China's Economic, Environmental and Social Development in Crossfire – Province-specific Analysis of China's Ecological Modernization and Sustainability

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ABSTRACT

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This study concentrated to examine ecological modernization process and sustainability of Chinese provinces. The examination focused on the differences between the westernmost and the easternmost China. Data of Chinese Statistical Yearbook was used during the years 2001–2010. Analyses were implemented with SPSS 20. and Excel 2010. Among general statistical analysis, Principal Component Analysis and a relatively new sustainability window analysis were carried out in this study.

The new sustainability method was used to determine the minimum (socially sustainable) and maximum (environmentally sustainable) economic growth level in certain socio-techno-economic production system. Among sustainability analysis of the provinces, other purpose of the study was to test the sustainability window assessment tool at provincial level (earlier applied at national comparisons).

Sustainability assessment was done for 25 provinces, which were located in the westernmost and the easternmost China. The sustainability assessment concentrated to study changes in socio-techno-economic production systems of each provinces. The method can produce three different outputs of analysed regions: socially and environmentally sustainable regions; only socially sustainable, but environmentally unsustainable regions; socially and environmentally unsustainable regions. The method aimed to examine ecological modernization process of provinces and this meant that three dimensions of sustainable development (economic, environmental, socio-cultural) were taken into account in the analyses. In practice, the analyses were implemented by using GDP as economic dimension, SO2 emissions to illustrate environmental dimension, and composite indicator of social well-being (consisted of private owned vehicles, employment and literacy) reflecting socio-cultural dimension of sustainable development. The composite indicator was built based on the analysis of the Principal Component Analysis.

Main results can be divided into three different categories: the easternmost provinces with sustainability window and actual economic growth in side of the window (totally sustainable regions), the easternmost provinces with sustainability window and economic growth outside of it (only socially sustainable regions), and the westernmost provinces without sustainability window (unsustainable regions). As a summary, the first group of division had relatively succeeded ecological modernization process and, their socio-techno-economic production systems were able to change into sustainable. In the second group, ecological modernization process succeeded to change tracks of socio-techno-economic production systems towards sustainable direction, but efficiency the systems weren't enough for sustainable economic growth. The third group of provinces had very inefficient socio-techno-economic production systems, and the whole structure of the system wasn't proper for sustainable economic growth.

Key words: China, Ecological Modernization, Sustainability Indicators, Sustainability

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1 INTRODUCTION

Economic development of China has been extremely fast during recent decades. As a whole, China's development has already contained huge multidimensional structural changes such as urbanization and transformation of economic structure (Lu, 2012, 23; The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 13).

The previous development trends have brought negative environmental impacts, such as serious air pollution and climate change within the borders of China and in outside world. However, the development has also brought both positive and negative social impacts. From the environmental point of view, two of the most attention received phenomenon has been SO2 and CO2 emissions, which are the second highest in the world. This is mainly a result of China's growth pattern, which is highly based on energy intensive industrial and usage of natural resources. **(**The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 13–14.)

Especially air pollution is causing serious environmental and health problems, which are mainly consequence of expanded heavy industry and proliferation of transport (Pope et al. 2007; Likens and Bormann, 1974). Despite the vast economic growth, approximately 10% per year, from the social viewpoint, a middle class has raised its head even though poverty is still a serious and concrete issue especially in the western part of China. Also consumption for unnecessary consumer goods has increased remarkably, which can be interpreted as improved level of average welfare. (Kallio, 2005, 80.) Equally the previous notice supports the fact that China's per capita income has reached the level of middle-income countries (World Bank database, 2009). This can be interpreted as positive social impact of China's economic growth. Some positive signs can also be detected in slight decrease of income inequality (The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 8).

Practically this unsustainable structure of society, which is causing vast environmental problems, requires improvements. Basically a repairing of such environmental problems in a large scale has been attempted to solve by following options: exploiting top-grade

technology developed by modern science, political decision-making such as legislation and environmental agendas. (Hajer, 1995.) On the other hand, it is important to remember that technology developed by humankind in the era of western industrialization has played an important role in generating the problems. (Beck, 1990, 223– 228; Volti, 2010, 13, 97–02.)

The largest challenges are linked to a dilemma of economic growth within unsustainable economic structure and its complicated relation with environmental problems and social well-being. (Mol & Spaargaren, 2000, 39). Usually non-environmentally friendly economic structure causes positive side-effects to socio-economic groups, as increased well-being. The same contradiction can be found from contemporary China. The dilemma is shown that unsustainable economic structure, mainly still based on heavy-industry, is far away from environmentally sustainable conditions, but partly the same economic structure has helped many people to get out of poverty and gain some standard of living within the greatest pace of economic growth. (Fang, Cote & Qin, 2007, 315–316.) Also reforms for greener development have opposite issues, when transformation towards environmentally friendly economic structure causes negative impacts on some socio-economic groups and regions in a short time period. This has been noticed in China as well. (The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 248–249.)

Because of the high pollution rates and increased pressure from outside world have awaked China concerning their unsustainable economic structure. Likewise, both economic growth and climax of industrialization occurred relatively late compared to western countries as well as environmental awakening. (Zhang, Mol & Sonnenfeld, 2007, 661–662.) Chinese increased concern about their environment and external pressure have led to more systematic environmental strategies and implementations (Bell, 2011, 25–32). Thereby principles of sustainable development have been taken to adopt, but slowly. Recently, political targets, such as Five Year Plans, have been giving more space for environmental goals. (Schreifels, Fu & Wilson, 2012, 780.)

The reasons mentioned above are creating a relevant base for sustainability analyses of China. Quite often sustainability analyses were implemented at nation-state level while

doing comparisons between sustainability levels at global scale (Talberth & Bohara, 2006, 744). China as an economic power and as a polluter is the world-famous phenomenon, which is more interesting to study as an own entity. What makes the China even more interesting in terms of research are following features: acreage of China, which is really wide consisting of several varying geological areas, and it is still divided very unequally economically, socially, and environmentally (Lu, 2012, 301–302). Another compelling point is that it can't be categorized clearly either to developing or to developed countries. Rather it can be seen reaching the development of the western world (The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 3). Nonetheless, according to UNDP Human Development Report (2003) the statistics are supporting the fact that China can still be accounted as developing country.

This package of features provides interesting basis to assess sustainability at province level. Equally this enables an opportunity to study the vast development gap between the west and the east China from sustainable development point of view. The purpose of this study is to review sustainability of China at province level by using a theory of ecological modernization as a frame of reference. In other words, an aim of the study is to examine ecological modernization process of China and to show differences what comes to the ecological modernization process between the westernmost and the easternmost provinces. Three selected case provinces are providing more accurate picture of the process and is showing the main differences between them. In turn, a concept of sustainable development was applied when building a methodological tool for assessing sustainability and ecological modernization process of China. The assessment attempts to take into account the economic, social, and environmental conditions unlike generally has been done by taking only one or two dimensions into account, such as Human Development Index has (UNDP, 1990).

Nowadays these issues are attempted to examine and solve in the frames of sustainable development, in multi-level scale. As a consequence, scientists including a number of other agents have developed many different indicators and frameworks to measure sustainability in different ways. When measuring sustainability, the greatest challenge has usually concerned how to examine inter-linkages of economic, social and environmental

dimensions. (Singh, Murty, Gupta, & Dikshit, 2008.) This study attempts to bring some fresh viewpoint into this field as well, by applying a novel Sustainability window analysis method, which takes into account all three dimensions mentioned above. A one interesting provincial sustainability assessment for China was carried out by Hara, Uwasu, Yabar and Zhang (2009) for the years 2001 and 2005, which however had different approach at some extent than this study.

Main research questions of this study are that how China is changing its track towards sustainable development, and what kind of differences there can be found both at the province level and at east side versus west side level. In addition, it is intended to dig into the dilemma of sustainable development, while measuring it. The Ecological modernization theory from the field of environmental sociology is used as a frame of reference in this study, and assessment is in line with idea of sustainable development.

The hypothesis for the study is that the easternmost provinces have reached sustainability level more successfully, when used sustainability window as an evaluating tool. In turn, large and inefficient provinces in the west side of China are not able to reach in the sustainable level in this hypothesis.

A topic of the master thesis was born while I was working at Finland Futures Research Centre in the CHEC-project (China and European Union in the context of global climate change: Analysis of changing economic structures and related policies). There were a great innovative group of experts who were developing interesting methodologies to assess sustainability. My idea was to apply one of these interesting dynamic methodological models and in my opinion master thesis was a great opportunity to try that.

The study comprises 5 chapters after the introduction part. The second chapter consists of historical overview concerning the formation of the ecological modernization theory among an outset of environmental sociology. Also key elements of the theory and its applicability together with the presentation of the concept of sustainable development will be presented. The chapter ends up with a linking the theory into China.

In turn, the third chapter presents shortly a purpose of the study and the main research questions that one is seeking answers via this study. The fourth chapter consists of data introduction and methods that were used in this study. The idea of the main methodological tool, Sustainability window, and its origins will be presented. Hereinafter, a necessary operationalization process for sustainability window analyses will be done.

The fifth chapter consists of the main results of this study, they are presented with support of tables, diagrams and map. The latter part of the chapter comprises three case provinces, which are selected with following reasoning: one province that has sustainability window and its economic growth has reached sustainable level in terms of the analysis method, the second province has sustainability window, but economic growth is not on sustainable level in terms of the used method. The final province is selected to illustrate the situation, when there is no existing sustainability window at all.

The sixth chapter is dealing with main conclusions of the study and discussion part. The conclusion part consists of review of results and assessing the suitability of the sustainability window as a tool to measure ecological modernization process and sustainability of regions. Finally there will be general discussion about the study and some suggestions for further study.

2 FROM THE ROOTS OF ECOLOGICAL MODERNIZATION IN THE BEGINNING OF CHANGED TRACK TOWARDS SUSTAINABLE DEVELOPMENT

In this review it is clear to proceed to the first environental awakening, which mainly elucidates the main insights of humankind what comes to increasing understanding of inter-linkages of nature and society. This approach allows a link deeper into the ecological modernization theory. Practical way to go further is defining main points of the sustainable development concept, which is used as a guiding structure of methodological part. This way is creating a good start to present the main sustainability indicators and their background. Finally all of the above can be linked into context of China.

2.1 Environmental sociology examining relationship between society and nature

The world has changed a lot since the 70's when already most of the western countries had faced a climax of industrialization process within scientific and technological development. However, this remarkable development raised new questions in a public debate concerning limited natural resources and air pollution. The modernization process itself has caused many negative side-effects to western world, and nowadays also to developing countries. On this basis society and environment cannot be viewed separately. (Dickens, 2004, 58–62.) Scientists in the field of environmental sociology have provided some interesting theories and approaches to explore inter-linkages of society and environment including consequences of the inter-linkages (Catton & Dunlap, 1978, 44).

In a broader perspective environmental sociology is a relatively new sub-discipline in sociology. Despite of that its significance in social sciences has grown towards the present day. According to Ylönen and Litmanen (2010) together with Dunlap and Michelson (2002) among many others a hegemonic status of natural sciences concerning environmental issues has been part of the reason for slow formation of environmental sociology.

Nowadays there has been well-established understanding that environment and society can't be viewed separately unlike many classical social theories suggested (Dickens, 2000, 58). The classical theories are not questioning the assumption that modernization process is built upon earth's limited natural resources. In other words, classical theories of sociology weren't able to see any contradiction between environmental problems and modernization process. (Ylönen & Litmanen, 2010, 51.) Regardless, some classical theorists, such as Engels for instance mentioned about negative consequences of modernization process for environment (Dickens, 2004, 67; Buttel, 2000b, 22–27). In contrast with the classical sociology, environmental sociology concentrates on society-environment relations at local, national and, global level. In addition, they are questioning many basic structures of industrialized capitalistic world (Spaargaren, Mol & Buttel, 2000, 2).

According to Spaargaren, Mol & Buttel (2000) there have been formulated three different schools of thought or rather approaches in the field of environmental sociology, which are simultaneously taking a stand on a debate of essence of modernity. The three schools of thoughts are formulated during the short history of environmental sociology: The Human ecology, The Risk Society and The Ecological Modernization. (Spaargaren, Mol & Buttel 2000, 4–6.) Noteworthy point is that environmental sociology is much more diverse field, than the previous categorization suggested. There can also be found other interesting approaches, such as built environment versus natural environment, environmental improvement or degradation, theoretical versus empirical, materialism versus idealism and paradigms versus theories (Dunlap, Michelson & Stalker, 2002, 17-24).

The Human ecology tradition can be seen as a starting impulse to emergence of environmental sociology and New Environmental Paradigm (Catton & Dunlap, 1978, 42-45; Spaargaren et al. 2000, 4). According to Buttel (2000b) in a sense all that can be seen as a basis for the Reflexice Modernization perspective, which includes at least two following theories: The risk society and The ecological modernization, because they also assume interconnection of environment and society as the Human ecology with its all forms suggested in the beginning. The Risk Society is laying on pessimistic assumptions that modernization process is creating new risks to humankind and environment. From this point of view technological development are not able to fix problems, but rather creating

new ones. In turn, the Ecological Modernization as a social theory provides a more optimistic approach compared to the previous ones. It sees technological change, and both national and local and nowadays also international environmental protection interventions combined with market forces, science and technology as potential solutions for environmental problems. (Buttel, 2000b, 20–24, 28–30; Dickens, 2004, 48–53.)

Formation of the theories introduced earlier, are highly linked to a changing character of thinking patterns in modern societies and especially in political field. This means that attitudes of societies towards environmental conditions have changed almost simultaneously during new theoretical approaches have appeared. (Spaargaren, 2000, 41.) Especially environmental non-governmental organizations, such as Greenpeace, were supporting a mindset of societies into more environmental friendly direction (Hajer, 1995, 277). Finally they succeeded to shift environmentalism as a part of government and hence upgrade environmental legislation and planning. (Mol, 2000, 138–139.) The first official event, when decision-makers adopted the idea in The United Nations Conference on the Human Environment, can be located in Stockholm in 1972. The main topic was based on the report Limits to Growth (1972), published by the Club of Rome, is based on systemic-theoretical research, which can be thought as a central base for contemporary computer modelling techniques. However, during that time it was completely a new method. (Meadows, 1972.) The report was emphasizing the point that world is a “biosphere” and interacting as a whole entity. It caused a spark in the discussion of intergenerational justice at first time. According to Hajer (1995, 25) characteristic of this period solutions of environmental problems were based on end-of-pipe technology.

After the beginning of the 80's, a way of thinking became even more environmental friendly by adopting an idea of sustainable development in the political field. There were a lot of debates of what really is sustainable development or environmental friendly, in general. As a result, The World Commission on Environment and Development (WCED) founded by the United Nations, published a report of Our Common Future (1987), which was creating conceptual foundations for environmental politics in the 90's. Also many countries from the western world published their own national environmental policy plans inspired by the report. (Hajer, 2010, 8–10.) A purpose of the commission is to examine a

relation of environment and development and seek solutions to achieve compatibility of these factors. WCED (1987) defined a concept of sustainable development as development that meets the need of present generation without risking the needs of future generations. To meet the need is totally dependent on the state of environment and hence requires environmental protection. (WCED, 1987, 41.)

A rise of the ecological crisis led to a new ecological consensus, which purpose was to implement global environmental governance. The UN Earth Summit in Rio de Janeiro in 1992 can be called as a turning point towards the consensus of sustainable development. Contrary what was expected, the meaning of sustainable development became even more unclear. At least one thing was clear, an increased fragmentation of environmental discourse simultaneously bringing up new questions and critiques. (Hajer, 1995, 1.) Even if the Brundtland's report published by WCED (1987) has defined a concept of sustainable development, there is still an ongoing debate how to measure it, and what does it practically mean. To find a solution to this the UN commission on Sustainable Development (CSD) within an implementation of Agenda 21 there was published a list of different kind of indicators, which are measuring sustainable development. (CSD, 2001.) By interpreting the preceding events, after the 80's there occurred a shift from classical environmental protection to a more comprehensive planning, which is based on environmental friendly economic growth, in other words, sustainable development. The history of environmental policy field including huge international political changes paved a way for the Ecological modernization theory.

2.2 From the abstract to practice: from the sustainable development to the ecological modernization

Before going any deeper to the ecological modernization theory, it is necessary to mention that ecological modernization can be categorized as a political program and a social theory. As a theory it refers to continuity and transformation (Mol, 1997, 140). As a socio-political program it tries to describe dilemmas between different institutions and actors in the

context of environmental issues. In turn, as a theory of social change it attempts to analyse processes of modernization and rationalization in the context of environmental issues, and later on in the context of sustainable development. (Spaargaren, 2000, 52–53.) Practically they are two different things, but they require each other in practice. (Mol, 1997, 140.) Rather can be stated that ecological modernization as a political program needs scientific evidence and expertise and on the other hand as a social theory it examines political decision-making and consequences of that (Hajer, 1995, 138–152, 160–174). As a theory and as a political program it supports the idea that economy can benefits from environmentalism. In other words,*"ecologizing of economy"* and "*economizing of ecology"*, as Huber (1982) noted, has achieved almost a hegemonic position in the political field, and in business world as well as in civil society. (Hajer, 1995, 261-263.)

The current view is that the Ecological Modernization as a social theory illustrates social and economic change into a more green thinking, and how environmental friendly development has intertwined into the economy on local, national, and international level. Therefore, the main idea is to analyse how industrialized countries are dealing with environmental crisis. (Mol & Sonnenfeld, 2000, 3.) According to Mol (1997) ecological modernization concept is mainly related to technological institutions, state interventions and market economy (Mol, 1997, 140).

A change in the mindset of societies can be called a modernization process, which has adopted ecological thinking inside of it. Practically this means that economic growth, industrial development, production and consumption patterns can be re-adapted in terms of environmental sustainability. (Mol, 1997, 141.) This sort of restructuring of society can be seen at some extent irreversible. Reasoning behind it is environmental productivity, which is imitating the idea of labour productivity for instance. The theory is based on the idea of a win-win situation for both economy and environment. This can be seen revealed by similar analogies such as environmental productivity versus economic productivity. (Spaargaren, 2000, 54–55.) Nowadays, it can be called as development, which pays attention to environment protection, social justice and economic effectiveness. It also comprises an idea of both process and product innovations such as clean technology. However,

transformation towards this requires market forces to bring those innovations in society and hence causing social and strcutural changes. (Mol, 1997, 140–141.)

Research Group for China Modernization Strategies (2007) has summed up very understandably some core elements of the ecological modernization, which are innovation, prevention and structural change. They also have categorized main points of the core elements sheltering the developers' ideas. The ecological restructuring of modern industrial society requires transformation of social practices and institutions by adopting environmental awareness. In addition, the modern technology is a key concrete mechanism behind the whole process, but these technological innovations are promoted by the governments and encouraged by the market economy. Also new international and national environmental agendas are seen playing a significant role with preventive and forward-looking policies. Specifically the preventive policies should be based on long-term structural changes including production and consumption modes, macroeconomic and technology structures. (Research Group for China Modernization Strategies, 2007.) Each approach can be categorized as macro-sociological theories, which is specialized in inter-linkages of environment and systemic changes.

The previous part broadly comprised the main idea of the theory, but despite of this there can be found several different variations of the theory including different emphasis. According to Buttel (2000a, 57) also many other actors outside of environmental sociology have adopted the theory or at least some features of it. There can be found at least three different ways of usage of the term in different contexts: sociological context, depicting environmental discourses of environmental policy and as a synonym for strategic environmental management via industrial ecology (Buttel, 2000a, 58–59).

Though there are some different emphases how to analyse transformations of societies in this frame of reference. Analytical approaches concerning the transformation of societies can be categorized in five clusters: first a changing role of science and technology as more preventive than fixing, second increasing significance of market dynamics referring to power to ecological restructuring, third transformation of nation-state into more flexible direction within co-operation with other such as local actors, fourth increased role of social

movements and changing discursive practices and fifth new ideologies including intergenerational solidarity to challenging the old counter-positioning of economic and environmental interests. (Mol & Sonnenfeld, 2000, 3–5.)

As earlier told, several versions of ecological modernization theory can be found. It may give a quite fragmented picture of the wholeness, and for this reason it is important to present briefly the formation of the theory with different emphases. According to Choy (2007, 11–15) the theory has developed during three development periods. This categorization provides a clear way to understand formulation process of the theory. In addition, according to Christoff (1996) the authors can be divided by the "weak" and "strong" version of ecological modernization, where the previous one refers to narrow understanding as a techno-corporatist form as Hajer (1995) stated. The latter one refers to reflexive version, which adopts a broader approach by taking into account more different dimensions, which are quite much in line with sustainable development (Carter, 2007, 230). However, the ecological modernization emphasis more a significance of business sector, because they are key players, what comes to transformation of society into a sustainable one (Carter, 2007, 229).

The first phase takes place in the beginning of the 80's. Martin Jänicke and Joseph Huber created first, however dissenting, outlines for the theory. Jänicke (1986) emphasized a significance of state-interventions in change of development path into more sustainable direction. More specifically he argued that environmental crisis had led states into a crisis. Changing of production and consumption pattern into a more green form would be impossible without refreshing a basis of state-interventions. He also saw that state had to support actively the ecological modernization process by adopting a green industrial policy for instance. (Jänicke, 1986; Spaargaren, 2000, 46.)

In turn, Huber (1982) emphasized that industrial-production, consumption and technical innovations were playing a significant role among market economy and business. Practically he noticed that organiaztion of production including production technology and consumption were based on unsustainable practices. (Huber, 1982; Spaargaren, 2000, 49.)

He also paid attention to interaction between economic and both scientific and technological development. (Ylönen & Litmanen, 2010, 67.) Practically he provided a fresh approach by introducing sustainable production and consumption in the frames of capitalism. Therefore, sustainability may not be opposite for production and consumption, or technology though it has been usually assumed in that time. (Spaargaren, 2000, 49.) In addition, he referred to significance of markets with following argument: "The main process of the modernization is the "ecologizing of economy" and the"*economizing* of *ecology*" (Huber, 1982).

In the second phase Arthur Mol and Gert Spaargaren showed that there can be found relevant inter-linkages between technical, socio-economic and policy formations. An emphasis from technical innovations to significance of state and market increased during this time, which takes place in the end of 80's and the beginning of 90's. In that time the most important step forward, was recognition of importance of state and markets. (Ylönen & Litmanen, 2010, 68.) Naturally that has been and still is a huge challenge for states, because usually administrative systems of states are relatively rigid adapt themselves. Along the way Jänicke has changed his emphasis from state-interventions to new political forms, principles and instruments, which are reshaped by the state, private sector and civil society. (Spaargaren, 2000, 46-47.) This can be called as policy-networks-approach, which is dealing environmental issues at different levels such as regional level and from de-centralized viewpoints (Godfroy & Nelissen, 1993, s). In other words, this could be called as multilevel management. In this sense the Ecological Modernization can be seen as a theory of political modernization (Spaargaren, 2000, 47).

The last phase, after the mid 90's, included an idea of expanding the theory into new areas, not only into Europe. In practice, this consists of attempts to apply it into industrialized countries such as ones in Asia. David Sonnenfeld truly expanded the theory to examine Asia's pulp and paper industry sector, but finally Arthur Mol, Jos Frijns and Phuong Phung for instance examined suitability of the theory to growing economy Viet Nam. (Frijns, Jos., Phuong, Phung, T. & Mol, Arthur, P.,J., 2000.) However, they accepted that the theory needs to be flexible when applying it outside of the western world (Mol & Sonnenfeld,

2000, 5–8.) Despite of the many variations of the social theory there can be found some common basis behind all of the variations. Especially all of them recognize a significance of innovative structural change as a solution in ecological modernization. This phase was also in line with the new consensus of sustainable development. (Choy, 2007, 11–15; Ylönen & Litmanen, 2010, 68.) Mol (2000) has noted that globalization within global markets is playing important role for environmental deterioration and reform as well. Basically it has both negative and positive impacts on environment. (Mol, 2000, 122–124.) Especially he paid attention to the positive impacts referred to synchronization of globalization and ecological reforms from the perspective of ecological modernization. In other words, Mol figured out a significance of global organized pressure towards nation-states to change their old-fashion institutions by providing exchange of environmental information. (Mol, 2000, 136–137).

There has been a lot of critics concerning overoptimism of science and technology, which were main stones especially in Huber's theory. Ulrich Beck (1992) was one among others who has been related to this critical approach. They rather see the technological development within industrialization process as a reason for environmental problems. A premise in Huber's theory is that science and technology can fix most of environmental problems. He didn't pay a critical attention to negative consequences and side-effects of science and technology. (Spaargaren, 2000, 52.)

As a counter-argument Mol and Spaargaren (1991) noted that there may be space for relevant debate concerning the significance of technological development, because already in that time there occurred a shift from end-of-pipe technology to more preventive technologies. Additionally environmental problems must be seen in a more holistic way by seeing them as complex and interdependent, which means that only technological fix or end-of-pipe technology is not enough. There need to be found the root causes and hence both fixing and preventive solutions. (Weale, 1992, 122–132.) Also both preventive and repairing policies can be implemented at the same time. Environmental movements can be seen the agents behind the new preventive environmental policies (Spaargaren, 2000, 56). The proponents of the ecological modernization, also argues that it is highly dependent on what direction technological development is brought. (Pinch, 1987, 46–47.) According to

the theory there is a chance to change a track towards greener society via political decision-making and technological development.

The ecological modernization also attempts to decrease dependency of social well-being on the input of natural resources and similarly diminish environmental degradation. (Carter, 2007, 227.) Practically this means cultural change towards more sustainable development in the field of science and policy by consulting scientific experts and exploiting technology. This also included adoption of new strategies of environmental policy-making. (Hajer, 1995, 24–41.) Despite of the Hajer's notion above, some says there can be found some worthy of mentioning differences between the ecological modernization and sustainable development as concepts. According to Carter the ecological modernization is only a variation or a half-sister of sustainable development concept. (Carter, 2007, 208.)

By following the Carter's (2007) presentation, the ecological modernization can be categorized as a half-sister of sustainable development, the fact is that sustainable development in practice is very challenging to implement or provide a clear blueprint for political decision-makers. In turn, the ecological modernization gives more practical ways for dealing with problems faced by industrialized countries. When sustainable development is offering wide-ranging proposals for industry, in turn the ecological modernization recommends industrial sector to take environmental protection more seriously. The recommendations are also based on an assumption that business will also benefit from it. (Carter, 2007, 229.)

Arthur Mol (1995) referred to rationalization process, where the ecological sphere has challenged the economic sphere, on which the rationalization has usually based on. (Mol, 1995, 30). In other words, this means that development cannot be assessed only by economic criteria. Also ecological and social criteria must be taken into account. Inspired by this many scientists have developed different kind of indicators, which are taking into account environmental sphere or dimensions. Subsequently adopted concept of sustainable development was functioning as a theoretical basis for indicators. (Spaargaren, 2000, 54.) Also Hajer (1995) noted that there would be better opportunities to integrate ecological

rationality part of social decision making, by putting a set of social, economic and scientific concepts, which enable to change environmental issues into calculable forms. (Hajer, 221–223.)

Right after the next part of the chapter there is a brief review of the most common sustainability assessment tools. The tools have provided more practical opportunities to measure sustainable development. The most common indicators will be presented on that chapter as well. Before that the main idea of the concept of sustainable development will be introduced including its main components. This brief introduction part will also help to understand the reasoning behind the sustainability assessment tools.

2.3 Concept of Sustainable Development as part of Ecological Modernization

At first an idea of sustainable development and other related terms, which are relevant in this study will be presented in this part of the chapter. Despite of this there is no need to go too deep into the concept, because its three famous conceptual dimensions are working only as pacemakers for methodological part of the study. Still the Ecological Modernization is highly linked to the idea of sustainable development as earlier noticed, and thereby on number of criteria and indicators. Despite of its paradigmatic status, there can still be found huge ambiguities of the sustainable development as a concept, and yet the implementation of the idea in practice has been considered a challenging one (Carter, 2007, 213, 227).

In the Report Limits to Growth, Meadows D., H., Meadows, D. L., Randers & Behrens (1972) examined mutuality of five following variables through modelling: industrial production, pollution, population growth, food production, and resource depletion. Nonetheless, presumptions that were presented in the publication weren't taken as seriously as nowadays, while they are enjoying confidence of politics and scientists. In turn, even if the publication insightful and a pioneer of its time, the computer modelling was rather primitive. (Meadows et al., 1972.) Due to this forecasts till 2010 were considerably more pessimistic comparing the current forecasts and situations. In addition,

according to Carter (2007) there were inaccurates and data incorrects at some extent. Notwithstanding it is relevant to note that the forecasts revealed unsustainable development path and realities related to that.

A noteworthy point in the systemic-theory is that we are living in a large and relatively closed ecosystem (earth), which is highly defined by its biophysical limits. There amount of energy is constant and all factors are impacting on it. In other words, human and society are not separate from nature. But various activities are influencing on nature, and nature is reacting with a variety of its own even surprising counteractions to return equilibrium of homeostatic state. In other words, the effects are inevitably two-way-going. (Chiras, 2001, 12, 110–114.) Understanding this, the idea of sustainable development received a serious boost in that time.

Before presenting the whole concept of sustainable development it is important to review what is development and sustainability according to current view. The development could be explained as a process of change. In turn, the sustainability comprises the maintenance of social life within supporting capacity of the Earth. (Garcia, 2000, 229.) As a result sustainable development can be understood as Garcia (2000) has written: *"intentional and conscious control of the relationship between society and nature"*. However, Garcia (2000) criticized the both concepts and their combination meaning by sustainable development. He noticed that official requirements of sustainability are insufficient, especially because the maximum scale of carrying capacity is impossible to determine. (Garcia, 2000, 229-231.)

Nowadays, there has been defined a broad concept of sustainable development, which can be seen as a good basis for a more advanced definitions. In this case, a purpose is to view only the broader definition. Sustainable development is built around a goal, which meets the needs of contemporary generation without harming secure of those for future generations (WCED, 1987, 41–43). In addition, in political context the concept of sustainable development is not as new as one would think. For example Theodore Roosevelt, The President of United Stated used the concept in his speech already 90 years backward (Chiras, 2001, 9).

One can find several different variations, how sustainable development is defined. However, the core, but relatively abstract elements of sustainable development are quite clear, but how to link them to reality varies a lot depending on the valuation and operationalization process. Despite of the many variations, the main approach accepts an idea that ecological sustainability is a necessary condition for socio-cultural and economic sustainability (de Groot et al., 2002, 397–398; Dunlap, 2002, 10-11). According to Kaivo-oja and Haukioja (2003, 484–485) the most essential problems are linked to following issues: should assessment adopt anthropocentric or naturalistic basis, how the interests of future generations should be taken into account, and how culture and transformation of values should be dealt with. A lot of attention should be paid on the overall examination of the system or rather society within its environment (Kaivo-oja & Haukioja, 2003, 488).

The clearest way to understand the idea of sustainable development is to divide the concept into three parts and view the parts separately. When viewing the sustainable development in parts it consists of three aspects: economic, sociocultural, environmental aspects. Each dimension is intricately interconnected and is impacting on each other including feedbacks. Also special requirements of all three dimensions should be taking into account without any contradictions. A dialogue and relation between the elements mentioned above are in a key position when implementing such development. (Kaivo-oja & Haukioja, 2003, 488–489.) However, this requires a lot of research from different fields, as well as a broader advanced multidisciplinary research tradition (WCED, 1987, 264–266).

The economic dimension comprises an idea of economic sustainability, when economy is adapted in terms of natural conditions and requirements. In addition, the dimension requires relatively stable economies including equitable distribution of wealth, and regional self-reliance. (WCED, 1987, 42–46; Chiras, 2001, 10.)

The second one the ecological sustainability as a dimension of sustainable development means that action of humankind is inside the frames of nature's carrying capacity. This seeks to pay attention to Earth’s biophysical limits and humankind’s dependency on it. In other words humankind is totally dependent on Earth’s ecosystem services and goods, such

as natural resources like oil and coal. In this dimension special attention must be paid in clean air and water, decreased use of non-renewable natural resources, and maintaining biodiversity among many other things. In addition, interdependence of humans and nature has been taken into account. Examples of this are less environmental damaging production- and consumption patterns and structures. (WCED, 1987, 52-54; Chiras, 2001, 12.)

In turn, the third socio-cultural sustainability attempt to maintain and increase human dignity including equality, justice and compassion. The concept refers to improvement and promotion of human well-being. According to the previous aspects the concept includes more than just a clean and healthy environment. It also consists of respectable work, good salary, creativity, peace and a host of other factors. In addition, it includes political freedom, human rights, inviolability and access to basic needs such as food, clothing, shelter and water. Reasoning behind of this dimension is referring to intergenerational equity, internal equity of generations and ecological justice. (WCED, 1987, 49–50; Chiras, 2001, 9–10, 13–14.)

One of the biggest challenges is to get needs to be met and simultaneously environment protected. To achieve these conditions at global scale there has been emphasized especially participation, co-operation and addressing the root causes. Participation in this context refers to taking responsibility in business world as well. Otherwise regulations and laws alone would be pointless. In addition, choices of private consumers are playing a significant role, because they have potential power to shape market world into a more sustainable path. In turn, co-operation can be understood as global scale environmental treaties, which are implemented on national, international and supranational and also local and regional scale. (WCED, 1987.) This can be also called as multi-level management. Traditionally in a decision-making process there has been emphasis of relief of symptoms instead at the expense of an actual determination of causes. Nowadays more emphasis has put on the root causes, not just technological fixes. (Chiras, 2010, 12–15.)

The concept of sustainable development is quite dynamic and it has been updated at least at some point, while new information is gained. In other words, one should not think the

nature of sustainable development as a permanent and stable. The reality of economic, social and biological systems are rather regenerating and changing, and this is highly included in the term of sustainable development. (Voinov, 2000; Holmberg & Sandbrook, 1994, 24–25.) An important point is to understand that even if the concept of sustainable development has been built on the ecological criteria, there exist several political choices in defining of sustainable development (Spaargaren, 2000, 55).

Some experts have noted that the ecological modernization is a basic required process for sustainable development, because it comprises key factors, such as clean technology and change of value basis (Kaivo-oja & Haukioja, 2003, 484). Recent studies suggest that there may not be need to determine any absolute carrying capacity in the context of sustainable development. The concept itself is built around an idea of a changing process. Renewals of economic, social and environmental systems consist of on-going processes including their own natural and artificial lifespans. (Voinov, 2000.)

Consequently this means that it may not be even relevant to determine any absolute scale, but an examination of relative changes of systems could be more appropriate. Therefore one should not look for absolute levels, when measuring sustainable development, but rather see it as a process of dynamic inter-linkages, which are changing in time and space. On the one hand, the real world is relatively closed and on the other hand, it could be thought as a relatively open system depending on approach (Töttö, 2010, 270). Either for this reason, it may not be meaningful to measure sustainable development from absolute point of view.

2.4 Sustainability assessment tools

During the recent decades there has been developed several different kind of indicators and methods to measure ecological modernization process and sustainability globally, regionally and locally in a long and short time scale. In other words, these indicators are able to describe and follow the process of ecological modernization process towards sustainable societies. The approach of sustainability assessment tools are highly dependent

on the researcher and what do one is willing to measure. (Sing et al. 2008, 191.) There seems to be an everlasting drive to develop better indicators for measuring sustainable development or rather ecological modernization process towards it (WCED, 1987, 264–265). On a one hand, the world is changing all the time, which practically requires new methodological approaches to assess sustainability development.

A purpose of sustainability indicators is to provide information for decision-makers, companies as well as civil societies. In addition, it helps to plan environmental management strategies and assesses conditions and provides warning information for prevention of possible damages (Lundin, 2003; Berke & Manta, 1999, 7.) It is essential to take into account all well-established aspects of sustainable development, which are economic, environmental and socio-cultural or technological development depending on what purpose the information is explored for. (Singh et al, 2008, 191.)

The main idea of these types of indicators and methodologies is to give a clear picture of development's condition by summarizing complex and multi-dimensional development path into an understandable and simpler form. One important notion has been presented by Meadows (1998, 2): "*Indicators arise from values (we measure what we care about), and they create values (we care about what we measure)*". In other words, indicators are always based on values we have, and they are also reproducing and creating new ones. Likewise, when climate of values are in a changing process, new indicators will be developed to measure conditions of the real world, and hence from new sets of values.

The notion of Meadows leads straight to the debate of how sustainable development should be measured and on what values they are based on. Singh et al. (2008) have written a great overview of majority of indicators that has been created to assess sustainable development. According to Lundin (2003) approach of sustainable development indicators can be divided into two different categories based on approaches: "top-down" approach and "bottom-up" approach. The first one refers to the framework, which is defined by researchers. The second one is based on the approach, where different stakeholders have participated in the framework process together with experts. (Lundin, 2003; Singh et al. 2008, 192.) There can be found numerous frameworks of sustainability assessment, which

each one is limited in accordance with their own purposes (Singh, et al. 2008, 191). For this reason there is no need to specify all of those.

Another way to categorize the indicators is by its methodological framework, which is more practical classification from this study point of view. There have been formulated two distinct methodologies in the Sustainability Assessment field. The first ones are based on neo-classical models, which are mainly used by mainstream economists, who accept an idea of sustainable economic growth as part of sustainable development. In other words, neo-classical models are built-in idea that economic welfare is measured on terms of the level of consumption, and natural environment is valued for its functions. (Singh, 2008, 195.) The other approach is based on a more holistic framework by Ness, Urbel-Piirsalu, Anderberg & Olsson (2007). It includes three areas, which are arranged on a time continuum. The first ones are indicators of indices giving retrospective information of sustainability. The second ones consist of product-related assessment tools focusing more on material and energy flows. This latter one refers to integrated assessment of sustainability, which has focused on tools that measure policy and project, as well as possible consequences of those. (Ness et al., 2007, 502-504; Singh et al., 2008, 194–196.)

It has been very common way to calculate single indices or indexes to assess sustainable development. Especially this has been very common in neo-classical models. As an example of these sort of indicators are GPI (Genuine Progress Indicator) and SNI (Sustainable National Income). (Singh et al, 2008, 195.)

Another established way to measure sustainability is to build composite indicators, which can be seen as an innovative way to evaluate sustainable development. Composite indicators consist of so-called sub-indicators and they don't have common meaningful unit of measurement. In addition, there is no clear existing way of weighting them. In addition, some critics say that these kind of composite indicators are too subjective, and there are so many ways to implement mathematical basis for an indicator. Despite of the critics there has been going on increased popularity of composite indicators while the concern of environmental condition and social well-being have increased. A counter-argument for the

previous criticism is that still all kind of indicators are based on subjective values at some extent. (Meadows, 1998; Singh et al, 2008, 191.)

There can be clearly found out that whether the indicator is composite indicator or not, only one or two dimensions from sustainable development has been taken into account. For instance, Human Development Index (HDI) created by the United Nations (1990), consists of three dimensions, which are long and healthy life, knowledge, and GDP per capita (UNDP, 1990, 2014; Singh et al., 2008, 199). In other words, only two dimensions of sustainable development (economic and socio-cultural) have been taken into account in this indicator.

Let another example be Environmental Policy Performance indicator developed by Adriaanse (1993). This composite indicator is designed for Netherlands to measure environmental pressure of the country. It consists of six themes: acidification, climate of change, dispersion of toxic substances, disposal of solid waste, eutrophication and both odour and noise. (Adriaanse, 1993.) This indicator includes only one dimension of sustainable development (environmental dimension). On a one hand, it is fairly comprehensive, but doesn't show inter-linkages with other two dimensions of sustainable development.

The previous examples are illustrating a large part of scene of sustainability assessment tools. As summarizing, inter-linkages between all three dimensions of sustainable development, and especially in the process of ecological modernization is very challenging to measure. One reason for this is that there may be some increasing de-linkage between the three dimensions. (Kaivo-oja, Panula-Ontto,Vehmas & Luukkanen, 2013, 44.)

2.5 China's transformation from heavy-industry economy to greener one

The western world has already expanded their industrial and modernization processes into developing countries as well, which directly means that the same problems will be faced by them in the future, and some of them has already faced it. China is a one illustrative example of it. Especially its industrialization path reminds a lot of other developed

countries' path, but the pace of industrialization is totally on a new level. Contemporary and highly industrialized China is facing similar unsustainability problems as western countries did few decades backward, but in much larger scale. (Fang et al., 2007, 315–316.) Therefore, China provides a great opportunity to view consequences of this shifting process including both negative and positive ones.

After the 90's it has been very obvious that the developing countries are facing so-called dual pressure meaning by simultaneous economic development and environmental protection encouraged by international organizations (Research Group for China Modernization Strategies, 2007; Harris, 2011, 223, 230). In that context track-change towards ecological modernization is very challenging. As earlier told, the new interesting aspect in the field of environmental sociology is to apply the theory of ecological modernization into a new context outside of Europe. This perspective is very important to take into account. The theory has been applied in China before by Zhang et al. (2007) for instance. An approach in this study is different at some extent.

When applying the theory into a one country, it must be remembered that each culture and nation is always a case, which has its own features, but also many general ones. For this reason the theory may never fit in without problems. For instance, there might be some greater difficulties with the theory when applying it into the least developed countries. In turn, a lot better ground can be provided by a country, which has recently faced a climax of industrialization as western countries did three decades earlier. China has many interesting features, which are functioning as a driving force to review it in the frames of Ecological modernization.

Several analyses have been produced about China from the ecological modernization perspective, but methodological approach has been different. It has mainly stayed on international comparing level and viewing the ecological modernization indexes, which are not in line with approach of this study. (Research Group for China Modernization Strategies, 2007; Zhang et al., 2007, 664.) While representing the China in through the eyes of the Ecological Modernization theory, there will be some problematic aspects in it,

which must be overcome by a relevant sociological argumentation. This also provides a chance to refine the theory for more suitable form for this study.

There has been presented some critics towards the theory mainly concerning neglected attention of a role of actors. Also in the field of environmental sociology, there exists the dualism of between micro and macro analyses, where the previous one emphasizes a significance of actor behaviour and the latter one a significance of institutional developments. (Spaargaren, 2000, 59.) According to Spaargaren (2000, 60) the ecological modernization is neither actor emphasized or system-imposed. Rather it is having both features at the same time. Here Spaargaren (2000) is referring to Giddens' theoretical actor-structure dilemma, which is criticized by not taking into account structural constraint to social actors. Structure is always both enabling and constraining for social actors. (Spaargaren 2000, 60; Giddens, 1984, 25–28.) On a one hand, one could point out that structures are always run by some actors. In China both the central government and local governance consists of actors, who are in co-operation with experts, who are qualified to assist to changing a track towards sustainable development (Zhang, 2007, 661).

In one way the Ecological modernization can be seen centralizing political decision-making by implementing state interventions and hence it will provide sustainable basis for economic growth as Jänicke (1986) has emphasized. Transformation of society structures into sustainable ones can be implemented with centralized decision-making including reforms and adopting new innovations. Additionally it supports both aspects an idea of preventive and fixing actions. (Hajer, 1996, 251.) According to Dryzek (2005) especially countries, which policy styles consists of a culture of planning, intervention and a close working relationship between the state and industry, are more open to ecological modernisation thinking.

There is quite centralized and strict decision-making process led by The Central Government ruled by The Communist Party in China. Recently provinces have gained more independence in decision-making, nevertheless the final word comes from the Central Government. Also vast state-interventions are key parts of China's political culture.

(Mattlin, 2005, 244–246.) Equally relationship between state and industry is very powerful. From this viewpoint a significance of state-interventions as Dryzek (2005) suggested, cannot be underestimated.

However, according to some theorists like Carter (2007) there might be some problematic factors in this application of the theory as well. As a concept Ecological modernization accepts that environmental problems are a structural outcome of capitalist society (Carter, 2007, 227). On the other hand some theorists believe that it is a structural outcome of industrialization and highly administrated technological system of modern society (Spaargaren & Mol, 1992, 323). There are some differences on emphasis either China cannot be called as a capitalistic or technologically advanced country. More specifically it is the socialist market economy, which on a one hand has integrated as part of the global economic world. Both the Economic Reform in 1978 by Deng Xiaoping, and its accession as a member to the World Trade Organization (WTO) in 2001 can be seen as the two significant milestones for that. (Nojonen, 2000, 27.)

Nevertheless, it may not be relevant to say nowadays that only the structure of capitalist society causes environmental problems. For example China is facing the same problems as developed capitalist societies, even if it is the socialist market economy. On this basis it is relevant to invalidate Carter's statement. The problem is not the structural outcome of capitalist society, but rather industrial structure of society. Also Joas' (1996) statement is supporting the latter point that capitalism can lead to industrialism, but it is not necessary. Also non-capitalist industrialization and capitalist de-industrialization exist. (Joas, 1996, 235.) Like earlier told, China is fast industrialized society without capitalism. In addition, the concept of ecological modernization is mostly based on transforming the nature of industrialization (Carter, 2007, 227). Consequently on this basis, China is not less good for applying the ecological modernization theory than western countries.

There can be found several reasons what makes this ecological modernization process interesting especially in China's case. Firstly, China is very large country what comes to its population (estimated to be over 1,35 billion in 2012) and its acreage, which is 9,596,961

km^2 (World Bank, 2014). In addition, there are significant regional differences from environmental, social and economic viewpoints between provinces of China. Characteristic of the last decade has been accelerated economic growth and fast urbanization, but it was basically regional and mainly located to eastern China. As a consequence it led to a vast gap between western inland and eastern coastal regions. Also China's central government tried to resolve it by implementing the West China Development Program in the early 21st century. The program included multiple mega-projects of massive infrastructure development. In turn, after the mid-21st century the central government expanded the focus on coastal regions as well. (Nojonen, 2000, 38–41; Lu, 2012, 54.) Also the Special Economic Zones located mainly in the east-cost regions since the beginning of the 80's have contributed uneven development of provinces (Lu, 2012, 46–48).

Secondly, the modernization process including industrialization and urbanization have been occurred in much faster and larger scale in China compared to western countries always from the industrial development to environmental problems in due time. (Zhang et al., 2007, 661; The World Bank & Development Research Center of the State Council, the People's Republic of China, 2013, 8–9.) Staggering development path of China reminds a lot of the events in western countries in the beginning of 1900's, when The United States and The Great Britain were experienced mass production and vast economic development (Perez, 1983, 365—366). However, during the 80's and the 90's China had not even had a chance to experience the most explosive economic growth within climax of industrialization and mass production. There was not even a discussion about environmental problems, because the main goals of China were concentrated on economic growth and modernizing its economic structure since 1964 (Zhang et al, 2007, 660).

After the economic reform in 1978, very fast industrialization was mainly based on heavy-industry (natural resources, energy and physical capital), which led China to a challenging situation. At that time agriculture dominated the economic structure, but structural change led to a situation, where manufacturing and service sector increased their role in economic structure till today (Fan et al., 2003, 360). During the industrialization within westernization process, a culture of China seemed to be alienated from nature versus its historical perspective. Particularly China has adopted an idea from the western world that

natural resources can be exploited unlimitedly by humankind. As a result, China is suffering badly from pollution caused by its industrial structure, which is simultaneously a significant source of income (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 247–249).

China's economic growth is highly based on increasing consumption of natural resources, high investments, and high emissions to environment, which is promoted by low efficiency in the process of production (Fang et al., 2007, 315-316). As a consequence of this huge development of China, there rose many negative side-effects such as environmental problems and both social and regional imbalances, which contain possible social and economic risks. Economic structure has led to a high dependency on coal. According to the U.S Energy Information Administration estimations, as the biggest coal producer, China alone produced coal 46% of coal production globally in 2012. In turn, coal consumption has increased over 2,3 billion tons during the 10 recent years. 49% of global coal consumption was consumed by China in 1012. (Ayoub, 2014.) In addition, energy total consumption has tripled since 1978, but acceleration has got off the ground after the 90's, when the coal consumption was doubled**.** Even if the Chinese government has adopted sustainable development in their five-year policy programs, still approximately 70% of China's total energy comes from coal. Naturally this means, that coal will be the main source of energy economy for several decades, and energy. (U.S. Energy Information Administration, 2014, 3.)

After 2000 development of China got some new features, which can be characterized as massive growth of economy, exports, welfare, and energy consumption, and finally emissions. At least millions of Chinese got out of the poverty in this economic structure, but it didn't happen without negative side-effects, such as impaired air quality. (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 77, 79-81.) Especially increased amount of SO2 emissions were exceeded both national and international guidelines in many cities of China. Like in Europe in the 80's, also China started develop improvements for air quality from SO2 emission reductions. One of the first wakeup calls was SO2 emissions, which were causing huge amount of pollution into air. As a consequence there appeared smog and acid rains, which caused

several health problems, even mortality and environmental degradation. (Schreifels et al, 2012, 780; Klimont et. Al, 2013, 1; Cao et al., 2012, 373–376.)

As a result of increased income level, population is demanding improved well-being and cleaner environment. In other words, people are not willing to give away achieved benefits. (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 248–249.) This only increases the pressure of China's Central Government to pay attention to environmental degradation. On the other hand, there will be regions, socio-economic groups and industries, which are going to suffer from ecological modernization process, and environmental protection. China has tried to reconcile air pollution and emissions by intensifying environmental protection since 2005 implemented by China's State Environmental Protection Administration (SEPA) (Zhang et al., 2007, 661). According to Zhang et al. (2007) practically China adopted international goals by implementing new laws and regulations, which were in line with the Programme of Action for Sustainable Development (2004). Among adoption of environmental policies also a lot of attention received GreenOlympics in 2008 was symbolizing a shift towards more sustainable thinking (Beyer, 2006).

The emphasis of sustainable development had to be in the fields of atmospheric protection such as SO2-emissions, and acid rain control, mitigation of global climate change, and protection of the ozone layer. Technological inventions and transformations of economic structure have been practical ways to realize these goals. (Schreifels et al., 2012, 783.) In theory this supported the idea of ecological modernization. At first time the Central government included reduction goals of SO2 emissions 10% below 2000 in China's 10th Five-Year Plan goals. For instance FDG (flue gas desulphurization) technology was installed on 14% of thermal power plant capacity by the end of 2005 (Schreifels et al., 2012, 779). Before this environmental reform in the Five-Year Plans, majority of goals were concentrated on increasing actively economic prosperity (Mattlin, 2005, 246). Despite of the environmental reform the goal was not reached till 2005, and SO2 emissions were 28% above the levels of 2000. In turn, the 11th Five-Year Plan goals were even tighter concerning the SO2 emissions. The goal from 2006 till 2010 was to reduce 10% below the level of 2005. FDG technology was installed on 86% of thermal power plant capacity by

the end of 2010 and finally the emissions were 14% below the levels of 2005. (Schreifels et al., 2012, 779–785; Klimont et al., 2013, 4.)

Many critics have paid attention to Eurocentrism of ecological modernization theory meaning by focus on the one hand only a national-level and on the other hand only highly developed western countries (Zhang et al, 2007). There might be some serious problems to apply this in very poor countries, but for instance China cannot be counted as poor or technologically backward country nowadays. Currently China consists of even higher technological skills than the western world did. From the ecological modernization point of view, it also means better possibilities to exploit technology to treat environmental problems and prevent becoming ones. Recently China has expressed its concern of pollution, and planned to develop new innovations for sustainable growth. From this basis the China has changed its track towards sustainable development meaning by production and consumption, and hence decreasing pollutants. A lot of weight has been put on R&D activities and technological innovations to change of economic structure into more sustainable direction by expanding service sector at expense of heavy-industry. (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 223-229.) Huber also noticed that advanced technologies are the key solution in the process of change production process in industry (Spaargaren, 2000, 52–53). Equally this requires close state-industry collaboration (Carter, 2007, 237). The previous notions are in line with China's recent political implementations.

3 PURPOSE OF THE STUDY AND MAIN RESEARCH QUESTIONS

As the previous chapter shows, there are many relevant aspects to explore China in the frames of Ecological Modernization. Theory of ecological modernization is an attempt to describe techno-socio-economic changes into a more environmental friendly and sustainable path in the western societies.

Hajer (1996, 28) has noticed that the role of science has changed from finding evidence for environmental disaster to measure critical level or stress of pollution. Secondly there exists

an idea that environmental protection will pay itself back. Finally it is important to find effectiveness of interventions. By leaning on the previous comments a purpose of this study is to measure ecological modernization process of China. Timing of China's ecological modernization process within the climax industrialization can be seen as an interesting feature, because during that time the western world has already adopted many environmental agendas, such as Agenda 21.

As earlier told, China's development has been very fast and it is the second largest economy in the World. Despite of that most of the development has located into east coast of China, where also majority of Special Economic Zones are located. In other words this means that China's regional development has been rather unequal from social, environmental and economic viewpoints. (Lu, 2012, 301–302.) In a more precise scope the aim is to examine sustainability of China at province level, by combining three dimensions of sustainable development (economic, environmental and social). In other words, this practical quantitative measurement is based on attempt to measure sustainable development of China in the frames of Ecological Modernization. At least one intersting chinese provincial sustainability analysis was carried out for the years 2000 and 2005 by Hara, Uwasu, Yabar and Zhang in 2009. It was based on aggregated time-series scores (Hara et al., 2009, 81).

Recently, China has put a lot of effort in changing a track towards sustainable development. At first, China paid attention to SO2 emissions in 2005, as many western countries did two decades before. China has also tried to get rid of poverty, and currently there has been a lot of discussion about a new emerging middle class (Kallio, 2005, 74–80). At least, there has been some discussion that China is facing some sort of revolution of sustainable development, but slightly. There has been a huge political climate change going on over a decade, and this can be seen from many decision-making processes and China's five year plans. (Zhang et al. 2007, 665.) However, these sort of signs from recent history must be assessed with empirical data.

Now there is a great opportunity to explore what kind of influence these changes has caused in ten years starting from 2001 till 2010. But on the basis of unequal regional development viewed by many aspects, there is a need to explore sustainability at province level. This is the best way to find out influences of political decision-making and socio-techno-economic changes. This study is based on the scientific part of the theory, which is concentrated on assessment of sustainability, and how the track-switching has succeeded in China. China's case provides a great empirical basis to test, whether environmental policies, regulations and technological development have improved the efficiency of socio-techno-economic system of China or not. Province-analysis is very interesting especially, because they are competing with each other. Also annual economic growth of each province is very much in a scale of general state. Therefore, the province economic growth level reminds a lot of outside world economic growth at state level. (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 5.)

As earlier noticed, ecological modernization approach has provided practical tools to study societal transformation towards sustainable direction, but it has serious lack of an overall picture. In turn, sustainable development as a sister concept for ecological modernization has focused on the overall picture, but it is still very controversial concept and very challenging to measure. (Carter, 2007, 213, 227.)

As the previous overview showed that mostly all sustainability indicators are measuring sustainable development from the very narrow perspective. In other words, the ecological modernization have informative and well thought basis for building tool to measure sustainability. And on the other hand, sustainable development provides better conceptions to assess sustainability, but tools to measure it is very problematic and mainly one-dimensional. This study attempts to measure ecological modernization process of China by using three conceptual dimensions of sustainable development (economic, social and environmental). There was gathered a brief overview of the most popular sustainability indicators and assessment tools, which consist of national and global indicators. However

there is always a need to develop and invent even better indicators for different purposes. More specific way to make an assessment is to extend it to province level.

The purpose of the study is to examine state of ecological modernization process in China. The study attempts to answer following questions. How the socio-techno-economic systems of China's provinces have changed during the years 2001-2010? In other words, how ecological modernization process has developed? How China has succeeded to change its track towards sustainable development during that time? What kind of differences there can be found between the provinces and between the easternmost and the westernmost provinces?

For the previous research questions will be answered by applying a relatively new sustainability assessment tool, Sustainability window, invented by expert group in Finland Futures Research Centre (Frameworkpaper, 2013). Earlier the assessment tool was applied at global level. The analysis is based on the three dimensions of sustainable development, and the analysis is concentrated on inter-linkages between them.

4 DATA AND METHODOLOGIES

It is necessary to have a little discussion concerning reliability of data from China, because some issued were related to an acquisition process of data. There has been wide conversation related to insufficient data gathering and manipulation of unreliable statistics. Next there will be presented sustainability window methodology, which was used as a main methodological tool in this study. This methodology requires a complementary operationalization process. In this study it also requires a supplementary method, which was Principal Component Analysis.

4.1 Data acquisition

Data for this study was selected from the Chinese Statistical Yearbook database during the years 2001–2010. The data from these years was selected for several practical reasons.

First a new Chongqing province was declared in 1997. It would be challenging to adapt data before the 1997 and data after 1997 into a comparable form. Secondly during the years 1990–1998 many key reforms were made for statistical methods. (Chinese Statistical Yearbooks, 2001–2010.) Thirdly it was important to have relatively fresh data, which makes analyses more topical. Also data acquisition from the database was leaned heavily on the ecological modernization theory and the three dimensions of sustainable development. In addition, earlier studies and methodological tools were guiding the selection of the statistical data (Singh et al., 2008).

In this study there will be used following statistics concerning China during the years 2001–2010: Constant GDP (yuan), Possession of Private owned vehicles (transport vehicles), Literacy rate, Employment rate, and SO2 emissions (from industry and consumption). All data was selected from 25 provinces. (Chinese Statistical Yearbooks, 2001–2010.) There was some technical difficulties in the database website, which practically meant that it was not possible to get the data from each provinces. The data was easily available from the 25 provinces, which fortunately were located in the westernmost and the easternmost part of the China. Practically this enables the comparison of the east and the west, which is very significant, because of the huge development gap between the regions. Therefore, the data is providing interesting information about sustainability differences between the west and the east part of China.

There also exists a general discussion about inconsistency and lack of reliability of the Chinese official statistics. That's why the analyses should be interpreted only as indicative ways and the information is broadly illustrative. Specifically there can be found serious problems related to calculation methods of GDP in China. One mentionable issue is that GDP nominal at a national level does not always add up with the provincial ones. (Koch-Weser, 2013, 4.)

As an example of this, before 2001 national GDP was remarkably greater than the sum of provincial GDP. Logically national GDP should be the sum of provincial GDP, but there are argumentations towards and against depending on years whether the central level is exaggerated or local level is who to blame on. In turn, also economic growth locally

exceeds the central economic growth. In general, there is incomplete survey coverage. In addition, similar ambiguities and inaccuracies can be noticed from the unemployment rate, under-reported income distribution mainly by wealthy household and migrant workers. (Koch-Weser, 2013, 4.)

Despite of the reliability debate of statistics, it still can provide a sufficient and relative basis for sustainability analysis, but results must be interpreted with caution. At least, the data can ratify the suitability of the sustainability method, even if the accuracy of the data is not the best. In addition, statistical uncertainty is very normal phenomenon, when working with statistics. It is also important to remember that data is never the whole reality, but it is able to represent it at some extent. (Töttö, 2010, 228-229.)

4.2 Methodology

Naturally, methodological approach was quantitative in this study. However, quantitative analyses will always be based on qualitative choices and hence an actual difference cannot be done. Rather they should be seen intertwined with each other. (Töttö, 2004, 9–11.) Especially the previous statement is providing one approach to view sustainability. The formal ecological modernization is concentrating on measuring sustainability and the process towards it, but it is not totally clear how to define the sustainability. It is always, at least to some extent, based on political interests, and subjective choices, or values as Meadows (1998, 2) noticed.

When measuring sustainability of China, it is necessary to go back to the concept of sustainable development. The concept consists of three dimensions (economic, socio-cultural, and environmental). The indicators were selected by their potentiality to describe these three dimensions of sustainable development. There has been ongoing debate about how indicators should be operationalized, and how the concept of sustainability should be defined in this context. In this study, indicator choices were mainly based on indicator choices according to earlier studies (Singh et al., 2008, 198–209).

According to Singh et al. (2008, 195–197), there are some main points that need to be taken into account, when building a tool for assessing sustainable development in general. Especially a great attention has to be paid to selection of sub-indicators. Firstly it is important to make a clear thinking process how each sub-indicator is illustrating sustainable development. Secondly assessment of quality of data must be done. There has to be clear solutions how to substitute missing data points, correlation results and what kind impact a chosen method has for results. (Singh et al., 2008, 197.) Models are based on rational and careful consideration, which is generally built on earlier theories and studies. One significant feature of models like these is simplicity. According to Singh et al. (2008, 195) there must be balance between simplification and complication.

One of the purposes in this study is to apply a relatively new sustainability assessing tool in the context of China at province level. The method is called Sustainability window developed by expert group from Finland Futures Research Centre (Frameworkpaper, 2013). It is a novel dynamic model to measure ecological modernization process or rather evaluating multi-dimensional sustainability. (Frameworkpaper, 2013, 1). If defining its position in the field of sustainable assessment tools, it could be categorized as a combination of neo-classical and holistic framework, which assesses retrospective sustainable development regionally. However, this model takes a critical position towards economic growth, and reveals inter-linkages between economic, social and environmental dimensions.

The theory of Ecological Modernization and the concept of sustainable development are intertwined with each other in this assessment tool. A purpose of the ecological modernization itself is to find solutions to change a track of country's development into more environmental friendly and sustainable direction by reorganizing production and consumption processes. In other words, main point is not to question the industrial process, but only change its direction. A goal is to change production structure of society into to a sustainable level. (Huber, 2010, 279–283.) The sustainability window is functioning as a tool to view this ecological modernization process.

Practically this means that some general indicator for economic criteria such as GDP is not the only indicator, which indicates development. There should be taken into account other criteria as well, for instance emissions of production based on ecological rationalization. This brings us to the forms of different rationalities and conflicts between them studied by Touraine (1995) for instance. In some cases economic rationalization, technological rationalization and ecological rationalization may not be in line with each other, but on the one hand there can be observed some analogies what comes to concepts such as environmental productivity and capital productivity (Spaargaren, 2000, 55). This is highly linked to practical work, when creating new indicators to measure sustainable development, and ecological switch-over, as Mol (2000) used to say.

4.2.1 Sustainability window as a main analysis method

The sustainability window is a new quantitative assessment tool, which was evolved from The Advanced Sustainability Analysis (ASA) framework (Kavio-oja, Luukkanen & Malaska, 2001). In this method the sustainability analysis is particularly assessing relative changes of different dimensions of sustainable development. Unlike the large scale (ASA) framework, the sustainability window is providing a simpler way to assess sustainability in terms of economic growth, by taking into account socio-economic development and environmental impacts. (Framework paper, 2014, 2.) Like earlier mentioned, one of the key problems in sustainability assessment has been de-linkage of all three dimensions (Kaivo-oja et al., 2013, 44). Practically, this has led to a situation, where only one dimension is included in aggregated indicators in terms of monetary.

As a concept sustainability window has its origins in the concept of sustainable development, but it evaluates both ecological modernization process, and sustainability level of certain region. Rather, it is a tool for making assessment of sustainability of economic growth in terms of environmental impacts “costs” and socio-economic impacts “gains”. (Frameworkpaper, 2013, 1.) The sustainability window attempts to combine properly all three dimensions of sustainable development. Practically this requires three proper and relatively simple indicators, which are able to illustrate dimensions of sustainable development for assessment. The main idea is to pay attention to the "gains" of

economic growth, and the "costs" of economic growth. In other words, the first one refers to socio-economic impacts, and the latter one refers to environmental impacts of economic growth. According to the framework paper (2014), also sustainability window must be operationalized by selecting three indicators, which illustrates the three dimensions of sustainable development: economic, socio-economic and environmental dimensions. (Frameworkpaper, 2014, 4.)

The sustainability window is providing at least one way to view phase of regional ecological modernization process towards sustainable development. Secondly, it is able to inform the relative sustainability level from the socio-economic and the environmental point of views as a functon of GDP. In addition, an examination can be limited to wider or narrower topics depending on what one wants to get an answer to. In other words, it can be applied at state level or at city level, for instance. Also some testing was done for international comparison (Frameworkpaper, 2014, 9–12).

Before going further into the mechanisms behind the sustainability window calculations, it is necessary to clarify, which types of categorizations the method can extract out. Theoretically it can produce three different sustainability results of analysed regions: socially and environmentally sustainable regions; only socially sustainable and environmentally unsustainable regions; socially and environmentally unsustainable regions. The figure 1 is illustrating the categorization and helps to perceive all extraction options more clearely.

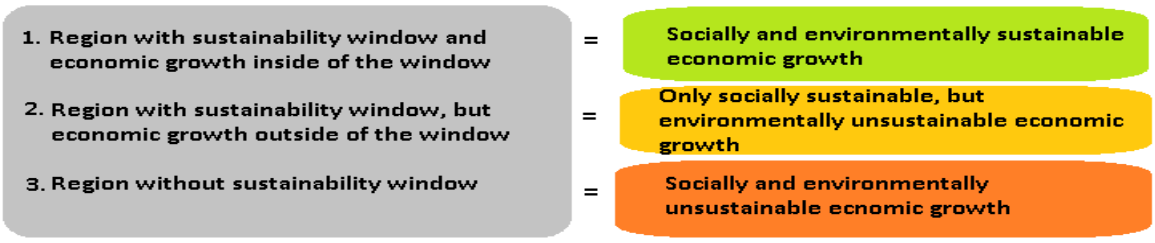

Figure 1. Three possible results of sustainability window analysis

As can be seen in the figure 1 the first region model with sustainability window and economic growth inside of it means socially and environmentally sustainable economic growth, where a socio-techno-economic production system is based on sustainable structure. To interpret this, the ecological modernization process for the system has succeeded in these types of regions. In turn, the second types of regions with sustainability window, but economic growth outside of it, have only socially sustainable economic growth. Practically a socio-techno-economic production system is not sufficient from environmental perspective, but the production system has potential to become sustainable one with lower economic growth, if the system structure remains the same. The third sort of regions without sustainability window have socially and environmentally unsustainable economic growth, which means that a socio-techno-economic production system is totally based on unsustainable structure. It can be interpreted that this types of regions are lack of ecological modernization process or the process has not succeeded.

There are some requirements, which are increasing the validity of sustainability window. Indicators of each three dimensions have to represent development change during time. However, indicators such as rankings or percentage shares are problematic, if they are applied in sustainability window framework, but it is not completely ruled out. (Frameworkpaper, 2014, 5.) Socio-economic or rather well-being (*well)* indicator must represent positive development of social dimension. In turn, environmental *(env*) indicator must reflect a negative development of environmental dimension. In addition, during the selection of indicators it is also important to take into account, if analysis is applied to developing countries or developed countries. Depending on a context selection of indicators have naturally different requirements. (Frameworkpaper, 2013, 8.)

A method is based on finding minimum and maximum levels of sustainability for economic growth. And this interval between the minimum and maximum level is called as sustainability window. (Frameworkpaper, 2013, 5.) The clearest way to explain reasoning behind the assessment tool is divide introduction with three separated figures. The figure 2 illustrates how the minimum level of sustainability for economic growth is defined. In turn, the figure 3 is presenting how the maximum level of sustainability for economic growth is defined. In the figure 4, the figures (2) and (3) are combined, when there can be found an

interval between the minimum and the maximum points. This interval is the sustainability window.

The calculation for three categorization of regions (figure 1) is based on the following two-steps. At first there will be presented calculation and interpretation of social dimension as a function of economic dimension. Secondly the same things will be went through concerning environmental dimension as a function of economic dimension.

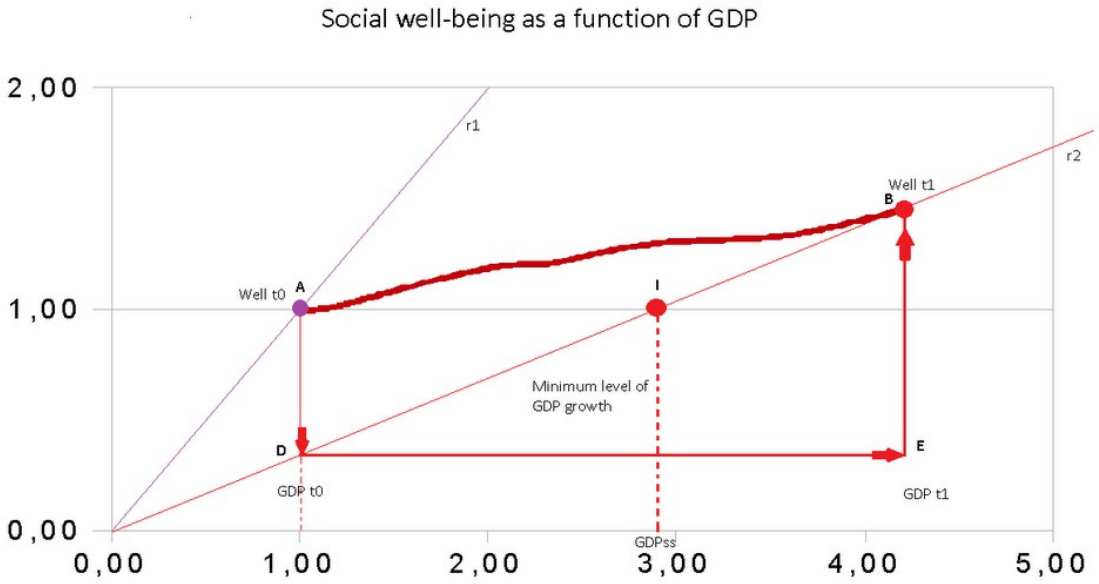

Figure 2. Changes in Social well-being as a function of GDP during 2001–2010. The minimum level of GDP growth is defined from socio-economic perspective

In the figure 2, a base year or rather a starting year is 2001 and an end year is 2010. The starting and the ending years are referring to a time period for which the sustainability window analysis is made. The relative change of GDP is plotted on x-axis and in turn, relative change of social well-being during the same time interval is plotted on y-axis. Therefore development of social well-being is indicated as a function of GDP. In the figure 2, a point A refers to the starting point for all indexed time series, which are for both GDP and social well-being. In the base year, the social well-being variable was coded as *well t0* and GDP as *GDP t0*. In turn, the social well-being of the comparison year or rather the end year was coded as *well t1* and GDP as *GDP t1*. (Frameworkpaper, 2013, 5–7.)

A socio-techno-economic production system in the base year 2001 is represented as ray 1 in the figure 2. In other words, if the system hasn't change during the time period, output of the system would have continued its advance along this ray. In turn, the ray 2 illustrates changes in the socio-techno-economic production system. This ray 2 is the new socio-techno-economic production system in 2010. Therefore, it represents a shift from the A to D, then a shift to E as a result of increased GDP, and finally as shift to B. The sum of shifts A-D and E-B is describing the changed level of social well-being as a function of GDP from *Well t0* to *Well t1* concerning Guangdong province in this example. A shift from ray 1 to ray 2 is representing social well-being "productivity" of GDP. (Frameworkpaper, 2013,7.) In other words, the sum of shifts is describing ecological modernization process from the socially sustainable point of view.

To interpret this, GDP should grow or stay at least at the level of GDPss, which refers to mimimum socially sustainable level of GDP in the figure 2. (Framework paper, 2013, 6–7.) A point, which is defining the GDPss in the figure is calculated by following formula for time period *t0- t1*:

$$\left\langle \frac{\text{Econ t1}}{\text{Econ t0}} \right\rangle \left\langle \frac{\text{Well t1}}{\text{Well t0}} \right\rangle$$

Formula (1) (Frameworkpaper, 2013)

In the formula (1) the *econ* variable represents the level of economic activity. The *econ t0* refers to economic activity in 2001, and the *econ t1* to economic activity in 2010. In turn, the *well*-variable represents socio-economic dimension in the analysis and it must be interpreted as a positive development of social dimension. Analogically the *well t0* refers to social well-being in 2001, and the *well t1* to social well-being in 2010. (Frameworkpaper, 2013, 5–7.)

In the figure 3, a base year and end year are the same as in the earlier figure 2. Equally the relative change of GDP is plotted on x-axis, and in turn SO2 emissions are plotted on y-axis. To clarify, development of SO2 emissions are indicated as a function of GDP. As in the figure 2, also in the figure 3, the point A means a starting point for both indexed time series (GDP and SO2). (Frameworkpaper, 2013, 7.)

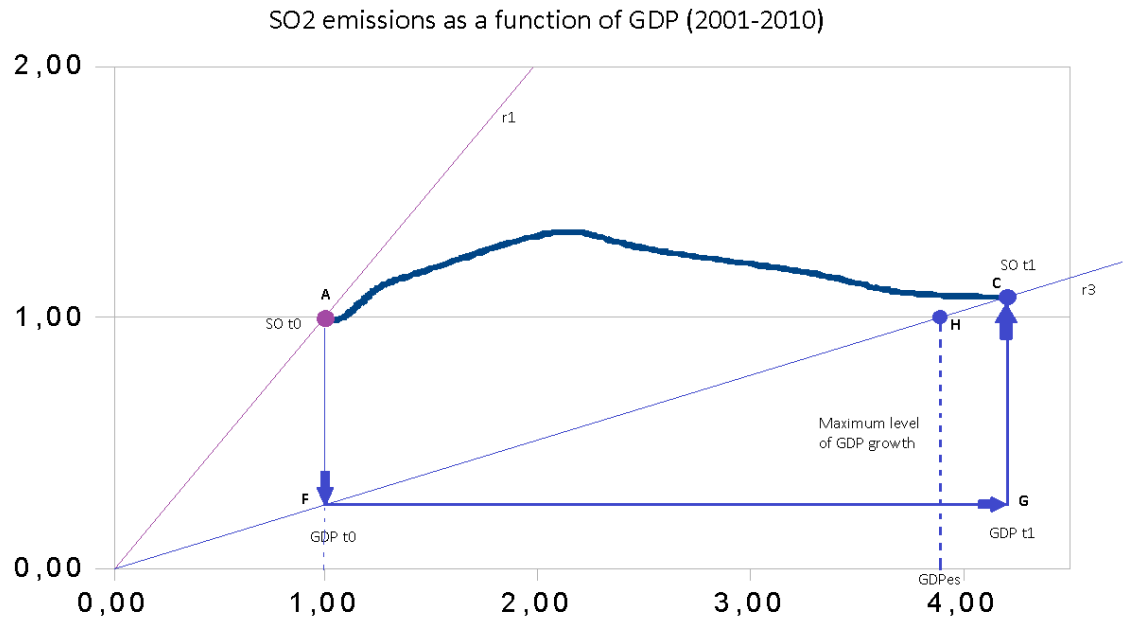

Figure 3. Changes in SO2 emissions as a function of GDP during 2001–2010. The maximum level GDP growth is defined from environmental perspective

As was in the figure 2, equally in the figure 3 SO2 emissions and GDP of the base year (2001) were coded as *SO2 t0* and *GDP t0*. Similarly, SO2 emissions and GDP of the end year (2010) were coded as following symbols: *SO2 t1* and *GDP t1*. Equally as in the figure 2, also in the figure 3 ray 1 illustrates a socio-techno-economic production system in the base year 2001. The same assumptions are applied in the figure 3 as in the second figure. However, in the figure 3, ray 3 represents a new socio-techno-economic production system in 2010. In turn, the shift from ray r1 to ray r3 describes SO2 productivity of GDP, or rather an efficiency improvement in the system. A shift from the A to F, and then a shift to G as a result of increased GDP, and as shift to C. In turn, the sum of the shifts A-F and G-C is illustrating changed level of SO2 emissions from *Env t0* to *Env t1* as a function of GDP.

A shift from ray1 to ray 3 represents SO2 productivity. (Frameworkpaper, 2013, 5–7.) In other words, the sum of shifts is describing ecological modernization process from the environmental sustainability point of view.

According to figure 3 the maximum environmentally sustainable level of economic growth is coded as *GDPes*. The emission level should not exceed the point H. To interpret this GDP should stay below or not exceed the level of GDPes, which refers to environmentally sustainable level. (Framework paper, 2013, 6–7.) In turn, the maximum bound of sustainability window is calculated by following formula:

$$\left\langle \frac{\text{Econ t1}}{\text{Econ t0}} \; \frac{\text{Env t1}}{\text{Env t0}} \right\rangle$$

Formula (2) (Frameworkpaper, 2013)

In the formula (2) the *econ* variables were the same as in the formula (1). In turn, the *env* variable represents environmental dimension of sustainability. This must be interpreted as a negative development, such as pollution. In this case the *env t0* refers to SO2 emission levels in 2001, and the *env t1* to SO2 emission levels in 2010.

In the figure 4, two earlier figures (2 & 3) are combined. The GDP is plotted on the X-axis, and both SO2 emission and social well-being are plotted on the Y-axis. Points B, C, E and G are perpendicular to x-axis, and crossing it at GDP t1. Point B refers to level of social well-being in 2010; Point C refers to level of SO2 emissions in 2010. (Framework paper, 2013, 5.)

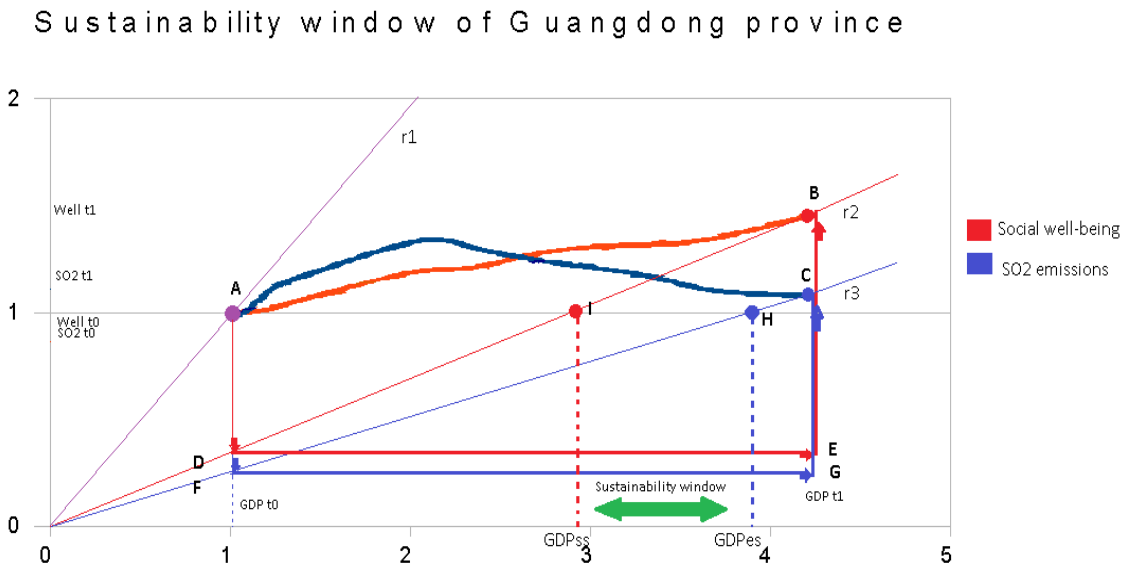

Figure 4. Changes in SO_2 emissions and social well-being as a function of GDP in Guangdong province in the period 2001–2010

In a summary, the *GDPss* point is referring to minimum socially sustainable level of economic growth and the *GDPes* to environmentally maximum level of economic growth. (Frameworkpaper, 2014, 6.) In the figure (4) the space between (I) and (H) is representing sustainability window. The same points are located as *GDPss* and *GDPes* in the x-axis, which are representing the socially and environmentally sustainable GDP growth. In other words, to be sustainable, economic growth should be somewhere between the minimum (I) and maximum (H) points. Thereby economic growth could be at sustainable level from environmental and socio-economic perspective.

Essential attention must be paid on the boundary points (*GDPss*) and (*GDPes*). Technically the minimum economic growth (*GDPss*) can be higher than the maximum economic growth (*GDPes*). Practically this means there is no existing sustainability window for the economy. (Frameworkpaper, 2013, 6.) In other words, the relative change of environmental (*env*) indicator has surpassed the relative change of social (*well*) indicator. Figure 14. (page 70) helps to illustrate a situation, where the point *GDPss* is higher than the point *GDPes*.

4.3 Operationalization

One of the main parts of the study is a careful operationalization process, which is very meaningful in quantitative analyses especially when abstract concepts, such as trust or happiness, must be converted into a measurable form. Specifying the previous sentence, the measurable properties, which are referred by theoretical concepts, will be measured. (Töttö, 2010, 168.) Before creating a new indicator or a meter to measure some phenomenon, it is important to pay attention to conceptual validity and reliability of indicator.

In a nutshell the conceptual validity, including internal and external validity, attempts to show that designed meters are measuring what it is desired to be measured. In other words, validity of claims, concepts and meters attempts to describe reality truthfully as possible. (Maxwell & Delaney, 2004, 23.) Conceptual validity is largely based on a high level argumentation and previous studies. The conceptual validity refers to internal quality of research, which basically means how selected research data and indicators created on that basis are reflecting the reality. (Yhteiskuntatieteellinen tietoarkisto, 2008.) Nevertheless, there aren't any indicators or data, which would tell an absolute truth about the reality. Everything is always based on interpretations by researcher (Singh et al., 2008, 191).

In turn, the reliability of a meter or indicator is rather related to more technical abilities of a meter, which refers to repeatability and consistency of a meter. The reliability has been divided into two different aspects: stability and consistency. The first one refers to the stability of meter in terms of time. (Yhteiskuntatieteellinen tietoarkisto, 2008.) Sometimes it is very challenging to show. The sustainability window as a methodological tool may not meet all the requirements of this. On the other hand, it may not be even relevant to have too much stability, when one is examining unstable phenomenon such as ecological modernization process. Instead, the consistency, which can be evaluated with Cronbach's alpha, which will be explained later.

Sustainability window can be counted as an indicator, which is based on systemic thinking, and it attempts to measure ecological modernization process. By applying the sustainability window is an attempt to examine the process in China. The assessment tool consists of

components, which in this case are three followings: economic dimension, social dimension and environmental dimension, as earlier noticed.

Before calculating the actual sustainability windows, it is necessary to select variables, which at least to some extent are reflecting dimensions of the three dimensions of sustainable development. The selection must be done carefully, but despite of that each quantitative variable as well as the indicator itself have problematic issues and limitations.

Like noticed in the previous part of the chapter, the socio-economic dimension in sustainability window is quite challenging to define. Basically it is dependent on available data and thought of researcher. There has been used freedom in this study to solve and build an own socio-economic or rather a social well-being indicator for the sustainability window. The indicators for illustrating economic and environmental dimensions are considerably easier to select compared to social dimension. On that account this part is mainly focused on operationalization process concerning selected indicators for sustainability window evaluation. Furthermore, the analysis method like usually had its own limitations and requirements concerning variable selections. The operationalization of the dimensions will be presented starting from the economic dimension to the environmental one and then the social one.

4.3.1 Economic dimension

When selecting variable describing economic (*Econ)* dimension of sustainability, it was naturally GDP according to previous research (Singh et al., 2008; Hara et al., 2009). A one advantage of the sustainability window tool is that economic growth is described as own dimension unlike Hara's et al. (2009) study, where GDP was aggregated as part of social dimension. Therefore in this study the methodological tool provides more information concerning relation of economic growth and social well-being. In addition, it accepts the idea of de-growth, if the efficiency of the system has not improved.

In the beginning GDP (yuan) data was presented at current GDP. However, the GDP must have comparable character between different years. Indices were calculated in Chinese

Statistical Yearbooks database, which enabled converting GDP current into the GDP constant. The transformation from GDP nominal to GDP real enables realistic comparison between the analysed years. (Kennedy, 200, 17–18.) GDP constant takes into account impact of inflation to price changes for instance. The real GDP or rather constant GDP calculation is based on usage of prices from some specific base year. (The World Bank, 2014.) Practically this provides information about output without impacts changes in prices.

4.3.2 Environmental dimension

A selection for the second environmental (*env*) dimension requires a variable or an indicator, which describes a negative development from environmental point of view, such as pollution. This is based on a matemathical requirements of sustainability window anlaysis that increase in this indicator describes negative development in environmental dimension of sustainability (Frameworkpaper, 2013, 8). In this study one was ended up to select sulphur dioxide emissions to reflect environmental dimension. Naturally the best and the most topical selection for variable would have been CO2 emissions, but data was available only for national level.

However, reasons why sulphur dioxide was the second choice, is that sulphur dioxide emissions are usually coming from the same sources than CO2 emissions such as industrial burning process, transport/traffic or energy production and fossil fuels (especially coal). (EPA, 2014.) However, sulphur dioxide has less climate-warming features than carbon dioxide, but then it has more factors, which are dangerous for health of humans, animals and plants. One example is sulphuric acid depositions, which are weakening condition of forests (EPA, 2012).

In addition, many studies of SO2 emissions have been done in the western countries already since the 70's. It is these emissions, which were serving insights into the way in which ecological modernization impacted on environmental policy making in the UK and the Netherlands for instance. Also in that time ones took seriously SO2 emissions and acid rains. On the other hand, these emissions achieved a great public attention and therefore

becoming as the emblem of environmental discourse. (Hajer, 1995, 5.) As earlier noticed in this study, China has recently faced the same situation (Schreifels et al., 2012, 779–785; Klimont et al., 2013, 4). It is interesting to examine the systemic change into more sustainable direction by policy implementations and FDG technology for instance.

In this study the data of SO2 total emission consists of emissions through industrial activities and non-industrial and other activities. Compared to availability of other air pollutant variables, sulphur dioxide data was relatively easy to get. (Chinese statistical yearbooks, 2001–2010.)

However, ones must bear in mind that SO2 emissions are not indicating the whole scale of environmental problems. It only has potential to reveal ecological modernization process in sulphur dioxide emission decrease in the system's level. This does not tell anything more or about any other type of emission development.

4.3.3 Social dimension

The third and maybe the most challenging one, the social dimension (*well*), requires a variable, which describes best social well-being of society. It is still not undisputed internationally what comes to definition of social well-being. In many cases it is defined in several ways depending on cultural context. Normally only one indicator for social well-being may give a misleading picture. For this reason there will be more space to reflect pros and cons of social well-being indicators. Despite of that few independent facts need to be taken into account when selecting variables.

When calculating sustainability window, there are few mathematical requirements for indicator. Increase in well-indicator needs to describe positive social development. (Frameworkpaper, 2013, 8.) It is highly value-based issue, what is defined as socially sustainable development. In this study, there was ended up in a solution to build a social well-being composite indicator from three basic indicators. It consisted of private owned vehicles, employment and literacy. Like earlier noted, there is not a clear definition of

social well-being, but previous selections were based on earlier studies and literature (Singh et al., 2008.)

Possession of Private Vehicles (passenger vehicles 10 000 units) were gathered from the set of Possession of Civil Motor Vehicles, which refers to the total number of vehicles that are registered and received vehicles license tags from The Transport Management Office under the department of public security at the end of the reference period. Possession of Civil Motor Vehicles is divided into a structure of motor vehicles and into an ownership of private vehicles (passenger vehicles) and vehicles for the unit's use. Noteworthy is that the ownership of private vehicles includes cars. The ownership of private vehicles was used in the analysis. In turn, the Employment rate refers to employed population in each province, and Literacy rate has taken account the literate population. (Chinese statistical yearbooks, 2001–2010.)

Widely accepted and used indicator for measuring social well-being has been private consumption or private property, even if it doesn't impact on well-being of the poorest population. In this light, especially private owned vehicles can be seen as one of the best indicators of social well-being. (Norton, 1998, 243.) Practically this may not reveal poverty rates, but increased middle-class. In this study the focus is on increased well-being, which means that private ownership or consumption is indicating social well-being at some extent. There are several studies that are supporting the private vehicles such as car ownerships as an indicator in terms of social well-being (Chamon, Mauro & Okawa, 2008, 5, 24, 39). This is also revealing the phenomenon of proliferation of middle-class in China. According to Li Chunling (2004) there are several ways to explore the rise of middle-class, and it is important to pay attention to increased consumption of durable goods such as cars or televisions, which are usually revealing at least inaccurate size of the middle-class.

In other words, basing on the previous statement, the rate of private owned vehicles are indicating relatively well direction of social well-being especially in developing countries nowadays. Similarly private owned cars indicated increase in social well-being in western countries, within their developing phase for example in United States in the beginning of 1900s and in Europe after the Second World War. (Chamon et al., 2008, 7–8.)

As the research shows car ownership rates are minimal in the lowest income countries, but have increased via economic growth including income growth simultaneously. The same has happened in China during the last fifteen years. As studies shows post-war period car ownership rates were relatively low during the 60's in Europe. Equally the same occurred in US before The First World War. These car ownership booms were mainly a consequence of car mass production and increased income levels. (Chamon et al., 2008, 7–8.)

According to Chamon et al. (2008) private ownership of cars or vehicles is indicating better both income distribution and purchasing power of Chinese population than computers and other electronics. For example the study shows that consumer goods per 100 households in 2006 were the followings: computer 47,2 and mobile telephones 152,9 in urban China when automobile rates were only 4,3. In other words, this means that car is a different consumer good, which can be bought easily by middle-class, but not the poorer sections of population. However, the previous data was not available from rural areas. (Chamon et al., 2008, 5, 24, 39.)

In general, there are plenty of reasons why car ownership is a relevant variable, when creating indicator of social well-being. First, cars are relatively homogeneous product and not dependent on time or country so far. Even if price of cars has declined during the decades, the prices are still relatively high, meaning that only middle-class population is able to buy cars. (Chamon et al,. 2008, 3.)

The second part for the composite social indicator was employment rate. Generally one may think that employment may not tell a lot of social well-being. At some point the previous argument is true, but on the other hand it depends on a place, time and cultural context when employment rate is indicating more or less well-being. For example employment does not indicate social well-being so clearly in Finland mainly because of a universal unemployment benefits among many other assistance services (STM, 2007, 4). The same cannot be said about developing countries or China for instance, where insufficiency of comprehensive social security systems is reality (Shi & Sato, 2006, 3).

Usually poverty has been the worst in rural China, but since the 90's there has emerged a new urban poverty phenomenon, which is highly linked to unemployment in urban areas. This is mainly a consequence of two reasons: massive flow of rural-urban migration brings rural poverty to urban regions and insufficient financial assistant for unemployed people. (Shi & Sato, 2006, 3.)

Basing on the preceding, Finland can be counted as a welfare state in so far, but a welfare system of China is a totally different kind of. There is not a universalistic social security system for population. Basically the most comprehensive social security system is integrated to hukou-registration (residence registration system). The system covers only the local population access to health and social services. On a one hand social health insurance doesn't cover all unemployed (Shi & Sato, 2006, 3). The health insurance scheme is managed by the Government and it comprises both rural and urban areas. However, rural farmers are mainly funding medical care system by themselves, when Government or state-owned enterprises are funding the urban ones. (Hu, Cai & Zhai, 1999, 77.) Roots of the registration system extend till 1950's, when it was developed by controlling spontaneous migration from rural to urban areas. According to Luova's article, almost half of migrant workers in East China have no access to health and social services. (Luova, 2005, 52–53.) This emphasizes the significant role of job as indicating social well-being in China.

It can be concluded that employed persons are having better chances for at least some sort of social well-being compared to unemployed or employed without the legal *hukou*-registration system. Employed people have at least incomes, which may not indeed lead to huge profits. Employment data like all other data used in this study includes population within the hukou-system (Chinese statistical yearbooks, 2001-2010). Thus this also means that the employment statistics doesn't take into account illegal or migrant workers outside of the hukou-system. There have been done many evaluations about rates of migrant workers. According to estimation, 130 million migrant workers were living in urban areas in 2004, but any accurate rates are not made. (Luova, 2005, 52.) This fact reveal distorts of the official employment data, and research results must be interpreted with caution.

The third significant selection for the composite indicator is literacy rate. The ecological modernization theory has been critiziced for a lack of agency. And it has been attempted to complement by paying attention to citizen-consumers. (Spaargaren, 2000, 56–57.) The private owned vehicles are representing the citizen-consumer-part, but approach should be wider. It should also take into account other parts of agency.

Literacy is a very important enabler, because most of contemporary world is always based on texts in some form. Logically, literacy increases and promotes capacity of agency. Also Anthony Giddens (1984) paid a lot of attention to role of agency and noted that also both body and system organization has both constraining and enabling characteristics. He also noted the following: "*A literate population can be mobilized, and can mobilize itself, across time-space in ways quite distinct from those pertaining within largely oral cultures"* (Giddens, 1984, 261).

According to Bynner's (2002) British Cohort Study, functional literacy and numeracy skills promote gaining employment and more likely to progress in the workplace in the Great Britain. The skills didn't totally prevent from unemployment or poverty, but decreased the risk of it (Bynner, 2002, 26). In addition, another study showed that literacy had positive impacts on health. According to other study illiteracy or low literacy skills predicted poorer physical health than with literacy skills, with statistically significant level ($P < 0.002$). (Weiss, Hart, McGee & D'Estelle, 1992, 257–264.)

Literacy is a quite good complement for the package of social well-being, because it empowers people. Especially literacy skills are almost necessary in contemporary information society, which is very far developed in China as well (Donald, 2000). By interpreting this, literacy can be seen very significant well-being indicator, which is also generating active agency. According to Donald (2000), it increases probability of employment especially in service and IT sectors, which are increasing trends in China (The World Bank & Development Research Center of the State Council, the People's Rebulic of China 2013, 191).

4.4 A new built well-being indicator

While applying the sustainability window as an assessment tool at China's province level, it was clear that only one indicator to measure social well-being wouldn't tell enough. For this reason, there had to bring something more into a model. The best choice to solve the problem was to build a composite indicator to represent social well-being. This is commonly used method in the sociological field as well as in the field of sustainability assessment (Singh et al, 2008, 197, 206–207; Metsämuuronen, 2008, 9). In addition, the idea of combining the social indicators is to give a more comprehensive picture of a condition of social well-being in each provinces.

For this reason Principal component analysis was exploited in this study to examine whether social indicators constitutes a communal component. Analysis was implemented for three indicators describing social well-being: Private owned vehicles, Employment and Literacy. Also Saving deposits of household was in thought, but was left to the discretion, because of the lack of consistency with other indicators. Additionally, there was some issues concerning the validity of saving deposits data in Chinese statistics. (Koch-Weser, 2013, 4).

A main purpose of Principal Component Analysis, PCA is to compact common features of information from larger data into a brief component. Generally, the Principal Component Analysis compacts information from a correlation matrix of variables. Components and factors are so called groups of variables behaving in the same way. In other words, they are linear combinations of original variables. In addition, there are some basic requirements for data. Firstly, there must be correlations between original variables. Secondly it can be applied for numerical continuous variables and ordinal variables as well. (Metsämuuronen, 2008, 28-32.) A composite indicator should be based on a theory, pragmatism, empirical analysis or at least intuitive appeal. It is quite accepted to use Principal Component and Factor analysis when constructing sustainability assessment tools (Singh et al., 2008, 195).

Kaiser-Meyer-Olkin-test (KMO-test) and Bartlett's Test of Sphericity indicates relevance and sufficiency of correlation matrix for PCA analysis. The KMO-test must exceed 0.6 or 0.5 depending on the author (Metsämuuronen, 2008, 36; Kaiser, 1977). In turn, in the

Bartlett's Test of Spherecity significance of level must be below ($p < 0.05$), which verifies suitability of data for Principal Component Analysis. (IBM: Case Studies, 2014).

There is some debate concerning the limits, but rules above are followed in this study. There can also be found some critical dicords towards PCA and EFA, because these analyses may include very subjective selections (Sing et al., 2008). However, there exists theories and critical thinking, which can help one when making selections concerning the analyses.

Goodness of component or factor model can be examined by evaluating its content or by assessing communaltities and component loadings. The latter one is called eigenvalue, which is taking into account each loading of variable in the principal component. General rule has been that eigenvalues of extracted principal components should be at least 1. In turn, communalities of variables should exceed 0.30. Finally to examine consistency of variables is verifying if the variables are reflecting the same latent factor. This can be evaluated by using Cronbach's alpha. (Metsämuuronen, 2008, 28–31.)

Like Singh et al. (2008, 209) stated that there are statistical scientific rules, which guarantee meaningfulness and consistency of composite indicators. (Singh et al., 2008, 209.) Again, the rules can be misleading without critical sociological thinking. A dialogue between these two will guarantee better composite indicators.

5 RESULTS

This chapter consists of three parts. In the first part, results of the Principal Component Analyses, which validates suitability and functionality of composite indicator of social well-being, will be presented. The second part includes results of sustainability window analyses, which were done for 25 provinces and the final part consists of three case provinces, which are representing three different phases of ecological modernization process. The cases were selected basing on their different conditions in terms of sustainability assessment, and their location: the one from the north-east area, the other from the south, and the third one from the west area.

5.1 Results to build social well-being composite indicator

A practical way to create an indicator for social well-being was to build a composite indicator by implementing the Principal Component Analysis to verify suitability of the data. Analyses were done with SPSS 20. A suitability of the data was assessed by applying KMO's test (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) and Bartlett´s Test of Sphericity. KMO's test results were between (*.510–.785*) and Bartlett's was very significant $p < .001$ concerning each analysed provinces. (Table 1.)

Table.1 Kaiser-Meyer-Olkin Measure of Sampling Adequancy and Bartlett's Test Of Sphericity from each analysed provinces of China. Bartlett's test is statistically highly significant *** p<.001

KMO & Bartlett's tests	
Beijing	,634 ***
Tianjin	,639 ***
Hebei	,571 ***
Shanxi	,781 ***
InnerMongolia	,743 ***
Liaoning	,785 ***
Jilin	,758 ***
Heilongjiang	,763 ***
Shanghai	,587 ***
Jiangsu	,744 ***
Zhejiang	,710 ***
Fujian	,510 ***
Jiangxi	,763***
Shangdong	,752 ***
Guangdong	,785 ***
Guangxi	,524 ***
Hainan	,780 ***
Guizhou	,596 ***
Yunnan	,746 ***
Tibet	,722 ***
Shaanxi	,615 ***
Gansu	,684 ***
Qinghai	,701 ***
Ningxia	,761 ***
Xinjiang	,726 ***

There exists a recommendation that a sample size should be 200-300 (Metsämuuronen, 2008, 29). The data was relatively small for the Principal Component Analysis. However, Metsämuuronen (2008) also noted, that small data is also suitable if correlations between the variables are high. Correlations were high concerning all variables of each province (Appendix 1 and 2). Despite of the small sample size, the Principal Component Analysis was carried out, because it served very well the main analysis tool of the study.

Table 2 . Results of the Principal Component Analysis from 25 provinces

	Principal component analysis					
	Communalities					
	Employment rate	Literacy	Private owned vehicles	Eigenvalues	Cumulative %	Cronbach's alpha
Beijing	0,964	0,983	0,994	2,941	98,03	0,942
Tianjin	0,96	0,993	0,985	2,938	97,935	0,822
Hebei	0,928	0,96	0,992	2,881	96,025	0,898
Shanxi	0,981	0,969	0,982	2,932	97,75	0,919
InnerMongolia	0,989	0,962	0,985	2,936	97,857	0,911
Liaoning	0,977	0,979	0,985	2,942	98,047	0,917
Jilin	0,932	0,905	0,952	2,789	92,964	0,912
Heilongjiang	0,967	0,93	0,966	2,862	95,416	0,941
Shanghai	0,91	0,909	0,987	2,806	93,926	0,691
Jiangsu	0,98	0,937	0,975	2,892	96,409	0,882
Zhejiang	0,967	0,961	0,989	2,917	97,23	0,883
Fujian	0,93	0,912	0,996	2,838	94,613	0,823
Jiangxi	0,919	0,959	0,959	2,837	94,572	0,791
Shangdong	0,956	0,956	0,98	2,892	96,404	0,913
Guangdong	0,98	0,969	0,978	2,927	97,558	0,829
Guangxi	0,906	0,367	0,941	2,214	73,792	0,592
Hainan	0,966	0,981	0,981	2,928	97,584	0,847
Guizhou	0,909	0,464	0,908	2,28	76,015	0,619
Yunnan	0,968	0,934	0,977	2,879	95,964	0,789
Tibet	0,959	0,913	0,976	2,847	94,914	0,729
Shaanxi	0,692	0,839	0,93	2,46	81,999	0,682
Gansu	0,774	0,912	0,941	2,628	87,59	0,713
Qinghai	0,943	0,983	0,946	2,872	95,741	0,735
Ningxia	0,917	0,961	0,955	2,833	94,446	0,724
Xinjiang	0,969	0,981	0,932	2,882	96,071	0,721

Extraction method was Principal Component Analysis and rotation method was accomplished with Varimax analysis. Variables loaded well into a one component with high communalities (0.69–0.98) concerning each provinces social indicators (Table 2.) As expected, only one component was extracted from each province with initial eigenvalues were between 2,214–2,942. According to Metsämuuronen (2008) a rule of thumb for

proper eigenvalues must reach to 1.0. Components were able to explain 73,79–98,03 % of variance of the variables.

Cronbach's alpha concerning all assessed provinces were between 0,59–0.94 (Table 2). Internal consistency between private owned vehicles, literacy and employment was mainly good or excellent in 21 provinces, but only acceptable in four provinces, which were Shanghai, Guangxi, Guizhou and Shaanxi. According to Metsämuuronen (2008) internal consistency should reach to $0.6 \leq \alpha < 0.7$ to be acceptable. When the object of research is the real world, which consists of so many factors, it is perfectly understandable that consistency is not excellent in each province. As a summary all three variables are describing the same dimension of social well-being. It was relevant enough to carry out the Principal Component Analysis, and build the composite social well-being indicator on this basis.

The data was also tested with Confirmatory Factor Analysis (CFA), but concerning the comparison PCA and CFA the first one turned out to be the best choice for this data. According to Metsämuuronen (2008) CFA is used is selected when there is a theory behind the idea. However, PCA provides more illustrative information about the data. Regardless, both analysis methods supported suitability of the data.

5.2 Results of sustainability window analysis

According to the table 3 below, ten out of 25 assessed provinces had sustainability window, which were Beijing, Tianjin, Hebei, Shanxi, Shanghai, Jiangsu, Zhejiang, Shangdong, Guangdong and Guizhou. All of them are located in the Eastside of China, expect the Guizhou province, which is in the south of center (Figure 6). According to table 3 the widest sustainability window was in Beijing province, and in turn Shanxi had the narrowest one. This can be interpreted that Beijing's ecological modernization path gave more space for sustainable economic growth compared rest of the provinces with sustainability window. In turn, Shanxi had the least space for economic growth, and for this reason economic growth has already exceeded its sustainability limit.

Table 3. Sustainability window results from each province of suitable data during 2001–2010. The *Min Growth %* means minimum economic growth. In other words, economic growth should not be under that. In turn, *Max Growth %* refers to maximum economic growth, which should not be exceeded. *SW* means that there exists sustainability window. *Actual Growth%* refers to actual economic growth of each province. Ultimately, *Growth is in SW* refers to fact that actual economic growth is inside of sustainability window, which means that in this scale development is on sustainable level

	Min Growth %	Max Growth %	SW exists	Actual Growth%	Growth is in SW
Beijing	47	772	x	400	x
Tianjin	244	444	x	378	x
Hebei	204	270	x	254	x
Shanxi	318	372	x	392	
InnerMongolia	513	233		620	
Liaoning	203	187		250	
Jilin	266	205		310	
Heilongjiang	163	68		182	
Shanghai	135	357	x	246	x
Jiangsu	248	365	x	326	x
Zhejiang	199	254	x	306	
Fujian	169	62		232	
Jiangxi	261	127		315	
Shangdong	241	356	x	307	x
Guangdong	190	290	x	321	
Guangxi	283	213		306	
Hainan	189	146		255	
Guizhou	271	392	x	309	x
Yunnan	171	136		230	
Tibet	138	-30		267	
Shaanxi	370	315		423	
Gansu	222	152		276	
Qinghai	238	7		336	
Ningxia	342	254		449	
Xinjiang	185	82		258	

To clarify the output of the sustainability analysis, provinces can be categorized in three different classes as the figure 5 shows. These classes consist of all possible outputs of sustainability window analysis.

Analyzed provinces categorized in terms of sustainability	
Socially and environmentally sustainable economic growth	Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Shangdong and Guizhou
Socially sustainable, but environmentally unsustainable economic growth	Zhejiang, Shanxi and Guangdong
Socially and environmentally unsustaianble economic growth	Inner-Mongolia, Liaoning, Jilin, Heilongjiang, Fujian, Jiangxi, Guangxi, Hainan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang

Figure 5. Analyzed provinces in different sustainability classes in terms of sustainability window

According to table 3 and figure 5 seven provinces, out of the ten provinces with existing sustainability window, had economic growth inside of the window. These provinces were Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Shangdong and Guizhou. In these cases provinces had a sustainability window and actual economic growth exceeded the minimum level of economic growth, which was required for socially sustainable economic growth. Secondly, the actual economic growth remained below the level of maximum economic growth. In other words, also from environmental viewpoint economic growth seems to be sustainable. This means that the actual economic growth was inside of the window, and therefore the actual economic growth is on sustainable level socially and environmentally. Practically this means that relative changes of three dimensions were based on sustainable development path.

Three provinces out of the ten had sustainability window, but actual economic growth exceeded both level of minimum economic growth and level of maximum economic growth as a function of GDP. In other words, actual economic growth was too high at the expense of environmental viewpoint, but good enough from the social well-being point of view. For this reason economic growth is not inside of the window, and the actual economic growth is socially sustainable, but environmentally unsustainable. The situation was in the following provinces: Zhejiang, Shanxi and Guangdong provinces.

In turn, 15 provinces had no existing sustainability window, which were Inner-Mongolia, Liaoning, Jilin, Heilongjiang, Fujian, Jiangxi, Guangxi, Hainan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. Most of the provinces were located in the West part of China. Also 5 provinces (Heilongjiang, Jilin, Liaoning, Jiangxi and Fujian) without sustainability window were located in in the east-coast areas. (Figure 6.) In these cases there is no existing sustainability window, because the minimum economic growth point exceeded the maximum economic growth point, which means that there is no space for sustainability window. In addition, actual economic growth is higher than the both required levels. As a result, actual economic growth is not based on sustainable practices, and the system is quite far from the ecological modernization process.

In the figure 6 there is a map, where all analysed provinces are coloured. According to figure 6 there can be seen that only provinces in the east coast area has sustainability window, except the Guizhou province. In turn, none of west China's provinces had sustainability windows. Widely said, all provinces with sustainability window have relatively smaller surface are than provinces without the sustainability window.

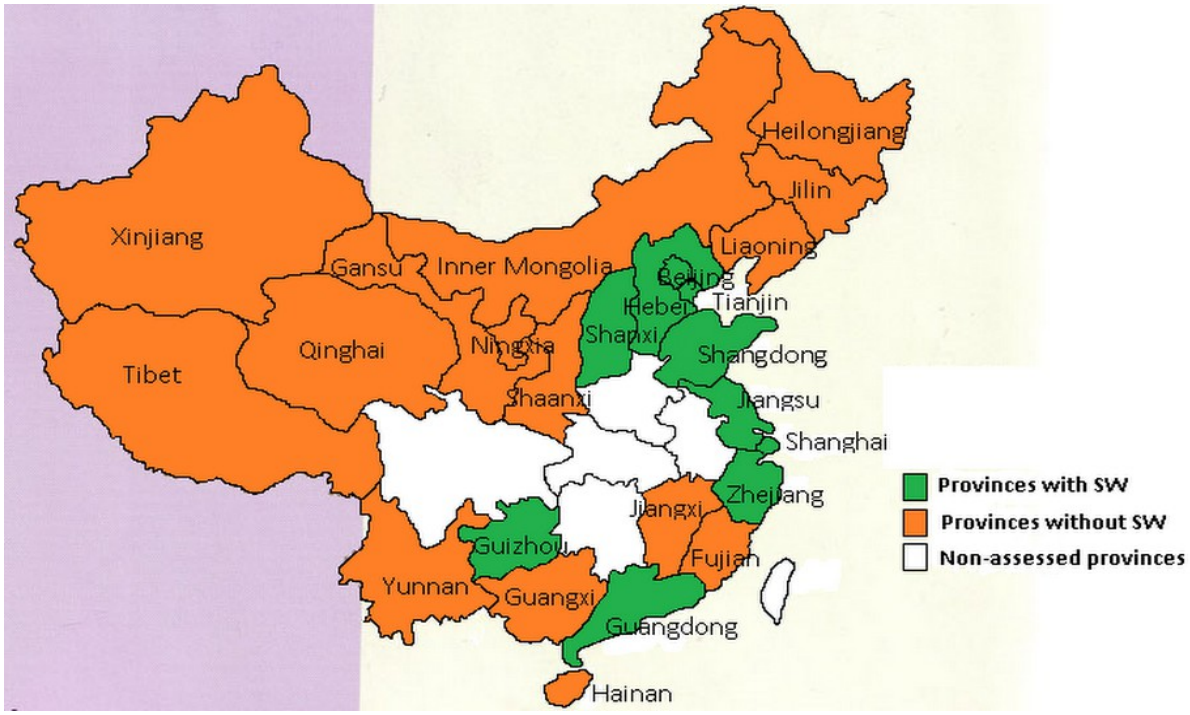

Figure 6. Map of China's provinces, where the sustainability analysis was carried out. The green areas refer to provinces, which have sustainability window available. The orange areas refer to provinces which have no existing sustainability window. The white areas are not assessed in this study

There must be taken at least brief review into cases to observe more detailed results and ecological modernization processes in socio-techno-economic production systems. The first case is Hebei, which had a sustainability window and economic growth within it. The second one is Guangdong province with sustainability window, but the economic growth wasn’t inside of the window. In turn, the third province is Xinjiang province, which didn’t have sustainability window at all.

5.3 Three case provinces (Guangdong, Hebei and Xinjiang)

To get a better understanding of development paths of each case province, the sustainability dimensions should be viewed separately at first. The case analyses also increase understanding of sustainability analysis and how it was constructed. In other words, trends of the sustainability dimensions were functioning as a basis for sustainability analysis. In the beginning will be presented GDP development of each province, secondly SO2 emissions and finally the development of social well-being during the years 2001–2010.

According to the figure 7 from the beginning of time scale till 2010 Guangdong had the highest GDP rate compared to Xinjiang's and Hebei's GDP rates during the whole time. Hebei had the second highest GDP rate and finally Xinjiang had the lowest GDP rate in this comparison. All GDP rates had increasing trends.

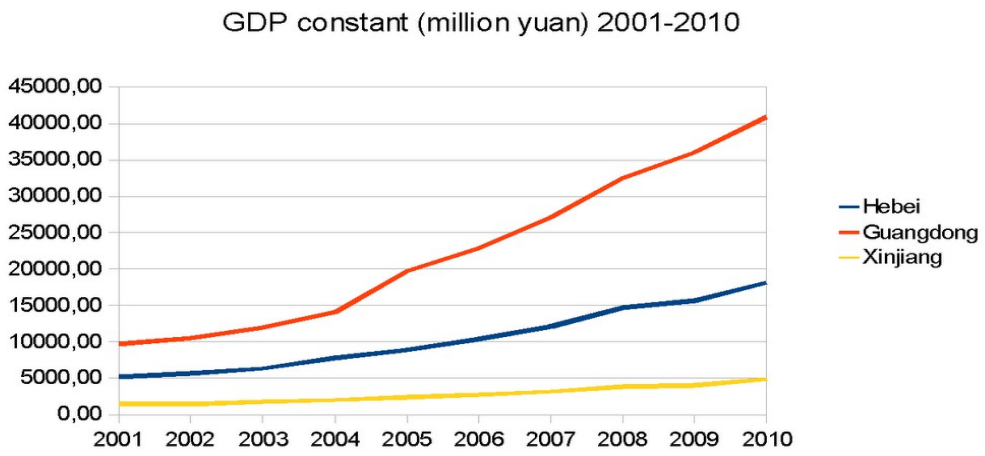

Figure 7. GDP constant (million yuan) from Hebei, Guangdong and Xinjiang provinces during the time 2001–2010

According to the figure 8 Hebei had the highest SO2 emissions in the province comparison. Guangdong had the second highest emission rates, and Xinjiang the lowest ones. Despite of this there can be clearly seen that Hebei's and Guangdong's emission development paths had decreasing trend. Only Xinjiang's trend seemed to be increasing slowly and then it was stabilized on the level of 60,000 tons since 2007.

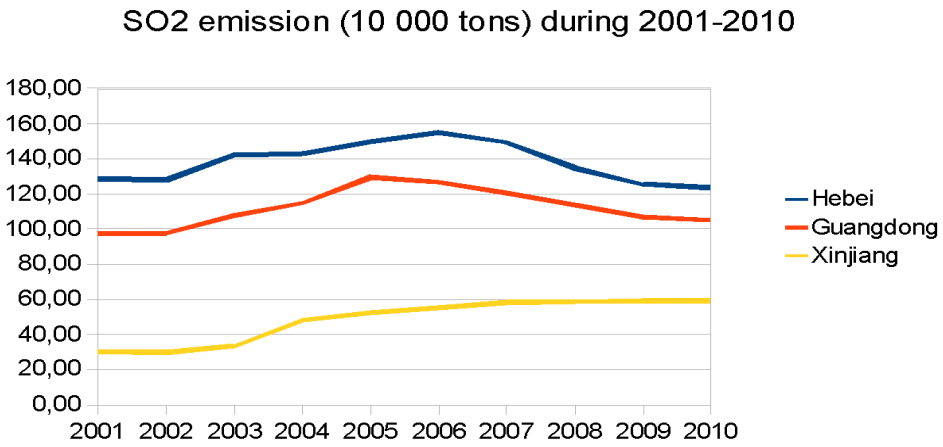

Figure 8. SO2 emissions (10 000 tons) from Hebei, Guangdong and Xinjiang provinces during the years 2001–2010

There can be concluded that the Hebei, which had the actual economic growth inside of the window, had also higher SO2 emission levels than Guangdong. In turn, Guangdong had sustainability window but the actual economic growth was not inside of the window, but it had lower level of SO2 emissions than the Hebei province. There the relativity of change in GDP and SO2 emissions was revealed. If the GDP growth trend were the same in the Hebei province as in the Guangdong, SO2 emissions would be clearly lower than in Guangdong's emissions. This is because the socio-techno-economic production system is much more efficient in Hebei's province. In other words, the system of Hebei produce less SO2 emissions as a function of GDP than Guangdong province's system. In turn, overall the GDP of Xinjiang was very low, and also SO2 emissions, compared to the two other provinces. However, SO2 emissions were relatively too high for such low GDP, which indicated inefficient socio-techno-economic production system.

According to figure 9 the Guangdong province had the highest rate of social well-being in the comparison of the provinces during the years 2001–2010. Hebei had the second highest well-being rate. Both provinces had increasing trends of social well-being, but the Guangdong's trend had. In turn, the Xinjiang province had the lowest rate of social well-being, but the trend was slightly increasing.

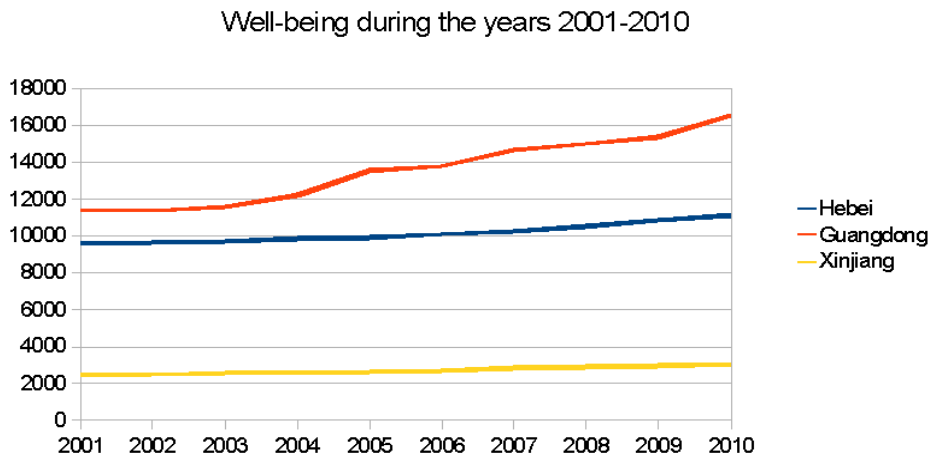

Figure 9. Composite indicator social well-being from Hebei, Guangdong and Xinjiang provinces during the years 2001–2010

The composite indicator of social well-being was applied in sustainability window as a dimension of social well-being (*well-indicator*). The well-indicator does not take into account the population growth, which is however very regularized by one-child policy in China (Zhang & Song, 2012, 306). Hence there might be a problem that the well-indicator is only illustrating changes in statistical population rate. For this reason the proportional growth of the well-indicator need to be compared with the population growth of assessed provinces. Because the method is relatively new and applied in a new way, it is also interesting to view how the development of social well-being differs from the population growth. The purpose of this brief review is to assess validity of the well-indicator.

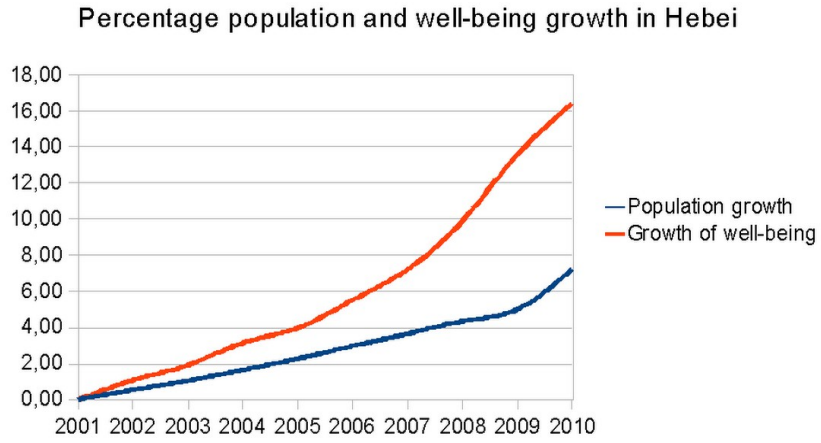

Figure 10. The percentage growth comparison of Hebei province during the years 2001–2010

According to figure 10 Hebei's population growth and growth of social well-being developed at quite different pace. As a whole, social well-being increased slightly over 16 % from the base year (2001) level till 2010. In turn, population growth exceeded 7% from the base year till 2010. Both curves developed pretty evenly from 2001 till 2007, when social well-being increased strongly compared to population growth. In turn, after 2009 population grew slightly faster than earlier years, but percentage growth was almost over three times smaller than social well-being.

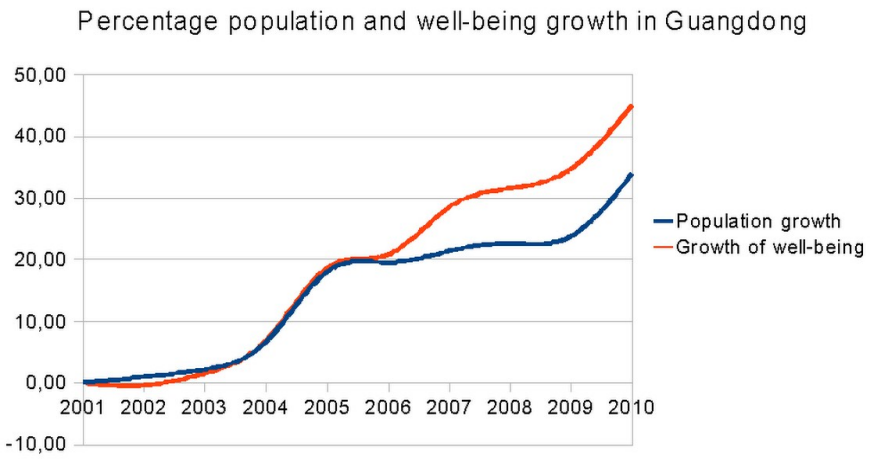

Figure 11. The percentage growth comparison of Guangdong province during the years 2001–2010

In the case of the Guangdong province, the growth of social well-being developed almost at the same pace with the population growth starting from the base year till 2006, as the figure 11 shows. Noteworthy is that social well-being even decreased below the level of population growth in 2002, but reached it again in 2003. Also percentage growth in both curves, were approximately at the same level from 2003 till 2006. However, since 2007 the development of curves diverged till 2010. During that time social well-being grew faster than population. As a whole, social well-being grew circa 45 % from the base year till 2010, and population 34%. Both curves increased relatively much in short time period.

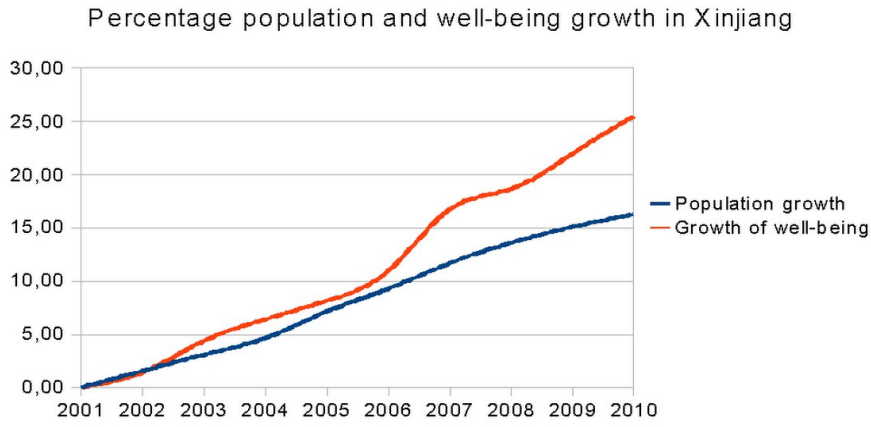

Figure 12. The percentage growth comparison of Xinjiang province during the years 2001–2010

According to figure 12 the westernmost province Xinjiang increased its population over 16% from the base year. In turn, social well-being grew over 25 % comparing to the base year level. Both curves developed almost in the same pace for first two years. Since 2003 the development of social well-being accelerated till 2006, but slightly compared to population growth. The population growth developed in a controlled manner. Finally, since 2007 the curve of social well-being separated its development from population growth with a little faster pace till 2010. On this basis can be noted that development of social well-being separated clearly from population growth in 2007 concerning Xinjiang province.

In summary, the social well-being seemed to increase a lot faster than population growth in this time period. In the beginning till 2006 the growth rate of social well-being developed quite same pace with population growth, but since that the curves grew relatively faster compared to population growth curve till 2010. There can also be noted that development of social well-being of Xinjiang was clearly backward compared to Hebei and Guangdong provinces. Also in sustainability analysis indicated similar conditions.

Practically this means, that the growth of social well-being is not totally a result of population growth. However, one must bear in mind that social well-being is always measuring well-being of people. Automatically this means that we need people to measure that. Of course that kind of indicator is always dependent on population and population growth at some extent. If the curves were exactly similar at every point, then trend of social well-being growth could be too similar with population growth.

In other words, basing on the previous assumptions there has occurred actual improvement in social well-being in China. If lines in the figures were very similar, this could mean that most of improved well-being is largely a result of population growth. On this basis the well-indicator seems to be working and measuring properly of social well-being.

5.4 Changes in the system

In the methodological chapter, there was presented the figure 4 of sustainability analysis of Guangdong province. That was one of the case provinces. In this part also the two other

case provinces must be described in same terms, because this increases understanding of sustainability analysis. The figures reveal also main differences between the provinces and the progression phase of ecological modernization.

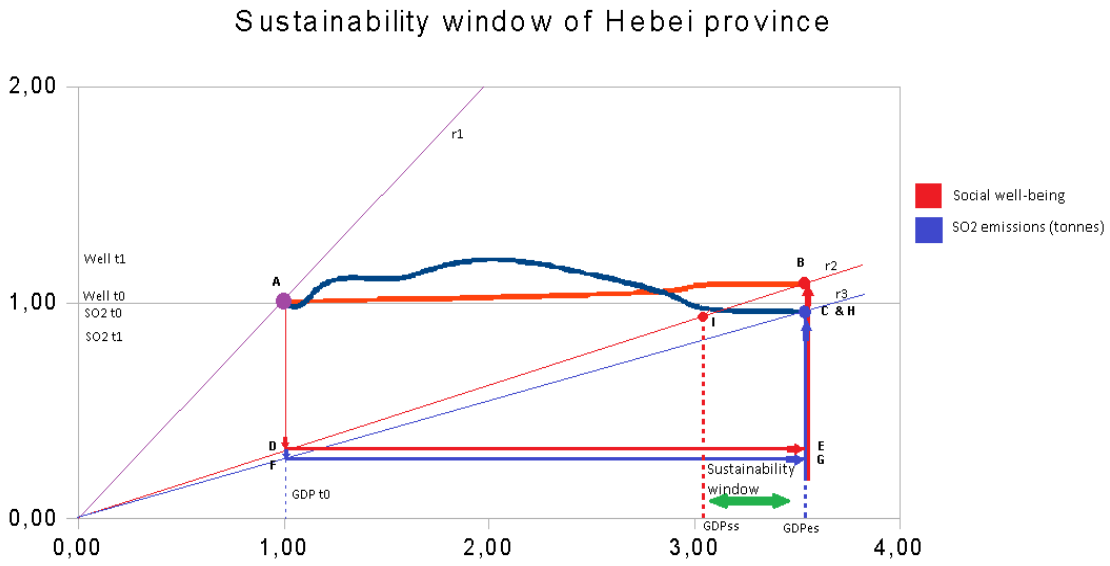

Figure 13. Changes in SO_2 emissions and social well-being as a function of GDP in Hebei province in the period 2001–2010

The first case was selected on the basis, where the province has a sustainability window and actual economic growth inside of the window. In the figure 13 can be found a systemic change in SO2 emissions and in social well-being in Hebei during the years 2001–2010. The development in this time interval reveals how the ecological modernization process has progressed in Hebei province. A shift from ray 1 to ray 2 represented increased productivity of social well-being and in turn a shift from ray1 to ray3 efficiency improvement from environmental perspective. In other words, the latter shift referred to a decrease in productivity of SO2 of GDP in Hebei province. The productivity of social well-being as a function of GDP has increased sufficiently. In turn, the productivity of SO2 emission has decreased in same terms Ecological modernization process seemed to be quite advanced, because relative changes of social well-being and SO2 emissions as function of GDP led to sustainable development in terms of sustainability window analysis.

The second case was the Guangdong province, which provided a good example of the situation, where can be found a sustainability window, but economic growth is not inside of it, meaning that the economic growth is not on a sustainable level in the current socio-techno economic production system. Either by ecological modernization process with the new socio-techno-economic production system wasn't sufficient for sustainable development. Practically this would mean that if the system's indicators continued its way along r2 and r3, it would require de-growth of GDP to reach sustainable level. As there can be seen in the figure 4. (page 47), that ecological modernization process was far enough to have a potential for sustainable economic growth.

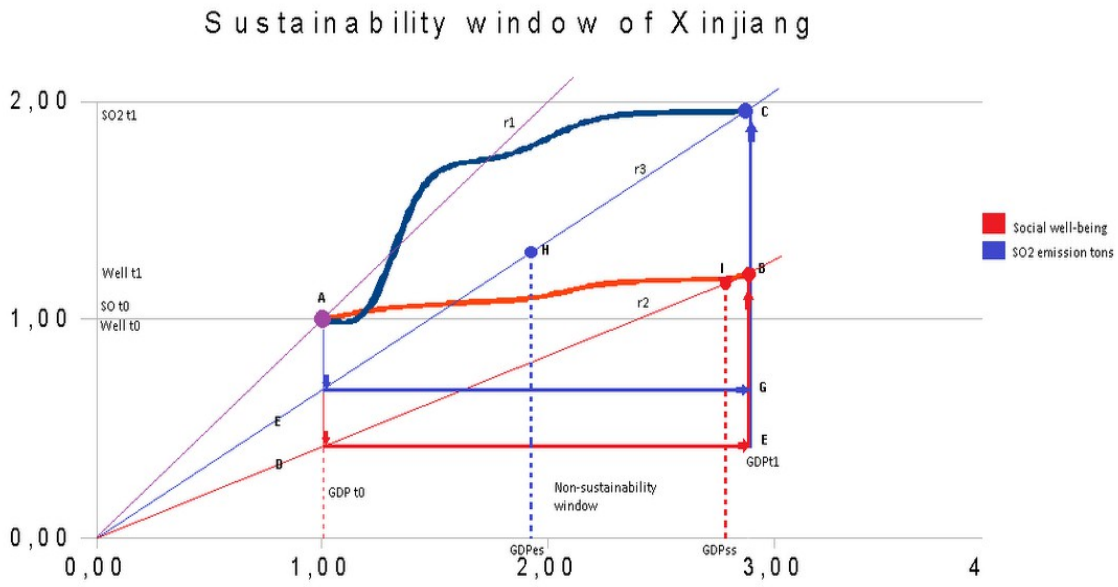

Figure 14. Changes in SO_2 emissions and social well-being as a function of GDP in Xinjiang province in the period 2001–2010

In turn the last case province was selected on the basis, where is no existing sustainability window. The figure 14. is illustrating the situation of Xinjiang province during the time 2001–2010. A shift from ray1 to ray 2 represented increased productivity social well-being of GDP. The relative change has been quite steady with slight increase. In turn, a shift from ray1 to ray 3 showed that inefficiency from environmental perspective. In practice, SO2 emissions as a function of GDP only increased, even if they should decrease. In this case ecological modernization process was not sufficient to improve a new socio-economic-

techno production system into a sustainable level. The process seemed to be very inefficient from both environmental and social viewpoints. There was no sustainability window available, which meant a lack of potential in the new socio-techno-economic production system of Xinjiang province.

6 CONCLUSIONS AND DISCUSSION

The economic growth has been very fast in China within its negative side-effects. Finally China has woke up for consequences of air pollution approximately a decade ago. Especially this can be seen from China's 10th Five Year Plan, where environmental protection goals were included in, especially SO2 emission regulations (Schreifels et al., 2012, 779). Additionally, there has been a great development gap between the east and the west part of China economically, socio-culturally and environmentally (Nojonen, 2000, 38–41; Lu, 2012, 54). Basically this means, that both pollution levels and economic growth as well as social well-being have been distributed unequally between the provinces as case analyses in this study showed. In other words, all that indicates that China is trying to ecologize their modernized society. For this reason the study focused to examine sustainability differences between different provinces, which included the westernmost and the easternmost provinces.

Above there has been analysed China's provincial sustainability in the ecological modernization reference of frame by assessing three dimensions (economic, environmental and socio-cultural) presented in the concept of sustainable development. A purpose of the study was to examine how the socio-techno-economic systems of China's provinces have changed during the years 2001-2010. Theoretically asked, how ecological modernization process has advanced in Chinese provinces and how they have succeeded to change its track towards sustainable development during that time? Because there can be found huge developmental differences between the provinces, it was interesting to ask: What kind of differences there can be found between the provinces and between the easternmost and the westernmost provinces?

Ten of the 25 analysed provinces during the years 2001–2010 had sustainability window. They were Beijing, Tianjin, Hebei, Shanxi, Shanghai, Jiangsu, Zhejiang, Shangdong, Guangdong and Guizhou. All of them were located in the east coastal areas of China except Guizhou, which is located in the south of central China. Seven out of the ten provinces with sustainability window had economic growth inside of the window, which means that economic growth is relatively sustainable from both the socio-economic and environmental perspectives. Only three of the ten provinces didn't have economic growth inside of the window. They were Shanxi, Zhejiang and Guangdong. According to sustainability analysis these provinces were socially sustainable, but environmentally unsustainable.

In turn, fifteen out of the 25 analysed provinces hadn't sustainability window, which were Inner-Mongolia, Liaoning, Jilin, Heilongjiang, Fujian, Jiangxi, Guangxi, Hainan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. They were located in the inland areas, especially in the west part of China. Only 5 provinces (Heilongjiang, Jilin, Liaoning, Jiangxi an Fujian) without sustainability window were located in in the east-coast areas. Because the provinces had no existing sustainability window, their economic growth is not based on sustainable development at all, in terms of sustainability window methodology and used data.

Results of the study supported the hypothesis that sustainability is more advanced in the east part of China economically, socially and environmentally. To interpret sustainability window analyses concerning the studied provinces, ecological modernization process was progressed sufficiently in 7 provinces, where economic growth was inside of the sustainability window. Therefore the relative changes of GDP, SO2 emissions and social well-being led to new socio-techno-economic production systems, where socially and environmentally sustainable economic growth was enabled.

There were three provinces, which had sustainability window, but economic growth was not inside of the window or rather had exceeded the environmentally sustainable level. In practice, ecological modernization process wasn't sufficient enough to change the old socio-techno-economic production system into new sufficiently effective one for actual

economic growth. These provinces had potential in their production system to convert into sustainable one. According to the analyses, if the new production systems stayed the same, it would require de-growth of GDP.

In turn, development in the westernmost provinces was quite different compared to the easternmost provinces, with sustainability windows. All 15 provinces had no existing sustainability window, which meant that ecological modernization process didn't change socio-techno-economic production systems into sustainable direction. In these provinces social well-being developed relatively slow as a function of GDP, which means inefficient productivity of social well-being. In turn, increase in SO2 productivity of GDP, meant that SO2 emissions increased too fast. Practically the new socio-techno-economic production systems were both socially and environmentally unsustainable.

From the economic point of view it is reasonable to say that different development phases of the East and the West China has connected to their differences in regional economic structures, urban areas, and Special Economic Zones, which were firstly implemented in the coastal provinces (Lu, 2012, 47). For instance, the coastal provinces, such as Beijing, Hebei, Shanghai, Shangdong, Jiangsu and Guangdong have both the highest population rate and the highest GDP per capita growth rate. The developmental level of these provinces are above the average level. (Lu, 2012, 30.) This can be seen from the results of sustainability window analyses as well. All of the provinces, that Lu (2012) has listed had sustainability window, and economic growth was inside of it in this study. In other words, the provinces with averagely higher GDP were sustainable economically, socially and environmentally.

In turn, there is some variation between the provinces without sustainability window. From the social well-being point of view especially the northwest provinces are mostly suffering from poverty. Their economic structure is mainly based on agriculture, which basically means low pollution rates including SO2 emissions. (Kallio, 2005, 76.) Inner-Mongolia, Shaanxi, Ningxia, Gansu, Qinghai, Xinjiang and Tibet are included in this categorization (Lu, 2012, 30). The sustainability window analyses supported the categorization. None of these provinces had sustainability window, because economic growth was not sustainable

from the overall development point of view. GDP growth was relatively slow compared to other provinces and social well-being was below the average. However, the SO2 pollution rates were relatively low compared to other provinces of China. This is a consequence of agriculture dominance.

From environmental point of view it is noteworthy to mention that heavy-industry cities are located to North-east provinces. For example Heilongjiang, Jilin and Liaoning are one of those. These three provinces differs from other provinces without sustainability window in their economic structure, which is based on heavy industry. Their GDP growth is averagely quite fast, because they have direct access to seaports. This industry is based on coal consumption, which automatically increases SO2 pollution among many others. (Lu, 2012, 30.) Even if the economic growth was quite fast and FDG technology has been implemented in these provinces, the economic structure for GDP growth is environmentally and socially unsustainable.

According to Hara's et al. (2009) study, aggregated sustainability indexes developed in improved direction from 2000 till 2005 concerning most provinces in China. However, the main improvements were focused on the socio-economic components. Also degradation of environment component occurred during that time interval. According to ranking results indicated that most sustainable provinces were Beijing, Tianjin, Hainan, Fujian, Shanghai and Zhejiang. In turn, the least sustainable provinces were Guizhou, Gansu, Shanxi, Jiangxi, and Inner-Mongolia. Time intervals for analysis and sustainability scores were calculated from different components than in this study, and therefore the results of these two studies are not fully comparable.

The main idea is laying on assumption that scientific-technological development is not just a reason for environmental and social problems, but rather they are in key factors in transformation towards sustainable development. (Mol, 1997, 140.) This can be interpreted that the context, where scientific-technological development was implemented during industrialization, is rather a reason for environmental and social problems. However, it is necessary to understand a significance of political decision-making and political

implementations, which enables the technological solutions and transformation towards sustainable and less polluting direction.

As a conclusion the development of the west and the east China have developed in different pace and in different phase during the years 2001–2010. Also a vast gap between the East and the West China can be found from sustainable development point of view. There can be interpreted with caution that ecological modernization has advanced towards sustainable development from 2001 till 2010 concerning the East part of China. At least de-linkage between SO2 emission and social well-being has occured concerning provinces with sustainability window. After 2006, when FDG technology was deployed extensively trend of SO2 emission decreased in most of the provinces (Schreifels et al., 2012, 779–785; Klimont et al., 2013, 4).

However, what cannot be disputed is that China is still facing a huge sustainability problems in many levels, and many ways. This study showed only one aspect of the track-switching process, which is giving a quite bright picture. If there was be selected CO2 emissions instead of SO2, the result could have been different. Despite of that, to change the economic structure into more sustainable direction, China has developed its technologcial innovations R&D activities quite well to answer for future demand for commercialization of green technologies and R&D. Also pressures from the outside world and the growing concern in China within the Reform of energy pricing and national environmental and energy efficiency standards are pushing to that direction. (The World Bank & Development Research Center of the State Council, the People's Rebulic of China, 2013, 158, 223-229.)

6.1 Sustainability window evaluation discussions as indicator

To revise a noteworthy point is that assessment tool is always based on rationalization and values of researcher (Meadows, 1998,2). Practically this is dependent on research questions and researcher itself, what kind of indicators one is selected for the assessment of sustainability. In this case, the main attention was focused on SO2 emissions and social well-being. Development of SO2 emissions was interesting, because in this scene there has

already happened some emission reduction via policy implementations and technological developments (Schreifels et al., 2012, 779–785; Klimont et al., 2013, 4).

Other kind of indicator selections could have been done. If there was selected another emission type, such as CO2, the picture wouldn't have seemed to be as bright as this study showed in terms of SO2 emissions. Also many different selections could have been done concerning about the building of social well-being indicator for sustainability assessment. On the one hand, choices about that in this study are supported by many studies of social well-being (Chamon, Mauro & Okawa, 2008; Chungling, 2004; Luova, 2005; Bynner, 2002; Donald, 2000). In addition, it would have been different study, if other kind of indicators were selected for analysis. In that case, it could have given answers to different questions.

Earlier the analysis method was carried out with international level, but with different indicator choices, which were GDP, CO2 and Non-poor (Frameworkpaper, 2013). By contrast, in this study the analysis were implemented at province level of China. On this basis, it is relevant to note that the method is at least in principle possible to apply for many regions such, as cities, provinces, nation-states and mainlands only if data is available. Secondly it is important that definition and geographical demarcation of region for sustainability assessment is well-grounded.

The sustainability window has naturally its pros and cons. Some might say that the tool is highly based on the subjective thinking. But on the other hand, it can be taken as a positive thing as well, because even the definition of sustainable development is very ambiguous, it can also provide some flexibility to select different indicators to examine different dimensions of reality and sustainable development.

Also different data years could have given different picture of ecological modernization process, because the tool is based on relative values of different indicators. For instance wider time interval could have revealed many other intersting aspects of the process. But in China's case the most interesting part of the ecological modernization process took place after 2000, when explosive economic growth and environmental policy implementations

occurred. This point indicates well, how important the cultural context is for the analyses in general. If the analysis were done for some other country, probably time interval could have been different depending on the cultural context, trends of social well-being and emissions.

The sustainability window is functioning as a great tool for assessing sustainable development in the frames of the ecological modernization, which can be counted as practical way to examine process towards sustainable development. Therefore it enables assessment with two levels. At first, it extracts minimum and maximum economic growth points, from the data, which are defining sustainability level of certain region. Secondly, by obsrving the figures, it reveals ecological modernization process of certain region quite accurately. Example of this, figure-analyses were done concerning case provinces. In addition, this study showed that it is not a problem to apply the theory of ecological modernization in non-capitalistic country as long as it is highly industrialized.

For further research concerning indicator aspect of the study, it would be interesting to construct composite indicator for environmental dimension, when implementing sustainability window analyses. The environmental dimension could consist of main air pollution emissions or maybe also waterpollution could be included in it as well. It could also be interesting to apply sustainability window analysis for western countries. This would be challenging, but interesting, because the main assumptions for social well-being is rather different compared to developing countries.

This study was quite macro- and environmental sociological, which mutes voice of general population. Further study from China's point of view, could examine environmental knowledge of local population in different regions. In addition, the interview or survey could be implemented for rural and urban China. Also continuing of wider sustainability analysis for macrolevel would be interesting and absolutely needed.

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Appendixes

Appendix table 1a. Correlation matrix of Principal Component

Correlation Matrix			
Beijing	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,949 ***	1	
Private owned vehicles	0,967 ***	0,995 ***	1
Tianjin	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,960 ***	1	
Private owned vehicles	0,949 ***	0,998 ***	1
Hebei	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,893 ***	1	
Private owned vehicles	0,941 ***	0,986 ***	1
Shanxi	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,959 ***	1	
Private owned vehicles	0,979 ***	0,960 ***	1
InnerMongolia	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,959 ***	1	
Private owned vehicles	0,992 ***	0,952 ***	1
Liaoning	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,964 ***	1	
Private owned vehicles	0,973 ***	0,976 ***	1
Jilin	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,862 ***	1	
Private owned vehicles	0,930 ***	0,891 ***	1
Heilongjiang	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,914 ***	1	
Private owned vehicles	0,967 ***	0,913 ***	1
Shanghai	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,826 ***	1	
Private owned vehicles	0,941 ***	0,940 ***	1
Jiangsu	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,930 ***	1	
Private owned vehicles	0,986 ***	0,922 ***	1
Zhejiang	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,934 ***	1	
Private owned vehicles	0,974 ***	0,967 ***	1
Fujian	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,845 ***	1	
Private owned vehicles	0,968 ***	0,943 ***	1
Jiangxi	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,899 ***	1	
Private owned vehicles	0,899 ***	0,957 ***	1

Appendix table 1b. Correlation matrix of Principal Component Analysis.

Shangdong	Employment rate	Literacy	Private owned vehicles
Employment rate	1		
Literacy	0,923 ***	1	
Private owned vehicles	0,958 ***	0,957 ***	1
Guangdong	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,960 ***	1	
Private owned vehicles	0,973 ***	0,957 ***	1
Guangxi	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,350 *	1	
Private owned vehicles	0,972 ***	0,415 *	1
Hainan	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,957 ***	1	
Private owned vehicles	0,957 ***	0,978 ***	1
Guizhou	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,458 *	1	
Private owned vehicles	0,953 ***	0,457 *	1
Yunnan	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,913 ***	1	
Private owned vehicles	0,977 ***	0,927 ***	1
Tibet	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,885 ***	1	
Private owned vehicles	0,976 ***	0,910 ***	1
Shaanxi	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,576 *	1	
Private owned vehicles	0,712 **	0,890 ***	1
Gansu	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,721 *	1	
Private owned vehicles	0,765 *	0,948 ***	1
Qinghai	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,953 ***	1	
Private owned vehicles	0,898 ***	0,957 ***	1
Ningxia	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,901 ***	1	
Private owned vehicles	0,893 ***	0,956 ***	1
Xinjiang	**Employment rate**	**Literacy**	**Private owned vehicles**
Employment rate	1		
Literacy	0,983 ***	1	
Private owned vehicles	0,911 ***	0,929 ***	1

* p.< 0.05 statistically almost significant
** p.< 0.01 statistically significant
***p.< 0.001 statistically highly significant