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Standardisation Processes in China and the European Union Explained by Regional Innovation Systems\(^1\)

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Abstract

Standardisation processes and policies demand increased attention due to their contribution to enterprise competitiveness and relation to trade barriers. However, standardisation differs considerably per region. In order to investigate these differences in more detail, the standardisation processes for digital terrestrial television in China and the European Union are compared in terms of actors involved, their roles and relations, and the institutions governing standardisation processes. The structure and underlying dynamics of these regional innovation systems are analysed and compared. The analysis is based on a set of functions describing the underlying dynamics of both systems. For every step in the standardisation process, the influence of innovation functions, actors and institutions is listed and evaluated in detail. Based on the results major differences between standardisation processes in China and the European Union are identified. It further will be pointed out that these differences can be related to major differences in the institutional set up and dynamics of the related innovation systems.

Keywords: standardisation process, innovation system, innovation system functions

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1. Introduction

During the past decade the importance of standards has increased [Tassey, 2000]. One of the reasons for this is that many new technologies are systems or networks. Such technologies, as for example digital television, depend on standardisation for widespread adoption, as interface standards are needed in order to enable different components of the system to work together. The increased use of standards leads to a potentially large business market for a specific technology, and the payment of more royalties for the intellectual property rights (IPR) incorporated in the standard.

As a result of the growing economic importance of standards, policy attention for standards is increasing as well: In China the standardisation policy forms one of the pillars of the science and technology policy, and the domestically developed standards should help China to become an innovative knowledge-based economy. In the European Union simultaneously, standardisation has become an integral part of the policies to increase the competitiveness of enterprises and to remove barriers to trade. [Suttmeier & Yao, 2004; EC, 2004]

Literature suggests that standardisation processes are influenced by their wider environment [Czaya & Hesser, 2001]. Little attention has been paid to the exact definition of this wider environment, but scholars have argued that factors like legislation, administrative processes, technical possibilities and cultural traditions have to be taken into account. [Lehenkari & Miettinen, 2002] The concept of an innovation system [Freeman, 1987] encompasses all these aspects and will be used in this paper as the context in which standardisation processes develop.

To investigate the relation between standardisation processes and innovation systems a case study approach is used: the standardisation processes for digital terrestrial television in China and the European Unions are investigated and compared with one another and with the
respective innovation systems. These comparisons provide insight in the theoretical relations between standardisation processes and innovation systems. Accordingly, the central research question is:

- Can the differences in the standardisation processes for digital terrestrial television in China and the European Union be explained by differences in the innovation systems of the two regions?

2. Approach
In order to explain the structure of standardisation processes by the innovation systems in which they take place, first in the next two sections standardisation processes, innovation systems and the choices made in this research are briefly described.

2.1 Standardisation processes
Standards may arise in various ways. They can be explicitly negotiated in dedicated committees, or they can emerge from market-mediated processes. The first case is known as de jure standardisation, the second case as de facto standardisation. This article focuses on the first type. [David & Greenstein, 1990]

Standardisation processes can be analysed according to two approaches. The first approach is the functionalist view. This approach explains standardisation processes in terms of the (expected) technical efficiency and the economic benefit of the standard. The constructivist view contrarily explains standardisation processes as a product of political interests, cognitive resources and institutional constraints, in other words it sees standardisation as a social problem. [Feng, 2003] The approach used in this article is a subset of this second approach and is called actor-centred institutionalism.
As the name implies actor-centred institutionalism focuses on actors as well as institutions. As far as the actors are concerned the interest lies in which actors participate in the process and the roles they fulfil. Actors typically involved in standardisation processes are industries,
government, academia and users. In case of digital terrestrial television the users are the broadcasters. Institutions are defined here as ‘the system of rules that structure the course of action that a set of actors may choose’. This definition includes both formal legal rules and social norms. Examples in the standardisation process are participatory rules and decision-making rules. [Schmidt & Werle, 1998]

2.2 Digital Terrestrial Television
The process through which a television programme appears on a household television screen can be broken down into three steps. First, the production (filming) and processing of a programme take place in a television studio or on location. Then the pictures are transmitted by broadcasters via cable, satellite or terrestrial networks. Finally a television set in the household receives the signal and renders it in image form. A Digital Terrestrial Television (DTT) signal is received through an aerial connection by an antenna. The transmission standard determines how it is sent from the broadcaster to the households. The reception devices in these households have to be adapted to the transmission standard. [Grimme, 2001] The digital terrestrial broadcasting system consists of four steps that need to be defined in a standard: (1) multiplexing (combining audio and video in an organised manner), (2) transport formatting (randomise the data into a complete noise-like nature so that the channel space is used with maximum efficiency), (3) Forward Error Correction (FEC, add redundancy in order to recover errors after transmission), and (4) modulation (transform the data into sinusoidal waveforms for final transmission). These steps are performed at the receiver side in reverse order.

Standards for digital broadcasting are compatibility standards. Like any information good, television programmes are characterised by high development costs and nearly constant marginal costs. [Shapiro & Varian, 1998] Once the content of the programme is produced, the cost of multiplying and distributing it to more viewers is near zero, resulting in strongly declining average costs with increasing viewers. Hence, if the hardware (television technology) is standardised, the economies of scale are substantial. [Grimme, 2001]
DTT standardization is especially interesting for this study, not only because all actors are present: industries, government, academia and users, but also since the lessons learned from DTT standardisation can be generalized towards other technology-rich standards, including telecommunications, broadcast, ICT, telematics and telemedicine. In the generalisation of the results, non-technology information standards like test methods or variety-reducing standards like paper formats can not be included [Munden, 2004], [Swann, 2000]

2.2 Innovation systems

Innovation systems are used as frameworks to assess factors that influence the ability of a region or sector to create and supply technological knowledge for its economic advantage. The innovation systems analysed in this article are regionally delimited. For the standardisation processes we are interested in the way they are organised in specific regions rather than in specific technology fields, with the regions being China and the European Union. Hence, since our interest in standardisation processes is regionally based and we want to relate these standardisation processes to innovation systems, we should apply a regional approach for the innovation systems as well.

There are two approaches to analyse innovation systems: the structure approach and the function approach. The structure approach sees innovation systems as being composed of several building blocks that interact with one another. These building blocks consist of actors and/or institutions, which have different roles in the innovation system. [Fang et al., 2002] The function approach focuses on those activities, called functions, in the innovation system that result in technological change. More than one actor can perform functions, and actors can perform more than one function at a time. [Hekkert et al., 2005]

Both the structure and the function approach are used. The function approach is needed as the fulfilment of certain functions influences how the steps in the standardisation process are
performed (see section 2.3). The structure approach on the other hand can help to explain which actors are involved, how they are related and which institutions govern their behaviour in the standardisation process.

Hekkert et al. [2005] developed a set of functions consisting of ‘the creation of technological knowledge’, ‘the exchange of information through networks’, ‘articulation of demand’, ‘regulation and formation of markets’, ‘supply of resources for innovation’, ‘prioritising of public and private resources’, and ‘development of advocacy coalitions for processes of change’. So far these functions have mainly been used to study technological innovation systems. This article, however, uses them to describe regional innovation systems. Due to this new approach, some functions have to be interpreted different or are less appropriate.

The main difference concerns the interpretation of the function ‘formation and creation of markets’. The usual interpretation of this function focuses on the regulation that stimulates markets or that creates protected spaces for new technologies. Hence it focuses on the regulatory role of the government in relation to innovations. In this article however this function is interpreted more widely as to include the general role of the government in relation to all operations of industry and academia. This interpretation also includes the informal institutions guiding the relations between the government and the market, which also shape the behaviour and the opportunities of market actors and is derived from Amable, Barré and Boyer [1997] who labelled this function ‘relations between state and economy’. Due to the special importance of IPR for innovations as well as standards, this part of the regulation is given special attention to.

The regional approach also has consequences for the functions ‘articulation of demand’, ‘prioritising of public and private resources’ and ‘development of advocacy coalitions for processes of change’. These functions focus on specific technologies and cannot be easily described in general terms concerning all sectors of a region. Accordingly, these functions are not considered.
2.3 Framework

Now the concepts ‘standardisation processes’ and ‘innovation systems’ have been introduced, the (expected) relations between them are described. For this, the standardisation process is seen as being composed of several successive steps. It is argued that how each step is performed depends on a number of innovation system functions and the actors fulfilling these functions.

These relations are described below.

Initiative to develop a standard

The first step in the standardisation process is the initiative to develop a standard. This initiative is taken in response to observed real needs or can anticipate on expected future needs. If the need for a new standard is observed, action and initiative are taken to start a standardisation process. Different actors are then brought together in order to combine all the competences needed for the development of a standard, and the successive steps of the standardisation process are planned. Which actors possess these competences depends on the fulfilment of the innovation system function ‘relations between state and economy’, or more specifically, the relation between the government and respectively the universities and the industry: If a region is characterised by the stimulation of bottom-up initiatives of university and industry actors, these actors will have the authority and experience to start up technological projects like standardisation process; if on the other hand the region is characterised by strict top-down practices directed by the government, companies will largely lack these competences and the government is then more likely to be the driving force behind standardisation processes. Hence, it is expected that the first phase is shaped by the function ‘relations between state and economy’.

Formulation of requirements

The second step in the standardisation process is the formulation of requirements to which the final specifications of the standard should adhere. These requirements can include technical as well as commercial aspects. For the formulation of the commercial requirements interactions
between the final user and the developer of the standard are desirable. Users are generally the one with most practical knowledge and experience, and they are also most aware of market needs. Consequently, user participation in the formulation of the requirements helps to ensure the applicability of the standard.

These user-producer interactions are part of the innovation system function ‘exchange of information through networks’. For this reason, the fulfilment of this function determines how this step is performed.

*Development of technical specifications*

The third step of the standardisation process concerns the development of technical specifications. This step results in specifications that represent a technological state of advancement, meet market needs and are friendly in use. [Chochliouros & Spiliopoulou, 2003]

In order to get such specifications existing knowledge has to be combined and in many cases, additional research has to be carried out as well. For this, actors are required that have the necessary technological competences and that are willing to contribute their technologies and competences to the development of the standard. Furthermore, interaction with the market is needed to assure wide acceptance and applicability of the specifications. Whether this step is well performed, depends on the fulfilment of the following innovation system functions.

Whether the necessary actors are present in a specific innovation system depends on the fulfilment of the innovation system functions ‘creation of technological knowledge’ and ‘supply of resources for innovation’. The former function assesses the technological competences by looking at the output of knowledge and technology development activities; the latter focuses on the (human) resources available within the innovation system as a whole and within certain types of actors in particular. For the former function the amount and type of R&D in the total region as well as per sector are relevant indicators; for the latter function, the education level and the supply of researchers.
The mere presence of actors with technological competences is not sufficient; they have to be willing to actively participate and contribute to the development of the specifications as well. This depends between other things on the IPR policy of the standardisation process. If this policy is well accepted by technology developers, they will be willing to participate. If not there will be more reluctance to join the process. The IPR policy of the standardisation process will be influenced by the attitude towards IPR in the wider environment. Hence, the next relevant innovation system function relates to the function ‘relations between state and economy’, more in particular ‘IPR regulation’. Regarding IPR regulation it is important to know whether an acceptable well-enforced framework exists in the region.

Capable actors and a good IPR policy can lead to state-of-the-art technological specifications, but this does not guarantee large-scale adoption. For this, it is also important that the specifications are widely accepted, applicable and friendly in use. Involving various actors during the development of the technical specifications helps to make sure that ideas from different backgrounds are incorporated into the specifications. Furthermore involving actors offers mechanisms for alignment and feedback, which enhances the acceptance for and the usability of the standard. These interactions are addressed in the innovation system function ‘exchange of information through networks’ and concern linkages between universities and the market, and industry linkages for innovation.

As is argued above, the involvement of various actors can be beneficial for the acceptance of the resulting specifications. However, the involvement should be organised in such a way that all the involved stakeholders are heard and really contribute to the specifications. This is mainly determined by the decision-making rules in the standardisation process. Transparency and openness also contribute to the acceptance of the final specifications.

It is expected that the institutions governing the relations between state and economy and the transparency about them influence these institutions. This reflects a top-down versus a bottom-
up approach. In other words, these institutions will be shaped by the innovation system function 'relations between state and economy'.

An overview of the relations between steps in the standardisation process and innovation system functions is presented in table 1.

< Insert table 1 here >

To analyse the innovation systems a combination of the function approach and the structure approach is used. The selected innovation system functions are operationalised based on table 1 and on the indicators used in the European innovation scoreboard.

3. Results
In this part the results are presented. In section 3.1 the standardisation processes for digital terrestrial TV (DTT) in China and the European Union are analysed. This is followed by a description of the innovation system of the two regions in section 3.2. In section 3.3 these results are compared.

3.1 Standardisation processes for DTT
The standardisation processes for DTT in China and the European Union are dealt with in this section. For both regions first a general introduction to the standardisation system is given and then the structure of the standardisation process for DTT is described.

3.1.1 Standardisation process for DTT in China
Standardisation policy is one of the three major strategies of the Chinese government to improve China’s international competitiveness [Xue, 2005; MOST, 2002]. By pursuing its
standardisation strategy, China tries to fulfil various goals. In the first place China wants to reduce its royalty payments to overseas patent holders and improve its negotiation position during royalty negotiations. This will decrease China’s dependence on foreign know-how and foreign high-tech companies. Another goal is to lay a foundation for the future of China’s science and technology system and its technology industry. Other motives for China’s standardisation strategy include protection of the domestic market, national security and national pride. [Linden, 2004; Sigurdson, 2004] The standardisation of digital terrestrial television fits well within these goals.

The standard for digital terrestrial television is seen as a mandatory national standard. Chinese national standards are developed in a centralised administrative system combined with responsibilities of administrative departments and civil associations. [SAC, 2005] In 2001 the Standard Administration of China (SAC) was established under the Administration for Quality Supervision Inspection and Quarantine (AQSIQ). The tasks of SAC are between others to develop the Chinese standards agenda, to manage and coordinate the technical committees and to oversee the standard-setting activities of other government agencies. SAC has to approve all national standards. After SAC has approved a national standard, it is sent to the Standard Press of China (SPC). This is an organisation under AQSIQ and is the only publication centre in China that is allowed to publish national standards. [SAC, 2005; Xiao, 2004]

The technical committees and subcommittees under SAC are each focused on a specific technology or business area and have the task to draft national standards. In addition to the committees directly under SAC there are also technical committees and subcommittees under various ministries and departments of the State Council and under departments in provinces, autonomous regions and municipalities. [SAC, 2005; Suttmeyer & Yao, 2004]

An overview of this national standards system is given in figure 1.
Now the general background of standardisation processes in China has been described, the standardisation process for DTT will be explained. This process is dealt with step by step.

Initiative for standardisation process and formulation of user requirements
In China the central government took the initiative for the development of the standard for DTT in 1996 by appointing a team of universities and research institutes to develop a prototype. Shanghai Jiao Tong University (SJTU) led this team. It was expected that this would lead to a standard for DTT, but other institutes also proposed DTT system solutions. In December 1999 Tsinghua University proposed an alternative terrestrial transmission system, and more candidate plans were welcomed until May 2001.
Currently three proposals are left: DMB-T from Tsinghua University, ADTB-T from SJTU and TiMi from the Academy of Broadcasting Science. [Gao, 1999] There was no evidence found that (user) requirements have been formulated at the beginning of the process.

Development of specifications
Although there are different standard proposals, the structure of the groups that developed them is comparable. The academia played the main role in developing the specifications as they develop the technology. For the role of industry a distinction has to be made between Chinese companies and foreign companies. The different standard proposals were supported by a number of Chinese companies, but they only had a minor role in the process. Concerning the DMB-T proposal companies were initially not involved in the development of the technical specifications. Gradually however, several companies got some influence in the standard design. [Zheng, 2005; Commercial Weekly, 2004] Concerning the ADTB-T proposal the main role of the Chinese companies was testing proposed specifications and giving feedback on them.
Several foreign companies tried to be involved in the development of the specifications, but the government prohibited this. [Yip, 2005, Yun, 2005]

The government had a central role on the general level of the standardisation process as will be described later, but was not directly involved in the development of the specifications. The broadcasters at last were not involved in the developments of the specifications; nor have they tried to be. The broadcasters were approached later on when the standard proposals were ready for implementation. [Yun, 2005]

**Institutions**

For the DTT standardisation process no official participatory rules have been established. The major purpose of the standardisation process was to develop Chinese IP and to stimulate the development of China’s science and technology system and industry. As a consequence, the Chinese government welcomed proposals from Chinese universities, but did not allow foreign companies to participate.

The Chinese government represented by the State Planning Commission was in control over the various steps in the process and had the authority to make the final decision on the standard. The State Planning Commission decided when test rounds, amalgamation plans, etc. were arranged and who should carry them out. Other actors did not have any formal say in this. The government also funded the standardisation process, either directly via funds for standardisation purposes or via funds for science and technology programmes. [Chenyun, 2005]

There was little transparency in the standardisation process as steps were decided on ad hoc basis, and thus it was uncertain what and when the next step would be. [Yip, 2005; Peng, 2005] The lack of openness was further emphasised by its confidentiality.
The IPR policy had not been decided on yet at the time of writing; how the IPR will be managed and how the potential revenues will be distributed was still uncertain. Some reports indicate that the government would capture all the developed IPR. [Yun, 2005]

3.1.2 Standardisation process for DTT in Europe

In the year 2000 the European Council adopted the Lisbon Strategy. This Strategy is aimed at making the European Union the most competitive and dynamic economy in the world by 2010. Standardisation can help achieving this goal by pursuing the following objectives. [EC, 2004] The first policy objective of European standardisation is to play a role in the completion of the single internal market. A second objective is to constitute a tool for the advancement of European competitiveness and to allow for technological innovation. Another objective is to help attain goals of protecting the health, safety and environment of Europe’s citizens. Furthermore, European standardisation offers a way to promote self-regulation by interested stakeholders. [EUR OP, 2002; Vardakas, 2003]

The standard for digital terrestrial television is a European standard. The European Commission is the highest organisation involved in European standardisation and is in principle able to intervene in all European standardisation activities. [Grimme, 2001] In practice however, the role of the European Commission in standardisation processes is limited. There are three European standardisation organisations (ESOs) that have the authority to publish European standards: the European Committee for Standardisation (CEN), the European Committee for Electro-technical Standardisation (Cenelec) and the European Telecommunications Standardisation Institute (ETSI). Each of these organisations serves its own domain. The standardisation for digital television falls under ETSI. Collaboration between these ESOs is achieved via the Joint Presidents’ Group (JPG), which has the function to act as a forum of discussion for matters of common policy. [EUR OP, 2002]
All the standardisation organisations have their own technical committees and subcommittees, which in turn have their working groups. The drafting process might follow a mandate from the European Commission, but also Technical Committees and individual members of ESOs may come up with initial documents for standards. [Rothery, 1996]

Moreover, standard proposals may arise via organisations from outside the ESOs. These organisations may be feeder organisations with which the ESOs have close ties and which have the status of Associated Standards Body (ASB). These organisations must adhere to the criteria of open membership and voluntary standards application. For those organisations that do not conform to the ASB requirements, the Unique Acceptance Procedure (UAP) is available to deliver input. In this way grey *de facto* standards and standards from platforms and consortia can be formalised. [Egyedi, 1996]

An overview of this European standards system is shown in figure 2.

< Insert figure 2 here >

*Initiative for standardisation process*

The standardisation process for DTT in the European Union was a joint initiative of governments, manufacturers and broadcasters. Together they started the Digital Video Broadcasting (DVB) Project in 1993 that provided a forum for gathering all the major European television interests into one group, giving all stakeholders a fair say in the discussion. The DVB Project developed various standards for digital television under which the standard for digital terrestrial television. The DVB Project is composed of several boards, modules and working groups which are all open for all the different actor groups. [DVB, 2005]
**Formulation of requirements**

For the DTT standard, the commercial module set commercially based guidelines for the technical specifications that were later developed in the technical module. These commercial or user requirements were formulated from the point of view of the consumer, and were in principle technology-agnostic. By separating the commercial requirements from the technical ones, it could be objectively decided which technology fulfils the requirements best. [DVB, 2005; Luijt, 2005]

The broadcasters play the main role in this step, but the manufacturers also participate actively. This is not in the last place in order to influence the user requirements in such a way that requirements related to their own IPR are considered most important.

**Development of specifications**

The technical module translated the user requirements into technical solutions. During this development process there was ongoing contact between the commercial and technical module. [Porath, 2005] After the specifications had been developed, they had to be approved by the Steering Board, which then submitted them to the relevant standards body (ETSI). ETSI in turn turned the specifications into an official standard. [Bruin & Smits, 1999; Luijt, 2005]

The manufacturers were the most active group in the technical module, as they were the ones who came up with the technologies. The broadcasters were also well represented. But as they have generally speaking less technical know-how than manufacturers, their influence in the technical modules was in practice somewhat smaller. [Luijt, 2005; Porath, 2005]

The government had mainly an observer role. This can be understood as the European governments were more interested in the fact that a standard was developed within a certain timeframe and with the support of the various parties rather than in any specific technical specification of the standard. The universities at last had a minor role. Universities were allowed to join, but only few universities were actual members of the DVB Project. [Luijt, 2005]
The institutions of the DVB project were as follows. The government, manufacturers and broadcasters were together in control of the process. This process was characterised by openness, consensus and transparency. All interested parties were allowed to join, and the whole process is well-structured with predefined steps and procedures. Member fees financed the process and the IPR policy was accepted by all members. [DVB, 2005; Luijt, 2005]

3.2 Innovation Systems

This section describes the innovation systems of China and the European Union according to the functions and actors given in section 2.3.

3.2.1 Innovation System of China

China’s innovation system and its development should be seen in its historical context. Until 1978 China was a communist state purely based on the plan economy. Since then several reforms have taken place to gradually transform China to a socialist market economy in which the command economy coexists next to a market-based economy. These reforms continue today.

*Function 1 Creation of Technological Knowledge*

China’s R&D intensity, the percentage of its GDP that is spent on R&D, has sharply risen during the last couple of years with a percentage of 0.64% in 1997, to 1.01% in 2001 and 1.3% in 2003. With this level China’s R&D intensity is still lower than that of OECD countries, but it is relatively high compared with countries with similar living standards. [MOST, 2003; Hu & Jefferson, 2004]

China’s share of development in the total amount of R&D activities is however considerably higher than in most countries and goes mainly at the expense of basic research. This emphasis on development is also reflected in the number and types of patents that are granted to Chinese: this number remains low, and the patents they receive are mainly utility and design patents
representing incremental innovations and receiving weaker legal protection than inventions patents. [Wang et al., 2001; Hu & Jefferson, 2004]

A large share of China’s R&D is performed in universities and public research institutes. This is a consequence of China’s plan economy. Prior to the reforms organisations in China were subject to central policy and did not undertake more than one of the functions within the overall innovation system. Organisations had functional mandates for either research, or development, or manufacturing or distribution. Accordingly, most Chinese companies still have a poor ability in R&D: the R&D departments in nearly all manufacturing firms are primarily devoted to quality control and assurance activities. Only very few firms have made substantial and productive investments in internal R&D capabilities that enable them to develop new products and processes in-house. As a result, Chinese companies depend mainly on multinational corporations and to a lesser extend on universities for new technologies and innovations. [Hu & Jefferson, 2004; Sigurdson, 2004; Liu & White, 2002]

Function 2 Exchange of Information through Networks

During the plan economy era the central government did not only oversee the internal operations of research institutes and manufacturers, it also directed the transfer of research results between them.

Hence at the beginning of China’s transition to a market economy, its innovation system was split into isolated silos. [Liu & White, 2002; Tang, 2003; Linden, 2004]

Collaboration between universities and industries in China is currently increasing, but is still in an early phase and their level is considerably lower than in OECD countries. After two decades of economic reforms research institutes and manufacturers have not moved significantly beyond the functional boundaries established under the command economy. The barriers between the different parts of the innovation system still exist: the science and technology network and the industrial network are still somewhat misaligned. What universities and research institutes offer...
to enterprises is usually one-way technology, developed without the involvement of enterprises or users, and often not meeting business needs. Commercially interesting new technologies conversely are often industrialised in new companies affiliated to universities rather than offered to existing companies. This is partly the result of the absence of an effective intermediary system. In short, the number of cooperation projects for innovations between industry, universities and other partners is still low. [Motohashi & Yun, 2005]

*Function 3 Relations between state and economy*

Prior to the reforms the innovation system was strongly influenced by the decisions of the government. Since 1978 this structure has been changing step by step. This has led to changes in the relation between the government and other actors. [Michailova & Hutchings, 2004; Wang et al., 2001]

Throughout the 1990s the education and research system was reformed. Universities were given a legally independent status and were no longer primarily financed by the government. Simultaneously, government-owned research institutes were transformed into enterprises and stand-alone corporations and have been granted the rights to choose the R&D projects according to their business advantages. [Mu, 2002; Mu, 2004] Despite these reforms, Chinese academic leaders are still limited in their scope of decision-making and action, since they need to operate within a constrained political environment and respond to Party initiatives.

Since the beginning of the reforms many private enterprises have been established as the government has been working to clarify and improve the legal rights of private firms. However, the formulation of rights of private firms remains work in progress and state-owned enterprises and otherwise collectively owned firms still account for a dominant share in the economy. [Linden, 2004; Zedtwitz & Que, 2004; Sigurdson, 2004] Independent policy-making is still hard to realise for many enterprises and the government still heavily influences them. [Ji, 2004]
China’s accession to the WTO has played a major role in the opening up of the Chinese economy. The government’s control and the requirements for foreign enterprises are decreasing. In spite of this opening-up the Chinese government remains influential and differences in treatment between local and foreign firms continue to exist. [Prado, 2003]

*Function 4 Supply of Resources for Innovation*

Scientific literacy in China is very low. With only 5% of the whole population having received tertiary education, this figure is far lower than the average level in developed countries. This situation is changing however, now the enrolments in higher education are increasing rapidly. The fact that the number of engineers that China produces each year is four to five times that of the United States shows that improvements are being made. [Takahashi, 2003; Sigurdson, 2004]

The share of researchers in the total labour force is low in China. China has about 10 researchers (FTE) per 10 000 employees, while the average for the OECD is more than 60 researchers per 10 000 employees. In China half of the researchers are working in the industry, this is somewhat lower than the average share in the OECD. [OECD, 2003]

3.2.2 Innovation System of the European Union

In the mid-1980s competitiveness became an important goal of the European Union (EU). This steered the single market project and the establishment of a European Union level research policy. Later, in the 1990s the attention shifted from technology policy to innovation policy and the political willingness arose to generate an innovation-friendly institutional context at supra-national level. This could complement national efforts while stimulating cross-national dynamics appropriating the benefits of the economies of scale. Since then, the European innovation policy includes issues like intellectual property rights, information society, financing innovation and foresight exercises. [Borrás, 2002; Cordis, 2004]

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3 Europe’s innovation system is demarcated to the EU-15, thus to those countries that joined the European Union before May 2004.
Function 1 Creation of Technological Knowledge

The R&D intensity of the EU-15 declined during the 1990s from 1.92% in 1992 to 1.87% in 1997, but has been slowly increasing since then. With a current R&D intensity of 2.0% (2003), the European Union lags its main competitors the United States and Japan, but is clearly ahead of China. [Eurostat, 2004]

Typical for the types of R&D and patents in the European Union is the ‘European paradox’. This paradox describes the excellence and strength of the European Union in basic research, but the simultaneous failure to translate this in commercial excellence and success. [Soete & Weel, 1999; Caracostas & Muldur, 2001] This paradox is reflected in the relatively high share of R&D that is spent on basic research and relatively low share spent on experimental development. The relatively high share of high-technology patents in the total amount of patents is another sign of the European excellence in basic research. [OECD, 2003]

Function 2 Exchange of Information through Networks

The interaction between universities and the market is characterised by the European paradox: there is insufficient mutual appreciation of the opportunities that are offered by universities and industry, which lead to an unsatisfactory level and quality of collaborating activities. European universities often assume that education is a sufficient mechanism of diffusion of knowledge with the result that they often lack a clear strategy for other mechanisms of dissemination and transfer of knowledge. [Blythe et al., 2004]

In European companies internal sources are the most important source of information for innovation, closely followed by clients and customers: around 40% of the innovators named this last group as a very important source of information and as important partners in innovation cooperation projects. This implies that user involvement is common practice in Europe.
Universities and public research institutes, contrarily, ranked very low as important sources of information. [Eurostat, 2001]

**Function 3 Relations between state and economy**

In the European Union the patterns of political life are transforming. Gradually hierarchical forms of administration and government steering are becoming more heterarchical and networked forms of governance. The European Commission increasingly backs self-regulation. It sees self-regulation as an efficient, flexible and cost-effective alternative to regulation in many areas, achieving the same results without the delays of a time-consuming formal law-making process. [Borrás, 2002; Spiliopoulou & Chochliouros, 2003]

The remaining role of the European Union in relation to the industry is mainly one of gate keeping. The activities of the European Commission are focused on ensuring that competition in the internal market is not distorted in order to promote the competitiveness of the region as a whole.

Universities in the European Union are still very dependent on the state for their funding, as the current regulatory framework impedes large scale application of other sources of income. [EC, 2003]

The rights granted in intellectual property regulations of the European Union are strong in terms of granting exclusive rights to proprietors, but rather restrictive in terms of free public availability and diffusion of the information embodied in the rights. [Borrás, 2002]

**Function 4 Supply of Resources for Innovation**

Inhabitants of the European Union are relatively high educated. Of the total population in the age between 25 and 64 years old 65% has completed at least upper secondary education and 21.8% has also completed tertiary education. [Eurostat, 2004]
The number of researchers per employment in the European Union is with almost 60 researchers per 10 000 employees close to the average of the OECD. The share of researchers that is working in the industry is however considerably lower in the European Union than in its main competitors Japan and the United States. This is another sign of the European paradox. [OECD, 2003]

The results for the innovation systems of China and the European Union are summarised in table 2.

< Insert table 2 here >

3.3 Comparison of results standardisation processes and innovation systems

In this section the results of the analysis of the standardisation processes for digital terrestrial television are compared with those of the innovation systems of China and the European Union. Relating the differences in the various steps of the standardisation processes to specific innovation system functions does this.

Initiative for the standardisation process

The initiative to start the standardisation process, being the first step, was in China taken by the government while in the European Union by the manufacturers, broadcasters and government together. The difference can be explained by differences in the fulfilment of the innovation system function 'the relation between state and economy'. The large influence the Chinese government has over industry and university makes that these market actors lack the authority and competences to take the initiative for large projects such as the standardisation process for DTT. In the European Union conversely, the industry has much more autonomy and is
stimulated by the government to initiate such projects. Furthermore, self-regulation of interested stakeholders is promoted.

*Formulation of requirements*

The second step, the formulation of the requirements, is related to the innovation system function ‘exchange of information through networks’: the reason why this step has not taken place in China can be found in the fact that there is little awareness of the importance of the applicability of standards and innovations, and accordingly there are few interactions between industry and users and between universities and the market. In the European Union there is much more interaction between different actors and there is considerable awareness of the importance of applicability of innovations and standards. Consequently, the formulation of user requirements has been an important step in the process in Europe.

*Development of specifications*

Most differences are found in the step of the development of the specifications and concern the involved actors as well as the institutions. The differences in the actors involved in the standardisation processes and the roles they have can be explained by differences in the fulfilment of the innovation system functions ‘creation of technological knowledge’, ‘exchange of information through networks’ and ‘supply of resources for innovation’. In China relatively little R&D is done, it is focused on development and mainly performed by universities (function ‘creation of technological knowledge’). Companies have weak R&D capabilities and employ only few researchers (function ‘supply of human resources’). As a consequence universities have most technological competences, and hence are the ones that developed the technological specifications of the standard in China. The European Union conversely, has a higher R&D intensity and a considerably higher number of researchers per number of employees (function ‘creation of technological knowledge’ and function ‘supply of human resources’). The major share of the R&D is performed by the industry, which is also the main source of innovation. Universities on the other hand strongly focus on research rather than development, and pay little
attention to commercialisation. Consequently, the industry has been the pivot in the
development of the specifications in the European Union and universities only played a minor
role.

Although industry is the principal contributor of technology in the European process, firms
collaborate intensively with other actors: in the case of DTT most importantly with the
broadcasters. The broadcasters are the users of the standard, and as such, they could contribute
practical knowledge and ideas, and so enhance the applicability. This practice to involve users
in innovation projects is common in the European innovation system (function ‘exchange of
information through networks’). In China, contrarily, there is little interaction between different
parts of the innovation system, and especially between technology developers and users. This
lack of user involvement in the innovation system explains their absence in the standardisation
process for DTT.

Another difference between the two standardisation processes concerns the institutions, or more
precisely the general decision model, the IPR policy and the participatory rules. Differences in
these institutions can largely be explained by the innovation system function ‘relation between
state and economy’ and to a lesser extent by the function ‘exchange of information through
networks’.

In China the government has considerable control over processes in the innovation system: it
oversees activities and interactions and often has the exclusive authority to intervene. This top-
down structure controlled by the government is similar to the general decision model of the
standardisation process for DTT in China. In the European Union in contrast, the government
promotes self-regulation and bottom-up initiatives. This was also reflected in the decision model
in the standardisation process, as this was based on self-control and consensus. Hence, the
differences in decision model are related to the differences in the relation between the
government and the market (function ‘relations between state and economy’).
The (lack of) IPR policy in relation to the standardisation processes can also be explained by the innovation system function ‘relation between state and economy’. IPR regulations are still relatively new to China and there they are badly enforced. This reflects a lack of awareness of the importance of a good IPR framework, which is also the basis of the lack of an IPR policy in the Chinese standardisation process. In Europe, on the other hand, there is a great awareness of the importance of IPR regulation, which has led to an IPR framework that emphasises the rights of IPR-owners. This practice has resulted in the early formulation of an acceptable IPR policy in the standardisation process for DTT.

The differences in participatory rules can partly be explained by the innovation system functions ‘exchange of information through networks’ and ‘relations between state and economy’, and partly by the motives for standardisation. In China there is little practice to involve a wide range of actors in technological cooperation projects (function ‘exchange of information through networks’), and the government oversees interactions (function ‘relations between state and economy’). The government often treats foreign companies differently from local ones, and this enabled the government to do this in standardisation processes as well. The reason why the Chinese government excluded foreign companies from participation in the standardisation process should be sought in the motives for standardisation: the creation of Chinese IPR and at the stimulation of Chinese science and technology competences. In the European Union conversely, participation was open to all interested stakeholders. This reflects the wide range of actors commonly involved in innovation cooperation projects and the open attitude of the government.

The relations between the standardisation processes and innovation systems and their implications for China and the European Union are shown in table 3.

< Insert table 3 here >
4. Conclusions

4.1 Conclusion

Based on the comparison described in section 3.4, it can be stated that the differences in the standardisation process for digital terrestrial television in China and the European Union can be explained by the differences in the innovation systems of the two regions. The differences in the type of actors involved in the standardisation processes and in the roles they perform in the various steps reflect the differences regarding the fulfilment of the various innovation system functions. The same holds for the differences in institutions.

In more detail, the first step of the standardisation process, being the initiative to start the process, is related to the innovation system function ‘relations between state and economy’. The top-down structure in China’s innovation system made the government take the initiative for the standardisation process, while Europe’s bottom-up structure led to a joint initiative of various types of actors. The fulfilment of the second step, the formulation of requirements for the standard, can be explained by the fulfilment of the function ‘exchange of information through networks’. In China no requirements were formulated, as little awareness exists of the importance of the final applicability of standards and of the interactions between actors needed to achieve this. In the European Union contrarily, requirements were formulated as there is more awareness of the importance of the applicability of standards and there are more interactions between actors. The third step of the standardisation process, the development of specifications, is shaped by the innovation system functions ‘creation of technological knowledge’, ‘exchange of information through networks’, ‘relations between state and economy’ and ‘resources for innovation’. In China universities developed the specifications of the standard, as universities are the main source of new technologies in China, while only interacting to a limited extent with other actors and while being overseen by the government. In the European Union contrarily, the specifications were developed by the industry with participation of the final users, as the industry is the main source of innovation in Europe, typically making use of various types of
user and supplier linkages. The differences in the institutions at last can be explained by the function 'relation between state and economy': in China the institutions reflect the strong government control, while in the European Union the institutions contain the elements of self-regulation.

4.2 Further research
As the research project performed for this article was an exploratory study into the relations between standardisation processes and innovation systems, further research with more case studies is required to confirm the results. In further research the analysis needs to be extended to the relations between the adoption of the standard, which is the last step in the standardisation process, and innovation system functions.

This research project was also the first project that used innovation system functions for the analysis of (parts of) regional innovation systems. Due to this new scope of analysis some innovation system functions were interpreted slightly different or were not considered in the analysis. Further research is necessary to adjust the operationalisation of the innovation system functions to this different scope. Also additional innovation system functions might have to be developed to cover the whole scope of regional innovation systems.

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Soete, L. and Weel, B, ter, 1999. Innovation, knowledge creation and technology policy in Europe. Maastricht Economic Research Institute on Innovation and Technology, Maastricht University, Maastricht.


Table 1: Relations between standardisation processes and innovation system functions

<table>
<thead>
<tr>
<th>IS function</th>
<th>Phase</th>
<th>Initiative to start standardisation process</th>
<th>Formulation of requirements</th>
<th>Development of specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1 Creation of technological knowledge</td>
<td>- Amount of R&amp;D</td>
<td>- Types of R&amp;D</td>
<td>- Distribution of R&amp;D</td>
</tr>
<tr>
<td></td>
<td>F2 Exchange of information through networks</td>
<td>- University – market linkages</td>
<td>- Industry linkages for innovation</td>
<td>Relevant actors / relations</td>
</tr>
<tr>
<td></td>
<td>F3 Relations between state and economy</td>
<td>- Government – university relation</td>
<td>- Government – industry relation</td>
<td>- Transparency of policy and regulations</td>
</tr>
<tr>
<td></td>
<td>F4 Resources for innovation</td>
<td>- Education level</td>
<td>- Supply of researchers</td>
<td>Relevant actors</td>
</tr>
</tbody>
</table>

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Table 2: Comparison of the innovation systems of China and the European Union

<table>
<thead>
<tr>
<th>IS Region</th>
<th>IS Function</th>
<th>China</th>
<th>European Union – 15</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Function 1</strong></td>
<td><strong>Creation of technological knowledge</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R&amp;D intensity of 1.3% (2003)</td>
<td>Large emphasis on development, rather than on research</td>
<td>Relative large emphasis on research, rather than on development (especially at universities)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high share of total R&amp;D performed by research institutes and universities</td>
<td>Relatively high share of total R&amp;D is performed by universities, but overall industry’s share is higher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R&amp;D in companies focused on quality control rather than on development of new products</td>
<td>Internal R&amp;D in companies is main source of innovations</td>
</tr>
<tr>
<td></td>
<td><strong>Most important actors and relations</strong></td>
<td>Universities</td>
<td>Universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td><strong>Function 2</strong></td>
<td><strong>Exchange of information through networks</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>History of controlled isolated silos: little interaction overseen and directed by state</td>
<td>Companies depend on external sources for innovation</td>
<td>Little commercialisation of results university research: European paradox</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MNCs main source of new technologies</td>
<td>Companies depend mainly on internal sources for innovation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Universities main local source of new technologies</td>
<td>Users important source of information for innovation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Few collaborations for innovation development</td>
<td>One quarter of innovators involved in innovation cooperation projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No user involvement</td>
<td>Users and suppliers important innovation cooperation partners for industry</td>
</tr>
<tr>
<td></td>
<td><strong>Most important actors and relations</strong></td>
<td>Universities</td>
<td>Universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MNCs</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Few interactions</td>
<td>Industry – users relations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industry – suppliers relations</td>
</tr>
<tr>
<td></td>
<td><strong>Function 3</strong></td>
<td><strong>Relations between state and economy</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chinese government has large influence in operations of universities and enterprises</td>
<td>Main funding universities comes from enterprises</td>
<td>Autonomy of research projects in universities increases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Main funding universities still publicly or collectively owned</td>
<td>Main funding universities comes from government</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foreign companies subjected to</td>
<td>Enterprises operate within regulatory framework of government</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trend towards self-governance</td>
</tr>
<tr>
<td><strong>IPR framework</strong></td>
<td>special treatment</td>
<td>and bottom-up initiatives</td>
<td></td>
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<td>-------------------</td>
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</tr>
<tr>
<td></td>
<td>Lack of transparency and lack of rules</td>
<td>Transparency is promoted, but can still be improved; oversupply of rules</td>
<td></td>
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<tr>
<td></td>
<td>➔ Top-down structure</td>
<td>➔ Bottom-up structure</td>
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<tr>
<td></td>
<td>IPR regulations relatively new</td>
<td>Emphasis on individual proprietary rights rather than on social benefits of free access</td>
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<tr>
<td></td>
<td>IPR regulations badly enforced</td>
<td>IPR regulations relatively well enforced</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Most important actors and relations</strong></th>
<th>Government – university</th>
<th>Government – university</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Government – local industry</td>
<td>Government – industry</td>
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<tr>
<td></td>
<td>Government – foreign industry</td>
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<thead>
<tr>
<th><strong>Function 4</strong></th>
<th><strong>Supply of human resources</strong></th>
<th><strong>Most important actors and relations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5% of population have completed tertiary education</td>
<td>Industry</td>
</tr>
<tr>
<td></td>
<td>10 researchers per 10 000 employees, half of them in industry</td>
<td>Universities</td>
</tr>
<tr>
<td></td>
<td>21.8% of population have completed tertiary education</td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Close to 60 researchers per 10 000 employees, half of them in industry</td>
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</table>
### Table 3: Relations between standardisation processes and innovation systems

<table>
<thead>
<tr>
<th>IS function</th>
<th>Phase</th>
<th>Initiative to start standardisation process</th>
<th>Formulation of requirements</th>
<th>Development of specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F1 Creation of technological knowledge</strong></td>
<td>China</td>
<td></td>
<td>Efficient (use of) networks and inter-actor linkages are needed in order to enable learning by interacting and so enhance applicability and technological quality of specifications of a standard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>University</td>
<td></td>
<td>University mainly develops specifications</td>
<td></td>
</tr>
<tr>
<td><strong>F2 Exchange of information through networks</strong></td>
<td>China</td>
<td></td>
<td>Few university – market linkages Step does not take place</td>
<td>Industry – user linkages Step does take place</td>
</tr>
<tr>
<td></td>
<td>EU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industry</td>
<td></td>
<td>Industry - supplier linkages Limited participation</td>
<td></td>
</tr>
<tr>
<td><strong>F3 Relations between state and economy</strong></td>
<td>China</td>
<td></td>
<td>Institutions about the relations between government and market shape institutions about control and decision making in standardisation processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EU</td>
<td></td>
<td></td>
<td>Awareness of the importance of a good IPR framework is needed, for the establishment of an acceptable IPR policy in the standardisation process</td>
</tr>
</tbody>
</table>

- Amount of R&D
- Types of R&D
- Distribution of R&D

- University – market linkages
- Industry linkages for innovation

- Government – university relation
- Government – industry relation
- Transparency of policy and regulations
- IPR framework

- Few university – market linkages
- Limited participation

- Industry – user linkages

- Step does take place
<table>
<thead>
<tr>
<th><strong>Most important actors/relations &amp; implication</strong></th>
<th><strong>China</strong></th>
<th><strong>EU</strong></th>
<th><strong>Top-down relations:</strong> Government–university Government – industry ➔ Government is initiator</th>
<th><strong>Top-down relations:</strong> Government–university Government – industry ➔ Top-down decision model/large influence government ➔ Weak IPR policy</th>
<th><strong>Bottom-up relations:</strong> Government–university Government – industry ➔ Industry is initiator or joint initiatives</th>
<th><strong>Bottom-up relations:</strong> Government–university Government – industry ➔ Bottom-up decision model / small influence government ➔ Strong IPR policy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F4 Resources for innovation</strong></td>
<td>- Education level - Supply of researchers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Most important actors/relations &amp; implication</strong></td>
<td><strong>China</strong></td>
<td><strong>EU</strong></td>
<td></td>
<td></td>
<td>University ➔ University possesses main human resources</td>
<td>University &amp; Industry ➔ Both sectors possess relevant human resources</td>
</tr>
</tbody>
</table>
Figure 1: China’s national standardisation system
Figure 2: Europe’s standardisation system