompted some researchers working in rather different geographical contexts to identify ways of restricting highly skilled mobility or, more positively, developing means of promoting return. Ha-Joon Chang (2007)[9] has argued that the open, market-based policy prescriptions the richer nations have sought to impose upon the developing countries are not only wrong but hypocritical, since many of the richer and successful advocates of free trade historically embraced protectionism into order to build their competitive capacity. These included Chang's own home country, South Korea. South Korea and Malaysia are still in the forefront of the development of return incentives and packages.

The findings of the ResIST research do not support the institution of policies designed to impose restrictions on individuals' free movement rights, although

[7] Commission of the European Communities - CEC- (2008). *A strategic European framework for international science and technology cooperation.*
[8] For more information on EU policy see section 1 of Gill and Ackers (2007). See also Oliver's thematic paper page 8-16 (Oliver, op. cit.) for a specific look at EU policy on S&T cooperation with third countries and information on how the EU promotes the immigration of third country nationals.
[9] Ha-Joon Chang (2007). *Bad Samaritans: Rich Nations, Poor Policies and the Threat to the Developing World.* London: Random House Business Books.

increasing the opportunities remain and work effectively in the home countries and incentivising return is critical. Rather the research has identified the role that opaque and restrictive domestic employment policies play in encouraging people to leave (Ackers, 2008).[10] Mouton's thematic paper (Mouton et al., 2009, op. cit.) focuses on capacity building within the 'donor' regions with targeted funding for institutions rather than individuals. Esau and de Waal's thematic paper (Esau and de Waal, 2009: 17)[11] argues that restrictions on migration may be impractical and simply not work. Oliver's thematic paper argues that there is scope for policy development at European and national level to encourage a greater return on scientific mobility for sending region (Oliver, 2009).

The identity of the scientific diaspora and the role of diaspora policies

One means of promoting sustainable scientific mobility in the development context is through effective harnessing of knowledge embodied in the scientific 'Diaspora' (Gill and Ackers, op. cit.). Lowell and Gerova (2004)[12] proposed a classification of interventions and initiatives to redress the brain drain, known as the six 'R's – reparation (the compensatory tax principle discussed above), restrictions, recruitment, return, retention and resourcing diaspora policies. To this list ResIST has added a seventh 'R' – remittances: the extent to which the highly skilled abroad can be mobilised to send home what Oliver has called 'knowledge remittances' as well as financial remittances (Oliver, op. cit.). Research suggests that highly skilled migrants actually send less money home than their unskilled compatriots (Khadria, 2002;[13] Ackers and Gill, 2008).[14] The research indicates a high level of investment on the part of expatriates and especially black South Africans in the education of siblings and social and healthcare support for their families back home. Although such remittances are unlikely to have a major immediate effect on the national economy and particularly in the science sector, they play an important to the families concerned and the education of future generations. Of course, these kinds of remittances also increase the potential for forms of education-related mobility. As Meyer suggests, 'networks-make-migrants' (2001),[15] what is less clear is the consequences of these processes for sending countries.

Building on previous research in an Eastern European context (Ackers and Gill, op. cit.), Oliver's thematic paper for ResIST (Oliver, op.cit.) suggests that scientists

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[10] Louise Ackers (2008) *Ethical Dilemmas: Individual Human Rights versus Sustainable Development. Excellence, Migration and Equality Policy: Managing Unintended Consequences?* ResIST Thematic Paper, Deliverable # 11. Available at: http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.

[11] Simone Esau and Liezal de Waal (2009) *Where have all the health scientists gone? : A South African question*. ResIST Thematic Paper, Deliverable # 10. Available at: http://www.resist-research.net/paperslibrary/full-and-final-results.aspx.

[12] Lowell, B.L. and Gerova, S.G. (2004). *Diasporas and Economic Development: State of Knowledge*. Institute for the Study of International Migration, Georgetown University. Prepared for the World Bank.

[13] Binod Khadria (2001) 'Shifting Paradigms of Globalisation: The Twenty-first Century Transition towards Generics in Skilled Migration from India' *International Migration*, 39, 5, pp.45-72.

[14] Louise Ackers and Bryony Gill (2008) *Moving People and Knowledge: Scientific Mobility in an Enlarging European Union*. Cheltenham: Edward Elgar Publishing.

[15] Meyer, J-B. (2001), 'Network approach versus brain drain: lessons from the diaspora' *International Migration,* 39 (5), 91–110.

operate in international, scientific, networks rather than networks with co-nationals per se. These networks include continued contact with professional (scientists) in the sending country. Furthermore, migrant scientists display a very strong sense of commitment to their peers and to scientific development in the sending country and are often actively seeking ways of providing support. It may be that personal professional intelligence about changing intellectual and policy agendas, and academic and research opportunities, which people naturally acquire when based in their own country, needs to be rather more systematically sourced abroad. In addition, in order to mobilise any such opportunities, the migrant scientist may feel the need to signal his or her presence abroad, to remain visible. Diaspora networks are in this sense an outgrowth of individual migrating scientists' behaviour, and establish a natural base for policies which can encourage return or the sending home of knowledge remittances.

However – and here we come across a central paradox of diaspora management – the evidence suggests that without strong scientific institutions and a degree of 'critical' mass, sending countries cannot benefit from knowledge exchange and it is difficult to identify any benefits of mobility. In other words, scientific migration tends to hollow out or de-institutionalise scientific institutions in the sending countries, in processes discussed in more detail below, whilst the strength of such home institutions is key to the effectiveness of policies for retention, return, or securing the benefits of knowledge remittances.

In countries or institutional contexts where there is capacity the 'brain circulation' thesis may apply and sending countries may realise certain returns on outward migration. Yet even in these more favourable circumstances Oliver's work suggests caution about the impact of such networks. Individually motivated and directed professional activities involving the sending country were more prevalent than involvement in formal networks/organisations. Policy makers need to consider ways of harnessing the potential in informal professional networks rather than generating new kinds of often artificial and unsustainable formal networking initiatives.

The RESIST research included a review of diasporal policies in a number of African countries and concluded that in general it was too soon to judge the effectiveness of most of them in increasing knowledge remittances and eventual return, although there seems to be some evidence of success of Botswana in internationalising key posts in their science community as a basis for retention of their nationals. South Africa's research professorships, an element of the country's S&T strategy, follow a similar international recruitment pattern. The findings on the motivations and behaviour of individual scientists suggests that effective return and professional reintegration of at least some key researchers remains critical to knowledge transfer and exchange ensuring that knowledge returns with the individual scientist. However the activities of those who contribute professionally to the sending country prior to or in lieu of return are currently overlooked and could be better supported.

Supporting the professional contributions of researchers prior to return is important. This study found that those who anticipated returning to the sending country were less likely to seek to contribute at a distance – they anticipated that they would share their knowledge and skills upon return. However if return isn't realised these contributions are never made. Professional activities conducted at a distance ranged from informal knowledge exchange and sharing ideas to training doctoral candidates, delivering professional training, conferences and seminars through to joint collaborative projects.

Some of the smaller scale and 'more every day' contributions such as writing a paper, giving guest lectures or using professional contacts to bring researchers together, were overlooked by researchers who saw 'making a contribution' as something major or outstanding. A combination of formal and informal relationships bolstered by concrete activities was central to the success of many of the examples of cross national collaboration. A further key to success was maintaining research interests in fields that were relevant to the sending countries. This supported the continued relevance and further development of existing social networks.

Migration and the motivations of individual scientists

In order to throw light on the motivations of individual migrating scientists, the study included interviews with highly skilled people who had left less developed countries (South Africa, Turkey) to work in more developed countries (the UK, Germany), some half of whom had since returned home. For highly skilled South African health professionals, the 'pull' factors which increased their incentive to migrate included personal professional opportunities such as gaining international experience, or specific training or scholarship opportunities; access to human and non-human resources: technologies, networks and contacts; financial factors in terms of higher salaries and the opportunity to repay student debt; and the attractions of international travel.

The 'push' factors – the perceived home country negatives which propelled them towards emigration – were in many cases the direct reciprocal of these: international isolation and lack of 'broader horizons' and new approaches; poor resources for clinical research and lack of 'critical mass' in research environments; pay, hours and working conditions, and lack of job opportunities, including, for white (male) South Africans, the perceived limitations of opportunity for this social group resulting from affirmative action in favour of previously disadvantaged groups; and wider social and economic factors, including perceptions of crime rates, the economic downturn, and falling standards in public health care and education.

There was a third set of 'enabling factors', which facilitated the migration decision or choice of location. These included existing professional or personal links, skills or affiliations: the ease of registration with professional bodies; existing professional contacts; location of critical mass of academic or clinical expertise; common language; and colonial ties and dual citizenship.

An important finding for diasporal management is that taking the first step in international scientific migration may also lower the personal barriers to further moves. Respondents based in the UK were more likely to consider future moves to locations such as Australia and New Zealand. However, the effect is not permanent: those who had returned to South Africa had mixed feelings about staying or moving elsewhere.

Overall, Germany is the third choice for Turks training abroad behind the US and the UK. Most of the Turkish scientists interviewed worked in engineering, biological or medical sciences or IT. Their choice of specific institution mostly rested on scientific reputation in the literature and established professional and personal links – similar enabling factors as those for the South African health professionals. Most of those interviewed initially went to Germany to pursue postgraduate education at masters or PhD level, and, as with the South African group, in some cases this appeared to lower

the barriers to taking a job in Germany or a third country. A large majority of those who remained in Germany remained in the academic sector, but those who had returned to Turkey were equally split between industry and academia.

The development of international networks and collaborations was a key motivation for those moving to Germany either for training or academic jobs. More of those working in Germany developed such personal networks and collaborations further, helped by the lack of barriers to academic exchange within Europe; returnees to Turkey maintained such links to some extent if working in academia but much less if in an industrial job. One interviewee pointed out that since Turkish universities had less established links at institutional level, the onus for collaboration fell on the individual. Many more pointed to unattractive conditions for research in Turkey: low investment in R&D by government and companies, and low numbers of internationally competitive researchers. These seems to be a strong 'push' factors for initial migration, although more research would be needed to establish whether such conditions also impede Turkey's ability to identify and absorb potential knowledge remittances from those abroad and from returnees; and how far more generally Turkey could be seen to be benefiting from 'brain circulation', or whether the less elite of Turkish academic institutions may themselves be suffering from a degree of 'de-institutionalisation' (see below) as European labour market dynamics play out.

The costs and consequences of scientific migration: scientific de-institutionalisation in Sub-Saharan Africa

Although the empirical work focused on Turkish and South African researchers and not on researchers from less developed areas of Sub-Saharan Africa, the project included a review of scientific institutions (mainly universities) in some of these much less developed contexts, from which South Africa draws many of its researchers.

As the diaspora management paradox set out above makes clear, the relatively poor state of research facilities in many African countries can be seen as both cause and consequence of the gradual erosion of human capital through the brain drain. The loss of highly skilled personnel in some African countries appears to be on such a scale as to be contributing to processes of de-institutionalisation of science and technology across much of sub-Saharan Africa. Numerous studies have been conducted over the past 10-15 years that demonstrate quite convincingly that research at former well-resourced and supported institutions such as Makerere University in Uganda, Ibadan in Nigeria and University of Dar es Salaam in Tanzania have deteriorated; that research infrastructure and the general state of laboratories at many institutions has suffered from a lack of maintenance and timely replacement of old equipment. In addition the generally poor quality of library resources has not improved significantly with many university libraries not even using automated management systems; the demand for sufficient research funding for ongoing research and scholarship continued as does the need for proper research management and support at most of these institutions.

Many of the scientific institutions across Africa exhibit similar fragilities. They are susceptible to the vagaries of political and military events and are severely under-resourced and suffer also from a lack of clarity and articulation of science governance issues (demonstrated by constant shifts in ministerial responsibility for science). In fact, one could even refer to some of these science systems and the associated

institutions as operating in a "subsistence" mode where they struggle to even reproduce themselves. A "subsistence mode" in this context would refer to a system that basically produces knowledge for its own use only and does not export knowledge. In fact it does not make a significant contribution in the global game of knowledge production. It is even debatable whether one can talk of a science "system" in many of these countries as they do not exhibit typical "systemic" characteristics. As well as the loss of highly skilled personnel, three other factors continue to shape and affect the (de) institutionalisation of science in these countries: the continuing legacy of colonial science in many countries; the destabilizing influence of political events and civil and regional wars; the role of international agencies in shaping African sciences.

Such sustained de-institutionalisation has significant effects on modes of knowledge production in these countries. Because of low domestic investment in R&D, most African universities and scientists rely heavily on international funding. In addition, because of poor institutional capacity, funding for research is not channelled through a properly articulated and monitored system of public funding (e.g. through a national funding agency), the individual scientist and academic at a university receives his or her funding directly from foreign funders (or through the mediation of a local representative). Those who are privileged to receive such funding use it to pursue their own research interests (not surprisingly) and also to advance their own careers. This allows them to travel overseas, attend international conferences and in general have the required resources to build their own individual research capital. This focus on building one's own curriculum vitae must be understood within the context of poor academic salaries and working conditions and a general lack of sufficient research and library resources. But, this kind of scientific endeavour rarely converts into building institutional research capacity. It is not linked, for example, to training doctoral or even post-doctoral students. In fact, the fact that there are so few doctoral programmes at many of these universities means that "reproducing" existing scientific work through doctoral students is not even possible.

One of the direct consequences of this is that many academics increasingly revert to consultancy work – often for international agencies and governments rather than for local agencies. As part of a recent study of public science in the SADC region, members of the ResIST team collected data on the extent and nature of consultancy activities in these countries. A major finding of this research is that two thirds of all academics in the region regularly engage in consultancy. Consultancy can be a healthy part of academic practice, extending the reach of academic knowledge. In these African cases it appears that it was rather a substitute for the development of academic capacity. In a recent study on this phenomenon in health research in East Africa, Daniel Wright (2008)[16] comments on the impact that this consultancy culture has had on "normal research practice" and on the development of future research capacity. As he observes: "Financial insecurity leads researchers to take on any work available, and consequently: There are no research traditions being developed". Not surprisingly, "the CVs of highly experienced researchers often list numerous consultancy reports but very few journal publications, jeopardising their applications for senior jobs. The conflict between consultancies and academic publications reportedly generates a

[16] Wright, D. (2008) "Most of our social scientists are not institution based - they are there for hire—Research consultancies and social science capacity for health research in East Africa" in *Social Science and Medicine*, Vol. 66: 110 – 116.

professional culture in which: "the point is to try and chase the quick money, and not take advantage of the chance of academic growth".

One of the key issues that this underlies is the necessity of putting South African skilled migration flows into the context of understanding the scope, nature and motivations of exchanges of skilled personnel between South Africa and other parts of Sub-Saharan Africa, including taking account of the wider impacts of the de-institutionalisation processes discussed earlier. How far does the fact that South Africa can draw on migration from elsewhere in the continent mitigate the effects of out-migration, and how far does this contribute to brain drain elsewhere? Establishing these dynamics, based on a small sample of sub-Saharan African economies, must be a priority for future research.

Other European parallels?

In the case of Central and Eastern Europe (CEE), brain drain is also a pressing reality, even though we do not have evidence of de-institutionalisation to quite an extent as in the case of the sub-Saharan Africa. The enlargement of the EU to include the former communist countries alleviated the migration process and indeed served as an incentive for considerable percentages of the workforce in, for example, Poland, Lithuania, Romania, or Latvia to seek employment abroad. However, to take the case of Latvia – one of the EU's more fragile economies – the emigration of scientists and other highly skilled R&D personnel in fact started much earlier: the most substantial losses took place throughout the 1990s (Ozolina, 2009).[17] Firstly, a share of scientists left for abroad directly after the collapse of the Soviet Union, when the local S&T system had to be completely reorganised from serving a small but often quite specialised role in the vast Soviet S&T industry to constituting a national research system. Furthermore, throughout the 1990s the R&D funding in Latvia was extremely low, which contributed to the push factors for emigration. Overall, out of 17 000 researchers in 1991, there were only 4000 left in 2000 (Kristapsons et al., 2003a: 17).[18] There are no precise data available, but reports suggest that most of them changed profession, while up to 3000-5000 may have emigrated to work in S&T abroad (ibid; Kristapsons et al., 2003b: 85).[19]

However, after 2000 the national R&D investments were slowly but steadily rising and universities could invest additional funds in retaining young scientists and also 'regaining' back some of those who had moved abroad earlier. There is no evidence in the case of Latvia to suggest that closer integration with the EU in the first decade of 2000 has increased emigration of scientists from Latvia. Instead, the existing research suggests that scientists have found opportunities to emigrate also before the policy developments fostering mobility within Europe. The push factors, as far as it can be seen so far from the existing studies, have been more influential than the pull factors.

[17] Analysis of Latvia has been provided by Liene Ozalina and is based on her 2009 Report for ResIST *STI Policy in Latvia: 'Catching-up' with the West'*. Available at http://www.resist-research.net/cms/main.aspx, accessed 15 May 2009.
[18] Kristapsons, J., Martinson, H., Dagyte, I. (2003a) "Baltic R&D Systems in Transition: Experiences and Future Prospects". Riga: Zinatne.
[19] Kristapsons, J., Adamsone, A., Tjunina, E. (2003b) "Innovation Policy in Seven Candidate Countries: the Challenges". Final Report. Available at: http://www.innovation.lv/ino2/publications/final_report/romania_final_report_march_2003.pdf, accessed on 29 February 2008.

Accordingly, it is a vehemently expressed concern of the management representatives of local S&T institutions lately that if the research budgets shrink again, as it is currently experienced due to the recent economic hardship, brain drain will increase and there will be no third change to convince the émigrés to return once again.

Policy conclusions and recommendations

(a) European policy on international recruitment and its links with other policy domains

What can EU policy do to remedy these losses of scientific and economic capacity in the developing worlds and within its own borders? What can developing countries and member states in less favoured regions do themselves? As has been indicated, there are some tensions within current EU policy. Policy approaches to promoting migration and immigration in the European Research Area place an emphasis on individualism and migration between centres of excellence. This is in tension with other policy narratives stressing the importance of balanced growth and sustainability. EU policy does seek to address capacity building within third countries (see Oliver 2009). However, where international cooperation policies are tailored to developing countries the policy on migration is not. This tension is a familiar one in labour economics, and in many areas of labour market management relatively easily resolved. Countries that embrace many of the mechanisms characteristic of the social cohesion policy paradigm from ResIST's work in work package 1 often do so on the basis that higher social insurance arrangements will allow more flexible labour market regulation which in turn may help deliver greater growth. Balanced growth in these instances comprises a safety net beneath a higher risk, higher performing economy – in ResIST's terms, KEPP on the back of SCOPP.

However, such balanced growth mechanisms do not apply equally across all economic regions, or easily scale up to the world regional or international level. Our perspectives on what needs to be accounted for changes as we change scale and become conscious of the interactions between different policies, and the ways that they may been seen. One provocative thought that arises from this focus shift that international aid serves the function form of social insurance or compensation for developing countries which allows for international recruitment of their highly skilled or for free trade; another form of KEPP on the back of SCOPP. Similarly there might be resistance to the idea that the European structural funds are a compensation for the economic imbalances that result from the free movement of scientists and technologists within Europe. The point of these slightly perverse thought experiments is to emphasise the importance that migration policies, along with those for trade, aid, and intellectual property, are seen as linked and interdependent. A wider process of accountability would have involved detailed accounting for the pluses and minuses of these separate elements, so as to be sure that the total policy package is seen to deliver net benefits to developing regions and countries.

We recognise that efforts are under way in the EU to attempt to reconcile the tensions underlying policy in the field of Migration, Internationalization and Development. These policies have commonly been addressed through different policy fields and in different ways by sending and receiving countries – and this should be encouraged. The EU seeks to coordinate international cooperation in R&D throughout the Member States – again though migration policy remains fairly distinct from capacity building

policies. Since return and reintegration grants and international networking grants arguably help to support capacity building there is further scope to draw these policies together.

Special attention still needs to be applied to the creation and maintenance of internationally competitive S&T. This is a highly capital and skill intensive activity, and institutions in developing countries and regions whose intellectual capacities have been built up over decades can lose them rapidly. In the short term this loss for developing countries can threaten not just the science base as such, but a whole range of capacities essential to trade in and diffuse and regulate science-based products and services. At the same time, of course, such losses of highly skilled personnel undermine the longer-term strategic objectives of training the next generation and developing local knowledge economies. These considerations of course apply as much within Europe, in differences between countries and regions, as in Europe external policies, where Europe's hunger to suck in more scientists and technologists in order to compete in the premier league of international competition could be seen as a major contribution to the entrapment of many countries in the lower leagues.

(b) Policy and practice to improve the contribution of the scientific diaspora

Every effort should be made to support effective knowledge transfer and exchange. Supporting networking and circulatory migration patterns should supplement and not replace attempts to support return. International networking grants already exist (for example FP 7 International Staff Exchange Scheme or the UK Royal Society Networking Scheme). Consideration should be given to developing a specific 'Diaspora Grant' based on the principle of providing 'seed corn' funding to support migrant scientists based in the EU to develop or maintain professional networks within the sending country.

Policy makers should support migrant scientists to maintain contact with colleagues in the sending country even where stays are relatively short-term and migrants (or the mobility grant itself) anticipate return.

Receiving countries should investigate the value of relatively small scale individual activities and support early career researchers to undertake them.

Smaller scale Diaspora Networking grants could be used to promote the value of engaging with activities such as presenting research, writing papers and planning grant applications. These could be targeted at early career researchers.

Capacity building activities and funding could be targeted at teams with long term and established links in the sending country. The UK/South Africa Royal Society/National Research Foundation Joint Collaborative Programme could be a useful model here.

Evaluative information is scant: There is need for a continuing effort to assess national and international policies in this area.

(c) Scientific mobility and institution-building in science in the Sending Countries

Focus on scientific institutions. The most general policy implication here speaks to the relationship between brain drain from the South and the state of scientific institutions in these countries. The continuing brain drain from this region will not be reversed

simply by looking at interventions that target individual scientists (such as home coming initiatives or diaspora networks or exchange programmes). Our analysis points to the key role of the institution and how the brain drain continues to erode institutional capacity and institutional research culture. Any attempt to reverse the brain drain will fail if it does not also consider interventions and initiatives that restore and eventual make these institutions sustainable research institutions.

Continuing investment in the essential Information and Communication Technologies. Research centres and programmes are in a sense the "superstructure" of science. But this is dependent on an extensive ICT infrastructure (fibre optic networks, information systems development, sufficient bandwidth, automated library management systems). Much effort and funding has over the past 5-10 years been invested in this area. However, it is clear that many challenges remain. Experience has shown that many universities have outdated administrative systems with archaic procurement policies that make the simple acquisition of computer equipment extremely difficult. Moreover the absence of a local support system (in the form of local vendors and maintenance companies) means that broken equipment often does not get repaired or replaced.

Training and technical advice in research policy, management and graduate studies. Very few African universities (outside of South Africa) have well-established research management offices. Although some effort has been made in recent years to strengthen the local expertise in this field, this is simply not enough. Our experience shows that many research managers at these universities are recently appointed, have very little knowledge of how to manage the institutional research profile and how to access funding and support to do so. In addition research directors and managers of doctoral programmes require much more training and support across a wide range of skills and competencies in such areas as the supervision of graduate students, development research plans and strategies, codes of conduct on integrity in research and so on. If capacity building is to replace de-institutionalisation, more ambitious and sustained efforts are required along these lines.

More broadly, we have seen it as one of our legacy responsibilities under ResIST to contribute to developing countries' capacity to undertake the kind of critical, independent policy study that Resist represents. Accordingly we have taken an initiative to set up a Science, Technology and Development Network to help focus work both on the issues and the analytic capacities needed – particularly in Sub-Saharan Africa – to engage with them, and to contribute to capacity building in this area. This work was done under WP0 and is reported in section 11 of this report, but is worth a mention here.

Policies of Sending Countries and the Role of 'Push' Factors

Out-migration and the potential damage this causes to scientific institutions is, as we have noted above, a function both of the policy and resource frameworks in the receiving countries (pull factors) but also of 'push' factors. The study has identified a number of characteristics of the South African context which have rendered scientific employment and, in some cases, residing in that country unattractive. The powerful emphasis respondents placed on 'push' factors underlines the importance of addressing the national policy environment. Factors identified including poor funding for research in some areas, lack of critical mass, poor working conditions and low pay and a general lack of job opportunities or inability to access those opportunities that do exist.

Arguably the lack of available positions throws a rather different perspective on the situation. If South Africa is managing to fill available positions effectively either through its own home grown researchers or via migration into the country (primarily from African countries) then the consequences of outward mobility appear somewhat over-stated. Certainly many potential returnees referred to the lack of research opportunities as a factor impeding their return.

The overall lack of opportunities is further complicated by a strong perception on the part of some respondents in the UK, that the opportunities that do exist in South Africa are not available on a transparent, meritocratic basis. Persistent discrimination against black people coupled with the unintended consequences of post-Apartheid employment equity policies have together contributed to a deep suspicion that recruitment and progression in science is distorted resulting in differential opportunity.

Wider social, economic and environmental factors further encouraged people to leave, including concerns about crime, the economic downturn, and falling standards in public health care and education.

Sending countries need to pay careful attention to the factors identified above to ensure that the positions and professional environment is as attractive as resources permit in order to discourage out-migration and ensure that excellence is allowed to flourish in science research.

10. Emerging technologies and inequality

Emerging Technologies are a particularly interesting site to understand the impacts of S&T on different forms of inequality. When technologies are already fully consolidated, public policies have limited tools for intervention. As we saw in section 8, policies that focus on improving the impact of technological innovations on social cohesion, with the aim of reducing inequalities, can be more effective if these consider the wider inputs into the process and do not simply focus on 'tinkering' with impacts, once technologies are in place. On the contrary, as argued in section 8, public intervention can make a difference through interventions with emerging technologies. In this section we take a particular look at specific emergent technologies, to better understand how technologies embed relationships, actors, services and contexts which frame their distributional impact.

Emerging technologies are new, science-based technologies that have a high potential to increase both economic growth and social inequality and appear as a strategic research site for examining the interactions of inequalities between countries and inequalities within countries. New, emerging technologies are of particular relevance in this regard in two ways. Because of the high research costs and skill requirements, these can generate distributional consequences through high relative prices at both structural and distributional levels. For this reason, emerging technologies have a higher potential than older technologies for generating inequalities in access and employment.

We focus here in particular on the distributional impact of new science-based technologies. These can be considered in terms of the business opportunities created, the employment generated, and how the benefits and costs accrue to different actors. The benefits and costs of creating, producing, and using the new technology vary considerably across countries and people, a situation which is shaped by policy interventions. In this regard it is of particular importance to understand the dynamics that link emerging technologies to patterns of inequality and the roles of public interventions in those dynamics. From the analysis of these impacts and dynamics is it possible to contribute to new ways in which policy actors can frame future policies in support of the development of specific new technologies? This is the central question framing this section, and for which we expect the reader will find considerable inputs here.

While received wisdom often links the emergence of new technologies to the role of creative individual inventors, who 'discover' new technologies, this simple vision has been discarded by studies of the processes underlying science, technology and innovation. The seemingly instantaneous nature of the process of discovery, and the linearity of the relation between inventor and technology, would correspond to a clear and simple process of technological development, with the final form and uses of technology being broadly independent from its wider social and policy context. On the contrary, the actual process of emergence of technologies is not only lengthier and more complex, but it also involves multiple actors, forms of knowledge, objects and institutional contexts shaping its development. As such, rather than looking at technologies independently, we will look at the different contexts and relationships in which they are embedded which frame their impact on local and global inequalities.

Identifying emergent technologies

With the objective of reflecting on a variety of these links and contexts, the work developed in the present study analysed five technologies in eight countries, and the corresponding distribution of business opportunities, employment, benefits, and costs. To capture the full impact of emerging technologies across different development levels, the analysis focused on technologies that emerged some time ago to be able to track actual effects rather than projecting them. The cases were information and telecommunications technologies and biotechnologies. Examples from the past were used to develop a framework for thinking about the future for new areas such as nanotechnology or synthetic biology. The five cases studied are: genetically modified (GM) maize, mobile phones, open source software, plant tissue culture, and recombinant insulin.

These technologies represent both proprietary and public ownership models, and range from simple to highly complex. The information and communication technologies (ICTs) we included are **mobile phones** (proprietary) and **open source software** (non-proprietary). Mobile phones are widely hailed as a modern technology that has helped the poor a great deal, and open source is thought to create better, less expensive software options as well as new business opportunities. Among biotechnologies, we chose one health product, **recombinant insulin**, the first biotechnology health product to be approved and one with wide applicability. In agriculture, we chose both a sophisticated product, **genetically-modified maize**, which is produced through genetic engineering, and at the other extreme, **plant tissue culture**, an older and relatively simple technique that was nonetheless just reaching one of our chosen country contexts at the beginning of the study.

Do national contexts frame distributional impacts of emergent technologies?

Because they are new, emerging technologies are the site of change and growth in both global and local economies. The techno-economic networks that support them are still young and malleable, but are projected to be more significant as time goes on. They therefore represent a good place for public interventions towards equality, and hence for the analysis of their impact on inequalities.

Secondly, because emerging technologies are research-based, they are more likely to be sold at high prices (as firms try to recoup research and development costs) and to demand high levels of skills in the production process. Both these characteristics give emerging technologies a higher potential than older technologies for increasing inequalities in access and employment.

Thirdly, emerging technologies stand at the intersection of global and national distributive processes. The dominant pattern in emerging technologies has been that new technologies have been developed in North America, Europe, or East Asia (the "Triad" regions), then diffused to other parts of the world, either when a multi-national firm decides to place a production facility there or when the technology becomes available for purchase. The benefits and costs that people experience in creating, producing, and using technologies as a result of this process vary greatly among countries and technologies, but a global pattern of inequality nonetheless emerges. When we consider only this pattern, technology-creating countries always

appear to be starting the revolutions, and technology-using countries always appear to be trying to catch up. To create a different pattern, however, many non-Triad countries invest in their local capabilities in emerging technologies, not only to provide better absorptive capacity for using the technologies to meet local needs, but also as the basis for using the emerging technology to create local business opportunities. Indeed, the Millennium Project task force on science, technology and innovation[1] recommended that every developing country invest in "platform technology" areas, such as biotechnology, ICTs, and nanotechnology. These investments might create a re-distributional pattern with significant implications for the relationships between technologies and inequalities.

While these characteristics provide an important justification for focusing on emergent technologies within the ResIST project, it also provides a framework for our analysis, and our basic underlying model. The classic model of technology diffusion posits that after a new science-based technology is developed in the research and development department of a firm, it is typically introduced in a sophisticated, high-priced version that is marketed to a limited number of high-end users. As the market expands, the price of production falls and the firms producing the technology market simpler versions in order to reach broader markets. Eventually, the price drops far enough that the product reaches a mass market.

It is, however, important to note here that inequality does not simply derive from market distribution. Different uses of the technology, even if not mass-marketed, can also contribute to different social impacts, eventually reducing inequality, within the same market distribution. The employment opportunities deriving from a particular technology can have wider impacts at the level of the capabilities of the workers beyond the specific employment opportunities. The technology can complement other existing assets or technologies. The technology can provide a particular added-value to those at the bottom of the pyramid, while being only a small improvement on earlier technologies for those at the top.

We gathered data on the five technologies using a common data collection protocol in eight different national contexts, including four developed and four developing countries. The ResIST team studied their own countries in Europe and Africa (Germany, Malta, and Mozambique), and a companion grant from the U.S. National Science Foundation allowed our U.S. colleagues to study countries in the Americas: Argentina, Canada, Costa Rica, Jamaica, and the United States. The fact that these countries ranged widely in size, national wealth, and science and technology capability is a strong point under the case study approach, since the operation of the classic model were examined under a wide range of conditions. The US here stands out, with the largest population, at approximately 300 million, compared to the less than half a million in Malta; the highest income per capita, at 46.040 USD, i.e. around 150 times higher than that of Mozambique and 10 to 15 times more than the Central and Latin America countries considered; and being the more technologically advanced, for example as measured by the technological achievement index developed by the UN Human Development Report. Germany and Canada follow, and Argentina, Costa Rica, Jamaica and Malta have intermediate positions. The latter being clearly more economically developed than the rest, but having particular conditions as a small

[1] Calestous Juma and Lee Yee-Cheong (2005) *Innovation: Applying knowledge for development*. London and Sterling, VA, USA: Earthscan.

State. Mozambique, the only country from Africa in this group, has much lower performance in the economic and technological indicators.[2]

Nevertheless, if we simply consider the enormous inter-country disparities we completely overlook in-country differences, which are also relevant here. In fact, social inequalities in the more advanced country analysed, the US, are considerable. Similarly, while the index of technological achievement of Mozambique is very low, it has groups of researchers, technicians and other users, who use and develop the new emerging technologies considered here, at an advanced level. This is precisely an important issue here. Distributional consequences for the individual technologies are not simply mediated by averages, but rather by specific conditions for particular individuals, firms, or communities. Understanding 'who' is being affected by lack of access, 'why' is this so, or 'how' can access be radically improved thus become central questions. As noted earlier, access is here a general question, which can be decoupled into different forms.

The basic logic of the data gathering and analysis was that *technological projects* affect *inequalities* in *valued items* through pathways that are technology-specific, mediated by *national conditions*, and shaped by *public interventions*.[3] We looked for distributional consequences of the technologies in four valued items: business opportunities, employment, benefits, and costs. Not every technology was relevant in every country, but in the end data was gathered for 34 country-technology pairs, leading to the analysis of results for each technology across the country examples and for each country across the technologies covered there.

Beyond price: the dependence of technology on infrastructure and capabilities

While the economic and technological conditions of countries where the use of these emerging technologies was studied are highly diverse, it is important to note that access to the technologies is not only mediated by the overall structural conditions. Other conditions, in particular the local existence of appropriate expertise and infrastructure were identified as central factors affecting the capacity of countries, firms, communities or individuals to benefit from these technologies.

A very clear illustration of the crucial importance of other factors determining patterns of use is in the open source example. By definition, the product itself is free, which means that other factors shape the distributional patterns. For the business applications, contrary to what might be expected, large firms were more likely than small ones to use open source software. While small firms typically have lower financial resources, and therefore would have strong incentives to use open-source software, rather than other standard packages at a cost, they often do not have the in-house expertise to absorb and maintain the product when it does not come bundled

[2] Population and GNI/capita data from the World Bank, World Development Indicators, 2007, and United Nations, Human Development Report 2001.
[3] For a fuller description of the concepts, see Susan Cozzens, Isabel Bortagaray, Sonia Gatchair and Dhanaraj Takur (2008), "Emerging Technologies and Social Cohesion: Policy Options from a Comparative Study", paper presented in the PRIME-Latin American Conference, Mexico City, September 24-26; available at: http://prime_mexico2008.xoc.uam.mx/papers/Susan_Cozzens_Emerging_Technologies_a_social_Cohesion.pdf.

with support from a proprietary software company. The importance of appropriate expertise thus becomes clear. One could expect that such open-source technologies could contribute to expand use by private consumers. However, they still rely on the existence of a complementary infrastructure, the computer. For those who do not have a computer, open source software still provides no benefit. In the case of Mozambique, where there are only 20,000 computers in a country of 20 million, not many will be able to benefit directly from open source software.

Recombinant insulin provides another appropriate example. In Argentina, Costa Rica, and Jamaica, there was a wide availability of recombinant insulin. This was largely through health insurance and public health services. However, where someone was not covered by this underlying social infrastructure, he or she did not have access to the technology – a situation that characterized a surprising 25% of Argentines and probably the full 40% of Jamaicans who work in the informal economy. Access was not directly dependent on the technology, but rather on the wider supporting infrastructure.

However, as the situation in Mozambique exemplifies, the (non)existence of this infrastructure does not fully explain existing inequalities. For the estimated 80,000 diabetics in the country, only enough insulin for perhaps 50-100 is imported. Doctors in Mozambique are reluctant to prescribe insulin to people in poor households who will not be able to maintain the necessary regimen. So ironically, while insulin is free through the public health service, rich people are much more likely to benefit from that policy than poor ones.

This finding points to the fact that pockets of concentrated expertise can make a difference in whether a technology's benefits are accessible in a particular country. Some of the national contexts in our study were better able than others to provide multiple opportunities for the absorption of new technologies into economy and society. The two major non-price constraints that we described above – capabilities and infrastructure – are not often constraints at all in the affluent countries in our study, Canada, Germany, Malta, and the U.S. In those countries, there the distributional issues have to do with spreading the business opportunities around geographically, creating equal opportunity for traditionally marginalized groups, and subsidizing access in some cases. Without special policy efforts to distribute the benefits broadly, emerging technologies are absorbed through the existing relations of power and production and tend to increase the wealth and influence of those already at the top in those societies.

Beyond individual technologies: focusing on Technological Projects

Because technologies do not take effect independently of wider, complementary, assets, services and capabilities, it is on this wider technological project, which some actor or set of actors (the "champion") tries to make happen, that we focused. This wider approach allows that any success in the wider use of the technology, or of its wider impact, is not an intrinsic feature of the technology but rather can be a result of adaption to different local conditions.

The way the technique is packaged – with what services, with what price and payment plan, and with what accessories – is of the essence. Mobile phones are a good example of this. They are a product-service combination, which not only includes the hardware

technology, but also the specific pricing options for the service itself. This was indeed a crucial factor in extending the market. While the mobile phone itself is a typical example of a new, advanced high-technology product, it is highly disseminated, even in countries like Mozambique. This is largely due to the way it is packaged, with the option of pre-paid plans, which have been largely developed as a way to improve the affordability of cellular access to low income consumers. The benefits in terms of easier access to communication networks in wider geographical regions, as well as the cost benefits from the less extensive technology infrastructure of mobile telephony vis-à-vis the fixed telephone network, could only be materialized if the technology was affordable to a wider population and not only to a small elite. This opportunity was provided by the pre-paid plans which contributed to reducing inequality in access to communication technologies. Ironically, however, while pre-paid phone plans make mobiles accessible to poor consumers, they cost more per minute used. Meanwhile, familiar forms of inequality tend to persist. According to a telephone survey in our study, mobile phones are heavily concentrated among male users in Maputo.

Other technologies provide clear examples of the need to focus on the *technological project* itself. Open source software is the project of a community, a movement of programmers, who wanted to defy the major software multinationals, and their proprietary software regimes, broadening access. Some corporate giants were also interested in a way to compete with the proprietary software manufacturers. While the specific software product is free, in its business forms the corresponding business model considers a wider set of services, of adaptation and maintenance that are not. BT maize is another example of a product which is designed to be used with another, a pesticide. As such, one cannot consider the technology independently of the wider technological project which requires the complementary pesticide. And while recombinant insulin can be considered an autonomous technological product, it is marketed along with a set of supplies for testing blood sugar and administering the drug itself. Although the technology was designed independently, together these constitute the wider technological project on which it is based.

The level of malleability of these technological projects does, however, vary. While in principle open source software can be used freely, in fact it typically requires in-house expertise, as discussed above. But the requirements of technical skills and infrastructural conditions may be more limiting to the creativity of technological champions, and create greater sources of inequality. Micro propagation, for example, has to be done in a clean facility. The level of investment required for the technology to be available strongly limits the possibility for the industry to lower the cost of the product far enough for small farmers to afford it in some of the countries we studied.

Contexts of public intervention

These technologies emerged in a diversity of institutional environments, including international public laboratories (plant tissue culture), publicly-funded university research (recombinant insulin, GM maize), and private laboratories (mobile phones and open source software). The institutional context of discovery does not predefine its social impact and is not exclusively linked to public or private initiative.

However, there are important differences in the contexts of use and commercialisation of the technologies. Intellectual property rules, a traditional instrument of STI policy, are an example where the institutional context makes a significant difference, as we

described earlier. In this way, the social benefits, in terms of reduced inequality, of each technology are dependent on such framework conditions. But the relevance of public intervention is not limited to traditional STI policy instruments, and other sectoral interventions can also be of significant relevance for the distributional impacts of emerging technologies. Five main categories of interventions that fall outside traditional STI policy emerged with particular relevance in the cases studied: public procurement; public utility oversight; anti-trust actions; health and safety regulations; and environmental protection.

Clearly, if an emerging technology represents an irreplaceable capacity to solve a basic problem, governments are likely to intervene to make sure that capability is available to everyone in some form. Among our cases, recombinant insulin exemplifies this phenomenon (with some exceptions, as noted below). Insurance schemes or health services provide access to basic medicines for most people in most places. In other cases NGO coalitions are likely to intervene to ameliorate the situation, as they did with AIDS medication. Interestingly, public provision also plays a role in tissue culture and micro propagation, where making quality planting material available to farmers is seen in some contexts as a public responsibility.

Similar examples were found in agricultural technologies. Public interventions can contribute to initially lower down price, in order to more rapidly expand take up of the new technology. Tissue cultured banana plantings were free for a while in Jamaica, in a program subsidized by the European Union. When the subsidy stopped, large farmers were able to import material and the small farmers simply went back to using previous methods. In other cases, the extent to which prices will effectively drop may be doubtful. The high capital and labour costs of micro propagation put a minimum price on the planting material that did not allow it to reach the market at the bottom of this agricultural pyramid, given free market conditions.

As we saw earlier, complementary assets of capabilities and infrastructure serve as important secondary factors shaping distribution. Public intervention can also contribute to enhance the importance of such complementary factors indirectly. In the case of the tissue-cultured orange flesh sweet potato plantings in Mozambique, a government laboratory has been working with several NGOs to provide the higher quality plantings to small farmers, mostly women. They are successful in part because the technique is publicly available and free, as well as because of their community-based multi-pronged approach involving education and subsidies.

However, most consumer goods fall outside this “essential” category. Nevertheless, social benefit does not derive simply from basic health, food and infrastructural conditions. While governments do not subsidize or purchase mobile phones for those with less resources, governments have started to acquire for their populations the new less expensive laptop computers (some of which are equipped with open source software). The social benefits of the use of the technologies can go beyond their primary objective, with other indirect benefits for reducing inequality, such as training or easier access to communication resources, and therefore justify direct public intervention.

The expected social benefits may justify instead forms of intervention without the use of direct subsidies, i.e. of an indirect nature. For example, public utilities are closely regulated because of the perception that they provide basic services that should be accessible to all citizens. Public utility oversight therefore plays a re-distributive role in some countries in the mobile phone example. Telecommunications regulators are

concerned with keeping services "affordable" and encouraging tariff structures that extend service broadly rather than concentrating it only among the affluent or in urban areas that are easier to serve. The lower infrastructure costs of mobile networks, and the potential for wider coverage, may not radically improve social benefits unless public regulators impose additional conditions beyond those defined by the markets, and thus imposing greater de-concentration or re-distribution.

Telecommunications regulators have sometimes allowed "natural monopolies" in land line service, but are more concerned with creating or maintaining competition in the mobile phone sector. The higher level of competition in the sector required through anti-trust regulation appears to contribute to the push to provide service in smaller increments to lower-income consumers. The characteristics of the technology also contribute: the ease of installing capacity and the negligible incremental costs of serving additional consumers within a geographic area.

Anti-trust principles are also behind the distributive effects of open source software. Open source software breaks one source of monopoly created by proprietary software companies, namely, ownership of and secrecy around source code. Opening up source code creates small and medium-scale business opportunities for support firms and others that want to develop applications, and thus distributes business opportunity more broadly than the five software giants (four American and one German) would do on their own. At the same time, however, the requirement for a high level of complementary programming skills to be able to absorb and maintain open source software has led to the irony that large firms are more likely than small firms actually to use it – a negative distributional effect.

The other sets of public interventions identified in the cases are health, safety, and environmental regulations. The different locations where the technology is produced and where it is used often requires that the corresponding different local regulatory processes have to be complied with. Recombinant insulin needed to be approved by the U.S. FDA, then re-approved in other countries, in order to be available for use. GM maize likewise needed to be cleared for planting, under regulations that vary from full approval in the U.S. and Canada to limited approval in Europe to outright prohibition in Costa Rica and Mozambique. Farmers in the Czech Republic, our example country for GM maize in Europe, only find GM maize useful if they are in an area that where their crops are susceptible to the European Corn Borer. If they need to use the GM variety, they not only face the higher costs of the seed, but also the higher costs of meeting European regulations for planting, such as leaving open zones around their field to prevent cross-fertilization. Small farms on the edge financially are not as likely to be able to absorb these costs as larger operations. Similarly, the regulatory approval process raises production costs for drug manufacturers – costs that they pass on to consumers in the form of higher prices. Of course, what is at stake here is not the need for health and environmental regulation, nor its cost. The social, and not least economic, costs of bad regulation are certainly much higher. Nor is it the ability to use public interventions to affect social impacts, as this regulatory process does not result from local initiative. Simply, it is clear that additional barriers to the access to the benefits of new drugs emerge through the regulatory process, which limits the access to populations in the less developed countries to the benefits of those drugs. Aware of that, pharmaceutical firms do not consider these markets in their calculations of production costs, and in that sense the incremental costs of access by the less affluent justifies the availability of certain drugs, where the social costs of limited access are particularly high, at a much reduced cost, even in conditions that do not correspond to

the justification of compulsory licenses, under patent law. This falls into the issues discussed in section 6, reflecting the constrained ability of developing countries to implement the policies necessary for their socio-economic development.

Distributional consequences of emerging technologies

As discussed earlier, the classic model of distribution of access to emerging technologies based on price does not fully characterize the potential impacts of emerging technologies on inequality. The assessment of the distributional consequences of emerging technologies must consider not simply the diffusion of technologies themselves, but also the business opportunities which these create, the wider employment effects and the overall benefits of costs derived from the actual use of, not simply viewed in terms of access to, emerging technologies.

While the access to the emerging technologies by business and individual consumers would be expected to be decreasing with the economic condition of the country, it could be expected that certain business opportunities linked to these technologies may arise in a more distributed way throughout different countries. However, we found that due to the science base of the emerging technologies studied, in three out of five technologies a strong role for intellectual property limited the business opportunities. In the mobile case, a welter of IP holdings tends to be cross-licensed within the industry. As a consequence, the advantage of being a country that is home to a technology creator is seen in the role the Blackberry patents are playing in Canada in keeping some manufacturing there. The original patent on recombinant insulin was licensed to firms that are still the main competitors in the field, and Monsanto protects its intellectual property in GM maize with an aggressive legal campaign. In all these cases, IP protection has the tendency of concentrating assets and business opportunities.

In contrast, in two of the studies IP is either not important (tissue culture) or used to disperse the business opportunities (open source, which enforces open IP). In these two cases, however, there were other barriers to entry for new businesses. In the open source example, an individual or company must have a high level of technical skills to get into the business. Skills are also quite important in plant tissue culture, plus the significant capital investment already mentioned for a clean facility. IP is therefore not the only aspect of emerging technologies that tends to concentrate business activity rather than spreading it. Likewise, the cases reveal a number of other strategies that large firms are using to hold onto monopoly rents that have their IP at the core, such as Monsanto's acquisition of local seed companies and related services.

The picture is much different for the low and middle income countries in our study, Argentina, Costa Rica, Jamaica, and Mozambique. There emerging technologies comes appear most often in the hands of multi-national firms (plant tissue culture being an exception). The multinationals not only own the new technology, but can also buy up any local firms that might compete with them – as Eli Lilly Company bought out the Argentine interest in synthesized porcine insulin in the 1920s. Ownership gives control and is clearly accompanied by relations of unequal power.

Across these low and middle income countries of the study, there is significant variation in the extent to which local businesses grow up around the technologies. Argentina supports a lot, and Costa Rica supports local as well as multinational banana farms through its research facility. But a number of businesses we would have

expected did not appear in the data: no open source firms in Costa Rica, despite a significant software sector; no plant tissue culture business in Jamaica.

The science base of the emerging technologies also implies that micro-enterprise is an unlikely beneficiary of the new development, and in three out of five stories, this hypothesis is confirmed. Nevertheless, opportunities arise for small business, such as in the open source project, which undermines the concentrating effects of the proprietary software business. And in the mobile phone story, micro-enterprise is a prominent feature, from local businesses that sell minutes on cell phones to those who do not own them to the ubiquitous pre-paid card vendors in Mozambique. Both these examples involve micro-enterprises based on re-selling small quantities of a product produced by another company.

While IP ownership strongly shapes the control of business opportunities, the employment associated with our five technologies remains, equally surprisingly, largely located in the affluent countries in the study. These were high-skill jobs in the pharmaceutical industry, which are not numerous but well-paid. At the other end of the spectrum are the sales jobs associated with emerging technologies that are shaped to reach a mass or even bottom of the pyramid market. In some cases the new product does not produce new jobs, but is rather absorbed into an existing production process. New jobs in the new industries thus do not always displace older jobs, but may in fact retain them.

Thus, what is at stake is not only the creation of new employment opportunities, but also the extent to which new technologies create unemployment in the old technology sectors. The most obvious loss of jobs associated with the technological changes we studied were the losses in landline telephones. In the farm sector, although micro propagation as an expensive input tended to help small farms fold and larger farms grow, the larger farms were employing people in different kinds of jobs, so no clear downward trend in employment was visible. The employment issue associated with ownership was the unhappy circumstance that multi-national enterprises were able to move jobs into and also out of a national economy. This was obviously disruptive nationally and can contribute to unemployment and poverty. But from a global viewpoint, the practice probably has a dispersing rather than concentrating effect. And Malta has used attracting foreign direct investment as an employment-generating opportunity.

Nevertheless, no major shifts in employment were visible in any of our case studies. The shift that seemed most likely was the substitution of recombinant for porcine-based insulin that affected the production facility in Argentina; but local action prevented the plant from closing and a local market maintains it. The contrast with well-known cases like Korea and Thailand in which production of high-technology products has moved to developing countries is striking, and illustrates how limited those other experiences are, and how hard it is to generalize from them to other developing countries.

All the technological projects we studied provided benefits, so the diffusion of the technology itself is one important indicator of the distribution of those benefits. As expected, price is an important determinant of diffusion or penetration rate, but we were interested to find that it was definitely not the only one. Complementary assets can even turn benefits into risks and costs for emerging technologies. One example is recombinant insulin. Doctors in Mozambique do not always prescribe insulin in medical situations where doctors in Europe or the U.S. would, because their patients

are so poor that their lives cannot sustain the regimen of the treatment. Under the circumstances of these patients, insulin can actually be a life-threatening drug; the risks of taking it would be greater than the benefits.

Distributional Technology Assessment: Reflecting upon policy options

Each technology's history is different, making the findings complex. They illustrate both the benefits and limitations of distributional outcomes. All were conceived in pursuit of some general public benefit. One could not predict beforehand, based simply on the institutional context of discovery, which of the five would produce the broadest benefits. They all show, however, that public interventions throughout the process do make a difference, from commercialization environments to competition policies. Options are available to public decision makers for spreading the opportunities and benefits of emerging technologies more broadly.

Public interventions on emerging technologies can usefully incorporate three concepts that have been used across the ResIST project. On the one hand, policies should try to reduce the *representational inequalities* that now characterize high-technology decision processes. Different groups within society experience the same new technology differently. To maximize benefits, a variety of groups should have a chance to shape technology itself and advise on the way it is incorporated into society.

On the other hand, *structural inequalities* underlie all of our cases – gaps in capabilities that affect the absorptive capacity of various countries, that is, their ability to use the technology effectively, broadly, and on their own terms. Our cases reflect structural inequalities not only the lack of relevant scientists and engineers, but also differences in basic education and living conditions. Interesting, by looking one technology at a time, we have shown that countries do have the option develop pockets of expertise to increase absorptive capacity in relation to a particular, important technology. A new approach to STI policy strategies, as discussed in section 8, also suggests that reducing inequalities can start in the conception of technological projects themselves. Countries that find the technical characteristics and economic relationships of current technologies difficult or unworkable can apply their inventive capabilities to discovering versions that work in a broader range of circumstances, including theirs.

Finally, a broader consequence of this discussion is that public policy can, and should, reflect upon the impact of emerging technologies in *distributional* terms. Furthermore, it can consider which type of public interventions might be appropriate to enhance the distributional consequences, in the form of business opportunities, employment, social benefits and costs, of emerging technologies, without hindering private initiative or the consolidation of the technology.

This process can be developed collectively, along the process of development or of adoption of the technology, in much the same way that emerging technologies are assessed by formal bodies in Europe and other countries. Technology assessment (TA) has become institutionalised in countries such as Denmark, the Netherlands, the UK to reflect upon the social implications of new technologies. We propose that this process be specifically broadened with the view to consider the social implications of new technologies, both for the needs of countries in the Global South, as well as to the benefit of the less favoured groups in our societies. The organisation of technology

assessment varies in different countries. In some cases it is formally institutionalised, in other cases it is developed in ad-hoc forms. Sometimes it has a true deliberative power, while in others it only has an advisory role. These different social technologies are discussed elsewhere (e.g. Nunes, 2007).

Even if national contexts do frame the social impact of emerging technologies, it is clear that such process of distributional technology assessment (DTA) can be organised collectively to the benefit of the less developed countries, to contribute to the emergence of the appropriate complementary assets, where necessary, and to consider different forms of public intervention. As will be discussed in section 11, there is much to be gained in this process through the sharing of global expertise. Such DTA process ought to be firmly grounded on networks of existing expertise, or more specifically, as we propose in the following section, on a Science, Technology and Development Forum. The different forms of public intervention, if considered beneficial, should then be decided at the national level. It will be the mix of local actors, in the business sector as well as in communities and in households, the corresponding complementary assets in terms of capabilities and infrastructures, and the public interventions that will dictate the distributional consequences of the new technology.

Such DTA would be an excellent example in line with the implementation of the KEPP approach, proposed in section 8. As we saw above, if left solely to the market conditions, adoption of emerging technologies in less developed countries would be expected to benefit only through a trickle-down effect. Only after price starts to decrease would then these populations expect to be able to benefit from these technologies. We saw above that the cases did not fully correspond to the model and that distributional consequences depend on other factors. Such process of DTA can then consider such factors at a more upstream stage, and therefore contribute to improve the distributional impact of emerging technologies.

Clearly, there is no one-size-fits-all set of recommendations that can be made based on our analysis. National circumstances and political traditions differ but have in common the objective of spreading the benefits of emerging technologies more broadly. The real worlds of emerging technologies are diverse, but all carry within them the possibility of more equal outcomes for the world's households.

11. Building and responding to networks of expertise

ResIST seeks to throw light on and develop strategies to counter an obdurate social problem. Since it was clear that we see science and technology systems, policies and processes as embodying and reproducing the inequalities that constituted that problem, it was clear from the outset that we needed to engage with those undertaking and managing S&T. This was necessary in order to tap into their perspective on the distributional issues that were of key importance for study to have some sense of how social, economic and S&T goals related in their own policy systems and, later, to refine our research results through dialogue with them. In this way we hoped to improve the relevance, utility and take-up of what we did, but we also saw it as a reflexive act, in following our own concerns, by tying ResIST into an accountability structure (some of the ironies of how this worked out in practice will be seen below). This can be seen as our first, short-term objective – to 'establish effective links with policy and practice in the three selected representative geo-economic areas.'[1]

The dialogue with policymakers and practitioners became one element of our second objective, to build about the capacities that would be needed on a continuing basis, after ResIST, to support further academic and policy work on the issues we raised – establishing 'a basis for sustained mutual learning on issues, mechanisms and models.'[2] This second objective developed as the project progressed. Both objectives were in service of a wider aim 'of retaining focus on the overall objectives to support policy and practice which can support balanced growth.'[3]

This chapter sets out briefly our work and our thinking under the first objective, what we hope will be our legacy from ResIST under the second, and takes up suggestions from ResIST's work as to what further the European Commission could do in support of expertise networks.

Networks of expertise and ResIST's accountability

There were two planned strands of dialogue under this immediate objective. The first was intended to be with the Commission. We sought to contribute to the growing dialogue between DG Research and DG Development, and raised this early in the research, the proposal eventually taking the form of Commission representation on our advisory group. Furthermore, we made arrangements with the Commission's scientific officer for the project at the time that involvement of, and communication with, relevant people in DG Research and DG Development would be initiated. Unfortunately, with the officer in charge leaving the relevant department, we heard nothing after that. After some prodding from our side, the Commission, in a strict application of principal-agent theory, saw participation in the Advisory Group as a potential conflict of interest and declined. However, the participation of the project scientific officer, or of an officer from DG Development, in the World Regional Meetings organised by ResIST with the status of observer could not be considered conflicting. Both Commission and ResIST objectives of accompanying the

[1] ResIST Description of Work, p. 23.
[2] Ibidem.
[3] Ibidem.

development of the project and benefiting early on from its insights would have been achieved. In addition, extensive opportunities for sharing expertise in an enlarged network had been created. From the perspective of ResIST, all this suggests a lack of accountability of the Commission to engage with the research it was sponsoring and especially with the goal to build networks of expertise. One cannot expect policy makers and practitioners from outside the EU to be very interested in such networks if the EU itself is apparently not interested in them. This implies a potential loss of benefit to the research and to the EU's own policy making.

We note also that over the first three Framework programmes, in which there has been a social science component, the role of scientific officers seems to have shifted away from substantive participation towards more routine and low-level forms of accountability. We believe that policy relevant research like ours can benefit if this can be countered and measures put in place to allow the boundaries between researcher, funder and policymakers to be managed in a more sensitive way, resulting in richer interactions. As it happened, the potential of such interaction was only glimpsed at our final policy seminar in which staff of the Commission took a full active part.

The second strand of dialogue was with policymakers and practitioners in the selected geo-economic areas (Europe, Southern Africa, Latin America and the Caribbean). Initial dialogue at meetings in Maputo, Rio de Janeiro and Istanbul led to the formation of a ResIST Advisory Group whose members contributed to discussion in further meetings in Coimbra, Stellenbosch and Brussels. This was very fruitful, and what ResIST has achieved can be seen largely as co-production based in these exchanges. The Advisory Group had a strong influence on our consideration of National Innovation Systems as a general reference point for our policy proposals – see section 7 of this report – as well as providing detailed feedback on individual work packages. With others they also contributed substantially to the idea of the follow-up action-research studies to ResIST, and to our reconsidering the disciplinary inputs and perspectives that should shape our future offerings of expertise on these issues. These issues are taken up below.

Developing networks of expertise as future capacity for development: what ResIST has done to date

We have also sought to contribute to research which seeks to counter inequalities within or between nations. Entirely on the basis of links with policymakers and practitioners made in the course of our research, we are in the course of working on a proposal to develop and apply ResIST's approach in four specific world regional contexts where we have worked:

- In support of the Turkish Programme of Local Innovation Platforms;
- In developing and applying a Caribbean Regional Policy Framework for S&T and Sustainable Development;
- In supporting a Public Health Initiative in Mozambique;
- In delivering a North-South Collaboration on Women's Health between the UK and Uganda.

A project proposal is expected to be put to funders in the last quarter of 2009. If successful, we expect such work to make a policy contribution in a local context, as

well as making a methodological contribution in, for example, mapping and measuring the effects of different approaches to research development.

We also sought to re-think our contribution to expertise networks, despite ResIST already being a widely-based collaboration between sociologists, anthropologists, philosophers, economists and political scientists, whose work is broadly informed by the interdisciplinary enterprise, science and technology studies (STS). At the 2008 joint meeting in Rotterdam of two professional STS societies, the Society for Social Studies of Science (4S) and the European Association for the Study of Science and Technology (EASST), as well as presenting the work of ResIST over two sessions, Rob Hagendijk organised a Development, Globalisation and STS Roundtable to consolidate and broaden such interdisciplinary collaborations in the context for development. The Roundtable was notable for bringing together Development Studies scholars ('sensitive to local contexts, blackbox-ing technology') with those specialising in STS ('sensitive to technology, blackbox-ing local contexts'), so as to combine their strengths, and compensate for weaknesses in intellectual perspectives/expertise[4]. It led to the establishment in September 2008 of a STS, Globalisation and Development network with a website (http://st-and-dev.net) and a programme of activity drawing on a range of funding sources, including a workshop in Amsterdam in June 2009 on *Technoscience and the Transformation of the Global South.* It has been a specific goal of these initiatives to involve young researchers and practitioners from the South, who have the possibility of being central actors in this process. As this network develops we hope that it will contribute to a programme of meetings and researcher exchanges in and with the Global South that will help to strengthen the capacities for research and analysis there.

Developing networks of expertise as future capacity for development: how the European Union could help further

In our Second Review Report (deliverable #34), produced under WP0 but drawing on work across the project, four specific proposals are set out which are aimed at supporting policy and practice which uses S&T for broad social and economic inclusion, a process which the paper calls building a 'social knowledge economy'. The first of these is discussed in the context of helping to bridge S&T capacity gaps in Europe; the other three are oriented primarily to international development contexts, but all can contribute to both purposes. They are:

Establish a firm basis for the assessment of the outcomes of different forms of public participation in setting and delivering research priorities, either in their own right, or in contributing to the delivery of public goods or services; recognizing the diversity in needs and settings. Under its WP3, ResIST has produced some interesting and detailed case studies of public involvement in current issues of public and environmental health, as well as in priority selection, which showed active processes of citizen involvement, the benefit of using local knowledge and processes of capacity-building; new questions were raised in this context, namely in regard to the understanding of its impacts (not possible within the time frame of the study), and further studies are needed, which are able to follow through on the direct impacts of policies developed

[4] A notable collaboration of this kind has been established in the STEPS programme in the University of Sussex, bringing together researchers from two distinguished organisations, SPRU and the Institute of Development Studies.

under these participatory processes, and which contribute to a carefully framed assessment of their wider distributional impact, whether and under what conditions such participatory processes produce new knowledge, i.e. new forms of knowledge production and whether they aid its wider distribution, and take-up. This would include a qualitative stage to tease out all the issues involved, and a second stage of work to try and model and measure them.

Support knowledge remittances through the fostering of knowledge, business and investment networks between the knowledge diasporas in Europe and their originating countries in the developing world. Provided that there are strong research institutions to build on in the sending countries, WP2's work under ResIST has shown that policies to promote return and encourage 'knowledge remittances' home can be effective. Although much of the onus to create the environment for successful policies falls to the originating countries, the EU can support such efforts by appropriate formats for scientific and technological collaboration with the sources of scientific supply to Europe, organized on a regional basis, and building on specific suggestions for help, particularly in the contexts of INCO collaborations. Some African countries are already trying to make systematic links with their diasporas in Europe in mobilizing them to provide business advice and or invest in business start-ups. Again, the EU could think creatively about how it could support such initiatives. For example, the EU could support visits by researchers from the South working in the EU to their own countries, in the context of local training initiatives, participation in local research projects, or in advisory roles to the local research system.

Press for wider and fairer arrangements for knowledge ownership and contribute to a wider debate through support of a South-based Science, Technology and Development Forum. The work of both WP1and WP4 have illustrated that the intellectual property system needs serious attention if social cohesion and economic development goals are to be reconciled. This applies particularly, but not exclusively, to the Global South. Specific recommendations of these work packages are to provide stronger protection for diffusion of innovations that meet basic needs; provide mechanisms that protect collective or public goods; and incorporate flexibility to adapt systems to different levels of national economic development. These are all 'business as usual' proposals, extending the scope of what already exists, although they require the EU's trade, aid and research and innovation policies to be reconciled into a distinctively different, more social cohesion-based stance in international negotiations.

More fundamentally the EU and its development partners, including the beneficiary countries, need to grapple with thinking about how different forms of knowledge are recognized, assessed and rewarded. Three issues have emerged in the course of ResIST's research and discussions with local policymakers and practitioners:

- there was a strong requirement expressed at both our Maputo and Rio meetings about the need to get existing knowledge of science and technology out to the people who can find new ways to use it in solving their basic problems. Coupled with this was a sense that the use of the national innovation systems approach was diverting attention from pro-poor innovative developments, policy and practice;
- how indigenous and traditional knowledges, which represent different ontologies and epistemologies from 'international science', can feature as part of a national research and/or development portfolio? When such knowledge contributes to the development of new products and processes

which are traded, how should it be rewarded and what constitutes fairness in the distribution of those rewards (see the discussion of the hoodia case in the indigenous knowledge chapter of this report)?

- how mechanisms like Public-Private Partnerships, which as ResIST WP3 has shown can be organised to demarcate and stabilize the distribution of risks and opportunities between diverse partners in technology projects in development, can more systematically factor in what local policymakers and practitioners can bring to the table, in understanding local needs, in helping to put individual projects into the context of local and regional development objectives, and in maximizing local learning from the project.

These issues are often sensitive, and discussion of them engages embedded interests and can resonate with other debates about nationalism, modernism and colonialism. This sometimes impedes constructive discussion. We recommend the formation of an international *Science, Technology and Development Forum*, with experts from around the world, that would explore, investigate and assess the effects of technological and scientific change on culture and society in technologically less advanced societies and especially with respect to the effects of such changes on the livelihoods of poor people and groups disadvantaged in terms of any of the three forms of inequality ResIST discusses: structural, representative or distributional. The experience in European (and other) countries with technology assessment could be extended to include the effects on other societies. Such a Forum would best be led from the Global South but with active support, participation from and accountability for the EU. Such an initiative would facilitate the discussion of these issues and the development of a comparative knowledge base.

Develop a broader set of indicators of the social knowledge economy: the relationships between science, technology and innovation policies and social cohesion, applicable to states with diverging values and needs in development. The science, technology and innovation system needs to be characterised and tracked on a basis which reflects this wider set of social objectives which we propose it serves. Instruments that identify/assess institutional diversity; public engagement in S&T and the effects of processes aimed at inclusivity; and wider social indicators of health, education, environment, inequality and happiness should be amongst those developed. The EU can play an important role in stimulating the creation of a network of technology assessment capabilities to characterize and support the consequences, in particular the distributional consequences, of technological change in less and medium developed economies and non-Western cultures. This is a second task that could be pursued through the proposed Science, Technology and Development Forum.

It is through the development of networks of expertise of the kind proposed here that the capacity to develop a more reflexive and inclusive science and technology policy can be established.

12. Recommendations

Our studies confirm the idea that science and technology can be important instruments in the fight against inequalities in contemporary societies but that they are often not systematically harnessed to that type of goals as a matter of self-conscious and reflexive policies across the branches of national government and transnational agencies and organizations for development collaboration. The inequalities that characterise the process of emergence of innovations – structural, representational and distributional – can as much be reduced as well as exacerbated unless full consideration is taken of the diverse actors and institutions, their identities and ontologies, and if STI policies does much more explicitly include considerations of inequality among their objectives. So, the ResIST project has important implications for policies at the national and global levels in countries in the Global South as well as inside the EU. It also raises questions and shows the need for further reflection on how dominant policy frameworks often travel from the North to the South, i.e. are transplanted and copied without being sufficiently taking into account how conditions differ and how lofty intentions may be marginalized by local institutional political and bureaucratic dynamics and interests as they are perceived by particular local stakeholders.

Broad conceptions of innovation and the importance to help the poorer parts of a country and its population are often endorsed in policy documents. Yet, there is reason to ask whether subsequent STI policy implementation in practice do not often diverge too much from such goals and approaches. Our work suggests that a divergence sometimes is threatening the policy approach chosen en its goals in favour of a focus on advanced internationally visible science and high tech as well as ideas about economic growth and competiveness expected to be dependent on developing these sectors. We do not deny the potential importance of such issues, but we believe that a broader innovation approach and the struggle against inequality with the help of science would benefit from a much more explicit articulation of goals of social cohesion and participation. The development and exposition on the differences between what we called a knowledge economy paradigm (KEPP) and a social cohesion paradigm (SCoPP) bring out these differences.

The conclusions summarised here lead us to formulate the following central recommendations. More detailed recommendations and elaborations on what is argued below can be found in the reports on and of the workpackages (Volume II through # of this report)

Policy objectives

We are recommending that national governments consider more explicitly the articulation of broader goals for the innovation process (SCoPP) than is nowadays often the case (KEPP). Furthermore we recommend that such an articulation is accompanied by the development of procedural arrangements as well as the organization of information (indicators, statistics) that such a broad approach requires. In addition a rethinking is of the most adequate organization of government and its

supporting bureaucracy so that broad developmental innovation approaches are easier to carry through.

A broader set of STI indicators is needed that address the impact of S&T on inequalities and social cohesion, and on the factors that affect this process. Such indicators should incorporate wider social indicators addressing issues of impact (such as inequality, health, education, environment, happiness), as well as indicators that reflect the processes through which inequalities are limited, or reproduced. These include indicators related to institutional diversity, inclusive processes and their effects, diverse knowledge inputs, public engagement in S&T. Obviously these indicators should not replace existing ones, but should be added.

Accountability

The accountability of science and technology processes should be a more explicit concern of STI policies. Accountability should not just be framed in terms of what can be quantitatively measured with existing science indicators but also with respect to the overall goals and whether these are being achieved. Transparency of processes of STI policy and who is responsible should be at the heart of this. Yet, accountability of processes in itself does not guarantee outcomes – these still require scrutiny.

Forms of accountability based on direct public engagement should be privileged over indirect ones where such is feasible and potentially effective. Such forms may be combined with indicator-based forms of accountability where appropriate. Participatory procedures, which allow for bottom-up contributions must take into account that the move from consultative to deliberative modes carries the strong implication that the decision making process has binding powers i.e. that consultation is not yet another form of political marketing.

The organization of accountability as an ongoing concern should be built into arrangements and procedures in designing specific projects and programmes aimed at mobilizing science and technology against inequality. Accountability to target populations and groups and participants should be treated with at least the same priority and importance as accountability to donors and agencies. Recognizably independent expertise will be very important in processes and designs for accountability, but it should support participative accountability and not be a substitute for it.

At the international i.e. global level questions of development, governance, participation and accountability is essential for the needs of the South, as well as those of the North. In a globalizing knowledge economy, all countries are expected to develop. To juxtapose one part of the world as developing or underdeveloped against another part that is already developed, misses a key feature of the currently emerging multipolar and interdependent world.

The capacity to participate, deliberate and to give and ask for accountability does not emerge spontaneously; specific training procedures, such as the citizenship schools implemented in some experiences of participatory budgeting, should be organised to enhance citizen participation. However, there is a central paradox here, in that such training may frame issues, select issues and modes of contribution in a way that limits the extent of participation and the range of outcomes that can be achieved.

Traditional knowledge, property rights and accessibility of advanced technologies

STI policy should recognize the value of many kinds of knowledge and incorporate them into the innovation processes, specifically including traditional knowledge.

Traditional knowledge can be vital to innovation as well as challenging. We recommend not to equate innovation straightforward and exclusively with patentability. To do so would deny the wider importance of traditional knowledge and experience. It may contribute to development, inclusion and equality in many other ways than being accepted as knowledge on a par with standards of advanced scientific research. To search for the compatibility of such knowledge with scientific methodology and standards of proof should continue where appropriate and should be intensified, but the search for its uses should not be limited to that issue. The key question is how to bring together various forms of knowledge and experience into innovative activity. Patent regimes are secondary to this. The fact that it may take a long time to translate and develop traditional knowledge and practices into patents and new products for international markets may say more about patent regimes and market relations than about the value of traditional knowledge for innovation and development. The working of patent regimes should be reconsidered and adapted when they become a hindrance to such innovative developments, especially where the value to many exceeds the benefits it offers to a few.

More specifically, the intellectual property system should provide stronger protection for diffusion of innovations that meet basic needs; provide mechanisms that protect the public domain; and incorporate flexibility to adapt systems to different levels of national economic development. Intellectual property protection should be moderated so that it is not used to suppress business opportunities for local enterprises in developing countries or limit their access to essential goods.

Stressing the importance of traditional knowledge and other forms of experience and lay knowledge, should not be taken to suggest that access to state of the heart high tech in developing countries would be a secondary issue. We recommend to see the creation of pockets of highly-skilled workers as critical in giving developing countries local access to new technologies. The additional recommendation is, however, to pay as much attention to creating and maintaining such units as to adsorption of their understanding amongst those who are not a part of such 'pockets'.

Basic infrastructure and education are important investments in increasing the capacity of highly unequal countries to absorb and diffuse new technologies widely as well as harnessing traditional knowledge towards innovation. We recommend that such diverse forms of knowledge are both integrated into education on the bases of their respective pragmatic virtue and potential as befits learning innovation systems.

Migration

We recognise that efforts are under way in the EU to attempt to reconcile the tensions underlying policy in the field of Migration, Internationalization and Development. These policies have commonly been addressed through different policy fields and in different ways by sending and receiving countries – and this should be encouraged. The EU seeks to coordinate international cooperation in R&D throughout the Member States – again though migration policy remains fairly distinct from capacity building

policies. Since return and reintegration grants and international networking grants arguably help to support capacity building there is further scope to draw these policies together.

It is important to recognise the diversity of contexts in which migration occurs. Policy recommendations need to pay careful attention to national context: policies are rarely transferable in any direct or simplistic sense and may generate unintended consequences (backlash). Policy developed in areas distinct from science or migration, for example national employment policies, may generate important externality effects shaping the attractiveness of both sending and receiving regions and migration behaviour.

In a globalizing knowledge economy the development of economically advanced parts of the economy is associated closely with economically less developed regions. In such a situation it would be a tragic mistake to treat the latter one-sidedly as a resource for raw materials and highly skilled workers for one's own economic region. Attention for what we have coined 'knowledge remittances' as well as capacity building should be an integral part of making and assessing policies with respect to migration and high-skilled labour. The policy agenda with respect to immigration in the EU seems to be too much driven by needs and motivation that are somewhat separate from the discourse on developing less advanced economies and local capacity building. These agenda's should be drawn together at the level of actual policy design and this should be done on the basis of a joint agenda of stakeholders and governments in which both domains are represented.

Looking at the sending countries, it is important to address factors that impact on emigration. Scientific mobility is shaped by push factors as well as the attraction of receiving countries. It is important to address factors relating to research environments such as access to facilities and resources as well as adequate working conditions and sufficient remuneration. In the context of developing countries and specifically African institutions, institutional capacity (and the deinstitutionalisation of universities) continues to have a marked effect on emigration and vice versa. Any attempt to stem or reverse the loss of scientific expertise will fail if it does not also consider interventions and initiatives that restore and eventually make academic institutions sustainable research institutions.

Destination countries have a role to play in promoting return and contributing to capacity building within the donor countries. This study supports the view that effective return coupled with professional reintegration is seen by science professionals as the most important mechanism for knowledge transfer. However, prior to and in lieu of return, individual scientists often engage in knowledge exchange with colleagues and friends in the sending country. Such 'knowledge remittances' are generally individually motivated and directed. Moreover such knowledge exchanges occur in the context of international networks of resources involving sending, receiving and further countries. Innovative and flexible schemes supporting short term travel (such as 'Diaspora grants') encourage both return and continued professional links/knowledge transfer. Where established links exist between research teams in the sending and receiving countries, targeted capacity building will help to ensure that doctoral and professional exchanges do not result in knowledge and human resources being lost to the sending country.

Emerging technologies and effects on distributive and other inequalities

Emerging technologies have a particular potential to impact on different forms of inequalities, in particular on distributive inequalities. Still being consolidated, different actors can intervene more or less directly in the configurations under which emerging technologies take form, and the technological projects in which they are central. Public interventions can have here an important role.

Public interventions on emerging technologies can usefully incorporate two concepts that have been used across the ResIST project. On the one hand, policies should try to reduce the *representational inequalities* that now characterize high-technology decision processes. Different groups within society experience the same new technology differently. To maximize benefits, a variety of groups should have a chance to shape technology itself and advise on the way it is incorporated into society. On the other hand, *structural inequalities* underlie all of our cases – gaps in capabilities that affect the absorptive capacity of various countries, that is, their ability to use the technology effectively, broadly, and on their own terms. Our cases reflect structural inequalities not only the lack of relevant scientists and engineers, but also differences in basic education and living conditions. Interestingly, by looking one technology at a time, we have shown that countries do have the option to develop pockets of expertise to increase absorptive capacity in relation to a particular technology. The work on alternative STI strategies through SCoPP[1] also suggests that reducing inequalities can start in the conception of technological projects themselves. Countries that find the technical characteristics and economic relationships of current technologies difficult or unworkable should apply their inventive capabilities to discovering versions that work in a broader range of circumstances, including theirs.

Looking at different forms of distributional inequalities, intellectual property protection shows to be a key policy for shaping business opportunities for emerging technologies, both within countries and in global economic relationships. Our results suggest that a broader range of economic actors will be able to develop the technology if patent and copyright protection are limited to their original purpose, providing a temporary monopoly, rather than being a strategic resource for large corporations to extend the monopoly. The more licensing is required for publicly-discovered techniques, and the more techniques that can be put in the public domain, the more organizations will develop them and the more uses will be invented. This diversity is the most powerful tool for spreading the benefits of emerging technologies broadly.

Our cases suggest that the new technologies are most likely to shift jobs from one category to another, demanding somewhat higher skills, rather than to cause wholesale unemployment. These results provide a cautionary note to counter the claims in developed countries that new technologies will generate enormous numbers of new jobs.

The uneven distribution of the costs of new technologies certainly features in our results, mostly in financial terms rather than in terms of health and safety risks. Our results suggest that policymakers should be vigilant about uneven distributions of costs. Regulators have a particular responsibility to spread costs and prices fairly.

[1] Cozzens, Kallerud, and Santos Pereira, "Science, Technology, and Innovation Policy for Social Cohesion", in preparation

When emerging technologies produce major improvements that can be provided at low cost to large numbers of people it is important for public policy to seek to create the conditions for benefits to spread. Sometimes that may be public procurement, as in health service provision of recombinant insulin. But the issue may also loop back to the discussion of business opportunities. Government can use competition to bring down prices and extend markets.

In summary, the real worlds of emerging technologies are diverse, but all carry within them the possibility of more equal outcomes for the world's households.