

Berrittella, Maria; Rehdanz, Katrin; Tol, Richard S. J.

Working Paper

The economic impact of the South-North water transfer project in China: A computable general equilibrium analysis

Nota di Lavoro, No. 2006,154

Provided in Cooperation with:

Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Berrittella, Maria; Rehdanz, Katrin; Tol, Richard S. J. (2006) : The economic impact of the South-North water transfer project in China: A computable general equilibrium analysis, Nota di Lavoro, No. 2006,154, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:

<https://hdl.handle.net/10419/4122>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

**The Economic Impact of the South-
North Water Transfer Project in
China: A Computable General
Equilibrium Analysis**

Maria Berrittella, Katrin Rehdanz
and Richard S.J. Tol

NOTA DI LAVORO 154.2006

DECEMBER 2006

CCMP – Climate Change Modelling and Policy

Maria Berrittella, *Centro Interdipartimentale di Ricerche sulla Programmazione Informatica dell'Economia e delle Tecnologie (CIRPIET), University of Palermo, Palermo, Italy*

Katrin Rehdanz, *Research unit Sustainability and Global Change, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg, Germany*

Richard S.J. Tol, *Economic and Social Research Institute, Dublin, Ireland,
Research unit Sustainability and Global Change, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg, Germany, Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands*

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
<http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm>

Social Science Research Network Electronic Paper Collection:
<http://ssrn.com/abstract=952938>

The opinions expressed in this paper do not necessarily reflect the position of
Fondazione Eni Enrico Mattei

Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it

The Economic Impact of the South-North Water Transfer Project in China: A Computable General Equilibrium Analysis

Summary

Water resources are unevenly spread in China. Especially the basins of the Yellow, Hui and Hai rivers in the North are rather dry. To increase the supply of water in these basins, the South-to-North Water Transfer project (SNWT) was launched. Using a computable general equilibrium model this study estimates the impact of the project on the economy of China and the rest of the world. We contrast three alternative groups of scenarios. All are directly concerned with the South-to-North water transfer project to increase water supply. In the first group of scenarios additional supply implies productivity gains. We call it the “non-market” solution. The second group of scenarios is called “market solution”. The market price for water adjusts such that supply and demand are equated again. In the third group of simulations the economic implications of China’s capital investment in infrastructure for the water South-North water transfer project is analyzed. Finally, the investment is combined with the increased capacity of water. If an increase in water supply in China leads to an increase in productivity of their water-intensive goods and services (non-market solution) this would result in a huge positive welfare effect from increased production and export. The effect on China’s welfare would still be positive, if a market for water would exist (market solution), but the world as a whole would lose. The negative effect for the rest of the world is largely explained by a deterioration of its terms-of-trade. Well functioning water markets in China are unlikely to exist.

Keywords: Computable General Equilibrium, South-North Water Transfer Project, Water Policy, Water Scarcity

JEL Classification: D58, R13, Q25, Q28

Address for correspondence:

Maria Berrittella
University of Palermo
Viale delle Scienze
Palermo 90128
Italy
E-mail: berrittella@ictp.trieste.it

1 Introduction

Total water resources in China amount to about 2,897 bln m³ per year, the fifth largest in the world (FAO AQUASTAT). However, with a population of about 1.28 bln in 2000, water availability is limited to an annual average of 2,259 m³ per capita, compared to the world average of about 8,036 m³ per capita; the UN defines this as slightly scarce. The uneven distribution of water resources and population aggravates the problem of scarcity. While the South is relatively water abundant, the Huang-Huai-Hai (3-H) river basins in the North are rather dry. More than a third of China's population is living in this densely populated region, which includes the mega-cities Beijing and Tianjin. In this area, more than 30% of China's cultivated land and GDP depends on less than 10% of the country's water resources (MWR, 2004a). Water availability is restricted to 500 m³ per capita on average, and falls below 400 m³ in the Hai river basin, which includes Beijing and Tianjin (MWR, 2004a). According to the UN, this is severe and most severe scarcity, respectively. Another reason for concern is the quality of the water. The shortage of wastewater treatment capacity, has led to problems of water pollution; wastewater is partly released untreated (WWC, 2003). The uneven distribution of water over time aggravates the problem further. The monsoon climate with its varied rainfall leads to serious droughts and floods. The 2002 drought reduced the amount of water resources in the Hai river basin by more than 60% to less than 150 m³ per capita (MWR, 2002). As a consequence, people in this area suffer from relatively severe water shortage. Estimates show a current water shortage in the 3-H river basins of 14.5 to 21.0 bln m³ per year (MWR, 2004a).¹ Governments officials estimate an annual damage of \$16 bln for the economy as a whole (Cernetig, 2000).

The management and distribution of the limited water resources are major issues for China's social and economic development. Population growth and increasing urbanization makes the problem even more imminent. Water demand in the 3-H river basins is projected to increase while water shortage will reach up to 28 bln m³ by 2010 per year and up to 40 bln m³ by 2030 (MWR, 2004a). For comparison, the total annual flow of the Huang (Yellow) river amounts to about 60 bln m³ (MWR, 2004b). An additional reason for concern is climate change. For China climate change models predict an overall increase in temperature but a substantial decline in rainfall over most parts of the country. Higher temperatures would imply larger water demand and higher evaporation (IPCC, 1997).

The Chinese government has identified several options for a sustainable water resource development strategy, including increasing efficiency of water use, protecting and developing water resources, and expanding the capacity of water supply (WWC, 2003). Zhou and Tol (2005) propose desalination. To increase the supply of water in the 3-H river basins the South-to-North Water Transfer (SNWT) project was launched. The idea dates back to 1952 but implementation did not start until the end of 2002. The project contains three alignments, the eastern, western and middle route. It will divert water from the lower, middle and upper reaches of the Yangtze river and build a network with the 3-H rivers. The total amount of water transferred to the North is projected to 44.8 bln m³ by 2050. The total amount of water supply will increase by 34.5% in the 3-H river basins (MWR, 2004b). Total investment is estimated at about \$60 bln (US Embassy, 2003); compared to the annual damage of \$16 bln quoted above, this implies a payback time of less than four years and a rate of return on investment of 36%.

An increase in water supply in China would increase the water use in all sectors including the agricultural sector. Although the primary recipients of the transferred water will be households and industry, it is very likely that part of the transferred water will be allocated to

¹ Given the large uncertainties in future water demand other studies arrive at different numbers. WB (2001), for example, shows a shortage of 37 bln m³ in the 3-H basins for 2000.

the agricultural sector.² In the 3-H river basins this sector uses currently about 70% of the total water supplied (MWR, 2004b). An increase in water supply and agricultural output would affect national and international markets of agricultural products and food supply. The water embedded in commodities is also known as virtual water (Allan, 1992 and 1993). Therefore, changes in water supply would affect virtual water trade as well. To our knowledge, this implication of the SNWT project has yet to be investigated. The appropriate tool is a multi-region, multi-sector general equilibrium model.

The CGE approach allows for a rich set of economic feedbacks and for a complete assessment of the welfare implications. The analysis is based on regions' total renewable water resources and differences in water productivity. Growing wheat in North Africa requires more water than growing it in Germany. Also, different crop types have different crop water requirements; and regions grow different crop varieties. The production of a ton of rice is e.g. more water intensive than the production of a ton of wheat. Berrittella *et al.* (2005a) use GTAP-W, a computable general equilibrium (CGE) model including water resources, to analyze the economic impact of restricted water supply for water short regions. Using the same model Berrittella *et al.* (2005b) analyze the economic impact of water pricing policies. In contrast, this study is concerned with increased capacity of water supply and the implications of the related capital investment in China as well as consequences for the world economy.

In this paper, we present the GTAP-W model and apply it to water supply management in China. Section 2 reviews the literature on water management, the SNWT project and economic models of water use. Section 3 presents the model used and the data on water resources and water use. The basic model and the corresponding data can be purchased from the Global Trade and Analysis Project (<http://www.gtap.agecon.purdue.edu/>). Section 4 lays down the base simulation scenarios and discusses the results. Section 5 presents the results of a sensitivity analysis. Section 6 concludes.

2 Previous studies

2.1 Water use in China and the North-South Transfer

As the supply of water is limited, attempts have been made to economize on the consumption of water. One way to address the problem is to reduce the inefficiencies in irrigation and urban water systems. In urban water systems, water is wasted through leakage. About 70% of all water supply in the 3-H river basin is used for agriculture but water use efficiency is generally low (MWR, 2004b). The current level and structure of water charges mostly do not encourage farmers to use water more efficiently. An increase in water price, for instance by a tax, would lead to the adoption of improved irrigation technology (e.g., Dinar and Yaron, 1992). The water saved could be used in other sectors, for which the value is much higher. In this paper, we do not look at a reallocation of water, but we do look at a reallocation of water-intensive products.

If countries increase irrigation water prices their agricultural production might become less competitive on the world market and food supply would decrease. Of course, food demand could be met by importing more water-intensive food from water abundant countries, and producing and exporting commodities that are more water-extensive. Yang and Zehnder (2001) suggest this for China to reduce the problem of water scarcity. So far, few studies provide estimates of global virtual water trade (see e.g. Chapagain and Hoekstra, 2004) or analyze this kind of water management strategy (Kumar and Singh, 2005). However, in China

² This is further discussed in section 2.

more than 60% of the population is engaged in agriculture (WWC, 2003) and price increases will have social implications as well. Jin and Young (2001) suggest compensation of farmers by other users for reallocation of water out of agriculture.

An alternative to alleviate the problem is to increase the supply of water as suggested by the SNWT project.³ Construction of the project was officially launched in 2002 and work started at the eastern route. This is the easiest to construct as it builds upon the existing irrigation and water transportation network of the Grand Canal. Water will be diverted from the lower Yangtze river and will be lifted 65m by pump stations to flow north and supply water for Tianjin. For a total investment of \$8-10 bln the eastern route will transfer 14.8 bln m³ per year (MWR, 2004a; US Embassy, 2003). A major concern is the low quality of the transferred water, due to the influx of untreated wastewater along the route (Yang and Zehnder, 2005).

Constructions of the slightly longer middle route (1,267 km) started recently (China Daily, 2005). Water will be diverted from the Han, a major tributary of the middle Yangtze river, to Beijing through canals. No pumping stations are needed for the project as the water can be conveyed by gravity. Investment costs are estimated at \$10 bln (US Embassy, 2003). Annual total water transfer capacity will be 13 bln m³ (MWR, 2004a). A major concern is the limited availability of water resources at the origin of the route (Yang and Zehnder, 2005). Also, the construction involves the relocation of about 320,000 people mostly because of an increase in an existing reservoir at the intake for the route (US Embassy, 2003).

Specific details about the western route are still to be finished and work is not likely to start before 2010. For this project water will be diverted from three upstream tributaries of the Yangtze river into the upper Yellow river. The route runs through a remote and mountainous area in western China at altitude above 4,000 meters which are frozen most of the year. Therefore, if ever built, it will be the most difficult route and the most expensive one too. Investment costs are likely to exceed \$37 bln for a total annual capacity of 17 bln m³ (MWR, 2004a; US Embassy, 2003). The total financial investment of about \$60 bln for the SNWT project will be only partly provided by the government (20%). A special water fee in the benefiting areas of 35% and bank loans of 45% will supply the rest (US Embassy, 2003).

Figure 1 about here

There are a number of studies debating the rationale, the feasibility and economic, environmental and social implications of the project (see e.g. Liu, 1998; Liu and Zheng, 2002; Ma *et al.*, 2006; Shang *et al.*, 2003; Shao *et al.*, 2003; Yang and Zehnder, 2001). Yang and Zehnder (2005), for example, state that an important reason for implementing the project was related to the environmental benefits arising from the water transfer. The increasing water shortage has led to severely degraded ecosystems and the environment. To prevent the ecosystem from further deterioration or allow for restoration of degraded systems about 23 bln m³ would be needed. Even if all available water conservation measures were implemented in the economic sector it would be insufficient to meet the projected ecosystem water requirements. However, they conclude that water supply to the environment is likely to be limited since all the economic sectors are served first and the environment is unlikely to recover if water prices continue to be too low to reduce demand significantly.

Two studies have especially looked at the economic implication of the project in relaxing water constraints in the future. The World Bank (2001) study uses a detailed optimization model including a variety of constraints; hydrological, physical and agronomic. The results

³ For a detailed description of the decision making process of the project see, for example, Yang and Zehnder (2005).

indicate that even if the government's management plan to improve irrigation efficiency, reduce unaccounted water supplies, increase water prices and treat waste water, together it will not be sufficient to meet future demand. Supply must be increased as well. Using a discount rate of 12% they conclude that the SNWT project, especially the east route, is highly profitable. They include information of the next stage of the SNWT project for the east and the middle route only and assume that these projects can deliver an annual water transfer of 19.4 bln m³ by 2020. The WWF (2001) adopts a less detailed cost-benefit approach. They assume a much higher potential for water savings due to increases in water use efficiency and conclude that the project should not be implemented. Similar, Jin and Young (2001) see a high potential for increasing water use efficiency in agriculture. They suggest that farmers should be compensated for reallocation of water out of agriculture.

Berkhoff (2003) analyzes the implications of the project in an agricultural development context focusing on the role of water in the rural economy. Reallocation of water from agriculture to municipal and industrial use is economically rational, but socially divisive. Employment in agriculture in that region is high. And despite the enduring water shortage, grain yields have been rising. One reason is groundwater mining. However, income levels of most farmers are still low. To mitigate the transition for the rural population, Berkhoff concludes that despite the large direct cost, environmental and socio-political arguments support the implementation of the project.

2.2 Economic models of water use

In order to obtain insights from alternative water policy scenarios on the allocation of water resources, partial and general equilibrium models have been used. While partial equilibrium analysis focus on the sector affected by a policy measure assuming that the rest of the economy is not affected, general equilibrium models consider other sectors or regions as well to determine the economy-wide effect; partial equilibrium models tend to have more detail. Most of the studies using either of the two approaches analyze pricing of irrigation water only (for an overview of this literature see Johannsson *et al.*, 2002). Rosegrant *et al.* (2002) use the IMPACT-Water model to estimate demand and supply of food and water to 2025. Fraiture *et al.* (2004) extend this to include virtual water trade, using cereals as an indicator. Their results suggest that the role of virtual water trade is modest. While the IMPACT-Water model covers a wide range of agricultural products and regions, other sectors are excluded; it is a partial equilibrium model.

Studies using general equilibrium approaches are generally based on data for a single country or region assuming no effects for the rest of the world of the implemented policy. Decaluwe *et al.* (1999) analyze the effect of water pricing policies on demand and supply of water in Morocco. Daio and Roe (2003) use an intertemporal CGE model for Morocco focusing on water and trade policies. Seung *et al.* (2000) use a dynamic CGE model to estimate the welfare gains of reallocating water from agriculture to recreational use for the Stillwater National Wildlife Refuge in Nevada. For the Arkansas River Basin, Goodman (2000) shows that temporary water transfers are less costly than building new dams. Gómez *et al.* (2004) analyze the welfare gains by improved allocation of water rights for the Balearic Islands.

Berrittella *et al.* (2005a) are an exception. They use a global CGE model including water resources (GTAP-W) to analyze the economic impact of restricted water supply for water-short regions. They contrast a market solution, where water owners can capitalize their water rent, to a non-market solution, where supply restrictions imply productivity losses. They show that water supply constraints could improve allocative efficiency, as agricultural markets are heavily distorted. The welfare gain may more than offset the welfare losses due to the resource constraint. Berrittella *et al.* (2005b) use the same model investigating the economic

implications of water pricing policies. They find that water taxes reduce water use, and lead to shifts in production, consumption and international trade patterns. Countries that do not levy water taxes are nonetheless affected by other countries' taxes.

Feng *et al.* (in press) is an interesting study for China using a recursive dynamic general equilibrium approach based on the GREEN model (Lee *et al.*, 1994) to assess the economic implications of the SNWT project. In their model China is divided into two regions; Beijing is chosen as the water recipient while the rest of China is treated as Beijing's national trading partner. The rest of the world acts as the international trading partner. The model comprises of 36 sectors with a detailed disaggregation of the industry and service sector, but no further disaggregation of the agricultural sector. Water is included as a production factor available at different quality. For the implementation of the SNWT project the authors assume a maximum transfer of about $1 \times 10^8 \text{m}^3$ from 2008. They compare four simulation scenarios; two sustainable water utilization scenarios (one with the SNWT project and one without) and two sustainable ones (one with the SNWT project and one without). The simulation results indicate that between 2010 and 2020 Beijing's GDP growth would be lower without the SNWT project and would be lowest under the sustainable water use scenario (and no water transfer). However, investment costs of the SNWT project are not considered.

In contrast to Feng *et al.* (in press), our analysis offers less regional detail but focuses in particular on the international implications of the SNWT project. Also, Feng *et al.* (in press) consider only part of the water transfer project relevant for Beijing (assuming an annual transfer of about $1 \times 10^8 \text{m}^3$) and not taking into account capital investment explicitly. We present results for the implementation of the complete SNWT project (water transfer of $44.8 \times 10^8 \text{m}^3$ per year) and the completion of the first two routes only ($27.8 \times 10^8 \text{m}^3$ per year). Capital investment is explicitly taken into account. In contrast to Berritella *et al.* (2005a and 2005b), this study is concerned with supply management and the effects of the SNWT project on China and the world economy.

3 Modeling framework and data

As in all CGE models, the GTAP-W model makes use of the Walrasian perfect competition paradigm to simulate adjustment processes.⁴ Industries are modeled through a representative firm, which maximizes profits in perfectly competitive markets. The production functions are specified via a series of nested CES functions (*Figure A1 in the Annex*). Domestic and foreign inputs are not perfect substitutes, according to the so-called "Armington assumption", which accounts for product heterogeneity.

A representative consumer in each region receives income, defined as the service value of national primary factors (natural resources, land, labour and capital). Capital and labour are perfectly mobile domestically, but immobile internationally. Land (imperfectly mobile) and natural resources are industry-specific. The national income is allocated between aggregate household consumption, public consumption and savings (*Figure A2 in the Annex*). The expenditure shares are generally fixed, which amounts to saying that the top level utility function has a Cobb-Douglas specification. Private consumption is split in a series of alternative composite Armington aggregates. The functional specification used at this level is the Constant Difference in Elasticities (CDE) form: a non-homothetic function, which is used to account for possible differences in income elasticities for the various consumption goods.

⁴ The model is a refinement of the GTAP model in the version modified by Burniaux and Truong (2002). The GTAP model is a standard CGE static model distributed with the GTAP database of the world economy (www.gtap.org). For detailed information see Hertel (1997) and the technical references and papers available on the GTAP website.

A money metric measure of economic welfare, the equivalent variation, can be computed from the model output.

In our modeling framework, water is combined with the value-added-energy nest and the intermediate inputs as displayed in *Figure A1 (Annex)*. As in the original GTAP model, there is no substitutability between intermediate inputs and value-added for the production function of tradeable goods and services. In the benchmark equilibrium, water supply is supposed to be unconstrained, so that water demand is lower than water supply, and the price for water is zero. Water is supplied to the agricultural industry, which includes primary crop production and livestock, and to the water distribution services sector, which delivers water to the rest of the economic sectors. Note that *distributed* water can have a price, even if primary water resources are in excess supply. Furthermore, water is mobile between the different agricultural sectors. However, water is immobile between agriculture and the water distribution services sector, because the water treatment and distribution is very different between agricultural and other uses.

The key parameter for the determination of regional water use is the water intensity coefficient. This is defined as the amount of water necessary for a sector to produce one unit of commodity. This refers to water directly used in the production process, not to the water indirectly needed to produce other input factors. To estimate water intensity coefficients, we first calculated total water use by commodity and country for the year 1997. For the agricultural sector the FAOSTAT database provided information on production of primary crops and livestock. This includes detailed information on different crop types and animal categories. Information on water requirements for crop growth and animal feeding was taken from Chapagain and Hoekstra (2004). This information is provided as an average over the period from 1997 to 2001. The CGE is calibrated for 1997. The water requirement includes both the use of blue water (ground and surface water) as well as green water (moisture stored in soil strata). For crops it is defined as sum of water needed for evapotranspiration, from planting to harvest, and depends on crop type and region. This procedure assumes that water is not short and no water is lost by irrigation inefficiencies. For animals, the virtual water content is mainly the sum of water needed for feeding and drinking. The water intensity parameter for the water distribution sector is based on the country's industrial and domestic water use data provided by AQUASTAT. This information is based on data for 2000. By making use of this data we assume that domestic and industrial water uses in 2000 are the same as in 1997.

The mechanism through which water transfer is introduced into the model is the potential emergence of economic rents associated with water resources. If supply falls short of demand, consumers would be rationed, and willing to pay a price to access to water, because water has an economic value, as it is needed in production. The opposite happens if supply is greater than demand. If water resources are privately or collectively owned, the owners receive an economic rent, which becomes a component of disposable income. The price for water is then set by the market at the level that makes water demand compatible with supply. In this setting, water supply is assumed to be completely inelastic (vertical). By introducing technologies for "effective" water production, the supply function could, however, be positively sloped. Therefore, we introduce a constraint on water amounts, in our model, which entails the creation of a new market and a new exchangeable commodity.

Finally, we make the link between output levels and water demand sensitive to water prices. In other words, we assume that more expensive water brings about rationalization in usage and substitution with other factors. The opposite happens if more water would be available. The actual capability of reducing the relative intensity of water demand is industry-specific, and captured by a price elasticity (*Table A3 in the Annex*), or rather the production cost

elasticity to water demand. Note that the elasticities are little more than informed guesses, derived from Rosegrant *et al.* (2002).

4 The economic consequences of the SNWT project

4.1 Design of model experiments

To assess the economic impacts and the international trade implications of the SNWT project for China and the rest of the world, we design three base scenarios. In the first scenario, we exclusively investigate implications of the increased water supply due to the construction of the SNWT project, not considering the capital investment necessary to make the additional supply available. In the second scenario, we consider the implications of capital investments in China without linking the investment to additional water supply. In the third scenario, we combine the first two scenarios to analyze the interrelation between increases in water supply through capital investment.

In the first scenario (called ‘base’ scenario), we increase the water supply in China by about 7%. This is equivalent to an increase of 44.8 bln m³ of water. It is the maximum amount of water that could be transferred if all routes would be implemented. The water transfer is implemented in the model by increasing the productivity in the water demanding industries. We interpret the water transfer as an improvement of production for the same level of non-water factor inputs. Although more water is available, current water users do not experience a drop in the value of that asset, or rather, they cannot capitalize the change in value. This reflects China’s underdeveloped property and capital markets. Nonetheless, in section 5, we report the results of a scenario in which the existing water rents changes.

In the second scenario (called ‘investment’ scenario), we account for the fact that capital investments are necessary to implement the SNWT project. In the standard GTAP framework, regional investments are endogenous variables. Furthermore, savings and investments are not equalized domestically, but only at the global scale. A hypothetical “world bank” collects savings and allocates investments, realizing the equalization of regional expected returns. We modified this procedure by defining regional investment exogenously for China. Following Bosello *et al.* (2004), we set the investment level in China augmenting the calibration value by the percentage change, due to the additional investment expenditure for the SNWT project. To ensure the equalization of global saving and investment, we then allowed for an endogenous adjustment of regional savings by assuming that all regional investments increase by the same percentage. In this way, the GTAP assumption of perfect international mobility of capital is respected. More specifically, in scenario 2 we simulate a total capital investment of about bln \$60, at a 10% discount rate, for the construction of all three routes by 2050.⁵ This is equivalent to an annuity of about \$7 bln.⁶ Finally, in the third scenario (called ‘base + investment’ scenario), we jointly simulate the capital investment of scenario 2 and the increase of available water as in scenario 1 for the case that the whole SNWT project would be constructed.

4.2 Simulation results

⁵ 2050 is the year when construction of all three routes is supposed to be completed.

⁶ Alternatively, we could have kept global investment at its initial level, and allocated more investment to China. As \$7 bln is small compared to global investment, the results would have been very similar.

Results for the scenarios described in section 4.1 are presented in Tables 1 to 4. The first three tables report values for some key economic variables including water demand, virtual water trade balance, trade balance and welfare indices on a regional level. Table 4 compares changes in prices and production levels in China.

The additional water supply, scenario 1 (base), increases water productivity in China. The resulting change differs between agriculture and water distribution services: productivity increases faster in more water-intensive sectors; the water distribution service sector, for example, needs more water to produce \$1 of output. More water supply leads to a decrease of virtual water imports in China. Furthermore, the shift in the production to more water-intensive goods and services in China leads to a decrease in exports of other goods and services. Overall, the change in China's trade balance is negative as prices for agricultural products on the world markets fall. The other regions reduce their demand for water due to the decrease in imports of water-intensive goods and services in China and increase the production as well as exports of non-water intensive goods and services. This leads to gains in terms of trade. Global welfare and GDP increase. On the regional level, China gains substantially, but most other regions are worse off. The changes in welfare are mostly a consequence of the changes of a region's terms-of-trade effect on welfare (compare Table 1). JPK is one of the regions that is better off. The main contribution to welfare in JPK comes from increased imports of agricultural products (especially cereals and other crops) at lower prices from China and to a much lower extent from higher exports of products of other industries to China. For China the largest contribution to the positive change in welfare comes from the technological change due to increased productivity in the water-intensive industries. The Hicksian equivalent variation increases by \$3.3 bln a year, for 44.8 mln m³ (75 \$/m³). This is rather smaller than the \$16.0 bln for 17.8 mln m³ (900 \$/m³) estimated by governments officials (Cernetig, 2000).⁷

Table 1 about here

In scenario 2 (investment), reported in Table 2, we simulate the capital investment necessary to build the western, eastern and middle Routes of the SNWT project. The increase of the investment demand leads to an increase in production of capital goods, but to a decrease in production in most other sectors in China, including water-intensive goods and services. Prices increase. Therefore, the demand for water decreases. As the production of water-intensive goods and services decreases, the virtual water exports decrease as well. In terms of international trade, China loses too as less goods and services are produced for the international markets. On the opposite, China gains in terms of welfare and GDP. The investment of \$7 bln leads to an increase in welfare of \$1 bln. The opposite effects occur for most other regions. The increase in investment in China is offset by a decrease in investment elsewhere. Water demand and agricultural production increase leading to a positive change in the virtual water trade balance in most regions. However, the change in trade balance is generally less positive compared to scenario 1. Although the production of most goods and services increases, the price changes are mostly negative and the overall effect on terms of trade is negative. Exceptions are JPK and SEA. The effect on welfare is more mixed. For countries like the US and CAN the change in welfare is less negative. For others, for example WEU and JPK, changes are more negative. For Japan this is most pronounced. One reason is that compared to scenario 1, no cheap imports of agricultural products from China are on the market. In addition, the increase in value of exports of products from 'other industries' and

⁷ We used the average shortage in the 3-H river per year (MWR, 2004a).

energy-intensive products is not enough to compensate for the loss originating from imports of commodities belonging to other industries of that sector from China. Again, changes in welfare are mostly a consequence of the changes of a region's terms-of-trade effect (compare Table 1). In scenario 2, this is also true for China. Global welfare decreases by \$0.5 bln.

Table 2 about here

Finally, in scenario 3 (base + investment), we jointly simulate the capital investment of \$60 bln (as in scenario 2) as well as the increase in the capacity of water. Consider also that in this scenario, we take into account the endogenous change in the capital investment (about 3.56%) due to the change in water supply of the base scenario.⁸ The results are reported in Table 3. Like in scenario 1, we assume a non-market solution where additional water supplied leads to increases in water productivity. Compared to scenario 1, the increase in productivity is slightly more pronounced in the agricultural sector, and less so in the water distribution services for the same increase in water availability. The water demand in most other regions decreases less. In terms of virtual water trade balance, the increase in exports from China and decrease in exports from elsewhere are slightly smaller. The change in trade balance is more substantial and for most regions more positive. This is particularly pronounced for the USA, JPK and WEU; for EEU changes are turning from positive to negative. For China, the trade balance is negatively affected in scenarios 1 and 2; in scenario 3, the negative effects is somewhat higher than the sum of the two compounding scenarios. Changes in regions' welfare are generally more negative. This is, again, a consequence of the changes in a region's terms-of-trade. The largest contribution to welfare improvements in China is caused by increased productivity in the water using sectors. Changes in global welfare are slightly less positive compared to scenario 1. This is caused by the more pronounced negative changes in regional terms-of-trade. For China, changes in welfare are more positive. However, the positive change in welfare is slightly smaller than the sum of scenarios 1 and 2.

Table 3 about here

Table 4 compares changes in prices and production levels in China as a consequence of the above scenarios. Increasing the supply of water in China (scenario 1) leads to higher production levels and supply of most water-intensive products. To clear the market prices fall. The investment scenario leads to only small changes in production levels and prices in China. The biggest percentage change is the increased production of capital goods due to the increased investment. In scenario 3, compared to scenario 1, market prices for products from water intensive sectors decrease less, but prices for all other goods and services increase more.

Table 4 about here

⁸ The total change in investment in China implemented in the model is 3.56% (base scenario) + 1.85% (investment scenario).

5 Sensitivity analysis

5.1 Design of model experiments

In the previous section, we assumed that the extra water would be shared between all water-users, that all three routes would be implemented, that no market for water would exist in China, and that the discount rate for the capital investment would be 10%. In this section, these assumptions are altered.

The purpose of the SNWT project is the supply of water to high value users, like households and industries rather than to the agricultural sector, in scenario 4 ('preferred allocation'), we simulate an uneven distribution of water transfer amongst the water-intensive industries. In particular, the water supply increases by 16.8% for water distribution services and only by 3.0% for agriculture. The additional water supplied to the agricultural sectors is equivalent to the amount transferred by the construction of the eastern route. As discussed above, a major concern is the low quality of the transferred water which might make it less valuable for other users. In this scenario (called 'reduced') we consider the fact that the western route is unlikely to be constructed. Additional capacity would drop from 44.8 bln m³ per year to 27.8 bln m³ (increase of 4%). This would occur if only the middle and the eastern routes would be constructed.

The second set of sensitivity simulations is based on the water quantities of scenario 1 (base scenario), but we now assume there is a water market in China; we refer to this scenario as the 'market scenario'. The water transfer is introduced into the model through the economic rents associated with water resources. As the water supply increases, the price of water falls and water owners lose part of their income. The positive effects of an increased water supply are partly offset by the decreased value of water. In the base scenario, water users are de facto subsidized (per unit). In the water scenario, this subsidy is clawed back (lump-sum).

The last set of sensitivity scenarios refers to the investment scenario (scenario 2 above). In the first alternative investment scenario, called 'investment 15%', we set the discount rate equal to 15% to reveal how sensitive the results are in terms of welfare and trade. The capital investment increases to an annuity of about \$9 bln. Furthermore, in the second alternative investment scenario, called 'investment reduced', we restrict the capital investment to the construction of the middle and eastern routes by 2050. As discussed above, the western route is particularly difficult to construct. Capital investment would be reduced to bln \$20. China's annuity decreases to about \$3 bln. In neither scenario additional water is supplied to water using sectors in China. The focus of those experiments is on the economic consequences of the investment.

5.2 Simulation results

Figure 2 compares the changes in welfare in China and the rest of the world for the different non-market scenarios.⁹ Also displayed is the contribution of the changes in terms-of-trade to changes in welfare for the respective scenario for the rest of the world. Omitted are the results for China as they would just mirror the above showing the opposite sign. It is evident that China's welfare would be higher if all three routes would be implemented and the water would be given to the sectors more equally (left-most three scenarios of Figure 2). The pattern is similar for the terms-of-trade effects although relative small in size. Including the investment to the first three scenarios (middle three scenarios) shows a similar picture with comparable numbers. The change in welfare is higher compared to the sum of the left-most three scenarios and the respective investment scenario individually indicating multiplicative

⁹ Rest of the world (ROW) refers to all regions except China and not to the specification used in previous tables.

effects. The investment scenarios (right-most three scenarios) have only a limited influence on China's welfare, but always positive.

The changes in welfare for the rest of the world are measured on the right axis of Figure 2 and always negative; although an order of magnitude smaller for most scenarios compared to the impact on China's welfare.¹⁰ The left-most three scenarios indicate that welfare losses for the rest of the world would be smaller if all three routes would be implemented and the water would be given to the sectors more equally. The investment scenarios (right-most three scenarios) lead to much higher negative impacts on welfare for the rest of the world. This is caused by the transfer of investment to China reducing investments elsewhere. Changes in terms-of-trade dominate the welfare impact. The welfare effect falls and rises with the annual investment in China. Again, combined scenarios (middle three scenarios) show more pronounced impacts on welfare and terms-of-trade compared to the individual ones (right-most three and investment scenarios) and the terms-of-trade effects dominate the welfare impacts. The welfare change is particularly pronounced in the scenario 'preferred + investment'. This is due to high negative changes in welfare in USA, WEU and JPK. For those regions the negative terms-of-trade effects are extremely pronounced.

Figure 2 about here

In the second set of simulations (Figure 3) we consider the existence of a water market (market scenarios). With extra water supply, the water price falls, and, hence, the water rent. As in the other scenarios, due to cheaper production of water intensive goods and services, more water supply leads to an increase in virtual water exports from China and to a decrease in virtual water exports to China. The change in the water trade balance is less pronounced than in the non-market scenarios. The changes in welfare for China and the rest of the world are generally smaller in size but all positive. These results come from two effects. First, the water rent falls, which is a loss of welfare. This is zero in the non-market scenario. Second, the output augmenting technology change is zero in the market scenario. This is positive in the non-market scenario. As in the non-market scenarios, China would benefit from the capital investments necessary to implement the SNWT project. This increase in welfare comes mainly from the positive terms-of-trade effects. If investment increases, the imports of the other goods and services decreases, leading to higher welfare.¹¹

Because there is now a negative welfare effect through the decrease in water rent, more water does not imply more welfare, as it does in the non-market-scenarios. An unequal allocation of the additional water would now increase welfare. Although China's agricultural production is lowest in the 'preferred allocation' scenario, prices are highest. Therefore, China's terms-of-trade deteriorate if there is more water available. This further reduces water rents.

Comparing the 'base' and the 'investment' scenarios to the 'base + investment' scenario indicates that the sum of the welfare changes is higher than the joint change. In the joint scenario, the production of agricultural goods and capital goods is higher, but prices are lower. As prices for water decrease more, the income from water rent is smaller as well.

If least water is directed to the agricultural sector (preferred + investment) welfare gains are highest. As less additional agricultural products are produced, prices fall less compared to the other two scenarios. This dampens the loss in water rents. Although the fall in water rents is

¹⁰ Please note that the scale of the two axis are different.

¹¹ Note that the results of the investment scenarios (right-most three scenarios) are identical in Figures 2 and 3. The only difference is that of scale.

largest in the ‘base + investment’ scenario, the higher investment leads to welfare improvements compared to scenario ‘reduced + investment’.

Comparing figures 2 and 3, welfare losses for the rest of the world are smallest in the non-market scenario if we consider only the increase in water supply. If water supply increases, the import of water-intensive goods and services in the rest of the world increases more in the non-market scenario compared to the market scenario. World prices for agricultural goods are lower. But, if we add the investment, the rest of the world is better off in the market solution. If investments in China increase, the previous increase of imports (mainly agricultural goods) is counterbalanced by an increase of exports (investment) to China, which are higher in the non-market scenario.¹²

Figure 3 about here

6 Discussion and conclusion

In this study, we estimate the impact of the South-North Water Transfer (SNWT) project on the economy of China and the rest of the world using a computable general equilibrium model called GTAP-W. We find that the SNWT would stimulate China’s economy and increase welfare. In our base case, the payback period of the SNWT would be slightly less than two years. For the eastern and middle route, the payback period would be just over a year; for the western route, a bit more than 3 years. Previous estimates find a range of economic damage of \$0.8 to \$1.1 per cubic metre of water shortage. We find benefits of \$0.7/m³ for additional water supply. If, as we assume, the SNWT project is (implicitly) financed at the international capital market, benefits slightly increase with the influx of investment. If, as the Chinese government plans, the water transferred is preferably allocated to industry and households, the benefits are halved.

These conclusions change drastically if we account for the current value of water. Additional water supply would reduce the implicit price of water, and hurt the “owners” of informal water rights. Then, the benefits of the SNWT are minimal – the difficult eastern route of the SNWT would reduce welfare – and water should be preferentially allocated to industry and households.

The economic and welfare impacts of the SNWT on the rest of the world are small but negative. The size of the effect may cast doubt on our choice of a *global* computable general equilibrium model. However, the negative effect for the rest of the world is largely explained by a deterioration of its terms-of-trade. This implies that the terms-of-trade of China would improve, which justifies that we embedded the Chinese economy in the world economy. The welfare gains of China far outweigh the welfare losses elsewhere – if we disregard the reduction in water rents. If that is included, global welfare falls due to the implementation of the SNWT project.

This analysis needs to be extended in several ways and a number of limitations apply. First, we consider regional water supply, implicitly assuming that there is a perfect water market and costless water transport within each region. Sector-specific water resources allow for sub-

¹² As indicated in Section 4, the changes in investment levels resulting from the ‘base’ scenarios are taken into account in the ‘base + investment’ scenarios. For the market solution the base scenario resulted in an increase in investment of about 3.56% (compare Table 4). In the non-market solution the changes was only 1.20%.

regional differentiation of water resources, but only to a limited extent. Second, we have not been able to allocate industrial water use to its different users. We rather used a simplifying assumption that water for domestic and industry use is supplied by the water service sector. Third, we were not able to differentiate between the different qualities of water supplied. Some of the difference is captured by defining sector-specific water, but not all. Fourth, in our model we assume that water is used efficiently and no water is wasted. The water intensity coefficient captures some differences, but these differences do not respond to price or other signals, except to the price of water. Fifth, for the agricultural sector, we used irrigation water plus rainfall, without distinction; water use is gross water use, ignoring evapotranspiration by crops. Sixth, we nested water at the upper level in the production function of the water intensive goods and services, so that water cannot be substituted with specific inputs in the production processes. Seventh, we used a single data set for water use and water resources, ignoring the uncertainties in the data. All this is deferred to future research. These caveats hold for the model. For its application to the South-North Water Transfer in China, we note the following problems. First, we do not take into account secondary benefits of increases in water supply to water scarce regions including health effects (including higher productivity of labour force), sanitation, peoples life-satisfaction assuming less water stress, functioning ecosystems. Second, we use data for China as a whole without dividing the country at least in two parts, the 3-H-river basin and the rest of the country. Disaggregating the data for China would require a new social accounting matrix and re-calibration. Third, we use a static CGE model based on 1997 data to analyse investment decisions.

Acknowledgements

We had useful discussions about the topics of this paper with Francesco Bosello, Alvaro Calzadilla, Roberto Roson, Jian Zhang and Yuan Zhou. Also, we would like to thank Arjen Hoekstra for directing us to the UNESCO-IHE publication on water footprints of nations. The Abdus Salam International Centre for Theoretical Physics, the Fondazione Eni Enrico Mattei, the Hamburg University Innovation Fund, Michael Otto Foundation for Environmental Protection, and the Princeton Environmental Institute provided welcome financial support. All errors and opinions are ours.

References

- Allan, J.A. (1992) Fortunately there are substitutes for water otherwise our hydro-political futures would be impossible. In: Proceedings of the Conference on Priorities for Water Resources Allocation and Management : Natural Resources and Engineering Advisers Conference, Southampton, July 1992, pp. 13-26.
- Allan, J.A. (1993) Overall perspectives on countries and regions. In: Rogers, P. and Lydon, P. (Eds.) Water in the Arab World: Perspectives and Prognoses, Cambridge, Massachusetts, pp. 65-100.
- Berrittella, M., Hoekstra, A., Rehdanz, K., Roson, R. and Tol, R.S.J. (2005a) The economic impact of restricted water supply: A computable general equilibrium analysis, FNU-93, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.
- Berrittella, M., Hoekstra, A., Rehdanz, K., Roson, R. and Tol, R.S.J. (2005b) The economic impact of water pricing: A computable general equilibrium analysis, FNU-96, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

- Berkhoff, J. (2003) China: The South-North Water transfer Project – Is it justified? *Water Policy* **5** 1-28.
- Bosello, F., Roson, R. and Tol, R.S.J. *et al.* (2004) Economy-wide Estimates of the Implications of Climate Change: Sea Level Rise, FNU-38, Centre for Marine and Climate Research, Hamburg University, Hamburg.
- Burniaux, J.-M. and Truong, T.P. (2002) GTAP-E: An energy environmental version of the GTAP model, *GTAP Technical Paper* n.16.
- Cernetig, M. (2000) Sands of time creep up on China's water, *The Globe and Mail* (Toronto), 31 July 2000.
- Chapagain, A.K. and Hoekstra, A.Y. (2004) Water Footprints of Nations, Value of Water Research Report Series No. 16, UNESCO-IHE Delft, The Netherlands.
- Decaluwé, B., Patry, A. and Savard, L. (1999) When water is no longer heaven sent: Comparative pricing analysis in a AGE model, Working Paper 9908, CRÉFA 99-05, Département d'économique, Université Laval.
- Diao, X. and Roe, T. (2003) Can a water market avert the “double-whammy” of trade reform and lead to a “win-win” outcome? *Journal of Environmental Economics and Management* **45** 708-723.
- China Daily (2005) Beijingers able to drink water from the Yangtze River in 2007. Available online http://english.people.com.cn/200202/09/print20020209_90220.html
- Dinar, A. and Yaron, D. (1992) Adoption and Abandonment of Irrigation Technologies. *Agricultural Economics* **6** 315-32.
- Feng, S., Li, L.X., Duan, Z.G. and Zhang, J.L. (in press) Assessing the impacts of South-to-North Water Transfer Project with decision support systems. *Decision Support Systems*.
- Fraiture, C. de, Cai, X., Amarasinghe, U., Rosegrant, M. and Molden, D. (2004) Does international cereal trade save water? The impact of virtual water trade on global water use. Comprehensive Assessment Research Report 4, Colombo, Sri Lanka.
- Gómez, C.M., Tirado, D. and Rey-Maqueira, J. (2004) Water exchange versus water work: Insights from a computable general equilibrium model for the Balearic Islands, *Water Resources Research* **42** W10502 10.1029/2004WR003235.
- Goodman, D.J. (2000) More reservoir or transfer? A computable general equilibrium analysis of projected water shortages in the Arkansas River Basin, *Journal of Agricultural and Resource Economics* **25** (2) 698-713.
- Hertel, T.W. (1997) *Global Trade Analysis: Modeling and applications*, Cambridge University Press, Cambridge.
- Intergovernmental Panel on Climate Change (1997) *The regional impacts of climate change: An assessment of vulnerability. A special report of IPCC Working Group II*. Edited by Watson, R., Zinyowera, M., Moss, R. and Dokken, D., Cambridge University Press, Cambridge.
- Jin, L. and Young, W. (2001) Water use in agriculture in China: importance, challenges, and implications for policy. *Water Policy* **3** 215-228.
- Johannson, R.C., Tsur, Y., Roe, T.L., Doukkali, R., and Dinar, A. (2002) Pricing irrigation water: A review of theory and practice, *Water Policy* **4** 173-199.

- Kumar, M. D. and Singh, O.P. (2005) Virtual Water in Global Food and Water Policy Making: Is there need for Rethinking? *Water Resources Management* **19** 759-789, doi: 10.1007/s11269-005-3278-0
- Lee, H., Oliveira-Martins, J. and van der Mensbrugge, D. (1994) The OECD GREEN Model: An updated overview, Working Paper No. 97, OECD, Paris.
- Liu, C. (1998) Environmental Issues and the South-North Water Transfer Scheme. *The China Quarterly* (156) 899-910.
- Liu, C. and Zheng, H. (2002) South-to-north Water Transfer Schemes for China. *Water Resources Development* **18** (3) 453-471.
- Ma, J., Hoekstra, A.Y., Wang, H., Chapagain, A.K. and Wang, D. (2006) Virtual versus real water transfers within China. *Philosophical Transactions of the Royal Society B* **361** 835-842.
- MWR (2002) 2002 Water Resources Bulletin, Ministry of Water Resources of China.
- MWR (2004a) South-to North Water transfer project. Bureau of South-to-North Water Transfer Planning and Design (27 August 2004), Ministry of Water Resources of China. Available online at <http://www.mwr.gov.cn/english1/20040827/39304.asp> .
- MWR (2004b) 2004 Water Resource Bulletin, Ministry of Water Resources of China. Available online at <http://www.mwr.gov.cn/english1/20051101/60142.asp> .
- Rosegrant, M.W., Cai, X. and Cline, S.A. (2002) World water and food to 2025: Dealing with scarcity. International Food Policy Research Institute, Washington.
- Seung, C.K., Harris, T.R., Eglin, J.E. and Netusil, N.R. (2000) Impacts of water reallocation: A combined computable general equilibrium and recreation demand model approach, *The Annals of Regional Science* **34** 473-487.
- Shang, Y., Wang, S., Yang, Z., Zhou, K. and Li, L. (2003) The cultural relics distribution characteristics along the canal line and appraisal of its influence by the middle route project for water transferring from south to north China. *Human and Ecological Risk Assessment* **9** (1) 403-420.
- Shao, X., Wang, H. and Wang, Z. (2003) Interbasin transfer projects and their implications: A Chinese case study. *International Journal of River Basin Management* **1** (1) 5-14.
- US Embassy (2003) Update on China's South-North Water Transfer Project. June 2003 report from US embassy Beijing, available online at <http://www.usembassy-china.org.cn/sandt/ptr/SNWT-East-Route-prt.htm> .
- WB (2001) China: Agenda for Water Sector Strategy for North China. Report prepared by World Bank, Washington.
- WWC (2003) Country Report of the People's Republic of China. World Water Council and Chinese Ministry of Water Resources, Marseille.
- WWF (2001) The Proposed South-North Water Transfer Scheme in China: Need, Justification and Cost, WWF China.
- Yang, H. and Zehnder, A.J.B. (2001) China's regional water scarcity and implications for grain supply and trade. *Environment and Planning A* **33** 79-95.
- Yang, H. and Zehnder, A.J.B. (2005) The Shout-North Water Transfer Project in China: An analysis of water demand uncertainty and environmental objective in decision making. *World International* **30** (3) 1-11.

Zhou, Y. and Tol, R.S.J. (2005) Evaluating the costs of desalination and water transport.
Water Resource Research **41**(3) W03003 10.1029/2004WR003749.

Annex

Table A1. Aggregations in GTAP-W

A. Regional Aggregation

- 1. USA** – United States
- 2. CAN** – Canada
- 3. WEU** – Western Europe
- 4. JPK** – Japan and Korea
- 5. ANZ** – Australia and New Zealand
- 6. EEU** – Eastern Europe
- 7. FSU** – Former Soviet Union
- 8. MDE** – Middle East
- 9. CAM** – Central America
- 10. SAM** – South America
- 11. SAS** – South Asia
- 12. SEA** – Southeast Asia
- 13. CHI** – China
- 14. NAF** – North Africa
- 15. SSA** – Sub-Saharan Africa
- 16. ROW** – Rest of the world

B. Endowments

- 1. Land**
- 2. Labour**
- 3. Capital**
- 4. Natural Resource**

C. Sectoral Aggregation

- 1. Rice** – Rice
- 2. Wheat** – Wheat
- 3. CerCrops** – Other cereals and crops
- 4. VegFruits** – Vegetable, Fruits
- 5. Animals** – Animals
- 6. Forestry** – Forestry
- 7. Fishing** – Fishing
- 8. Coal** – Coal Mining
- 9. Oil** – Oil
- 10. Gas** – Natural Gas Extraction
- 11. Oil_Pcts** – Refined Oil Products
- 12. Electricity** – Electricity
- 13. Water** – Water collection, purification and distribution services
- 14. En_Int_ind** – Energy Intensive Industries
- 15. Oth_ind** – Other industry and services
- 16. MServ** – Market Services
- 17. NMServ** – Non-Market Services

Table A2. Regional characteristics

	Population	GDP/cap	Renewable water resource ^a		Water use 10 ⁹ m ³ per year	Water intensity in agriculture ^c M ³ /\$	Water intensity other ^d m ³ /\$	Water imports 10 ⁹ m ³	Water exports 10 ⁹ m ³
			10 ⁹ m ³ per year	M ³ /person ^b					
USA	276	28786	3069	11120	479	2.9	3.7	57	125
CAN	30	20572	2902	96733	46	4.3	5.2	8	51
WEU	388	24433	2227	5740	227	2.6	3.5	256	96
JPK	172	35603	500	2907	107	1.4	1.6	82	0
ANZ	22	21052	819	37227	26	4.1	1.2	3	30
CEE	121	2996	494	4083	60	3.3	13.6	19	6
FSU	291	1556	4730	16254	284	9.1	28.0	27	61
MDE	227	3150	483	2128	206	4.9	6.8	35	19
CAM	128	2938	1183	9242	101	5.2	13.6	25	31
LAM	332	4830	12246	36886	164	3.9	5.9	35	68
SAS	1289	416	3685	2859	918	9.8	47.5	21	25
SEA	638	4592	5266	8254	279	10.1	12.8	58	35
CHI	1274	790	2897	2274	630	3.6	38.5	33	16
NAF	135	1284	107	793	95	8.5	39.5	27	4
SSA	605	563	4175	6901	113	11.4	6.4	14	132
ROW	42	3338	2984	71048	75	4.7	2.7	6	8

^a 2001 estimates taken from Aquastat.

^b UN criterion for water resource scarcity degree: slightly scarce (1700-3000), middle scarce (1000-1700), severe scarcity (500-1000) and most severe scarcity (<500).

^c Average water intensity covering crop/plant growth and animal production measured in water use/\$ output. Numbers differ considerably between countries and sectors. Note that water use includes the use of different kind of sources; rain, soil moisture and irrigation water. However, farmers pay for irrigation water only.

^d Note that in some countries only a low number of persons is connected to a distribution network. In others a number of self-supplied industries are not connected. However, both are included as users of the services the water distribution network provides. As a consequence, water use per \$ of output is overstated in the above table.

Table A3. Water price elasticities

	Agricultural sectors	Water distribution services
1 USA	-0.14	-0.72
2 CAN	-0.08	-0.53
3 WEU	-0.04	-0.45
4 JPK	-0.06	-0.45
5 ANZ	-0.11	-0.67
6 EEU	-0.06	-0.44
7 FSU	-0.09	-0.67
8 MDE	-0.11	-0.77
9 CAM	-0.08	-0.53
10 SAM	-0.12	-0.80
11 SAS	-0.11	-0.75
12 SEA	-0.12	-0.80
13 CHI	-0.16	-0.80
14 NAF	-0.07	-0.60
15 SSA	-0.15	-0.80
16 ROW	-0.20	-0.85

Source: Our elaboration from Rosegrant et al.(2002).

Figure A1 – Nested tree structure for industrial production process

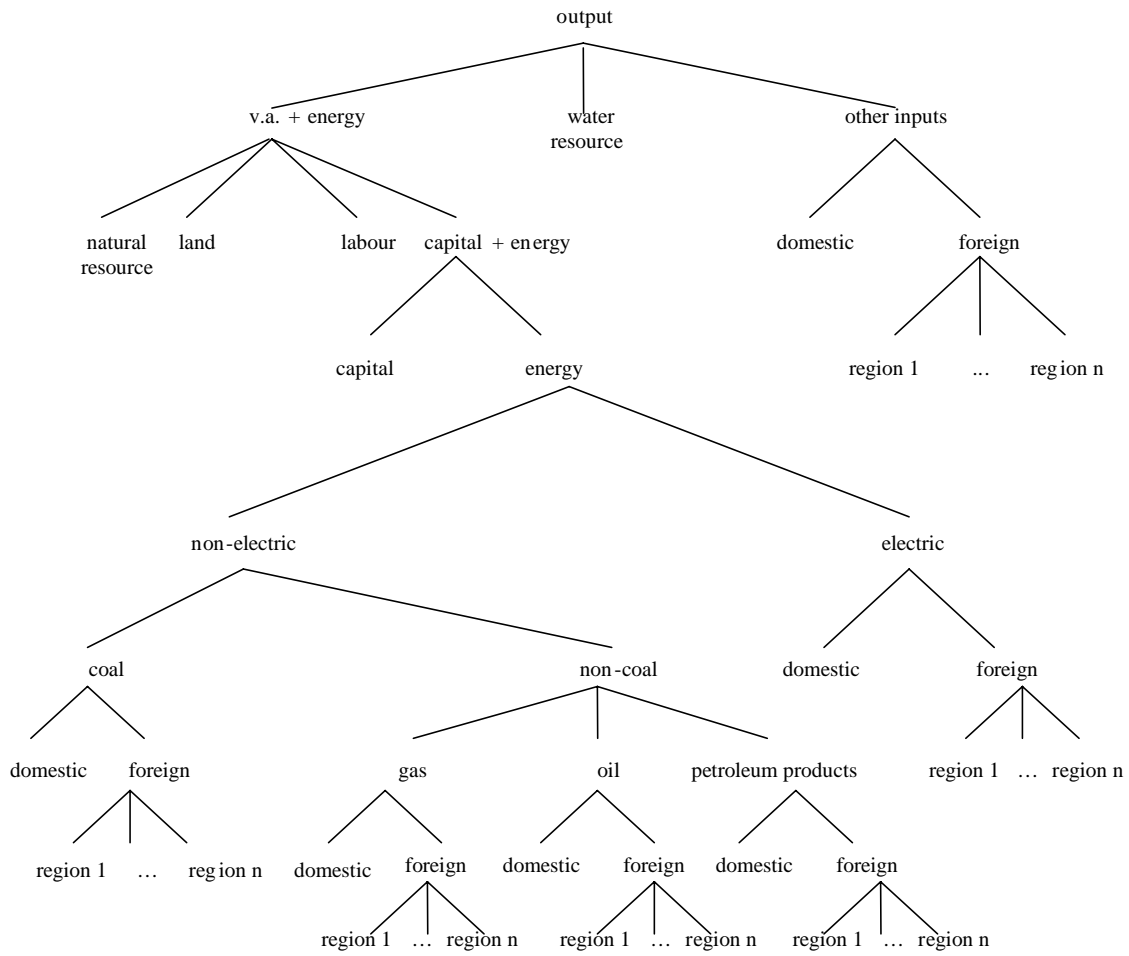
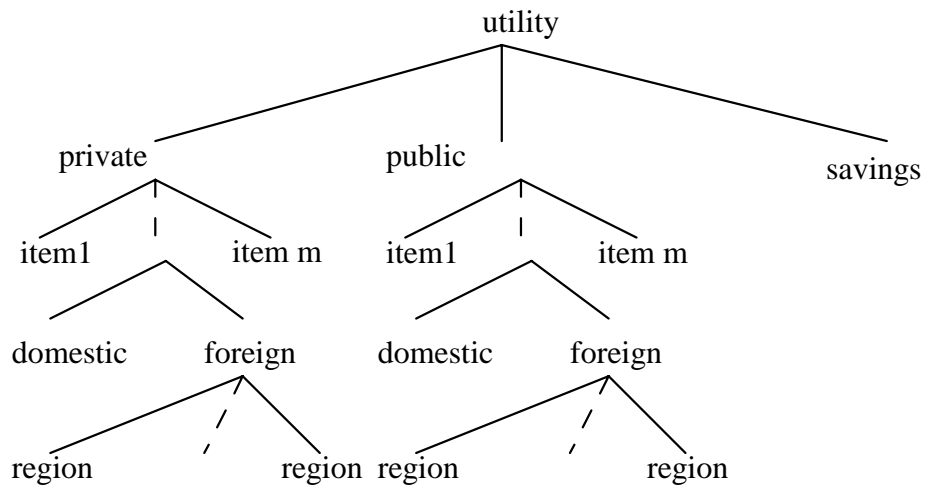
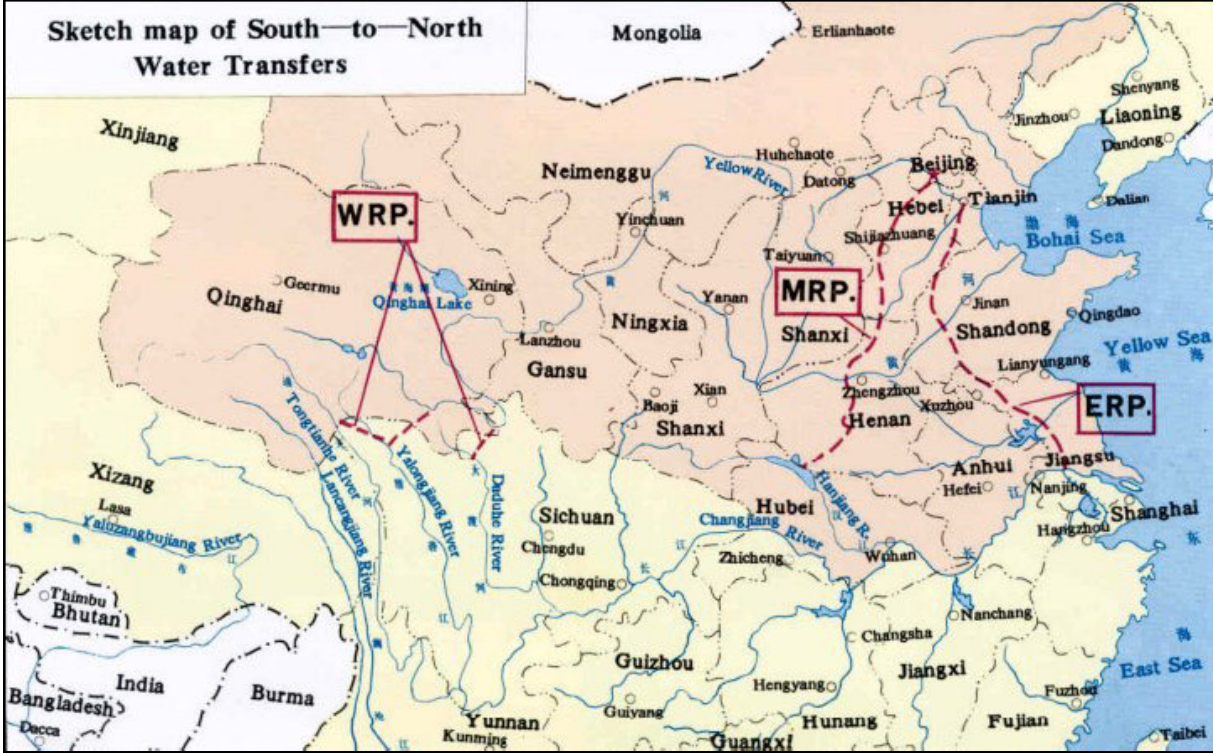


Figure A2 – Nested tree structure for final demand



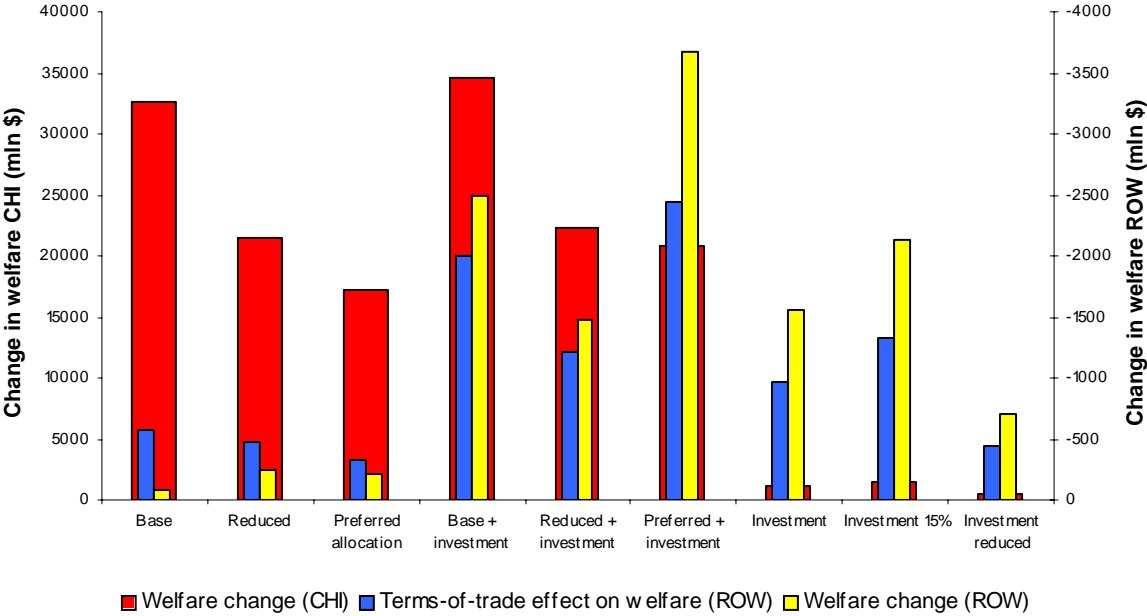
Figures and Tables

Figure 1: Sketch map of the South-to-North Water Transfer Project



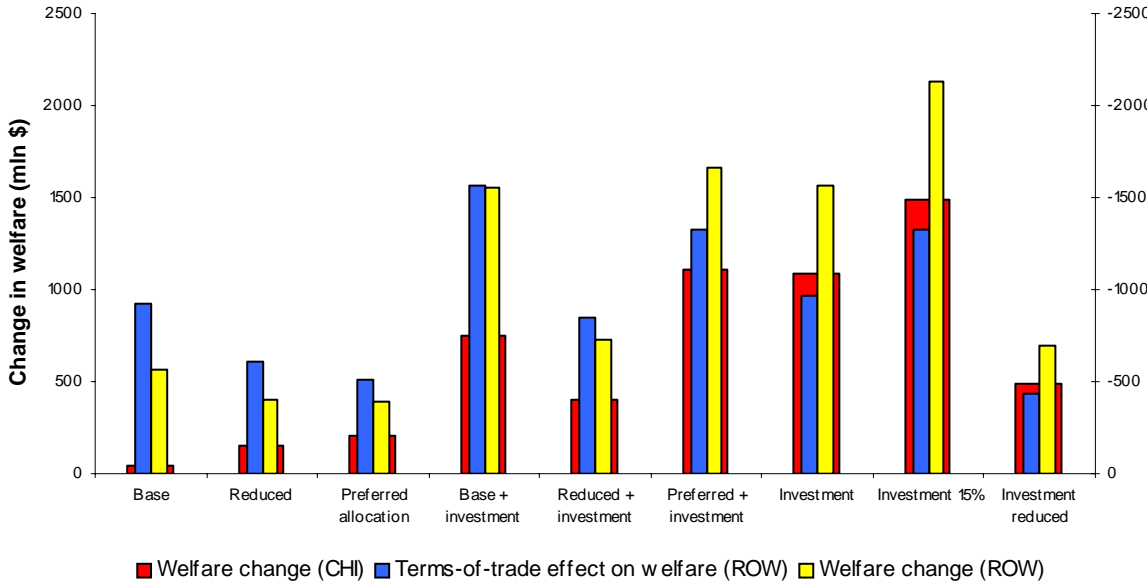
Source: MWR.

Figure 2: Welfare changes in China for the non-market scenarios¹



¹ ROW refers to all regions except China and not the definition used in table A1. “Change” indicates a gain for China and a loss for “ROW”.

Figure 3: Changes in welfare for the market scenarios¹



¹ ROW refers to all regions except China and not the definition used in table A1. “Change” indicates a gain for China and a loss for “ROW”.

Table 1. Construction of the western, middle and eastern routes (Scenario 1)

	Water demand (%)	Technical augmenting change (%)		Virtual water trade balance (change in billion m ³)	GDP (%)	Trade balance (change in mln \$)	Contribution of ToT to EV (change in mln \$)	EV welfare (change in mln \$)
		Agricultural sector	Water distribution					
USA	-0.88	0	0	-5.55	0.000	2542	-790	-862
CAN	-1.70	0	0	-1.55	0.000	211	-55	-53
WEU	-0.63	0	0	-3.26	-0.002	3323	-300	-448
JPK	-0.48	0	0	0.72	0.018	1678	234	990
ANZ	-1.43	0	0	-0.95	-0.001	132	-43	-51
EEU	-0.33	0	0	-0.19	0.000	114	-6	-7
FSU	-0.83	0	0	-1.76	0.002	146	80	91
MDE	-0.59	0	0	-0.44	0.010	220	308	383
CAM	-0.43	0	0	-0.60	0.002	125	-9	-3
SAM	-0.35	0	0	-1.70	-0.007	575	-119	-258
SAS	-0.10	0	0	-1.39	0.000	147	-79	-84
SEA	-0.40	0	0	-1.03	0.006	-119	317	352
CHI	6.58	14.84	41.80	22.49	3.198	-9353	579	32646
NAF	-0.41	0	0	-0.29	0.004	99	39	46
SSA	-0.57	0	0	-3.93	-0.008	129	-189	-217
ROW	-0.31	0	0	-0.56	-0.001	32	34	34

Table 2. Capital investment for the construction of all three routes (Scenario 2)

	Water demand (%)	Investment (%)	Virtual water trade balance (change in billion m ³)	GDP (%)	Trade balance (change in mln \$)	Contribution of ToT to EV (change in mln \$)	EV welfare (change in mln \$)
USA	0.03	-0.01	0.06	-0.001	1260	-277	-378
CAN	0.04	-0.01	0.02	-0.004	156	-6	-33
WEU	0.03	-0.02	0.01	-0.003	1674	-236	-501
JPK	0.07	-0.02	-0.06	-0.001	1925	-290	-341
ANZ	0.04	-0.02	0.01	-0.003	119	-16	-32
EEU	0.00	0.00	0.00	0.000	-10	6	5
FSU	0.02	-0.02	0.03	-0.002	131	-23	-33
MDE	0.01	-0.02	0.01	-0.001	116	-13	-25
CAM	0.01	0.00	0.00	-0.001	80	1	-6
SAM	0.02	-0.01	0.07	-0.002	269	-32	-76
SAS	0.00	-0.02	0.05	-0.002	160	-26	-41
SEA	0.02	0.00	-0.04	-0.001	432	-7	-19
CHI	-0.16	1.85	-0.25	0.007	-6432	971	1090
NAF	0.01	-0.02	0.01	-0.003	40	-7	-14
SSA	0.00	-0.03	0.06	-0.003	48	-40	-52
ROW	0.01	-0.01	0.01	-0.003	31	-6	-16

Table 3. Water transfer by all three routes and capital investment (Scenario 3)

	Water demand (%)	Technical augmenting change (%)		Investment	Virtual water trade balance (change in billion m ³)	GDP (%)	Trade balance (change in mln \$)	Contribution of ToT to EV (change in mln \$)	EV welfare (change in mln \$)
		Agricultural sector	Water distribution						
USA	-0.56	0	0	-0.02	-5.45	-0.001	4094	-1133	-1363
CAN	-1.21	0	0	-0.04	-1.51	-0.011	547	-83	-151
WEU	-0.50	0	0	-0.03	-3.21	-0.007	5345	-569	-1192
JPK	-0.29	0	0	0.02	0.63	0.015	5460	-342	289
ANZ	-1.23	0	0	0.00	-0.91	-0.008	354	-74	-116
EEU	-0.26	0	0	0.17	-0.20	0.011	-131	35	71
FSU	-0.56	0	0	0.08	-1.72	0.000	260	55	48
MDE	-0.56	0	0	0.15	-0.46	0.014	33	330	427
CAM	-0.38	0	0	0.07	-0.59	0.001	211	-4	-4
SAM	-0.30	0	0	-0.02	-1.59	-0.010	913	-161	-365
SAS	-0.10	0	0	-0.04	-1.26	-0.004	530	-140	-175
SEA	-0.36	0	0	0.19	-1.05	0.004	945	259	263
CHI	6.58	15.00	40.61	5.41	21.98	3.235	-18859	2005	34666
NAF	-0.40	0	0	-0.03	-0.27	0.001	118	31	30
SSA	-0.57	0	0	-0.04	-3.86	-0.010	135	-237	-273
ROW	-0.30	0	0	0.10	-0.55	-0.003	45	29	21

Table 4. % Variations in prices and production levels in China

	Scenario 1		Scenario 2		Scenario 3	
	Price change (%)	Change in production level (%)	Price change (%)	Change in production level (%)	Price change (%)	Change in production level (%)
Land	-26.59	0.00	-0.29	0.00	-26.34	0.00
Labour	3.48	0.00	0.49	0.00	4.21	0.00
Capital	4.70	0.00	0.53	0.00	5.46	0.00
Natural Resources	6.70	0.00	-0.21	0.00	7.12	0.00
Rice	-19.64	-0.27	0.23	-0.36	-19.37	-0.73
Wheat	-23.74	-0.08	0.25	-0.26	-23.50	-0.35
Other cereals and crops	-16.13	9.20	0.26	-0.20	-15.83	8.97
Vegetables and Fruits	-16.55	7.44	0.27	-0.17	-16.20	7.52
Animals	-18.76	10.26	0.30	0.04	-18.43	10.71
Forestry	2.87	0.10	0.45	0.00	3.51	0.03
Fishing	5.13	1.72	0.29	-0.06	6.00	1.82
Coal	2.39	-0.03	0.17	-0.13	2.76	-0.15
Oil	1.83	-0.88	0.18	-0.15	2.15	-1.06
Gas	2.26	0.85	0.30	-0.22	2.73	0.66
Refined oil products	1.73	1.11	0.22	0.06	2.09	1.31
Electricity	2.52	0.23	0.34	-0.18	3.04	0.14
Water distribution	-28.49	6.58	0.44	-0.01	-27.41	6.58
Energy intensive industries	1.79	-0.55	0.35	-0.33	2.31	-1.00
Other industries and services	-0.05	1.65	0.34	-0.51	0.45	0.95
Market services	2.28	1.70	0.40	0.54	2.86	2.34
Non market services	2.23	1.12	0.40	0.05	2.82	1.31
Capital goods	1.31	3.56	0.34	1.85	1.81	5.41

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

<http://www.feem.it/Feem/Pub/Publications/WPapers/default.html>

<http://www.ssrn.com/link/feem.html>

<http://www.repec.org>

<http://agecon.lib.umn.edu>

NOTE DI LAVORO PUBLISHED IN 2006

SIEV	1.2006	<i>Anna ALBERINI: Determinants and Effects on Property Values of Participation in Voluntary Cleanup Programs: The Case of Colorado</i>
CCMP	2.2006	<i>Valentina BOSETTI, Carlo CARRARO and Marzio GALEOTTI: Stabilisation Targets, Technical Change and the Macroeconomic Costs of Climate Change Control</i>
CCMP	3.2006	<i>Roberto ROSON: Introducing Imperfect Competition in CGE Models: Technical Aspects and Implications</i>
KTHC	4.2006	<i>Sergio VERGALLI: The Role of Community in Migration Dynamics</i>
SIEV	5.2006	<i>Fabio GRAZI, Jeroen C.J.M. van den BERGH and Piet RIETVELD: Modeling Spatial Sustainability: Spatial Welfare Economics versus Ecological Footprint</i>
CCMP	6.2006	<i>Olivier DESCHENES and Michael GREENSTONE: The Economic Impacts of Climate Change: Evidence from Agricultural Profits and Random Fluctuations in Weather</i>
PRCG	7.2006	<i>Michele MORETTO and Paola VALBONESE: Firm Regulation and Profit-Sharing: A Real Option Approach</i>
SIEV	8.2006	<i>Anna ALBERINI and Aline CHIABAI: Discount Rates in Risk v. Money and Money v. Money Tradeoffs</i>
CTN	9.2006	<i>Jon X. EGUIA: United We Vote</i>
CTN	10.2006	<i>Shao CHIN SUNG and Dinko DIMITRO: A Taxonomy of Myopic Stability Concepts for Hedonic Games</i>
NRM	11.2006	<i>Fabio CERINA (lxxviii): Tourism Specialization and Sustainability: A Long-Run Policy Analysis</i>
NRM	12.2006	<i>Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA (lxxviii): Benchmarking in Tourism Destination, Keeping in Mind the Sustainable Paradigm</i>
CCMP	13.2006	<i>Jens HORBACH: Determinants of Environmental Innovation – New Evidence from German Panel Data Sources</i>
KTHC	14.2006	<i>Fabio SABATINI: Social Capital, Public Spending and the Quality of Economic Development: The Case of Italy</i>
KTHC	15.2006	<i>Fabio SABATINI: The Empirics of Social Capital and Economic Development: A Critical Perspective</i>
CSRM	16.2006	<i>Giuseppe DI VITA: Corruption, Exogenous Changes in Incentives and Deterrence</i>
CCMP	17.2006	<i>Rob B. DELLINK and Marjan W. HOFKES: The Timing of National Greenhouse Gas Emission Reductions in the Presence of Other Environmental Policies</i>
IEM	18.2006	<i>Philippe QUIRION: Distributional Impacts of Energy-Efficiency Certificates Vs. Taxes and Standards</i>
CTN	19.2006	<i>Somdeb LAHIRI: A Weak Bargaining Set for Contract Choice Problems</i>
CCMP	20.2006	<i>Massimiliano MAZZANTI and Roberto ZOBOLI: Examining the Factors Influencing Environmental Innovations</i>
SIEV	21.2006	<i>Y. Hossein FARZIN and Ken-ICHI AKAO: Non-pecuniary Work Incentive and Labor Supply</i>
CCMP	22.2006	<i>Marzio GALEOTTI, Matteo MANERA and Alessandro LANZA: On the Robustness of Robustness Checks of the Environmental Kuznets Curve</i>
NRM	23.2006	<i>Y. Hossein FARZIN and Ken-ICHI AKAO: When is it Optimal to Exhaust a Resource in a Finite Time?</i>
NRM	24.2006	<i>Y. Hossein FARZIN and Ken-ICHI AKAO: Non-pecuniary Value of Employment and Natural Resource Extinction</i>
SIEV	25.2006	<i>Lucia VERGANO and Paulo A.L.D. NUNES: Analysis and Evaluation of Ecosystem Resilience: An Economic Perspective</i>
SIEV	26.2006	<i>Danny CAMPBELL, W. George HUTCHINSON and Riccardo SCARPA: Using Discrete Choice Experiments to Derive Individual-Specific WTP Estimates for Landscape Improvements under Agri-Environmental Schemes: Evidence from the Rural Environment Protection Scheme in Ireland</i>
KTHC	27.2006	<i>Vincent M. OTTO, Timo KUOSMANEN and Ekko C. van IERLAND: Estimating Feedback Effect in Technical Change: A Frontier Approach</i>
CCMP	28.2006	<i>Giovanni BELLA: Uniqueness and Indeterminacy of Equilibria in a Model with Polluting Emissions</i>
IEM	29.2006	<i>Alessandro COLOGNI and Matteo MANERA: The Asymmetric Effects of Oil Shocks on Output Growth: A Markov-Switching Analysis for the G-7 Countries</i>
KTHC	30.2006	<i>Fabio SABATINI: Social Capital and Labour Productivity in Italy</i>
ETA	31.2006	<i>Andrea GALLICE (lxxix): Predicting one Shot Play in 2x2 Games Using Beliefs Based on Minimax Regret</i>
IEM	32.2006	<i>Andrea BIGANO and Paul SHEEHAN: Assessing the Risk of Oil Spills in the Mediterranean: the Case of the Route from the Black Sea to Italy</i>
NRM	33.2006	<i>Rinaldo BRAU and Davide CAO (lxxviii): Uncovering the Macrostructure of Tourists' Preferences. A Choice Experiment Analysis of Tourism Demand to Sardinia</i>
CTN	34.2006	<i>Parkash CHANDER and Henry TULKENS: Cooperation, Stability and Self-Enforcement in International Environmental Agreements: A Conceptual Discussion</i>
IEM	35.2006	<i>Valeria COSTANTINI and Salvatore MONNI: Environment, Human Development and Economic Growth</i>
ETA	36.2006	<i>Ariel RUBINSTEIN (lxxix): Instinctive and Cognitive Reasoning: A Study of Response Times</i>

ETA	37.2006	<i>Maria SALGADEO</i> (lxxx): <u>Choosing to Have Less Choice</u>
ETA	38.2006	<i>Justina A.V. FISCHER and Benno TORGLER</i> : <u>Does Envy Destroy Social Fundamentals? The Impact of Relative Income Position on Social Capital</u>
ETA	39.2006	<i>Benno TORGLER, Sascha L. SCHMIDT and Bruno S. FREY</i> : <u>Relative Income Position and Performance: An Empirical Panel Analysis</u>
CCMP	40.2006	<i>Alberto GAGO, Xavier LABANDEIRA, Fidel PICOS And Miguel RODRÍGUEZ</i> : <u>Taxing Tourism In Spain: Results and Recommendations</u>
IEM	41.2006	<i>Karl van BIERVLIET, Dirk Le ROY and Paulo A.L.D. NUNES</i> : <u>An Accidental Oil Spill Along the Belgian Coast: Results from a CV Study</u>
CCMP	42.2006	<i>Rolf GOLOMBEK and Michael HOEL</i> : <u>Endogenous Technology and Tradable Emission Quotas</u>
KTHC	43.2006	<i>Giulio CAINELLI and Donato IACOBUCCI</i> : <u>The Role of Agglomeration and Technology in Shaping Firm Strategy and Organization</u>
CCMP	44.2006	<i>Alvaro CALZADILLA, Francesco PAULI and Roberto ROSON</i> : <u>Climate Change and Extreme Events: An Assessment of Economic Implications</u>
SIEV	45.2006	<i>M.E. KRAGT, P.C. ROEBELING and A. RUIJS</i> : <u>Effects of Great Barrier Reef Degradation on Recreational Demand: A Contingent Behaviour Approach</u>
NRM	46.2006	<i>C. GIUPPONI, R. CAMERA, A. FASSIO, A. LASUT, J. MYSLIAK and A. SGOBBI</i> : <u>Network Analysis, Creative System Modelling and DecisionSupport: The NetSyMoD Approach</u>
KTHC	47.2006	<i>Walter F. LALICH</i> (lxxx): <u>Measurement and Spatial Effects of the Immigrant Created Cultural Diversity in Sydney</u>
KTHC	48.2006	<i>Elena PASPALANOVA</i> (lxxx): <u>Cultural Diversity Determining the Memory of a Controversial Social Event</u>
KTHC	49.2006	<i>Ugo GASPARINO, Barbara DEL CORPO and Dino PINELLI</i> (lxxx): <u>Perceived Diversity of Complex Environmental Systems: Multidimensional Measurement and Synthetic Indicators</u>
KTHC	50.2006	<i>Aleksandra HAUKE</i> (lxxx): <u>Impact of Cultural Differences on Knowledge Transfer in British, Hungarian and Polish Enterprises</u>
KTHC	51.2006	<i>Katherine MARQUAND FORSYTH and Vanja M. K. STENIUS</i> (lxxx): <u>The Challenges of Data Comparison and Varied European Concepts of Diversity</u>
KTHC	52.2006	<i>Gianmarco I.P. OTTAVIANO and Giovanni PERI</i> (lxxx): <u>Rethinking the Gains from Immigration: Theory and Evidence from the U.S.</u>
KTHC	53.2006	<i>Monica BARNI</i> (lxxx): <u>From Statistical to Geolinguistic Data: Mapping and Measuring Linguistic Diversity</u>
KTHC	54.2006	<i>Lucia TAJOLI and Luca DE BENEDICTIS</i> (lxxx): <u>Economic Integration and Similarity in Trade Structures</u>
KTHC	55.2006	<i>Suzanna CHAN</i> (lxxx): <u>“God’s Little Acre” and “Belfast Chinatown”: Diversity and Ethnic Place Identity in Belfast</u>
KTHC	56.2006	<i>Diana PETKOVA</i> (lxxx): <u>Cultural Diversity in People’s Attitudes and Perceptions</u>
KTHC	57.2006	<i>John J. BETANCUR</i> (lxxx): <u>From Outsiders to On-Paper Equals to Cultural Curiosities? The Trajectory of Diversity in the USA</u>
KTHC	58.2006	<i>Kiflemariam HAMDE</i> (lxxx): <u>Cultural Diversity A Glimpse Over the Current Debate in Sweden</u>
KTHC	59.2006	<i>Emilio GREGORI</i> (lxxx): <u>Indicators of Migrants’ Socio-Professional Integration</u>
KTHC	60.2006	<i>Christa-Maria LERM HAYES</i> (lxxx): <u>Unity in Diversity Through Art? Joseph Beuys’ Models of Cultural Dialogue</u>
KTHC	61.2006	<i>Sara VERTOMMEN and Albert MARTENS</i> (lxxx): <u>Ethnic Minorities Rewarded: Ethnostratification on the Wage Market in Belgium</u>
KTHC	62.2006	<i>Nicola GENOVESE and Maria Grazia LA SPADA</i> (lxxx): <u>Diversity and Pluralism: An Economist's View</u>
KTHC	63.2006	<i>Carla BAGNA</i> (lxxx): <u>Italian Schools and New Linguistic Minorities: Nationality Vs. Plurilingualism. Which Ways and Methodologies for Mapping these Contexts?</u>
KTHC	64.2006	<i>Vedran OMANOVIĆ</i> (lxxx): <u>Understanding “Diversity in Organizations” Paradigmatically and Methodologically</u>
KTHC	65.2006	<i>Mila PASPALANOVA</i> (lxxx): <u>Identifying and Assessing the Development of Populations of Undocumented Migrants: The Case of Undocumented Poles and Bulgarians in Brussels</u>
KTHC	66.2006	<i>Roberto ALZETTA</i> (lxxx): <u>Diversities in Diversity: Exploring Moroccan Migrants’ Livelihood in Genoa</u>
KTHC	67.2006	<i>Monika SEDENKOVA and Jiri HORAK</i> (lxxx): <u>Multivariate and Multicriteria Evaluation of Labour Market Situation</u>
KTHC	68.2006	<i>Dirk JACOBS and Andrea REA</i> (lxxx): <u>Construction and Import of Ethnic Categorisations: “Allochthones” in The Netherlands and Belgium</u>
KTHC	69.2006	<i>Eric M. USLANER</i> (lxxx): <u>Does Diversity Drive Down Trust?</u>
KTHC	70.2006	<i>Paula MOTA SANTOS and João BORGES DE SOUSA</i> (lxxx): <u>Visibility & Invisibility of Communities in Urban Systems</u>
ETA	71.2006	<i>Rinaldo BRAU and Matteo LIPPI BRUNI</i> : <u>Eliciting the Demand for Long Term Care Coverage: A Discrete Choice Modelling Analysis</u>
CTN	72.2006	<i>Dinko DIMITROV and Claus-JOCHEN HAAKE</i> : <u>Coalition Formation in Simple Games: The Semistrict Core</u>
CTN	73.2006	<i>Ottorino CHILLEM, Benedetto GUI and Lorenzo ROCCO</i> : <u>On The Economic Value of Repeated Interactions Under Adverse Selection</u>
CTN	74.2006	<i>Sylvain BEAL and Nicolas QUÉROU</i> : <u>Bounded Rationality and Repeated Network Formation</u>
CTN	75.2006	<i>Sophie BADE, Guillaume HAERINGER and Ludovic RENO</i> : <u>Bilateral Commitment</u>
CTN	76.2006	<i>Andranik TANGIAN</i> : <u>Evaluation of Parties and Coalitions After Parliamentary Elections</u>
CTN	77.2006	<i>Rudolf BERGHAMMER, Agnieszka RUSINOWSKA and Harrie de SWART</i> : <u>Applications of Relations and Graphs to Coalition Formation</u>
CTN	78.2006	<i>Paolo PIN</i> : <u>Eight Degrees of Separation</u>
CTN	79.2006	<i>Roland AMANN and Thomas GALL</i> : <u>How (not) to Choose Peers in Studying Groups</u>

CTN	80.2006	<i>Maria MONTERO</i> : <u>Inequity Aversion May Increase Inequity</u>
CCMP	81.2006	<i>Vincent M. OTTO, Andreas LÖSCHEL and John REILLY</i> : <u>Directed Technical Change and Climate Policy</u>
CSRM	82.2006	<i>Nicoletta FERRO</i> : <u>Riding the Waves of Reforms in Corporate Law, an Overview of Recent Improvements in Italian Corporate Codes of Conduct</u>
CTN	83.2006	<i>Siddhartha BANDYOPADHYAY and Mandar OAK</i> : <u>Coalition Governments in a Model of Parliamentary Democracy</u>
PRCG	84.2006	<i>Raphaël SOUBEYRAN</i> : <u>Valence Advantages and Public Goods Consumption: Does a Disadvantaged Candidate Choose an Extremist Position?</u>
CCMP	85.2006	<i>Eduardo L. GIMÉNEZ and Miguel RODRÍGUEZ</i> : <u>Pigou's Dividend versus Ramsey's Dividend in the Double Dividend Literature</u>
CCMP	86.2006	<i>Andrea BIGANO, Jacqueline M. HAMILTON and Richard S.J. TOL</i> : <u>The Impact of Climate Change on Domestic and International Tourism: A Simulation Study</u>
KTHC	87.2006	<i>Fabio SABATINI</i> : <u>Educational Qualification, Work Status and Entrepreneurship in Italy an Exploratory Analysis</u>
CCMP	88.2006	<i>Richard S.J. TOL</i> : <u>The Polluter Pays Principle and Cost-Benefit Analysis of Climate Change: An Application of Fund</u>
CCMP	89.2006	<i>Philippe TULKENS and Henry TULKENS</i> : <u>The White House and The Kyoto Protocol: Double Standards on Uncertainties and Their Consequences</u>
SIEV	90.2006	<i>Andrea M. LEITER and Gerald J. PRUCKNER</i> : <u>Proportionality of Willingness to Pay to Small Risk Changes – The Impact of Attitudinal Factors in Scope Tests</u>
PRCG	91.2006	<i>Raphaël SOUBEYRAN</i> : <u>When Inertia Generates Political Cycles</u>
CCMP	92.2006	<i>Alireza NAGHAVI</i> : <u>Can R&D-Inducing Green Tariffs Replace International Environmental Regulations?</u>
CCMP	93.2006	<i>Xavier PAUTREL</i> : <u>Reconsidering The Impact of Environment on Long-Run Growth When Pollution Influences Health and Agents Have Finite-Lifetime</u>
CCMP	94.2006	<i>Corrado Di MARIA and Edwin van der WERF</i> : <u>Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technical Change</u>
CCMP	95.2006	<i>Paulo A.L.D. NUNES and Chiara M. TRAVISI</i> : <u>Comparing Tax and Tax Reallocations Payments in Financing Rail Noise Abatement Programs: Results from a CE valuation study in Italy</u>
CCMP	96.2006	<i>Timo KUOSMANEN and Mika KORTELAJINEN</i> : <u>Valuing Environmental Factors in Cost-Benefit Analysis Using Data Envelopment Analysis</u>
KTHC	97.2006	<i>Dermot LEAHY and Alireza NAGHAVI</i> : <u>Intellectual Property Rights and Entry into a Foreign Market: FDI vs. Joint Ventures</u>
CCMP	98.2006	<i>Inmaculada MARTÍNEZ-ZARZOSO, Aurelia BENGOCHEA-MORANCHO and Rafael MORALES LAGE</i> : <u>The Impact of Population on CO2 Emissions: Evidence from European Countries</u>
PRCG	99.2006	<i>Alberto CAVALIERE and Simona SCABROSETTI</i> : <u>Privatization and Efficiency: From Principals and Agents to Political Economy</u>
NRM	100.2006	<i>Khaled ABU-ZEID and Sameh AFIFI</i> : <u>Multi-Sectoral Uses of Water & Approaches to DSS in Water Management in the NOSTRUM Partner Countries of the Mediterranean</u>
NRM	101.2006	<i>Carlo GIUPPONI, Jaroslav MYSLAK and Jacopo CRIMI</i> : <u>Participatory Approach in Decision Making Processes for Water Resources Management in the Mediterranean Basin</u>
CCMP	102.2006	<i>Kerstin RONNEBERGER, Maria BERRITTELLA, Francesco BOSELLO and Richard S.J. TOL</i> : <u>Klum@Gtap: Introducing Biophysical Aspects of Land-Use Decisions Into a General Equilibrium Model A Coupling Experiment</u>
KTHC	103.2006	<i>Avner BEN-NER, Brian P. McCALL, Massoud STEPHANE, and Hua WANG</i> : <u>Identity and Self-Other Differentiation in Work and Giving Behaviors: Experimental Evidence</u>
SIEV	104.2006	<i>Aline CHIABAI and Paulo A.L.D. NUNES</i> : <u>Economic Valuation of Oceanographic Forecasting Services: A Cost-Benefit Exercise</u>
NRM	105.2006	<i>Paola MINOIA and Anna BRUSAROSCO</i> : <u>Water Infrastructures Facing Sustainable Development Challenges: Integrated Evaluation of Impacts of Dams on Regional Development in Morocco</u>
PRCG	106.2006	<i>Carmine GUERRIERO</i> : <u>Endogenous Price Mechanisms, Capture and Accountability Rules: Theory and Evidence</u>
CCMP	107.2006	<i>Richard S.J. TOL, Stephen W. PACALA and Robert SOCOLOW</i> : <u>Understanding Long-Term Energy Use and Carbon Dioxide Emissions in the Usa</u>
NRM	108.2006	<i>Carles MANERA and Jaume GARAU TABERNER</i> : <u>The Recent Evolution and Impact of Tourism in the Mediterranean: The Case of Island Regions, 1990-2002</u>
PRCG	109.2006	<i>Carmine GUERRIERO</i> : <u>Dependent Controllers and Regulation Policies: Theory and Evidence</u>
KTHC	110.2006	<i>John FOOT (lxxx)</i> : <u>Mapping Diversity in Milan. Historical Approaches to Urban Immigration</u>
KTHC	111.2006	<i>Donatella CALABI</i> : <u>Foreigners and the City: An Historiographical Exploration for the Early Modern Period</u>
IEM	112.2006	<i>Andrea BIGANO, Francesco BOSELLO and Giuseppe MARANO</i> : <u>Energy Demand and Temperature: A Dynamic Panel Analysis</u>
SIEV	113.2006	<i>Anna ALBERINI, Stefania TONIN, Margherita TURVANI and Aline CHIABAI</i> : <u>Paying for Permanence: Public Preferences for Contaminated Site Cleanup</u>
CCMP	114.2006	<i>Vivekananda MUKHERJEE and Dirk T.G. RÜBBELKE</i> : <u>Global Climate Change, Technology Transfer and Trade with Complete Specialization</u>
NRM	115.2006	<i>Clive LIPCHIN</i> : <u>A Future for the Dead Sea Basin: Water Culture among Israelis, Palestinians and Jordanians</u>
CCMP	116.2006	<i>Barbara BUCHNER, Carlo CARRARO and A. Denny ELLERMAN</i> : <u>The Allocation of European Union Allowances: Lessons, Unifying Themes and General Principles</u>
CCMP	117.2006	<i>Richard S.J. TOL</i> : <u>Carbon Dioxide Emission Scenarios for the Usa</u>

NRM	118.2006	<i>Isabel CORTÉS-JIMÉNEZ and Manuela PULINA: <u>A further step into the ELGH and TLGH for Spain and Italy</u></i>
SIEV	119.2006	<i>Beat HINTERMANN, Anna ALBERINI and Anil MARKANDYA: <u>Estimating the Value of Safety with Labor Market Data: Are the Results Trustworthy?</u></i>
SIEV	120.2006	<i>Elena STRUKOVA, Alexander GOLUB and Anil MARKANDYA: <u>Air Pollution Costs in Ukraine</u></i>
CCMP	121.2006	<i>Massimiliano MAZZANTI, Antonio MUSOLESI and Roberto ZOBOLI: <u>A Bayesian Approach to the Estimation of Environmental Kuznets Curves for CO₂ Emissions</u></i>
ETA	122.2006	<i>Jean-Marie GREThER, Nicole A. MATHYS, and Jaime DE MELO: <u>Unraveling the World-Wide Pollution Haven Effect</u></i>
KTHC	123.2006	<i>Sergio VERGALLI: <u>Entry and Exit Strategies in Migration Dynamics</u></i>
PRCG	124.2006	<i>Bernardo BORTOLOTTI and Valentina MILELLA: <u>Privatization in Western Europe Stylized Facts, Outcomes and Open Issues</u></i>
SIEV	125.2006	<i>Pietro CARATTI, Ludovico FERRAGUTO and Chiara RIBOLDI: <u>Sustainable Development Data Availability on the Internet</u></i>
SIEV	126.2006	<i>S. SILVESTRI, M PELLIZZATO and V. BOATTO: <u>Fishing Across the Centuries: What Prospects for the Venice Lagoon?</u></i>
CTN	127.2006	<i>Alison WATTS: <u>Formation of Segregated and Integrated Groups</u></i>
SIEV	128.2006	<i>Danny CAMPBELL, W. George HUTCHINSON and Riccardo SCARPA: <u>Lexicographic Preferences in Discrete Choice Experiments: Consequences on Individual-Specific Willingness to Pay Estimates</u></i>
CCMP	129.2006	<i>Giovanni BELLA: <u>Transitional Dynamics Towards Sustainability: Reconsidering the EKC Hypothesis</u></i>
IEM	130.2006	<i>Elisa SCARPA and Matteo MANERA: <u>Pricing and Hedging Illiquid Energy Derivatives: an Application to the JCC Index</u></i>
PRCG	131.2006	<i>Andrea BELTRATTI and Bernardo BORTOLOTTI: <u>The Nontradable Share Reform in the Chinese Stock Market</u></i>
IEM	132.2006	<i>Alberto LONGO, Anil MARKANDYA and Marta PETRUCCI: <u>The Internalization of Externalities in The Production of Electricity: Willingness to Pay for the Attributes of a Policy for Renewable Energy</u></i>
ETA	133.2006	<i>Brighta BERCEA and Sonia OREFFICE: <u>Quality of Available Mates, Education and Intra-Household Bargaining Power</u></i>
KTHC	134.2006	<i>Antonia R. GURRIERI and Luca PETRUZZELLIS: <u>Local Networks to Compete in the Global Era. The Italian SMEs Experience</u></i>
CCMP	135.2006	<i>Andrea BIGANO, Francesco BOSELLO, Roberto ROSON and Richard S.J. TOL: <u>Economy-Wide Estimates of the Implications of Climate Change: A Joint Analysis for Sea Level Rise and Tourism</u></i>
CCMP	136.2006	<i>Richard S.J. TOL: <u>Why Worry About Climate Change? A Research Agenda</u></i>
SIEV	137.2006	<i>Anna ALBERINI, Alberto LONGO and Patrizia RIGANTI: <u>Using Surveys to Compare the Public's and Decisionmakers' Preferences for Urban Regeneration: The Venice Arsenale</u></i>
ETA	138.2006	<i>Y. Hossein FARZIN and Ken-Ichi AKAO: <u>Environmental Quality in a Differentiated Duopoly</u></i>
CCMP	139.2006	<i>Denny ELLERMAN and Barbara BUCHNER: <u>Over-Allocation or Abatement? A Preliminary Analysis of the Eu Ets Based on the 2005 Emissions Data</u></i>
CCMP	140.2006	<i>Horățiu A. RUS (lxxx): <u>Renewable Resources, Pollution and Trade in a Small Open Economy</u></i>
CCMP	141.2006	<i>Enrica DE CIAN (lxxx): <u>International Technology Spillovers in Climate-Economy Models: Two Possible Approaches</u></i>
CCMP	142.2006	<i>Tao WANG (lxxx): <u>Cost Effectiveness in River Management: Evaluation of Integrated River Policy System in Tidal Ouse</u></i>
CCMP	143.2006	<i>Gregory F. NEMET (lxxx): <u>How well does Learning-by-doing Explain Cost Reductions in a Carbon-free Energy Technology?</u></i>
CCMP	144.2006	<i>Anne BRIAND (lxxx): <u>Marginal Cost Versus Average Cost Pricing with Climatic Shocks in Senegal: A Dynamic Computable General Equilibrium Model Applied to Water</u></i>
CCMP	145.2006	<i>Thomas ARONSSON, Kenneth BACKLUND and Linda SAHLÉN (lxxx): <u>Technology Transfers and the Clean Development Mechanism in a North-South General Equilibrium Model</u></i>
IEM	146.2006	<i>Theocharis N. GRIGORIADIS and Benno TORGLER: <u>Energy Regulation, Roll Call Votes and Regional Resources: Evidence from Russia</u></i>
CCMP	147.2006	<i>Manish GUPTA: <u>Costs of Reducing Greenhouse Gas Emissions: A Case Study of India's Power Generation Sector</u></i>
CCMP	148.2006	<i>Valeria COSTANTINI: <u>A Modified Environmental Kuznets Curve for Sustainable Development Assessment Using Panel Data</u></i>
IEM	149.2006	<i>Andrea BIGANO, Mariaester CASSINELLI, Anil MARKANDYA and Fabio SFERRA: <u>The Role of Risk Aversion and Lay Risk in the Probabilistic Externality Assessment for Oil Tanker Routes to Europe</u></i>
KTHC	150.2006	<i>Valeria GATTAI: <u>A Tale of Three Countries: Italian, Spanish and Swiss Manufacturing Operations in China</u></i>
NRM	151.2006	<i>Alessandra SGOBBI and Gregorio FRAVIGA: <u>Governance and Water Management: Progress and Tools in Mediterranean Countries</u></i>
SIEV	152.2006	<i>Pietro CARATTI and Gabriella Lo CASCIO: <u>Sustainable Development Policies in Europe</u></i>
KTHC	153.2006	<i>Mario A. MAGGIONI, Mario NOSVELLI and T. Erika UBERTI: <u>Space Vs. Networks in the Geography of Innovation: A European Analysis</u></i>
CCMP	154.2006	<i>Maria BERRITTELLA, Katrin REHDANZ and Richard S.J. TOL: <u>The Economic Impact of the South-North Water Transfer Project in China: A Computable General Equilibrium Analysis</u></i>

(Ixxviii) This paper was presented at the Second International Conference on "Tourism and Sustainable Economic Development - Macro and Micro Economic Issues" jointly organised by CRENoS (Università di Cagliari and Sassari, Italy) and Fondazione Eni Enrico Mattei, Italy, and supported by the World Bank, Chia, Italy, 16-17 September 2005.

(Ixxix) This paper was presented at the International Workshop on "Economic Theory and Experimental Economics" jointly organised by SET (Center for advanced Studies in Economic Theory, University of Milano-Bicocca) and Fondazione Eni Enrico Mattei, Italy, Milan, 20-23 November 2005. The Workshop was co-sponsored by CISEPS (Center for Interdisciplinary Studies in Economics and Social Sciences, University of Milano-Bicocca).

(Ixxx) This paper was presented at the First EURODIV Conference "Understanding diversity: Mapping and measuring", held in Milan on 26-27 January 2006 and supported by the Marie Curie Series of Conferences "Cultural Diversity in Europe: a Series of Conferences.

(Ixxxi) This paper was presented at the EAERE-FEEM-VIU Summer School on "Computable General Equilibrium Modeling in Environmental and Resource Economics", held in Venice from June 25th to July 1st, 2006 and supported by the Marie Curie Series of Conferences "European Summer School in Resource and Environmental Economics".

2006 SERIES

CCMP	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti)
SIEV	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anil Markandya)
NRM	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
KTHC	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
IEM	<i>International Energy Markets</i> (Editor: Matteo Manera)
CSRM	<i>Corporate Social Responsibility and Sustainable Management</i> (Editor: Giulio Sapelli)
PRCG	<i>Privatisation Regulation Corporate Governance</i> (Editor: Bernardo Bortolotti)
ETA	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
CTN	<i>Coalition Theory Network</i>