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Science, Technology and Development: Questioning the Technological Innovation through Biotechnology Cotton in Burkina Faso

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Abstract

The introduction of Bt cotton into the agricultural system in Burkina Faso has resulted in the devaluation of traditional knowledge and indigenous science, with the consequence of displacing the control of the ST-System of cotton by national actors (research, farmers, state) in favour of the interests and control of a private foreign actor (Monsanto), which has acted to maximise its economic gain at the expense of a large number of small farmers and the national agricultural research system. This finding challenges the new knowledge-centred development paradigm's optimistic and abstract view about the role of science and technology in development. Specifically, the validity of the claim that science and technological interventions will per se generate socio-economic development is not sustained. The ST-System approach in addition to the Techno-Economic Networks (TENs) were used in order to evaluate the role of science in development. The paper demonstrates that the debate on transfer or internal development of technology in developing countries should not overshadow an understanding of the forms of political control (both domestically and

internationally) that science and technology bring with them. Scientific and technological progress is not necessarily a panacea for development problems and in some cases may deepen poverty.

Keywords: Innovation, Biotechnology, Development, Burkina Faso

Introduction:

It has been usual, and indeed it still is not unusual, to speak of three co-ordinate "factors of production": land, labor, and capital. The reason for this threefold scheme of factors in production is that there have been three recognized classes of income: rent, wages, and profits; and it has been assumed that whatever yields an income is a productive factor. This scheme has come down from the eighteenth century… Seen in the light of later events this threefold plan of coordinate factors in production is notable for what it omits. It assigns no productive effect to the industrial arts… The unexampled advance of technology during the past one hundred and fifty years has now begun to call attention to its omission from the threefold plan of productive factors handed down from that earlier time. (Veblen 1921:19)

The aim of this paper is to investigate the empirical validity of the knowledge-centred development paradigm as it is implemented in the specific case of Burkina Faso and in developing countries in general. What appears as a nascent phenomenon in the 1920s in Veblen's observation, above, is now established? Scientific and technological knowledge, 'the industrial art' as Veblen (1921) termed it, is now part of the original threefold plan as a factor of production. The knowledge-centred development paradigm is celebrated by economists as the 'new consensus', in reference to the 'Washington consensuses about the market paradigm, while for the World Bank 'Poor countries—and poor people—differ from rich ones not only because they have less capital but because they have less knowledge' (World Bank 1999:1). The displacement is clear enough! However, there is a new omission. In the same way the 'market' was abstractly presented as the solution to development problems, science and technology appear in academic literature and policy documents as if they have some intrinsic attributes to improve the well-being of populations of developing countries regardless of the social contexts of their production and use (World Bank, 1989; 1993).

This paper sets out to challenge this abstract view. Based on a case study on Biotechnology cotton, this paper argues that the introduction of Bt cotton into the agriculture system in Burkina Faso, has resulted in the devaluation of traditional knowledge and indigenous science, thereby displacing the control of national actors (research, farmers, state, civil society) over the ST-System of cotton in favour of private foreign actors and their allies, who use this control and maximise their economic gain at the expense of large numbers of small farmers and the national agricultural research system, thus challenging the new knowledge-centred development paradigm's optimistic abstract view about the role of science and technology in development. In what follows I will first trace the emergence of the knowledge-centred development paradigm. Then I will highlight the state of the art on the role of science and technology in development.

Background to the Emergence of the Knowledge-Centre Development Paradigm

The knowledge-centre development paradigm is the third in the history of development thinking and practice (Cimoli et al. 2009; Rist 1997). The first was the institutionalist paradigm, which was later displaced by the market paradigm. The knowledge-centred paradigm is the latest in development thinking (Ibid).

The Institutionalist Paradigm

The institutionalist development paradigm dominated development policy between the 1950s and 1970s (Rapley, 1997). When the concept of 'development' entered international relations at the end of the 1940s it was on the basis of institutionalist economics that it was thought to be achieved. Constructed from European economic history, it posited that high labour mobility from traditional to non-traditional activities is the driver of growth, that science and technology are urban products, and that all urban production factors (physical and human) embody science and technology (Cimoli et al. 2009; Rist 1997). It follows that 'development' occurs when exportable goods and services of urban activities become dominant in all sectors of the economy (Tarp, 2002). As policy director, the role of the state is to establish collaboration between the public and private sectors to overcome information and coordination failures; to develop institutions to support investment in self-discovery and the diffusion of new activities in markets; to take a pragmatic approach to identifying binding constraints; to apply incentives and enforce sanctions for law breakers; to promote

transparent government procedures, accountability, and develop trade policies which expand markets and the demand for locally produced goods or services (World Bank, 1993; 1999; OECD, 1997; Cimoli et al. 2009). The nature of the economic agent seems irrelevant (but in practice the state is accorded an active role).

The theory found its most influential form in Rostow's stages of economic growth (Rostow 1960). According to Rostow "it is possible to identify all societies, in their economic dimensions, as lying within one of five categories: the traditional society, the preconditions for take-off, the take-off, the drive to maturity, and the age of high mass-consumption" (Rostow 1960:4). What is striking about this conceptualisation is its linearity, normativity, and the consideration of Western history as the standard of comparison for all other societies. Moreover, the main thing for him is the move from tradition to modernity, thus the association of his model with 'modernisation theory' (World Bank, 1993; 1999). As such, Rostow provided a recasting within the scientific framework and political framing of the Marshall Plan. The latter used the term 'underdeveloped' and naturalised it. From the Plan, the term 'underdevelopment' was associated with 'inadequate food', 'victims of disease', 'primitive and stagnant economic life', 'threat of poverty'. The Marshall Plan identifies 'economic growth' as the solution to these problems and 'scientific and technical knowledge' as the means to economic growth, as is clearly stated in the following: 'greater production is the key to prosperity and peace. And the key to greater production is a wider and more vigorous application of modern scientific and technical knowledge (Rostow 1960:72). The United States as a leader in that area and having a good standard of development would lead this through (with the help of any capable country). While development, of which Western society provides a concrete case, is something that can be brought about through purposive intervention, 'underdevelopment' appears by contrast to be natural. From the institutionalist perspective, indicators of development are the degree of diversification of the economy, the degree of urban activities in the economic structure, and the degree of satisfaction of 'basic needs', which was added to the first two indicators at the end of the 1970s (Raspley, 1997).

However, the above modernisation paradigm was challenged by another type of institutionalist approach called the 'dependency paradigm', which emerged at the end of the 1960s, Rist (1997) argues that 'If a paradigm may be defined as a set of hypotheses which for a time provide a research community with typical problems and solutions that can be applied to different situations, then the dependency school produced a perfect paradigm. Beyond individual variations were a body of concepts and a common theoretical perspective which

posed a radical challenge to the other dominant paradigm: that of modernization.' (Rist, 1997). In contrast to modernisation theory's abstract interpretation of economic development, dependency theory interprets 'development' and 'underdevelopment' as socially embedded and interrelated processes (Gaillard and Waast, 1993). In this respect, the dependency theory supports the idea that the economies of the countries of South are better understood within the international economic system. For example, according to this theory, colonisation destroyed social and economic features of countries under domination and blocked their natural evolution. In addition, market competition led to the formation of monopolies and free trade arrangements enabled monopolies to continue their expansion through the internationalisation of domestic markets. Dependency theorists thus 'concluded from their own observation that the international system, far from guaranteeing the South's prosperity, brought the effects of domination to bear upon it and locked it in dependence' (Rist 1997:109). The policy advised that countries of the South should opt out of the system by developing their industry, including appealing for foreign capital, form regional groups, encourage state intervention to control inequalities through land reforms and the redistribution of investment. In most cases this would require radical social change (e.g. revolution) (World bank, 1993). There has been little implementation of such policy recommendations, however as Rist (1997) has pointed out 'Such arguments greatly helped to reinsert the economic into the social-political order, so that it was no longer treated as an independent variable' (Rist 1997:118). What mattered in the institutional paradigm whether modernisation theory or dependency theory oriented, was structural transformation through diversification, rather than knowledge, which remains unspecified in the framework. Because knowledge was considered to be embodied in production factors (physical and human), high quality of knowledge was to be measured by the high return in non-traditional (modern/urban) activities (Dessai, 2009).

However, by the end of the 1970s, the modernisation paradigm did not result in the general prosperity promised. Instead developing countries continued to become increasingly poor, and within them only a small social category, representing the international capitalist branches and political elites, benefited from the wealth. It is in this context that a new development paradigm based on economic orthodoxy made a comeback, and dominated development discourse for almost three decades.

The Market Paradigm

The market paradigm dominated development discourse between the 1980s and 2000s. According to this paradigm, markets have the potential to generate their own internal

coordination (World Bank, 1999). For this reason, deliberate coordination of individual efforts is irrelevant and counterproductive because, competition provides opportunities to workers and producers and leads to high quality service (Ibid). Policy recommendations include the promotion of private investment in physical, human capital, new knowledge, competition – market entry and exit, free-trade, export and Foreign Development Investment would enable knowledge spill over (Rist, 1997). Domestic knowledge and technology sources are therefore unnecessary. Besides, states should focus on comparative advantage by specialising. And developing countries do not need to invest in advanced science and high technology, because free trade would enable their transfer from developed countries

Politically, the displacement of the problem of development from international negotiation, as required by the New International Order, to a humanitarian framework allows intervention by Western countries using political pressure to change political regimes that do not respect 'human rights' and economically, it opens new opportunities for the World Bank to intervene in countries' economies to promote growth. Even though, in its original statement, the World Bank accepted that the idea of 'basic needs' corresponds to humanitarian principles, method to achieve progress around meeting human needs and the aim of intervention was to achieve economic growth.

It is in this context of the growing influence of the South that the concept of 'human development' appears in a series of reports from the United Nations Development Programme (UNDP). According to UNDP 'the basic objective of human development is to enlarge the range of people's choices to make development more democratic and participatory (Rapley, 1997). These choices should include access to income and employment opportunities, education and health, and a clean and safe physical environment (Tarp, 2002). Each individual should also have the opportunity to participate fully in community decisions and to enjoy human, economic and political freedoms' (UNDP 1991:10). This definition provides a broader framework as it takes into account income, in the two respects of total income and its distribution, life expectancy, level of education and human liberty. In addition, there is a complementary evaluation framework based on the provision of national budgets and foreign aid for setting basic priority sectors (basic education, health, social security, water supply). Considering income, a means rather than an end, this conceptual 'revolution' aimed 'to break out of the economistic rut and to define the 'development performance' of the countries of the South in a different way' that was 'no longer equating per capita income with overall excellence' (Rist 1997:206).

Essentially this conceptual shift owes much to the influence of a competing development paradigm commonly called ‘dependency theory’. At the beginning of the 1990s the concept of development had become almost uncontested as it managed through the past decades of debate to integrate a wider view, so that in addition to being universal ‘development’ was becoming more and more trans-cultural. This is observable in the scope of indicators of measurement, which then include productivity growth rate, human rights (early 1980s), environmental protection (late 1980s), development as self-reliance, and human development (in 1990s). With the market paradigm, the role of knowledge is unspecified, on the assumption it will spread through free trade, although knowledge was entering institutions such as the World Bank as a commodity to be sold to developing countries through advice on development techniques. However, by the end of the1990s, the situation of poverty remained. Here is how the winner of the Nobel Prize for Economics, Joseph Stiglitz and his collaborators announced, in their book, the crisis of the growth paradigm: ‘We began this book with the inevitable reference to the ‘Washington Consensus’ and the damage done by the almost religious implementation of such an extremist version of economic orthodoxy. The times of the ‘Consensus’ are over, buried by the weight of its economic failures, in addition to its massive social disruptions’ (Cimoli, et al.2009:557). A niche was opened for a new paradigm.

The Emergence of the Knowledge-Centred Development Paradigm

The wearing out of the orgy of ‘market fanaticism’ because of its failure has given way to a new consensus, that Stiglitz and his collaborators called the ‘knowledge-centred development agenda’ (Cimoli, et al. 2009:557). The World Bank in its first report at the beginning of the millennium acknowledged that ‘Poor countries and poor people—differ from rich ones not only because they have less capital but because they have less knowledge’ (World Bank 1999:2). ‘Knowledge’ has taken over the place of ‘capital’ as a production factor. The knowledge-centred development paradigm conceives of ‘development as a process that links micro learning dynamics, economy-wide accumulation of technological capabilities, and industrial development. Different knowledge and different national ‘political economies’, of course yield different patterns of industrialization. However, it happens that all the countries which are nowadays developed undertook relatively high degrees of intervention to support their accumulation of technological capabilities and the transformation of their organizations of production especially in the early period of industrialization’ (Cimoli, et al.2009:543).

Slowly taking-off from the start of the millennium, its establishment as a dominant discourse on development was prompted by the economic crisis of 2008 (Cimoli, et al.2009)). Of course, the recognition of the role of knowledge in the economy is as old as economics. Smith (1776), List (1841), and Schumpter (1934; 1939; 1943) all addressed this basic problem.

Similarly, the 'development age' was opened with the feeling of duty to 'embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas' (Rist 1997:71). The institutionalist paradigm which was developed particularly by Rostow made technological progress a key in the diversification and specialisation of economic sectors. Even the dependency paradigm embraced by a large number of countries of the South were attempting to de-link from international systems in order to benefit more from the science and technology that they expected would result from a package of endogenous policy strategies. The UNESCO information policy in the early 1990s provided a framework for these initiatives; the end of the 1970s to the end of the 1980s saw the development of the first science and technology policies and the erection of higher education institutions in many countries in the South and in Africa in particular. However, for the institutionalist paradigm developed earlier in this chapter, 'the role of learning (how to discover, how to identify opportunities and constraints, etc.) and the product space literature highlight the role of capabilities in defining the direction of diversification. They fail to address the process of learning and the link between structural transformation and accumulation of capabilities. Learning itself and the evolution of capabilities remain in a black box.' (Nübler 2011:7). In other words, 'The thrust of institutional economics in the catching up debate is on the productivity-enhancing role of structural transformation (Ibid). Catching up is defined as a process of diversification into higher productivity and value-added activities, and of enhancing the complexity of economic structures and sophistication of the production and export structure' (Nübler 2011:5).

In 1990 African states developed their own strategic plans, with the support of the UNESCO full-fledged program which terminated in 1994. The strategic position of the World Bank enabled it to shape the initiative according, once again, to the market paradigm, with the result of prescribing for states a program of internal reorganisation aiming to boost African countries' economic development (Nübler 2011:5). This was consistent with the structural adjustment policy, which prescribed liberalisation and squeezed the role of the state and social sector including higher education.

The emergence of Burkina Faso Scientific Research

For the first time the Burkinabe government in the 1990s defined strategic lines of scientific research which enumerated the country's development sectors (1) more independence in doing and organising research; 2) the linking of all research programmes to social and contextual realities and needs; and 3) the linking of research activities to productivity. The five-year strategic plan for scientific research in Burkina Faso set out in 1995 to: 1) actualise the potential of research to contribute to the country's development; and 2) make the main research centre (CNRST) a tool and means to promote and coordinate research in order to realise the State's objectives (CNRST, 1994; 1995). It was considered that research should contribute to solving local and immediate economic and social problems, and that external financial support, although cost ely remained very necessary. However, the World Bank kept a hold on the training of technical staff for government, and training for private actors, while building its own knowledge bank, anticipating or implementing a commercialisation policy of expertise in development techniques, which it considered would become the most important activity. The prospect of a knowledge economy emulates several debates towards the end of the 1990s, but it was particularly after the crisis that the paradigm found its opportunity. However, from the perspective of the market paradigm that dominated development discourse during this period, 'Growth models assume capabilities implicitly as "given" and to develop automatically. For example, by expecting the transfer of knowledge and technologies via trade and FDI to developing countries, these models assume equal capabilities across developing and industrialized countries to absorb technologies.

What is distinctive about the knowledge-centred development paradigm is that 'Learning is viewed as the essence of development and the major rationale for industrial policies is to facilitate and shape the learning process for a rapid accumulation of domestic capabilities' (Nübler 2011:9). It is particularly from the beginning of the millennium that this paradigm was increasing coming to the centre of the development agenda. A series of events have since been initiated in support of the new paradigm. The World Bank produced a report in 1998, *Knowledge for development,* in which it clearly recognised knowledge as a production factor and laid down a policy agenda for the international development community: 'Development institutions have three roles in reducing knowledge gaps: to provide international public goods, to act as intermediaries in the transfer of knowledge, and to manage the rapidly growing body of knowledge about development' (World Bank 1998/99:6). In the next year, UNESCO held a conference on *the Role of Science in the Twenty First Century, the New*

Commitment claiming that 'Science is a powerful means of understanding the world in which we live and it is also capable of yielding enormous returns that directly enhance socio-economic development and the quality of our lives'[1]. A policy agenda was also expected to come out from the conference, as the title suggests. This gave a framework for the institutional deployment of the paradigm in developing countries. For example, in Africa. NEPAD was established in 2001with the aim of creating new conditions for development in Africa. The African Ministerial Council on Science and Technology (AMCOST) was created. The AMCOST held its first meeting in Johannesburg, South Africa in November 2003 (The meeting emphasised that, as a matter of priority, all countries should have comprehensive national Science and Technology Innovation (STI) policies with emphasis on the development of effective National Systems of Innovation). In September 2005, another ministerial conference was held in Dakar and again in 2007. At the African Union Summit in January 2007 in Addis Ababa, all Heads of States affirmed their commitment through a Declaration on Science, Technology and Scientific Research for Development, stating that: "We, the Heads of States and Government of the African Union, recalling our millennium commitments to achieve sustainable development for our Continent, ...realizing that the achievement of these goals depends on our countries' abilities to harness science and technology for development and also an increased and sustained investment in science, technology and innovation, ...commit ourselves to promote and support research and innovation activities and the requisite human and institutional capacities" (UNESCO, 2007: 5-6). In January 2009, the OECD and UNESCO organised a joint workshop which was held on *Innovation for Development: Converting Knowledge to Value*, and called for science to be made central in the development agenda. In April 2009, an expert meeting, *Innovation out of Poverty*, was held, by the OECD Development Co-Operation Directorate. In Burkina Faso at the National level In December 2010, the National Forum on Scientific Research and Technological Innovation (FRSIT) organised a conference *on Partnership between Public, Private, Researchers, Inventors, on the use of Research Results in Africa.* Today the discourse is now institutionalised.

I believe that, as it has been and continues to be for other countries, scientific and technological knowledge can contribute to achieving development goals in Burkina Faso and in developing countries more generally. It could be said that it is even a regret that we had to wait until recently to see this international awareness about such a contribution. My

[1]http://www.unesco.org/science/wcs/eng/overview.htm

contention is that it is rather surprising that the debunking of the supposed autonomy of 'capital' as it was for the 'market' in the theory and practice of development has not featured in the recent debate about science and technology for development. Transfer of scientific knowledge is seldom discussed in debate on development without regard to the forms of political control (both domestically and internationally) that science and technology bring with them. However, as Dickson put it 'the more an individual becomes dependent on a commodity owned and controlled by others, the more vulnerable he or she becomes to the ends that others seek to achieve through that ownership. Science is no exception.' (Dickson 1988:4). When it is about developing countries, there is in the debate in academia as among policy-makers a kind of return to nineteenth century scientism and technological progressivism, despite the enormously rich store of existing knowledge in the empirical social science studies of science and technology, as well as the huge amount of accumulated critical literature on development from the social sciences. In other words, to paraphrase Dickson, with respect to developing countries, 'the increasing central *economic* importance of science gives it a *political* significance that is often lost in debates that focus on how it is applied to socially desirable or undesirable ends' (Dickson 1988:5). There is a need to challenge this trend in development thinking and practice if science and technological progress is to realise its full potential to contribute to public welfare in developing countries.

A Return to Scientism and Technological Progressivism

For Kleinman (2005: 3-4),

Scientism has a long and varied history. Roughly speaking it is the notion that there is an inherent divide between facts and values –that they are intrinsically different categories of phenomena… As a result, we accept that science and scientists are the best possible arbiters of controversy, clearing away the tangle of politics and opinion to reveal the unbiased truth...As for 'technological progressivism…this is an idea with roots in the Enlightenment, when progress became a synonym for the good and technology came to be viewed as a tool in all progressive projects.

It is surprising that, although STS developed as the result of theoretical and empirical challenge to these assumptions, and led debates, in developed countries, for consideration of the social-political character of science and technology, they came to approach similar realities in developing countries from the perspectives of nineteenth century epistemologists. The existing literature which tries to be critical of science and technology, and biotechnology in particular, in developing countries are mainly institutional (produced outside academia, for

NGOs, governments, civil society). In this institutional literature the social processes in the problematic of development appear more sharply when looking into the literature about the socio-economic benefits of biotechnology agriculture.

Indeed, while biotechnologies may provide benefits in the area of food security, there may also be negative effects stemming from the way in which they are applied. These could, for example, result from reductions in biodiversity and also through changes in the patterns of ownership of seeds. Reductions in biodiversity undermine long-term food security because they reduce the available alternatives to currently cultivated crops (Scoones 2006). The vast majority of GM plants and seeds are developed by private companies in the United States and Europe. Because of the costs of research and development these companies claim that it is necessary and justified to protect their, investment in their inventions through patents and other forms of intellectual property rights (Tripp, 2009). With respect to developing countries little attention has been paid to these issues. Indeed, with the increasing recent importance of science and technology in development strategy there has been a shift in the political agenda on development which placed emphasis on the knowledge economy, dating from the end of the 1990s (Ibid). The result of this shift in the political agenda has been to direct the STS literature in two main directions. First, it focused on topics related to the diagnosis of science and technology resources in developing countries which is of policy relevance as this literature contributed to policy making at global level, or justifying policy attention at local level (Chataway, 2005). Second, there was a focus on topics related to future prospects, that is to say on how or why promoting science and technology in developing countries can promote development. These two patterns in the literature are interrelated; as they make up the two key steps in the policy-making process (diagnosis of problem/resources and policy options). The literature on agriculture biotechnology in developing countries is therefore just a case of a common general pattern in the broader reflection on the role science and technology for development. This explains why much of the evidence on benefits related to biotechnology in developing countries is largely institutional, made up of reports, conferences and workshops documentations from proponent organisations and their experts. Even the evidence about the opposite effects comes from natural sciences' literature. The STS literature, which is dominantly pro-oriented, builds on the institutional evidence.

Some scholars have however contributed to the understanding of the role of science and technology in promoting the welfare of populations in developing countries (Chataway, 2005). They analyse the intersections of globalisation, technology and politics through a detailed

empirical examination of agricultural, but these can hardly be classed as STS literature. The STS literature on agriculture biotechnology in developing countries is rather heavily concerned with examining the process of introduction of biotechnology in these countries, its structural effects, looking at linkages between industry and university, diagnosis of science and technology resources, policy orientation on how to develop science and technology and the possible impact on development (Nightingale and Martin, 2004). Very few have explored issues regarding public understanding. This trend only holds for the broader global developing countries; with regard to Africa specifically, dynamic on science and technology for development only began around a decade ago. The STS literature on agricultural biotechnology and on science and technology in general, has so far been engaged in diagnosis and policy options without exploring what this means on the ground in terms of benefits. In doing so, STS scholars working on developing countries often neglected a large body of literature on development from other social sciences that could have expanded the scope of their questions and analyses.

The Neglect of a Large Body of Literature on Knowledge and Social Inequalities

The anthropological literature challenges STS approaches to the role of science and technology in development. In both subsistence and cash crop economy knowledge and technology are found to be interwoven with the relations of reproduction. The literature in agricultural anthropology is concerned with various topics, including subsistence agriculture, cash crop economy, industrialisation (green revolution), and what some had termed gene revolution (biotechnology agriculture). The subsistence economy is characterised by key general features. First, there is the nature of seeds used for cultivation. Although they had undergone various processes of domestication, they nevertheless remain close to their natural make-up. Second, there are the kinds of actors involved in agriculture. In subsistence economies, the low differentiation of the economy implies that with the exception of ethnic specialisation, production is commonly undertaken by all groups (Schwartz, 1993; Brasselle et al., 2002; Kaminski and Bambio, 2009; Kaminski et al., 2011; Kaminski and Thomas, 2011. Third, the division of labour reflects the social system (Malinowski, 1965; Bohannan, 1968). This system was mainly made up of familial networks of actors. As a result of that, the interactions between actors around indigenous cotton production were more limited in terms of diversity, and very stable. The users as well as the producers were within the same family and so shared cultural similarities. Indeed, in addition to the traditional way of growing cotton, the organisation and the processing were all distributed within the same family or kinship

group. The system was less open and less commercialised with very few actors involved (Schwartz, 1991; Isaacman and Roberts, 1995; Gray, 2008). Growing, spinning and weaving were done in the family in terms of producers and users of the artefact (indigenous cotton). Furthermore, the usage of indigenous cotton mainly centred on familial consumption (Schwartz, 1991; 1993). Therefore, the type of cotton, the organisation and its usage were bounded by family needs (Gray, 2008).

Anthropologists have been mainly concerned with the analysis of this system. Reproduction is a key aspect for understanding how the domestic economy operates. This kind of society is the only one which is both economic and social and which also manages the physical reproduction of human beings (Malinowski; 1965), and is characterised by particular agricultural knowledge and techniques, 2) specific form of land use, 3) use of human strength as the major source of energy in agriculture, and 4) individual means of agricultural production. The focus of the analysis is the social system. Although objects (knowledge and tools) are involved in the production processes, researchers' attention is directed to the systems of relationships within which these objects circulate. Similar approaches were used with respect to colonial agriculture. Colonisation was a complex set of processes and had a deep impact on African society's structures and foundations and as with any society Burkina Faso's traditional cotton growth structures reflect this process (Labouret, 1928; Schwartz, 1991; 1993). In fact, with colonisation came a new political regime with the aim of changing the subsistence economy to a market economy. This new social system was more open and mainly market based (Ibid). In African countries, the 1991 liberalisation which promoted the free market did not significantly change the production and agricultural systems (Gray, 2008). The development of the new states offered anthropologists material for examining the relationships between the state and capital. As in the traditional system, one can see the significant shaping effect of the social system which directs the distribution of benefit though in a context of improved knowledge and technology of production.

Similarly, the literature in agricultural economics challenges the decontextualized interpretation of the role science and technology for development. Some of the literature is convergent with the dependency theory This strand of the literature considers that the State should control and engage the population in development strategies (Zagre, 1994; Izard, 2003). It supports the view that contact with industrialised countries will increase production and integration if this is based on the promotion of mutual interests and the international organisations in charge of sharing knowledge and financial resources will allow developing

countries to modernise their economy (Amin 1981). However, it contends that outcomes of these processes are dependent on the degree of autonomy of developing countries, because too much subordination of developing countries to the international economic systems would constitute obstacles to development. In the broader Social Sciences literature, development studies and rural sociology show the implications of social systems in economic life (Herring 2007). On the one hand this treatment relates to modernisation assumptions and on the other it tends to reflect a more Marxist approach to the problems of under-development. With respect to modernisation assumptions, the regular occurrence of words (or ideas) about farmers 'resistance' or 'adoption' of techniques, can be seen to complement anthropological analyses already reviewed, as being the other extension of anthropological research. Here it is about the engineering social change (or development). The main aim of agricultural anthropology or of anthropology *tout court* was to provide solutions to the obstacles to the establishment of capitalist economies in the colonies (Juma, 2001; Kolawole, 2001; James, 2002). The interest in farmers' acceptance of or resistance to new agricultural practices reflected this economic and political context, although these kinds of studies did not end even after colonisation ended. There was an underlying cultural bias in this literature but its interpretations of users' responses clearly show cultural and political dimensions of technologies which were supposed to be neutral. These questions are almost absent from the STS literature on science and technology for development.

As can be seen, the analysis here is also regularly brought back to the social system, and is less about its material conditions; even in a changing situation due to changes in material conditions, the interests of the researcher are how a new social system will emerge to structure the material changes. Although the mechanisms change, the same obstructing processes are found in modern state systems which are reflected in colonial and postcolonial political systems. The review of literature on agricultural economics has shown that the common attribute of this literature about knowledge, technology and welfare in Developing Countries is its emphasis on the social system to explain the success or failure of agriculture practices aimed at improving the welfare of the concerned social groups under study. Researchers are aware that agricultural practices involve knowledge and technology and that these can evolve as the social context changes. Nevertheless, they consistently account for the combinations of these resources and their effects by the social system which is already in place**.** This is important for the purpose of this thesis, because the STS literature *paradoxically* stresses issues of knowledge and technology in relation to developing countries

virtually without regard to this aspect. As Cozzens (Cozzens, 2002:101) observed more than a decade ago 'the majority of the [the literature] has studied the process of innovation and not its outcomes. Traditional innovation studies still focus narrowly on making new things in new ways, rather than on whether the new things are necessary or desirable, let alone their consequences for jobs and ways'. Access to knowledge and technology, as that of the products resulting from their use, are however political, because both involve issues of social relationships and power, as it has always been the case any scarce resource.

Discussion and conclusion

Regarding the role of science in development, the STS literature has been engaged in relation to diagnosis and policy options. The contribution of this paper has been to provide empirical evidence from the implementation of an innovation in the agricultural sector in a developing country. This paper demonstrated that the debate on transfer or internal development of technology in developing countries should not overshadow the forms of political control (both domestically and internationally) that science and technology bring with them. Another theoretical contribution is that this paper investigates the social inequalities among actors of the system in relation to their pattern of control. The common attribute of the literature about knowledge, technology and welfare in Developing Countries is the emphasis on the social system to explain the success or failure of agriculture practices to improve the welfare of the particular social groups being studied. Researchers are aware that agricultural practices involve both knowledge and technology and that these can evolve as the social context changes. In addition, they consistently take account of the combinations of these resources and their effects on the social system in place**.** This is important for the purpose of this thesis, because, as will be seen in the next section, the STS literature paradoxically stresses issues of knowledge and technology in relation to developing countries virtually without regard to this aspect.

This chapter is organised into two main sections. The first section deals with knowledge and technology in subsistence and the cash crop economy in relation to the specific social system. The second section is concerned with knowledge and technology in colonial industrialisation and agricultural modernisation in relation to the social system of a capitalist economy.

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