Coal mining and human wellbeing: A case-study in Shanxi, China

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Abstract

Coal has been an essential source of energy that has fuelled economic growth and development throughout modern history. Its use has delivered astonishing developments in human living standards and wellbeing. Coal is the most affordable and widely available source of energy. It is particularly essential for developing countries, such as China, as it helps deliver economical and stable electricity to underpin economic growth and poverty alleviation. That said, environmental problems associated with coal, such as human-enhanced greenhouse effects generated when coal is burned are of concern.

For host (mining) communities, coal mining seems to also be a two-edged sword. Coal resource development, for example, can bring numerous jobs, can increase household incomes and can generate revenue for governments, which is significant for regional development. But numerous negative impacts have been documented; coal mining can adversely affect natural capital (environment), human capital, social capital, institutional capital and the economy (e.g. through inflation). These 'capitals' all contribute to human wellbeing; so the impacts of mining on human wellbeing are complex and multifaceted. Some impacts, such as mining revenues, are tangible, likely positive, and can be easily observed and quantified from market transactions. In contrast, other impacts, on the environment, culture, and society, are often intangible are thus much less easily quantified or observed.

Existing mining impact assessment processes, such as environmental/social/economic impact assessment, and assessments of eco-compensation for mining, struggle to quantify the numerous non-market impacts of mining; they thus struggle to provide data to defensibly assess trade-offs between the benefits and costs of mining that takes account of all tangible and intangible impacts on host communities. This difficulty results, partly, from the fact that currently available methods (mostly traditional economic non-market valuation techniques) for assessing intangible impacts are on occasion inadequate – particularly when assessing numerous simultaneous and inter-related impacts. The life satisfaction (LS) approach, shows advantages over other non-market

valuation methods, and has been successfully used to assess a range of non-market goods, but it has not yet been used to measure the impacts of mining.

This study aims to assess the impacts of coal mining on LS – associated with the more general term 'human wellbeing', which includes objective and subjectice dimensions. Specifically, it uses insights from the wellbeing literature and from the LS approach to quantify and compare multiple impacts of coal mining; and it assesses the trade-off between benefits (mostly monetary – e.g. through income) and costs (numerous, often intangible) of coal mining on host communities. In doing so, it offers insights into how coal mining affects a range of wellbeing factors or life domains. It also provides insights about the net impacts of mining, about who benefits most/least from coal mining and about how one might target policy to compensate those who do not perceive a net benefit. It thus identifies policy priorities to help mitigate the negative and enhance the positive impacts of coal mining on human wellbeing.

This study focusses on 3 major research questions, each of which is directly linked to an identified research gap:

1. How does coal mining affect people's subjective perceptions of different wellbeing factors? This includes the importance attached to each wellbeing factor, satisfaction with each factor, and people's perception about the impacts of coal mining on these factors.
2. Does information about the impacts of coal mining derived from subjective assessments of wellbeing convey the same message about the impacts of coal mining as 'objective' measures of wellbeing?
3. Is it possible to quantify the net impacts of coal mining (on broad 'domains' of life and on the overall wellbeing of host communities) and to determine how much should, in principle, be paid 'in compensation' to those who are, overall, impacted negatively?

Shanxi province, the most important coal producer in China, was selected as the case-study region. Within Shanxi, 5 types of case-study areas, including rural areas with coal mining (Rural With), rural areas close to coal mining (Rural Close), urban areas close to coal mining (Urban Close), urban areas far from coal mining (Urban Far) and rural areas far from coal mining (Rural Far) were selected for focus – providing insights from a cross-section of people with differential exposure to coal mining.

A comprehensive set of data on wellbeing was not available in the case-study areas. Therefore, questionnaire surveys were used to collect data on 29 different factors known (from the literature) to affect wellbeing. Residents were asked to indicate how important they thought each factor was to their overall wellbeing, how satisfied they were with each, and how they thought coal mining was (or could) impact those factors. They were also asked about their satisfaction with life overall, and to provide some basic sociodemographic information. 'Objective' indicators of air quality were collected at each location. A total of 542 valid questionnaires were collected.

Responses to questions about satisfaction (with factors), importance (of factors) and perceptions (of the impacts of coal mining on those factors) were examined separately, and 2 indices, one combining satisfaction and importance (Index of Dis-Satisfaction – IDS), and the other combining satisfaction and perceptions of impacts (Index of Dis-Satisfaction and Negative Impacts – IDSNI) were constructed. Indicators related to health and relationship were deemed – by the entire sample, and by each sub-sample – to be the most important factors; these were also the factors with which people from all the study areas were most satisfied. People living in coal mining areas were most dissatisfied with factors relating to environmental quality (air quality and water safety) and the economy (real estate prices and inflation), while people in non-coal mining areas were most dissatisfied with factors only relating to the economy. People from all the study regions expressed most concern about the impacts of mining on the factors relating to the environment and health. Both IDS and IDSNI indicate that in coal mining areas both environmental issues and economic issues were of high priority, and environmental issues were paramount. IDS indicates that in non-coal mining areas, economic issues and social issues (the quality of government, education and property safety) were of most concern.

Available objective wellbeing indicators were regressed against subjective wellbeing indicators, controlling for sociodemographic factors (such as age, family size and gender). The relationships between some subjective and objective indicators were statistically significant (e.g. higher levels of family income were associated with higher satisfaction with family income, and higher levels of PM_{10} were associated with lower levels of satisfaction with air quality), but some were not (the objective indicators of housing conditions did not always predict satisfaction with housing). These relationships were always mediated by sociodemographic variables indicating that subjective and objective indicators are not 'perfect' substitutes for each other. These results indicate that it is both possible and necessary to use subjective indicators of wellbeing in addition to traditionally used objective indicators to inform public policy in coal mining regions. Moreover, this study demonstrates approaches that can be used to explore the relationship between objective and subjective indicators which could be used to inform future policy makers about when it is most/least appropriate to use only objective or only subjective indicators.

Using principal component analysis, the 29 wellbeing factors were collapsed into 6 life domains: human capital, economy, social capital, institutional capital, living conditions and natural environment. Factor scores relating to each domain were retained for use as dependent variables in regression models. The sample was divided in two (rural and urban), and variables denoting proximity to coal mining and sociodemographic factors were included as regressors so that the impacts of mining on satisfaction with life domains and on LS could be assessed while controlling for other potentially confounding factors. Factor scores from each domain and measures of global life satisfaction were each regressed against numerous factors known to influence subjective assessments of wellbeing.

Urban residents were found to be relatively insensitive to the impacts of coal mining. Although people living in places with or close to coal mines in rural areas ("Rural With" and "Rural Close") had statistically significant lower levels of satisfaction across multiple life domains (the natural environment, the economy and society) than those living further away from mines, they were, however, more satisfied with their living conditions. After controlling for confounding sociodemographic factors, the analysis revealed that rural residents living in areas adjacent to coal mines had experienced lower levels of satisfaction with life overall than those living more than 10km away from mines. It was possible to use coefficients from the LS model to infer that a similar 'loss' of life satisfaction would be ‘engineered’ by reducing family income by 20,000 Yuan per annum; although that estimate should be treated as illustrative only since the model did not control for all potential statistical problems. The ‘loss’ in global LS was greatest for those who lived in rural areas adjacent to mines whose family were dependent upon non-coal mining industries for income: their LS was significantly lower than the LS of people whose families were dependent upon coal mining (even after controlling for income). This ‘loss’ of life satisfaction could be equivalently engineered by a reduction in family income of 47,000 Yuan per annum. Here too, the estimate is illustrative only.

These results suggest that the net impacts of coal mining for those who live in rural areas adjacent to mines are negative and that to mitigate these negative impacts, addressing environmental issues is a priority. Relocating people who live in coal mining areas, delivering more mining jobs to local residents and/or providing monetary compensation could also directly improve their life satisfaction (wellbeing). Delivering more jobs to local people is likely to be a less costly pathway to redistribute the benefits and costs of coal mining. It will not only improve the local economy in terms of improving local residents’ incomes, reducing income disparity and achieving fairness but it could also help prevent the degradation of social capital that can occur when numerous non-residential workers with limited meaningful attachment to local communities, are brought in from other regions.

This investigation furthers the understanding of coal mining or mining impacts on the wellbeing of host communities. It provides some useful information to address the negative impacts of coal mining or mining and to improve local wellbeing, and offers a new tool for mining impact assessment and compensation. Importantly, this approach to assessing net impacts and the trade-offs associated with the coal mining industry could potentially be used to assess the net impacts and trade-offs of a wide range of other industries and/or policy and development choices (e.g. the tourism industry, construction of dams), worldwide.

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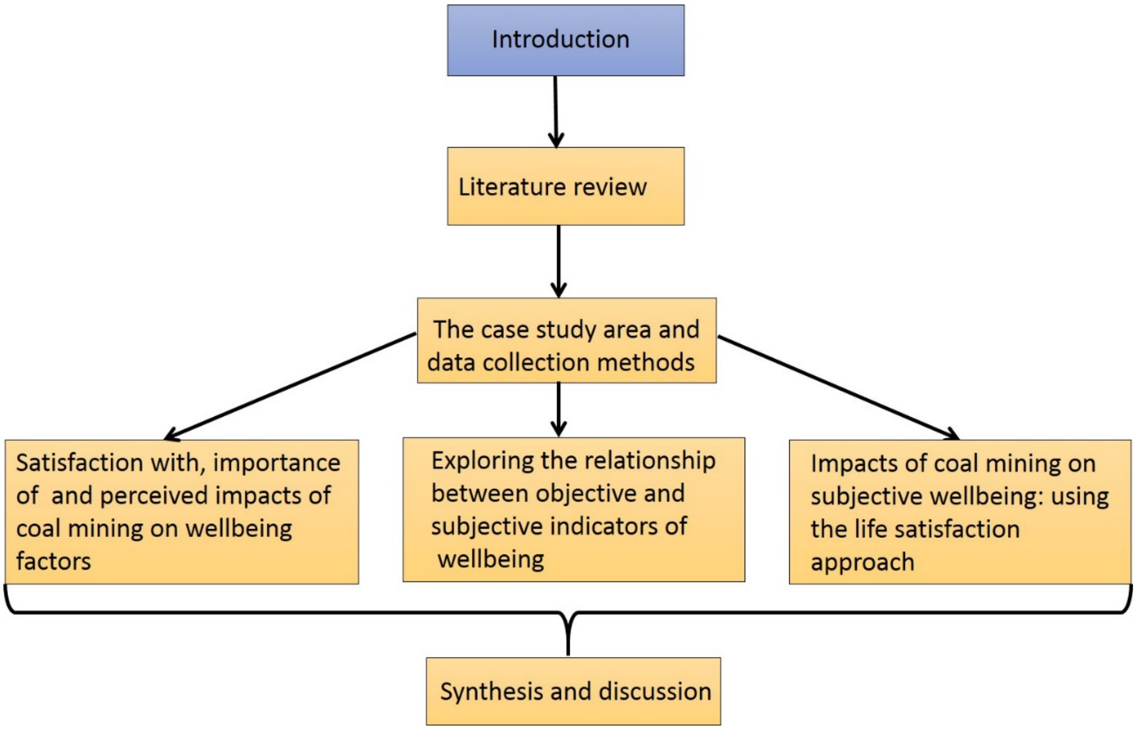
Thesis outline



CHAPTER 1 INTRODUCTION

Chapter outline

1.1 Introduction

1.2 The benefits of mining and coal mining

1.3 Downsides of mining or coal mining

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1.5 Structure of this thesis

1.1 Introduction

This thesis investigates the impacts of coal mining in a case-study area of Shanxi Province China, from the perspective of wellbeing.

Coal has played a fundamental role in the development of human civilization. Currently, coal is fuelling economic growth in many countries, especially in developing countries, such as China. Coal, as the most economical, cost effective, affordable and widely available source of energy plays a vital role in economic growth and poverty alleviation in developing countries. The coal industry also brings numerous jobs, increases in (some) household incomes, and raises revenue for the government, which is significant for regional development.

Nevertheless, various problems, associated with coal mining and coal use have become alarming and bitterly disputed global issues. Globally, coal mining and coal use are condemned for the irreversible worldwide climate change which they contribute to (Epstein et al., 2011, p. 10). Regionally, coal mining also causes severe environmental, social and economic problems in host communities.

Being a non-renewable resource, and recognising the irreversible impacts associated with coal mining, makes the exploitation of coal unsustainable in the long run, and thus violates several criteria of the strict definition of sustainable development (Kates et al., 2005). However, in the exploitation of coal, one form of capital, natural capital, is being substituted or traded off to gain other forms of capital, including infrastructure development, new technologies and new knowledge. This is consistent with the discourse of the sustainable development, albeit with significant assumptions made about the substitutability of one form of capital with another (OECD, 2002).

This raises an important question about net impacts: are the benefits sufficiently large to ‘make up for’ the costs? Answers to such questions are required to make responsible and defensible social decisions about the exploitation of this resource. This is a complicated and challenging task as the trade-off can be considered with a worldwide, national or regional scope – e.g. considering global warming and human development or weighing up the economic benefits of coal mining against the multiple associated problems within a country or a region. Additionally, it often involves political factors – a fair and defensible trade-off that takes into account the welfare of all the stakeholders (such as the host communities – the closest proximity to coal mining and where coal mining occurs) may compromise economic growth prioritized by government policy.

Academically, the deficiency of the current assessment approaches to this challenge contribute to the difficulty of defensibly assessing net impacts and/or trade-offs. The most widely used environmental impact assessment (EIA) in mining practice today, in theory, requires that all impacts, environmental, economic and social, be integrated (Hundloe et al., 1990). Cost-benefit analysis, can make a contribution to this task: in which case the magnitude of impacts are assessed using money as a standard metric, so that benefits and costs can be compared. However, in practice, it is often difficult to include all impacts in a cost-benefit framework especially when intangible values (that are not traded in the market, such as those relating to the environment, culture, and society) are impacted. These can be exceedingly difficult to measure using money metrics (Hundloe et al., 1990; Ivanova et al., 2007; Gillespie and Kragt, 2010). Indeed, the more 'intangible', and more loosely connected an impact is to the market, the more difficult it is to adequately measure with limited budgets or time frames. This often limits the number of non-market factors properly assessed within a CBA and thus the accuracy of net impacts/trade-off assessments when impacts are numerous and varied (as for the case of mining).

Focusing on host communities, this study aims to assess the multiple (positive and negative) impacts of coal mining on the wellbeing (formally, 'life satisfaction'), of residents in Shanxi (the most important coal producing province in China). It offers insights into how coal mining affects a range of wellbeing factors or life domains. It uses the 'life satisfaction' approach to measuring multiple impacts of coal mining on wellbeing and assesses the net impact (on life satisfaction). In doing so, this investigation improves our understanding of impacts that coal mining in particular, and mining in general, has on the wellbeing of host communities. It provides useful information about ways to address the negative impacts of coal mining and to improve local wellbeing, and offers a new tool for mining impact assessment. Importantly, this approach to assessing net impacts and trade-offs associated with the coal mining industry could potentially be used to assess the net impacts and trade-offs associated with a wide range of other industries and/or policy and development choices (e.g. the tourism industry, construction of dams), worldwide.

To help the reader gain a full understanding of the depth and breadth of coal mining's impacts, the general benefits of mining and coal mining, in particular, are introduced in section 1.2. The downsides of mining and coal mining, in particular, are described in section 1.3. The current research and policy focus is discussed in section 1.4. The specific research objectives addressed in this thesis are presented in section 1.5.

1.2 The benefits of mining and coal mining

Mining[2] is one of the oldest and most important contributors to modern societies. Human beings depend on fossil fuels and precious metals for energy, electronics, transportation, infrastructure, and other aspects of everyday life. According to the World Bank, non-renewable mineral resources play a dominant role in 81 countries, which collectively account for a quarter of the world's GDP, and half of the world's population (The World Bank, 2015). There are consensus among researchers that mining have the potential to promote significant economic development (Ascher, 1999, David, 1998 and Deaton 1999, cited by Amponsah-Tawiah and Dartey-Baah, 2011, p. 63)

In developed countries, such as Australia, the mining industry is one of the most important national industries. It adds value that accounts for 10.2% of Australia's Gross Domestic Product (GDP). The mining industry directly employs 2.3 % of the total workforce. However, it also contributes to employment in other related industries, such as construction, transport, retail and warehousing, manufacturing and professional goods and services, scientific and technical services (Department of Employment, 2014). In developing countries, such as China, from 2008 to 2011, the mining industry contributed a yearly average of 5.5% to China's GDP (Zhang et al., 2015), and employed

[2] Coal is not a mineral (Alva et al., 2009), but in some literature and official statistics, the term "mineral extraction/development" is often interchangeable with "mining", which includes coal mining (e.g. Lei et al., 2013; Mineral council of Australia, 2011).

6.3 million (Zhang et al., 2015), higher than employment from many other industries (Lei et al., 2013).

Coal, as one of the most important fossil fuels, has been an essential source of energy that has fuelled economic growth and development throughout modern history. It powered the industrial revolution and delivered astonishing developments in human living standards and wellbeing since then. It facilitated the advancement of virtually all other industries and agriculture, powered transport, communications and commerce, provisioned health and education services and influenced the shape and size of human settlements.

Currently, coal is the world's largest source of electricity, accounting for over 40% of global electricity production (International Energy Agency, 2016). Coal is still the backbone of the economy in many countries. The coal industry provides a significant direct contribution to the gross domestic product (GDP) of many nations (Coal Association of Canada, 2011; National Mining Association, 2014). For example, Australia's coal economy in broader terms, including both the supply-side and demand-side considerations, represents 4.2 % of GDP (Mineral Council of Australia, 2016). Furthermore, coal mining is a significant contributor to regional economies: the coal economy contributed 16.3% to the regional product of West Virginia (National Mining Association, 2014). The coal industry makes a significant contribution in the form of taxes, royalties and charges in many countries with rich coal resources, such as Australia (Australians for Coal, 2014). These revenues are used to improve infrastructure and public services, which improve the quality of life of many people in those regions.

Coal production provides numerous jobs directly and indirectly. In the United States, the domestic coal mining industry was responsible for 154,000 direct jobs and over 400,000 indirect jobs in 2008 (The truth about surface mining, 2016). In Australia, the coal industry employed almost 180,000 people in 2011 and 2012 (Mineral Council of Australia, 2016).

Coal is of even greater importance to the developing world where the demands for rapid development largely rely on coal as the cheapest energy source. Compared to other energy, coal is more affordable and relatively straightforward to convert to electrical power (OECD, 2002), which is an essential condition for economic growth and poverty alleviation (Cousins, 1998; Karekezi, 2002; Pachauri and Spreng, 2004; Kammen and Kirubi, 2008). Coal's dominant position in the global energy mix is also because of its wide distribution across the world (see Figure 1.1).

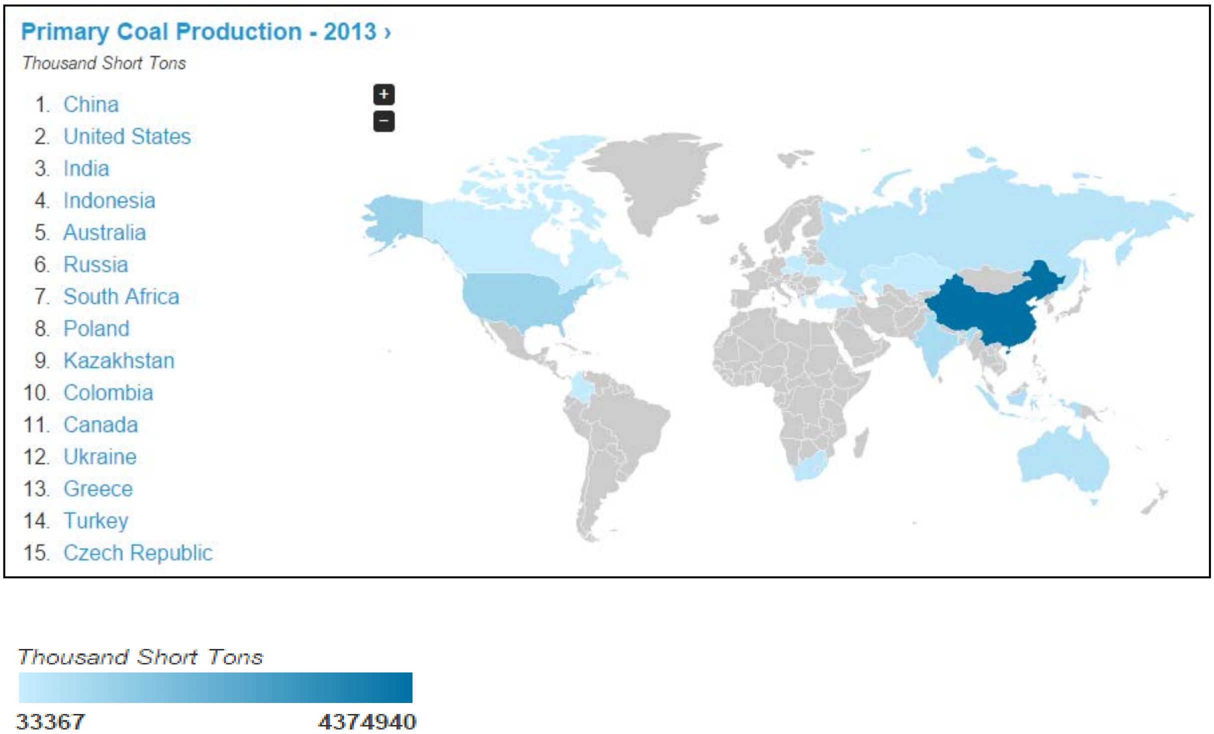


Figure 1.1 Coal production all over the world

Source: From IEA Energy Atlas[3], accessed on 20 January, 2016.

China is the largest producer and consumer of coal in the world. China alone accounted for over 48% of total global coal consumption (World Energy Council, 2013).Coal consumption accounts for 70% of China's primary energy consumption and is expected to remain the dominant fuel source in China for the coming two or three decades (OECD/IEA, 2012; Dai et al., 2014). Coal-fired power generation has enabled the spectacular economic transformation of this developing country into the second largest economy on the planet while dramatically reducing poverty and lifting millions of people into the expanding ranks of the middle classes.

[3] http://energyatlas.iea.org/?subject=2020991907

The coal industry accounts for a great part of the GDP in China, and makes the greatest contribution to social employment, especially by absorbing rural labourers (Lei et al., 2013). Especially, coal mining boosts the economy in the coal mining areas, for example, the coal industry accounts for 56.6% of GDP in Shanxi Province in 2012 (Editor of Land & Resource Herald, 2013), which is the most important coal producer in China.

1.3 Downsides of mining or coal mining

In his review of the oil, gas, and mining sectors in developing countries, Ross (2001) commented that; "…the best course of action for poor states would be to avoid, export-oriented extractive industries altogether, and instead work to sustainably develop their agricultural and manufacturing sectors that tend to provide direct benefits to the poor, and more balanced forms of growth" (p. 17). Friends of the Earth, an International non-government organisation (NGO), argued that, without guarantee for economic growth and poverty and alleviation, fossil fuel and mining projects caused dramatic negative impacts on ecology, local communities (e.g. health and social inequity) and called for the phasing out of public financing for mining and fossil fuel projects (Friends of the Earth International, 2001). The mining industry by its very nature is a "footprint industry", bringing with it numerous social and economic impacts (Weber-Fahr, 2002).

However, not all agree with the assessment that extraction of non-renewable resources is always detrimental for developing countries. According to Krannich and Greider (1984), "any assertion about disruption and reduced wellbeing among boom-town residents must be clearly qualified by a recognition that such effects may be observed only with respect to some indicators and then not always among all of the boom town subpopulation" (Krannich and Greider, 2001, p. 548). Richards (2002) asserted that: "farming and forestry have a far larger footprint than mining, and probably a far greater negative environmental impact if the effects of fertilizers and pesticides are considered" (Richards, 2002, p. 18). Although important, comparing the impacts of coal mining with other industries is beyond the scope of this thesis.

The impacts of mining on the natural environment are relatively well studied. Environmental problems of mining activity vary with the resources being mined, the location of the activity, method of mining and onsite processing and transport of material, etc. The literature that investigates environmental impacts of mining often focuses on particular resources (e.g. coal, or gold). In contrast, the literature that investigates social and economic impacts of mining does not tend to focus on a particular type of resource, but rather on mining in general. This is probably because the social and economic impacts of mining depend on social and economic context (e.g. on political systems and cultural backgrounds) rather than mineral type. Social and economic impacts thus vary across countries with different politics systems and cultural backgrounds, but may be shared by countries with similar political systems and cultural backgrounds. Therefore, the next section of this chapter reviews literature on the environmental impacts of coal mining in particular, while, focusing on the social and economic impacts of mining in general, except where information about the social and economic impacts of coal mining, specifically, are available.

1.3.1 Coal mining and the natural environment

There are two main methods of extracting coal: underground or so-called deep mines and open-cut mines which are often called open-cast or surface mines (World Coal Association, 2016). While environmental impacts differ depending on many variables, such as the methods of mining, invariably, coal mining and the use of coal causes several common problems: globally, environmental problems, such as human-enhanced greenhouse effects, acid rain and the release of numerous other pollutants associated with the mining and burning of coal are of concern; regionally, "each stage in the life cycle of coal – extraction, transport, processing, and combustion – generates a waste stream and carries multiple hazards for health and the environment" (Epstein et al., 2011, p. 73).

Environmental impacts on land, water and air have been examined by numerous studies (e.g. Zullig and Hendryx, 2010; Bian et al., 2010; Colagiuri et al., 2012) and include:

(1) Impacts on land

- Land subsidence caused by underground coal mines, may result in the reduction of crop production, surface fracture and soil loss, drainage system failure, damage to building and infrastructure.
- Disposal of solid mining waste on land may lead to slope failure and erosion; inundation of lands; explosion by spontaneous combustion.
- Visual and landscape impacts including surface scarring, presence of shaft towers, damage to vegetation etc.
- Constraints or change on land use.

(2) Impacts on water resources

Losses of surface and ground water, lowering of the ground water table, changing of water courses and potential leaching of contaminants from coal mining into ground water.

(3) Impacts on air

Emission of particulate matter and gases, including methane, sulphur dioxide and oxides of nitrogen, causes air pollution.

1.3.2 Mining and economic growth

Davis and Tilton (2005) reviewed the controversial relationship between mineral extraction and economic growth. The conventional view, resting on principals from neo-classical economics, argues that "mining plays an essential role in the economic process by converting mineral resources into an output that can be directly consumed or converted into another form of capital that raises future output in other sectors"(p. 234). Coal can be directly consumed for the energy required for the production of numerous industrial goods. Britain, the United States, Germany and Norway, and recently Australia, Canada, Botswana, Chile are examples of countries or some regions within these countries that use mineral wealth to promote economic development (Gylfason, 2001; Davis and Tilton, 2005).

However, endowment with non-renewables is not necessarily a guarantee for economic and social development. Several studies, either using cross-country samples (e.g. Sachs and Warner, 2001; Gylfason, 2001; Mehlum et al., 2006), or using within-country samples (Xu and Wang, 2005; Fu and Wang, 2010), found that countries/regions with great natural resource wealth tend nevertheless to grow more slowly than resource-poor countries/regions, giving rise to the term “resources curse”. Explanations for the phenomenon are diverse and controversial (Davis and Tilton, 2005; Gylfason and Zoega, 2006). It can be summarized as follows: Natural resources crowd-out other activities (such as investment in the development of human capital) believed to be a powerful driver of economic growth. However, as Sachs and Warner (2001) noted, “just as we lack a universally accepted theory of economic growth in general, a complete answer to what is behind the curse of natural resources, therefore awaits a better answer to the question about what ultimately drives growth”(p. 833).

In spite of the controversy, even the conventional view suggests that the resource-curse problem is not about mining *per se*. The fault lies with the government and the other entities that decide how the newly converted wealth is used (Davis and Tilton, 2005; Mehlum et al., 2006). Countries with good quality institutions that promote accountability and state competence will tend to benefit from resource booms, while countries without such institutions may suffer from a resource curse (Robinson et al., 2006; Boschini et al., 2007). Thus, whether mining contributes to or damages wellbeing seems to depend to a large extent, on governance and public policy. Some thus argue that more effort should be spent on finding out why in some cases mining is a positive force and in others a negative force for development, and finally the implications for public policy (Davis and Tilton, 2005).

Other impacts of mining on the economy include changes in local living costs (Carrington et al., 2011), and equity of opportunity among local residents, not all of whom share in mining’s economic benefits (Xu and Wang, 2006; Zhang et al., 2008; Zhao and Liu, 2011). Furthermore, the typical boom and bust of mining sectors (Vincent, 1997; Davis and Tilton, 2005) and the absence of alternative opportunities diminish community resilience, leading to considerable stress on communities when a mine closes down (Warhurst and Noronha, 1999, cited by Noronha, 2001, p. 54).

1.3.3 Mining and human capital

Mining has profound impacts on the human capital of communities in which it is situated. In addition to the injurious effects on the health of mine workers and nearby residents it also negatively affects the educational opportunities and skills development of host communities.

Thousands of miners die from coal mining accidents each year. Nearly 80% of the World's total deaths due to underground coal mine accidents occur in China every year (Bian et al., 2010). Coal mining also poses threats to mental health (Krannich and Greider, 1984), and physical health of local communities (Bian et al., 2010; Zullig and Hendryx, 2010, 2011; Colagiuri et al., 2012), such as lung cancer, chronic heart, respiratory and kidney diseases. For example, "each 1,462 tons of coal mined increased the probability of a hospitalisation for chronic obstructive pulmonary disease by 1%, and each 1,873 tons of coal mined increase hypertension by 1%"(Colagiuri et al., 2012, p. iv).

Natural resource abundance may reduce private and public incentives to pursue education and accumulate human capital. Using cross-country data, Gylfason (2001) demonstrated that public expenditure on education relative to national income, expected years of schooling for girls, and gross secondary-school enrolment are all inversely related to the share of natural capital in national wealth (GNP). This was due to: firstly, the availability of high levels of non-wage income – e.g. dividends, social spending, low taxes (Gylfason and Zoega, 2006), allowing communities to become richer without improving their education level and working skills; secondly, many people become confined to low-skill intensive and natural-resource-based industries, and thus fail to improve their own or their children's education and earning power; thirdly, with a sense that natural resources are their most important asset, nations may neglect the development of their human resources, underinvesting in education.

1.3.4 Mining and social capital

Following on from the previous sections above, it follows that communities exposed to some of the environmental, economic and social changes associated with mining are vulnerable with the fabric of society often being severely damaged. Social capital, a multi-dimensional construct encompassing interpersonal relationships, social support networks, civic and community engagement and observance of cooperative norms that underwrite generalised trust, can be irreparably damaged by the mining industry (OECD, 2001).

Mining companies tend to hire a non-residential workforce, a practice that has fundamental impacts on mining areas in many parts of the world. The regional and often remote locations of mines (Carrington et al., 2011), present difficulties with sourcing labour. Additionally, many mining projects have a finite project life, providing further rationale for the tendency of hiring transient workers (Gillies et al., 1991, cited by Carrington et al., 2011, p. 338). Other documented incentives for a transient and non-resident workforce include work preference from mining companies, avoidance of the cost and maintenance of purpose-built towns, service provision and ease of managing industrial disputes (Carrington et al., 2011).

The reliance on a large non-resident workforce who have no meaningful attachment to the community, might disrupt existing social bonds and networks leading to a loss of community identity and personal security (Carrington et al., 2011). The incidence of criminal and anti-social behaviour is often the visible and outward symptom of damaged social capital of host communities. Several studies have demonstrated that both are higher in mining areas in developing countries (Kitula, 2006), and developed countries (Lockie et al., 2009; Carrington et al., 2011), undermining trust and civic engagement.

Social capital is also significantly impacted by real and perceived social injustice resulting from "the unequal or unfair social distribution of rewards, burdens, and opportunities for optimising life chances and outcomes" (Colagiuri et al., 2012, p. v). Social injustice arising from a number of sources, categorised by Colagiuri et al. (2012), includes unevenly distributed burdens of environmental damage and perceptions of damage and impacts on health; the impact of water pollution on securing safe water for household use, producing food and recreational opportunities, and the social and economic cost and benefits associated with the mining activity. In particular, injustice of social and economic cost sharing arise from:"

- *the cost of environmental damage to communities and society*
- *inability of the community to capture economic benefits*
- *social changes inhibiting the generation of alternative means of economic capital to mining*
- *sociodemographic changes resulting in labour shortages in other industries; reduced access to and affordability of accommodation; increased road traffic accidents*
- *increased pressure on local emergency services*
- *increases in criminal and other anti-social behaviours*" (Colagiuri et al., 2012, p.v).

1.3.5 Mining and institutional capital (governance)

Natural-resource-rich economies seem especially prone to socially damaging rent-seeking behaviour and corruption (Marshall, 2001; Sachs and Warner, 2001; Petermann et al., 2007). For example, the government may be tempted to offer tariff protection to domestic producers, among other privileges (Sachs and Warner, 2001). The corollary of rampant rent-seeking is often corruption. Corruption is further encouraged by the very characteristics of the mining sector such as the requirement for large initial capital expenditure, its sudden wealth and easy money image and the high level of government regulation in many countries (Marshall, 2001).

Auty (2001) found that the 'developmental' state, characterized by sufficient autonomy and the aim to raise long-term social welfare to support good economic performance, is strongly associated with poor resource endowment. In contrast, the political state in most natural-resources-rich economies tends to be predatory, with much self-interest in the maximization of profit, and the desire to deploy resource rents to promote sectional interests rather than to pursue a coherent policy goal of improving long-run social welfare. With a false sense of security, derived from the income stream related to natural resource abundance, governments may lose sight of the need for good quality economic management, including bureaucratic efficiency, institutional quality and free trade (Sachs and Warner, 1999).

Notwithstanding, it needs to be emphasized that it is not the existence of natural wealth that results in the poor institutional quality, but it is poor governance that fails to avert the dangers that accompany the free gifts of nature (Gylfason, 2001; Mehlum et al., 2006). Poor quality institutions may be especially prone to being seduced by the rent that can be easily produced from mining industries, resulting in the deterioration of institutional capital. As discussed in section 1.3.2, countries with good quality institutions that promote accountability and competent governments can turn natural resource riches into an unambiguous blessing (Gylfason, 2001).

1.4 The current policy focus on and research gaps of coal mining's impacts on host communities

Despite the many problems emerging from coal use, discontinuing the use of this most cost effective, affordable and widely available source of energy is unlikely in the foreseeable future. Coal use is forecast to rise by over 50% to 2030, and widely expected to replace oil as the world's largest source of primary energy source within a few years (World Energy Council, 2013). Worldwide electricity demand is expected to increase by 90% between 2008 and 2035 – and roughly 80 percent of new electricity in the developing world is to be coal-fired (International Energy Agency, 2010).

Globally, governments are thus challenged to control the adverse impacts of mining, without frustrating mining activity (Eccert, 1994). Most developed countries have well-developed regulations on environment management in mining regions or host communities, but most of these regulations are not appropriate, practical or desirable in developing countries (Otto and Barberis, 1994). "In the developing world, environmental considerations receive less attention than the economic and social components of sustainable development owing to lack of educational awareness, technical expertise, technological capacity and financial resources" (OECD, 2002, p. 8).

While struggling with efforts to address the environmental impacts of coal mining, governments of many developing countries lack the ability or political will to effectively address its many other impacts such as those affecting social wellbeing, social injustice (Morrice and Colagiuri, 2013), corruption (Sachs and Warner, 2001) and development of human capital in host communities. What receives far too little attention is the distribution both of the benefits and also of the social costs of mining booms (Richardson, 2009, cited by Carrington et al., 2011, p. 346), and a defensible and fair system for assessing the trade-off between the positive and negative impacts of coal mining that take account into the wellbeing of host communities.

Identifying a trade-off between the positive and negative impacts for host communities is difficult. This is due partly to political reasons – the conflict between interests of mining companies, central and local governments and host communities (Kitula, 2006). It is also partly for economic reasons – economic growth and poverty alleviation are the priority of the government policy in developing nations (OECD, 2002). "Governments appear reluctant to modulate the costs and redistribute some of the benefits if it means inhibiting the industry's growth and standing in the global economy" (Carrington et al., 2011, p. 347). Thus, fair distribution of benefits and costs from mining and the wellbeing of host communities, may give way to national economic development in the country.

The reaching of a mutually agreed trade-off position is difficult, also because many relevant values are not easily amenable to market valuation yet can profoundly affect people's wellbeing and quality of life. During the second half of the 20th century, a wide range of impact assessment practices, such as environmental impact assessment (EIA), social impact assessment (SIA), and economic impact impacts assessment (EcIA) (cost-benefit analysis, in particular) have been used with varying success to assess the impacts of mining. However, they are all limited in quantifying the impacts of mining on intangible values that cannot be traded in the market. This important and seemingly intractable problem will be further explored in chapter 2.

Developing more environmentally-friendly mining technologies to alleviate the environmental problems and sound mining management to minimize social and economic issues exerted on host communities should always be on the agenda of those who make decisions about mining activity. Gaining a better understanding of the impacts of mining, especially on the distribution of its positive and negative impacts, and of the trade-off between those impacts is essential to inform decisions about the sustainable development of mining activity. Having an increased awareness of the net impacts of coal mining on host communities is admittedly only one piece of information; but a vitally important one, if there is a genuine desire to maximise the benefits and, where possible, mitigate the costs, of this important industry.

Thus, this study aims to investigate the impacts of coal mining on host communities with the intention to assess the trade-off between a broad range of well-documented, yet empirically under-quantified 'impacts' – be they market or non-market, tangible or intangible.

1.5 Structure of this thesis

This thesis is organised into 7 chapters. Following this general introduction to the thesis topic (chapter 1), in chapter 2, the literature is reviewed. The initial discussion focuses on an array of traditional approaches to assessing the environmental, social and economic impacts of (coal) mining. That overview is followed by a discussion of approaches used to assess non-market (intangible) 'impacts', including the life satisfaction (LS) approach that is adopted in this study. The second half of chapter 2 justifies the decision to use the LS approach to investigate trade-offs for host communities affected by mining.

Chapter 3 begins with an overview of case-study areas, followed by a discussion of the methodological approaches used for primary data collection (specifically, on the design of the questionnaire and the field survey). The specific methods used to address each of the key research questions that drive investigation of the thesis, and associated results are presented in three main chapters.

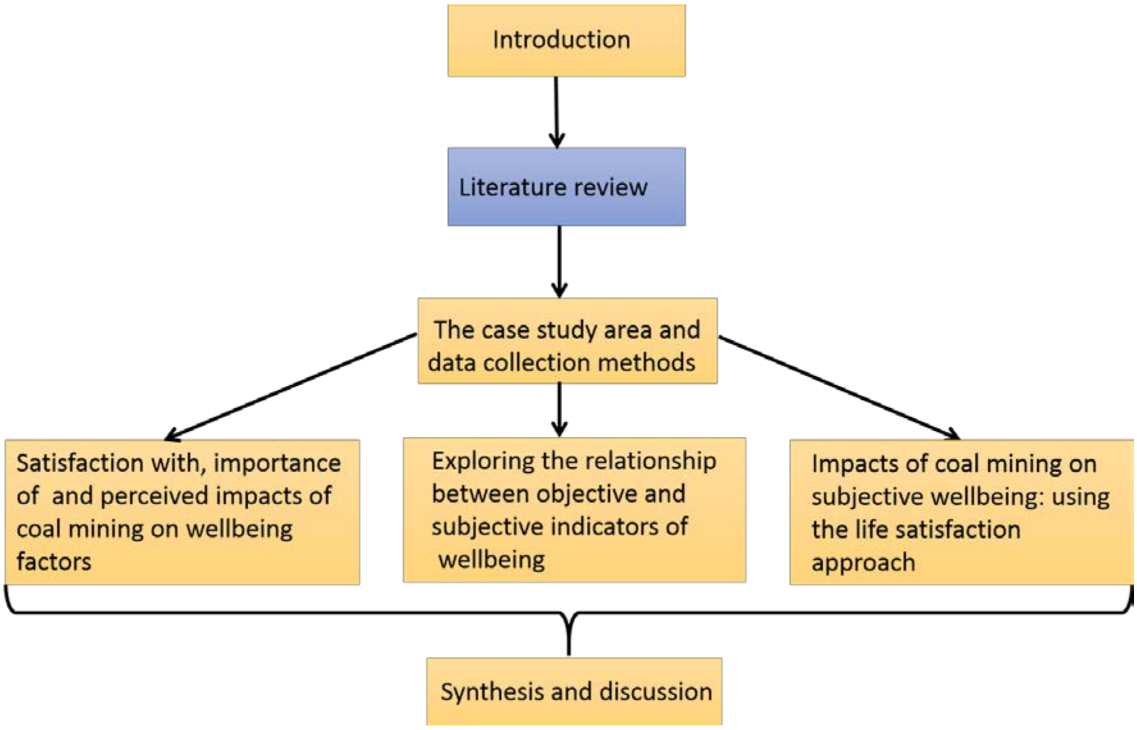
First, Chapter 4 presents 'subjective' data relating to respondents' wellbeing (their perception of how important 29 factors are to overall wellbeing and their satisfaction with those factors). It also presents data about their perceptions of the way in which coal mining impacts those factors. Two indices that combine information about satisfaction, importance and perceptions of impact are also developed, to facilitate a more nuanced interpretation of the data.

Second, Chapter 5 compares objective and subjective indicators of 'wellbeing' across the 5 types of case-study areas – the aim being to determine if the indicators convey similar messages and can thus be used interchangeably. Regression analysis is then used to further explore the relationship between objective and subjective indicators, controlling for a range of other factors known to influence subjective assessments.

In the third main data chapter (6), the impacts of coal mining on various indicators of subjective wellbeing (including satisfaction with different life domains and global life satisfaction) are investigated – making it possible to consider 'net impacts' across multiple factors within specific life domains and 'net impacts' across multiple domains.

This thesis closes with chapter 7, which summarises, synthesises and discusses key findings, contributions, and the implications for public policy and future studies.

Thesis outline



CHAPTER 2 LITERATURE REVIEW

Chapter outline

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2.2 Approaches to assessing the impacts of coal mining

2.2.1 Traditional approaches to assessing the impacts of coal mining

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2.6 Summary: research gaps and questions

2.1 Introduction

The previous chapter outlined the nature and scope of (coal) mining's impacts, including impacts on the biophysical, economic and social milieu of human beings. It concluded that an essential challenge to governing bodies the world over is balancing the good with the bad, and that such a balance should be considered at multiple geographical and social scales and include both market and non-market values. While mining may deliver net benefits for a country overall or for some sections of society at some locations, a distributional analysis may reveal that at different social or geographical scales such net benefits are not apparent and may indeed present as a net negative impact.

This chapter firstly summarizes the traditional methods used to investigate the impacts of coal mining and identifies their limitations. This is followed by examining the literature about non-market valuation techniques that could potentially address the limitation of traditional methods to mining impact assessment (section 2.2). Literature on the factors that contribute to wellbeing and indicators used to measure wellbeing is reviewed in section 2.3. The connection between wellbeing and impacts of coal mining is discussed in section 2.4. This chapter concludes with clearly identified research gaps; associated research questions are proposed – which provide a focus for the investigations reported on in subsequent chapters of the thesis.

2.2 Approaches to assessing the impacts of coal mining

Some of the benefits and costs of coal mining can be transacted through markets (e.g. mining revenues and capital cost), while intangible impacts, such as those affecting most environmental, cultural and social values, are not normally associated with goods or services that are tradeable in the markets (Gillespie and Kragt, 2010). These 'non-market' values do not have prices attached to or associated with them. Thus, one of the challenges of social decision making is to include all relevant values irrespective of whether or not their 'value' is revealed via market mechanisms (e.g. through prices). Non-market impacts, a core interest of this study, are most frequently assessed using non-market valuation methods. There are several traditional and more recent, innovative methods, which are examined below.

2.2.1 Traditional approaches to assessing the impacts of coal mining

Currently used common approaches to identifying and assess the significance of mining's impacts include environmental impact assessment (EIA), social impact assessment (SIA) and economic impact assessments (EcIA). "Environmental assessment requires that all impacts, ecological, economic, and sociological, be integrated. Economic valuation [cost-benefit analysis (CBA)] permits this" (Hundloe et al., 1990, p. 55). CBA entails one to conduct non-market valuation studies to generate data for use within the broader analysis (Ivanova et al., 2007; Gillespie and Kragt, 2010). The outputs of these processes are then used by various government instrumentalities as one input to help decide whether the benefits of a proposed project outweigh its negative impacts to the extent that it makes the project desirable (Hundloe et al., 1990). These approaches also identify those entities most affected by the negative impacts of the project and the value of those impacts. This can then be used to design compensation packages for stakeholders or to identify suitable ecological offsets.

2.2.1.1 EIA, SIA, and EcIA

EIA, is the most widely used assessment process. Formally, it is "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made" (IAIA, 1999). "Both EIA theory and statutory requirements – the latter with some possible exceptions – emphasize that impacts are to be assessed in relationship to ecological, social, and economic impacts" (Hundloe et al., 1990, p. 56). EIAs often have embedded within them multiple-objective planning activities, including separated sophisticated analyses of the effects of a project in terms of economic efficiency, regional development, environmental and social impacts (Hundloe et al., 1990).

The EIA process is backed by a legal framework in most countries and most countries require an environmental impact assessment before giving permission to a mining project (IAIA, 1999). However, in practice, EIA varies between countries. In many cases, especially in developing countries, "implementation of EIA often falls considerably short of international standards. They frequently suffer from insufficient consideration of impacts, alternatives, and public participation. In the worst case, they are not conducted at all" (Li, 2008, p. 1).

"The emergence of SIA during the 1990's [is] a significant component of EIA and today [it is] (sometimes) an independent activity" (Joyce and MacFarlane, 2001, p. 4). Social impact assessment is a systematic process setting the scope for the assessment, identifying and predicting the magnitude and significance of impacts, and devising management plans to mitigate negative impacts and enhance positive social outcomes (Rranks, 2012).

SIA involves the consideration of changes in a number of aspects: people's way of life, interaction with one another on a day-to-day basis; their culture (shared beliefs, customs and values); their community (the cohesion, stability, character, services and facilities); their environment (the quality of the physical environment, the adequacy of lifelines and basic services, their safety, feeling of security and their access to resources) (Burdge et al., 1995 and Cox and Miers, 1995, cited by Ivanova et al., 2007, p. 214).

SIA "focusing on those changes that are most important within a community rather than on those that are easiest to measure or with which researchers are familiar" (Ivanova et al., 2007, p. 214). Social Impact Assessment (SIA) is carried out by social scientists (Dutta and Bandyopadhyay, 2010). It is a systematic process of identifying and mitigating impacts on individuals or society, involved with public participation – in consultation with the individuals or society affected (Ivanova et al., 2007; Dutta and Bandyopadhyay, 2010).

Traditional economic impact assessment (EcIA) generates an estimate of the economic consequences of a particular project, with an emphasis on changes in sales, income and employment (Ivanova et al., 2007). The focus of EcIA is on understanding the likely order of magnitude of impacts rather than the net benefits to society (Ivanova et al., 2007).

There are a range of tools that can be used for EcIA, such as input-output modelling, or general equilibrium modelling (Jensen and West, 2002 and Rolfe et al., 2005a, cited by Ivanova et al., 2007, p. 213).

An economic assessment often includes cost-benefit analysis (CBA) (Ivanova et al., 2007). Distinct from the normal focus of an EcIA on the identification of income, spending and employment impacts, CBA can provide some evaluation of the net impact of a project (Ivanova et al., 2007). It incorporates 'values' that are not assessed by traditional impact assessment, and thus allows one to consider trade-offs between all benefits and costs – irrespective of whether or not those benefits and costs are associated with the market (Ivanova et al., 2007). It provides a structured way of aggregating monetised data about benefits and costs – weighting them against each other according to specific rules (e.g. including discount rates) (Atkinson and Mourato, 2006). However, it always encounters difficulties in practice, as discussed in more detail below.

2.2.1.2 The comparison and application of traditional approaches to mining impact assessment

Potential economic and social impacts are usually assessed through the EIA process (Hundloe et al., 1990; Ivanova et al., 2007), which requires the application of SIA and EcIA. Traditional EcIA focuses on the economic domain, and has the potential to identify the net impact/trade-off of a (mining) project through CBA, but it may be too divorced from the community of interests (Ivanova et al., 2007). In contrast, social impact assessment can tap into different community groups, discover how they could be affected in details and identify the important issues, but it fails to comprehensively assess the trade-off between benefits and costs. The lack of integration of social and economic impacts assessment techniques may limit the usefulness of their application (Ivanova et al., 2005, 2007).

Cost-benefit analysis, in particular, can marry the environmental, social and economic aspects of 'impact' and can provide a straightforward method for assessing the 'net' impact of a project (Hundloe et al., 1990; Atkinson and Mourato, 2006). There are a few studies that have used CBA or approaches similar to CBA in mining contexts. For example, Bai et al. (2011) used CBA to analyse the impacts of coal mining on local water ecoservices, economy and society, although it only focused on the negative impacts of coal mining on water. Some analyses which are similar to CBA (in that they combining the benefits and costs from coal mining) have been used in mining contexts: for example, Hendryx and Ahern (2009) estimated the impacts of coal mining on public health (using the value of statistical life lost) and the economic benefits of the coal mining industry; None of these studies, however, address a wide range of biophysical and social impacts identified throughout the world (and discussed in chapter 1); instead they generally focus on just one or two non-market impacts.

Another relatively common framework, which attempts to consider damage to the biophysical environment, is that of eco-compensation whereby the biophysical impacts of mining are assessed and those stakeholders suffering a consequent economic loss are compensated [4]. Existing studies on eco-compensation standards lack quantitative assessments of the costs and benefits of numerous intangible impacts of coal mining on the environment, economy and society, and there has been inadequate analysis of the allocation of compensation among groups who compose the main stakeholders (Bai et al., 2011).

Researchers have been exploring approaches to incorporate multiple intangible values within these assessment frameworks with varying success (e.g. Noronha, 2001; Song, 2012). For example, Song (2012) proposed the concept of "General eco-economic indices for mining exploration compensation" to calculate an eco-compensation standard that incorporated economic losses resulting from damage to the environment. Economic losses from air pollution and water pollution were calculated by comparing the value of agricultural (and aquacultural) production before and after the mining (p. 139). This approach has much promise in agricultural regions, but may not be useful in other regions – particularly if one does not have data on agricultural production 'before' and 'after' coal mines emerged. Also, the 'value' of some environmental impacts, such as those associated with noise and visual amenity are not captured by this type of

[4] "Ecological compensation in a coal mining region can be classified as either broad or narrow. Broad ecological compensation is carried out mainly through land requisition, relocation, and ecological reconstruction, as well as by supporting resource-based cities [regions] to achieve sustainable development. Narrow ecological compensation only includes land reclamation and ecological reconstruction" (Bai et al., 2011, p. 144). Ecological compensation here refers to the broad definition.

analysis which focuses only on agricultural production (goods and services that are more closely associated with the market) – the ‘tangible’ impacts of degradation. Additionally, this framework has, thus far, been unable to incorporate the potential impact of rising inequality or losses in social capital that may be associated with mining, nor has it been able to offer a strong and straightforward estimate of the net impact of mining on the host communities to inform public policies.

In theory, a comprehensive CBA includes estimates of all benefits and all costs associated with the project/program being evaluated, using a common measuring rod (Hundloe et al.,1990) – traditionally, a monetary one. Likewise, a comprehensive eco-compensation assessment should estimate the financial dollar equivalent of all the damage (costs) associated with a mine. The current studies cited above which use CBA or approaches similar to CBA, as well as the eco-compensation, all attempt to assess impacts that are not directly traded in the market but are, nonetheless, indirectly associated with the market (e.g. damage to agricultural land implies loss of agricultural production). The values of these non-market impacts can thus be inferred through the market, using either market or revealed market approaches, which will be discussed in detail in the following section.

But mining impacts many things which have little or no link to marketed goods and services, thus requiring CBA and eco-ceompensation researchers to undertake other non-market valuation exercises (that rely on hypothetical markets), for use in the wider analysis. The more ‘intangible’, and more loosely connected an impact is to the market, the more difficult it is to adequately measure. The quality of the broader CBA (or similar) studies will thus depend, at least in part, on the quality of the non-market valuation study that estimates the ‘value’ of these various non-market impacts. Measuring these impacts (particularly the intangible impacts) using a monetary measuring rod is not a trivial task, which explains why the current literature cited above usually assess limited number of non-market impacts.

While highly useful as a decision-making tool, CBA thus suffers from multiple limitations, which derive from behavioural and scientific uncertainty and the difficulty of bringing all relevant variables to a common monetary base to allow their addition when calculating net benefit. In practice, it is often too difficult to generate monetary estimates of the 'value' of all non-market impacts, so many are often omitted from the analysis. These problems have limited the theoretically wide scope of both CBA (Hundloe et al., 1990) and eco-compensation. This might also help explain why CBA is not widely used to assess the impact of mining activity (Ivanova et al., 2007) and why many of the known impacts of mining are excluded from the assessments of eco-compensation.

2.2.2 Assessing the value of non-market goods

As explored above, many of the limitations of traditional methods used to assess the impacts of mining arise from the challenges of estimating the value of numerous intangible and difficult-to-monetise impacts. Much research effort has been invested in developing techniques to allow reliable monetary expression of the value of non-market goods. While considerable progress has been made, significant challenges remain and to date the validity and reliability of monetary evaluations of non-market goods remains contentious. The following sections expand on some of the more common approaches to non-market valuation designed to overcome the difficulties inherent in common impact assessment practice.

2.2.2.1 Traditional approaches which generate monetary estimates of the 'value' of non-market goods and their applications in mining contexts

There is a large body of literature that looks at ways of assessing the non-market goods in monetary terms, so that they can be compared with other (monetary) values on a somewhat equal footing. Termed "Economic valuation methods", these approaches can estimate the effect of changes in either the quantity or quality of non-market goods on utility (Dolan and White, 2007). Broadly, valuation methods fall into one of three main types: market-based approaches (MB), revealed preference approaches (RP) and stated preference (SP) approaches. The life satisfaction (LS) approach (discussed in the following sub-section) is an emerging, non-traditional valuation approach that offers much promise (Dolan and Metcalfe, 2007).

MB approaches essentially rely on observable market prices, costs, expenditures or revenues. For example, they assess the 'value' of changes in agricultural production or the cost of repairing damaged structures (Loomis et al., 2003; Morrison, 2009; Li et al., 2011). These approaches can only be used to assess impacts that are directly related to the market (if impacts are not directly related to the market, one cannot obtain price, cost or expenditure/revenue data). Another limitation of MB approaches is that "they only provide a lower bound on community values as the community may be willing to pay more than the replacement cost to prevent damage" (Morrison, 2009, p. 11).

RP approaches include techniques such as hedonic pricing and the travel cost method and do not require one to be able to directly 'observe' market prices. Instead, these approaches use "complementarity or substitute relationships between environmental goods and market goods to infer the value attributed to environmental conditions from observed behaviour with respect to market goods" (Welsch, 2006, p. 802).

Rather than using actual or 'related' markets to infer values, SP approaches use hypothetical approaches. Formally, individuals are directly asked to value environmental goods, using specially constructed questionnaires to capture an individual's willingness to bear a financial impost in order to achieve some potential (non-financial) environmental improvement, or avoid some potential environmental harm (Bennett and Blamey, 2001). Examples are the contingent valuation (CV) method and the choice modelling or choice experiment method (de Bekker - Grob et al., 2012). The contingent valuation method focuses on valuing a non-market good as a whole, while the choice modelling/experiment method focuses on valuing specific attributes of a non-market good (Welsch, 2006; Fujiwara and Campbell, 2011). Choice modelling, grounded in random utility theory, assumes that the benefit of an attribute (A) can be measured in terms of the frequency with which a person chooses A over a competing attribute (B) (Centre for International Economics, 2001).

Both RP and SP approaches have significant disadvantages. RP methods are based on "stringent assumptions concerning the rationality of agents and the functioning of markets" (Welsch, 2006, p. 802). SP surveys use hypothetical scenarios from the respondents, which may entail unreliable results and strategic behaviour (Welsch, 2006). Both RP and SP can only capture those impacts that individuals are actually aware of. The values that individuals are not aware of cannot be captured, although they exist

(Welsch, 2006). Choice modelling is considered superior to conventional SP methods, as the instrument used to gain the information of 'willingness to pay' forces respondents to consider multiple trade-offs between attributes. However, the attributes involved are limited to 6 or 7, as respondents have difficulty processing more than this number (Centre for International Economics, 2001).

As mentioned in the previous section, most previous studies that have estimated the non-market impacts (but directly associated to market) of coal mining or mining using MB approaches (e.g. Noronha, 2001; Hendryx and Ahern, 2009; Epstein et al., 2011; Li et al., 2011; Song, 2012). Studies using RP and SP to assess those impacts not directly associated with the market are relatively few, but they do exist.

Using hedonic pricing to assess the values of the environmental impacts of coal mining, Trigg and Dubourg (1993) found that the environmental costs of coal mining in the UK significantly reduced its economic viability. Ivanova et al. (2007) were one of the first to use choice modelling within an integrated assessment of the impacts of coal mining in the Bowen Basin, Australia. They used results from the choice modelling study to help assess the trade-off between social and economic costs and benefits, arguing that the results should be put in the context of wider issues that arose from the stakeholder analysis. The study of Gillespie and Kragt (2010), a more recent one, used discrete choice experiments to value the non-market environmental, cultural and social impacts of underground coal mining and incorporated the derived values into the frame of CBA.

The shortcomings of existing studies using MB, RP and SP are derived from the inherent disadvantage of the approaches they adopted. One of the limitations of studies using MB has been discussed in detail in the last section, for example, they can only assess impacts that are directly related to the market. But another, more fundamental shortcoming of these studies is that they only deal with a limited number of impacts associated with coal mining. This is not a reflection on the quality of the analysis undertaken by researcher, but rather a reflection of the great empirical difficulty of undertaking these non-market valuation studies – they involve significant amounts of time, data, and sophisticated analyses to generate reliable estimates. Trigg and Dubourg (1993), for example, only consider environmental impacts; Gillespie and Kragt (2010) and Ivanova et al. (2007) only included 4 and 6 impacts, respectively, although these impacts were across environmental, social-economic domains. As discussed in section 1.2 and 1.3, the potential impacts of mining or coal mining can be numerous, and studies which focus on just 4 to 6 impacts may be insufficient to investigate trade-off amongst a large number of impacts that are typically associated with coal mining project.

2.2.2.2 The life satisfaction approach to 'valuation'

Traditional non-market approaches to valuation all assume that goods and services are 'valuable' because they contribute to people's 'utility' (economic parlance for what social scientists often refer to as 'wellbeing', or 'life satisfaction' (e.g. Easterlin, 2001; Dolan and Metcalfe, 2007; Fujiwara and Campbell, 2011). These approaches all assume that 'utility' cannot be measured in cardinal terms and instead can only be compared in ordinal terms (e.g. noting that someone is happier in situation A than in situation B)(Chambers and Echenique, 2016; The OHIO State University, 2016).

In contrast, the LS approach assumes that 'utility' can be measured in cardinal terms (Welsch, 2006). The LS approach can be used to estimate the monetary value of non-market goods by looking at how they affect people's reported satisfaction with life – the proxy for 'utility' (Fujiwara and Campbell, 2011).

Simplistically, the approach requires one to

1) Collect data on LS, income, and other factors known to influence LS (say air quality).
2) Regress LS against income and other factors – e.g.
   LS = a + b (Income) + c (Air quality)
3) Estimate the monetary 'value' of air quality by looking at how much extra income someone earns, would 'compensate' them for diminished air quality (formally, 'compensation' means keeping LS constant – changing both income and air quality). Hence monetary 'value' of air quality can be calculated by dividing the coefficients from the regression equation:
   $\partial LS/\partial Income = b$
   $\partial LS/\partial Air\ quality = c$

$$\partial \text{Air quality} / \partial \text{Income} = c/b$$

In other words, by comparing the marginal utility/disutility of non-market goods, with that of income, the trade-off between income and non-market goods can be determined, providing a monetary value of the non-market factor/good of interest.

This approach has several advantages over traditional non-market valuation approaches. Firstly, in contrast to RP and SP approaches, the LS approach does not presume rational agents and perfect markets (Frey et al., 2004; Welsch, 2006). Secondly, this technique does not rely on asking people how they value "public goods or bads/negative and positive externalities" (Frey et al., 2004, p. 5), nor does the LS approach require an individual to fully understand cause and effect relationships. Instead, individuals are asked in surveys how satisfied they are with life, and econometric analysis is used to identify if and how their answers change with different amounts (or qualities) of non-market goods. For these reasons the life satisfaction approach is cognitively less demanding on respondents than contingent valuation and choice modelling and does not evoke response bias (Welsch, 2006). Thirdly, there is no reason to expect strategic behaviour, since the survey questions do not relate to the target non-market goods in any way.

However, it is uncertain whether LS data is a good measure of utility (Ambrey and Fleming, 2011). Three major difficulties identified and discussed by (Fujiwara and Campbell, 2011) include:

(1) Remembering past experiences. People who remember and emphasize past experience/utility might lead to biased judgement of current life satisfaction;

(2) Context effects. People may take their current mood as a good indicator of their wellbeing in life in general (Schwarz and Strack, 1999);

(3) Reporting LS. When reporting LS in a face-to-face interview, individuals may adjust their life satisfaction scores in order to give more socially desirable responses. For example, reported life satisfaction level is higher in face-to-face surveys than in postal.

In spite of the limitations above, the LS approach is an effective way to value non-market goods. The body of literature that uses this approach to consider the 'value' of a range of non-market goods and services is growing rapidly and includes studies of: airport noise (Van Praag and Baarsma, 2005), air pollution (Welsch, 2006; Luechinger, 2009; MacKerron and Mourato, 2009), inequality (Blau and Blau, 1982), terrorism (Frey et al., 2009), corruption (Welsch, 2008) and disasters (Luechinger and Raschky, 2009). In these and other studies, reported life satisfaction has been used as an empirically adequate and valid approximation for individual utility.

However, to the best of my knowledge, the LS approach has not been used to contribute to the assessment of the impacts of mining industries or projects, and the challenge to fully incorporate impacts on non-market environmental and social aspects remains.

The following section will discuss the emerging literature on life satisfaction or wellbeing, as well as the feasibility of using the life satisfaction (wellbeing) approach to assess the multiple impacts of mining and to explore the trade-off between the benefits and costs of mining industries or projects.

2.3 Human wellbeing

Terms related to "wellbeing" in the literature are "life satisfaction", "subjective wellbeing", "happiness", and "quality of life (QOL)". These terms are often used interchangeably: see Easterlin (2003a), Rehdanz and Maddison (2005), Costanza et al., (2007), Johns and Ormerod (2007) and Dolan and Metcalfe (2007) as examples. Life satisfaction or happiness is conceived as a measure of "the degree to which an individual judges the overall quality of his or her life-as-a-whole favourably or unfavourably" (Ehrhardt et al., 2000, p. 181). This is sometimes termed global life satisfaction (GLS). In this study, life satisfaction or GLS is thought to be one of the dimensions of subjective wellbeing, and subjective wellbeing is one of the measurements of wellbeing, detailed in 2.3.1.2. In contrast, the phrase of "quality of life" is closer to that of "wellbeing", as they both refer to objective and subjective measurements of numerous factors; these two terms are thus sometimes used interchangeably (e.g. Van Praag and Baarsma, 2005; Costanza et al., 2007). This will be discussed further in the following section.

2.3.1 The definition and dimension of human wellbeing

2.3.1.1 Definitions of human wellbeing

The term 'wellbeing' or "human wellbeing" is used in various disciplines, such as economics, psychology, and sociology. Because these different disciplines use differing research instruments, have different standpoints, ask different types of questions, and are based upon different theoretical views and ontological presuppositions (Gasper, 2010), the definition, measurement and determinants of wellbeing are not used with great consistency or precision (Kahn and Juster, 2002; Dodge et al., 2012; Rablen, 2012). As such, it may be best to think of the term 'wellbeing' as having different roles and occasions of relevance, and then select a particular definition or build a particular synthesis to serve a particular research purpose (Gasper, 2010).

Despite the complexity and difficulty of pinning down a single definition of wellbeing, it is widely accepted by researchers that wellbeing contains subjective and objective dimensions (Dale, 1980; Muldoon et al., 1998; Veenhoven, 2002; Gasper, 2004, 2005, 2010; Oswald and Wu, 2010). A categorization of conceptions of wellbeing by Parfit (1984) has become widely used in philosophical ethics (Muldoon et al., 1998; Gasper, 2004). They are as follows: 1) In hedonism, wellbeing is seen as the pleasure – a mental statement; 2) In desire theories: wellbeing is seen as preference/desire fulfilment; and 3) In objective list theories, it is understood as the satisfaction with the substantive list of elements that make a life well lived. Evidently, any single one of these understandings of the concept is incomplete (Gasper, 2004); a comprehensive conception or measurement of wellbeing should include both objective and subjective dimension.

2.3.1.2 Objective wellbeing and subjective wellbeing

According to Gasper (2010), there is far more than a binary contrast between 'subjective wellbeing' (SWB) and 'objective wellbeing' (OWB). Both objective and subjective wellbeing can refer to subjective states or to a person's condition and circumstances, can be undertaken using private values or values endorsed through a public procedure, and can be self-reported or be externally observed (Gasper, 2010). There are many relevant interpretations of both 'objective' and 'subjective' wellbeing, and the two concepts overlap, but one of the most popular distinctions between the two – preferred by Gasper (2010) and other researchers, relates to the fact that SWB focuses on subjective states, while OWB focuses on a person's conditions and circumstances (Gasper, 2010).

The well-accepted and most often cited definition and application of OWB and SWB is as follows. Objective wellbeing (OWB) refers to an "objective view of a person's wellbeing given their objective circumstances" (Rablen, 2012, p. 299). It is a measure of 'hard' facts (Veenhoven, 2002) and observable variables, that we generally believe are important for a good life (Argyle, 2001). Objective indicators, generally defined as counts of various types of phenomena (e.g. life expectancy, levels of income and education, residential, densities and unemployment figures, and pollution levels) are most often regarded as quantitative facts and are often selected from census data and other accessible and verifiable official registers (Dale, 1980). OWB can be expressed as a set of indicators (e.g. economic wellbeing, social welfare and the status of the bio-physical environment) or a single composite index (Lepper and McAndrew, 2008).

SWB refers to 'soft' matters (Veenhoven, 2002), and is measured by general mental-state accounts of an individual's personal assessment of his/her life (Dolan and White, 2007) or subjective responses of likes and dislikes (Dolan and White, 2007; Lepper and McAndrew, 2008; Rablen, 2012). According to Diener (2000), subjective wellbeing consists of four components: global life satisfaction, satisfaction with important life domains, positive effects of experiencing pleasant emotions and moods, or, conversely, negative effects of experiencing unpleasant emotions and moods. Global life satisfaction and satisfaction with discrete life domains are the two basic approaches to the definition and measurement of subjective life quality (Cummins, 1996). Global life satisfaction is the most commonly used of measures of life evaluation, and satisfaction with important domains, is proved to be strongly related to overall life evaluations (OECD, 2013). Examples of SWB indicators are life satisfaction (LS), and the Happiness Index. These indicators are sourced from empirical surveys, or in some countries from various databases such as in the World Database of Happiness (EHERO, 2014), and the Personal Wellbeing Index (The International Wellbeing Group, 2013).

2.3.1.3 The application of OWB and SWB and the relationship between OWB and SWB

Governments tend to pursue the more easily obtained objective indicators of wellbeing, while paying less consideration to examining and improving subjective wellbeing (Diener and Suh, 1997; Abdallah et al., 2011; Rablen, 2012). For instance, the objective approach is currently dominant in the Scandinavian countries, in particular in the Swedish 'level of living' studies (Veenhoven, 2002). The UK National Indicators that are used to evaluate local government consist primarily of objective indicators such as crime, mortality, and employment rates (Rablen, 2012).

The reluctance among policymakers to reduce reliance on OWB is probably because it can be measured by tangible indicators that are relatively easy to collect and understand, and are relatively easily connected to government policies and budgets. But OWB may be heavily influenced by the values of those who construct indicators to measure it; such measures may thus not reflect public preference (Rablen, 2012) and/or may do little to inform makers of public policy (Veenhoven, 2002). Moreover, objective indicators fall short in measuring some intangible factors, such as trust and perceived street safety (Veenhoven, 2002), which partly explain why these values (or many other intangible values) are not measured by the official department. In contrast, SWB requires data about intangible concepts, such as people's thoughts and emotions (Rablen, 2012). Concerns that have been raised about indicators of SWB, focus on the fact that they may lack direct and obvious connections to government policy and budgets (Rablen, 2012). That said, there is much support for subjective indicators – the OECD (2013), for example, argues that the drivers of social policy should not be limited to information about material matters, but should also be informed by peoples' judgment of their lived experience, requiring the recruitment of subjective indicators.

Measures of SWB are now at the forefront of some academic analyses (Chen and Lin, 2014), and "are generally found to have a high scientific standard in terms of internal consistency, reliability and validity and a high degree of stability over time" (Welsch, 2006, p. 803). The International Wellbeing Index (IWI) has been used to measure subjective wellbeing in many western countries (The International Wellbeing Group,

2013) and developing countries, such as China (Knight et al., 2009; Davey and Rato, 2012; Monk-Turner and Turner, 2012).

Empirical studies that have explored the relationship between objective measurements and subjective measurements tend to be contradictory. For example, Schneider (1975) examined 'quality of life' rankings of US cities based on objective wellbeing indicators and subjective indicators of quality of life, and concluded that the level of wellbeing, measured by objective indicators, did not predict the subjective life quality experienced by individuals living in those cities. In contrast, Oswald and Wu (2010) found that the ranking of quality of life in each US state was consistent between subjective and objective approach. Emmons and Diener (1985) found that objective conditions were only predictive of satisfaction in a few domains. Differences between these studies will be further discussed later in this chapter.

Given the unconfirmed relationship between OWB and SWB, and given that both concepts have strengths and weaknesses, they are complementary and are both needed to obtain a comprehensive baseline picture of wellbeing in any jurisdiction or community against which development outcomes for society may be gauged (Dale, 1980; Diener and Suh, 1997; Veenhoven, 2002).

2.3.2 Factors that contribute to human wellbeing

The multiple impacts of coal mining were detailed in chapter 1. This section reviews the literature that addresses the following two questions. "Do the factors that coal mining have impacts on contribute to wellbeing or life satisfaction? And "What is the relationship between coal mining and human wellbeing or life satisfaction?"

The expanded full world model of the ecological economic system elaborated by Costanza et al. (1997) (see Figure 2.1) describes the interaction between wellbeing and four basic types of capitals.

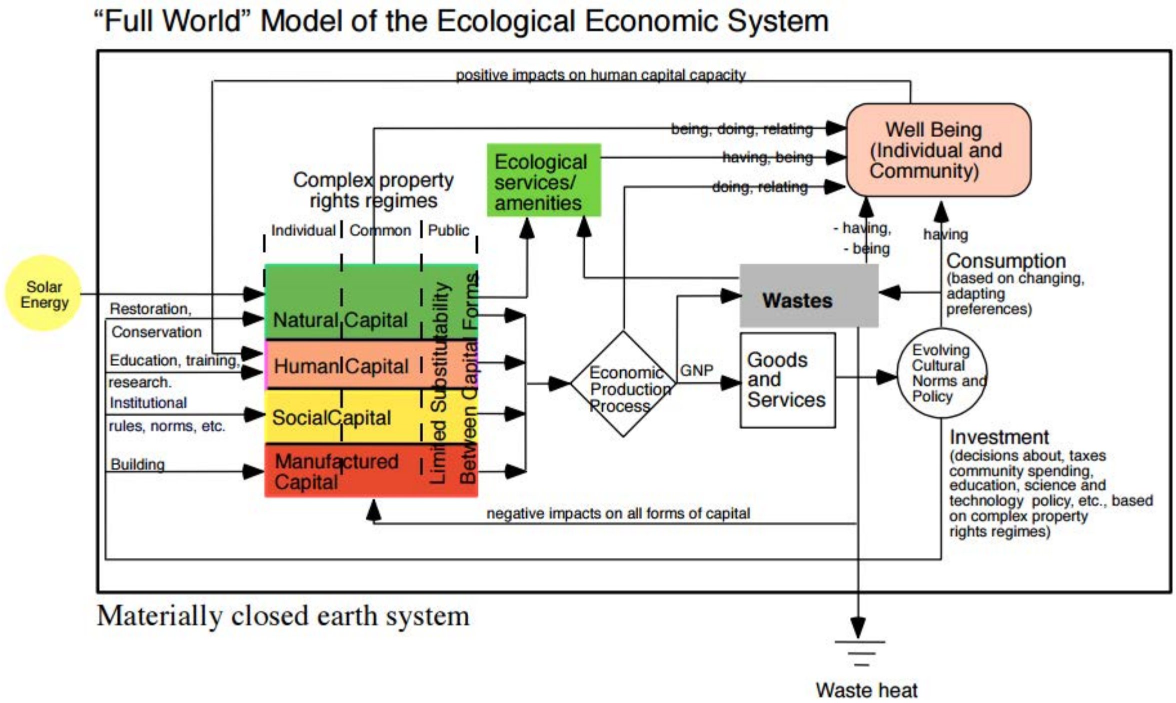


Figure 2.1 Full World Model of the Ecological Economic System

Source: From 'An Introduction to Ecological Economics' (Costanza et al., 1997, p. 275).

At the core of this model is the set of four basic types of capitals: natural, human, social, and built capital, and these four kinds of capital under the strict interpretation of sustainability are not seen as interchangeable (Costanza et al., 1997). Both economic goods and services and ecological services and amenities are produced and contribute in different ways to satisfying basic human needs and creating both individual and community wellbeing. The economic process generates waste and in doing so exerts a negative effect on wellbeing, as well as on capitals and ecological services (Costanza et al., 1997).

2.3.2.1 Natural capital and human wellbeing

Costanza et al. (2007) define natural capital as the "renewable and non-renewable goods and services provided by the ecosystems" (p. 271). Human beings depend on these systems for a variety of goods and services. As shown in Costanza's diagram (Figure 2.1), natural capital can contribute to wellbeing in three ways: directly (by, for example, providing an aesthetic experience); indirectly through the provision of ‘ecosystem services’[5]; and indirectly, when combined with other capitals in the economic production ‘process’ to generate other goods and services. A large body of literature by communities of economists, environmental scientists and psychologists has studied and firmly established that a good environmental quality significantly contributes to human wellbeing, while bad environmental quality reduces wellbeing (e.g. Welsch, 2002; Van Praag and Baarsma, 2005; Luechinger, 2009; MacKerron and Mourato, 2009; Ferreira and Moro, 2010; Menz and Welsch, 2010; Levinson, 2012; Cuñado and de Gracia, 2013; Guardiola et al., 2013).

2.3.2.2 Human capital and human wellbeing

Human capital is often conceptualised as a measure of people’s ability to produce goods and services that have ‘economic value’; it thus often refers to physical labour and to ‘know-how’ (Ekins, 1992; Earth Inc., 2007). Education is often chosen as a proxy measure of human capital.

Most previous studies have found that the accumulation of human capital contributes to wellbeing: education is frequently found to be positively correlated with reported levels of satisfaction (e.g. Di Tella et al., 2003; Ferrer-i-Carbonell & Gowdy, 2007; Welsch, 2007b; Brereton et al., 2008; Smyth et al., 2011). Diener et al. (1999) argue that education may also indirectly affect subjective wellbeing through other variables. Those with a higher education also generally have a higher income, are in better physical health and have higher participation rates in social activities (compared to those with less education) all of which are essential to wellbeing (Healy and Côté, 2001; Clark and Oswald, 2002; Frey and Stutzer, 2002b; Di Tella et al., 2003).

Some studies have, however, found a negative association between education and life satisfaction (e.g. Clark and Oswald 1996; Arifwidodo and Perera, 2011). One plausible explanation for this negative relationship is that education raises expectations; therefore, a comparison effect happens, where more highly educated people have a

[5] The Millennium Ecosystem Assessment (MEA), was one of the first, widely cited, frameworks for describing the important role that ecosystem services play for human wellbeing. In particular, this framework demonstrated how ecosystems services contribute to constituents of wellbeing, including security, basic material for a good life and health (Corvalan et al., 2005).

higher expectation for Quality Of Life (QOL), which lowers the actual condition of QOL (Clark and Oswald, 1996; Arifwidodo and Perera, 2011).

2.3.2.3 Social capital and human wellbeing

A substantial amount of literature shows evidence of a strong correlation between social capital and life satisfaction (e.g. Helliwell, 2003; Engelbrecht, 2009; Bartolini and Sarracino, 2011). Those who have frequent contact with family, friends and neighbours have higher reported levels of wellbeing than those with less contact (Helliwell and Putnam, 2004).

That said, it is not always easy to determine how to define and 'measure' social capital. Some researchers have argued that a measure of generalized trust is part of what is meant by the phrase 'social capital', while others have preferred to treat interpersonal trust as something that is generated and supported by other types of social capital (Helliwell, 2001), such as laws, political factors, economic factors, and crime rates within society (Vemuri and Costanza, 2006).

2.3.2.4 Manufactured capital and human wellbeing

Manufactured or built capital comprises goods "such as tools, equipment and buildings" (Costanza et al., 2007, p. 271), used for the production of goods and services (Helliwell and Putnam, 2004). As we all know, urban places supply more manufactured goods than rural places. Differences in the spatial organization and capital goods between urban and rural areas thus result in different socioeconomic outcomes that affect human wellbeing (Cutler et al., 1997; Vemuri and Costanza, 2006). There is a growing conviction among urban and regional policy makers that the character of the built environment is one of the factors influencing quality of life (QOL) (Arifwidodo and Perera, 2011).

A study exploring the relationship between QOL and the urban spatial pattern in Bandung city, Indonesia reveals a positive and significant relationship between self-reported wellbeing and the availability of urban facilities (Arifwidodo and Perera, 2011). Brereton et al. (2008) use the proximity to various built capital, such as landfill, rail station, airport, seaports and national/secondary roads to analyse Irish life satisfaction data. They conclude that: proximity to landfill has a negative effect on wellbeing, while proximity to the coast has a largely positive effect, diminishing with distance. The impact of proximity or easy access to major transport routes has different effects depending on the type of, and distance to, the amenity in question.

Vemuri and Costanza (2006) used the UN's Human Development Index (HDI) (1995) obtained from the United Nations Human Development Report (1998), as a composite of human and built capital. The HDI is a measure of human development, which comprises "a longevity index, an education index, and a standard of living index" (Vemuri and Costanza, 2006, p. 123). The reason to represent the human and built capital variables together was due to the high correlation between human capital variables and all the possible built capital variables (Vemuri and Costanza, 2006).

2.3.2.5 Institutional capital and human wellbeing

Although institutional capital is not included in the "full world" model, the literature demonstrates that the quality of institutions affects subjective wellbeing (e.g. Frey and Stutzer, 2000; Rehdanz and Maddison, 2005; Engelbrecht, 2009; Frey and Stutzer, 2010). Several proxies to measure institutional capital have been used, including levels of democracy, civil liberty, political rights, economic freedom, good governance and corruption in those literature. In particular, the efficiency and trustworthiness of the design and delivery of government were found of primary importance for poor countries, while more value appeared to be attached to building and maintaining the institutions of electoral democracy in developed countries (Helliwell and Huang, 2008).

2.3.2.6 Other factors that affect human wellbeing

(1) Income, income inequity and employment

Income is cited in most studies of wellbeing (e.g. Adamowicz et al., 1998; Diener, 2000; Diener and Oishi, 2000; McBride, 2001; Ferrer-i-Carbonell, 2005; Kahneman and Deaton, 2010), and the relationship between income and subjective wellbeing is the major focus of many of these studies.

At the macro level (e.g. GDP per capita), cross-country studies show that, in industrialized/developed countries the rise of real national income bring little or only a small amount of extra happiness over time (Easterlin, 1974; Oswald, 1997). However, the effect of income on wellbeing is significantly stronger in developing countries and/or in regions with relatively high unemployment rates (Stanca, 2008). In general, the main factors that improve quality of life in poor countries seems to be income, but once a certain level of development is attained, the main attributes that influence wellbeing are other factors, such as friends and good family life (Costanza et al., 2007; Arifwidodo and Perera, 2011). More will be discussed of this complicated relationship between economic growth and wellbeing in section 2.4.

At the micro level (household or individual income), the effects of income on human wellbeing differ across case-study areas. For example, Frey and Stutzer (1999, 2000) found that improvements in financial situation hardly raise happiness in Sweden, while other studies found that higher household or individual income was statistically correlated with higher levels of life satisfaction or quality of life, in developed countries (Van Praag and Baarsma, 2005; Welsch, 2006, 2008; Luechinger, 2009; MacKerron and Mourato, 2009) and developing countries (Arifwidodo and Perera, 2011).

Income inequality also negatively affects human wellbeing (e.g. Daly, 1987; Diener et al., 1999; Easterlin, 1995, 2003; Layard 2003; Stutzer and Frey, 2010). Increases in income do not always contribute to increases in subjective wellbeing in OECD countries, but the effect of relative income on subjective wellbeing in both OECD and developing countries is obvious, and this effect is larger in the developing world (Helliwell, 2003). Once basic needs are met, it seems that simple increases in income do less to raise life satisfaction. What starts to matter more, apparently, is to earn more than others (Helliwell, 2003) – thus the effect of income on life satisfaction appears to change as the average income of a country evolves (Costanza et al., 2007; Arifwidodo and Perera, 2011).

At a micro-economic level, employment status, which is closely associated with income, also influences human wellbeing (Frey and Stutzer, 1999b; Ballas and Dorling, 2007; Brereton et al., 2008). At a macro-economic level, the national inflation rate and unemployment have also been found to be negatively associated with national measures of wellbeing (Di Tella et al., 2001; Engelbrecht, 2009). Unemployment is invariably associated with lower levels of wellbeig (Oswald, 1997), and the effect of unemployment on wellbeing is significantly stronger in countries with higher GDP per capita and higher unemployment rate (Stanca, 2008).

(2) Sociodemographic factors

Linked to the discussion of social capital, being in a stable marriage and good quality of interpersonal relations also has a positive and statistically significant relationship with wellbeing; those being separated or divorced generally report low levels of wellbeing (Ferrer - i - Carbonell and Frijters, 2004; Ferrer-i-Carbonell and Gowdy, 2007; Brereton et al., 2008; Arifwidodo and Perera, 2011). Clark and Oswald (2002) report that getting married could increase overall life satisfaction (happiness) by the same amount as an extra 70,000 $US of income per annum; widowhood would reduce happiness by an amount equivalent to a reduction in income of 170, 000 $US per annum.

Age is one of the most cited sociodemographic determinants of human wellbeing. Age reflects the life cycle pattern in human wellbeing and shows a consistent U-shaped relationship with life satisfaction falling until mid-life, then rising with age (e.g. Di Tella et al., 2003; Brereton et al., 2008).

Subjective wellbeing has also been shown to be affected by the following sociodemographic variables: (1) family size (Frijters and Van Praag, 1998; Frey and Stutzer, 2000; Moro et al., 2008; Stutzer and Frey, 2008) (2) house type/tenure (Brereton et al., 2008; Moro et al., 2008); (3) gender (Frey and Stutzer, 2000; Brereton et al., 2008; Moro et al., 2008; Arifwidodo and Perera, 2011).

(3) Genetic factors

It is widely acknowledged that both happiness and depression can be hereditary (e.g. Sullivan et al., 2000; Lyubomirsky et al., 2005; Zidanšek, 2007). Research on identical twins suggests that genetics explains around 50% of all observed differences in reported 'happiness' or life satisfaction level (Lyubomirsky et al., 2005; Zidanšek, 2007). More specifically: genetic factors have been estimated to account for between 39% and 58%

(Tellegen et al., 1988) or between 40% and 55% (Diener et al., 1999) of happiness in adults; and between 35% and 57% of happiness in children (Braungart et al., 1992) As It is extremely difficult to obtain genetic information for standard LS studies, researchers must content themselves with exploring the influence of other factors, knowing that their final models might be unlikely to account for more than 50 % of all variation.

2.3.3 Wellbeing indicators used in the literature

The previous section discussed the four types of capital that support human wellbeing, as well as some other factors that were found to influence wellbeing. Evidently, the number of different factors that affect wellbeing are enormous and diverse (Cummins, 1996). However, these factors are frequently related (e.g. income and education), so variables (or indicators) that are used in empirical studies to capture the influence of factors on wellbeing often share a great deal of their variances. Cummins (1996) demonstrated that 68% of 173 different variables from the literature could be grouped into seven life “domains”, including material wellbeing, health, productivity, intimacy, safety, community emotional wellbeing and spirituality.

There are several well-documented studies of wellbeing which consider numerous life domains including (but not limited to) the wellbeing indicators of OECD (OECD, 2011) and the International Wellbeing Index (The International Wellbeing Group, 2013). These examples (below) highlight the fact that there is no commonly agreed set of ‘domains’ about which researchers and organisations who are interested in wellbeing regularly collect data.

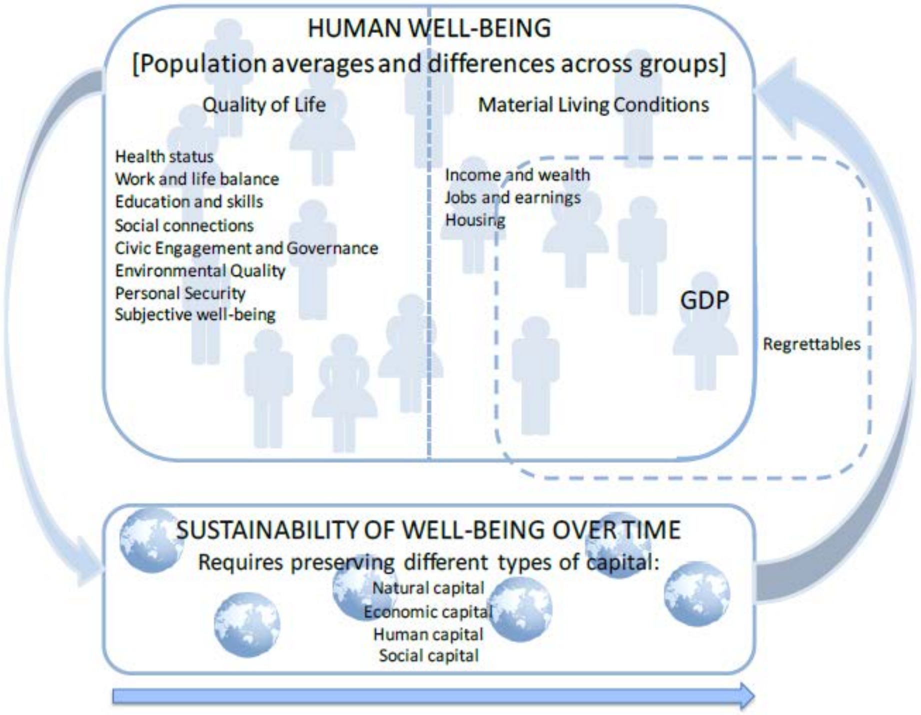


Figure 2.2 Framework for OECD wellbeing indicators

Source: From 'Compendium of OECD well-being indicators' (OECD, 2011, p. 5).

In the OECD's framework of wellbeing indicators (Figure 2.2), subjective wellbeing only refers to how people evaluate their life as a whole, without measuring the satisfaction with different wellbeing factors. Other factors, such as health status, work and life balance etc., apart from global life satisfaction, are all measured by objective wellbeing indicators.

The International Wellbeing Index (IWI), including Personal Wellbeing Index (PWI) and National Wellbeing Index (NWI), is the measurement of subjective wellbeing that has been applied to many countries (Knight et al., 2009; Davey and Rato, 2012; Monk-Turner and Turner, 2012; The International Wellbeing Group, 2013). The NWI measures satisfaction with various conditions in a country, region, or city via six domains: business, economic, social situation, environment, government, security and social conditions, while the PWI measures individual satisfaction with domains relating to personal health, achievement in life, personal relationships, personal safety, community connectedness and future security (The International Wellbeing Group, 2013).

2.4 Coal mining and human wellbeing

Human wellbeing is affected by various environmental, economic, social and psychological variables. As discussed in section 1.2 and 1.3, coal mining has multiple impacts on various life domains, which are essential to human wellbeing. If something (say coal mining) has multiple impacts on the environment, economy, society and individual, then it is difficult to determine, *a priori* what the total effect on wellbeing will be.

As discussed in chapter 1, although coal mining has various impacts on environmental, economic, social domains, it is essential for economic growth, and may help increase incomes and alleviate poverty, especially in underdeveloped countries or regions. However, caution should be exerted if economic growth is seen as a final goal of human development, because economic growth does not necessarily indicate a higher level of subjective wellbeing. This has been highlighted by numerous researchers – a recent example being Easterlin and Sawangfa (2009) who examined the relation between long-term economic growth and growth rate of subjective wellbeing in 13 developing countries with a time span of 16 years. They concluded that economic growth does not necessarily increase subjective wellbeing. Daly and Farley (2010) also argued that subjective wellbeing declines after a certain level of economic growth is reached, which is identifies as uneconomic growth (see Figure 2.3).

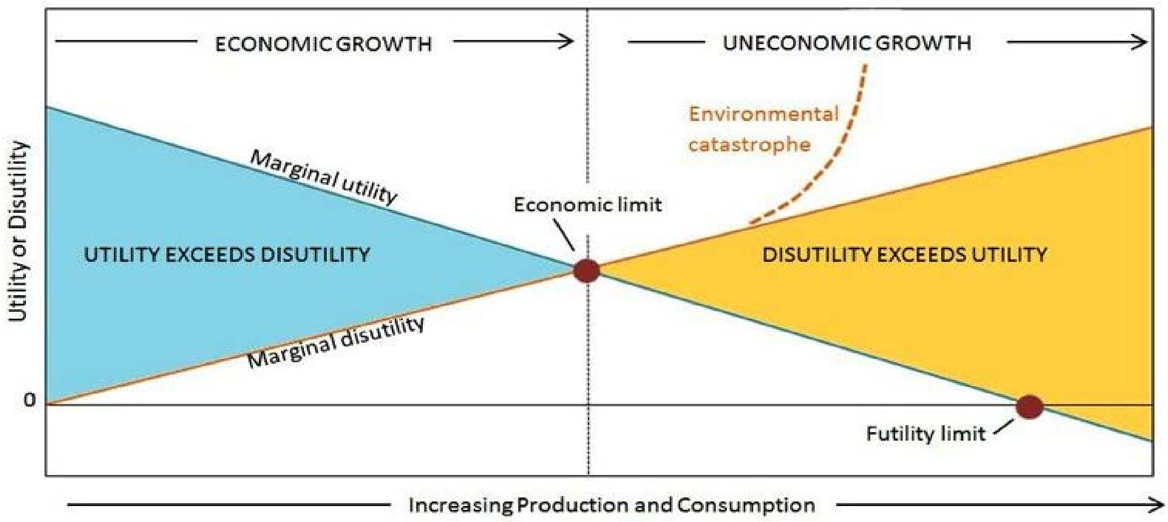


Figure 2.3 Limits to the economic growth

Source: From 'Three limits to growth' (Daly, 2014) [6], accessed on 25th August 2015.

Here utility, substituted with life satisfaction (LS) in the LS studies, refers to the overall satisfaction that a person gains from the consumption of a good or service (in the diagram, the good is presumed to be 'income' – or, from a macroeconomic perspective, GDP). Marginal utility is the additional benefit or satisfaction derived from obtaining an additional unit of that good or service (i.e. a little more GDP). The law of diminishing marginal utility states that the more one has of something, the less satisfaction an additional unit provides. Contrarily, marginal disutility is the additional cost of producing one more unit. In this case, it might be the amount of leisure time, or natural resources are given up to produce more GDP. The law of increasing in marginal cost means that more sacrifice or cost occurs as production increases. In other words, to be 'rich' (to earn more GDP), one must use more resources (such as labour, fertilizer, leisure time, or environmental goods) and the amount of extra resources required to increase production, increases as GDP increases. Marginal sacrifice increases while marginal benefits decrease. When marginal disutility surpasses marginal utility, uneconomic growth occurs (Daly and Farley, 2010).

This provides at least one explanation for the findings of Easterlin and Sawangfa (2009). people are becoming wealthier, but they must 'give up' other things (free time,

[6] http://steadystate.org/three-limits-to-growth/

environmental quality) to get that wealth. And the value of what is ‘given up’ can – and on occasion does - exceed the value of the extra wealth. This warns us that better human wellbeing should be the continuing and final goal for the economy (Frey and Stutzer, 2002b), and a major criterion for the evaluation of governments and societies (Kahn and Juster, 2002), rather than economic growth (Daly and Farley, 2010). Especially, in a country that is already rich, policies aim at raising economic growth may be of comparatively little value (Oswald, 1997).

The relationship between Daly’s model and coal mining is as follows:

- Coal mining affects all ‘capitals’ (as discussed above), it also generates wealth. All of these affect wellbeing.
- Some of the effects are positive (being wealthier can improve wellbeing, especially in developing countries or regions)
- Some of the effects are negative (being less healthy, or having a degraded ecosystem can reduce wellbeing).
- The core issue is whether the positive impacts, outweigh the negative (in which case ‘economic’ coal-mining is on-going), or whether the negative impacts outweigh the positive (in which case ‘uneconomic’ coal-mining is on-going).

As discussed above, the current approaches used to assess the impacts of mining are not equipped to assess such a wide range of impacts simultaneously. Some, like CBA, can in theory, but struggle in practice - primarily because they require one to generate monetary estimates of the ‘value’ of intangibles, and this can be exceedingly difficult to do across numerous, often inter-related, factors. If, instead of aiming to monetise impacts before assessing, one can directly measure wellbeing level as an outcome, then the problem is somewhat simplified. One can assess whether the net impact on wellbeing is positive or negative, and consider trade-offs, not using money metrics, but rather using ‘wellbeing’ metrics. This allows one to assess benefits and costs and to determine whether a coal mining project is economic or uneconomic, in which regions, and from whose perspective. This could provide important information to complement existing methods for assessing the ‘impact’ of mining projects.

There are a range of studies that have directly or indirectly investigated the impacts of coal mining or mining on human wellbeing. The following section explores the current wellbeing research in mining contexts.

2.5 Literature examining human wellbeing in coal mining regions

The previous studies that investigated the impacts of coal mining or mining on human wellbeing in host communities have furthered the understanding of the impacts of mining. However, there are significant research gaps in many aspects, which are discussed in detail in the following sections.

2.5.1 Lack of holistic investigations into a range of wellbeing factors and the trade-off between benefits and costs

Some previous research is relatively comprehensive, covering a wide range of aspects of mining's impacts, such as Kitula (2006), but most literature that examines the impacts of coal mining or mining (cited in section 1.2 and 1.3), focus on just one or two aspects – most commonly, the environment (Bian et al., 2010), health (Coggon and Taylor, 1998; Hendryx and Ahern, 2008), social impacts (Lockie et al., 2009; Carrington et al., 2011), health and economic impacts (Hendryx and Ahern, 2009) or social and the economic impacts (Ivanova et al., 2007).

Furthermore, no holistic investigations into the impacts of mining on the overall quality of life or on the wellbeing of host communities could be found; neither were there holistic investigations that assesses the trade-off between benefits and costs. This is likely at least attributable to the fact that most researchers focus on objective wellbeing indicators – which are particularly difficult to source across a broad spectrum of life domains.

In some regions, especially in developing countries, the officially available objective wellbeing indicators are very limited, which restricts the investigation into the impacts of mining. Some research on intangible/non-market impacts of coal mining, such as on social capital and institutional capital discussed in section 1.3.4 and 1.3.5, have been undertaken, but these mostly qualitative studies – no doubt because these factors are particularly difficult to measure and quantify (see section 2.3.1.3), especially if seeking to quantify using money as the metric (see section 2.2.1.2). This is also the reason why traditional cost-benefit studies have been unable to incorporate a broad range of intangible impacts, and why a comprehensive assessment of the trade-off between all costs and benefits is difficult to achieve (see section 2.2.1.2).

2.5.2 Lack of subjective wellbeing measurement

Most literature examining the impacts of coal mining or mining (cited in 1.2 and 1.3), uses objective indicators, which are not always well linked to the concept of wellbeing (particularly given the concept suggests that one needs to include both objective and subjective dimensions). For example, Stedman et al. (2004) and Hajkowicz et al. (2011) directly referred to the relationship between coal mining and wellbeing in Canada and Australia respectively, using predominantly objective indicators of wellbeing such as human capital, unemployment, income and life expectancy. Zullig and Hendryx (2011) analysed health- related QOL for residents of U.S. counties with and without coal mining. But they only examined the health-related quality of life, including physical and mental health, which is just part of QOL or human wellbeing.

There is limited research discussing measures of mining's impacts with subjective wellbeing indicators. Noronha (2001) suggested using three different approaches to measure current wellbeing and progress towards improved wellbeing in mining regions. First, she suggested the use of a set of objective indicators relating to environmental, economic, social and political domains within a framework (The presser-state-response (PSR) model[7]) that linked human activities, environmental impacts, and social responses, and monitored changes over time in mining regions. Second, she suggested that one

[7]"The PSR model has initially been developed by the OECD to structure its work on environmental policies and reporting. It considers that: human activities exert pressures on the environment and affect its quality and the quantity of natural resources ('state'); society responds to these changes through environmental, general economic and sectoral policies and through changes in awareness and behaviour ('societal response')" (OECD, 2003, p. 21).

could use a Quality Of Life (QOL) instrument which could either be an aggregate measure of wellbeing or could, in a more limited way, capture the subjective satisfaction of individuals within mining regions (i.e. what is an individual's level of satisfaction for each objective condition, e.g. concentration of particles in the air and people's satisfaction with air quality). Third, she suggested using a regional income accounting framework which deducted the (total) cost of mining from total income (This framework used mainly market-based approaches, the disadvantages of which have been discussed in section 2.2.2).

Although the use of a measure of subjective wellbeing in mining regions was proposed by Noronha (2001), as far as I know, there was no other case studies using subjective measurement and this framework. Noronha (2001) suggested the needs to simultaneously investigate all major domains, environmental, economic, social and political, the use of both objective indicators and subjective wellbeing (quality of life) indicators and quantitative approaches to assess the net impacts. This is an advance given to the fact that current studies use mainly objective wellbeing factors, cost-benefit analysis and only involve limited life domains.

There is limited literature that considers the impacts of mining on subjective wellbeing or subjective perceptions of the quality of life – particularly across a broad range of life domains. Krannich (1984) examined the impacts of rapid growth caused by resource boom on personal wellbeing using an index reflecting each respondent's subjective perception of his/her integration into the community of residence, a subjective sense of the level of stress experienced in everyday life, and self-reported symptomatic indicators of psychological distress or impairment. These indicators focused on mental health, and social connection, not on the broad concepts of SWB or life satisfaction discussed in section 2.3.1.2.

The investigation of Dai et al. (2014) into the impacts of coal mining on wellbeing of herdsman in Inner-Mongolia, was involved with subjective wellbeing – asking the herdsmen about how satisfied they were with the compensation they received from the government. But that study does not refer to satisfaction with other wellbeing factors. Surveys conducted by Commonwealth Scientific and Industrial Research Organisation

(CSIRO), assessed Australian/Chinese/Chilean's satisfaction with living in their community (Moffat et al., 2014a; Moffat et al., 2014b; Zhang et al., 2015), which is different from satisfaction with life as a whole - the common measure of life satisfaction.

2.5.3 Lack of importance weighting

There has been much debate about whether one should weight different life domains when assessing overall wellbeing (Chen and Lin, 2014), and – if so, how one should determine the weights. Some researchers argue that there is no need to use weights since the life domains typically used by researchers have near-universal relevance and thus in-built importance, and potentially equal weight (Trauer and Mackinnon, 2001; Wu and Yao, 2006; Chen and Lin, 2014). Other researchers argue that importance is likely to have been implicitly considered by respondents when assessing domain satisfaction. That is, they believe that when individuals express extreme satisfaction or dissatisfaction with certain life domains, they also tend to attach greater importance to these domains (Trauer and Mackinnon, 2001), so it is unlikely that an individual will express strong feelings about a domain if she/he thinks it is unimportant (Chen and Lin, 2014).

However, the measures of importance and satisfaction were not always strongly correlated (Russell et al., 2006; Wu and Yao, 2006). Trauer and Mackinnon (2001) only noted that extreme satisfaction and dissatisfaction were associated with higher ratings of importance, but there may not be a linear relationship between importance and satisfaction (Chen and Lin, 2014). Other researchers have confirmed the importance weighting of wellbeing factors can provide more insights than only using satisfaction measurements (Larson, 2010; Larson et al., 2013; Chen and Lin, 2014; Larson et al., 2014). Larson (2010) clearly demonstrated that, at a regional level, importance weighting provided critical insights to the problems perceived by people that a simple solicitation of satisfaction scores would not be able to reveal.

Although there are difficult empirical issues to address when applying weights (Wu and Yao, 2006; Chen and Lin, 2014), weighting importance, at least, takes those differences into account (Wu and Yao, 2006; Hsieh, 2012). Understanding subjective importance could provide additional information of where resources might be allocated for policy makers when making decisions to improve wellbeing (Costanza et al., 2007; Chen and Lin, 2014). Although, there are many studies that include questions about the importance of particular life domains (Hsieh, 2003; Tost, 2005; Hsieh, 2012; Chen and Lin, 2014), investigating different methods of using that information to weight satisfaction scores is still a neglected area of wellbeing research. It is even rarer to find examples of studies conducted in developing countries, such as China. There are but a few studies that investigate subjective wellbeing in China (e.g. Brockmann et al., 2009; Davey et al., 2009; Davey and Rato, 2012; Monk-Turner and Turner, 2012); fewer still consider importance weighting/ranking, especially in the mining context.

2.5.4 Lack of investigation into perception of local residents about impacts of mining

Objective data that could be used to investigate the impacts of coal mining on local wellbeing are often very limited, and also, objective data have limitations itself. One of the shortcomings of using only objective wellbeing indicators to examine the impacts is that, sometimes, it is difficult to ensure that the measured problems are actually associated with (or attributable to) coal mining. As Hendryx and Ahern (2009) stated when discussing some of the limitations of his study, “despite the significant associations between coal mining activity and both socioeconomic disadvantages and premature mortality, it cannot be stated with certainty that coal mining causes these problems” (p.548). They just assumed the link, based on previous literature about the impacts of social disparities and the previously documented problems of coal-dependent economies.

Moffatt and Pless-Mulloli (2003) also noted that uncertainties about the health impact of polluting industries are the hallmark of many environmental controversies. They used subjective knowledge of local residents (specifically, local residents’ perception of coal mining’s impacts on health) to reduce this uncertainty. They concluded that environmental health studies that utilise both objective and subjective knowledge have a better chance of arriving at conclusions that are meaningful to the scientific and affected communities. However, this study was only limited to the impacts on health, not referred to other wellbeing factors, such as social capital. It was assumed that the link between mining and other life domains, such as social capital, was of greater uncertainty than the link between mining and health, as there is much less literature or empirical evidence that confirmed the impacts of coal mining on these factors.

Dai et al. (2014) investigated the impacts of coal mining on the wellbeing of herdsman in Inner-Mongolia by asking herdsmen's perception of the coal mining's impacts on income, and also the perception of where coal was utilized etc. This study, again, only investigated perception on very limited impacts of coal mining. A survey conducted by CSIRO, investigated Australian/Chinese/Chilean attitudes/perceptions towards mining, asking about the significance of mining, perceived positive/negative impacts of mining, fairness, faith in governance and trust (Moffat et al., 2014a; Moffat et al., 2014b; Zhang et al., 2015). This survey involved the impacts of mining across multiple wellbeing factors. But like other studies cited above, it did not connect the perceived impacts to the satisfaction level with those factors. Even if the nagative imapcts of coal mmining on certain wellbeing factors are percieved, people might be still satisfied with those factors. These factors, thus, might not be a policy priority compared to those factors with which people are dissatisfied with that are, indeed, impacted by coal mining. To find out whether the factors that people are dissatisfied with, are negetively affected by coal mining is thus an important goal.

To sum up, these existing studies confirmed that investigations of perceived impacts can generate reliable results, and are necessary, because local residents are the ones who are strongly exposed to the impacts of coal mining and are thus in a better position to describe the impacts than those with limited 'lived' experience of the industry. However, as discussed above, previous researchers who have considered perceptions of impact have focused on only a limited number of wellbeing factors, have not compared the perceptions of those with and without lived experiences adjacent with mining, and have not combined information about perceptions of impact, with that of satisfaction.

2.5.5 Lack of the empirical alignment between subjective and objective wellbeing measurement

Not only does the current literature lack studies that investigate a broad range of SWB indicators, and use subjective measurement to investigate non-market impacts of coal mining, but it is particularly impoverished when it comes to studies that consider the extent to which measures of objective subjective wellbeing align in a coal mining regions.

Only very limited number of studies were found which empirically examined the relationship between indicators of OWB and SWB, but none of them were in mining or coal mining contexts. Schneider (1975) examined rankings of 'quality of life' in US cities. Objective indicators were derived from census data at the city level and subjective indicators were captured at an individual level. The analysis suggested that objective indicators of the quality of life in regions defined by political boundaries (cities) did not relate to the subjective wellbeing of individuals living in those cities. Notably, this study did not control for sociodemographic factors when comparing wellbeing indicators, which might affect the result.

In contrast, a most recent study by Oswald and Wu (2010) controlled for sociodemographic factors, finding that the ranking of quality of life among each US state was consistent between objective and subjective measurement. Similar to Schneider's (1975) study, this study also used highly aggregated objective indicators that reflected differences in the geographic characteristics of regions – amenities and dis-amenities for each state, such as air quality, sunshine, coastal land, inland water, national Parks, waste sites, environmental greenness, violent crime, the cost of living etc.

Aggregated objective wellbeing data were often used as data at individuallevel were hardly available (to compare with the subjective measures). However, highly aggregated indicators of objective wellbeing do not capture differences likely to occur within a large geographical area (social conditions are likely to vary greatly between different geographic areas within cities/states), so may not have accurately reflected the 'subjective' experiences of residents (Schneider, 1975). This is confirmed by Lee and Marans (1980) who used regressions to control for personal characteristics, and found that the correlation between objective measures of crime and respondents' feelings of safety is stronger among individuals whose view of neighborhood size is in line with the relatively large territorial base for objective crime statistics – objective and subjective data are in a similar scale.

Emmons and Diener (1985) used objective and subjective data at an individual level and controlled for sociodemographic factors to measure the wellbeing of 149 college students. They concluded that objective conditions were often poor predictors of subjective wellbeing, but this was not always the case within certain domains (e.g. love life). Although the sample size for this study was quite small, this study offered some interesting insights – since objective indicators do not always predict subjective indicators, it is necessary to examine when they were consistent and when were not.

"The discrepancies between objective and subjective indicators do not detract from the value of either – they merely reinforce the need for the parallel development of both sets of indicators" (Lee and Marans, 1980, p. 62). To maximise the value of both approaches, the profitable approach would be to gain the knowledge of possible reason for divergence between subjective and objective indicators offering different perspective of the same domain (Lee and Marans, 1980). The current literature lack aliment between objective and subjective measure of wellbeing in different backgrounds, and lack systematically explanations for divergence between these 2 measures.

2.5.6 Lack of comparison of different case-study areas characterized by different intensities of coal mining

Brereton et al. (2008) and OECD (2013) argue that LS studies should consider geography – comparing, for example, urban and rural areas, or places that have different environmental/spatial characteristics. As discussed in chapter 1, there are multiple impacts associated with coal mining and one would thus expect places with different intensities of coal mining to differ in terms of some environmental characteristics, such as the air quality and the distance to waste disposal. Comparing regions that have different intensities of coal mining could thus further the understanding of the extent to which coal mining affects wellbeing in different contexts. For example, air quality in coal mining areas is generally poor, but it is through the comparison of those areas to areas without coal mining, that one can know to what extent the air pollution is caused by, or at least likely to be attributable to coal mining.

There are a limited number of studies that have made this comparison. Kitula (2006) compared a range of objective indicators between mining communities and non-mining communities in Tanzania. Hendryx and Ahern (2009) investigated the impacts of coal mining on mortality by comparing cases with different intensities of coal mining (the study sites included: Appalachia with high levels of coal mining, Appalachia with lower mining levels, Appalachia without coal mining, and other counties in the nation). The survey conducted by CSIRO (Moffat et al., 2014a; Moffat et al., 2014b; Zhang et al., 2015), which investigated Australian/Chinese/Chilean attitudes/perception towards mining also compared attitudes in mining and non-mining regions and in (non-mining) metropolitan areas.

However, most studies on the impacts of coal mining have only examined impacts within coal mining areas, without making a comparison to places that do not have mining. This study investigated the impacts of coal mining on human wellbeing of host communities by comparing places with different intensities of coal mining.

2.6 Summary: research gaps and questions

Coal mining has multiple impacts, both negative and positive, on many factors which might matter to wellbeing. Traditional approaches, such as EIA, SIA and Economic approaches, make a valuable contribution to the understanding and assessment of the impacts of coal mining. However, their inability to assess a broad range of market and non-market costs and benefits limits their application. Cost-benefit analysis (CBA) has the theoretical capacity to include all costs and benefits and to thus generate an aggregate estimate of net benefits, but the quality of the CBA depends crucially on the quality of the non-market valuation techniques that are used to generate estimates of the intangible costs and benefits (in monetary terms). It is notoriously difficult (and resource intensive) to generate monetary estimates of value for many intangibles, so

CBA is often limited empirically. The life satisfaction (LS) approach has been testified by a large number of studies and has proven to be a potentially effective approach to valuing non-market goods. It also generates information that allows one to assess trade-offs between multiple market and non-market impacts, as well to assess the impacts of coal mining on wellbeing and different life domains. However, no research has been found using the LS approach to assess the impacts of mining or coal mining.

Wellbeing is a concept that comprises objective and subjective dimension, and is thus often 'measured' using both subjective and objective indicators. Both of these indicators have their advantages and disadvantages. Although indicators of SWB are gaining importance and popularity, it is only really indicators of OWB that have been traditionally pursued by governments. Both are needed to complete a comprehensive picture of human wellbeing.

Most literature that examines the impacts of coal mining or mining, focuses on impacts on particular domains. To the best of my knowledge, there are not holistic investigations of mining's impacts on quality of life or wellbeing of the host communities, or holistic assessments of the net benefit (impact) of mining.

While most literature, whether directly referring to the concept of wellbeing or not, investigates objective dimensions of mining's impacts, there is limited research that measures mining's impacts on subjective wellbeing indicators, as well as subjective indicators weighted by importance. The investigation into the perception of local residents about the impacts of mining on a range of wellbeing factors, the combination of perceived impacts of mining and satisfaction, and comparison between different intensities of mining is also impoverished. There is also limited research that has investigated the relationship between OWB and SWB, especially in a mining context.

Thus, the core research question proposed for this study is:

How does coal mining affect human wellbeing in host communities?

The over-arching research question is answered through the following sub-questions;

- How does coal mining affect people's subjective perceptions of different wellbeing factors?

  ● What factors are important to people's lives? Do people's perceptions of what is important differ in places with different intensities of coal mining?

  ● How satisfied are people with those factors? Does satisfaction with particular factors differ in places with different intensities of coal mining?

  ● How do people think coal mining affects various aspects (factors) of their life? Do people's perceptions of coal mining's impacts differ in places with different intensities of coal mining?

  ● Are people satisfied with the factors that they attach great importance to? Can one identify policy priorities by combining information about satisfaction and importance – i.e. can we identify factors which people are very dissatisfied with and attach great importance to?

  ● Are the factors that people are dissatisfied/satisfied with negatively/positively affected by coal mining? Can one identify policy priorities by combining information about satisfaction and impact – i.e. can we identify factors which people (either rightly or wrongly) 'blame' coal mining for impacting most negatively?

- Does information about the impacts of coal mining derived from subjective assessments of wellbeing convey the same message about the impacts of coal mining as 'objective' measures of wellbeing?

  ● Do the objective indicators suggest that there are differences in wellbeing between (a) areas with different mining intensities (b) rural and urban areas?

  ● Do objective and subjective indicators convey similar information (a) using aggregated data (b) using regressions at individual level to control sociodemographic factors?

- Is it possible to quantify the net impacts of coal mining (on broad 'domains' of life and on the overall wellbeing of host communities) and to determine how much should, in principle, be paid 'in compensation' to those who are, overall, impacted negatively?

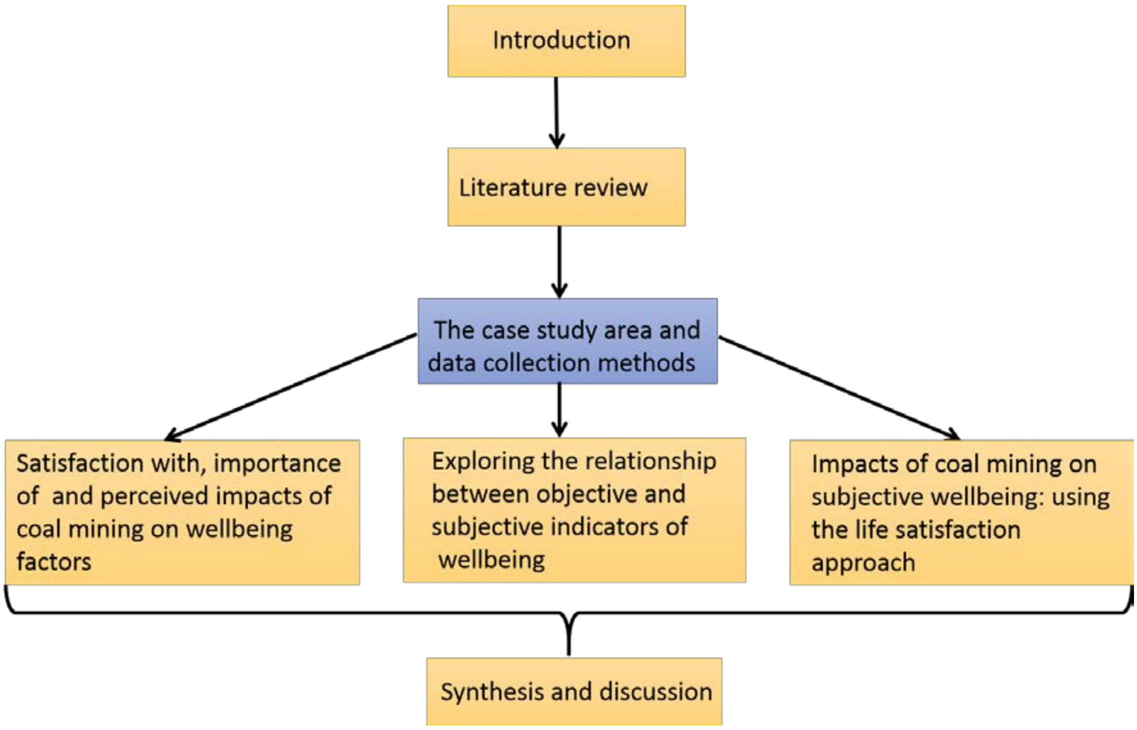
    - How does coal mining affect satisfaction with life domains (after controlling for confounding factors)?

    - How does coal mining affect global life satisfaction (after controlling for confounding factors)?

    - If the net impact of mining, on global life satisfaction, is negative, then how much extra income would need to be paid to the negatively impacted people, to raise their 'satisfaction' to the same level as their unaffected counterparts?

After providing some background information about the case-study area, the following chapter discusses the general methods that are used to answer these questions, focusing on the development of the questionnaire, sampling, and the conduct of the survey. Methodological details (e.g. the statistical approaches) are discussed in the later chapters, since those methods vary across specific research questions.

Thesis outline



CHAPTER 3 THE CASE-STUDY AREA AND DATA COLLECTION METHODS

Chapter outline

3.1 Introduction

3.2 Coal mining in China

3.3 Shanxi province

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- 3.4.1 Questions for the questionnaire
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- 3.4.3 Wording and sequencing questions

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3.6 Sample overview

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3.1 Introduction

To assess the 'impact' of coal mining on wellbeing, one needs to develop (a) a sampling framework (deciding where, and from whom, one needs to collect data); and (b) a questionnaire that will allow one to collect suitable data. As regards the sampling framework: I chose to work within a region (Shanxi) where coal mining is prevalent and important. Within that region, I chose to collect data in sub-regions with differential exposures to coal mining so that I could compare results, and thus draw inferences about the extent to which observed differences (in factors relating to wellbeing) were, or were not, likely to be attributable to mining. As regards the questionnaire: the literature discussed in the previous chapter clearly highlighted that wellbeing is a holistic concept, and that to adequately measure it, one needs both objective and subjective data – in addition to other contextual data (such as age and gender) known to be associated with subjective assessments of wellbeing. I thus developed a comprehensive survey focusing on subjective indicators; but sought to supplement that information with other 'objective' data collected in the survey and elsewhere.

This chapter begins by providing some background information about the case-study area, including a short history of government regulations relating to coal mining, the problems associated with coal mining (section 3.2), and a description of Shanxi Province (section 3.3). The development of the questionnaire is described in section 3.4. The sampling framework and the process of data collection are presented in section 3.5, followed by a sample overview in section 3.6. Importantly, this chapter only discusses the general methods that are pertinent to the analyses presented in chapters 4, 5 and 6. Those other chapters also contain methodological discussions – but focus on the methods that are specific to each.

3.2 Coal mining in China

Section 1.3.2 highlighted the fact that the relationship between resource development and economic growth varies across countries. The relationship between resource-dependence and wellbeing may vary also within regions or countries, as Stedman et al. (2004) noted. Thus, investigations of coal mining and wellbeing should be based on specific case studies. Social problems associated with coal mining in China are characterised by the special history of government regulation.

From 1949 to 1994, state-owned enterprises (SOEs), which enjoyed large rents generated by government-enforced monopolies, were the dominant players in the mining sector (Wright, 2008; Zhang et al., 2008). These monopoly rents are the excess income resulting from government regulation restricting the operation of the market. Rent seeking is involved with the often legal efforts of enterprises or organizations to create, maintain or oppose those monopoly rents, and the corrupt efforts by individual bureaucrats to capture a part of those rents for themselves (Wright, 2008). Apparently, these rents did not necessarily improve local welfare (Zhang et al., 2008).

Under the new regulations that were put in place after 1994, SOEs still enjoyed preferential treatment in developing large mineral reserves, but local governments were allowed to auction the development rights of small-scale mineral reserves left over by the state sector to the private sector. As a result, many small-scale mines were privatized and local governments enjoyed rents through their control over mining licences and permits (Zhang et al., 2008).

Since 2009, the coal mining industry has undergone mergers and acquisitions through government executive order. For example, in 2011, the total number of coal mines in Shanxi was cut down by 60% as a result of the closure of small coal mines. After mergers and acquisitions, new coal mines were operated by more than 130 companies, among which state-owned or controlled companies accounted for more than 50% (Zhou, 2011).

Like many other developing countries, the mining regions of China suffer from environmental and ecological problems caused by coal mining, and both the academic circle and policy makers tend to devote most attention to the environmental impacts. The social impacts of coal mining in China are paid relatively less attention, and very little literature in China includes a comprehensive analysis of the multiple impacts of mining, or provides empirical evidence of those impacts.

The benefits and burdens of coal mining in China have been distributed unevenly geographically and socially. At the government level, the central government obtains a higher proportion of tax and fees revenue from coal mining than local governments (Zhao and Liu, 2011; Lei et al., 2013). At the individual level, coal mining enterprises and individual bureaucrats who are involved with rent-seeking behaviour obtain most benefit from coal mining, while local residents have been left bearing the brunt of the negative externalities (Xu and Wang, 2006; Zhang et al., 2008; Zhao and Liu, 2011).

The unfair wealth distribution of resource development, and rent- seeking behaviour can significantly widen the gap between the rich and poor (Xu and Wang, 2006). When industry participants accumulate wealth, other local residents who are not able to share the resource rent become relatively worse off (Xu and Wang, 2005; Shao and Qi, 2008). Resource dominant economies also restrain the accumulation of human capital and the development of science and technology (Xu and Wang, 2005). Zhan et al. (2015) empirically found that resource dependence reduces government expenditure on human capital. While most of the compensation for coal mining areas is limited to control of environmental pollution and recovery of ecology, the impact on the quality of life experienced in mining communities through, for example, changes in the distribution of income, or changes to social capital has not been given much recognition to date (Zhao and Liu, 2011).

3.3 Shanxi province

Shanxi was selected as the case-study area, as it is the most important province for coal production, transportation, export and energy and chemical production (China Energy Information Network, 2009).

The cumulative amount of coal resources identified in Shanxi ranks first in China, accounting for 27% of the whole country. This is despite the fact that Shanxi accounts for just 1.6% of China's total land mass. About 40% of land in the whole province contains coal (China Energy Information Network, 2010). The coal industry is not only the main contributor to local GDP (Editor of Land & Resource Herald, 2013), but coal from Shanxi also plays a significant role in the whole country, being exported to 26 out of 30 of China's province (Statistical Yearbook of Shanxi, 2014). It remained the largest and the most important coal producer until 2009, being replaced by Inner-Mongolia afterwards. In 2014, Shanxi produced the biggest yield of coal again, accounting for 25% of coal production in China. During that year, 66% of the coal produced in Shanxi was exported (Ma, 2014). China is in need of coal to fuel its economy. So the fact that coal resource development dominates Shanxi economy will not change in short term.

The impacts of coal mining in Shanxi are typical of impacts reported throughout the world. The industry is a two-edged sword. According to the list released by China's environmental watchdog in 2004, Linfen, Yangquan and Datong – all cities within the Shanxi Province – stood out on the black list (Qin, 2004). Since then, Linfen has been cited as one of the most polluted places in China (e.g. Blacksmith Institute, 2007; Green Forward News, 2014). Apart from having a substantive coal mining industry since 1978, the numerous of private (illegal) mines within the Shanxi province is problematic; illegal mines are some of the biggest polluters, as they do not follow any government regulations (Green Forward News, 2014).

Since the consolidation of coal mining industry (after 2009), management and supervision from government have been enhanced. Also, the government has put in efforts to address environment problems by, for example, shutting down highly polluting factories, and managed to reduce pollution. Linfen, consequently, is no longer considered to be the "most polluted place on the Earth" (Official Website of China National Radio, 2010).

Shanxi is a large province with a large population (see Table 3.1). Sampling across the whole province would have been difficult and problematic, because there are substantive differences between regions. Most notably are differences in language (dialect): it would have been almost impossible to find research assistants who could speak all of the dialects used in Shanxi Province. I thus focused on three regions: Shuozhou, Yangquan and Linfen (highlighted in Figure 3.1). This selection was based on the following considerations: first, they are located in the northern, central and southern parts of Shanxi province, thus providing diverse geographic coverage. Second, these areas play important and active roles as coal producers. Shuozhou produces most coal and has the largest identified reserves; in terms of forecast reserves, Linfen ranks first (China Coal Information, 2013). Third, compared to other areas, the industries of

Shuozhou and Yangquan are relatively homogeneous – with coal production and electricity being the two main industries (see Table 3.2). Evidently, residents of these regions have had some exposure to coal mining, processing and transportation, and are thus likely to be in a good position to comment upon its impacts.

Figure 3.1 Map of Shanxi province

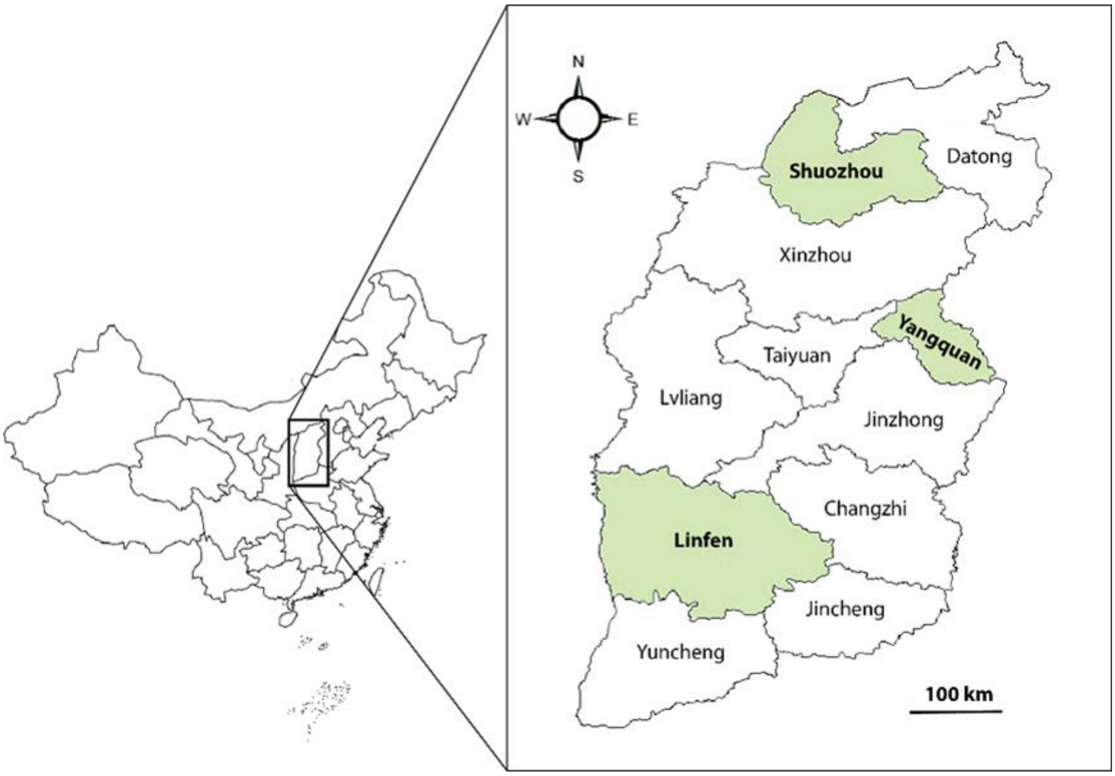

Table 3.1 Area and population of case-study areas (2013)

District	Area (Km^2)	Population
Shuozhou	10662	1,744,169
Yangquan	4451	1,386,030
Linfen	20589	4,390,837
Shanxi	156,000	36,298,019

Source: From Shanxi Bureau of Statistics (2014).

Table 3.2 Output for major industrial products above designed size (2013)

City in Shanxi	Coal (10000 tons)	Electricity (100 million kwh)	Crude Steel (10000 tons)	Steel Products (10000 tons)	Pig Iron (10000 tons)
Taiyuan	3711.5	279.2	977.8	939.4	698.6
Datong	10898.6	388.4	43.2	1.0	49.0
Yangquan	6456.9	114.0			
Changzhi	11270.4	341.6	632.4	610.7	611.1
Jincheng	7855.8	232.0	278.0	273.4	346.2
Shuozhou	22091.5	278.7		0.2	
Jinzhong	8455.9	213.4	214.7	203.4	81.4
Yuncheng	541.8	204.0	843.1	827.8	603.9
Xinzhou	5683.3	270.0		60.0	13.2
Linfen	4861.7	191.3	1287.3	1320.7	1313.4
Lvliang	11676.1	91.0	395.0	363.3	362.5
Total	9350. 4	2603.7	4671.4	4486.2	4303.2

Source: From Shanxi Bureau of Statistics (2014).

3.4 Questionnaire Development

As discussed in section 2.3.1, wellbeing can be measured by objective and subjective indicators across multiple life domains. The most commonly used subjective indicators are those relating to global life satisfaction and to satisfaction with different life domains. To investigate the impacts of coal mining on human wellbeing, data relating to both objective and subjective indicators (global life satisfaction and satisfaction with different wellbeing factors) were thus collected.

OWB (objective wellbeing) indicators are not always acquired from official registers, neither are SWB (subjective wellbeing) indicators always collected from questionnaires or surveys (Gasper, 2004) (see Table 3.3). For this study, subjective wellbeing data, were collected via questionnaire, and were all self-reported, while objective indicators were either self-reported by respondents or observed by investigators (see highlighted part in Table 3.3).

Table 3.3 Refined terms for subjective/objective wellbeing

	Self-report indicators	Non self-report (subject–independent) indicators
Measure of SWB	'Self-report subjective'(e.g.: 'I am very satisfied with how far I can walk')	E.g. monitoring of types of brain function and physiological indicator that express SWB
Measure of OWB	'Self-report objective' (e.g.: 'I can walk 100 metres')	'Objective'– observing how far people really (can) walk, etc.

Source: From 'Human well-being: concepts and conceptualizations' (Gasper, 2004, p. 10).

Note: Highlighted parts are measures used in this study.

3.4.1 Questions for the questionnaire

The questionnaire included questions that are broadly grouped into three categories:

1) Questions about respondents' perceptions

This includes their perception about their own wellbeing, what they think is important to their wellbeing and how coal mining affects their wellbeing.

2) Questions about respondents' characteristics

These questions refer to sociodemographic information, such as age, employment status, marital status etc.

3) Questions about objective indicators

These questions refer to a few objective indicators, such as family income and whether respondents have a bathroom or flushing toilet in their houses. This category will be presented in detail in the following section.

3.4.1.1 Question about respondents' perceptions

- **Questions about overall life satisfaction**

There are numerous ways of measuring global life satisfaction (GLS). Generally, these approaches are classified into three (Hsieh, 2003), namely those: (1) using a number of multiple-item life satisfaction measures (e.g. Satisfaction with Life Scale (SWLS) by Diener et al. (1985)) (2) using a single-item question to evaluate life satisfaction (e.g. Cantril ladder by Cantril (1965)) (3) summing satisfaction scores that have been attributed to questions relating to individual life domains (e.g. Campbell et al., 1976). The third approach is questioned by some researchers. Hsieh (2003) argued that the extent to which summing across satisfaction within various domains represents GLS is unclear. Fugl-Meyer et al. (1991) argued that GLS may be greater or less than the sum of domain-specific satisfactions, and using a single measure of global satisfaction and separate measures of domain-specific satisfaction would be a better choice.

This study followed that advice. Two different approaches were used to measure GLS – the scale of 0 to 100 measument similar to Cantril Ladder (Cantril, 1965) and Satisfaction With Life Scale (SWLS) (Diener et al., 1985). In the Cantril ladder, people are asked to rate how they value their life in terms of the best possible life (10) through to 0 (the worst possible life). The International wellbeing group (2013), who has developed the Personal Wellbeing Index, argues that converting the scale of 0 to 10 to the scale of 0 to 100, does not alter the statistical properties of the data, but offers the advantage that wellbeing Index data can be directly compared to data of other scales used to measure life satisfaction in terms of their means and standard deviations. Therefore, a scale from 0 to 100 is used in this study instead of 0-10. In SWLS, respondents are asked to express their agreement on 5 statements about subjective wellbeing with a seven point scale (Diener et al., 1985). The final score of SWLS is the sum of score from each question.

- **Wellbeing factors across multiple domains selected for the questionnaire**

As discussed in section 2.3.3, there is no commonly agreed set of 'domains' about which researchers and organisations who are interested in wellbeing regularly collect data. Davey and Rato (2012) encouraged the use of diverse and creative measures; different instruments can be chosen according to study aims, sampling approaches, socio-cultural context, etc. As no previous research could be found that assessed the impacts of coal mining on human wellbeing using a range of subjective wellbeing factors, this study had to be exploratory.

The factors that affect wellbeing and common wellbeing indicators used in the literature were discussed in section 2.3.2 and 2.3.3. The variety of wellbeing indicators used in the literature are enormous and diverse, but highly correlated and can be grouped in to several life domains (Cummins, 1996). As such, each life domain can be considered as an aggregate of a number of components/factors (Cummins, 1996), for example, the environmental domain might include air quality and water quality, and water quality may include quality of underground water and surface water. Different individuals may group factors which represent a certain life domain in different ways. Therefore, empirical researchers must seek to strike a balance between developing questions that will collect sufficient information about a variety of life domains and the need to keep questions to a manageable number (Cummins, 1996). This was considered when developing questionnaire for this study.

Factors which the broader literature had identified as being impacted by coal mining (either directly or indirectly) or important to wellbeing were thus used to guide development of the survey instrument. Eventually, this study included questions about 29 factors, which covered all the capitals and life domains identified from the literature that contribute to wellbeing (see Table 3.4 and Appendix A–1).

These factors generally covered those of OECD wellbeing indicators (OECD, 2011), PWI (The International Wellbeing Group, 2013) and 7 life domains that Cummins (1996) identified, with refinements from the broader literature and some contextualisation for the case-study areas. For example, air quality and water quality were selected as key factors to assess the domain focusing on the natural environment. Instead of asking questions about the general natural environment quality, questions about air quality and water quality were asked – since these are core environmental issues impacted by coal mining. Questions about the concentration of dust and the cleanliness of the air were asked separately, as coal mining may have different impacts on different aspects of air quality. Questions about “spirituality and religion” were not included, as in this area residents are not generally religious.

Table 3.4 Selected wellbeing factors according to the literature

Selected wellbeing factors		Literature about the impacts of coal mining on wellbeing factors	Literature that illustrate that these factors have effect on wellbeing
Broad wellbeing factors in the literature	**Refinded factors in this study**		
Air quality		(Bian et al., 2010; Zullig and Hendryx, 2010, 2011; Colagiuri et al., 2012)	(Welsch, 2006, 2007a; MacKerron and Mourato, 2009; Ferreira and Moro, 2010; Menz and Welsch, 2010; Levinson, 2012; Cuñado and de Gracia, 2013), air and water pollution (Welsch, 2002; Luechinger, 2009), noise pollution (van Praag and Baarsma, 2005)
Water quality and access			(Guardiola et al., 2013)
Surface water			
Health	Physical health	(Bian et al., 2010; Zullig and Hendryx, 2010, 2011; Colagiuri et al., 2012)	(Winkelmann and Winkelmann, 1998; Frey and Stutzer, 1999b; Frey and Stutzer, 2002a; Di Tella et al., 2003; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Ferrer - i - Carbonell and Frijters, 2004; Winkelmann, 2005; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Brereton et al., 2008; Rehdanz and Maddison, 2008; Luechinger, 2009; MacKerron and Mourato, 2009; Powdthavee, 2010; Ambrey and Fleming, 2011; Levinson, 2012; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014a)
	Mental Health	(Krannich and Greider, 1984)	

Selected wellbeing factors		Literature about the impacts of coal mining on wellbeing factors	Literature that illustrate that these factors have effect on wellbeing
Broad wellbeing factors in the literature	**Refinded factors in this study**		
Education	Quality of education system and oppoortunity for education	(Gylfason, 2001; Gylfason and Zoega, 2006; Zhan et al., 2015)	(Frey and Stutzer, 2000, 2002a; Di Tella et al., 2003; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Alesina et al., 2004; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Abdallah et al., 2008; Brereton et al., 2008; Michalos, 2008; Ebert and Welsch, 2009; Luechinger and Raschky, 2009; Stanca, 2009; Powdthavee, 2010; Stanca, 2010; Ambrey and Fleming, 2011; Arifwidodo and Perera, 2011; Kountouris and Remoundou, 2011; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014b, a)
Relationship	Personal/family relationship	None	Cummins (1996)
Social capital	Participation of social activity	(Kitula, 2006; Lockie et al., 2009; Carrington et al., 2011)	
	Trust		(Helliwell, 2003; Engelbrecht, 2009; MacKerron and Mourato, 2009; Stanca, 2009, 2010; Bartolini and Sarracino, 2011)
	Help		
	Honesty		
Perceived safety	Personal safety		(Michalos and Zumbo, 2000)
	Property safety		
Quality of government		(Sachs and Warner, 1999, 2001; Gylfason and Zoega, 2006)	(Abdallah et al., 2008; Helliwell and Huang, 2008)

Selected wellbeing factors		Literature about the impacts of coal mining on wellbeing factors	Literature that illustrate that these factors have effect on wellbeing
Broad wellbeing factors in the literature	**Refinded factors in this study**		
Income		Individual income (Carrington, Hogg et al., 2011); Regional GDP (National Mining Association, 2014; Editor of Land & Resource Herald, 2013)	(Frijters and Praag, 1998; Winkelmann and Winkelmann, 1998; Diener et al., 1999; Frey and Stutzer, 1999b; Cummins, 2000; Frey and Stutzer, 2000; Michalos and Zumbo, 2000; Easterlin, 2001; Frey and Stutzer, 2002a; Welsch, 2002; Di Tella et al., 2003; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Ferrer - i - Carbonell and Frijters, 2004; Rehdanz and Maddison, 2005; Winkelmann, 2005; Seghieri and Desantis, 2006; Welsch, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Abdallah et al., 2008; Brereton et al., 2008; Inglehart et al., 2008; Rehdanz and Maddison, 2008; Smyth et al., 2008; Carroll et al., 2009; Engelbrecht, 2009; Luechinger, 2009; Luechinger and Raschky, 2009; MacKerron and Mourato, 2009; Stanca, 2009; Ferreira and Moro, 2010; Menz and Welsch, 2010; Powdthavee, 2010; Stanca, 2010; Ambrey and Fleming, 2011; Kountouris and Remoundou, 2011; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014a, b). Relative income studied by (Daly, 1987; Easterlin, 1995; Dixon, 1997; Diener et al., 1999; Easterlin, 2003b; Layard, 2003; Stutzer and Frey, 2010)
Income disparity		(Xu and Wang, 2006; Zhang et al., 2008; Zhao and Liu, 2011)	(Daly, 1987; Easterlin, 1995; Dixon, 1997; Diener et al., 1999; McBride, 2001; Easterlin, 2003b; Layard, 2003; Stutzer and Frey, 2010)
Fairness of income			

Selected wellbeing factors		Literature about the impacts of coal mining on wellbeing factors	Literature that illustrate that these factors have effect on wellbeing
Broad wellbeing factors in the literature	**Refinded factors in this study**		
Price	Price of necessities and real estate	(Carrington et al., 2011)	(Di Tella, MacCulloch et al. 2001, Engelbrecht 2009)
Inflation rate			
Housing		Land subsidence might cause damage to house (Bian et al., 2010); Improve living conditions (Zhang et al., 2015)	(Marans, 2003; OECD, 2011)
Electricity		(International Energy Agency, 2016)	(Cousins, 1998; Karekezi, 2002; Pachauri and Spreng, 2004; Kammen and Kirubi, 2008)
Transportation and communication		(Australians for Coal, 2014; Coal Association of Canada, 2011; Zhang et al., 2015)	(Brereton et al., 2008)

Note: The column “Literature that illustrate that these factors have effect on wellbeing” was selected from ‘The impact of economic, social and environmental factors on trip satisfaction and the likelihood of visitors returning’ (Jarvis et al., 2016, p. 14-16).

- **Questions about satisfaction with wellbeing factors**

The OECD (2013) argues that a longer (7 to 11 point) scale is better than a short (2 to 5 point) scale for single item measures of life satisfaction (satisfaction with wellbeing factors). In addition, many existing and widely-used scales for life evaluations are bipolar (running between two opposing constructs, i.e. from completely unhappy to completely happy) instead of unipolar (i.e. reflecting a single construct running from low to high),as bipolar scale anchors may be the least ambiguous in terms of all respondents interpreting the scale in the same way. Therefore, this study used a bipolar scale, with a score from 1 (strongly dissatisfied) to 7 (strongly satisfied), to measure satisfaction with different wellbeing factors (see Table 3.5).

- **Questions about importance of wellbeing factors**

In addition to asking respondents to indicate their level of satisfaction with particular wellbeing factors, the study also included questions asking about their importance. To align with the scale used to measure satisfaction with wellbeing factors, a 7-point scale was used to assess importance, ranging from very important (7) to very unimportant (1) (see Table 3.5).

Hsieh (2003) empirically proved that using discrete domain importance rating as a weighting factor did not improve the correlation between GLS measure and satisfaction with wellbeing factors, while the correlation was improved by using ranking of importance. As such, this study did not use importance scores to weight satisfaction scores in an overall regression explaining GLS. Instead, the importance scores were used to try and understand if those living in the different case-study areas had inherently different opinions about what is, or is not, important in life.

- **Questions of coal mining impacts on particular factors**

According to Stedman et al. (2004), the relationship between resource-dependence and wellbeing may vary between regions and industries. While impacts of coal mining on the natural environment are well discussed in the literature and have something in common, the social impacts may vary across countries and regions. Based on the particular economic and political climate described in section 3.2, the social impact of coal mining in China might be unique. Thus, the study also sought to learn more about people's perceptions of the impacts of coal mining, addressing the research gaps identified in section 2.5.4. For each of the 29 factors about which information on 'satisfaction' and 'importance' was collected, I also sought information on 'impact'. To align with the scales used on those indicators, a 7-point scale was used to assess the impact of coal mining on each wellbeing factor, ranging from a strong negative impact (1) to a strong positive impact (7) (see Table 3.5).

Table 3.5 Scales used in the questionnaire

<table>
<tr><td rowspan="3">Global life satisfaction</td><td>LS</td><td colspan="7">0–100</td></tr>
<tr><td rowspan="2">SW LS</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>Strongly disagree</td><td>Disagree</td><td>Slightly disagree</td><td>Neutral</td><td>Slightly agree</td><td>Agree</td><td>Strongly agree</td></tr>
<tr><td colspan="2">Satisfaction with wellbeing factors</td><td>Very dissatisfied</td><td>Dissatisfied</td><td>Slightly dissatisfied</td><td>Neutral</td><td>Slightly satisfied</td><td>Satisfied</td><td>Very satisfied</td></tr>
<tr><td colspan="2">Importance of wellbeing factors</td><td>Very unimportant</td><td>Unimportant</td><td>Slightly unimportant</td><td>Neutral</td><td>Slightly important</td><td>Important</td><td>Very important</td></tr>
<tr><td colspan="2">Coal mining's impacts on wellbeing factors</td><td>Strongly negative</td><td>Negative</td><td>Slightly negative</td><td>No impact</td><td>Slightly positive</td><td>Positive</td><td>Strongly positive</td></tr>
</table>

3.4.1.2 Questions about sociodemographic characteristics

Most wellbeing studies also include questions about various sociodemographic characteristics that have been shown to influence subjective wellbeing. Table 3.6 is a summary of the list of the relevant sociodemographic characteristics from literature. Following the lead of previous research, this study thus also included questions about respondents' age, gender, marital status, education level, employment status, family size (number of children and adults).

Table 3.6 Sociodemographic variables found to be significant in explaining overall life satisfaction

Explanatory variable	Studies where sociodemographic variable found to be significant in explaining overall satisfaction with life
Age	(Oswald, 1997; Frijters and Praag, 1998; Winkelmann and Winkelmann, 1998; Frey and Stutzer, 1999a, 2000; Michalos and Zumbo, 2000; Frey and Stutzer, 2002a; Di Tella et al., 2003; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Alesina et al., 2004; Ferrer‐i‐Carbonell and Frijters, 2004; van Praag and Baarsma, 2005b; Winkelmann, 2005; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Brereton et al., 2008; Rehdanz and Maddison, 2008; Smyth et al., 2008; Carroll et al., 2009; Ebert and Welsch, 2009; Luechinger, 2009; Luechinger and Raschky, 2009; MacKerron and Mourato, 2009; Stanca, 2009; Menz and Welsch, 2010; Powdthavee, 2010; Stanca, 2010; Ambrey and Fleming, 2011; Kountouris and Remoundou, 2011; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014b, a)
Gender	(Frey and Stutzer, 1999a; Michalos and Zumbo, 2000; Groot and Maassen van den Brink, 2003; Alesina et al., 2004; Winkelmann, 2005; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Brereton et al., 2008; Rehdanz and Maddison, 2008; Carroll et al., 2009; Ebert and Welsch, 2009; Luechinger and Raschky, 2009; Stanca, 2009; Powdthavee, 2010; Stanca, 2010; Levinson, 2012; Beja Jr, 2013; Ambrey and Fleming, 2014a)
Marital status	(Winkelmann and Winkelmann, 1998; Diener et al., 1999; Frey and Stutzer, 1999a, 2000; Michalos and Zumbo, 2000; Frey and Stutzer, 2002a; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Alesina et al., 2004; Ferrer‐i‐Carbonell and Frijters, 2004; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Rehdanz and Maddison, 2008; Carroll et al., 2009; Ebert and Welsch, 2009; Luechinger, 2009; Luechinger and Raschky, 2009; MacKerron and Mourato, 2009; Stanca, 2009; Ferreira and Moro, 2010; Powdthavee, 2010; Stanca, 2010; Arifwidodo and Perera, 2011; Kountouris and Remoundou, 2011; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014b, a)
Education level	Relationship found by (Frey and Stutzer, 2000, 2002a; Groot and Maassen van den Brink, 2003; Helliwell, 2003; Alesina et al., 2004; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Abdallah et al., 2008; Brereton et al., 2008; Ebert and Welsch, 2009; Luechinger and Raschky, 2009; Stanca, 2009; Powdthavee, 2010; Stanca, 2010; Ambrey and Fleming, 2011; Arifwidodo and Perera, 2011; Kountouris and Remoundou, 2011; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014b, a).
Employed or unemployed	(Winkelmann and Winkelmann, 1998; Frey and Stutzer, 1999a; Helliwell, 2003; Alesina et al., 2004; Winkelmann, 2005; Seghieri and Desantis, 2006; Ferrer-i-Carbonell and Gowdy, 2007; Welsch, 2007b; Brereton et al., 2008; Rehdanz and Maddison, 2008; Smyth et al., 2008; Ebert and Welsch, 2009; Luechinger, 2009; Luechinger and Raschky, 2009; Stanca, 2009; Ferreira and Moro, 2010; Powdthavee, 2010; Stanca, 2010; Beja Jr, 2012; Levinson, 2012; Beja Jr, 2013; Cuñado and de Gracia, 2013; Ambrey and Fleming, 2014a)
Family size	(Frijters & van Praag, 1998; Frey & Stutzer, 2000; Di Tella, MacCulloch, & Oswald, 2003; Moro, Brereton, Ferreira, et al., 2008; Stutzer & Frey, 2008)

Source: Selected from 'The impact of economic, social and environmental factors on trip satisfaction and the likelihood of visitors returning' (Jarvis et al., 2016, p. 14-16).

3.4.2 Collection of data relating to objective wellbeing

Although some data about objective wellbeing were available from various government departments, the data tendered to be aggregated over higher administrative levels than the scale required by the research question (reported, for example, at whole of county rather than village level). Thus, objective data also needed to be collected for this study. It was not financially feasible to collect objective wellbeing indicators for all the 29 factors, but the OECD "Framework for OECD wellbeing indicators" (see Figure 2.2), was used to guide the construct of the survey, collecting information about a variety of factors relating to material conditions – e.g. family income, housing (room per person, the existence of bathroom and flushing toilet) – and to quality of life (e.g. employment status, education level). Most objective data were thus reported by individuals and collected using questionnaires (see Appendix A–1), while data relating to air quality (which are difficult for individuals to measure and thus report on) were measured by the investigators using a hand-held air-quality monitor during the study. Specifically, researchers recorded the concentration of [8]$PM_{2.5}$ and PM_{10} at each sampling location. This measurement cannot be extrapolated to indicate average annual air quality, as the air quality is expected to vary with wind direction and strength and is subject to seasonal fluctuation. It is only presented as an indicator relative to other respondents and study sites.

3.4.3 Wording and sequencing questions

3.4.3.1 Wording of questions

The actual wording of the questionnaire is crucial. In this case, the survey was targeted at the general population, which means the potential respondents could have been any adult of any age and education level. Therefore, it was important that every single question could be understood easily without being explained.

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[8] PM (particle matter) refers to an air pollutant which has adverse effects on human health (Dockery et al., 1993). The degree of PM pollution is frequently assessed by continuous monitoring of the levels of PM_{10} and $PM_{2.5}$. PM_{10} is particulate matter with aerodynamic size 10 μm or less, while $PM_{2.5}$ is particulate matter with aerodynamic size 2.5 μm or less (RODRíGUEZ et al., 2004).

The following checklist of general principles (Dillman, 1978, Salant and Dillman, 1994, and DeVellis, 2003, cited by Larson, 2010, p. 74) was used as a guideline on wording the questionnaires.

Will the words be uniformly understood? Is the questionnaire objective?

Are the questions too vague? Too precise? Too cryptic? Too demanding?

Are the questions biased? Is the questionnaire technically accurate?

3.4.3.2 The sequence of questions

Some researchers suggested that sociodemographic questions about respondents, such as age, marital status, education level and income, should be asked at the end of questionnaire instead of the beginning to avoid the impact of any negative feelings on the answer behaviour and participation (Converse and Presser, 1986; Oppenheim, 1992). Thus, sociodemographic questions came at the end of this questionnaire.

The 'order effect' of questions refers to the fact that relative position of an item in an inventory of questions may uniquely influence the way in which a respondent reacts to the item (Perreault, 1975). Order effect could be controlled by producing different questionnaires, comprised of random orderings of relevant items (while maintaining proper overall sequence) (Perreault, 1975). Therefore, the sequence of the questions were regularly changed, except the demographic questions. Two measurements of GLS were located at the beginning and end of the questionnaire separately – SWLS was located at the beginning of the questionnaire to allow respondents to give their own first–impression evaluation, while the question about LS using scale of 0 – 100 was located at the end to allow respondents to evaluate their GLS after they had got through the evaluation of all the life domains.

3.4.3.3 Translation between Mandarin and English

The questionnaire was originally designed in English. It had to be translated into Mandarin because the potential respondents only speak Mandarin or a local dialect. Following Chen and Lin (2014), the questionnaire was firstly forward translated into

Mandarin by the author, then a backward translation was conducted by a different translator who had never seen the original survey questions. The backward translation was checked against the original to ensure there were no discrepancies between them.

3.4.3.4 Pilot testing

1) Expert testing

The expert group consisted of academic researchers, who had professional knowledge about wellbeing and the impacts of coal mining and experience about questionnaire design. They understood the purpose of this study and questionnaire better than other randomly selected respondents. Scientific merit, the relevance of the data collected, wording and layout of the questionnaire were discussed by this group. The questionnaire was improved in terms of clarity, scientific quality and accuracy after this process.

2) Sub-sample testing

Sub-sample testing was conducted to make sure the questionnaire was practicable. About 15 face to face interviews were performed during the pilot stage of this project. Not all of them were from coal mining areas or aware of the impacts of coal mining. However, they still helped to improve the questionnaire. The verbal feedback was collected, and signs of hesitation, confusion and discomfort when respondents answered the questions were observed. The questionnaire was tested for wording, understanding, and sequence of questions. The following checklist was used as a guideline to amendments on the draft questionnaire at the pilot stage (Dillman, 1978 and Salant and Dillman, 1994, cited by Larson, 2010, p. 75).

Are questions interpreted similarly by all respondents?

Are questions answered correctly (are some missed or elicited uninterpretable answers)?

Does each closed – ended question have an answer that applies to each respondent?

Does any aspect of the questionnaire suggest bias on the part of the researcher?

As a result of the pilot testing, some amendments were made to improve the questionnaire. Some of the questions were clarified, some relatively unimportant questions were deleted to shorten the questionnaire, and some wording was changed to make the questionnaire easier to understand. The layout and structure of the questionnaire were also modified according to respondents' suggestions.

3.5 Data collection

3.5.1 Sampling framework

As discussed in section 2.5.6, few previous studies that have looked at impacts of coal mining have compared impacts in regions with different intensities of coal mining. The literature strongly suggests that LS studies should consider geography – looking, for example, at urban or rural areas, or places that share similar environmental characteristics. As such, an investigation into the impacts of coal mining on life satisfaction/wellbeing should involve the comparison between places with different intensities of coal mining. Previous literature offers some clues about how to differentiate regions according to mining intensities. Kitula (2006) simply compared coal mining areas and non-coal mining areas. Hendryx and Ahern (2009) divided Appalachia with high levels of coal mining, Appalachia with lower mining levels, Appalachia without coal mining, and other counties in the nation. Regions were classified as being 'high' or 'low' intensity according to coal production. The CSIRO studies compared mining regions, non-mining regions, and other metropolitan areas (Moffat et al., 2014a; Moffat et al., 2014b; Zhang et al., 2015).

Counties in Shanxi Province, like many other provinces in China, have a large population, and contain a large number of villages. The diversities between the villages inside a county are dramatic: in a single county, there are villages immediately adjacent to coal mines and those relatively close to coal mines. Sampling of communities was stratified by distance on a scale of an average 10 kilometres of coal mining operations as detailed in Table 3.7. I also chose to differentiate between urban and rural areas because there are significant differences between lifestyles, livelihoods, and incomes in rural and urban areas of China (Yang and Cai, 2003; Lu and Chen, 2004; Kanbur and Zhang, 2005; Sicular et al., 2007) .

Information on distribution of coal mining was collected from local governments, various media outlets (e.g. websites) and via informal communications with local people. Study sites were identified within a general region that would allow a differentiation between places according to their proximity to coal mines. Reconnaissance of the study area revealed that: coal extraction (mining) in these areas was typically closely associated and often co-located with coal stockpiles, transportation routes and coal washing facilities, all of which, alone or in combination, would impact local residents' lives. Therefore, this study considered their variously combined impacts as the aggregated impacts of coal mining.

Table 3.7 Criteria for selecting sampling sites that represent different intensities of coal mining

Classification category	Defined as
Place with coal mining	Coal mining, with or without associated activities/facilities (such as coal washing and coal transportation), present within 10km of the administrative/residential area and present high-intensity exposure to impacts of coal mining.
Place close to coal mining	Coal mining, with or without associated activities/facilities, present within 10–20 km of the administrative residential area and present moderate-intensity exposure to impacts of coalmining.
Place far from coal mining	Coal mining, with or without associated activities/facilities, absent within 20 km of the administrative/residential area and presenting none or only light exposure to coal mining impacts.

As the access to urban facilities or major transport routes might have effect on quality of life (Brereton et al., 2008; Arifwidodo and Perera, 2011), villages were selected at similar distances from urban areas to minimize this effect. Coal mining is not allowed in the urban area. Therefore, 5 types of case-study region (see Figure 3.2) were identified, including rural area with coal mining (Rural With), rural area close to coal mining (Rural Close), urban area close to coal mining (Urban Close), urban areas far from coal mining (Urban Far) and rural area far from coal mining (Rural Far). The phrases “5/different (types of) study regions/ areas” and “regions/ areas/places with different intensities of coal mining” are used in the rest of this thesis, to refer to these 5 different types. The phrases “coal mining areas/regions” refers to Urban Close, Rural With and Rural Close, while “non-coal mining areas” refers to Urban Far and Rural Far.

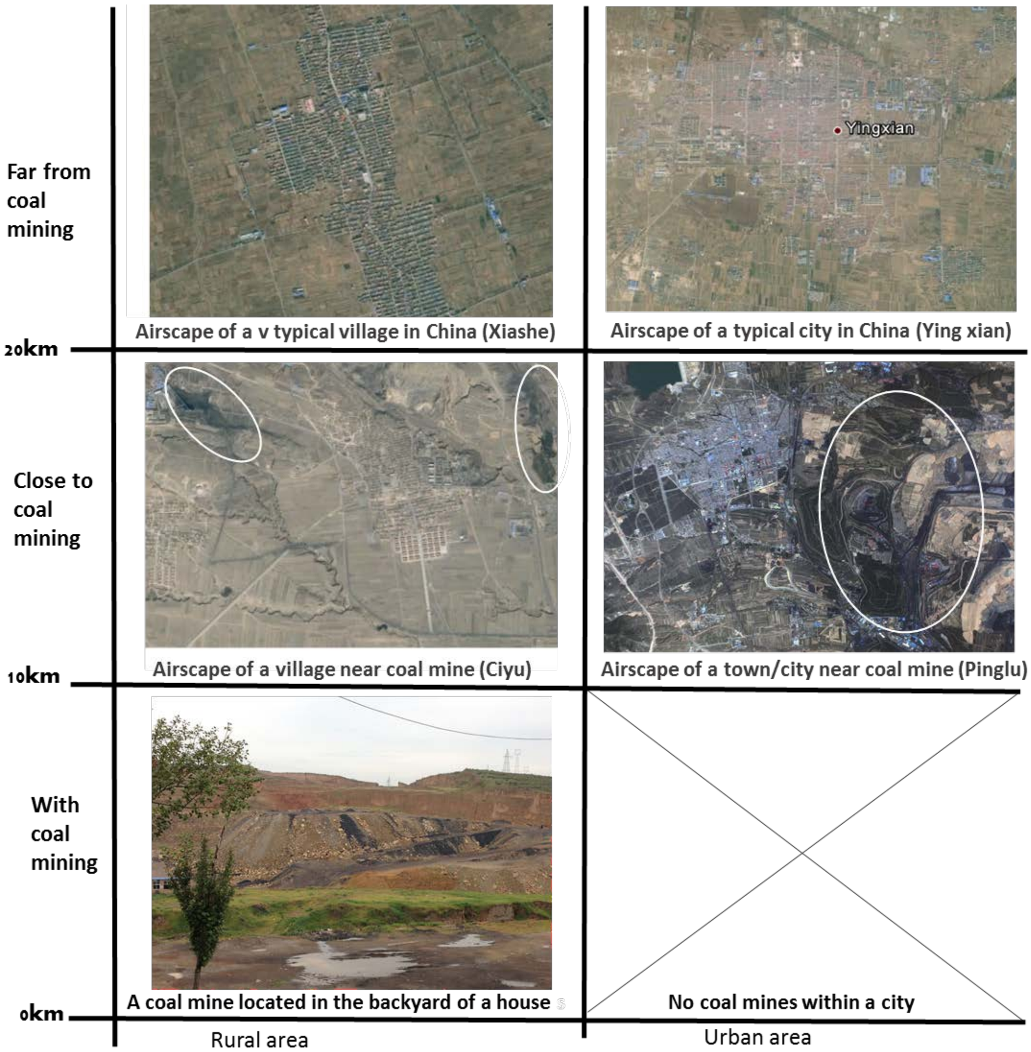


Figure 3.2 Different types of study region

Note: White circles indicate the location of coal mines.

Source: Pictures for Urban Far, Rural Far and Rural Close are screen shots from Google Map; The picture for Rural With was taken by investigator on 22th August, 2013; The picture for Urban Close is from the internet[9], accessed on 15th March 2015.

3.5.2 Survey implementation

Research assistants, who were university students and spoke the local dialect, were trained at a one day workshop. Research objectives, methods and interview techniques were introduced to them. They were asked to practise the interview process with each other. They went out in pairs to conduct the surveys by interview. Research assistants filled out the questionnaire according to the answers provided by respondents.

[9] http://world.haiwainet.cn/n/2014/1015/c456832-21219345-11.html.

Various survey approaches were considered. A mail survey is impracticable in China, because many households have no mail box, especially rural places. Door-to-door household surveys are impracticable in urban areas, because most urban residents live in apartments and are too suspicious to open their door for strangers. Thus in urban areas, research assistants approached potential respondents on the streets or in places such as public squares, parks, and shops. In rural areas, a door-knock survey covering as large an area as possible was conducted in each village. Places where local residents collected for social interaction (such as public squares) were also visited for data collection. Strategies used to control survey errors and data bias are discussed in the following section.

In places with coal mining, people were more suspicious of the purpose of investigators. They became willing to be interviewed once they observed other people being interviewed and once they heard more about the exact questions asked. In places far from coal mining, people were generally very willing to be interviewed.

The sampling framework had to be somewhat adjusted 'in field'. For example, after sampling two urban areas, it became apparent that these residents were virtually unaffected by coal, so further sampling effort was focused on rural areas. Moreover, the classification of villages selected for inclusion in the sample was adjusted after the survey when more information was acquired. A village had a coal mine which was less than 10 km from the village, but the coal mine was separated from the village by a hill. Thus, the connection between the coal mine and the village was very weak. In this study, this village was thus re-classified as "Rural area near (rather than with) coal". The following table provides details of the final sampling framework.

Table 3.8 Sampling of study regions

Sampling area	Urban area		Rural area		
	Urban Close	**Urban Far**	**Rural With**	**Rural Close**	**Rural Far**
Area 1 – Shouzhou	Centre of area 1		Ciyu	Zhaoshibazhuang	
	Pinglu district		Damuguajie	Wochang, Kangjiayao	
		Yingxian			Xiashe — including 12 villages[10]
Area 2 – Xiangning	Centre of area 2		Hucun, Jizhuanggou	Zhangma	
Area 3– Yangquan	Centre of area 3		Dacun, Banpo, Jieshang	Houjiagou, Changling	

3.5.3 Controlling survey errors

It is necessary to consider how to reduce different types of survey error when conducting a survey. Several common survey errors were considered in this study. According to Dillman (1991), four potential sources of error should be considered: sampling error, measurement error, non-coverage error and non-response error.

1) Sampling error

Sampling error is attributed to the fact that certain members of the population are deliberately excluded by selection of the subset of members (Dillman, 1991). This survey was designed to include respondents with diverse characteristics. When conducting interviews, the diversity of respondents was able to monitored and controlled by investigators, which helped control this error. Those who might not be able to make sensible judgements were excluded in the survey, such as people who are under 16 years old, or people who could not express themselves very clearly.

[10] Xiashe contains 12 relatively small and similar villages that closely connect to each other. These villages were considered as one location here.

2) Measurement error

Measurement error may result from characteristics of the question or questionnaire. Based on the literature, this questionnaire had been through a pilot test and modification in order to reduce this error.

3) Non-coverage error and Non-response error

Non-coverage error arises because some members are not included by the sampling frame and have no chance to be selected as the sample (Dillman, 1991), and non–response error stems from the fact that a certain group of the members of the sample population do not respond to the survey questions. To reduce these errors, we tried to cover as large an area as possible in each place we visited to interview potential respondents. We could not generate a 'perfect' stratified random sample, but as we conducted interviews, we monitored and controlled the diversity of respondents to identify and control these errors (e.g. specifically asking to interview a male, if relatively few males had been interviewed in one area/day).

3.6 Sample overview

Table 3.9 shows the number of responses collected from different areas – with an uneven number from each. The core interest of this study was to investigate the impacts of coal mining on wellbeing in regions with different intensities of coal mining. So areas without any mining at all were included for comparative purposes, but not covered in detail. Rural areas involved with coal mining (either near or immediately adjacent to mines) were the key interest of this study and account for the largest proportion of the total sample. Social science research in China is somewhat limited in that most data have been collected from urban samples, overlooking the rural residents who account for 60 of the total population (Davey and Rato, 2012). This study thus offers some insights about the subjective wellbeing in rural areas, that are of interest beyond observations relating to coal mining.

According to Cummins (1996), the utility of GLS measurement for comparison among small groups is limited. Sample sizes for places far from coal mining are relatively small (with just 59 individuals from 12 small villages that were classified as “rural far” and 30 individuals in regions classified as “urban far”), so the analytical approaches used in subsequent chapters take that into account (using, for example, non-parametric techniques ideally suited to small samples, and then focusing predominantly on the larger sub-samples in other analyses).

Table 3.9 also provides summary statistics relating to the sociodemographic characteristics of the sub-samples, compared to sociodemographic statistics collected by Chinese data collection agencies for their census in the Shanxi province. Most evident, is that the average family income of the urban samples is lower than the average family income recorded in the census data. In contrast, the family income of the rural samples is higher than that of census data. This indicates that it will be important to ensure that the effect which income has on wellbeing is considered in the analyses of chapter 6, to control for any potential bias that might arise if the sample is not representative of the population as a whole. The sample also includes a disproportionate number of men (compared to the census data), underscoring the importance of also attempting to control of the influence of gender when assessing contributors to SWB. The fact that incomes are higher for those who work for the coal mining industry than those who work in other industries (and these differences are statistically significant in two regions: Rural With and Rural Close), is consistent with census data (see Appendix B).

Table 3.9 Sample information

	Urban Close	Rural With	Rural Close	Urban Far	Rural Far	Urban areas	Rural areas	Total	Shanxi	
									Urban areas	Rural areas
Population from each Location	90	184	179	30	59	120	422	542		
Percentage of Population from each location	16.6%	33.9%	33.0%	5.5%	10.9%	22.1%	78.0%	100%	32.7%	64.3%
Family income										
Average family income	50765	33800	32288	60000	31949	53174	32900	37266	67367	23893
Percentage of family income sourced from coal mining	14.8%	32.1%	16.2%	0.0%	0.0%			18.7%		
Average family Income from coal mining industry	42895	39237	41071							
Average family Income from non-coal mining industry	31667	31210	31084							
Gender										
Percentage of male	42.2%	47.3%	35.8%	33.3%	35.6%	60.0%	59.2%	40.6%	51.4%	
Percentage of female	57.8%	52.7%	64.2%	66.7%	64.4%	40.0%	40.8%	59.4%	48.6%	
Marital Status										
Percentage of partnered	58.9%	85.3%	85.5%	76.7%	84.7%	63.3%	85.3%	91.7%		
Percentage of non-partnered	41.1%	14.7%	14.5%	23.3%	15.3%	36.7%	14.7%	8.3%		
Family size										
Average children per household	0.8	0.7	0.9	0.5	0.4	0.7	0.7	0.7	3.0	3.3
Average adult per household	3.2	3.3	3.2	3	3.3	3.1	3.3	3.2		
Age										
16–26	37.8%	11.7%	12.1%	23.3%	11.9%	34.2%	11.8%	16.8%		
26–35	23.3%	22.9%	16.1%	20.0%	5.1%	22.5%	18.0%	19.0%		
36–45	14.4%	16.8%	22.1%	16.7%	22.0%	15.0%	19.4%	18.5%		
46–55	7.8%	23.4%	20.8%	13.3%	27.1%	9.2%	23.0%	19.9%		

	Urban Close	Rural With	Rural Close	Urban Far	Rural Far	Urban areas	Rural areas	Total	Shanxi	
									Urban areas	Rural areas
56–65	5.6%	14.0%	19.5%	10.0%	20.3%	6.7%	16.8%	14.6%		
Above 65	11.1%	11.2%	9.4%	16.7%	13.6%	12.5%	0.9%	11.3%		
Education level										
Illiteracy or little literacy	6.7%	16.4%	20.8%	16.7%	33.9%	9.2%	20.4%	17.9%		
Primary school	17.8%	44.9%	44.3%	20.0%	28.8%	18.3%	42.4%	37.1%		
Junior Middle School	27.8%	23.4%	17.4%	13.3%	20.3%	24.2%	20.9%	21.6%		
Level of Senior Middle School	26.7%	4.2%	3.4%	30.0%	6.8%	27.5%	4.3%	9.4%		
Specialized Secondary School	3.3%	0.0%	0.0%	3.3%	0.0%	3.3%	0.0%	7%		
Junior College and Above	17.78%	11.21%	14.09%	16.67%	10.17%	17.50%	12.09%	13.3%		
Employment status										
Self-employed	27.8%	37.4%	46.3%	16.7%	44.1%	25.0%	41.5%	37.8%		
Has job	31.1%	23.4%	28.5%	40.0%	22.0%	33.4%	25.3%	27.1%		
Jobless	13.3%	27.6%	17.3%	13.4%	10.0%	18.6%	22.5%	19.4%		
Student	20.0%	3.3%	4.5%	16.7%	5.1%	19.2%	4.0%	7.4%		
Retired	7.8%	6.1%	9.4%	16.7%	10.2%	10.0%	7.80%	8.3%		

Notes: 1. Data for the entire Shanxi are extracted from Shanxi Bureau of Statistics (2014); Some data aligned with this study are missing because they are not available in the Yearbook or not comparable due to different measurements; 2. Average individual income is available in the yearbook instead of family income, thus average family income of Shanxi was roughly calculated as following:

Family income of urban areas=Average household size *total income per capital of urban households = 3.0*22455.63 ≈ 67367

Family income of rural areas= Average Household Size *total income per capital of urban households = 3.3*7153.50 ≈ 23893

3.7 Conclusion

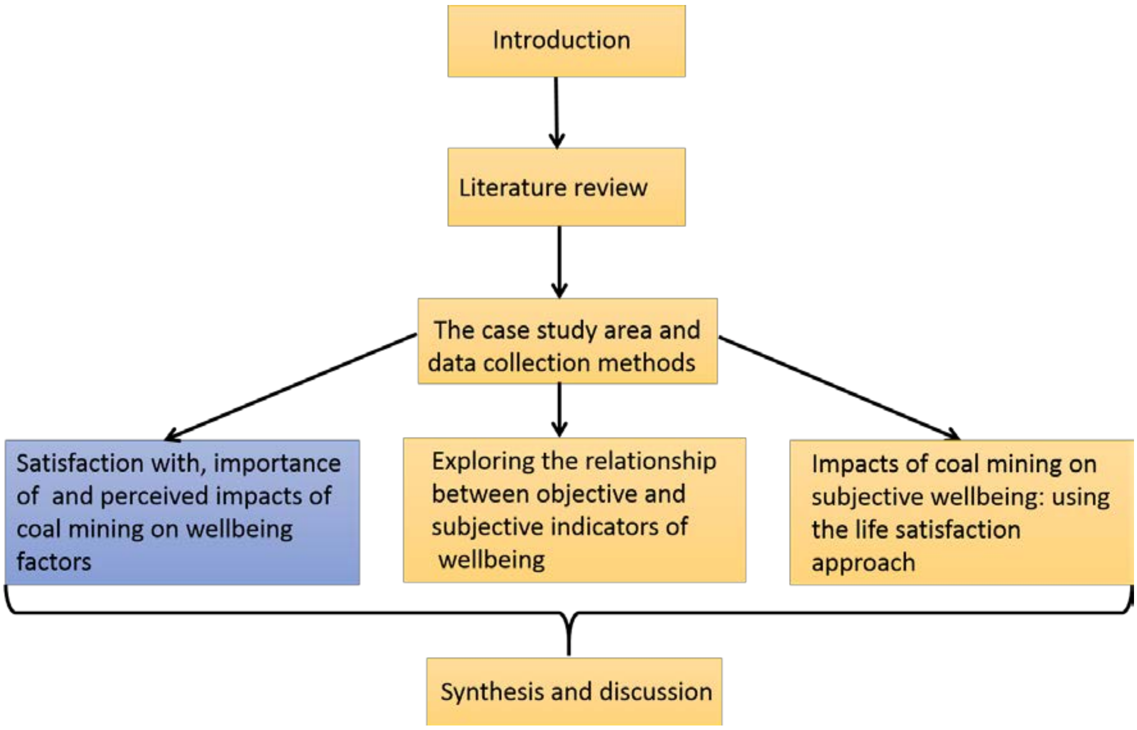
To investigate the impacts of coal mining on wellbeing, areas characterized with different intensities of coal mining (based on the distance of coal mining) were identified (these included Rural With, Rural Close, Urban Close, Urban Far and Rural Far) and data were collected from each type of area (albeit focusing on those 'with' and 'close to' coal mines, to draw out the intensities issue).

This study collected subjective, objective and sociodemographic data. Questions of subjective wellbeing included global life satisfaction and satisfaction with 29 wellbeing factors. Data relating to people's subjective perceptions about the importance of each factor to their overall wellbeing and their perception of the impacts of coal mining on those factors were also collected. Data relating to objective indicators were also collected, including that relating to material conditions (family income, rooms per person, the existence of bathroom and flushing toilet) and other factors known to influence quality of life (e.g. employment status, education). Interviewers also measured the concentration of $PM_{2.5}$ and PM_{10} in each study area). Questions relating to other sociodemographic factors known to influence wellbeing (such as age, gender and marital status) were also included.

The questionnaire was tested and improved through expert testing and sub-sample testing. Research assistants, who spoke the local dialect, were trained to conduct the interviews. We selected a random sample of participants – where possible, attempting to ensure that responses were collected from persons of different ages and gender.

The final sample included information from 542 people, collected from 16 different locations across 5 different regions. Most data (363 of the total) were from people living in rural villages that had mines immediately adjacent and that were close to coal mines.

Thesis outline



CHAPTER 4 SATISFACTION WITH, IMPORTANCE OF AND PERCEIVED IMPACTS OF COAL MINING ON WELLBEING FACTORS

Chapter outline

4.1 Introduction

4.2 Analytical method

4.2.1 Sub-research questions 1-3s

4.2.2 Sub-research questions 4

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4.3 Results

4.3.1 Sub-research question 1: the importance of wellbeing factors

4.3.2 Sub-research question 2: satisfaction with different wellbeing factors

4.3.3 Sub-research question 3: perception of the impacts of coal mining on wellbeing factors

4.3.4 Sub-research question 4: the relationship between satisfaction and importance

4.3.5 Sub-research question5: the relationship between satisfaction level and the impact of coal mining

4.4 Conclusion and discussion

4.4.1 Implications for policy makers

4.4.2 Methodological contribution

Synopsis

This chapter investigates respondents' subjective satisfaction with a range of wellbeing factors. It looks at what matters most/least to people's lives, how satisfied they are with those things, and at their perception of the impact that coal mining has on these factors. Visual comparisons are made between case-study areas characterized with different intensities of coal mining, and non-parametric tests are undertaken to ascertain the statistical significance of apparent differences. Two composite indices are developed from the data to generate further insights into potential policy priorities for those wishing to enhance wellbeing. The first blends responses to questions about importance and satisfaction to identify factors that are important to people and about which people are most dissatisfied (this focuses thought on 'fixing' the 'broken' things that matter most to people). The second blends satisfaction scores with perceptions of mining's impact, which focuses thought on factors which people are most dissatisfied with and which they are most worried that mining might affect. Although each analysis highlights subtly different issues, the general and pervasive message coming from all is that air quality is of significant concern in coal mining areas; also of more concern in coal mining areas (compared to areas with less mining) are issues of water safety, high real estate prices and inflation.

4.1 Introduction

As discussed in section 2.5.2, most literature that focuses on the impacts of mining/coal mining looks at objective measures; literature that considers peoples' subjective wellbeing is very scarce and there is a conspicuous absence of studies assessing the impacts of mining on a wide range of factors known to be associated with wellbeing; most studies focus on a narrow range of issues. This is especially the case for countries such as China.

As discussed in section 2.5.3, understanding the importance of subjective wellbeing could help inform policy priorities (Larson, 2010; Chen and Lin, 2014). Although some researchers have sought information from individuals about how 'important' they think various wellbeing factors are to their overall wellbeing (often termed 'weighting') (e.g. Hsieh, 2003; Tost, 2005; Hsieh, 2012; Chen and Lin, 2014), the weighting of importance is neglected in much wellbeing research, especially in China. None of the few studies that address subjective wellbeing in China (e.g. Brockmann et al., 2009; Davey et al., 2009; Davey and Rato, 2012) give much consideration to the weighting of importance amongst the different factors that contribute to subjective wellbeing.

Studies that investigate the perceived impacts of mining by host communities are even scarcer, although some examples exist (e.g. Moffatt and Pless-Mulloli, 2003; Moffat et al., 2014a; Zhang et al., 2015). As noted in section 2.5.4, information about people's perceptions of impacts can be combined with information gleaned elsewhere, to build a broader, more comprehensive understanding of the potential impacts of coal mining on host communities. As discussed in section 2.5.6, research that compares the impacts of mining in regions with different exposures to mining is also rare, leaving important knowledge gaps.

This chapter will help fill some of those gaps. The main research question addressed in this chapter is: How does coal mining affect people's subjective perceptions of different wellbeing factors? This over-arching question is answered with reference to five sub questions, each of which is directly linked to the identified research gap above:

1) What factors are important to people's lives? Do people's perceptions of what is important differ in places with different intensities of coal mining?
2) How satisfied are people with those factors? Does satisfaction with particular factors differ in places with different intensities of coal mining?
3) How do people think coal mining affects various aspects (factors) of their life? Do people's perceptions of coal mining's impacts differ in places with different intensities of coal mining?
4) Are people satisfied with the factors that they attach great importance to? Can one identify policy priorities by combining information about satisfaction and importance – i.e. can we identify factors which people are very dissatisfied with and attach great importance to?
5) Are the factors that people are dissatisfied/satisfied with negatively/positively affected by coal mining? Can one identify policy priorities by combining information about satisfaction and impact – i.e. can we identify factors which people (either rightly or wrongly) 'blame' coal mining for impacting most negatively?

The data used to answer these questions (and methods used to collect it) were briefly described in the preceding chapter. The next section (4.2) describes the methods used to analyse that data – i.e. the methods used to generate 'answers' to each individual research question. Section 4.3 presents results ('answers' to the individual research questions) and briefly discusses their relevance and implications in the context of the broader literature. Section 4.4 discusses the results more broadly, synthesising findings and noting the importance of context and of the complex inter-relationships between issues considered.

4.2 Analytical method

4.2.1 Sub-research questions 1-3s

Responses to questions about importance, satisfaction and impact were all recorded on a 7-point Likert scale (see section 3.4.1.1). In the first instance, I simply assigned values to responses with the lowest number (1) representing the most negative response (very unimportant/very dissatisfied / very strong negative impact); 4, representing a ‘neutral’ or ‘no impact’ response, and the highest number (7) representing the most positive response (very important/very satisfied/very strong positive impact). Mean responses for each factor were calculated and results were displayed in bar charts. Since this study intended to investigate the impacts of coal mining through the comparison between places with different intensities of coal mining, the mean scores pertaining to each factor, in each type of case-study area were also calculated and displayed with a radar chart to give visual impressions of importance weighting/satisfaction level/ perceived impacts of coal mining.

Not all researchers agree that it is appropriate to use Likert data in this way (since Likert responses, strictly speaking, provide only ordinal information), so these charts should be interpreted as providing only indicative information about the relative importance of different factors to overall wellbeing, the satisfaction with each factor and the perceived impacts of coal mining on each factor. Analytical approaches that are appropriate for Likert data were then undertaken. Specifically, the Kruskal-Wallis pairwise comparison test was used to determine if there were statistically significant differences in the distribution of responses to questions about each factor between the different case-study areas. This was done to determine if different people, living in areas with different intensities of coal mining felt (a) that different factors were more important (Question 1), or (b) more/less satisfied/dissatisfied with some factors (Question 2); or (c) that mining impacted different factors (Question 3).

4.2.2 Sub-research question 4

Factors which people consider to be extremely important to their overall quality of life, and with which people are very dissatisfied, should be the management priority for policy makers, and improvement in these factors has the potential to improve the quality of life of residents (Cummins and Nistico, 2002; Cummins, 2003). This ensures that policy makers are concentrating on (a) factors which matter ‘most’ to the public; and (b) which are also ‘broken’.

In the first instance, a radar chart was used to compare mean responses to questions about importance and satisfaction for each factor, as Larson et al. (2014) did when they investigated policy priorities for Great Barrier Reef in Australia. The Kruskal-Wallis pairwise comparison test was then used to compare the distribution of responses about satisfaction and importance for each factor. Finally, I calculated an Index of Dis-Satisfaction (after Larson, 2010 and Larson et al., 2013). This index has been used in some studies to create an 'Action List' of wellbeing factors to infer management and policy priorities in different contexts, such as in Australian tropical rivers region (Larson et al., 2013), along the coast of the Great Barrier Reef (Larson et al., 2014) and in smaller coastal regions (Larson, 2010).

This entailed inverting the satisfaction score (S) that each respondent, *i*, gave to each factor, *k* (yielding S_{ik}.) to calculate a dissatisfaction score: $DS_{ik} = 8 - S_{ik}$, and then multiplying that dissatisfaction score, by the importance score which each respondent gave to the corresponding factor (W_{ik}) to calculate the Index of Dis-Satisfaction (IDS) for each factor k:

$$\boldsymbol{IDS_{ik} = \frac{1}{N}\sum_{i=1}^{N} W_{ik} \cdot DS_{ik}}$$ **Equation 1**

Where N is the number of respondents for each type of case-study area.

Not only were such scores calculated, but also a plot of DS against W was generated, to provide a visual aid in the interpretation of scores.

4.2.3 Sub-research question 5

The literature about impacts of coal mining, described in Chapter 1 and 2, suggests that it is reasonable to assume that the positive/negative impacts of coal mining on certain wellbeing factors (e.g. negative impacts on the natural environment), may affect satisfaction with those particular wellbeing factors (lower satisfaction with natural environment). Combining responses to questions about (dis)satisfaction and perceived impacts thus allows me to identify the magnitude of coal mining's impacts and its potential consequence. This ensures that policy makers are concentrating on (a) factors which coal mining has negative impacts on; and (b) which are also 'broken'.

In the first instance, a radar chart was also used to compare mean responses to questions about mean score of satisfaction and the impacts of coal mining for each factor. Laron's IDS was then altered. Here, responses to questions about perceived impacts (rather than importance) were combined with satisfaction scores. First, responses to questions about impacts of coal mining were used to calculate a negative impact score $NI_{ik} = 8 - S_{ik}$. The Index of Dis-satisfaction and Negative Impact (IDSNI) was then calculated as.

$$\boldsymbol{INI_{ik} = \frac{1}{N} \sum_{i=1}^{N} DS_{ik} \cdot NI_{ik}}$$ **Equation 2**

Where N is the number of respondents for each type of case-study area.

This index was only calculated for people who lived 'with' or 'near' coal. People living far away from coal, had no actual experience with coal mining, and were thus only able to tell us about the way in which they thought mining might impact various wellbeing factors if coal mining were ever to start near their village. Their responses to questions about the impacts of coal mining (based on a hypothetical scenario), are thus not related to the actual satisfaction with those factors, since there are no coal mines in those regions and no impacts from coal mining were experienced by those respondents. Thus, this index was not suitable for non-coal mining areas. As for the case where I considered data relating to both importance and satisfaction (above), here too, a graph showing responses to both (dis)satisfaction and impacts was generated to help in the interpretation of the index.

4.3 Results

4.3.1 Sub-research question 1: the importance of wellbeing factors

As shown is Figure 4.1, the average importance scores associated with all 29 factors were above 5 (at least slightly important). This implies the selection of indicators is reasonable, because the factors people generally thought unimportant to their wellbeing should not be the concern of this study. Health and family relationships emerged at the top of this list, while income disparity, social life and indicators related to social capital were least important among all the factors.

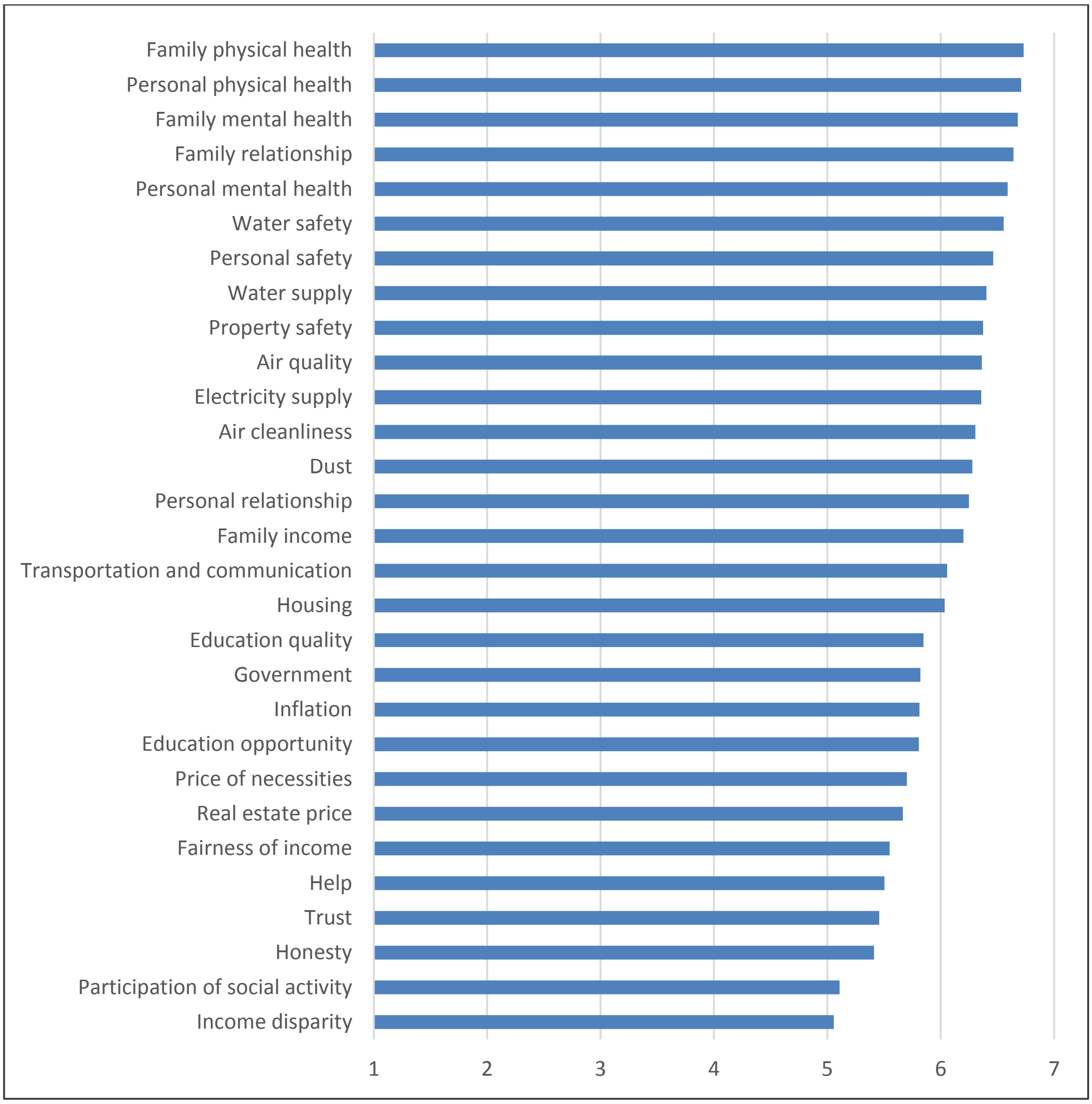


Figure 4.1 Mean scores relating to perceived importance of factors to overall wellbeing displayed from most important to most unimportant

Note: Scale ranks from "very unimportant" (1) to "very important" (7), 4 indicates "neutral".

Not only were health and relationships most important for the whole sample, they were also most important for each sub-sample (See Figure 4.2). Indeed, for these factors in particular, importance weightings do not vary much across regions characterized by different intensities of coal mining. For most factors, mean importance scores do not vary dramatically across different types of case-study areas (compared to satisfaction scores – shown in the next section). But residents living in rural coal mining regions (Rural With and Rural Close) attached significantly greater importance to factors relating to air quality.

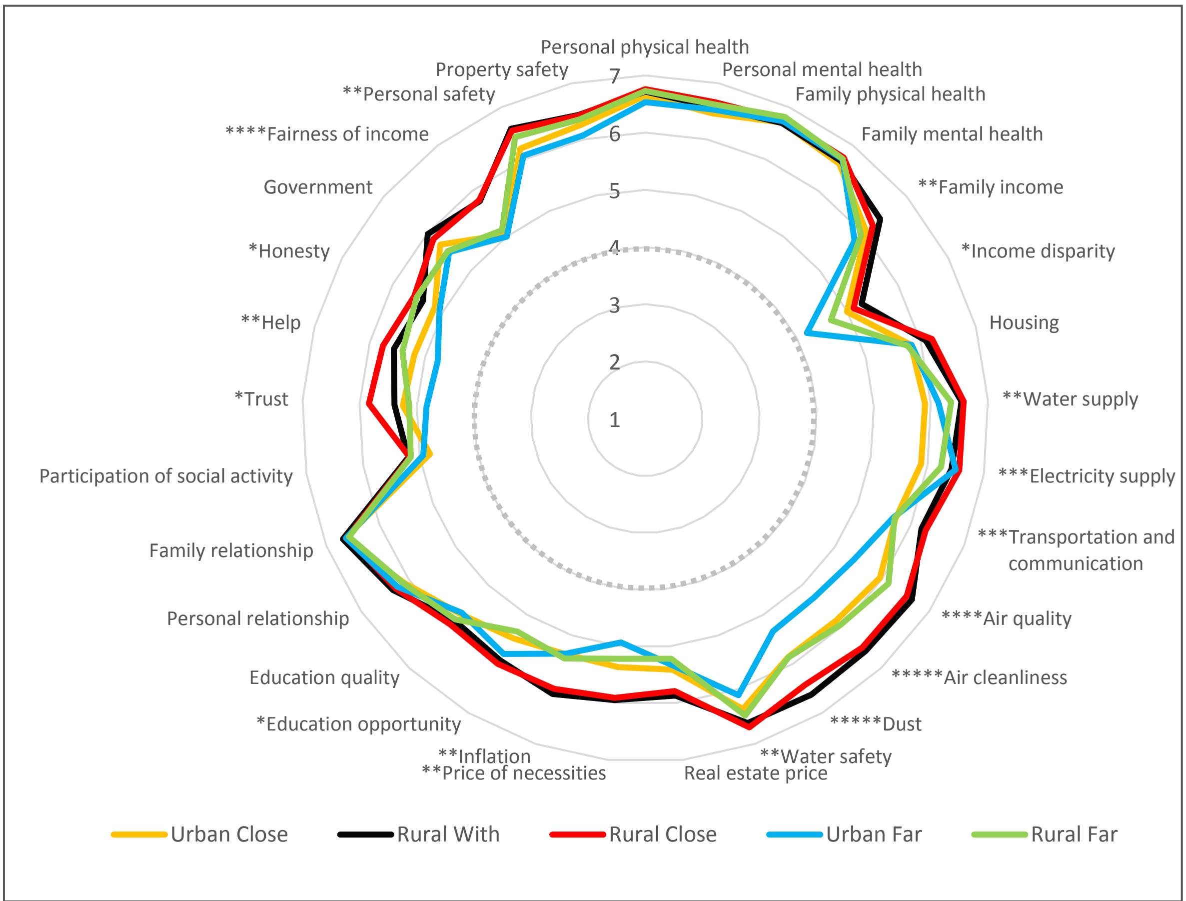


Figure 4.2 Mean scores relating to perceived importance of factors to overall wellbeing by study region

Notes: 1. Each '*' indicates that one of the paired observations was significantly different out of all paired comparisons across the 5 types of study areas; 2. Scale ranks from "very unimportant" (1) to "very important" (7), 4 indicates "neutral".

4.3.2 Sub-research question 2: satisfaction with different wellbeing factors

Most evident from Figure 4.3 is the fact that respondents were most dissatisfied with factors relating to air quality and economic and social aspects (Inflation, real estate prices, the quality of governments, the fairness of income, and income disparity). They were most satisfied with factors relating to relationships and health, which were also thought to be most important to their life from the previous analysis.

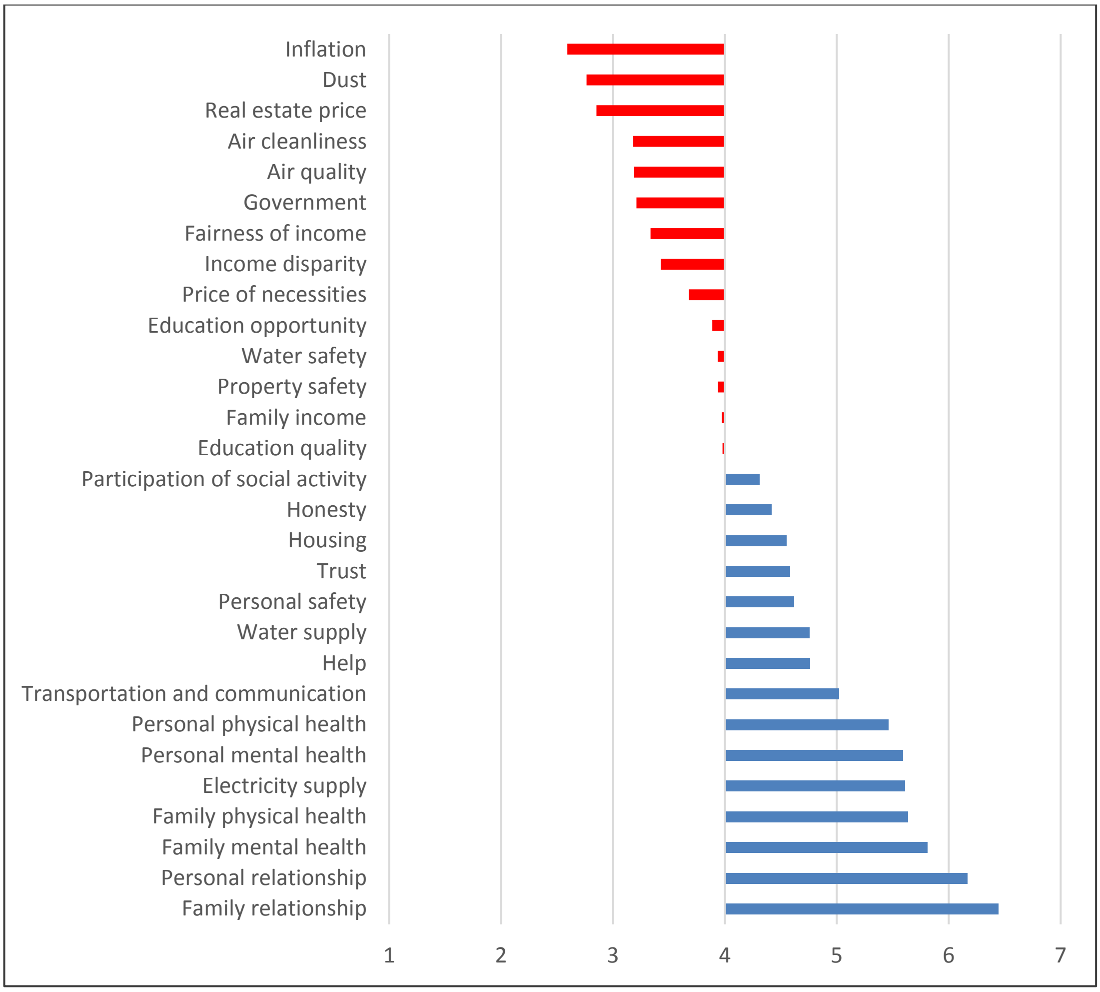


Figure 4.3 Mean scores relating to satisfaction with wellbeing factors displayed from most dissatisfied to most satisfied

Notes: 1. Scale ranks from "very dissatisfied" (1) to "very satisfied" (7), 4 indicates "neutral"; 2. Red colour indicates negative impacts, while blue colour indicates positive impacts.

Visually, it is evident from Figure 4.4 that people from all areas were quite satisfied with their health and their relationships (mean scores were generally around 6 without any significant difference between study regions). Responses to questions about satisfaction with family income were also similar across regions. The mean score relating to income is approximately 4 (without a significant difference between coal mining and non-coal mining areas), indicating that people in coal mining areas, were not more satisfied with their family income than those from non-coal mining areas. Rural residents living with and close to coal mining were less satisfied with income disparity than rural residents living far from coal mining.

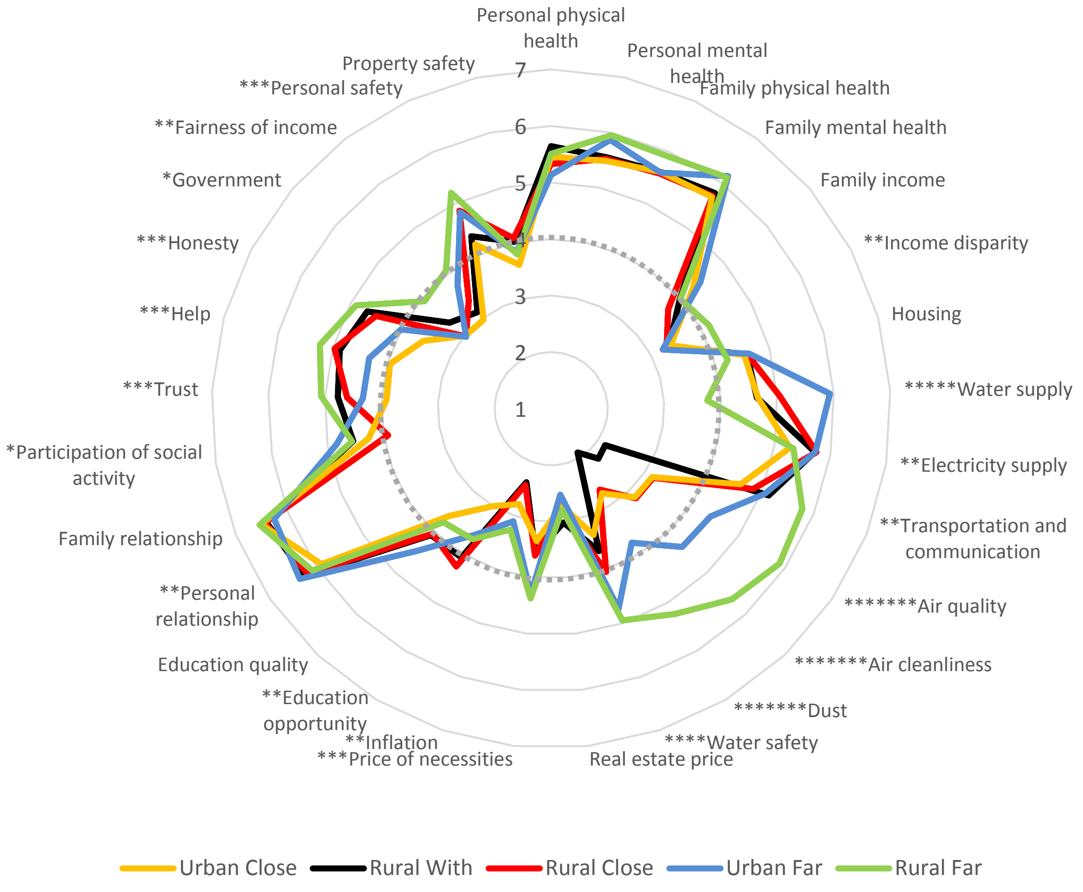


Figure 4.4 Mean scores relating to satisfaction with wellbeing factors by study region

Notes: 1. Each * Statistically significant difference between the distribution of response to questions about satisfaction and importance; 2.Scale ranks from "very dissatisfied" (1) to "very satisfied" (7), 4 indicates "neutral".

People living in coal mining areas were more dissatisfied with air quality, water safety, inflation and price of necessities than those living in non-coal mining regions. Those were also the factors that people living in coal mining areas most dissatisfied with among all the factors, while people living far from coal mines, instead, were most dissatisfied with wellbeing factors relating to inflation, real estate prices and education (air quality and water safety were not major concern).

There were few wellbeing factors that people living in coal mining area were more satisfied with than their 'non-coal mining' counterparts. Most interesting of all, perhaps, was the fact that people living in rural areas far from coal mining seem more satisfied with more wellbeing factors relating to air quality, water safety, the price of necessities, the quality of government and fairness of income and social capital (trust, help and honesty) than those living in any other region.

Distance from coal mining seems to be a decisive factor which affects the satisfaction with air quality, as people living in places far from coal mining, irrespective of whether they were in rural or urban areas, were more satisfied with air quality than those living in the places with or close to coal mining.

Responses to the question about water supply are a little more difficult to interpret, because answers may indicate (dis)satisfaction with either infrastructure or with the environment. Underground water is the main source of water supply in the case-study area, and not all regions have piped water in all houses.

- People living in urban areas far from coal mining were most happy with water supply, as 'Urban Far' represents the best situation – little damage to underground water resources from coal mining, and better water infrastructure, than in other areas.

- In rural regions far from coal mines (the least developed region among all the groups), satisfaction with water supply was much lower than in other regions.

- The 'moderate' satisfaction scores in places that were adjacent to or close to coal mines, may reflect the fact that although underground water supplies may have been damaged by coal mining, the mining activity was likely to have increased local government/council incomes enough to upgrade water supply facilities, thus the improved infrastructure may be partially compensating for real or perceived damage to underground water supplies. It became evident, while undertaking fieldwork, that in some villages adjacent to coal mines, residents relied on the coal company for water infrastructure.

Water safety is mainly associated with the existence of coal mining. People in the non-coal mining area were more satisfied with water safety than those in the coal mining area. In the coal mining areas, those living in the rural areas with coal mining were least satisfied with water safety than those living in the urban and rural area close to coal mining.

Those living in rural areas felt better able to trust, help and be honest with each other than those in urban areas. This urban-rural 'divide' with respect to social capital is likely due to more active social networks, civic participation and cohesion in rural areas (Hofferth and Iceland, 1998; Ziersch et al., 2009).

4.3.3 Sub-research question 3: perceptions of the impacts of coal mining on wellbeing factors

Generally, people's perception of the impacts of coal mining on most factors were negative, especially factors that relate to the natural environment and health (see Figure 4.5) [11]. The only factor thought to be positively impacted by coal mining was family income. Electricity supply, participation in social activities, relationships were thought to have no obvious relationship with coal mining.

[11] In the places far from coal mining, residents generally believed their daily lives were not related to coal mining, thus they were not affected by coal mining. Therefore, instead of asking how they thought coal mining affected them in their real life, they were asked the impacts they would expect if they had coal mining in their places.

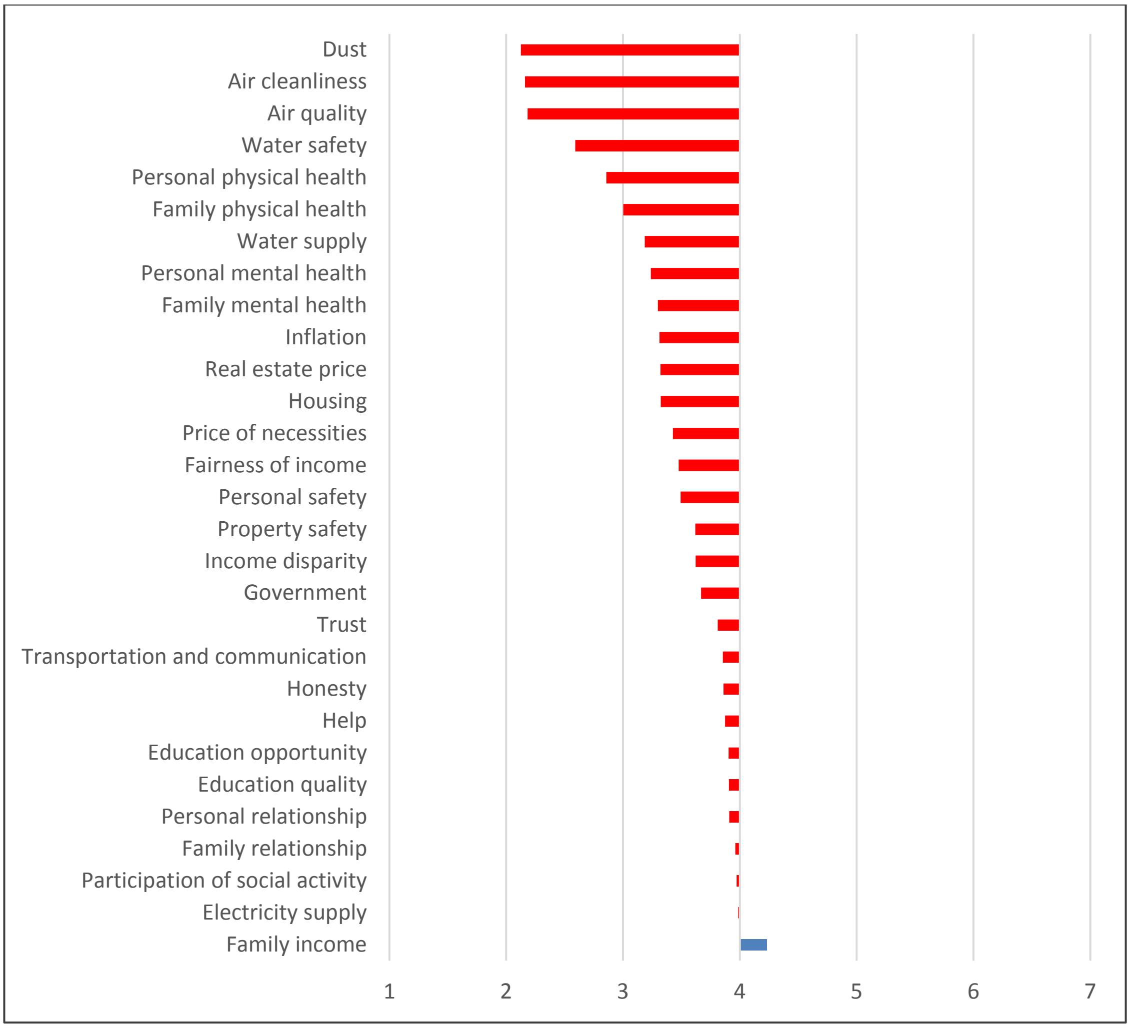


Figure 4.5 Mean scores relating to perceived impact of coal mining on wellbeing factors displayed from most negative to most positive impact

Notes: 1.Scale ranks from "strongly negative" (1) to "strongly positive" (7), 4 indicates "no impact"; 2. Red colour indicates negative impacts, while blue colour indicates positive impacts.

In Figure 4.6, the black line shows responses from people living in rural areas with coal mining. In almost all cases, the black line is inside the others, indicating that people living in those places felt that coal mining had a stronger negative impact – on most wellbeing factors – than people living further away from coal mines. The green line shows the perceptions of people living far away from coal mines, who thus have little experience of coal mining's impacts. Compared to other respondents, they seem to underestimate the negative impacts of coal mining while exaggerating the potential positive impact (on income). Specifically, residents living far from coal mining believed coal mining may bring higher income or help decrease income disparities. In contrast, residents living in coal mining areas did not report an obviously positive impact of coal mining on income, but instead reported negative impacts on income disparity. This is also consistent with the observation from 4.3.2: people in coal mining areas were not more satisfied with their family income or with income disparity than those from non-coal mining areas.

Also, different from residents living in coal mining areas, those living far from coal mining do not seem to think that coal mining would negatively impact the quality of government and/or fairness of income (in contrast to those who live with or near mining).

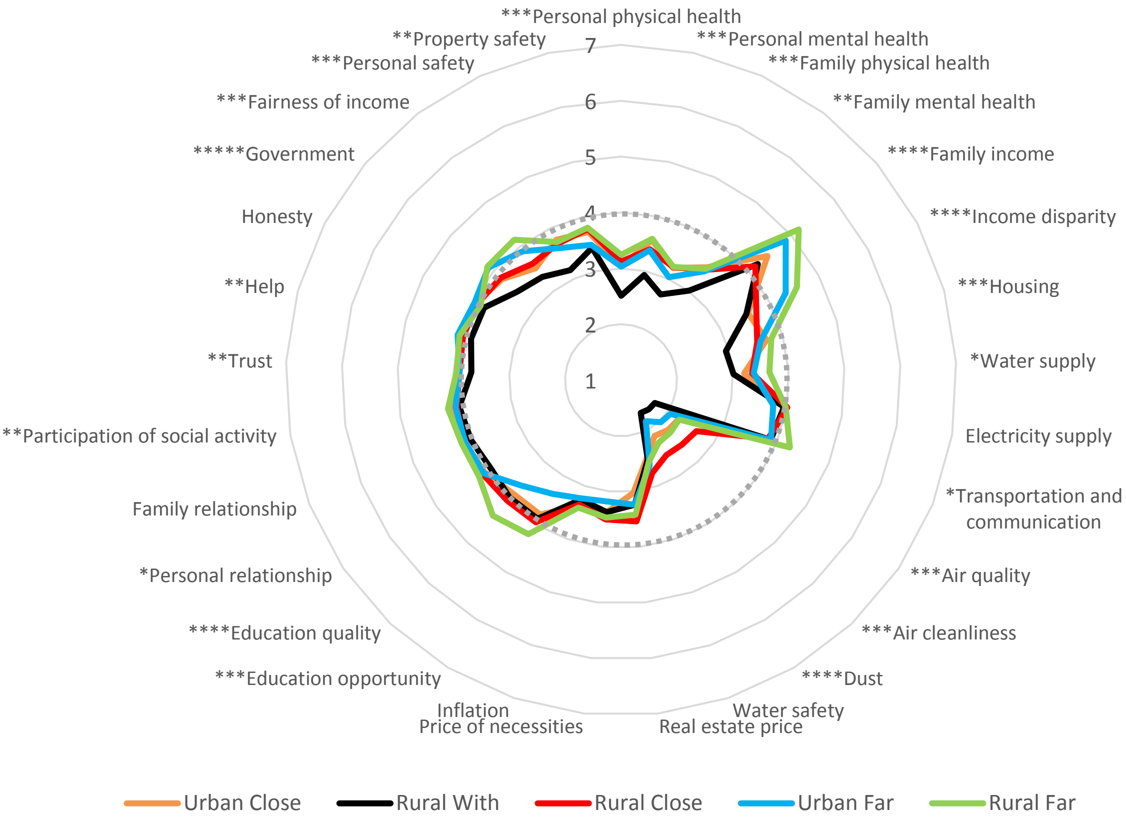


Figure 4.6 Mean scores relating to perceived impact of coal mining on wellbeing factors by study region

Notes: 1.Each '*' indicates that one of the paired observations was significantly different out of all paired comparisons across the 5 types of study areas; 2. Scale ranks from "strongly negative" (1) to "strongly positive" (7), 4 indicates "no impact".

Despite the optimism from people living far away from coal mines, in coal mining areas, respondents did not identify any obviously positive impacts (see Figure 4.6). Factors which related to the environment (e.g. air quality, water safety, access to water), the economy (e.g. inflation and real estate price) and health (physical and mental health) were all thought to be negatively affected by coal mining in all areas (mean score below 4). As illustrated below, coal mining had potential impacts on people's lives through its impacts on the natural environment – e.g. on water, hence the need to travel long distances for water (see Figure 4.7) and a visual impact (as per the white dog, turned black) (see Figure 4.8). This is also consistent with the message derived from Figure 4.4 – those living adjacent to coal mines were generally less satisfied with the wellbeing factors that were generally thought to be negatively affected by coal mining.

Figure 4.7 Travelling long distance to get water

Note: Due to a period of coal mining, the underground water was damaged. Village folk have to travel far to get water for daily use.

Source: Taken by the investigator in a village with coal mining on 22th August 2013

Figure 4.8 A little "white dog" in a village with coal mining

Note: This white street dog turned to black due to exposure to coal dust.

Source: Taken by the investigator in a village with coal mining on 21th September 2013

Figure 4.9 A little dog in a city close to coal mining

Note: This was a clean street dog with normal colour as the coal dust was not very heavy.

Source: Taken by the investigator in a city close to coal mining on 28th September 2013

4.3.4 Research question 4: the relationship between satisfaction and importance

Figure 4.10 depicts people's (mean) satisfaction with each of the 29 factors, together with the importance they attach to each. The satisfaction score is significantly lower than importance scores for all wellbeing factors except personal relationships. This result is similar to that of Larson et al. (2014), although the wellbeing factors used in that study were different due to a different purpose of their research. Generally, relationships, including family relationships and personal relationships, were very important, and people were satisfied with their own relationships. By contrast, air quality was deemed important, but people were generally very dissatisfied with it. Other factors that were important but which people were dissatisfied with included fairness of income, the quality of government, income disparity, inflation and real estate prices.

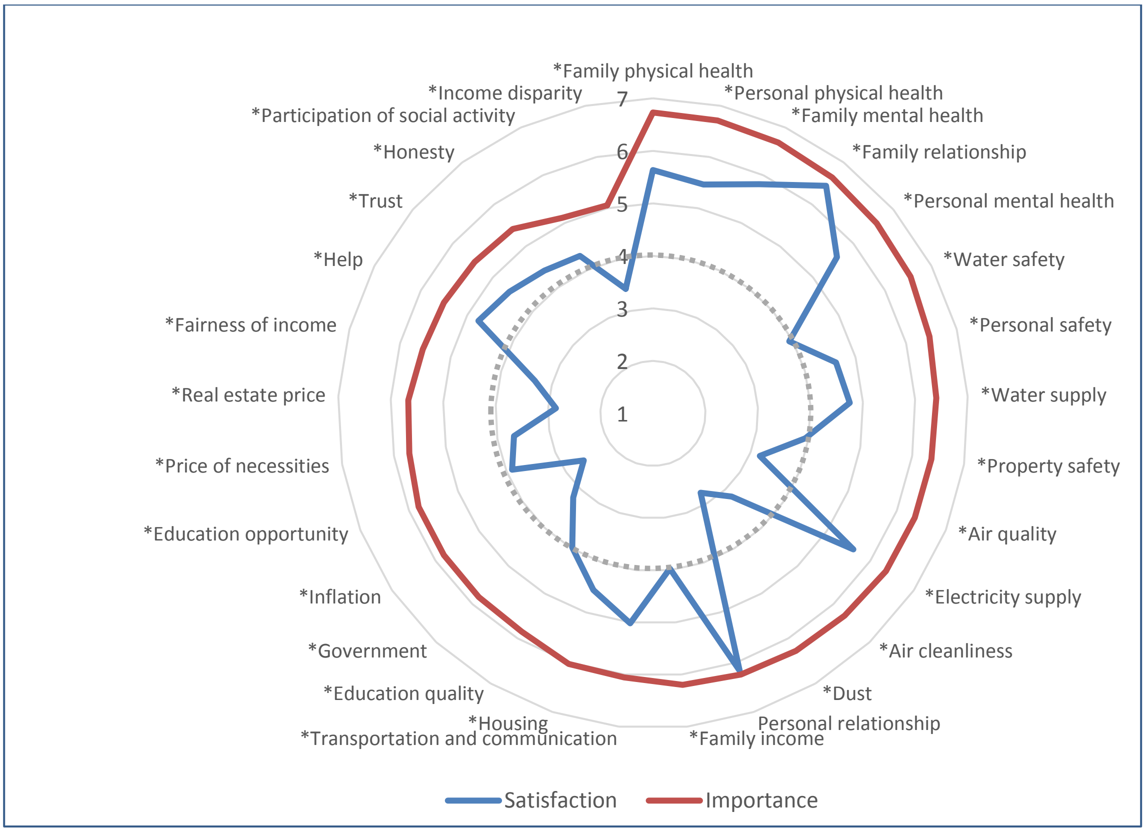


Figure 4.10 Mean scores relating to satisfaction with and importance of wellbeing factors

Notes: 1.Wellbeing factors ranks by the scores of importance; 2. '*' indicates statistically significant difference between the distribution of response to questions about satisfaction and importance; 2. Scale ranks from "very unimportant /dissatisfied" (1) to "very important/satisfied" (7), 4 indicates "neutral".

Figure 4.11 shows the mean importance score associated with each factor, plotted against the mean Dis-Satisfaction score. The majority of the wellbeing factors in the graph appear to be arranged along a negatively sloping curve (R^2=0.216). Those receiving high dissatisfaction scores and importance (relating to the natural environmental (air quality, dust, air cleanliness and water safety) and the economy (inflation and real estate prices)) are in the upper right quadrant of the graph, those receiving low dissatisfaction scores (health) and high importance scores are in the lower right quadrant. Generally, there are no outliers (i.e. no factors that receive very high/low dissatisfaction scores but very low importance scores). This relationship is generally consistent with the argument of Friedlander (1965) and Trauer and Mackinnon (2001), but the linear relationship was not very strong – similar to the findings of (Chen and Lin, 2014) – which suggested a need for more detailed investigations of the relationship between those variables.

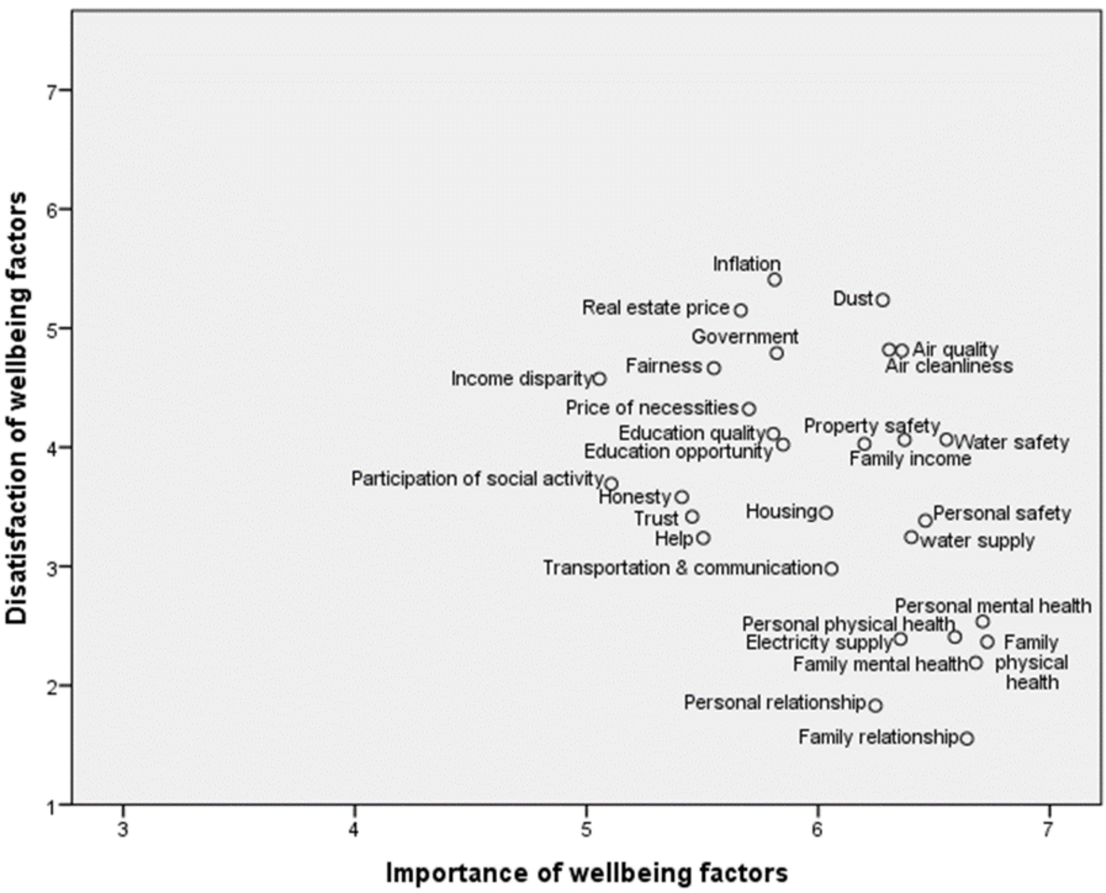


Figure 4.11 The relationship between mean scores relating to dissatisfaction and importance

Notes: Scale of satisfaction ranks from "very satisfied" (1) to "dissatisfied" (7), 4 indicates 'neutral'; Scale of importance ranks from "slightly important" (3) to "very important" (7), 4 indicates "neutral". No factors have score of 'importance' below 3.

Table 4.1 presents the Indices of Dis-Satisfaction (IDS), for each factor, by case-study area. The indices are remarkably different between coal mining areas (Urban close, Rural With and Rural Close) and non-coal mining areas (Urban Far and Rural Far). In coal mining areas, wellbeing factors relating to the natural environment (especially dust in the air) and the economy (inflation and the price of real estate prices) have the highest indices, while in non-coal mining areas, environment indicators have relatively low indices; instead, real estate prices, inflation, property safety and education system emerge as policy priorities (with the higher indices). Real estate prices and inflation are common issues in all the places, with a slightly higher values of IDS in coal mining areas – indicating a bigger magnitude of problems in coal mining areas.

Table 4.1 IDS [12]for individual factors, arranged from highest to lowest score for each type of study region

Urban Close		Rural With		Rural Close		Urban Far		Rural Far	
Wellbeing Factors	IDS	Wellbeing Factors	IDS	Wellbeing Factors	IDS	Wellbeing Factors	IDS	Wellbeing Factors	IDS
Dust	31.022	Dust	39.561	Dust	34.966	Real estate price	29.367	Real estate price	28.288
Water safety	29.922	Air quality	38.065	Inflation	32.765	Government	27.567	Water supply	27.458
Real estate price	29.189	Air cleanliness	37.416	Air quality	31.852	Inflation	26.667	Property safety	27.051
Air quality	29.178	Inflation	35.692	Air cleanliness	31.832	Property safety	25.933	Inflation	26.000
Government	28.967	Real estate price	30.813	Real estate price	30.228	Education opportunity	25.333	Education quality	25.169
Air cleanliness	28.800	Water safety	29.612	Government	29.584	Dust	22.333	Family income	23.492
Inflation	28.500	Government	28.308	Fairness of income	27.819	Fairness of income	21.600	Education opportunity	23.288
Property safety	27.800	Fairness of income	28.168	Family income	27.040	Family income	21.000	Government	22.186
Education opportunity	27.400	Price of necessities	27.678	Price of necessities	26.034	Education quality	20.667	Housing	22.051
Price of necessities	25.933	Family income	25.967	Property safety	25.792	Income disparity	19.933	Fairness of income	20.458
Fairness of income	25.500	Property safety	25.598	Income disparity	25.507	Personal safety	19.800	Water safety	19.780
Education quality	24.800	Income disparity	25.523	Water safety	25.074	Water safety	19.633	Price of necessities	18.797
Income disparity	23.800	Personal safety	24.037	Education quality	23.905	Honesty	19.633	Income disparity	18.690
Personal safety	23.667	Education opportunity	22.935	Education opportunity	22.470	Housing	19.567	Personal safety	17.814
Family income	22.562	Education quality	22.701	Housing	21.383	Air quality	18.467	Participation in social activity	17.644
Honesty	22.433	Water supply	22.505	Participation in social activity	21.201	Price of necessities	18.100	Personal physical health	16.322

[12] IDS is calculated using equation 1 in section 4.2.2. Higher value of IDS indicates factors of greater important and dissatisfaction.

Urban Close		Rural With		Rural Close		Urban Far		Rural Far	
Wellbeing Factors	**IDS**	**Wellbeing Factors**	**IDS**	**Wellbeing Factors**	**IDS**	**Wellbeing Factors**	**IDS**	**Wellbeing Factors**	**IDS**
Trust	20.989	Housing	20.780	Trust	20.309	Personal physical health	17.900	Electricity supply	16.322
Help	20.733	Honesty	18.121	Transportation & communication	20.242	Air cleanliness	17.700	Honesty	16.322
Housing	20.522	Participation in social activity	17.958	Personal safety	20.121	Help	17.033	Dust	15.610
Water supply	20.111	Transportation & communication	17.621	Honesty	19.255	Trust	16.700	Trust	14.119
Transportation & communication	19.189	Trust	17.033	Water supply	18.289	Transportation & communication	16.367	Family physical health	14.069
Participation in social activity	17.178	Help	16.879	Personal physical health	18.262	Family physical health	16.233	Help	13.508
Personal physical health	16.811	Personal physical health	15.869	Help	17.732	Participation in social activity	14.900	Personal mental health	13.458
Personal mental health	15.878	Personal mental health	15.682	Personal mental health	16.678	Electricity supply	14.700	Air cleanliness	13.458
Electricity supply	15.789	Family physical health	15.603	Family physical health	16.436	Personal mental health	14.067	Air quality	12.678
Family physical health	15.611	Electricity supply	14.631	Family mental health	15.523	Water supply	12.400	Transportation & communication	12.475
Family mental health	14.767	Family mental health	14.472	Electricity supply	14.765	Family mental health	12.200	Family mental health	12.328
Personal relationship	12.267	Personal relationship	10.664	Personal relationship	11.195	Family relationship	11.600	Personal relationship	10.610
Family relationship	9.722	Family relationship	10.402	Family relationship	10.322	Personal relationship	10.000	Family relationship	9.610

4.3.5 Research question 5: the relationship between satisfaction level and the impact of coal mining

Figure 4.12 depicts people's (mean) satisfaction with each of the 29 factors, together with the (mean) score relating to the perceived impacts of coal mining on each factor. In coal mining areas, the factors that people were most dissatisfied with included those relating to: air quality (dust, air quality, and air cleanliness), inflation, the price of real estate and necessities, the quality of government, the fairness of income, income disparity and water safety. These factors (especially those relating to the natural environment) were also the factors which respondents felt that coal mining generally had negative impact on.

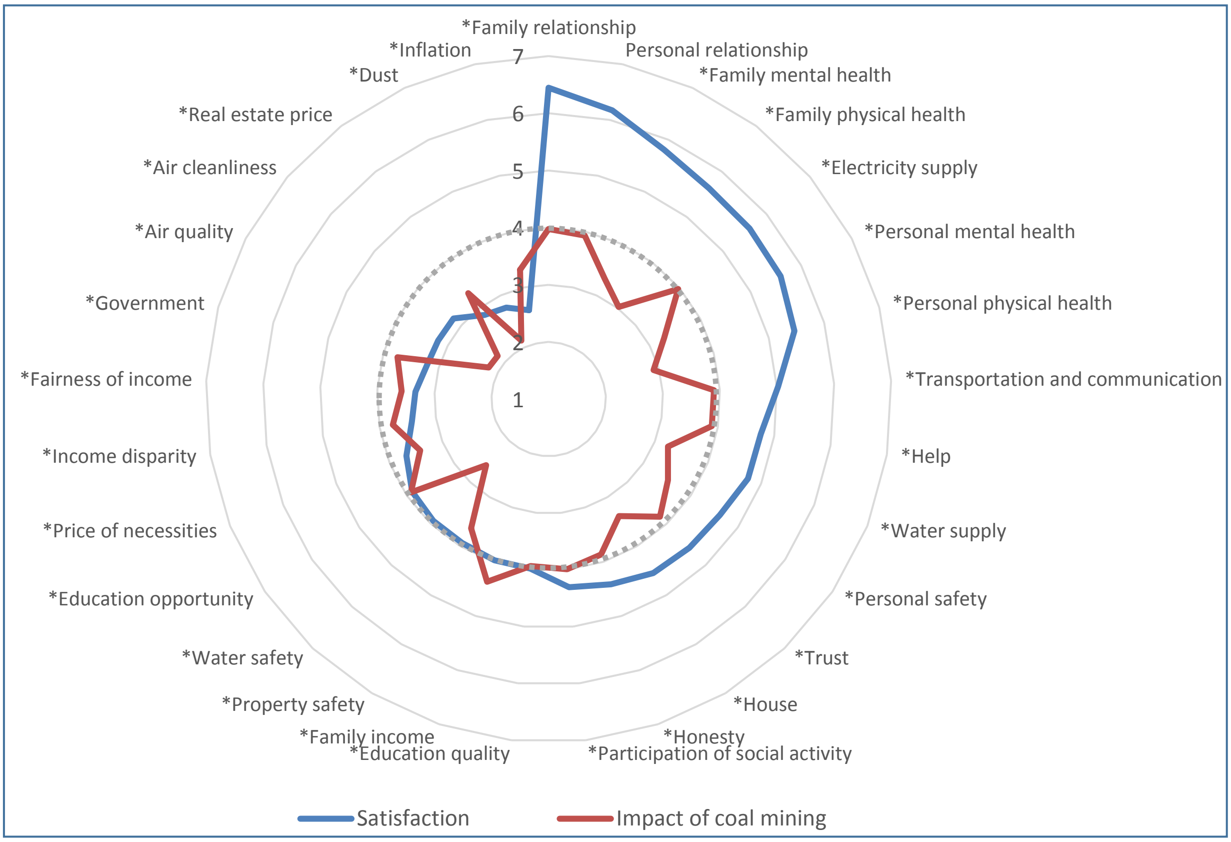


Figure 4.12 Mean scores relating to satisfaction with and perceived impact of coal mining on wellbeing factors

Notes: 1. Wellbeing factors ranks by the scores of satisfaction; 2. '*' indicates statistically significant difference between the distribution of response to questions about satisfaction and importance; 3. Scale ranks from "very dissatisfied/negative impacts" (1) to "very satisfied/positive impacts" (7), 4 indicates "neutral/no impacts". 4. Only samples from coal mining areas (Urban Close, Rural With, Rural Close) are included in this graph.

As discussed in section 4.3.2, there were few wellbeing factors that people living in coal mining area were more satisfied with than their ‘non-coalmining’ counterparts (see Figure 4.4). The factors related to the natural environment (air quality and water safety), which were believed to be most negatively affected by coal mining (see section 4.3.3), were also those where the gap between satisfaction scores in coal mining and non-coal mining areas was greatest (see Figure 4.4).

Coal mining was also perceived to have negative impacts on others factors, such as health, but people seemed quite satisfied with these factors, suggesting that they might not be as high a policy priority as other factors (also, fixing environmental issues, could help mitigate at least some health issues).

To further explore the relationship between satisfaction and perceived impacts of coal mining, the mean dissatisfaction of each factor was plotted against its mean negative impact score for the coal mining areas (Figure 4.13). Only coal mining areas were included in this analysis. In these areas, there were a number of factors (mainly environment factors) appearing in the upper right quadrant of the graphs, indicating both high levels of dissatisfaction, and ‘blame’ being attributed to coal mining.

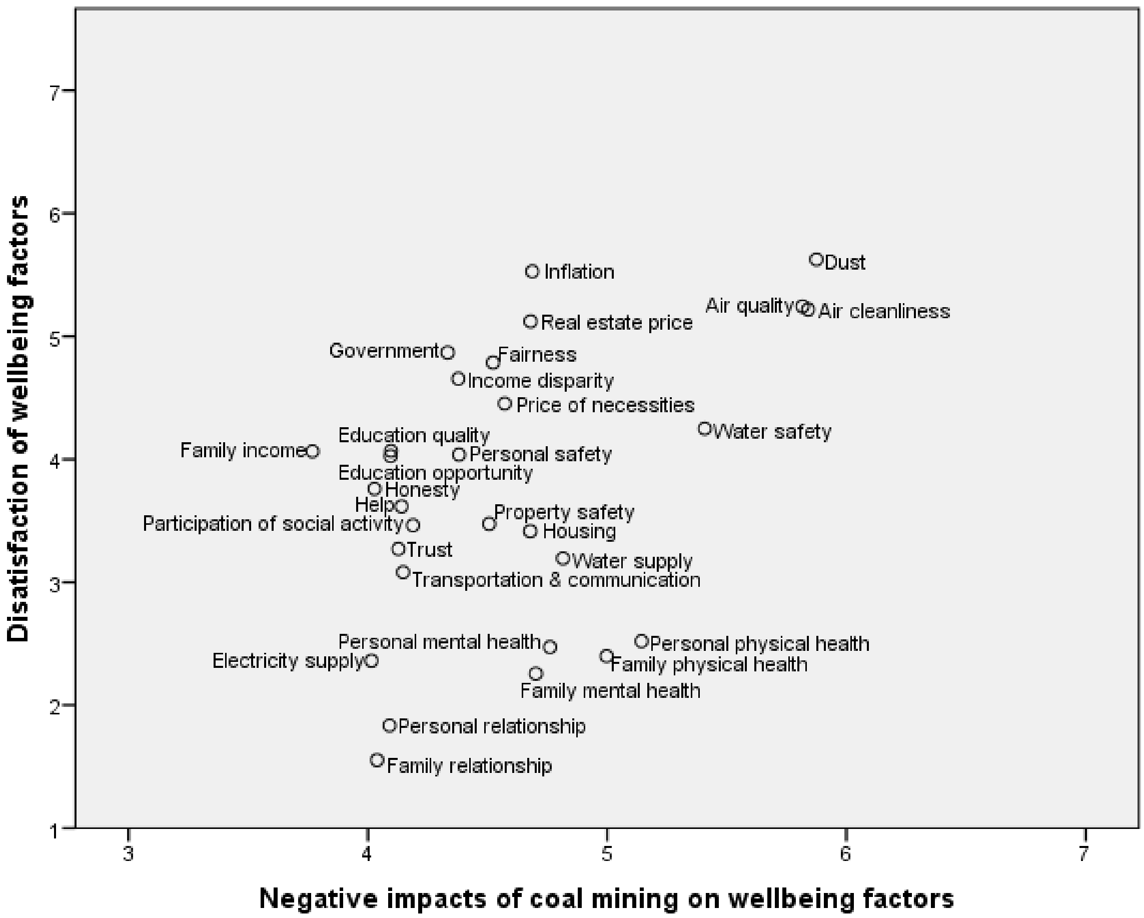


Figure 4.13 The relationship between mean scores relating to dissatisfaction and perceived impact of coal mining

Notes: Scale of satisfaction ranks from "very satisfied" (1) to "dissatisfied" (7), 4 indicates 'neutral'; Scale of negative impact ranks from "slightly negative" (3) to "strongly positive" (7); 4 indicates "no impact". No factors have score of 'negative impact' below 3.

Table 4.2 presents the IDSNI scores associated with each factor, for each type of case-study area. Dust, air quality, air cleanliness, water safety, real estate prices and inflation were clearly identified as factors with the highest levels of dissatisfaction, on which coal mining is perceived as having a strong negative impact. These factors emerge at the top 5 of IDSNI ranking and are very consistent across all the coal mining areas.

Table 4.2 IDSNI[13] for individual factors, arranged from highest to lowest score for 3 types of study region

Urban Close		Rural With		Rural Close	
Wellbeing Factor	**IDSNI**	**Wellbeing Factor**	**IDSNI**	**Wellbeing Factor**	**IDSNI**
Dust	31.60	Dust	39.27	Dust	30.01
Air quality	29.07	Air quality	37.57	Air cleanliness	27.41
Air cleanliness	28.99	Air cleanliness	37.20	Air quality	27.26
Real estate price	27.21	Inflation	27.10	Inflation	26.19
Water safety	26.88	Water safety	25.49	Real estate price	23.64
Inflation	24.72	Real estate price	24.20	Water safety	22.09
Fairness of income	23.22	Fairness of income	23.14	Government	21.30
Price of necessities	22.30	Government	21.91	Fairness of income	20.79
Government	21.62	Income disparity	21.54	Price of necessities	20.43
Income disparity	21.31	Price of necessities	20.82	Income disparity	20.34
Education opportunity	20.80	Personal safety	18.80	Property safety	16.54
Property safety	19.17	Property safety	18.66	Family income	16.41
Education quality	18.79	Water supply	18.19	Participation in social activity	16.40
Honesty	18.04	Housing	17.60	Education quality	15.97
Water supply	17.30	Education opportunity	16.78	Housing	15.27
Trust	16.79	Education quality	16.49	Education opportunity	15.11
Help	16.49	Family income	15.96	Water supply	14.43
Personal safety	16.16	Participation in social activity	14.35	Honesty	14.22
Housing	15.27	Honesty	14.20	Trust	13.86
Transportation and communication	14.75	Trust	13.86	Personal safety	13.84
Participation in social activity	14.74	Help	13.15	Transportation and communication	13.55
Personal physical health	13.35	Personal physical health	13.07	Personal physical health	13.05
Family income	13.13	Family physical health	12.86	Help	12.37
Family physical health	11.98	Personal mental health	12.83	Family physical health	11.88
Personal mental health	11.33	Transportation and communication	12.19	Personal mental health	11.51
Electricity supply	11.09	Family mental health	11.14	Family mental health	10.59
Family mental health	10.45	Electricity supply	9.17	Electricity supply	9.14
Personal relationship	8.60	Personal relationship	7.34	Personal relationship	7.24
Family relationship	5.94	Family relationship	6.62	Family relationship	6.17

[13] IDSNI is calculated using equation 2 in section 4.2.3. Higher value of IDSNI indicate factors with which people are more dissatisfied and coal mining has stronger negative impacts on.

4.4 Conclusion and discussion

Key findings are summarised in Table 4.3 and discussed in more detail below.

Table 4.3 Summary of findings

	Urban Close	Rural With	Rural With	Urban Far	Rural Far	Common issues	Specific to mining
Importance	Family physical health	Personal physical health	Personal physical health	Family physical health	Family physical health	Health and relationship	Mean importance scores do not vary dramatically across different types of case-study regions, except factors relating to air quality.
	Family relationship	Family physical health	Family physical health	Family mental health	Personal physical health		
	Personal physical health	Family relationship	Family mental health	Family relationship	Family mental health		
	Family mental health	Family mental health	Water safety	Personal physical health	Personal mental health		
	Personal mental health	Air quality	Personal mental health	Personal mental health	Family relationship		
Perceived impacts	Dust	Dust	Dust	Dust	Air quality	Dust, air cleanliness, air quality, water safety,	Although the top 5 perceived impacts of coal mining were similar across regions, perceived impacts on income and income disparity vary between coal mining and non-coal mining regions.
	Air cleanliness	Air cleanliness	Air cleanliness	Air cleanliness	Air cleanliness		
	Air quality	Air quality	Air quality	Air quality	Dust		
	Water safety	Water safety	Water safety	Water safety	Water safety		
	Real estate price	Personal physical health	Personal physical health	Family physical health	Family physical health		
	Real estate price	Dust	Inflation	Real estate price	Real estate price		

	Urban Close	Rural With	Rural With	Urban Far	Rural Far	Common issues	Specific to mining
Dis–Satisfaction	Dust	Air quality	Dust	Government	Inflation	Dust, air cleanliness, air quality, water safety, real estate price, inflation	The most dissatisfying factors in coal mining areas related to the environment and the economy, while most dissatisfying factors in non-coal mining areas only related to the economy.
	Inflation	Air cleanliness	Real estate price	Inflation	Education opportunity		
	Fairness	Inflation	Government	Income disparity	Education quality		
	Government	Real estate price	Air quality	Education opportunity	Water supply		
IDS	Dust	Dust	Dust	Real estate price	Real estate price	Real estate price, inflation	In coal mining areas, both environmental and economic issues emerge on the top of IDS list, but the environment is not a concern in non-coal mining areas.
	Water safety	Air quality	Inflation	Government	Water supply		
	Real estate price	Air cleanliness	Air quality	Inflation	Property safety		
	Air quality	Inflation	Air cleanliness	Property safety	Inflation		
	Government	Real estate price	Real estate price	Education opportunity	Education quality		
IDSNI	Dust	Dust	Dust			None	In coal mining areas, both environmental and economic issues emerge on the top of IDSNI list.
	Air quality	Air quality	Air cleanliness				
	Air cleanliness	Air cleanliness	Air quality				
	Real estate price	Inflation	Inflation				
	Water safety	Water safety	Real estate price				

In this case-study region, factors associated with health and relationship were deemed – by the entire sample, and by each sub-sample – to be the most important contributors to wellbeing. For most factors, mean importance scores do not vary dramatically across different case-study regions, except factors relating to air quality. Health and relationship were also the factors with which people in each sub-sample were most satisfied. People in coal mining areas were most dissatisfied with factors relating to air quality and the economy, while people in non-coal mining areas were most dissatisfied with factors only relating to the economy. People expressed most concern about the impacts of mining on the environment (air quality and water safety) and health, which is consistent across all the case-study regions. Compared to people living in coal mining regions, people living in non-coal mining regions seem to underestimate the negative impacts of coal mining while exaggerating the potential positive impacts.

Respondents from rural areas with coal mining recorded the strongest perceptions about the negative impacts of mining on most wellbeing factors, and were most dissatisfied with factors relating to the environment. Those with little exposure to coal mining (i.e. respondents living far away from coal mining) expected that coal mining would bring (comparatively) less severe negative impacts than those who lived with or near coal, and expected stronger positive impacts on their household income and on income disparities.

No similar study could be found in a mining context with which to compare these results, however, similar observations have been found in a tourism context. Termed the "Irridex model", this theory "postulates that resident's attitudes towards tourism are euphoric in the early stages, progressing to apathy, irritation and, eventually, antagonism" (Diedrich and García-Buades, 2009, p. 519). Observations from this study suggest that the Irridex model might also apply in a mining context, in that those with little experience of the industry seemed to underestimate its potential negative impacts, and overestimate its positive impacts. This is particularly so in rural areas, where poverty is a significant problem, and the prospect for higher incomes from mining is very attractive. Some village folks said: *"We will be lucky if we have coal mining in our village. Life will be better because we could get money from that."*

People in rural areas had stronger views about the potential impacts of coal mining than those in urban areas. The economy in rural areas is less developed and less diverse than that in urban areas, and the available options for livelihoods is also very limited (Kanbur and Zhang, 2005; Sicular et al., 2007). This may at least partially explain why rural residents who have no experience of mining hold relatively positive attitudes towards it, given the potential for coal mining to diversify their livelihoods. That said, rural residents are also likely to be dramatically impacted by coal mining once they have it (Rural With). Residents from urban areas with more diverse industries and more options for livelihoods, had more balanced views on mining – they were neither so strongly exposed to coal mining (Urban Close), nor longed for the benefits from coal mining (Urban far) as their rural counterparts. The urban sample from which these insights have been drawn is, however, relatively small: future studies are needed to explore the dependence on mining industry in terms of the differences between urban and rural areas.

Importantly, this analysis relies on aggregated data and thus describes the 'average' situation in each type of study region. This does not mean that each village (or each individual within each village) is in the same situation, given the diversity of villages and individuals included in this study. While environmental damage was a common concern across all villages with or close to coal mining, a diverse range of other issues impacted different villages in different ways. As discussed below, this is likely to have led people to have quite different attitudes towards coal mining – even if living within the same village or same 'type' of case-study area.

- The ownership and location of coal mines

After the coal mine consolidation program (which was advanced by the government from 2009 onwards), more than half of the coal mines came under the control of government (Zhou, 2011), and most illegal coal mines were closed. But there are still a small number of 'illegal' coal mines scattered around Shanxi province, and these often generate conflicts between the coal mine operators, the local governments and host communities. In one village, an illegal coal mine was located almost in the backyard of several houses, but was only operated at night to avoid trouble. There were continuous conflicts between the owners of this coal mine and village folk, as evidenced by the following comments made by respondents when collecting data:

> *"The head of our village has shares in the coal mine, they are on one side against us."*
>
> *"A lady was even badly injured in the conflict. Since then, nobody tried to fight with the owner of the coal mine and the local government".*

People living in this village generally had strong negative attitudes towards coal mining.

- The distance of the individual from coal mines or coal transportation

In the same village referred to above, a lady living beside the road, could never go to sleep because heavy trucks passed by her front door almost 24 hours a day. A special road was built for the transport of coal, but the truck drivers were reluctant to use it – the road through the village was shorter and more direct. In another village with coal mining, explosives were regularly used, breaking windows and causing cracks to the houses nearby. These respondents generally had more strong negative attitudes towards coal mining than others in the same village who lived further away from the road or the area were explosives were set.

Figure 4.14 Heavy truck carrying coal through the middle of a village

Source: Taken by the investigator in a village with coal mining on 22th August 2013

- Association with the coal mining industry

People living in places with coal mining tended to have extreme attitudes towards coal mining; these varied according to whether they (or someone else in their immediate family) were working in the coal mine or were dependent upon some other industry (e.g. agriculture) for their livelihood.

In one of the villages with a coal mine, people's attitudes towards coal mining were generally positive – perhaps at least partially because the coal company had, as policy, the goal of hiring at least 1 person from each household. Anecdotal evidence suggests that this policy arose because the chairman of the coal company is from that village. When a woman was asked about the impacts of coal mining, she was hesitant to express openly what she actually thought. "*I don't want to say anything bad about coal mining, because my whole family is counting on it. If coal mines are closed here, my husband will lose his job, and we cannot make a living"*. Notably, this situation is rare – it was the only village visited by investigators that seemed to have a generally positive outlook on mining.

In contrast, in another village with coal mining where people did not obviously benefit from coal mining, the attitudes towards to coal mining were uniformly negative. A family reliant on agriculture obviously resented coal mining: "*coal mining brings me nothing but misery. A lot of my sheep died after they ate the grass covered by coal dust. Some of them fell down into a crack [in the ground] caused by coal mining, now I don't have many sheep left".*

Compared to those who lived in villages that had a coal mine within its boundaries, the attitudes of people living in villages that were a little more removed from the mine (formally classified as being 'close to' coal mining) were much more neutral. They were, however, acutely aware of the potential negative impacts of coal mining, and may have even directly experienced some. One man said:

> *"I felt lucky that we don't have coal mines in our village, so I still have my farmland, I have been doing odd jobs with an unsatisfying income in the city, but my farmland makes me feel secure. Rumour has it that coal has been found*

underground in my village. I would definitely be the first person opposed to coal mining here, because ordinary people like me could not benefit from coal mining, only those officers or rich people can. If they start mining here, the only consequences will be that we will lose farm land and suffer from all the environmental damage from coal mining. Even now, it already has impacts on us. In the farmland beside the special road for coal transportation, the corncobs are black inside. But there was no compensation for that." (To reduce the dust from coal transportation, it is required by law that all the trucks carrying coal should be covered by a special cloth. However, it was said that 99% of these trucks are not covered).

The diversity of perspectives clearly indicates that having a single "standard" policy towards all mining in the developing world or even a single "standard" policy towards all mining across all regions within a single country may be undesirable. The data reveal several common issues associated with coal mining (generally negative environmental impacts, and few positive economic impacts), but there is diversity at a village level. Having a solid understanding of unique situations and of the reason behind diverse perspectives could help inform development of regional specific policies better able to improve the wellbeing of residents in coal mining areas.

There is also much diversity at an individual level. In particular, one expects that the importance which individuals attach to wellbeing factors, people's satisfaction with various wellbeing factors and their perceptions about the impacts of coal mining on those factors will depend upon a host of other factors, not the least of which relate to 'personality' and to the sociodemographic characteristics and economic status of individuals. But these are all subjective indicators of wellbeing; as discussed in section 2.3.1.2, objective indicators, traditionally used by governments, can also be used to assess wellbeing. Is the message from subjective wellbeing mirrored by objective indicators? This question will be explored in the following chapter.

4.4.1 Implications for policy makers

Using subjective indicators, this chapter provides useful information to help assess the likely impacts of mining and identify regional policy priorities.

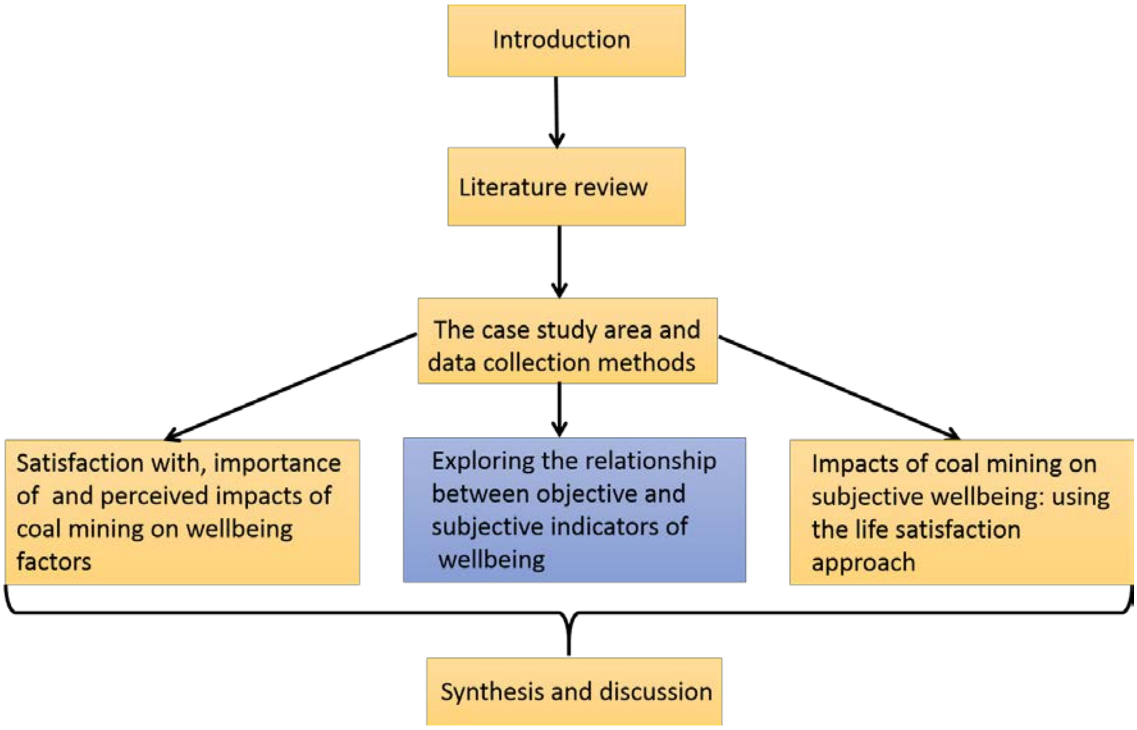
All indicators suggest that environmental problems should be the policy priority in the coal mining areas. In particular, both the composed Index of Dis-Satisfaction (IDS) and Index of Dis-Satisfaction and Negative impacts (IDSNI) indicate that both environmental issues (air quality and water safety) and economic issues (the inflation rate and the price of real estate prices) were of high priority in coal mining areas, and environmental issues were paramount. However, IDS indicates that priority lists differed between coal and non-coal mining areas. In non-coal mining areas, factors relating to the environment were not a 'priority', instead, economic issues and social issues (the quality of government and education) were of most concern.

4.4.2 Methodological contribution

This chapters clearly demonstrated a technique for identifying different policy priorities in mining and non-mining areas. The technique is largely transferrable to other contexts – to consider the impacts of an industry, or a project and to generate straightforward 'action-lists' to infer public policy priorities.

If seeking to replicate this type of study in another context, one could develop a list of potential wellbeing factors that are likely to be affected by a particular project, and information about those factors could be collected from different areas (e.g. those which have been exposed to, or have lived with similar projects, and those where the project is likely to be implemented) to learn more about its likely impact. This would best be done by a combination of expert group and community qualitative research, such as focus groups to determine consensus on factors. Follow-up studies could also be implemented at regular intervals after project start, to gauge actual impact (and to compare actual with projected impact for further information).

Thesis outline



CHAPTER 5 EXPLORING THE RELATIONSHIP BETWEEN OBJECTIVE AND SUBJECTIVE INDICATORS OF WELLBEING

Chapter outline

5.1 Introduction

5.2 Analytical method

5.3 Results

5.3.1 The relationship between objective and subjective indicators relating to family income

5.3.2 The relationship between objective and subjective indicators relating to air quality

5.3.3 The relationship between objective and subjective indicators relating to housing

5.3.4 The relationship between objective and subjective indicators relating to education

5.4 Conclusion and Discussion

5.4.1 Implications for policy makers

5.4.2 Methodological contribution

5.4.3 Implications for future studies

Synopsis

This chapter explores the relationship between 4 'pairs' of objective and subjective indicators relating to 4 different factors known to influence wellbeing. Data deficiencies (mostly relating to objective indicators) precluded more comparisons. For each pair, I explored the relationship between these two measures of wellbeing – using both aggregated (regional) and individual data.

When using data at an aggregated regional level (across the 5 types of study region), some of the 'pairs' of objective and subjective indicators conveyed very consistent messages: high actual income was associated with high satisfaction with income, and high concentration of PM_{10} was associated with low satisfaction with air quality. However there was a divergence between other pairs of subjective and objective indicators, such as those relating to housing and education, not conveying the same message.

I also considered the relationship between objective and subjective indicators using individual data. When doing so, each subjective indicator was regressed against its 'paired' objective indicator and sociodemographic variables known to influence subjective assessments. In each case the regression was run using both the entire dataset and then also sub-sets of data, relating to each type of study region. This analysis confirmed the consistent message between the subjective and objective indicators relating to income and air quality – although the relationship was mediated by sociodemographic factors. Not all the objective indicators of housing are good predictors of satisfaction with housing. The relationship between subjective and objective indicators associated with education was, as for the aggregated data, inconsistent. Thus, it is possible to conclude that objective and subjective indicators are not always a substitute for each other; both are needed to gain a complete picture of wellbeing in some cases.

5.1 Introduction

As noted before, coal is vitally important to both developed and developing economies. But coal mining's well documented harm to the natural environment and negative effects on human mortality and morbidity has spurred a significant body of literature that looks more broadly at the impacts of coal mining on various life domains. These studies have, however, been largely limited to examining objective indicators of wellbeing, with or without directly referring to the concept of wellbeing. Not only does the current literature lack studies that investigate a broad range of SWB indicators, but it is particularly impoverished when it comes to studies that compare or use both subjective and objective indicators.

The previous chapter investigated various indicators of subjective wellbeing across 29 wellbeing factors. It considered the importance of each factor (to overall wellbeing), people's satisfaction with each factor, and their perceptions of the way in which coal mining affects them. A complex picture emerged: people from areas with different exposures to coal mining were differently satisfied with several wellbeing factors (particularly those relating to the environment and the economy), but some differences also seemed attributable to other factors (such as rural/urban contexts). Would the message be similar if looking at objective indicators too? The main research question addressed in this chapter is thus: Does information about the impacts of coal mining derived from subjective assessments of wellbeing convey the same message about the impacts of coal mining as 'objective' measures of wellbeing? This over-arching question is answered with reference to the specific sub-questions below:

1) Do the objective indicators suggest that there are differences in wellbeing between
    a. Areas with different mining intensities;
    b. Rural and urban areas.
2) Do objective and subjective indicators convey similar information?
    a. Using aggregated data (Visually in the chart);

b. Using regressions at individual level to control for sociodemographic factors.

The approaches used to analyse data are described in section 5.1. Section 5.2 presents the methods used to address these questions, whilst section 5.3 presents results. This chapter is closed by a discussion.

5.2 Analytical method

To examine the relationship between objective and subjective wellbeing indicators, one first needs to identify 'pairs' of objective and subjective indicators which effectively align (i.e. refer to the same wellbeing factor). As demonstrated in the last chapter, several different types of subjective indicators associated with 29 different wellbeing factors were collected in this study. It was much more difficult to obtain 'objective' measures at small scale (e.g. village): few were available from central data-collection agencies, and collecting objective measures for each wellbeing factors (e.g. crime or corruption rates within each village) was well beyond the resources of this study. Nevertheless, it was possible to obtain 'objective' indicators relating to income, air quality, housing and education. The 'pairs' of subjective and objective indicators assessed in this chapter thus include:

1. Actual family income and satisfaction with family income. Objective data relating to actual family income were collected in the survey (see Appendix A, Q49); Respondents were not asked to provide their exact income; rather to indicate an income range. The midpoint of each range was used as the estimate of family income. For the unbounded top bracket ($120,000 Yuan), a fairly conservative mid point 125,000 was assumed. This is applied onwards in this thesis. Subjective data about family income are respondents' self-reported satisfaction with their family incomes (see Appendix A, Q10)

2. Actual air quality and satisfaction with air quality. Objective data relating to air quality were concentrations of $PM_{2.5}$ and PM_{10}, measured during

the field visit and used as a crude proxy for environmental quality (OECD 2011). Both $PM_{2.5}$ and PM_{10} have well documented adverse effects on human health (Dockery et al. 1993). Only PM_{10} was used here, given the close correlation in measures. Subjective data about air quality are respondents' self-reported satisfaction with the air quality in the places they lived in (see appendix A, Q19[14]).

3. Actual housing conditions and satisfaction with housing. Objective data relating to actual housing conditions were collected in the survey (see Appendix A, Q51 and Q52). Respondents were asked to tell whether he/she had a bathroom and toilet in his/her house, and how many rooms were in the house (enabling me to calculate 'rooms per person'). These indicators were used as a crude proxy for housing conditions (OECD, 2011). Subjective data about housing are respondents' self-reported satisfaction with their own housing conditions (Q15).

4. Actual education levels and satisfaction with the current education system (education quality and opportunity). Objective data relating to education were collected in the survey (see Appendix A, Q46). Respondents were asked to provide their education levels. The education level then was converted to years of schooling to make the analysis more straightforward. This is applied onwards in this thesis. Subjective data about education are respondents' self-reported satisfaction with the education opportunity and quality in the places they lived in (Q27 and Q28).

Having identified suitable 'pairs', data were divided according to 5 types of study region (Urban Close, Rural With, Rural Close, Urban Far, Rural Far).

To answer research question 1 (part a and b), the mean value of each objective and subjective indicator was calculated for each type of region. Non-parametric tests

[14] Respondents were asked how satisfied they were with the air quality as a whole (appendix A, Q19), air cleanliness (Q20) and dust in the air (Q21). Only the air quality as a whole (Q19) was used here, as it might be more representative for the air quality, although the answer for the 3 questions were very consistent.

(Kruskal-Wallis) were then used to determine if the observed differences in objective indicators across regions with different intensities of coal mining were statistically significant, and if the difference between urban and rural areas was statistically significant. Non-parametric tests (Kruskal-Wallis) were only done for objective indicators; results of non-parametric tests relating to subjective wellbeing indicators were presented in the previous chapter (see section 4.3.2) and also used for the analysis here.

To answer research question 2a, the mean score of each objective and subjective indicator (for each 'pair' of data) were plotted to visually determine if the indicators were conveying similar types of information. The results of the non-parametric tests (Kruskal-Wallis) conducted on both objective and subjective indicators were used to further the analysis.

As discussed in section 2.3.2.6 and 3.4.1.2, sociodemographic factors such as marital status (Ballas and Dorling, 2007; Brereton et al., 2008), age (Stutzer and Frey, 2008), family size (Frijters and Van Praag, 1998), gender (Moro et al., 2008; Arifwidodo and Perera, 2011) have all been shown to influence subjective assessments of wellbeing. Furthermore, Lee and Marans (1980) noted that personal and social characteristic (such as age, income, education etc.) affect the relationship between objective and subjective indicators, they thus controlled for these factors in the regression when they examine the relationship between objective and subjective indicators. Therefore, to further explore the relationship between objective and subjective indicators of wellbeing (and to answer research question 2b), each subjective indicator was thus regressed against its 'matching' objective indicator and other sociodemographic ('control') variables (derived from the literature review (see Table 3.6)), as detailed in Equation 3. Several regressions were run for each pair of subjective and objective indicators: the first using the entire sample, the others using sub-samples from each type of study region.

$$SAT_i = f\,(OWB, Age_i, Female, NotPartnered_i, NoOfChildren_i, NoOfAdult_i, Schooling_i, EmploymentStatus_i) \qquad \textbf{Equation 3}$$

Where:

SAT_i	– satisfaction score associated with a particular wellbeing factor, reported by person *i*
OWB_i	– objective indicator associated with a particular wellbeing factor
$NoOfChildren_i$	– the total number of children living in the respondents house
$NoOfAdult_i$	– the total number of adults living in the respondents house
Age_i	– age of the respondents
$Female_i$	– a dummy variable, set equal to 1 if person *i* was female (0 otherwise)
$Notpartnered_i$	– a dummy variable, set equal to 1 if person *i* had no partner (0 otherwise)
$Schooling_i$	– maximum of years of schooling the respondent has
Employment $status_i$	measured using a series of dummy variables, set equal to 1 if: – retired – jobless – students – self-employed

In these regressions, the dependent variable (the subjective indicator) was measured on a 7-point Likert scale. As such, ordinary least squares regression (OLS) – which assumes that the dependent variable is continuous – is not the theoretically correct regression procedure. Usually, ordinal regression is more suitable. Both OLS and Ordinal regression were thus used. The two different types of regression produced very similar results (in terms of significance and relative magnitude of coefficients)[15], which accords with empirical findings from other researchers who have reported that choice of regression technique has little or no impact on results (e.g. Frijters and Praag, 1998; Welsch, 2006; Luechinger, 2009; MacKerron and Mourato, 2009; Ambrey and Fleming, 2011; Levinson, 2012). It is the OLS results which are reported on here, since they are more straightforward and easier to interpret than results from ordinal regression (MacKerron and Mourato, 2009).

[15] See Appendix C for results of ordinal regressions examining the relationship between objective and subjective wellbeing indicators.

5.3 Results

5.3.1 The relationship between objective and subjective indicators relating to family income

Figure 5.1 presents the plot of mean family income and satisfaction with income for each type of study region. Visually, a higher level of family income is associated with a higher level of satisfaction with income.

The non-parametric tests (Kruskal-Wallis test, pairwise comparisons) undertaken on objective measures indicate that annual family income in urban areas is significantly higher than in rural areas ($p = 0.000$), irrespective of their proximity to coal mines. Although there is no statistically significant difference in satisfaction with income across the 5 regions (see the result of Kruskal-Wallis test in Figure 4.4), Figure 5.1 clearly demonstrates that, people living in rural areas were generally dissatisfied with their family income (mean values were below 4), while people living in urban areas were generally satisfied with their family income (mean values were above 4). As such, both the objective and subjective measures relating to income convey a consistent message: higher family income generally indicates higher level of satisfaction with income; and actual family income and satisfaction with income in urban areas is higher than in rural areas, irrespective of their proximity to coal mines.

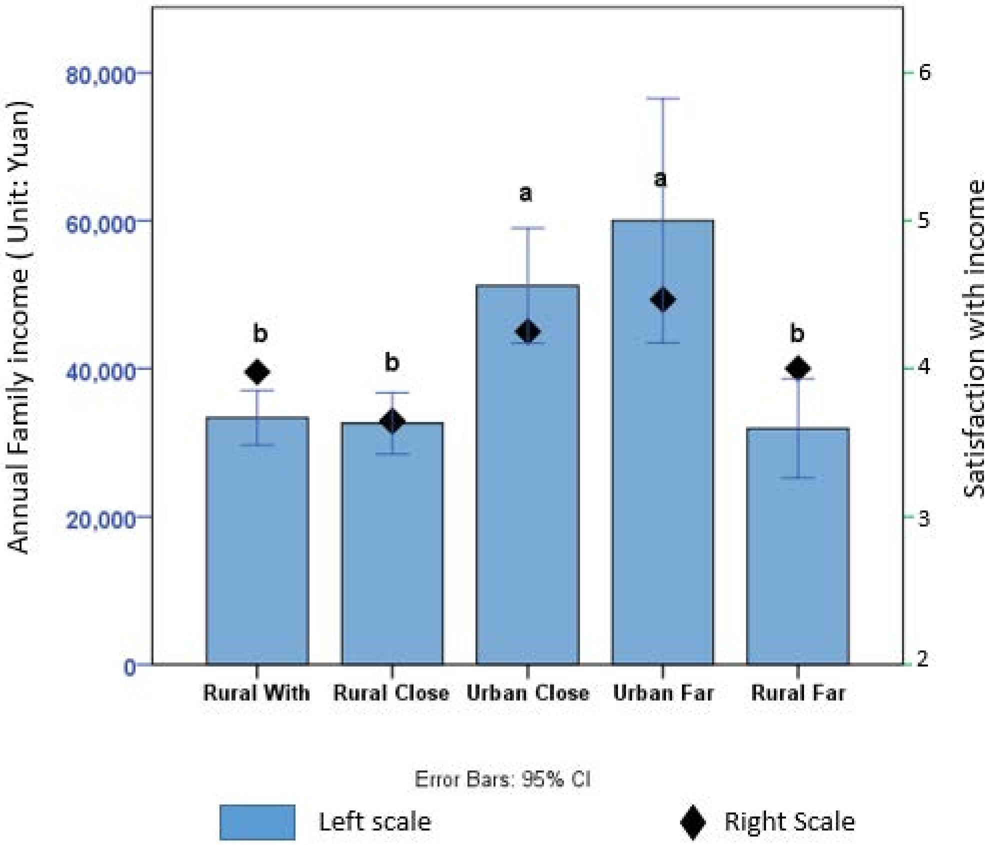


Figure 5.1 Annual family income and satisfaction level of income by study region

Notes: 1. Letters above bars 'a' and 'b' indicate statistically significant differences and similarities of annual family income among different regions; 2. Scale of satisfaction with family income ranks from "dissatisfied" (2) to "satisfied" (6), 4 indicates "neutral". (Only the range of '2 to 6', instead of '1 to 7', is shown in this graph, because the actual mean scores only fall into this range).

Table 5.1 displays results from the regression of 'satisfaction with income' against actual income and other variables – for the entire sample, and for each sub sample. The F-statistics (and associated p-values) indicate that all models are (overall) statistically significant: the (adjusted) R^2 suggest that the models explain between 15% and 56% of all variation. In all cases, the coefficient on actual income is positive and statistically significant, confirming the relationship between subjective and objective measures. However, this relationship is mediated by sociodemographic factors. Generally, older people were more satisfied with their family income than others earning the same amount. Other researchers report that old people are often more satisfied with their lives than the young (e.g. Frey and Stutzer, 2000), thus they might also have higher satisfaction with some important life events, such as income. Retired people were more satisfied with their income than those who were still working. Females were generally less satisfied with family income than males, which is also consistent with other studies (Hess et al., 2004; Stevenson and Wolfers, 2009).

Table 5.1 OLS regression results – with dependent variable being subjective measures of respondent satisfaction with income

		Total sample	Urban Close	Rural with	Rural Close	Urban far	Rural Far
Income		0.000020***	0.000162***	0.0000175**	2.53E–05***[16]	3.58E–05***	2.17E–05***
		(2.69E–06)	(4.65E–06)	(7.50E–06)	(7.98E–06)	(7.79E–06)	(5.84E–06)
NoOfChildren		–0.088	0.374	–0.174	–0.052	–0.243	–0.565**
		(0.084)	(0.257)	(0.147)	(0.145)	(0.391)	(0.232)
NoOfAdult		–0.041	0.281***	–0.247***	0.047	–0.265	–0.096
		(0.055)	(0.099)	(0.088)	(0.089)	(0.224***)	(0.180)
Age		0.021***	0.025	0.002	0.013	0.050**	0.056***
		(0.007)	(0.020)	(0.013)	(0.012)	(0.025)	(0.018)
Female		–0.304*	0.435	–0.258	–0.500*	–0.432	–0.080
		(0.164)	(0.370)	(0.273)	(0.292)	(0.488)	(0.421)
Not partnered		0.258	1.005*	0.026	–0.575	1.844**	0.782
		(0.247)	(0.528)	(0.469)	(0.425)	(0.789)	(0.661)
Schooling		–0.028	–0.114*	–0.023	–0.034	–0.054	0.042
		(0.027)	(0.065)	(0.049)	(0.048)	(0.091)	(0.072)
Employment Status	**Retired**	1.150***	1.481	2.009***	1.297**	–1.632	0.526
		(0.325)	(0.949)	(0.406)	(0.570)	(1.382)	(0.532)
	Unemployed	0.006	1.138	–0.140	0.480	–1.555	–1.109*
		(0.223)	(0.653)	(0.333)	(0.430)	(0.987)	(0.647)
	Student	0.430	0.397	0.778	0.983	–2.680***	–0.357
		(0.379)	(0.604)	(0.694)	(0.587)	(1.025)	(0.817)
	Self-employed	0.237	0.742*	0.347	0.261	–1.097	–0.043
		(0.195)	(0.435)	(0.367)	(0.339)	(0.644)	(0.462)
Constant		2.698***	1.546747	4.376***	2.641***	2.984	0.879
		(0.536)	(1.378998)	(0.959)	(0.953)	(2.196)	(1.460)
Observations		533	84	183	177	30	59
[17] R^2		0.138	0.269	0.196	0.181	0.557	0.406
F		8.73***	4.43***	6.77***	3.31***	7.22***	8.66***

Notes: 1. Robust standard errors are in parentheses; 2. Significant variables are highlighted in red, ***P<0.001,**p<0.05,*P<0.1.

[16] 'E' is a scientific notation, which would be written as '× 10^{n}'. Thus '2.53E–05' represents '2.53×10^{-5}'. This applies to the whole thesis.

[17] R^2 reported here is the adjusted R^2 for the full model, but unadjusted R^2 for sub-population, because STATA does not report adjusted R^2 for sub-population. This applies to other tables of OLS regression results in this chapter.

5.3.2 The relationship between objective and subjective indicators relating to air quality

Figure 5.2 presents the plot of mean PM_{10} and satisfaction with air quality across each type of study region. Visually, higher levels of PM_{10} are associated with lower levels of satisfaction with air quality. Significant differences in air quality (PM_{10}) across the 5 types of study region were identified with the Kruskal-Wallis test (pairwise comparisons, P=0.000). Air quality varied with proximity to coal mining with areas closest to coal mines demonstrating the worst air quality. The observed correlation between air pollution and proximity to coal mines confirms the validity of the categorisation of sampling areas in this study. Air quality did not significantly vary between urban and rural areas.

The previous chapter's analysis found statistically significant differences in reported levels of satisfaction with air quality across different types of regions (see the result of Kruskal-Wallis test in Figure 4.4) – people living in coal mining areas expressed significantly lower levels of satisfaction with air quality. As such the objective and subjective measures relating to air quality convey a clear and consistent message: people living in places with high levels of PM_{10} (coal mining areas) are less satisfied with air quality than those living in areas with lower levels of PM_{10}.

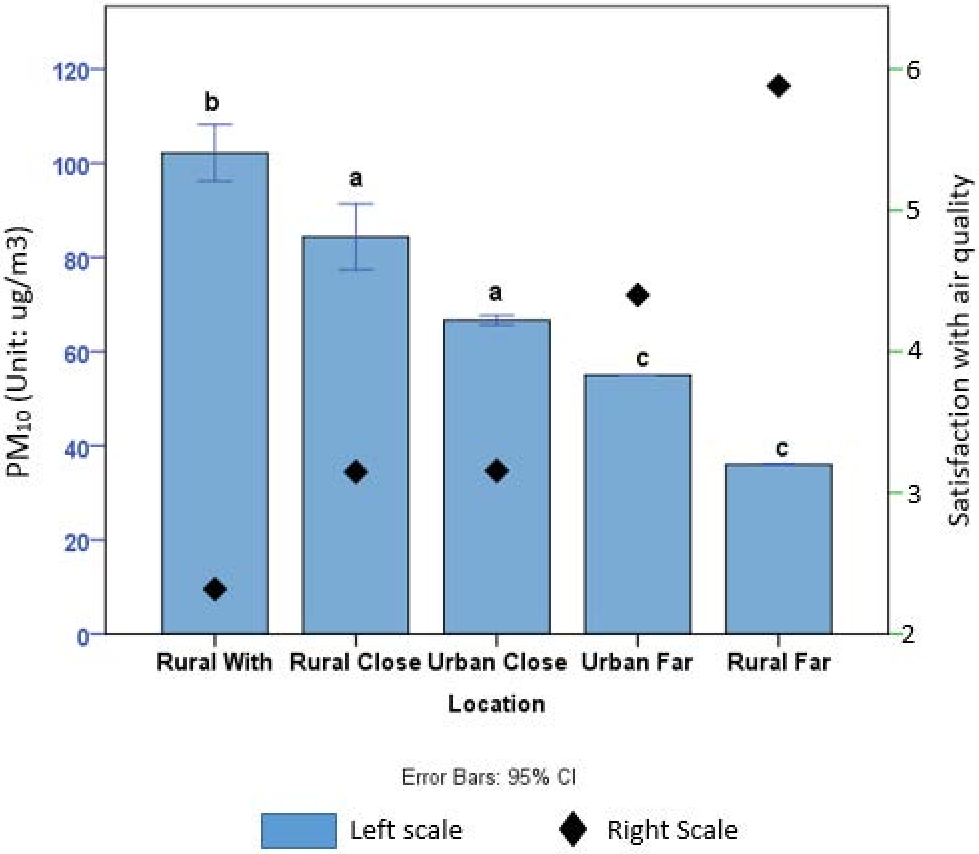


Figure 5.2 Concentration of PM $_{10}$ and satisfaction level of air quality by study region

Notes: 1. Letters above bars 'a', 'b' and 'c' indicate statistically significant differences and similarities of PM_{10} among different areas; 2. Scale of satisfaction with air quality ranks from "dissatisfied" (2) to "satisfied" (6), 4 indicates "neutral" (Only the range of '2 to 6' is shown in this graph, instead of '1 to 7', because the actual mean scores only fall into this range).

Table 5.2 shows the results of the OLS regression of 'satisfaction with air quality" against actual concentrations of PM_{10} and other sociodemographic factors for the entire sample and for 2 rural sub-samples[18]. The F-statistics (and associated p-values) indicate that all models are (overall) statistically significant: the (adjusted) R^2 suggest that the models explain between 7% and 17% of all variation. For the entire sample, the link between PM_{10} and satisfaction with air quality had the expected negative relationship and was statistically significant. In sub-samples that had fewer observations, the relationship was not always significant – at least partially attributable to the small sample size, but likely

[18] Sub-data sets of Urban Close, Urban far and Rural far, with 3,1 and 2 values of PM_{10} respectively, are not suitable for the regression. Thus, the regressions have only been done for sub-data sets of Rural With and Rural Close (see Table 5.2).

also related to the fact that there was but one single PM_{10} measure for each village, so variations were minimal (unlike the income situation, where the objective indicator was uniquely associated with each respondent).

Table 5.2 OLS regression results – with dependent variable being subjective measures of respondent satisfaction with air quality

		Total sample population	Rural with	Rural Close
PM_{10}		–0.019***	0.001	–0.013***
		(0.002)	(0.003)	(0.004)
NoOfChildren		–0.008	0.083	–0.036
		(0.095)	(0.154)	(0.140)
NoOfAdult		0.124**	0.063	0.095
		(0.061)	(0.073)	(0.108)
Age		0.004	–0.002	0.025
		(0.008)	(0.011)	(0.015)
Female		0.120	–0.091	–0.332
		(0.183)	(0.260)	(0.331)
Not partnered		–0.122	0.629	0.004
		(0.277)	(0.468)	(0.417)
Schooling		–0.088***	–0.025	–0.093
		(0.030)	(0.039)	(0.060)
Employment Status	**Retired**	0.322	–0.686	–0.906
		(0.364)	(0.395)	(0.697)
	Unemployed	0.209	–0.480	0.285
		(0.253)	(0.345)	(0.463)
	Student	1.033**	0.297	1.886***
		(0.411)	(0.758)	(0.508)
	Self-employed	0.103	–0.069	0.183
		(0.218)	(0.301)	(0.377)
Constant		4.879***	2.258***	3.867***
		(0.614)	(0.767)	(1.162)
Observations		542	184	179
R^2		0.174	0.068	0.158
F		10.15***	1.83**	4.57***

Notes: 1. Robust standard errors are in parentheses; 2. Significant variables are highlighted in red, ***P<0.001,**p<0.05,*P<0.1.

As for the case when assessing the relationship between subjective and objective measures relating to income – here too, it is clear that the relationship is mediated by sociodemographic factors for the whole sample, although sociodemographic factors do not matter for the sub-samples. People with more education were less satisfied with a given level of air quality than others. This might be because educated people have higher expectations, which lowers the actual condition of wellbeing (Clark and Oswald, 1996; Arifwidodo and Perera, 2011). People who had more adults living in their houses were more satisfied with air quality than people living in smaller households. People who were still studying were generally more satisfied with a given level of air quality than people who had a job. Why this might be the case is unclear. One explanation for the latter case might be because people who were still studying spend more time away from the village or the mine than those who were working/live in the same place, and are thus less affected by poor air quality in that region.

5.3.3 The relationship between objective and subjective indicators relating to housing

Figure 5.3 shows the percentage of houses with bathroom and flushing toilets and satisfaction with houses across the 5 different types of study region. No apparent consistency is found between the objective indicators of housing and satisfaction with housing. The percentage of houses with bathrooms and flushing toilets was much higher in urban areas than in the rural settlements. Amongst rural areas there was a positive relationship between the proximity of settlements to coal mines and the proportion of houses with bathrooms and flushing toilets (see Figure 5.3). It could be inferred that the existence of coal mining has improved local housing conditions and public infrastructure (Coal Association of Canada, 2011; National Mining Association, 2014), as the existence of bathrooms and flushing toilets requires reticulated water supply and functioning sewerage systems.

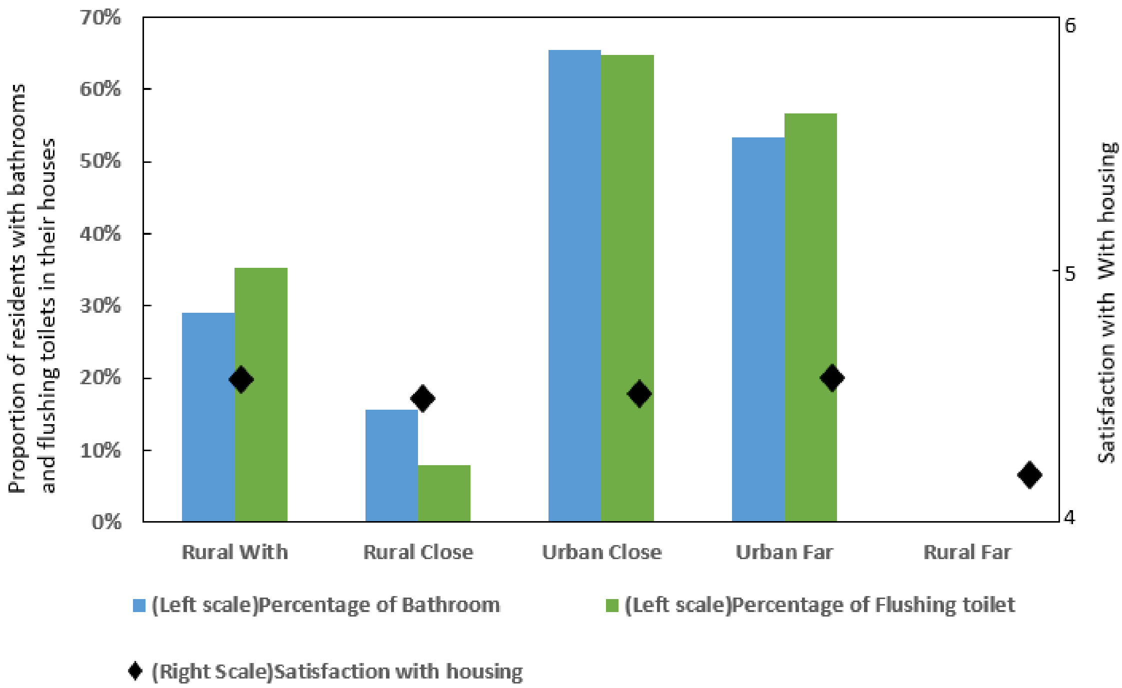


Figure 5.3 Percentage of houses with bathrooms and flushing toilets and satisfaction with housing by study region

Note: Scale of satisfaction with housing ranks from “neutral” (4) to “satisfied” (6) (Only the range of ‘4 to 6’ is shown in this graph, instead of ‘1 to 7’, because the actual mean scores only fall into this range).

Figure 5.4 presents average number of rooms each individual possesses and satisfaction with houses across the 5 different types of study area. Again, there is no visual consistency between these 2 indicators. No significant difference were found in the number of rooms per household amongst the households from different areas using the non-parametric tests (Kruskal-Wallis test, pairwise comparisons) (see Figure 5.4).

Similarly, the previous chapter did not find any significant differences across the areas in terms of satisfaction with housing (see the result of Kruskal-Wallis test in Figure 4.4). That said, subjective assessments and objective indicators relating to satisfaction with housing do not seem to convey either a strong or a consistent message. The potentially positive impacts of coal mining on housing are apparent in the objective indicators, but not in the subjective indicators.

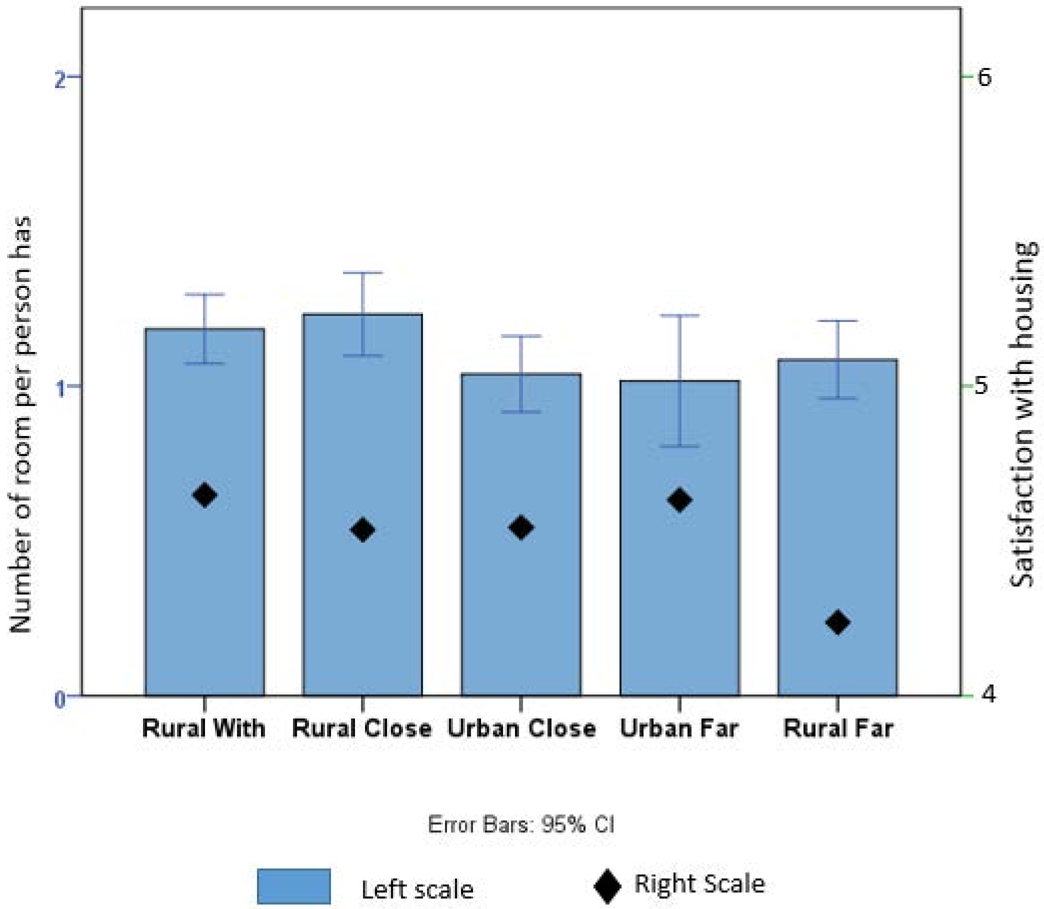


Figure 5.4 Average number of rooms each individual possesses and satisfaction with housing by study region

Note: Scale of satisfaction with housing ranks from "neutral" (4) to "satisfied" (6) (Only the range of '4 to 6' is shown in this graph, instead of '1 to 7', because the actual mean scores only fall into this range).

Table 5.3 shows the results of the OLS regression of 'satisfaction with housing" against actual housing conditions and other sociodemographic factors for the entire sample and for the rural sub-samples. The F-statistics (and associated p-values) indicate that all models are (overall) statistically significant: the (adjusted) R^2 suggest that the models explain between 8% and 61% of all variation. The apparent lack of a consistent relationship between subjective and objective measures associated with housing (from the aggregated data above) is at least partially explained by the regression equations. Generally, the existence of a bathroom and having more "rooms per person" made a positive contribution to satisfaction with housing, while having a flushing toilet did not seem to have an effect. When sub datasets were used, "room per person" was no longer a significant variable, and the effect of "bathroom" and "flushing toilet" varied among different areas. Again, the relationships between all the objective and subjective indicators were mediated by sociodemographic factors.

Table 5.3 OLS regression results – with dependent variable being subjective measures of respondent satisfaction with housing

Variables		Total sample population	Urban Close	Rural with	Rural Close	Urban far	Rural Far
Bathroom		0.893***	0.204	1.048**	0.986**	0.759	
		(0.295)	(0.853)	(0.417)	(0.457)	(1.091)	
Flushing toilet		0.241	1.301	–0.468	0.800	2.831**	
		(0.294)	(0.795)	(0.409)	(0.582)	(1.279)	
Roomperperson		0.229**	–0.024	0.155	0.278	–0.091	–0.356
		(0.115)	(0.270)	(0.199)	(0.238)	(0.484)	(0.663)
NoOfChildren		0.041	0.173	–0.144	0.146	–0.848***	–0.152
		(0.094)	(0.258)	(0.166)	(0.140)	(0.268)	(0.411)
NoOfAdult		0.055	0.002	–0.192**	0.235**	0.429**	0.006
		(0.062)	(0.117)	(0.092)	(0.109)	(0.186)	(0.280)
Age		0.019**	0.055**	0.018	0.002	0.015	0.023
		(0.008)	(0.024)	(0.013)	(0.014)	(0.032)	(0.028)
Female		–0.356*	–0.241	–0.279	–0.225	–0.750	–0.579
		(0.183)	(0.410)	(0.289)	(0.341)	(0.523)	(0.722)
Not partnered		–0.274	0.226	0.294	–1.193***	1.277	0.230
		(0.280)	(0.602)	(0.511)	(0.417)	(1.278)	(1.068)
Schooling		–0.039	–0.065	–0.040	0.020	–0.125	–0.115
		(0.030)	(0.054)	(0.052)	(0.056)	(0.118)	(0.102)
Employment Status	**Retired**	0.332	0.070	0.648	0.045	1.551	1.527
		(0.362)	(0.962)	(0.559)	(0.644)	(1.357)	(0.942)
	Unemployed	–0.332	–0.210	–0.590	0.060	–1.002	–0.709
		(0.249)	(0.839)	(0.378)	(0.464)	(1.429)	(0.845)
	Student	0.880**	1.168*	1.006	0.810	0.137	1.539
		(0.414)	(0.594)	(0.676)	(0.734)	(1.376)	(1.212)
	Self-employed	0.218	0.075	0.231	–0.068	1.957***	0.611
		(0.218)	(0.479)	(0.368)	(0.381)	(0.651)	(0.759)
Constant		3.520***	2.196	4.725***	3.130***	1.997	4.697*
		(0.601)	(1.589)	(0.996)	(1.105)	(2.162)	(2.438)
Observations		536	88	181	178	30	59
R^2		0.075	0.356	0.133	0.12	0.61	0.116
F		4.32***	6.82	2.26***	2.58	14.08	1.32

Notes: 1. Robust standard errors are in parentheses; 2. Significant variables are highlighted in red, ***P<0.001,**p<0.05,*P<0.1.

5.3.4 The relationship between objective and subjective indicators relating to education

Figure 5.5 shows the percentage of respondents who had completed a certain level of schooling across each type of study region. There is no obvious difference between coal mining and non-coal mining areas, while urban areas had a larger proportion of respondents with higher levels of education than did rural areas. That there is no apparent relationship between mining and education should not be interpreted as conclusive evidence of 'no link'. Other Researchers who have examined the relationship between resource dependence and education/human capital have used longitudinal or time-series data at provincial (Zhan et al., 2015) or country level (Gylfason, 2001; Gylfason and Zoega, 2006), and have used indicators such as public expenditure/investment on education (Gylfason, 2001) or human capital (Zhan et al., 2015)) and resource dependence rate (share of industrial output of mineral industries in GDP (Zhan et al., 2015) or share of natural capital in national wealth (Gylfason, 2001; Gylfason and Zoega, 2006)). Future research could thus seek to re-check the findings using a more substantive data set.

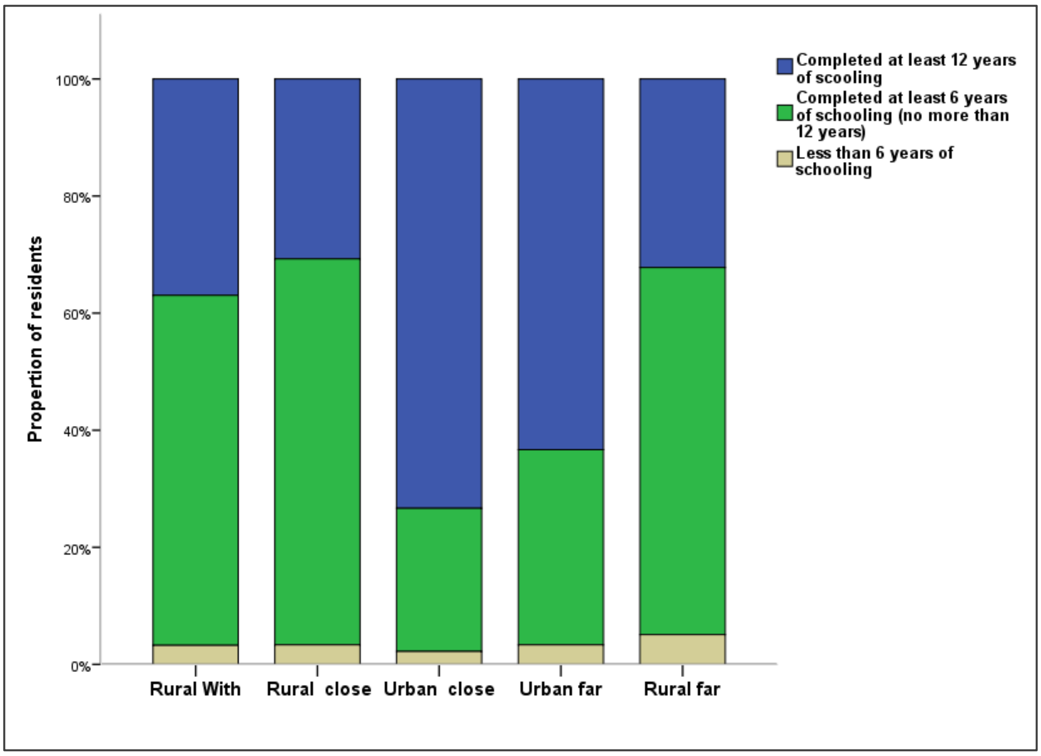


Figure 5.5 Percentage of people with different education levels by study region

Means scores relating to respondent satisfaction with educational opportunities and with the quality of education within regions are displayed in Figure 5.6. There is no apparent difference in satisfaction with the education quality and education opportunity between mining or non-coal mining areas. Interestingly, urban residents were less satisfied with their educational opportunities than rural residents, with significant differences between Urban Close and Rural With, Urban Close and Rural close (see the result of Kruskal-Wallis test in Figure 4.4). This might be associated with the fact that in urban areas, people have a preference for better schools but do not have equal access to them. Those who were not able to be admitted to the ideal school experienced "relative deprivation" – people felt deprived if they were doing less well than their counterparts in the long term (Knight et al., 2009). In contrast, in rural areas, it was common that several villages shared one school, and most rural residents confined their reference group to the village (Knight et al., 2009), therefore, much less comparison was involved. Compared Figure 5.5 and Figure 5.6, there is no obvious relationship between these objective and subjective indicators of education were found.

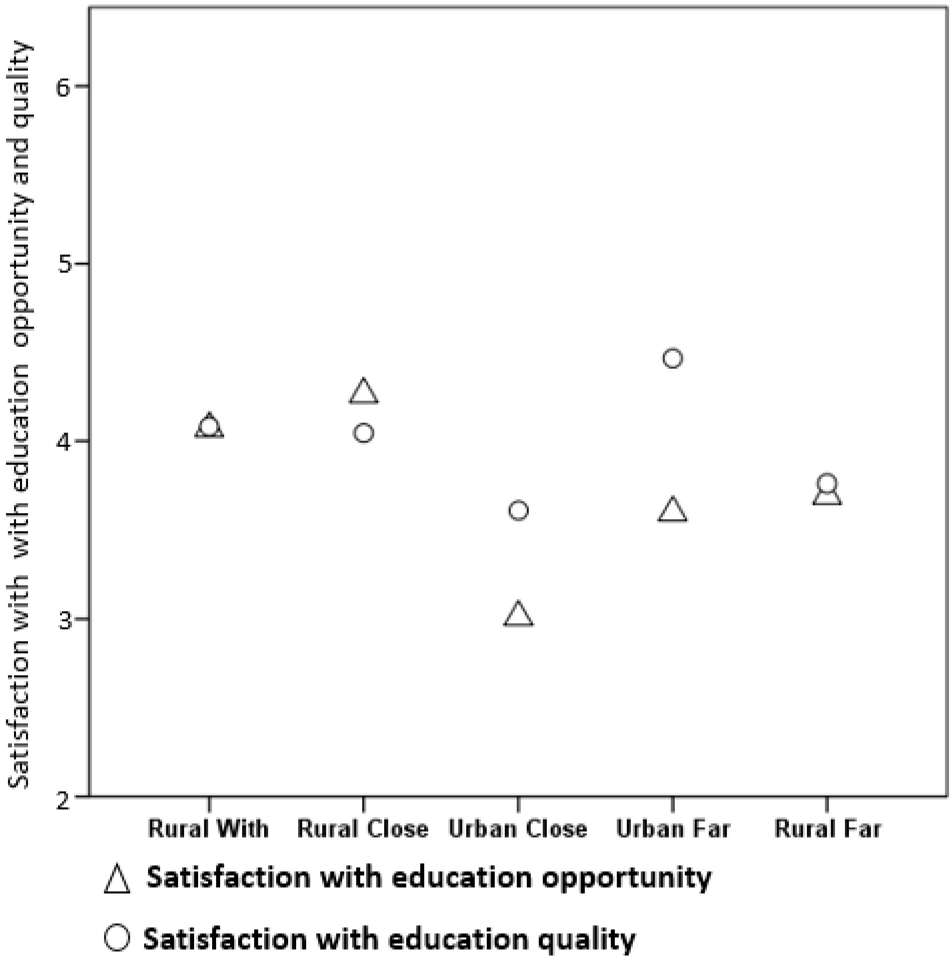


Figure 5.6 Satisfaction with education opportunity and quality by study region

Note: Scale of satisfaction with education opportunity and quality ranks from "dissatisfied" (2) to "satisfied" (6), 4 indicates "neutral" (Only the range of '2 to 6', instead of '1 to 7', is shown in this graph, because the actual mean scores only fall into this range).

The results of OLS regression (see Appendix C-4) also indicates that objective indicators of education (years of schooling of individuals) were not a significant contributor to satisfaction with education opportunity and education quality, for any of the datasets considered and the explanatory ability of these models was very low compared to the models above.

5.4 Conclusion and discussion

The objective indicators considered above suggest that coal mining has a significant negative impact on air quality and a significant positive impact on housing conditions (high percentage of bathroom and flushing toilet). There was not, however, a discernible link between other objective indicators of wellbeing and the coal mining intensity of the study regions, including income, and perhaps education. There were, however, significant and discernible differences in the objective indicators relating to family income, housing and education between urban and rural areas. This finding is consistent with the findings of others (Davey and Rato, 2012), further confirming the vast urban/rural divide in China. Coal mining does not seem to help minimize the gap between urban and rural areas, except for living conditions.

While some objective indicators of wellbeing are relatively easy to obtain and track in time (e.g. those relating to income), such indicators are not always collected for some wellbeing factors (e.g. factors relating to social capital). As discussed in section 2.3.1.3, central data collection agencies do not generally collect 'subjective' data, so it can be particularly difficult to access subjective indicators for numerous wellbeing factors. Until, and unless, one is able to access both objective and subjective indicators, over time, across numerous domains, we can only work with admittedly sub-standard data to draw whatever inferences we can about the extent to which the two sets of wellbeing indicators are aligned and if OWB can be used to infer SWB or vice versa.

In this study, I assessed the relationship between 4 different pairs of subjective and objective indicators. When using aggregated data, it was clear that higher levels of actual family income were associated with higher satisfaction with income, and that higher levels of PM_{10} were associated with lower satisfaction with air quality. When using individual data (in the regression analyses) and controlling for sociodemographic factors, it was revealed again, that objective indicators of annual family income and air quality (PM_{10}) were generally good predictors of subjective satisfaction with family income and air quality, respectively – although these relationships were partially mediated by sociodemographic factors.

Generally, objective indicators of housing were not very good predictors for subjective satisfaction with housing: there were no consistency between these indicators when using aggregated data; when using individual data, the existence of flushing toilets and number of rooms per person were not good predictors of satisfaction with housing, while having a bathroom seemed to indicate high satisfaction with housing – again, these relationship were partially mediated by sociodemographic factors. No matter if using aggregated or individual data, subjective and objective indicators relating to education did not seem to be portraying similar types of information.

To briefly recap key results relating to the 'impact' of mining on wellbeing: it matters not whether one considers objective or subjective indicators, there is no apparent relationship between coal mining and family income. Average family incomes, and average 'satisfaction' with family incomes are similar in mining and non-mining regions. This is despite the fact that coal mining is said to be a significant contributor to the local economy (Editor of Land & Resource Herald, 2013), and despite the fact that those who work in the mining industry earn, on average, higher incomes than those who work in other industries (see Table 3.9 and Appendix B). Evidently, for every family within a coal-mining region who has someone works in the industry and brings home an inflated income, there is another 'matching' family that is not associated with the mining industry and brings home a deflated income (so on average, they balance out). But that begs a more sophisticated investigation – given over to chapter 6.

Objective and subjective indicators also tell a consistent – although entirely negative – story about the impact of mining on air quality. Coal mining had negative impacts on air quality (higher level of PM_{10} and lower level of satisfaction with air quality in coal mining areas than non-coal mining areas). These findings are also consistent with the findings of other researchers (e.g. Zullig and Hendryx, 2010; Bian et al., 2010; Colagiuri et al., 2012).

Coal mining may also have positive impacts on housing conditions. This is only revealed by the objective indicators considered here – but is supported by findings from the broader literature (Zhang et al., 2015).

When looking at the relationship between objective and subjective indicators, it seems that objective indicators can be used to predict satisfaction for some wellbeing factors, but not for others. This is consistent with the findings of Emmons and Diener (1985). They suggested that one might expect there to be different, and potentially unpredictable relationships between objective and subjective indicators because some of the 'domains' that contribute to wellbeing may be more (or less) inherently satisfying than others. In this study, housing conditions were consistently given relatively high satisfaction scores (see Figure 5.4, satisfaction scores with housing were all above 4 (neutral)), indicating that housing might be one of those such domains. Davey and Rato (2012) also confirmed that rural residents in China were generally satisfied with their living standards despite the low life quality in objective terms.

The inconsistency between objective and subjective indicators of housing partially reflect the inadequacy of the objective measurements of wellbeing: they may, quite simply, reflect too narrow a lens on what constitutes 'wellbeing'. For example, good housing conditions are not only reflected in the existence of bathrooms and flushing toilets and more rooms: other factors, such as dampness, and the quality of construction, will also influence people's satisfaction with their housing, and thus ultimately their wellbeing. Anecdotal evidence suggested that people from coal mining areas were concerned with the safety of their houses due to the likely subsidence caused by coal mining, which might partly explain why they were not significantly more satisfied with their housing despite the fact that they had 'better' housing (measured by objective indicators used here and OECD (2011)) than those living far away from coal mines. Until or unless one is able to obtain more 'objective' data describing a broader range of factors that contribute to housing quality, it seems as if subjective measures (which will likely encompass the other, difficult-to-measure factors) are likely defensible indicators of the housing quality and of the contribution that good quality housing makes to overall wellbeing.

Even without this 'scope' issue (where an indicator of satisfaction likely encompasses a broader range of factors than those captured by a single objective indicator), it will not always be the case that subjective and objective indicators exactly align and measure the same thing. In this study, the subjective indicator relating to education was defined in terms of educational opportunity/quality and it may thus capture aspects of institutional capital; in contrast educational attainment (the 'objective' measure used in this study) is more likely an indicator of human capital (e.g. Frey & Stutzer, 1999; Di Tella et al., 2003; Lange and Topel, 2006; Smyth et al., 2011). Misalignment of indicators thus likely explains the lack of correlation between them. A better-matched subjective indicator of educational attainment might instead be 'how satisfied are you with your education level?' Although such a question might better match the objective indicator, it would not convey much valuable information about education quality, opportunity and/or concerns with the education system – again suggesting that comprehensive assessments of wellbeing are probably best undertaken with a mix of subjective and objective indicators.

The link between objective and subjective indicators might also 'break down' for other reasons. For example, air quality or many other objective indicators (Oswald and Wu, 2010) are not always available at smaller geographic scales, so that researchers need to use objective wellbeing data that have been collected at one scale, when making comparisons with subjective wellbeing data that have been collected at another scale (e.g. from individuals) (e.g. Schneider, 1975; Oswald and Wu, 2010). This is termed as "scale discordance" by Lee and Marans (1980) – "a terms used to recognize that the territorial base of an individual's subjective evaluation may not coincidence with the boundaries of the unities used for the collection of objective data" (Lee and Marans, 1980, p. 47). Lee and Marans (1980) also pointed out that scale discordance affects all domains of wellbeing that incorporate a territorial component (e.g. satisfaction with air quality in a village), and is one of the explanations for the imperfect relationship between objective and subject measure of wellbeing.

As discussed in section 2.5.5, if researchers are interested in the wellbeing of people from diverse regions (like those considered here – e.g. villages with or without mining), then using highly aggregated objective wellbeing indicators at the county level (including numerous villages) might eliminate those variations among villages and mask important difference (Schneider, 1975). This is often referred to as 'unobserved heterogeneity'. Lee and Marans (1980) found that there would be a greater correlation between the objective and subjective measures when the 2 sets of data are at a similar geographic scale. Thus, it can be inferred that when examining the relationship between objective and subjective measure of wellbeing that incorporate a territorial component, maintaining the 2 sets of data at a similar geographic scale – and probably a smaller scale as objective data collected from a large geographic area tend to mask more heterogeneity – may reduce scale discordance and unobserved heterogeneity.

In this particular study, all the objective and subjective were collected at individual level except air-quality measure, which was collected on the basis of locations (one reading for one village or city). As a village in China is a much smaller geographic area than a city, one can expect lower level of scale discordance and unobserved heterogeneity for samples from villages than for samples from cities. However, it would have been present if, for example, some respondents in a village lived up-wind from a coal mine, while others lived down-wind. Future study may better investigate this issue using the air-quality data with higher resolution (e.g. at individual household level).

In particular, objective indicators fall short when measuring attitudinal matters, such as "trust" and "perceived safety" in the street (Veenhoven, 2002), that are considered as indicators of social capital in this study and many other (e.g. Prewitt et al., 2014). According to Prewitt et al. (2014), social capital can be measured by objective indicators – e.g. using network structures that link individuals (such as voluntary association memberships); but these objective indicators are inherently different from subjective indicators (such as measures of trust in others or of norms of reciprocity) and thus measure different elements of social capital.

5.4.1 Implications for policy makers

By exploring the impacts of coal mining using both objective and subjective indicators, this chapter further confirms that coal mining does not have any obvious impacts on income in host communities. Coal mining improves the living conditions, but it dramatically affects the natural environment and people's satisfaction with the natural environment (air quality, in particular). Messages from objective data in this chapter confirms the policy priority in coal mining areas should be addressing environmental issues (air quality in particular), which is consistent with the finding from the previous chapter using subjective data.

The analysis of this chapter also demonstrates that despite the fact that objective indicators are considered by some to be 'superior' indicators, and that they are based upon objectively verifiable data, they are not unambiguously 'better'. This analysis illustrates that not only do subjective wellbeing indicators provide feedback about, for example, the level of satisfaction of local residents with existing conditions, but they also provide information about some factors which objective indicators are unable to adequately capture. While objective indicators provide useful information, they also omit important aspects of wellbeing, especially when single, aggregated measures, mask differences within regions, and are not able to reveal information about people's preferences.

It seems that subjective indicators are an important complement to objective indicators when seeking to describe, measure and/or explain wellbeing, and thus inform public policy. The consistency between objective and subjective indicators of air quality and income indicates that it might be appropriate to choose any of them to measure these indicators. Notably, since this relationship between objective and subjective is partially mediated by sociodemographic factors, it is thus correct to say that improvements in household income (or reduction in PM_{10}, or in the number of houses that have bathrooms) will be accompanied by improvements in people's satisfaction with their income (or air quality or housing). But it does not necessarily mean people who have high income (or good air quality, or a bathroom in their housing) will be more satisfied with their income (or air quality, or house) than others with lower income (or with poor air quality or no bathroom).

For other wellbeing indicators, where the objective indicators are not good predictors of subjective indicators, both may be needed to inform public policy (in this case, improvements measured by objective indicators are not always reflected with improvements in satisfaction).

5.4.2 Methodological contribution

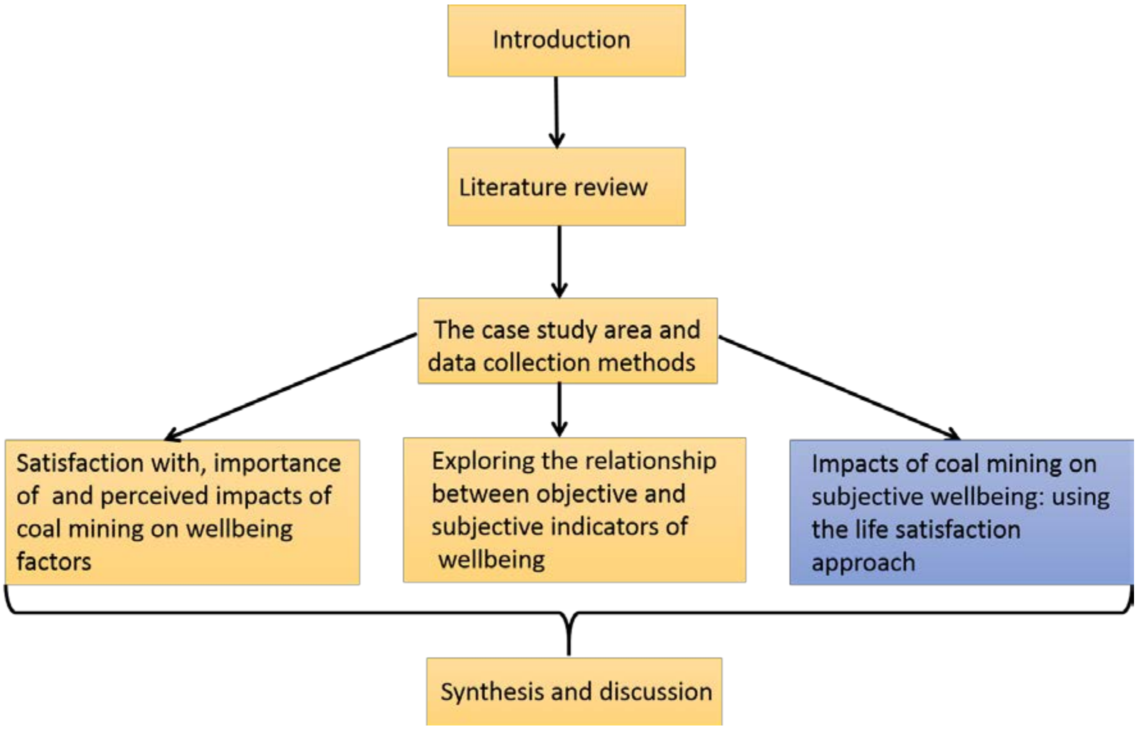
Not only does this chapter illustrate that objective and subjective indicators do not always convey consistent messages (thus demonstrating the utility of subjective indicators to inform public policy), but it also demonstrates empirical approaches to examine the relationship between these 2 sets of indicators. Using these approaches, future studies can examine the relationship between objective and subjective indicators relating to other wellbeing factors and in other social contexts. The general approaches then enable researchers or decision makers to decide when (in which regions, and for which factors/domains) it may be appropriate to use only objective indicators, when it may be appropriate to use subjective indicators, and when it might be necessary to use both. This study also offers direction for future studies to better investigate the relationship between these 2 measures of wellbeing. For example, future studies can control for sociodemographic factors, align the scope of these 2 measures and use data with higher resolution (e.g. at individual level) to reduce the scale discordance and unobserved heterogeneity.

5.4.3 Implications for future studies

As noted earlier, when working with regional environmental data, unobserved heterogeneity occurs when a person living in one part of a region experiences different conditions to those of someone living elsewhere in that region (Welsch, 2006), which might be one of the issues that affect the relationship between objective and subjective indicators. This exploratory investigation into the relationship between PM_{10} and satisfaction with air quality did not address that potential problem, like many/most other life satisfaction studies (e.g. Welsch, 2006). Using time-series data, some studies that have sought to investigate the relationship between air pollution and life satisfaction have demonstrated techniques for dealing with the problem of unobserved heterogeneity by, for example, including distance from central business district (MacKerron & Mourato, 2009) or distance from air monitoring system (Ferreira et al., 2013). Future studies could thus usefully consider the link between subjective and objective measures of air quality, using such techniques or data at individual level to control for unobserved heterogeneity and generating results that could be treated with more confidence.

The relationship between objective and subjective indicators of wellbeing might be different in different cultures/settings, suggesting the need for further research to confirm or refute findings here in other social contexts. Further research could also explore relationships between more objective and subjective indicators to inform public policies.

Thesis outline



CHAPTER 6 IMPACTS OF COAL MINING ON SUBJECTIVE WELLBEING: USING THE LIFE SATISFACTION APPROACH

Chapter outline

6.1 Introduction

6.2 Analytical method

6.2.1 Assessing the impacts of coal mining on different life domains

6.2.2 Assessing the impacts of coal mining on global life satisfaction

6.3 Results

6.3.1 Determinants of satisfaction with life domains

6.3.2 Impacts of coal mining on global life satisfaction

6.4 Conclusion and discussion

6.4.1 Implications for policy makers

6.4.2 Methodological contribution

6.4.3 Implications for future studies

Synopsis

This chapter uses more sophisticated techniques than those employed in chapter 4 to test for statistically significant 'impacts' of coal mining on subjective wellbeing – considering impacts on satisfaction with different life domains and on global life satisfaction (GLS). Life satisfaction models were developed to generate empirical results – essentially regressing satisfaction (with a particular life domain, or with life overall) against numerous sociodemographic factors known to influence life satisfaction, and also variables capturing mining intensity.

Coal mining was found to have statistically discernible impacts on satisfaction with various life domains in host communities. Strong evidence is found to support previous 'suggestive' results, namely that: those living in rural coal mining areas were less satisfied with the natural environment, the economy and society than those living in rural areas disassociated from mining. Evidence was also found to suggest that those living in rural coal mining areas were generally more satisfied with their living conditions than those living further away from the mines. So there are clearly some 'costs' and some 'benefits'.

The analysis of overall life satisfaction allowed for an assessment of 'net' impacts on host communities – statistically significant, and negative in rural areas with coal mining. It was found that those living in rural areas with coal mining were less satisfied with life overall, than those living further away (either near or far away). I was able to use coefficients from the model to infer that if one wished to ensure that these 'unsatisfied' people were given enough money to raise their satisfaction to a similar level as those living further away, then those people would need, on average, 20,000 Yuan per annum. The analysis also demonstrated that those who were dependent upon coal mining for their household income, were much more satisfied with life overall, than those who lived in the same village, but were dependent upon other industries. The models suggest that if one wished to ensure that these 'unsatisfied' people were given enough money to raise their satisfaction to a similar level as those who depend upon the mining industry for their household income, then they would need, on average, 47,000 per annum. These models used to generate these estimates are, like most models, inherently imperfect – so results should be treated with caution: generating indicative, rather than precise estimates of 'net impact'.

6.1 Introduction

Current methods for conducting mining impact assessments, such as environmental impact assessment, social impact assessment and economic impact assessment are limited in their ability to simultaneously assess a large variety of non-market impacts associated with of coal mining. It is thus difficult to adequately assess trade-offs associated with mining (e.g. potential increases in income weighed against negative impacts on air quality). Although market-based (MB) approaches, revealed preference (RP) and stated preference (SP) have been used to assess some of the impacts associated with mining (e.g. Trigg and Dubourg, 1993; Ivanova et al., 2007; Gillespie and Kragt, 2010; Li et al., 2011), the methodological techniques constrain researchers to consider only a small number of impacts. The life satisfaction (LS) approach, which may avoid some of those disadvantages, has not previously been used to assess impacts of mining. Thus, this chapter uses the LS approach to assess the multiple impacts of coal mining, the ultimate aim being to provide better information about the impacts of coal mining on different life domains, and on the quality of life overall.

Most apparent from the literature review in chapter 2, is that numerous factors influence GLS – these include, but are not limited to things such as satisfaction with particular life domains, location (e.g. rural/urban) and a range of sociodemographic factors such as age, gender, education, and marital status. Table 3.9 in chapter 3, clearly shows that the sociodemographic characteristics of the different sub-samples included in this study varied significantly; there were, for example, a higher percentage of males included in the Rural With sample (47%), than in the Rural Close or Rural Far samples (approx. 36% each). Since sociodemographic variables influence GLS (and satisfaction with life domains – as shown in chapter 5), it is not strictly valid to simply compare GLS (or satisfaction with particular life domains) across regions, attributing differences to rural/urban local or to distance from coal mines. One needs to determine if there are differences in GLS (or satisfaction with particular life domains) across regions with different intensities of mining, after having controlled for differences associated with 'confounding' factors (such as age and gender).

The overarching research question addressed in this chapter is thus: Is it possible to quantify the net impacts of coal mining (on broad 'domains' of life and on the overall wellbeing of host communities) and to determine how much should, in principle, be paid 'in compensation' to those who are, overall, impacted negatively? It is answered by addressing the following sub-questions:

1) How does coal mining affect satisfaction with life domains (after controlling for confounding factors)?
2) How does coal mining affect global life satisfaction (after controlling for confounding factors)?
3) If the net impact of mining, on global life satisfaction, is negative, then how much extra income would need to be paid to the negatively impacted people, to raise their 'satisfaction' to the same level as their unaffected counterparts?

Methods used to analyse the data are described in section 6.2. Section 6.3 presents results relevant to the research questions followed by a discussion in section 6.4.

6.2 Analytical method

The hypothesis underlying the investigations of this chapter is that a respondent's stated satisfaction (with a particular life domain or with life overall) will depend upon proximity to coal mining, and to a range of other factors, relating to location (urban/rural) and to the sociodemographic characteristics of respondents. To test this hypothesis, a series of multiple regressions were conducted, using stated satisfaction (with particular life domains, and later, with life overall) as the dependent variable, and including sociodemographic variables as regressors – in addition to variables associated with proximity to coal mining. Further details are given below.

6.2.1 Assessing the impact of coal mining on different life domains

6.2.1.1 Identifying 'domains' and dependent variables for use in regression equations

In theory, one could investigate the 'impact' of mining on each of the 29 different wellbeing factors discussed in Chapter 4, using the life satisfaction approach. However, as noted in chapter 2, many of those wellbeing factors are likely related. Several researchers have undertaken analyses that have grouped the numerous factors considered by researchers to influence wellbeing into a smaller subset of 'domains (e.g. Cummins, 1996; Larson et al., 2011, 2013, 2014). The general method used by these researchers was the principal components analysis (PCA) with varimax rotation (e.g. Larson et al., 2011, 2013, 2014), and it is the approach that was used in this study.

Specifically, I used PCA to identify factors that grouped together into common domains. Having done this, I then sought to calculate a 'score' for each component (i.e. each life domain). Scores can be calculated using a variety of approaches, the appropriateness of which depends on context. There are two main classes of score computation: non-refined and refined. Non-refined scores are computed using simple methods, such as calculating the sum or average of all variables identified as belonging to a domain (DiStefano et al., 2009). Refined scores, in contrast, are computed using more sophisticated and technical methods, such as regression scores. In general, non-refined scores are thought to be more stable across samples than refined methods (Grice & Harris, 1998, cited by DiStefano et al., 2009); and sum/average scores are preferred when undertaking exploratory research (Tabeachinck and Fidell, 2001 and Hair et al., 2006, cited by DiStefano et al., 2009). Moreover, using an average score preserves variation in the original data, helps retain the scale metric and fosters comparison across factors (DiStefano et al., 2009). For these reasons, mean scores were used here. Specifically, the mean score for each life domain was calculated by calculating the mean of all factors within each domain that had a loading value above 0.3 – only using 'marker' factors with stronger loading to take into account a factor's relationship to the life domains (DiStefano et al., 2009). It is those means scores which are used as the dependent variable in each regression equation.

An aggregated radar chart was created, showing scores for each 'domain' by study region. This chart was compared with the chart from chapter 4 (Figure 4.4) to check for observational consistency and to make a preliminary assessment about the way in which these aggregated indicates of satisfaction with life domains differed across case-study areas.

6.2.1.2 Selecting independent variables and defining the generic model

As discussed in section 2.3.2.6, sociodemographic factors such as marital status (Ballas and Dorling, 2007; Brereton et al., 2008), age (Brereton et al., 2008; Stutzer and Frey, 2008), family size(Frijters and Van Praag, 1998; Frey and Stutzer, 2000; Moro et al., 2008; Stutzer and Frey, 2008), and gender (Frey and Stutzer, 2000; Di Tella et al., 2003; Brereton et al., 2008; Moro et al., 2008; Arifwidodo and Perera, 2011) have all been found to affect subjective wellbeing. These 'control variables' were thus included as regressors in the models (see equation 4).

$$DS_i = f\,(Withcoal_i,\ Farcoal_i,\ Miningincome_i,\ Withminy_i,\ Income_i,\ Miningincome_i,\ Age_i, Female_i,\ NotPartnered_i,\ NoOfChildren_i,\ NoOfAdult_i,\ Education_i,\ EmploymentStatus_i) \qquad \text{Equation 4}$$

Where:

DS_{ij}	– factor score for life $domain_j$
	proximity to coal was measured using two dummy variables, set equal to 1
WithCoal	– adjacent to a coal mine
FarCoal	– living more than 10km away from a coal mine
NearCoal	– the reference group (live within 10 km from a mine)
$MiningIncome_i$	– a dummy variable, set equal to 1 if individual *i* was dependent upon the mining industry for income (0 otherwise)
$WithMiny_i$	– was an interactive variable (Withcoal*MiningIncome), set equal to 1 if individual *i* lives in places with coal mining and get income from coal mining(0 indicates individual *i* lives in places with coal mining and does not get income from coal mining)
$Income_i$	– family income of person *i*
$NoOfChildren_i$	– the total number of children living in the respondents house
$NoOfAdult_i$	– the total number of adult living in the respondents house
Age_i	– age of the respondents
$Female_i$	– a dummy variable, set equal to 1 if person *i* was female (0 otherwise)
$Notpartnered_i$	– a dummy variable, set equal to 1 if person *i* had no partner (0 otherwise)
$Schooling_i$	– maximum of years of schooling the respondent has
	measured using a series of dummy variables, set equal to 1 if:

Employment status$_i$	– retired – jobless – students – self-employed

Note the potential impacts of mining are captured within the model in multiple ways. First, dummy variables were used to distinguish respondents according to their proximity to a coal mine. Second, a dummy variable was also used to identify people who were dependent upon the coal industry for their living. Third, an interactive (dummy) variable was used to distinguish between those living adjacent to coal mines who were (or were not) dependent upon the coal mining for their income. These variables were used for the following reasons.

- When collecting data in the field, it seemed that the attitudes of individuals towards coal mining were different between those who relied upon coal mining for their family income, and those who did not (e.g. those relying on agriculture, see the quotes in p. 124 and p. 125). Differences in income dependence might thus affect attitudes towards the mine.
- People working for the coal mines often originated from other regions (having migrated from other areas for mining jobs). Irrespective of income dependence, there might be attitudinal differences, related to 'place of origin' [19].
- Preliminary data analysis highlighted significant differences between the mean income of those dependent on the coal mining industry for household income, and those dependent upon other industries (see Table 3.9 and Appendix B).

6.2.1.3 Running the regressions

There were no observations collected from urban areas 'with' coal mining – since coal mines are not permitted to operate within urban areas – and whilst relatively large samples were collected in rural areas, the urban samples were quite small. As such, it was not feasible to develop a single model, using 'matching' dummy variables to capture distance to mines. Two data subsets were thus used for the analysis: that pertaining to

[19] Although this study did not collect data from the mining companies, anecdotal evidence (collected during conversations with residents of villages) suggests that on average, only about 30% of coal miners are 'local' residents; most workers are imported, by companies, from other regions.

data collected from urban areas, and that collected from rural areas. Not only does this simplify the analysis, and allow one to explicitly allow for differences in coefficients between rural and urban areas, but it allows for a focus on rural areas, which are more closely exposed to the impacts of coal mines than urban areas, and which are the core major interest of this study. This approach is also in line with other studies of wellbeing in China which usually differentiate urban (Appleton and Song, 2008; Smyth et al., 2011) and rural areas (Knight et al., 2009).

As discussed in the preceding chapter, ordinary least squares (OLS) regression was designed for a continuous, and normally distributed, dependent variable. The factors scores used to here does not strictly satisfy that assumption (although using mean factor scores rather than Likert data markedly reduces, if not eliminates, the problem of categorical data). So in the first instance, both OLS and ordinal regression were run. As was the case for chapter 5 (section 5.2), and has been the case in many other studies cited in section 5.2, differences between OLS and the models were negligible[20]. So OLS was thus used for primary analysis, results from the ordinal regression were used as a cross-reference and robustness check.

6.2.1.4 Using coefficients to draw inferences about the impacts of mining on satisfaction with life domains

In urban areas, there were only two groups (Urban Close and Urban Far). A single dummy variable ('FarCoal') can distinguish between the two, with the reference group being Urban Close ('NearCoal'). This means it is possible to simply inspect the coefficient on the identifying dummy variable ('FarCoal'), determining if it was statistically significant, and (if so) if the presence of mining had a positive or negative impacts on satisfaction with particular life domains (after having controlled for all other factors).

In rural areas, however, there were three groups (Rural With, Rural Close and Rural Far). The reference group is Rural close ('NearCoal'), which means that it is possible to tell if there are statistically significant differences in the satisfaction with particular domains

[20] See Appendix D-1 for results of ordinal regressions examining the determinants of satisfaction with life domains.

between those living Rural With and Rural Close, by examining the coefficient on the dummy variable 'WithCoal'. Similarly, it is possible to tell if there are statistically significant differences in the satisfaction with each domain between those living in Rural Far and Rural Close by examining the coefficient on 'FarCoal'. However, post-estimation tests must be undertaken to assess differences between Rural with and Rural Far, by examining the coefficients 'WithCoal' and 'FarCoal'.

To explain, consider the following simple equation describing the relationship between the variable of 'WithCoal' and 'FarCoal'. If the coefficients on the two variables are identical, then the difference between the two will be zero. The hypothesis underlying post-estimation tests is thus that there is no significant difference between the coefficients of these 2 variables, i.e. that:

$\beta_1 WithCoal_j - \beta_2 FarCoal_j = 0$ **Equation 5**

Where:

$\beta 1$ = the coefficients of 'WithCoal' from the results of Equation 4

$\beta 2$ = the coefficients of 'FarCoal' from results of Equation 4

The statistical packaged used to analyse data (STATA) has an in-built post-estimation test that allows one to specify such a null hypothesis, and it is that which was used here.

6.2.2 Assessing the impacts of coal mining on global life satisfaction

6.2.2.1 Preliminary analysis of the dependent variable and its relation to mining

As stated in section 3.4.1, the questionnaire collected data relating to GLS using two different methods: the 0 – 100 scale, similar to Cantril's Ladder (Cantril, 1965) and the Satisfaction With Life Scale (SWLS) (Diener et al., 1985). To determine which measure would be better to use in the regression analysis, the consistency of responses across the two measures at both a regional level (by observing the mean values across 5 regions) were firstly looked at. Then the consistency of responses at an individual level was also looked at (checking correlation). Since the 2 measurements of global life satisfaction seem to provide similar information, the finer-scale measure of GLS (specifically, the LS rating (0 – 100)) was selected for use in the subsequent analyses.

Non-parametric tests (Kruskal-Wallis pairwise comparisons) were also used to test for the statistical significance of differences in GLS across the five study regions, and the distribution of responses were examined in urban and rural areas. The obvious differences confirmed the wisdom of separating data sets before undertaking the regressions. The impacts of coal mining on global life satisfaction were then investigated, using approaches identical to those for satisfaction with each domain, which allows holding constant the influence of other confounding factors. These regressions used the same dependent variables identified in Equation 4.

Again, both OLS and ordinal regression were used; again, they produced similar results (with respect to the significance of coefficients)[21], so the OLS results are used for ease of interpretation. As previously post-estimation tests were also used to identify statistically significant differences between the coefficients for Rural With and Rural Far. Post-estimation tests were also used to identify statistically significant differences between the constants in the urban and rural models to compare the coefficients relating to Urban Close and Rural Close.

6.2.2.2 Determining the 'value' (cost) of mining on GLS

As discussed in section 2.2.2.2, coefficients from the LS equation can be used to estimate the amount of extra income, which can be given to an individual to compensate for the presence of a mine in their region (assuming, for the moment that coal mines have a negative net impact on life satisfaction). This 'compensation' ensures that the increase in LS associated with the increased income, exactly corresponds to the decreases in LS that is associated with the presence of the mine.

To explain, consider the following simple equation describing LS.

$$LS_{ij} = \alpha + \beta_1 CoalMine_j + \beta_2 Income_I + \beta_3 X_{Ij} \qquad \textbf{Equation 6}$$

Where:

LS_{ij} is the reported LS of individual *i*, in community *j*

$CoalMine_j$ is a dummy variable set equal to 1 if there is a coal mine associated with community *j*

[21] See Appendix D-2 for results of ordinal regressions examining the determinants of global life satisfaction.

Income$_j$ is the income of individual *i*, in community *j*

X_{ij} is a vector of the other variables known to influence LS

β_1 = MC $_{CoalMine}$ is the impact of a coal mine on LS

β_2 = MB$_{Income}$ is the (marginal) impact of additional income on LS

Holding all 'confounding' factors constant, the difference in LS between an individual living in a region that has a coal mine, and an 'identical' individual (e.g. same sociodemographic, same income) who lives in a region without a coal mine is β_1. So if a mine were to 'appear' in a region that previously did not have one, the model predicts that LS would go down by β_1. Each unit of income (RMB) gives an extra 'β_2' units of LS. So one could 'compensate' for the mine, by giving each individual within that region an increase in income = β_1/β_2 (termed the marginal rate of substitution = marginal disutility of mining / marginal utility of income).

This approach to assessing, and then comparing, the marginal disutility of a range of public 'bads' with the marginal utility of income has been used in many studies focusing on: airport noise (Van Praag and Baarsma, 2004), air pollution (Welsch, 2006; Luechinger, 2009; MacKerron and Mourato, 2009), terrorism (Frey et al., 2009), corruption (Welsch, 2008) and disasters (Luechinger and Raschky, 2009). Some have even proposed a compensation scheme using the results of LS studies to compensate those experiencing reduced wellbeing from public 'bads' (e.g. airport noise (Van Praag and Baarsma, 2005)). A similar approach is thus used here, to assess the extent to which proximity to coal mining affects GLS, and to calculate the income that would be required to 'compensate' people for any negative impacts, although such calculations were done relative to the 'reference group' (e.g. those living near coal).

Here

- The amount of income that would need to be paid to 'compensate' someone who lived 'with coal', compared to those who lived 'near coal', is calculated as:

$$\text{MRS}=\frac{\partial GLS/\partial WithCoal}{\partial GLS/\partial Income}=\frac{\partial WithCoal}{\partial Income}$$

- The amount of income that could be taken away from people who were living adjacent to coal mines and were dependent upon the coal mining for their income (similar to a 'negative compensation'), compared to those who were living in the same region but were not dependent upon the coal mining for their income is calculated as:

$$MRS=\frac{\partial GLS/\partial WithMiny}{\partial GLS/\partial Income}=\frac{\partial WithMiny}{\partial Income}$$

6.3 Results

6.3.1 Determinants of satisfaction with life domains

Table 6.1 presents the factor loadings from the PCA of responses to questions about satisfaction with individual subjective wellbeing indicators – with the names that were allocated to each factor shown across the top of the table. Satisfaction with each of these 29 wellbeing factors collapsed to 6 life domains. The six life domains are generally consistent with the grouping of Cummins (1996) (see section 2.3.3) – although, in this study, property safety and personal safety loaded separately onto factors identified as 'living conditions' and 'social capital'. This loading is most likely occur because many people link their property safety to their house (living conditions), while personal safety is more strongly linked to social capital (Rose and Clear, 1998; Akçomak and ter Weel, 2012; Zhong, 2013). Family income loaded onto two factors 'economy' and 'human capital'; evidently because it is strongly linked to both (Dagum, 2004). Personal and family relationships, similar to the domain termed "intimacy" by Cummins (1996) in this study, loaded on both 'social capital' and 'human capital'. Water safety loaded onto both 'living conditions' and 'environment'. Water safety seems more obviously associated to environment than living conditions, and the analysis of the previous chapter strongly demonstrated that, water safety, along with other environmental indicators, was more likely to be negatively affected by coal mining. While living conditions might not or not negatively affected by coal mining (objective indicators indicated that coal mining had positive impacts on living conditions). Thus, water safety" was excluded from "living conditions" when we calculated aggregated scores from the factors loading.

Table 6.1 Life domains created using PCA on satisfaction scores for the 29 wellbeing factors, with factor loadings

Human capital	Economy	Social capital	Institutional capital	Living conditions	Natural environment
Family mental health (0.841)	Inflation (0.668)	Honesty (0.802)	Education quality (0.794)	Water supply (0.688)	Overall air quality(0.941)
Family physical health (0.788)	Price of necessaries (0.659)	Help (0.766)	Education opportunity (0.777)	Electricity supply (0.680)	Air cleanliness (0.939)
Personal mental health(0.782)	Income disparity (0.644)	Trust (0.759)	Participation of social activity (0.455)	Property safety (0.475)	Dust (0.908)
Personal physical health (0.725)	Real estate price (0.626)	Personal relationship (0.442)	Transportation & communication (0.388)	~~Water safety (0.465)~~	Water safety (0.401)
Family relationship (0.425)	Fairness (0.531)	Personal safety (0.344)	Government (0.343)	House (0.436)	
Personal relationship (0.426)	Family income (0.504)	Family relationship (0.344)			
Family income (0.366)					

Notes: 1.Highlighted wellbeing factors are loaded onto more than one life domain, “water safety” was deleted from “living conditions” as explained above; 2. Factor loadings are in parentheses.

Figure 6.1 shows the mean satisfaction score for each life domain. Satisfaction with natural environment varies most across different regions, while other domains, especially human capital, do not vary much. This is consistent with the message from Figure 4.4 (which looked at the 29 individual wellbeing factors).

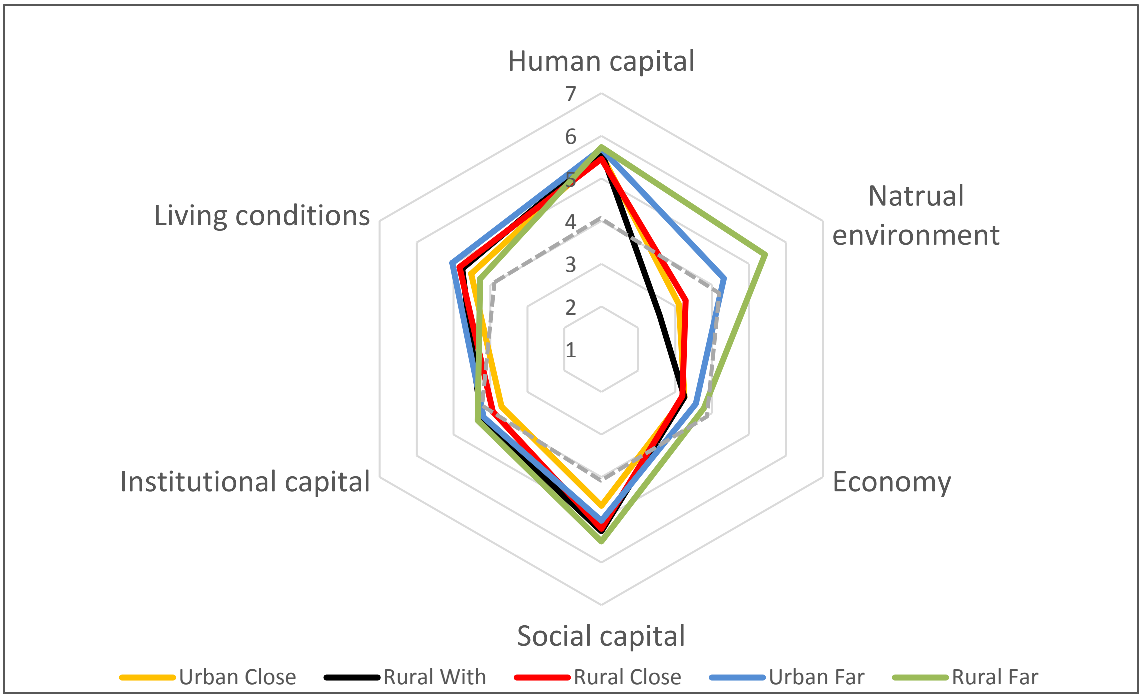


Figure 6.1 Satisfaction with life domains

Note: Scale ranks from "very dissatisfied" (1) to "very satisfied" (7), 4 indicates "neutral".

Table 6.2 presents the results from the regressions that sought to determine if mining impacted particularly life domains, holding constant other potentially confounding factors. Overall, most of the models were statistically significant, although the explanatory power of these models is not high. Income had a positive impact on (satisfaction with) human capital and on the economy in both urban and rural areas, and with living conditions in rural areas. Age had positive impact on some life domains. Females were less satisfied with institutional capital than males in rural areas. Students were more satisfied with some life domains than those who were working. Years of schooling is inversely correlated with (satisfaction with) living conditions and the environment in rural areas. The number of children and/or adults living in the house and marital status are not significant in any of the models.

As shown in Table 6.2, in rural areas, those living far away from coal mines reported high levels of satisfaction with the human capital, economy, institutional capital, and environment than rural residents living close to coal mines; they, however, reported lower levels of satisfaction with their living conditions. In urban areas, those living far away from coal mines reported higher levels of satisfaction with institutional capital and the environment than those living close to coal mines.

Notably, rural residents living near coal mines (the reference group), were less satisfied with the natural environment than those living far from coal, and more satisfied than those living in rural areas with coal mining. MacKerron and Mourato (2009) simply compared the effect of NO_2 on LS (measured by a 11-point scale) to other studies that using different scales to measure LS (e.g. Welsch (2003), in which LS was measured by a 4-point scale). Since all the dependent variables in Table 6.2 are measured by a similar 7-point rating scale, and independent variables of all the models are uniform, the comparison between coefficients of different models is more straightforward. Coefficients within the environmental domain appear to be larger than those relating to any other life domain, indicating that coal mining has stronger impacts on satisfaction with environment than on other domains.

Table 6.2 Results from OLS regression of factor scores (relating to satisfaction with different life domains) and other variables (sociodemographic factors and proximity to coal mines)

	Human capital		Economy		Social capital		Institutional capital		Living conditions		Natural environment	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
WithCoal		0.129 (0.116)		–0.147 (0.141)		–0.029 (0.118)		0.096 (0.141)		–0.187 (0.141)		–.738*** (0.186)
FarCoal	0.037 (0.170)	0.231* (0.133)	0.250 (0.247)	0.456*** (0.158)	0.269 (0.223)	0.206 (0.137)	0.521** (0.221**)	0.321* (0.168)	0.321 (0.237)	–0.632*** (0.180)	1.112*** (0.344)	2.048*** (0.228)
MiningIncome	0.059 (0.245)	0.216 (0.212)	–0.070 (0.250)	–0.051 (0.233)	–0.185 (0.244)	0.123 (0.213)	0.657** (0.284)	0.181 (0.209)	0.095 (0.266)	0.036 (0.226)	0.725** (0.354)	–0.266 (0.303)
WithMiny		–0.180 (0.258)		0.466 (0.281)		–0.130 (0.261)		0.042 (0.274)		0.205 (0.272)		0.173 (0.352)
Income	6.25E–06*** (2.23E–06)	5.78E–06** (2.33E–06)	0.0000101*** (3.01E–06)	0.0000103*** (2.05E–06)	2.50E–06 (2.53E–06)	4.69E–07 (2.12E–06)	1.3E–06 (2.4E–06)	3.82E–06 (2.38E–06)	4.59E–06 (3.32E–06)	5.24E–06** (2.44E–06)	4.76E–06 (4.30E–06)	5.24E–06 (2.44E–06)
NoOfChildren	0.029 (0.119)	–0.007 (0.053)	0.153 (0.152)	0.041 (0.055)	0.085 (0.114)	–0.020 (0.058)	–0.082 (0.122)	–0.063 (0.065)	–0.185 (0.178)	–0.053 (0.058)	–0.256 (0.186)	0.007 (0.007)
NoOfAdult	0.052 (0.057)	0.009 (0.036)	0.146 (0.095)	–0.048 (0.037)	0.001 (0.060)	0.006 (0.042)	0.032 (0.070)	0.013 (0.039)	0.089 (0.075)	0.003 (0.039)	–0.050 (0.112)	0.010 (0.153)
Age	0.015 (0.009)	0.007 (0.004)	0.007 (0.011)	0.012** (0.006)	0.000 (0.008)	0.013** (0.005)	0.014 (0.011)	0.004 (0.006)	0.022* (0.012)	0.005 (0.005)	0.004 (0.015)	0.054 (0.052)
Female	0.193 (0.184)	–0.031 (0.109)	0.019 (0.218)	–0.094 (0.121)	–0.175 (0.181)	–0.005 (0.104)	–0.192 (0.196)	–0.339*** (0.125)	–0.223 (0.250)	–0.173 (0.117)	–0.297 (0.316)	0.172 (0.237)
NotPartnered	0.435* (0.230)	–0.232 (0.166)	–0.275 (0.263)	0.153 (0.181)	–0.010 (0.227)	–0.105 (0.154)	–0.251 (0.253)	–0.013 (0.177)	–0.110 (0.322)	–0.079 (0.181)	–0.349 (0.378)	–0.005 (0.073)
Schooling	–0.007 (0.025)	–0.004 (0.017)	–0.007 (0.036)	–0.030 (0.019)	–0.044 (0.227)	–0.003 (0.017)	–0.021 (0.034)	0.014 (0.021)	–0.037 (0.034)	–0.056*** (0.019)	–0.001 (0.046)	–0.096*** (0.028)
Employment Status: Retired	0.369 (0.427)	0.152 (0.202)	–0.064 (0.526)	0.215 (0.242)	0.890** (0.380)	–0.182 (0.201)	0.057 (0.579)	0.101 (0.263)	0.177 (0.511)	0.116 (0.220)	1.584*** (0.581)	–0.274 (0.320)
Employment Status: Unemployed	0.155 (0.304)	–0.330** (0.147)	0.538 (0.428)	–0.178 (0.158)	0.136 (0.416)	–0.001 (0.142)	–0.115 (0.349)	–0.013 (0.159)	–0.403 (0.536)	–0.118 (0.167)	0.659 (0.548)	–0.005 (0.197)
Employment Status: Student	–0.187 (0.309)	0.029 (0.273)	1.097*** (0.321)	0.155 (0.260)	0.487 (0.297)	–0.133 (0.234)	1.103*** (0.269)	–0.752** (0.358)	1.367*** (0.361)	0.514** (0.255)	0.871** (0.408)	0.890** (0.402)
Employment Status: Self-employed	0.276 (0.235)	0.013 (0.117)	0.136 (0.274)	–0.120 (0.147)	0.202 (0.222)	–0.128 (0.124)	–0.058 (0.253)	–0.044 (0.148)	0.353 (0.283)	0.087 0.144	–0.228 (0.348)	0.127 (0.188)
Constant	4.201*** (0.684)	5.092*** (0.338)	1.755** (0.763)	2.874*** (0.386)	4.873*** (0.697)	4.777*** (0.343)	3.243*** (0.829)	3.845*** (0.423)	3.595*** (0.843)	5.107*** (0.397)	2.946** (1.168)	3.690*** (0.541)
[22] R^2	0.153	0.075	0.236	0.116	0.128	0.065	0.207	0.059	0.219	0.075	0.293	0.348
F	1.87**	2.48***	3.84***	4.08***	1.71*	2.62***	4.14***	1.71**	3.23***	2.25	5.73***	19.17***

Notes: 1.Robust standard errors are in parentheses; 2. Significant variables are highlighted in red, ***P<0.001,**p<0.05,*P<0.1..

[22] Unadjusted R^2 is reported here, because STATA does not report adjusted R^2 for sub-population. This applies to the other table of OLS regression results in this chapter.

The results of post-estimation tests for differences across coefficients (reported in Table 6.3) indicate that, in rural areas, those living long distances from coal mines report higher levels of satisfaction with the economy, social capital and the environment, but lower levels of satisfaction with their living conditions, than those living adjacent to coal mines.

Table 6.3 Synthesis of tests for statistically significantly differences in model coefficients for the urban/rural models

Life domain	Urban and rural datasets	Results from equation 4		Results from post estimation (equation 5)
		Compare WithCoal to NearCoa	Compare FarCoal to NearCoal	Compare WithCoal to FarCoal
Human capital	Urban		0.037 (–0.17)	
	Rural	0.129 (0.116)	0.231* (0.133)	–0.101 (0.131)
Economy	Urban		0.25 0.247	
	Rural	–0.147 (0.141)	0.456*** (0.158)	–0.603** (0.161)
Social capital	Urban		0.269 (0.223)	
	Rural	–0.029 (0.118)	0.206 (0.137)	–0.234* (0.135)
Institutional capital	Urban		0.521** (0.221)	
	Rural	0.096 (0.141)	0.321* (0.168)	–0.225 (0.17)
Living conditions	Urban		0.321 (0.237)	
	Rural	–0.187 (0.141)	–0.632*** (0.18)	0.445** (0.187)
Natural environment	Urban		1.112*** (0.344)	
	Rural	–.738*** (0.186)	2.048***	–.2.786*** (0.206)

Notes: 1.Robust standard errors are in parentheses; 2. Significant variables are highlighted in red, ***P<0.001,**p<0.05,*P<0.1.

To sum up, rural areas seems more sensitive to impacts of coal mining than urban areas – a result likely at least partially attributable to the fact that the sample was larger in rural areas, and thus more able to pick up statistically significant differences. In rural areas, coal mining has significant negative impacts on satisfaction across multiple domains, including those of: natural environment, economy, social capital, institutional capital and human capital. The only positive impacts are associated with living conditions. The impacts of coal mining on satisfaction with the environment was stronger than other domains, and correlated to the distance from coal mines.

6.3.2 Impacts of coal mining on global life satisfaction

6.3.2.1 Preliminary analysis of the dependent variable and its relation to mining

Figure 6.2 and Figure 6.3 display the level of life satisfaction obtained by the two different measures. Life satisfaction (LS) was measured via a scale of 0 to 100, while SWLS use a sum of scores from five 7-point-scale questions. Visually, the two figures provide similar information about the way in which mean measures of GLS differ across the regions. At the individual level, the correlation between the two measurements of life satisfaction was 0.435 (P= 0.01 level). Cohen (1988) suggests a weak correlation when correlation coefficients range in 0.10 to 0.29, medium when r=30 to 0.49, and strong when 0.50 to 1.0.

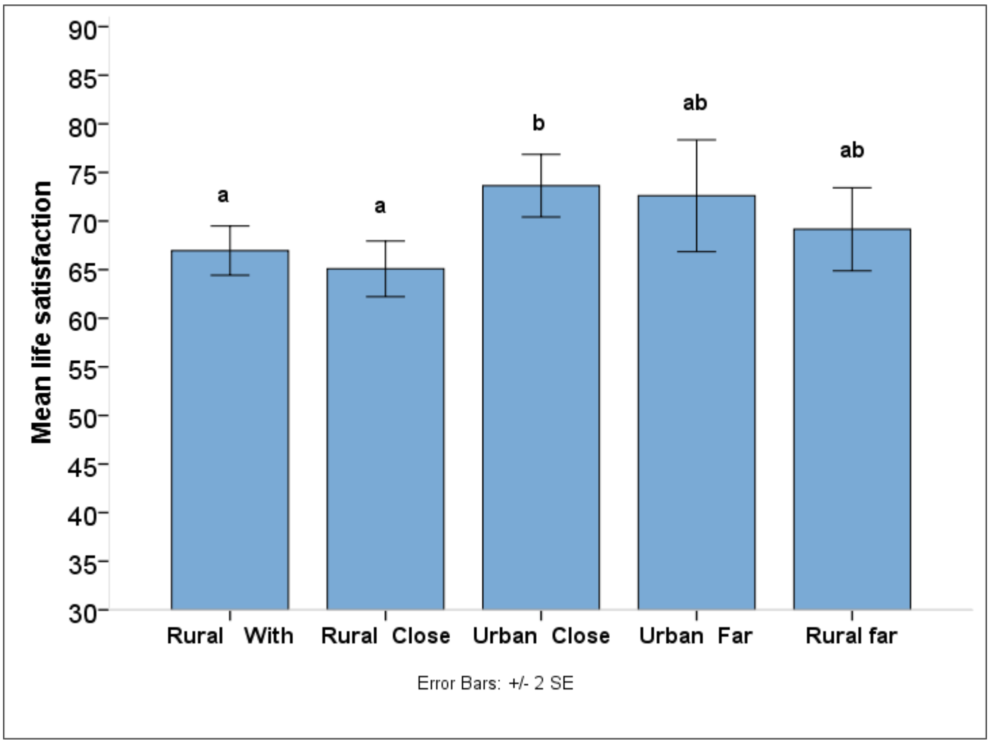


Figure 6.2 Life satisfaction level of residents from different types of study region

Note: ‘a’ and ‘b’ is different, ‘a’ and ‘b’ is not different from ‘ab’.

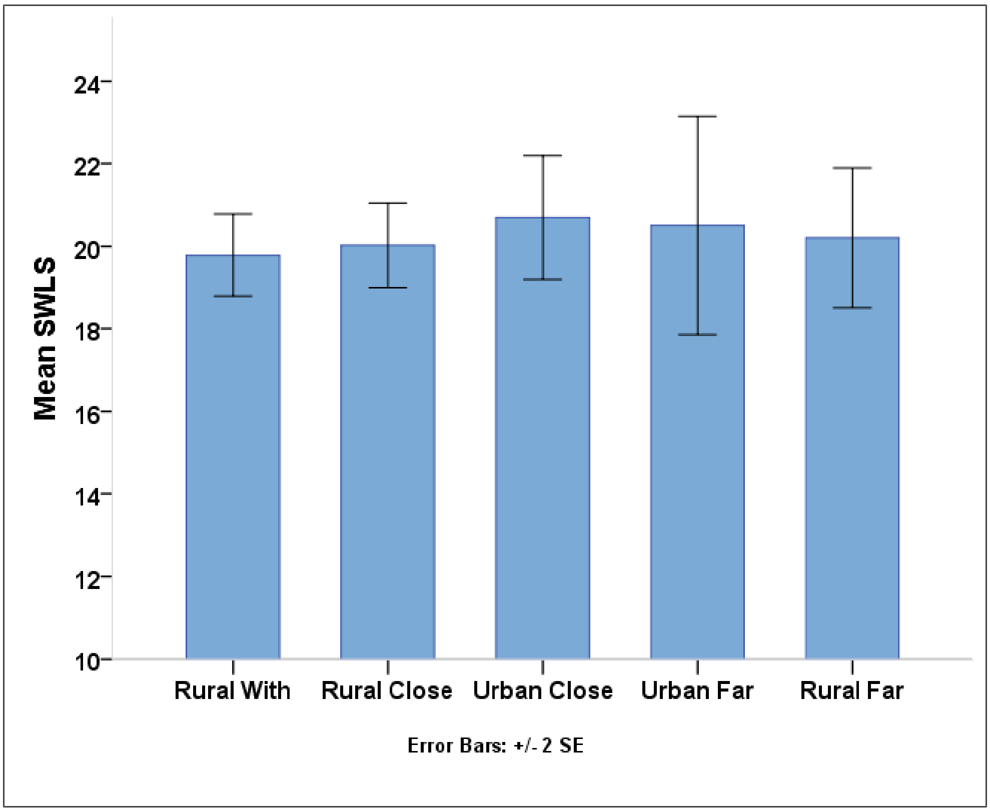


Figure 6.3 SWLS of residents from different types of study region

Urban residents close to coal mining had, on average, higher levels of GLS than rural residents living in the places with or close to coal mining, and these differences were statistically significant (Kruskal-Wallis, pairwise comparisons, P=0.000) (see Figure 6.2 which uses letters to demonstrate similarities and differences: measures which are statistically similar, share the same letter). Evidently, it seems that it is not only differences in proximity to mining, but also differences in the urban/rural landscape that affect GLS.

Figure 6.4 and Figure 6.5 show the distributions of responses to the GLS question in both urban and rural areas. In both regions, there is a characteristic peak at the higher end of the LS ratings, showing that the majority of respondents were satisfied with life. This finding is similar to the findings of MacKerron and Mourato (2009), Knight et al. (2009) and Davey and Rato (2012).

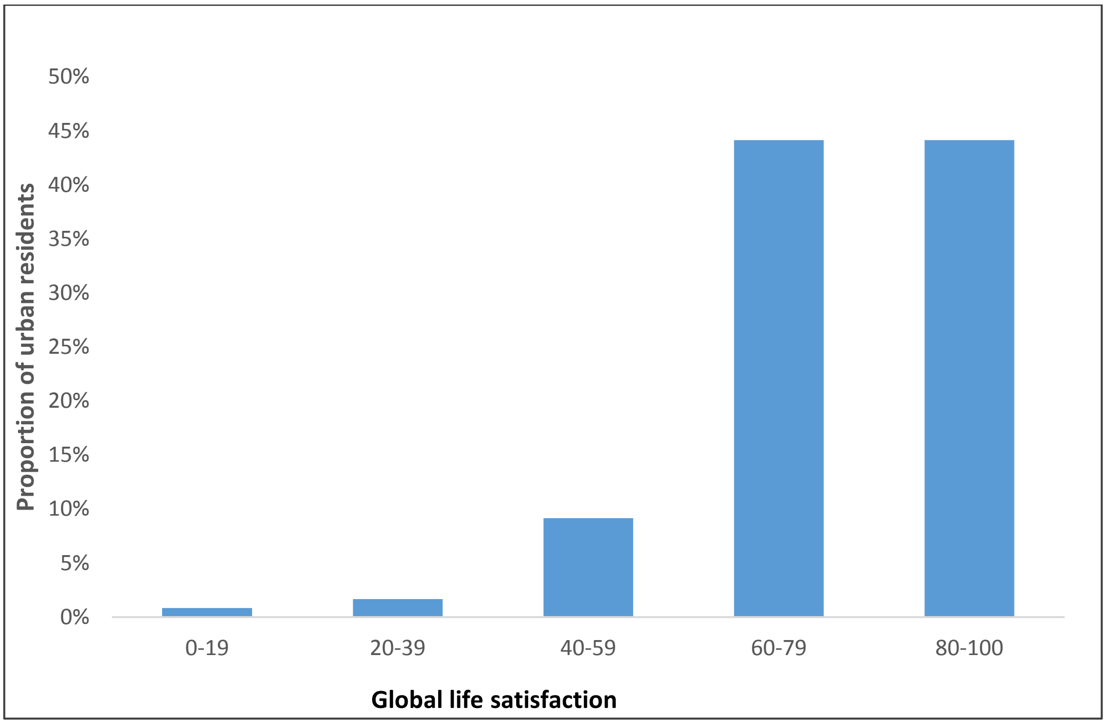


Figure 6.4 Distribution of global life satisfaction of urban residents

Note: Horizontal axis shows score of global life satisfaction measured by the scale of 0 to100

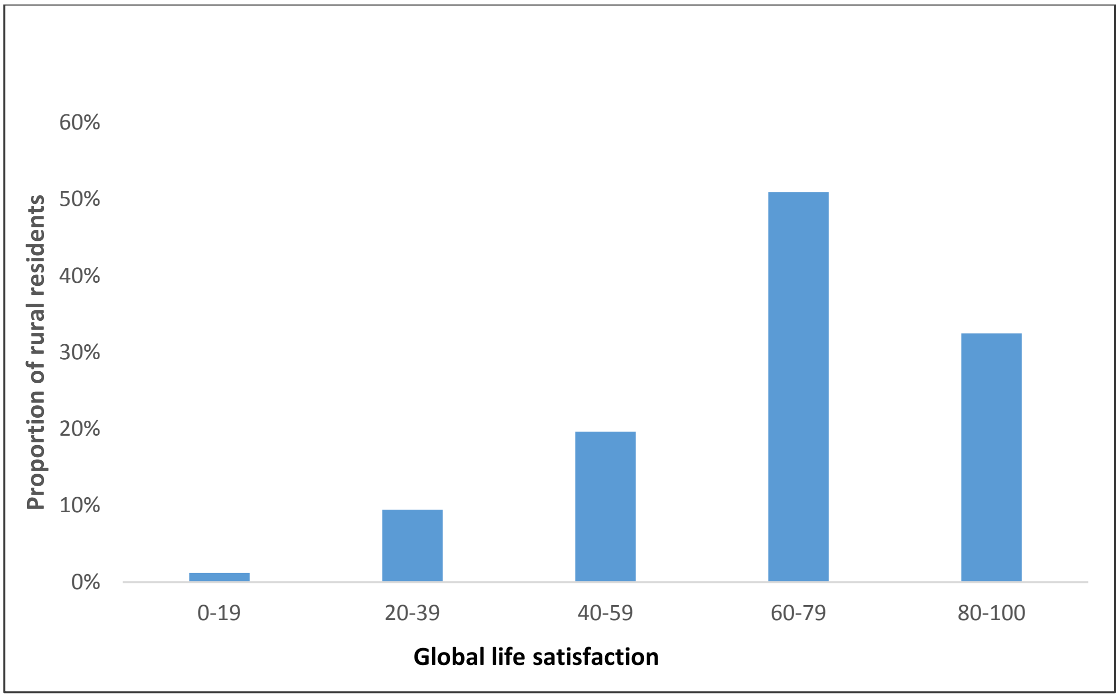


Figure 6.5 Distribution of global life satisfaction of rural residents

Note: Horizontal axis shows score of global life satisfaction measured by the scale of 0 to100

As displayed in Table 6.4, mean LS in rural areas, with an average of score of LS (66.6) was very similar to that of other wellbeing studies on rural China. Mean LS for urban areas (73.4) is slightly higher than the normative range of 60 –70 points from previous studies (Lau et al., 2005; Smyth et al., 2011), but is still within the normative range for the means of 70–80 of western samples. The difference may be at least partially explained by the nature of the biases in the sample, since the urban sample in this study was quite small. Moreover, since the latest data from previous studies were 6 years earlier than this study, it could also be because wellbeing has improved in China in recent years.

Table 6.4 Comparison of average life satisfaction scores between sample in this study and other studies

<table>
<tr><th colspan="2" rowspan="2">This sample</th><th colspan="2" rowspan="2">Other samples from China</th><th colspan="2">The normative range of previous research</th></tr>
<tr><th>Chinese samples</th><th>Western samples</th></tr>
<tr><td>Urban areas</td><td>73.4 (15.3)</td><td>6 cities in China: 67.0 (14.5)[a]</td><td>Hong Kong: 65.9 (16.9) [c]</td><td rowspan="3">60–70[e]</td><td rowspan="3">70–80[f]</td></tr>
<tr><td>Rural areas</td><td>66.6 (17.9)</td><td>64.2 (18.9)[b]</td><td>Rural China: 53.4 (17.4)[d]</td></tr>
<tr><td>The year of data</td><td>2013</td><td>2007/2006</td><td>2002</td></tr>
</table>

Note: Standard errors are in parentheses. Mean scores using different scales in different studies were converted to the standard 0–100 format [23].

a (Smyth et al., 2011)

b (Davey et al., 2009)

c (Lau et al., 2005)

d (Knight et al., 2009)

e & f (Lau et al., 2005, Smyth et al., 2011; MacKerron and Mourato, 2009;The National Wellbeing Index, 2013).

Those points aside, it seems as if the distribution of LS scores in rural and urban areas may be somewhat different: responses in the rural area follow a more ‘normal’ distribution than in the urban area (skewed to the right). The vast gap in both mean GLS and in the distribution of GLS between urban and rural areas, also justifies the divide of datasets into urban and rural areas.

6.3.2.2 Determinants of global life satisfaction

Table 6.5 presents the results of the regression that considered the impacts of variables on GLS. Overall, the models are statistically significant. The goodness of fit data suggest that the models are ‘reasonable’, with R^2 of 0.193 and 0.154, for the rural and urban areas, respectively. These R^2 approach the range of existing environmental quality and personal wellbeing studies in which the range is typically 0.2– 0.3 (Brereton et al., 2008; MacKerron and Mourato, 2009; Smyth et al., 2011). As discussed in section 2.3.2.6, research on identical twins suggests that genetics explains around 50% of all observed

23 The formula for converting scales to the standard format of 0 to100: $\frac{X - K^{\min}}{K^{\max} - K^{\min}}$ x 100, Where X=the score or mean to be converted , k^{min}= the minimum score possible on the scale, k^{max}= the maximum score possible on the scale see details in (The International Wellbeing Group, 2013, p. 19)

differences in the level of reported 'happiness' or life satisfaction (Lyubomirsky et al., 2005; Zidanšek, 2007), which at least partly explains the weak explanatory power of the models.

Table 6.5 Result from OLS regression of global life satisfaction and other variables (sociodemographic factors and proximity to coal mines)

Variables		Urban areas	Rural areas
WithCoal		Missing	–3.830*
			–2.175
FarCoal		–4.101	2.033
		–2.974	–2.533
MiningIncome		–8.784	0.016
		–5.878	–3.287
WithMiny		Missing	9.276**
			–4.067
Income		0.0001076**	0.0001964***
		–0.0000446	0.000
NoOfChildren		3.326**	0.065
		–1.631	–0.890
NoOfAdult		–0.104	–0.271
		–0.810	–0.592
Age		0.137	.145*
		(0.115)	.0866)
Female		–3.833	–5.062***
		–3.148	–1.899
Not partnered		–3.164	–3.198
		–4.743	–2.919
Schooling		0.601	–0.056
		(.411)	–0.303
Employment Status	**Retired**	13.025**	7.255**
		–5.192	–3.100
	Unemployed	3.959	–0.681
		–5.933	–2.415
	Student	5.696	3.780
		–6.730	–5.064
	Self-employed	3.234	1.474
		–4.760	(2.239515）
Constant		54.279***	56.780***
		(7.362）	(17.838）
Observations		113	413
R^2		0.193	0.154
F		3.05***	5.53***

Note: Robust standard errors are in parentheses. ***P<0.001,**p<0.05,*P<0.1.

The effect of sociodemographic variables on GLS is generally consistent with those identified in the models of domain-specific satisfaction. Income is a significant positive contributor to global life satisfaction in both urban and rural areas. Retired people were more satisfied with their life than others – even those of similar age and income. Age was only positively significant in rural areas. People with more kids have higher levels of satisfaction than other people in urban areas. Females were less satisfied with life overall than males in rural areas.

After controlling for these sociodemographic differences it is possible to consider the impact of mining. In urban areas, there were no statistically significant difference in GLS between those who live close to or far from coal mining. Similarly, there were no differences in GLS between those dependent on mining and other industries for household income.

In contrast, in rural areas, people living in places with coal mining were less satisfied with life overall than those living in places further away from coal mines (both 'close to', or 'far away') (The difference between WithCoal and FarCoal is from post-estimation: WithCoal minus FarCoal, Coefficient= –5.863, P=0.029). Noticeably, people living adjacent to coal mines who were dependent upon coal mining for their income, had higher reported levels of GLS than those who were not dependent upon coal mining (even when both groups earned the same amount of income).

In both models the constants were statistically significant. However, post-estimation comparisons of these coefficients reveal that there is no statistically significant difference between them. This suggests that the variables included in the models are able to explain systematic differences in GLS between Urban Close and Rural Close – i.e. systematic differences are largely attributable to things such as age, retirement status, income, and proximity to mining.

6.3.2.3 Assessing the economic 'value' (cost) of mining on GLS

- The amount of income that would need to be paid to 'compensate' someone who had previously lived 'near coal', but then found themselves 'with coal' was calculated as:

$$\text{MRS}=\frac{\partial GLS/\partial WithCoal}{\partial GLS/income}=\frac{\partial WithCoal}{\partial Income}= 3.830 / 0.0001964 \approx 20{,}000$$

- The amount of income that would could be taken away from people (similar to a 'negative compensation') who previously lived 'near coal', but then found themselves 'far from coal' is assumed approximately equal to zero, since the coefficient on 'Far Coal' is statistically insignificant.

It is interesting to note the statistical significance of the coefficient on the dummy variable 'WithMiny'. This suggests that in rural areas, those who are dependent upon mining for income have higher GLS than people dependent upon other industries (say, agriculture). If one wanted to raise the GLS of other people to the same level as those working in the mining industry, then one would need to 'compensate' them with extra income, the amount of which can be calculated as:

$$\text{MRS}=\frac{\partial GLS/\partial Withminy}{\partial GLS/\partial income}=\frac{\partial WithMiny}{\partial Income}= 9.276 / 0.0001964 \approx 47{,}000$$

Whether this difference reflects the fact that people who work in the mining industry (perhaps, having migrated from another region (see footnote 19, p. 163)) are inherently 'happier' than those who do not, or whether the presence of a mine reduces the GLS of people who are trying to earn a living in other sectors, cannot be determined from these data.

6.4 Conclusion and discussion

Income is a significant positive contributor to some life domains and global life satisfaction no matter whether in urban or rural areas. That is consistent with findings from much research undertaken in both developed (e.g. Van Praag and Baarsma, 2005; Welsch, 2006, 2008; Luechinger, 2009; MacKerron and Mourato, 2009) and developing countries (Arifwidodo and Perera, 2011), and particularly with wellbeing studies undertaken in urban China (Smyth et al., 2011). Knight et al. (2009) found out that increases in the absolute level of income has a relatively weak impact on wellbeing in rural China – what matters most is the impact that relative income has. The data in that study were inter-province in 2002. It might be different after 14 years, and at different scales of data (in this case, village/city level in one province).

The results associated with the other sociodemographic factors, such as age, are generally also consistent with findings from previous studies. Notably, age has a positive and significant impact on subjective assessments of satisfaction with several life domains, such as the economy, social capital and living conditions, and also on GLS in rural areas. As discussed in 2.2.3.5, other researchers have found that 'middle aged' people tend to have lower satisfaction with many factors than the young and old. The finding here is probably in line with this, as the majority of respondents were over 35 years old (see Table 3.9) – suggesting that the sample for this study is (simplistically), on the right hand side of the "U"– shaped relationship so frequently observed, thus explaining the uniquely positive relationship.

Previous studies about the effect of having more children on wellbeing were mixed (Dolan et al., 2008). The result reported here – that having more children can increase life satisfaction – is consistent with those in the studies on subjective wellbeing in China (Appleton and Song, 2008; Smyth et al., 2011).

Females were less satisfied with life than were males. Previous studies into the effect of gender on wellbeing have published differing results. Some previous researchers have found no gender differences for GLS (Travers and Richardson, 1993; Saunders, 1996), some have found that women are generally happier than men (Clark and Oswald, 1996; Hartog and Oosterbeek, 1998), but others (Hess et al., 2004; Stevenson and Wolfers, 2009) have found that men are happier. Subjective wellbeing studies undertaken in urban China, in particular, found that man were less satisfied with their lives than women (Russell et al., 2006; Appleton and Song, 2008). However, gender was not a significant variable in the study about wellbeing in rural China (Knight et al., 2009), in which data were collected at a provincial-level. Thus, based on the mixed evidence, it might be thought that the gender effect on wellbeing is complicated, which might depend on the cultural factors, geographic areas the data covered, in terms of urban and rural areas, the administration level in terms of inter-province or single province, or even the type of wellbeing measure (Smyth et al., 2011).

People with higher education level reported lower levels of satisfaction with their living conditions and with the environment than others. This might be explained by the fact that highly educated people have higher expectations which lowers reported levels of satisfaction (Clark and Oswald 1996; Arifwidodo and Perera, 2011).

That coal mining had impacts on satisfaction with various life domains (even after controlling for confounding factors) was clearly illustrated in this study: reported satisfaction with the natural environment and the economy were significantly lower in rural coal mining areas (Rural With and Rural Close) than in areas disassociated from mining (Rural Far). Satisfaction with human capital, social capital and institutional capital in coal mining areas (either Rural With or Rural Close) also tended to be lower than in rural areas far from coal mining. In contrast, rural residents living far away from mines were generally less satisfied with their living conditions than others. In urban areas, residents living a long way away from mines were more satisfied with the natural environment and institutional capital than those near mines. The consistency between these results and the findings of other researchers is discussed below.

Satisfaction with the natural environment (overall air quality, air cleanliness, dust and water safety) varies obviously with distance from coal mines, reflecting the significant impact of coal mining on the environment which has been documented in a large number of studies (e.g. Szczepanska and Twardowska, 1999; Ghose and Majee, 2000; Tiwary, 2001; Bian et al., 2010). The concern with environment is often related to the concern with health (Mackerron and Mourato, 2008). That coal mining had a negative impact on human capital found in this study is also well documented in the literature (Bian et al., 2010; Zullig and Hendryx, 2010, 2011; Colagiuri et al., 2012).

Although coal mining is said to be a significant contributor to the local economy (Editor of Land & Resource Herald, 2013), people were less satisfied with the economy in rural coal mining areas than in the non-coal mining areas. Notably, in this study the economic domain not only includes satisfaction with income, it also captures (satisfaction with) the inflation rate, the price of necessities, real estate prices, income disparities, and fairness/equity. The message from chapter 5, highlights that actual family incomes and satisfaction with income do not seem to be higher (or lower) in mining areas, so dissatisfaction with the economic domain likely reflects dissatisfaction with other economic factors.

The observed dissatisfaction with the economy in rural coal mining areas might thus be explained by the following dynamic. Within coal mining regions, the economy is supported by coal mining, but this drives up living costs (Carrington et al., 2011) and creates a significant income gap between those dependent upon the coal mining industry and those dependent on other industries (see Table 3.9, Appendix B, and (Carrington et al., 2011)). Local residents who are not able to share the resource rent become relatively worse off (Xu and Wang, 2006; Zhang et al., 2008; Zhao and Liu, 2011).

This is consistent with a survey undertaken by the CSIRO, which highlighted the fact that benefits from mining in China were not distributed fairly, and that people living in mining regions strongly believed that incomes were less equitable in their area as a consequence of mining than those living in non-mining areas (Zhang et al., 2015). These issues are also similar to what happened in other countries (Carrington et al., 2011). As the proportion of population who had jobs from coal mining was relatively small in any area (see Table 3.9), the level of global life satisfaction and satisfaction with the economy were still lower in the places with higher intensities of coal mining. Interestingly, the statistical significance of the dummy variable 'WithMiny' indicates that resentment between mining and non-mining sectors may go beyond observed income differences (the regression controls for those differences, but still finds evidence to suggest that those not associated with the mining industry were disaffected).

This study also found evidence of the negative impacts of coal mining on social capital (honesty, help, trust, personal relationships and personal safety), which is consistent with the findings of other studies (e.g. OECD, 2001; Kitula, 2006; Lockie et al., 2009; Carrington et al., 2011). The uneven distribution of benefits from coal mining, the issues over the amount of compensation from coal mining, and the competition over mining jobs, induced conflict and mistrust in the coal mining area. Although this study did not collect data from the mining companies, anecdotal evidence (collected during conversations with residents of villages) suggests that on average, only about 30% of coal miners are 'local' residents; most workers are imported, by companies, from other regions. The reliance on a large non-resident workforce, who had no meaningful attachment to community, might disrupt existing social bonds and networks leading to a loss of community identity and personal security (Carrington et al., 2011).

This study found that coal mining also affected institutional capital in some regions (Urban close and Rural Close), which is consistent with the findings of many other studies (e.g. Marshall, 2001; Sachs and Warner, 2001; Petermann et al., 2007). Evident from those studies, if the governance is poor and fails to avert the dangers that accompany the free gifts of nature, natural-resource-rich economies breed socially damaging rent-seeking behaviour and corruption.

In contrast, it seems that mining is positively associated with better living conditions, (which capture factors such as water supply, electricity supply, property safety and quality of housing). This was the only domain that people living in places with coal mining and near to coal mining were more satisfied with than those living far from coal mining. This is consistent with the message from the objective indicators presented in chapter 5, which showed that the percentage of houses with bathrooms and flushing toilets in coal mining areas was larger than that in non-coal mining areas. The survey by CRISO in China also highlighted the perceived improvements in infrastructure by residents living in mining areas in China (Zhang et al., 2015).

The impacts of coal mining on life domains is thus demonstratively complicated, with negative impacts on multiple domains and positive impacts on living conditions. As discussed in chapter 2, in normal circumstances, it would be exceedingly difficult to discern a 'net impact', without undertaking several non-market valuation studies, seeking to monetise the value of the non-market impacts associated with the environment, and with social and institutional capital. The global life satisfaction model, however, allows one to consider the net overall impact of all effects.

After controlling for sociodemographic and 'mining proximity' factors, there were no significant differences between urban and rural areas in terms of global life satisfaction (a subjective measure). This is in spite of the apparently 'obvious' gap in objective wellbeing indicators between urban and rural areas (e.g. fewer houses with bathroom and toilets in rural areas) highlighted in chapter 5. This confirms insights from previous chapters that objective measures alone, do not provide information about how satisfied people are with their life. This difference between subjective and objective assessments is consistent with the findings of Davey et al. (2009), who conducted a door-to-door and street survey in both an urban area and a farming community (using PWI), finding similar subjective wellbeing levels in both regions. This finding was, despite significant differences in objective indicators. This may be partly explained by recent improvements in lifestyle in rural areas – respondents may compare today's situation (when they feel there is 'enough' to satisfy their needs) with their past (when they were in poverty), concluding that life is, indeed better now than it has been and thus feeling relatively satisfied (Davey, Chen et al., 2009; Davey and Rato, 2012). Anecdotal evidence also suggests that there have been more marked improvements in rural lifestyles of late, than in urban lifestyles, perhaps also explaining why rural respondents' outlook on life overall is similar to that of urban residents, despite the vast gap revealed by objective indicators in this study .

When GLS was compared across different regions without controlling for confounding sociodemographic variables (such as age, gender) it seemed as if there were no differences associated with coal mining. However, when sociodemographic factors were controlled for (within the regressions), the statistically significant impact of mining became apparent: rural residents living in areas with higher intensities of coal mining had lower levels of life satisfaction than do those living more than 10km away from coal mining. Living in the places with coal mining is equivalent, in life satisfaction terms, to a drop of about 20,000 Yuan in annual family income compared to people living near coal mining.

What also seems to matter is whether rural residents obtain a direct benefit from coal mining or not: those who lived in places with coal mining and who were dependent upon coal mining for their household income, reported significantly higher levels of life satisfaction than those who were dependent upon other industries for their living. This difference in life satisfaction is equivalent to a difference in income of 47,000 Yuan.

In contrast, there was no significant difference in GLS between urban residents living close and far from coal mining. Since there was no difference in GLS between rural residents living close to coal mines and far from coal mines either, it might be inferred that close proximity to coal mines is a decisive contributor to GLS – only people living very close to the mines (in this case, Rural With) were affected. There was statistical difference in the satisfaction with the natural environment and institutional capital between urban areas close to coal mines and far from coal mines, but there were no significant difference in satisfaction with any other domain between these 2 groups. Rural residents near coal mines, in contrast, were more dissatisfied with multiple life domains than those living far from coal mines (the environment, the economy, the institutional capital and human capital), but more satisfied with living conditions than those living far from coal mines. Thus, apart from distance, urban areas might be relatively insensitive to the impacts of coal mining, confirming the suggestion from section 4.4. The potential reason for this was also discussed in that section.

The core issue for coal mining areas revealed by this chapter is that there is an uneven distribution of benefits and costs from coal mining, both at a reginal level and individual level. At the regional level, the nature of mining itself tends to breed this inequity – local communities in coal mining areas tend to bear most of the environmental and other social costs associated with mining (as confirmed in this study by the negative impacts of coal mining on satisfaction with those life domains), while the benefit flows largely to the central government and elsewhere (Davis and Tilton, 2005). The host communities get little from mining besides monetary benefits flowing from corporate taxation and royalties (Zhao and Liu, 2011; Lei et al., 2013; Davis and Tilton, 2005), which might be used to improve living conditions in this case. This further explains that residents living in areas with higher intensities of coal mining have lower life satisfaction levels, after controlling for other factors.

At individual level, people whose family income were dependent on coal mining were the ones who benefited from coal mining, and experienced higher level of GLS than those whose income were not dependent on coal mining. Data collected in this study indicate that the proportion of respondents whose households were dependent upon the mines for income were 32.%, 16% 15%, respectively in Rural with, Rural close, and Urban close (see Table 3.9). As noted above, most workers (approximately 70%) are imported by companies from other regions. Those non-residents workers may lack attachment to local communities (Carrington et al., 2011), the negative impacts of coal mining on the local environment and community may thus not be as much of a concern to them as it is for permanent residents with attachment to affected places and people. The differences might also at least partially reflect the fact that those who were working in other industries (e.g. agriculture), might experience damages that directly impinge upon their lifestyle and thus affect their wellbeing even it has little impact on income. The interviewees' concern with the impacts on coal mining on their livestock and farmland demonstrate this (see the quotes in p. 124 and p. 125).

Other studies of the resource curse in Shanxi province confirm that coal resource development tends to impede economic growth. Xu and Wang (2005), for example, used data at the province level, and Fu and Wang (2010) used data at the city level, empirically testing the "resource curse" hypothesis and finding evidence to support it in Shanxi Province. This study, using subjective wellbeing data collected at the individual level, not only finds that mining does not seem to have an unambiguous and positive impact on incomes in Shanxi Province (which is consistent with previous studies on the resource curse), but has also furthered the understanding of the potential negative consequences of mining to other domains, such as environmental and social domains.

As discussed in section 2.4, uneconomic growth occurs when the marginal disutility of an activity (here, the negative impacts of coal mining) outweigh its marginal utility (here, the positive impacts of coal mining). This study found a net negative impact of coal mining on GLS, which could also be inferred from strong negative impacts of coal mining on multiple environmental, economic and social domains, but positive impacts only on living conditions. This might suggest that for those who participated in this study, coal mining is an 'uneconomic' form of growth – at least for those in the rural areas with coal mining.

6.4.1 Implications for policy makers

This study highlights the fact that coal mining does not necessarily improve the wellbeing of those living in host communities. On the contrary, coal mining had net costs to people living in rural places with coal mining. This is revealed by the significantly lower level of reported global life satisfaction for people who live with mining compared to those who live further away. It is attributable to the negative impacts that mining has on the environmental, social, and economic domains. Although coal mining did not appear to generate net negative impacts to those living in Rural Close and Urban close areas (might be because the negative impacts were not very strong or did not outweigh the positive impacts), it did negatively impact the environment, economy, human capital and institutional capital in those regions. The direct implications of this chapter for policy makers to improve wellbeing in coal mining area (especially in Rural With) and the problems associated with these strategies are discussed below.

- Relocation

Those living in places with coal mining who were not employed in the industry had relatively low levels of overall life satisfaction and were less satisfied with multiple life domains than other people. Relocating these people might thus improve their wellbeing.

Relocating entire villages is not common and very few instances of that were encountered in this survey. Instead, it seems more common for individual houses to be relocated – particularly if an individual's land is to be used by the coal mining company. Discussions undertaken with local residents while collecting data revealed that they do not generally self-relocate, most likely because they are unwilling or unable to abandon their houses and spend their own money building a new house somewhere else. Instead, mining companies who need to access land, compensate people to encourage them to move to other places (some even move to urban areas). The statistical analysis in this study did not consider relocated individual or households, as they were dispersed in different places.

Relocation may have improved the wellbeing of those who moved into better dwellings than the ones they vacated. But such opportunities can create perverse incentives. Some people, see the possibility that they could be relocated, and enlarge their existing houses, or even adding a second or third floor – with the expectation of more compensation (see Figure 6.6). This is a private form of 'rent seeking' – wasteful expenditure of money (building a house that one knows will be knocked down) in an attempt to gain still more money (see the definition of 'rent-seeking' by Henderson

(2008)). To the best of my knowledge, no one has empirically studied the extent of this from of rent-seeking, which is different from the well-documented rent-seeking behaviour usually conducted by governments (Marshall, 2001; Sachs and Warner, 2001; Petermann et al., 2007; Wright, 2008).

Figure 6.6 Simple dwellings built to elicit compensation

Source: Taken by the investigator in a village with coal mining on 25th August 2013

- Financial compensation

This study suggests that people living in places with coal mining, especially those unable to obtain jobs from coal mining, could, potentially, be financially compensated. This study also generated some estimates of the magnitude of compensation required, which could be used as a straightforward reference for public policy. However, there are some problems likely to arise should this option be considered.

It may be difficult to implement using existing compensation systems, characterized by rent-seeking and corruption. This also at least partly explains the low level of satisfaction with institutional and social capital in the coal mining areas. According to local residents, in many cases, the financial compensation that coal companies paid to regions was managed by local governments. Without enough transparency and supervision, self-benefit-motivated government officers might be involved with rent–seeking behaviour; a sensitive topic in the coal mining areas in China. In some coal mining villages, some people were reluctant to be interviewed for this study especially when they were not sure what questions would be asked about coal mining. However, they expressed openly, sometimes indignantly, their opinion on matters relating to issues of monetary compensation (see the quotes in p. 123).

When the head of one village answered the question about family income, another respondent overheard his answer. He said to the investigator afterwards, “He is lying. He is the richest person in this village, and owns a lot of real estate in the city, because he got a lot money from the coal company. Anecdotally the investigator found that this was not an extreme case: corruption associated with mining is an open secret in China, and is also well discussed in the literature in other contexts (e.g. Marshall, 2001; Sachs and Warner, 2001; Petermann et al., 2007). However, due to the obfuscating nature of corruption, there is very little empirical evidence of actual levels of corruption in the mining sector or its interaction with individuals and communities (Marshall, 2001). These difficulties will remain (perhaps even be exacerbated) if formal compensation programs include a broader range of impacts (such as those identified in this study) than those normally considered (such as damage to the physical environment and direct economic loss of local residents (e.g. loss of house/land or farmland, or the loss of income that could have been generated from the land) (Zhao and Liu, 2011)).

a

b

Figure 6.7 Government building of Pinglu (a), and residential dwelling in a village with coal mining, administrated by the Pinglu government (b)

Source: Photo ‘a’ was taken by the investigator in a city close to coal mines on 22th August 2013; Photo ‘b’ was taken by the investigator in a village with coal mining on 25th August 2013.

A second fundamental problem with the idea of using LS studies to firstly estimate required amount of compensation and then actually pay that compensation is that the system itself, creates an incentive for (perverse) strategic behaviour on the part of those involved in the survey. In this study, questions about satisfaction with life overall were not linked to coal mining, and were asked before the questions about coal mining. In addition, the interviewees were not aware that the data could, in principal, be used to estimate financial compensation. Thus, there was no reason for respondents to answer the life satisfaction questions strategically. However, if policy makers decided to use life-satisfaction studies as a way of estimating compensation, and if people grew to expect it, then they may cease responding honestly to questions contained within LS surveys – instead responding strategically so as to maximise compensation (just as some behave strategically when thinking they may receive compensation if asked to relocate). Likewise, governments (or mining companies) might be given a strong incentive to manipulate the subjective measurement in their favour (Frey and Gallus, 2013). Thus, like relocation policies, compensation policies also have the potential to create perverse incentives and caution must be exerted if considering using LS studies in this way.

- Delivering more jobs from coal companies

As mentioned above, anecdotal evidence, consistent with the survey data, suggests that on average, only about 30% of coal miners were 'local' residents; most workers were imported, by companies, from other regions. This suggests that the mines could potentially, provide more jobs for 'locals'.

Hiring non-residents workers is a common practice in the mining sector, not only in China, but also in developing countries like Australia (Carrington et al. 2011). However, the reason for coal companies hiring non-resident workers differs between China and other countries. For sparsely populated countries, the difficulty of sourcing labour due to the isolation of the mining sites, as well as short project life are the basic reasons for the tendency of hiring non-residential workers (Gillies et al., 1991, cited by Carrington et al. 2011, p. 338). In China, with a high density of population, it is not difficult to source labour in most regions suggesting that there may be other reasons for this practice.

Anecdotal evidence collected during discussions with respondents when collecting data, suggests that one of the reasons coal companies hire miners from other regions is because of a perception that local residents are more 'resilient' and thus potentially less easily controlled or manipulated. Local residents have more family and community support, than miners brought in from elsewhere, and in the event of accidents or other disputes, they tend to demand higher compensation and are able to hold out for longer against the companies during negotiations. As such local residents may be more 'costly' and/or more 'difficult' to deal with than workers brought in from other areas. Anecdotal evidence suggests that locals who manage to find jobs with coal companies are most often those who have a strong personal relationship with the owner. That said, local residents who manage to get jobs in the coal mining industry are likely to be allocated the low-pay/low-risk jobs, rather than the high-pay/high-risk jobs given to outsiders.

As discussed in section 4.4, in one of the villages included in this study, a condition imposed upon the coal company when it sought permission to start operating in the region, was that it hired 'locals'. Results from the regression analysis undertaken in this chapter suggest that people who were dependent upon coal mines for household income (and thus more intimately associated with them) had higher GLS than those dependent upon other industries. So there is *prime facie* evidence to suggest that such a strategy might improve the LS of residents. The evidence is not, however, conclusive: it is possible that requiring (or suggesting) that people who are currently working in agriculture may not want to work in mining – and would be even unhappier if forced to change (although this line of reasoning presumes that people have alternatives: such may not be the case).

That point aside, by providing more jobs to locals, the mine will have a more significant, positive, impact on the local economy in terms of improving local residents' income, reducing income disparities and thus improving equity. Delivering more jobs means allocating more benefits to people living in coal mining areas, which is an important pathway to compensate people experiencing the negative side effects of coal mining. Additionally, hiring more local residents could help maintain and improve social capital. It can reduce the factors that induce conflict and mistrust in the host communities resulting from the uneven distribution of benefits and costs, the competition over mining jobs and the flow of a large amount of non-resident workforce into local communities. As discussed in section 1.3.4, large numbers of non-resident workers without meaningful attachment to the resident community can contribute to the disruption of social capital (OECD, 2001; Kitula, 2006; Lockie et al., 2009, Carrington et al., 2011), so a 'hire local' policy could help reduce those impacts. Notably, caution must be exerted when delivering more jobs to local communities. Affirmative action policy, which regulates the allocation of scarce positions in employment could possibly reduce incentives for effort and skill acquisition in the targeted group (Fryer Jr and Loury, 2005).

Compared to the options of relocating residents or providing monetary compensation, providing more mining jobs to locals seems a less costly strategy for coal mining companies, whose training and salary costs are unlikely to be different for local and non-local workers. However, delivery of more mining jobs from coal companies requires the formulation of clear compensation standards and procedures which not only guarantee local residents' rights but also ease the coal companies' concerns with the negotiation power of locals. In reality, these strategies of relocation, money compensation and job delivery might have to be combined or used accordingly under the supervision of government with a transparent mechanism.

6.4.2 Methodological contribution

The effects of coal mining or mining in general may vary between districts or countries, as it is a complicated issue that may involve government policies, the mining industry management, or even historical and cultural factors. Notwithstanding, this chapter further confirmed that subjective wellbeing data provide information about people's satisfaction with existing conditions in local communities, and can be used to supplement objective wellbeing indicators that are traditionally used.

This study extends the research on coal mining or mining impact assessment by offering a new tool to assess impacts associated with mining. As discussed in section 2.2.1.2, the difficulty of simultaneously quantifying numerous intangible impacts using non-market valuation techniques limits their application in traditional impact assessments. The LS approach, with the capacity to compare the impacts of mining, on wellbeing, of both monetary and non-monetary impacts, allows for a more comprehensive assessment of the trade-offs associated with mining (indeed with any) industry, and can thus offer policy makers a straightforward reference to determine whether a project is economic or non-economic. If it is non-economic (in that a net cost (on GLS) is likely to occur), the monetary net cost can be used as a reference for compensation for those impacted groups. The LS approach can also allow one to identify differences in impacts (be they positive or negative) between different groups (in this study, impacts between those who were, or were not, dependent on the mining industry for their livelihood were compared), again, in monetary values, and to adjust compensation amounts accordingly.

Therefore, the LS approach, offering different insights into communities' preferences, can be used as a complementary tool for a range of other traditional approaches of mining assessment (Ivanova et al., 2007). Alternatively, the LS approach could be incorporated into the cost benefit analysis (CBA) framework and used instead of other techniques (such as choice modelling (e.g. Gillespie and Kragt, 2010)) to capture, and to measure a wide variety of non-market impacts, such as those associated with air pollution (Welsch, 2006; Luechinger, 2009b; MacKerron and Mourato, 2009).

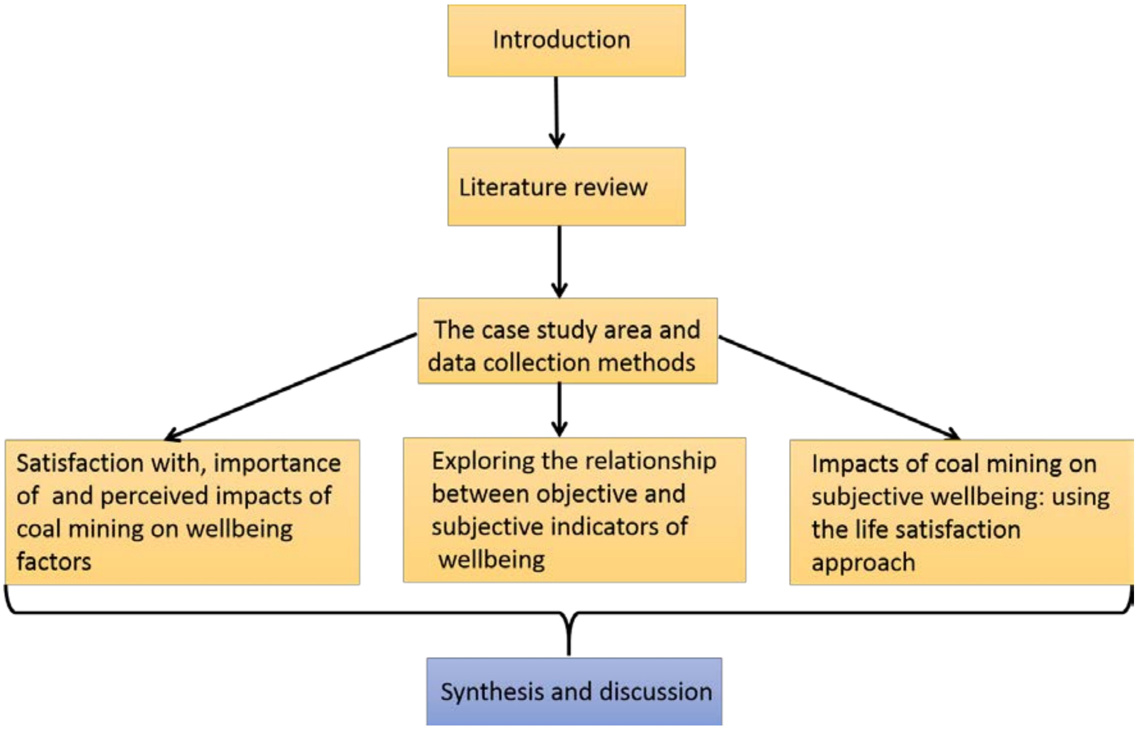
6.4.3 Implications for future studies

The dummy variables relating to coal mining were not significant for urban samples in terms of GLS and satisfaction with most domains, which might be because urban residents are less vulnerable and thus less sensitive to the impacts of coal mining than rural residents (see section 4.4 and earlier this section). However, the lack of statistical significance may reflect the fact that the urban sample was relatively small. Future research, working with larger samples, could shed light on this important issue.

Also, Knight et al. (2009) found out that increases in the absolute level of an individual's income has a relatively weak impact on wellbeing in rural China: what increases satisfaction most, is an increase in income *relative to* others. Future studies could also thus usefully expand this research by considering relative income in the LS models.

Endogeneity may also be an issue that future studies could consider, and thus improve upon the techniques demonstrated here. Endogeneity of income is a common problem in the LS literature (e.g. MacKerron and Mourato, 2009; Ferreira and Moro, 2010; Pischke, 2011). It occurs because income depends on many factors such as working hours, stress, health risks, etc. that also impact LS and which are difficult to control for (Ferreira and Moro, 2010). Omission of such factors induces downward bias in the income estimates, which could result in an upward bias in these estimates of 'compensation' (Ferreira and Moro, 2010). That said, some researchers (e.g. Pischke, 2011) have used instrumental variables to control for endogeneity, finding that results do not differ much between models that do, and do not control for endogeneity. As this study did not control for endogeneity issues, estimates of compensation are only illustrative and may not be accurate. When using as a guide for policy makers, future studies with more sophisticated econometrics to control for this issue may need to generate monetary values with more confidence.

Thesis outline



CHAPTER 7 SYNTHESIS AND DISCUSSION

Chapter outline

7.1 Introduction

7.2 Overview of the thesis

7.3 Empirical contributions

7.4 Discussion of empirical findings

7.5 Methodological contributions and implications for policy makers or practitioners

7.5.1 Methodological contributions and insights for monitoring / measuring wellbeing

7.5.2 Methodological contributions to the impact assessment literature

7.6 Implications for future research

7.7 Concluding comments

7.1 Introduction

This chapter first reviews key parts of the thesis and presents clear answers for each of the core research questions addressed in the 3 main data/analysis chapters (section 7.2). Key findings are synthesized in section 7.3 – highlighting the main empirical contributions of the thesis. Section 7.4 discusses empirical results within the context of the broader literature. The methodological contributions of this research and implications for policy makers or practitioners are discussed in section 7.5, whilst section 7.6 highlights key areas in need of future research.

7.2 Overview of the thesis

Coal has played a vital role in human history. Threats of anthropogenic climate change associated with coal use have become a concern, and have given rise to demands for cleaner, renewable fuels. Nevertheless, for decades to come, coal use will likely continue to grow, mostly driven by growth in the developing world (International Energy Agency, 2010). Coal, as the most affordable and widely available source of energy is of particular importance to poor regions with abundant coal resources: coal does not only generates affordable energy, which is essential for economic growth, eliminating poverty and improving wellbeing (Cousins, 1998; Karekezi, 2002; Pachauri and Spreng, 2004; Kammen and Kirubi, 2008), but coal mining and processing also directly promotes regional development and wellbeing by delivering jobs, and tax revenues for government to fund infrastructure improvements.

Benefits aside, host communities are most exposed to the negative impacts of coal mining, with the industry affecting natural capital (e.g. land, water and air (Bian et al., 2010; Colagiuri et al., 2012)), human capital (e.g. education (Gylfason, 2001), health (Bian et al., 2010; Zullig and Hendryx, 2010, 2011; Colagiuri et al., 2012)), social capital (e.g. trust, social injustice (Kitula, 2006; Carrington et al., 2011)), institutional capital (e.g. promoting rent seeking and corruption (Marshall, 2001; Sachs and Warner, 2001; Petermann et al., 2007)), and the broader economy (e.g. increasing prices (Colagiuri et al., 2012)). But coal is rarely mined to meet only the needs of local residents; rather it is transported to other regions to support the economy of the whole nation. A core question thus becomes: how does coal mining affect wellbeing in host communities, i.e. to what extent does the host community benefit from coal mining, considering all of the above?

This question, essentially, is about the incidence and distribution of benefits and costs. It receives relatively little attention – by either researchers or by policy-makers/advisors. One reason for this is that current methodological approaches designed to inform comprehensive assessments struggle to fully account for, and provide quantitative information about such a broad and diverse range of impacts as those associated with coal mining.

There are numerous existing frameworks for assessing the impacts of mining, such as environmental impact assessment (EIA), social impact assessment (SIA), and economic impact assessment (e.g. cost benefit analysis (CBA)) which have been used with varying success in multiple contexts (e.g. Joyce and MacFarlane, 2001; Ivanova et al., 2007; Li, 2008). In theory, a comprehensive impact study would consider all impacts. Some frameworks (specifically, CBA) even allow one to generate estimates of 'net impact'. This is done by firstly identifying 'impacts' and then using both market and non-market valuation techniques to generate monetary estimates of the 'value' of all impacts, including those relating to environmental degradation), which can be added, or subtracted from other financial estimates to calculate 'net benefit'.

Established methods for generating monetary estimates of the 'value' of non-market impacts include revealed preference (RP) and stated preference (SP) approaches – with a relatively long history (and almost 50 years of research to support them). Hedonic pricing (one of several different RP methods) and choice modelling (a type of SP method) have been used in mining impact assessments (Trigg and Dubourg, 1993; Ivanova et al., 2007; Gillespie and Kragt, 2010), but these studies most often consider only a limited number of non-market impacts – almost certainly because of the technical difficulties (and thus resource costs) of generating estimates of non-market impacts. Moreover, RP and SP approaches require one to assume that respondents are 'rational', have full (perfect) information, and that markets are in equilibrium (Welsch, 2006). As such, existing methods for assessing impacts of mining are limited in their ability to simultaneously quantify numerous impacts on values that are not amenable to non-market and to thus assess potential trade-offs between the costs and benefits of mining, properly taking into account the welfare of host communities (Ivanova et al., 2007).

This study aimed to address those issues by asking – from the perspective of residents of host communities – whether the positive aspects of coal mining outweigh the negative. Identifying trade-offs between positive and negative impacts, provides a policy reference, which can be used to address impacts of mining thus maintaining, and potentially even improve local wellbeing.

Life satisfaction is considered to be one of the dimensions of wellbeing, although sometimes the phrase is used interchangeably with 'wellbeing' (see section 2.3). Coal mining has the potential to impact numerous factors that contribute to wellbeing, so this study looked beyond just LS, investigating the impacts of coal mining on overall life satisfaction and on numerous factors (and domains) known to influence wellbeing.

This fills important knowledge gaps: not only does previous research lack comprehensive assessments of a large number of the benefits and costs of coal mining (individually, or 'in aggregate'), but it also lacks research that provides insights about the utility of subjective (as opposed to objective) indicators of wellbeing. Most previous research has used objective indicators of wellbeing – such as income – when assessing impacts. But there may be instances when objective indicators are unavailable (almost always when considering indicators of social capital) or inadequate (consider a region-wide measure of average annual rainfall that fails to capture differences in rainfall within the region). Previous research lacks examples of investigations that use subjective indicators of wellbeing; examples of studies could not be found that explore the relationship between objective and subjective indicators, and/or that provides guidance about situations in which it is 'better' to use objective or subjective indicators when assessing 'impacts'.

This thesis thus collected data on, and tested the efficacy of several types of subjective indicators: specifically, the perceptions of local residents of the importance of wellbeing factors to their overall wellbeing, their satisfaction with those factors, and their perceptions about the way in which coal mining affects those factors. The relationship between those indicators, and between subjective and objective indicators was also explored, thus providing information to fill important gaps in our understanding of the ways in which to measure and monitor wellbeing.

The LS approach was then used to assess net benefit. It is a relatively new method, which, unlike other non-market valuation approaches, does not require one to assume rationality, or equilibrium; neither does it evoke strategic behaviour (Welsch, 2006). It has been used to assess the 'value' of a wide range of non-market goods (e.g. air pollution (Welsch, 2006; Luechinger, 2009; MacKerron and Mourato, 2009), airport noise (Van Praag and Baarsma, 2005), corruption (Welsch, 2008)), but is has never been used in mining contexts. Therefore, this study adopted the LS approach to measure the net impact of coal mining on LS and on satisfaction with various life domains. The thesis thus does more than just assess net impact; it also provides comprehensive information about the impact of mining on a broad range of factors known to influence wellbeing, and in doing so, demonstrates a new method for considering mining (or other) 'impacts'.

Shanxi Province in China was selected as the case-study area. Data were collected from places with different intensities of coal mining, including rural areas with coal mining (Rural With), rural areas close to coal mining (Rural Close), urban areas close to coal mining (Urban Close), urban areas far from coal mining (Urban Far) and rural areas far from coal mining (Rural Far). This sampling strategy was chosen to enable cross-regional comparisons that allow for insights which could not be gleaned if focusing only on, for example, mining communities.

In total, 542 questionnaires were completed, providing information about people's global satisfaction with life (GLS), about their satisfaction with 29 factors known (from the literature) to contribute to wellbeing, about their subjective assessment of the importance of those factors to overall quality of life, and about the perceptions of the impacts of mining on those factors. Background sociodemographic information (also known to be associated with subjective assessments of wellbeing) was also collected.

Figure 7.1 provides a visual overview of the key research questions addressed, the methods adopted and the answers for each research question. The discussion below, provides more detailed ‘answers’ to core questions.

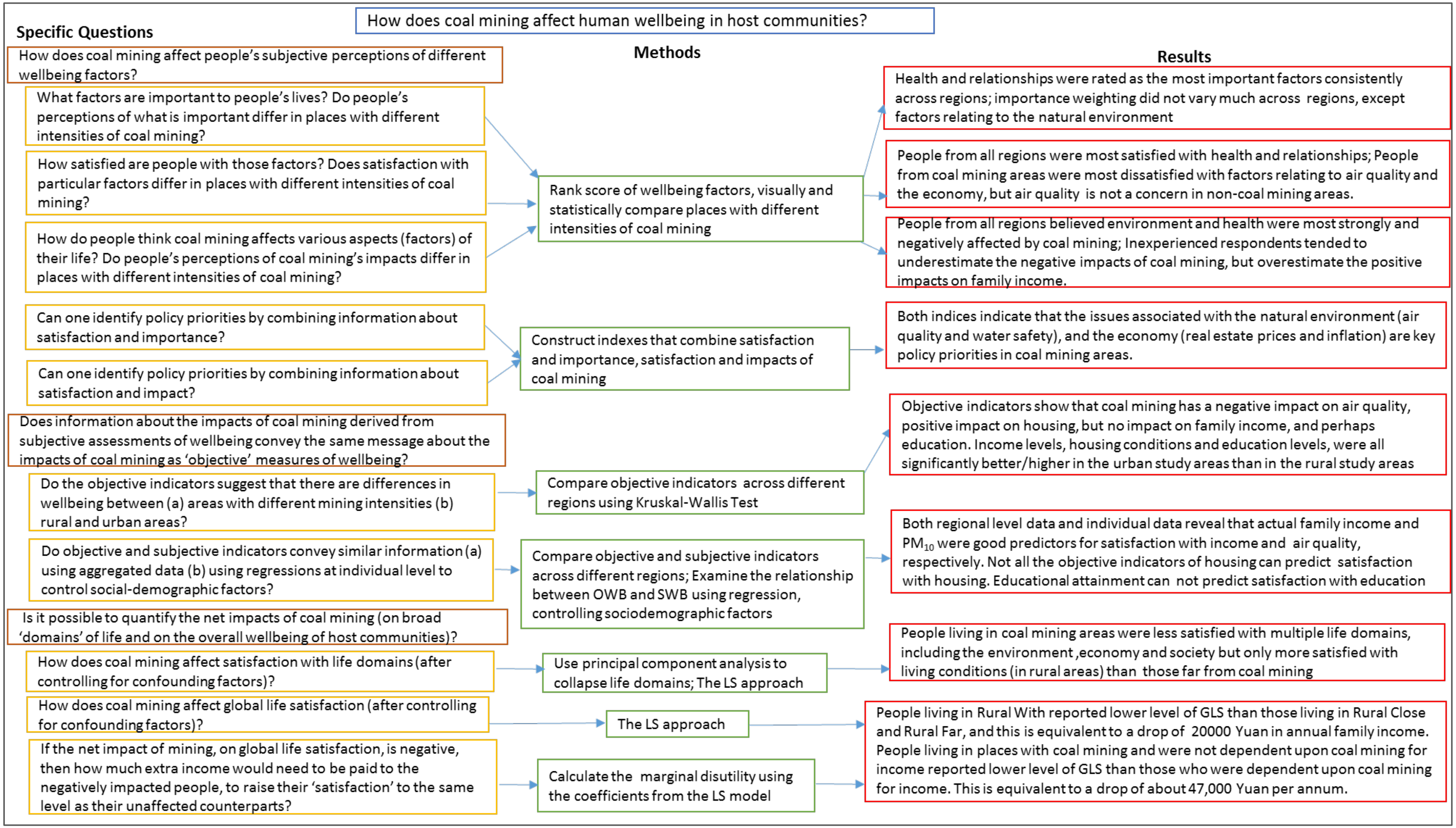


Figure 7.1 Overview of the thesis

1. The overarching question considered in Chapter 4 was: How does coal mining affect people's subjective perceptions of different wellbeing factors? This includes satisfaction with different wellbeing factors, the importance attached to each factor, and people's perception about impacts of coal mining on these factors.

   Sub-questions, and summarised 'answers' are as follows:

   1.1. What factors are important to people's lives? Do people's perceptions of what is important differ in places with different intensities of coal mining?

   Health and relationships (with family and friends) were rated as the most important wellbeing factors consistently across regions. For most factors, mean importance scores do not vary dramatically across different types of case-study regions. But residents living in rural coal mining regions attached significantly greater importance to factors relating to air quality.

   1.2. How satisfied are people with those factors? Does satisfaction with particular factors differ in places with different intensities of coal mining?

   Overall, respondents were most satisfied with factors relating to health and relationships, which was consistent across regions. People living in coal mining area were less satisfied with factors relating to air quality, water safety, inflation and price of necessities than those living in non-coal mining areas. The factors with which people living in coal mining areas were most dissatisfied related to air quality and the economy; in non-coal mining areas, people were most dissatisfied with factors relating to the economy while air quality was not a concern.

   1.3. How do people think coal mining affects various aspects (factors) of their life? Do people's perceptions of coal mining's impacts differ in places with different intensities of coal mining?

   Overall, the perceived impacts of coal mining on most factors were negative, among which the most concerning factors related to the natural environment and health, which was also consistent across regions. Compared to people living in coal mining regions, people living in non-coal mining regions seemed to underestimate the negative impacts of coal mining while exaggerating the potential positive impacts. In particular, residents living far from coal mining believed that coal mining may bring higher income or help decrease income disparities, while residents living in coal mining areas did not report any obviously positive impact of coal mining on income; instead they reported a negative impact on income disparity.

1.4. Are people satisfied with the factors that they attach great importance to? Can one identify policy priorities by combining information about satisfaction and importance – i.e. can we identify factors which people are very dissatisfied with and attach great importance to?

The Index of Dis-Satisfaction (IDS), which combines satisfaction and importance scores, reveals that in coal mining areas respondents were most dissatisfied with and attached greatest importance to factors relating to the environment (air quality and water safety) and the economy; factors relating to the environment were not a major concern for respondents in non-coal mining areas.

1.5. Are the factors that people are dissatisfied/satisfied with negatively/positively affected by coal mining? Can one identify policy priorities by combining information about satisfaction and impact – i.e. can we identify factors which people (either rightly or wrongly) 'blame' coal mining for impacting most negatively?

The Index of Dis-Satisfaction and Negative Impacts (IDSNI), which combines scores relating to satisfaction and perceptions of the impact of coal mining, convey the message that factors relating to the natural environment (dust, air quality, air cleanliness, water safety), and the economy (real estate prices and inflation) were the factors of dissatisfaction where coal mining had negative impacts.

2. The overarching question considered in Chapter 5 was: Does information about the impacts of coal mining derived from subjective assessments of wellbeing convey the same message about the impacts of coal mining as 'objective' measures of wellbeing?

   Sub-questions, and summarised 'answers' are as follows:

   2.1. Do the objective indicators suggest that there are differences in wellbeing between (a) areas with different mining intensities; and (b) rural and urban areas?

   Objective indicators reveal that coal mining had a significant negative impact on air quality (reflecting findings from the previous chapter relating to 'satisfaction with air quality' in mining and non-mining region). It had a positive impact on housing conditions (high percentages of households with a bathroom and flushing toilet). Coal mining had no obvious impact on family income (there were no statistically significant differences in family income across mining and non-mining regions, reflecting findings from the previous chapter which found no difference in 'satisfaction with income' across those regions). Coal mining had no obvious relationship with education. Family income, housing conditions and education levels, were all significantly better/higher in the urban study areas than in the rural study areas.

   2.2. Do objective and subjective indicators convey similar information when (a) using aggregated data and (b) using regressions at individual level to control sociodemographic factors?

   Both regional level data and individual data (analysed using regression to control for confounding sociodemographic factors) reveal that higher levels of actual family income were associated with higher levels of satisfaction with income, and that higher levels of PM_{10} were associated with lower levels of satisfaction with air quality. However, the objective indicators of housing selected in this study were not always good predictors of subjective assessments of satisfaction with housing, and there was no apparent relationship at all between the 'objective' indicator for education that was used here (the proportion of respondents who have completed a certain level of schooling) and satisfaction with education quality and opportunity. In all cases, when using regression, the relationship between objective and subjective indicators was mediated by sociodemographic factors.

3. The overarching question considered in Chapter 6 was: Is it possible to quantify the net impacts of coal mining (on broad 'domains' of life and on the overall wellbeing of host communities) and to determine how much should, in principle, be paid 'in compensation' to those who are, overall, impacted negatively?

   Sub-questions, and summarised 'answers' are as follows:

   3.1. How does coal mining affect satisfaction with life domains (after controlling for confounding factors)?

   Urban residents living close to coal mining were generally less satisfied with their environment and with institutional capital than urban residents living far from coal mining. In rural areas, those living in close proximity to mines (both Rural With and Rural Close) were less satisfied with the natural environment and the economy, and those living in either with coal mines or close to coal mines reported lower levels of satisfaction with social, institutional or human capital than those living further away from coal mines. In contrast, rural residents living in coal mining areas (Rural With and Rural Close) were more satisfied with their living conditions than those living further away. The impact of coal mining on the environmental domain seems to be more strongly negative than on any other domain, and those living immediately adjacent to mines (the 'Rural With' sub-sample) were even less satisfied with the environment than those living at least 10km away.

   3.2. How does coal mining affect global life satisfaction (after controlling for confounding factors)?

   Residents in urban areas seem relatively unaffected by proximity to mines: after controlling for sociodemographic factors, there was no statistically significant difference in GLS between 'Urban Close' and 'Urban Far' sub samples. In rural areas, residents of villages adjacent to coal mines were less satisfied with their life as a whole than those living further away from mines (Rural Close and Rural Far). However, the difference in GLS between Rural Close and Rural Far was not statistically significant (after having controlled for sociodemographic). People living in rural villages adjacent to mines who depended upon coal mines for their family income were significantly more satisfied with their lives than those living in the same region who were dependent upon other industries for their income.

3.3. If the net impact of mining, on global life satisfaction, is negative, then how much extra income would need to be paid to the negatively impacted people, to raise their 'satisfaction' to the same level as their unaffected counterparts?

Those living 'with' coal, would need to be compensated by 20,000 Yuan per household per annum, to raise their GLS to a similar level as households who are less affected by coal mines (those living close to, rather than 'with' coal mines). Those who were dependent upon non-mining industries for a living would potentially need to be 'compensated' 47,000 Yuan per household per annum, to raise their GLS to the same level as those in similar regions who work in the coal mining industry.

7.3 Empirical contributions

The various metrics used in this thesis all suggest that the impact of coal mining on the natural environment is most concerning. First, respondents perceived that coal mining had strongest negative impacts on the factors relating to the environment than on other wellbeing factors. Second, the objective indicator of air quality (PM_{10}, measured in each village in which data were collected) clearly showed that air quality was worse in regions with or close to coal mines than in regions further away. Third, respondents who lived in regions 'with' or close to coal mines were less satisfied with factors relating to the environment than those living further away from mines – even after controlling sociodemographic factors known to influence such perceptions in the LS models. Fourth, the coefficient (from the models about satisfaction with different life domains in chapter 6) for the environmental domain is of higher magnitude than coefficients for other domains, indicating that the impact of coal mining on the natural environment is stronger than any other impact. This is consistent with the message from the Index of Dis-Satisfaction (IDS) and the Index of Dis-Satisfaction and Negative Impacts (IDSNI), which indicate that environmental issues were paramount coal mining areas.

Coal mining did not have a positive impact on average income; but had a negative overall impact on the local economy. First, respondents from all areas believed that coal mining had negative impacts on the inflation rate, real estate prices, and price of necessities; respondents who lived with or near coal mines did not think coal mining had obviously positive impacts on their income (although those who lived far away felt that coal mines might improve their income). Second, objective indicator of income confirmed that there was no significant difference in the household income between those living with, near, or far from coal mines. Third, respondents from coal mining areas were not more satisfied with their income or with other factors associated with the economy. After controlling sociodemographic factors, coal mining was shown to have a negative impact on the economic domain.

Objective indicators were not available for factors relating to social and institutional capital. But subjective indicators suggested that coal mining might also have negative impacts on these domains; perhaps even on human capital. Qualitative evidence supported a link between the deterioration of institutional capital/social capital in coal mining areas, although statistical results were not always significant for all the coal mining areas (Urban Close, Rural With, Rural Close).

The only domain that coal mining had a demonstratively positive impact upon was that of living conditions. This was ascertained by objective indicators (the percentage of houses with bathrooms and flushing toilets in different case-study areas), and the high levels of reported satisfaction with living conditions after controlling for sociodemographic factors.

For the sample considered here, it is thus clear that coal mining generated negative impacts on multiple life domains in rural coal mining areas (Rural With and Rural Close); it only generated positive impacts within 1 domain (living conditions). For those living ‘with’ coal, the negatives outweigh the benefits, confirmed when analysing global life satisfaction (GLS). The net negative impacts were equivalent, in life satisfaction terms, to a drop of 20,000 Yuan in annual family income. In other words, this suggests that those living ‘with’ coal, would need to be compensated by 20,000 Yuan per household per annum, to raise their GLS to a similar level as households who were less affected by coal mines (those living close to, rather than ‘with’ coal mines). Those who were dependent upon non-mining industries for a living (e.g. agriculture) were even less satisfied with life overall, compared to those who worked in the mining industry. They would potentially need to be ‘compensated’ 47,000 Yuan per household per annum, to raise their GLS to the same level as those in similar regions who work in the coal mining industry. For rural areas and urban areas ‘close’ to coal mines, the negative impacts were apparent, but might not outweigh the positive (living conditions), as the GLS was statistically similar to those living far from coal mines, after controlling for confounding factors.

Other studies also found net negative impacts of coal mining in other places. For example, Hendryx and Ahern (2009) assessed negative impacts of coal mining on public health (using value of statistical life (VSL)) relative to the economic benefits of the coal mining industry in Appalachia region in USA, and found out the VSL costs outweighed the economic benefit from coal mining. Bai et al. (2011) found a monetary net cost of coal mining in Mentougou district of Beijing, using a CBA which estimated the economic benefit (output value of coal), social benefit (employment opportunity, annual per capita income and public infrastructure) and damage to water eco-service. Li et al. (2011) also found the ecological and environmental loss caused by coal mining was far more than its economic benefits in Mentougou district of Beijing.

However, these studies, like many other studies, use mainly market-based approaches to calculate the costs and benefits of coal mining. Thus they can only involve a narrow range of impacts, which could be easily linked to the market good, but very often exclude other intangible/non-market impacts. As discussed in chapter 1, coal mining has impacts on multiple life domains, so a defensible estimation of net impact should take into account a wide range of impacts. This highlights the need to comprehensively assess non-markets impacts on host communities in future mining impact assessments. Using life satisfaction (rather than money) as a metric, this study provides a comprehensive set of results which can be used to inform policy initiatives to address the negative impacts of coal mining. Specifically, the results indicate that multiple life domains are adversely affected (including those relating to the environment, the economy, or even institutional capital, social capital and human capital); policy makers could seek to explicitly redress those impacts, thus maintaining, or perhaps even improving the wellbeing of those in host communities by, for example, providing more housing (to ease pressure on real-estate prices) and/or ensuring that 'locals' have the opportunity to work in the mines (rather than importing workers from outside the region).

7.4 Discussion of empirical findings

This study highlights the fact that coal mining does not necessarily improve the wellbeing of those living in host communities. On the contrary, it brings net costs to people living in rural places with coal mining areas, consistent with studies that involved much less domains (Hendryx and Ahern, 2009; Bai et al., 2011). Key findings from this study, regarding the life domains likely to be positively and negatively impacted by coal mines are consistent with findings from studies in other countries or other extractive industries. So although socio-economic context varies widely form one part of the world to another, some of the insights generated by this study may also be relevant elsewhere. Similarly, the approaches used in this study can be generalized to other mining industries/projects or maybe other contexts.

Respondents to the survey indicated that the environmental conditions in regions with or close to coal mines were much better than several years ago – largely because of the industry reforms and consolidation of coal mines enforced by the Chinese government. This recent improvement in conditions is likely to have affected people's subjective assessments of current conditions (Emmons and Diener, 1985). In other words, expressed levels of satisfaction would have likely to be even lower if conditions had, instead, been better in the past (recent improvements prompt more positive responses). That respondents were still expressing dissatisfaction even after such improvements, indicates that environmental impacts connected to mining were still challenging (Eccert, 1994).

The main issue was air quality, especially dust: it ranked at the top of both the IDS (Index of Dis–Satisfaction) and the IDSNI (Index of Dis–Satisfaction and Negative Impact) lists, and in conversations with respondents, it was evident that people linked "air cleanliness" and "generally air quality" to dust. Apart from general geographic characteristics – such as an arid environment and lack of vegetative cover (Shanxi Government, 2013) – that contribute to the generation of dust, coal mining and coal transportation are significant sources of dust in rural areas, where coal mining is the dominant industrial activity. The issue does not seem to be one of a lack of regulation, but rather a lack of compliance and enforcement. One example is that in the coal mining areas truck drivers were reported as always violating regulations and using the shortest road through the village, instead of the special road built for coal transportation. Moreover, 90% of coal transportation trucks were not covered when they should have been (see section 4.4). Like other countries throughout the developing world, environmental considerations give way to economic and social benefits, at least partially because of less educational awareness and fewer financial resources (OECD, 2002).

Mining may increase regional and national product (or GDP) (Editor of Land & Resource Herald, 2013; National Mining Association, 2014), but it is clear from this study that economic growth does not necessarily produce higher levels of wellbeing – neither higher satisfaction with particular life domains, including that associated with the economy (the inflation rate, the price of necessities, income disparities, real estate prices, fairness, and family income), nor with life in general. This is consistent with the findings of Easterlin and Sawangfa (2009) that economic growth does not necessarily increase subjective wellbeing. This study also suggests that "uneconomic" growth described by Daly and Farley (2010), which refers to the point where the subjective wellbeing starts to decline, may occur in rural areas with coal mining.

Both qualitative and quantitative evidence from this study suggest that there are also negative impacts of coal mining on institutional capital and social capital. These problems were also illustrated by many other researchers in the general mining industry in a wide range of countries (e.g. Marshall, 2001; Sachs and Warner, 2001; Petermann, et al., 2007). In this study, empirical results indicate that people living in either Rural With, Rural Close or Urban With reported lower satisfaction with institutional capital and social capital after controlling for sociodemographic factors, which is confirmed or explained by qualitative evidence. As discussed in section 6.4.1, rent-seeking and corruption behaviour associated with the financial compensation is common in coal mining areas potentially eroding social capital. Moreover, in these regions coal companies hired most coal miners from outside the region, because of concerns that coal miners recruited from the resident community had stronger negotiating power in disputes arising between the workers and the company. Those non-resident coal miners may have little meaningful attachment to community, and may thus disrupt existing social bonds and networks, leading to a loss of community identity and personal security in the coal mining area (Carrington et al., 2011). In addition, many of those living in rural areas have limited options for work/livelihoods and coal mining may restrict the options still further (e.g. agriculture may become less viable due to the impacts from coal mining (see the quote in p. 124)). Locals may thus be forced to compete for limited jobs opportunities. This may, again, breed rent-seeking and corruption – those who have the power to allocate jobs might became rent seekers; those with the strongest personal relationship and/or who are wealthy enough to afford this rent are more likely to get work in the coal mining industry.

The core issue for coal mining areas revealed by this study is thus the uneven distribution of benefits and costs from coal mining for host communities. This is consistent with the findings of Zhang et al. (2015), who highlighted the fact that people living in mining regions more strongly believed that incomes were less equitable in their area as a consequence of mining than those living in non-mining areas. Notably, their findings refer to the general mining industry in China, not specifically to coal mining. Studies of coal mining and of other mining industries in other countries also display similar problems (e.g. Carrington et al., 2011; Kitula, 2006). The consistency of findings across all these studies suggest that the unequal distribution of costs and benefits within regions associated with mining industries is a common issue. Currently, most fossil fuel industries, that might be essential for economic development and the accumulation of wealth, are maintained at the expense of segments of society (The guardian, 2015). Mining companies, especially in developing countries, are often free from the full responsibility for the externalities, in terms of environmental and social costs (The

Guardian, 2015). Host communities who experience many of these negative externalities may not get enough benefit or compensation.

However, the problem is not mining *per se*, as noted by Davis and Tilton (2005). The "resource curse" occurs when a country (or other entity) with poor governance fails to avert the dangers that accompany mineral development or misuse the wealth generated from mineral extraction (Gylfason, 2001; Davis and Tilton, 2005). Local people's sharing of benefits from coal mining "depends upon the attitudes and policies of the company, the provincial government and the national government towards the area and its people" (Jackson, 1982, p. 170).

In this case, governments appear to be reluctant to redistribute some of the benefits and curb the costs if it means hindering the economic growth (Carrington et al., 2011). Additionally, corruption and rent-seeking behaviour associated with mining, also illustrated in this study, exacerbate this uneven distribution of benefits and costs. The observed problem of institutional capital in coal mining areas in this study is consistent with that argument, and might help explain the lower observed levels of satisfaction with other domains (e.g. economy), or even satisfaction with life overall.

As is apparent from the above, this study provides useful empirical insights about the impacts of coal mining. Although the relationship between resource-dependence and wellbeing may vary within regions or countries (Stedman et al., 2004), the consistency between the finding of this study and other studies involved with different industries in different countries may increase the confidence that problems associated with coal mining found by this study might be universal in other mining industries in other regions in China or even in other countries. As detailed at the end of chapter 6, these insights can be used to inform public policy, to mitigate the negative impacts of coal mining on host communities, and thus to improve wellbeing and to promote local development. This does not necessarily mean that there should be a universal policy to mitigate mining impacts, as the social/political system vary between countries.

7.5 Methodological contributions and implications for policy makers or practitioners

The methods demonstrated in this study can be used in broader contexts. This study makes a methodological contribution to two 'branches' of literature: that which is associated with the assessment of wellbeing, and that which is associated with the assessment of the impacts of mining (and other developments – e.g. dams or roads) on host communities. It demonstrates that subjective indicators of wellbeing can be used to inform policy makers of public preference, and that studies which use both subjective and objective indicators may thus provide a more comprehensive picture of wellbeing than those that use only one, or the other. It also demonstrated how the life satisfaction approach can be used to assess net impacts on life overall, and on life domains.

7.5.1 Methodological contributions and insights for monitoring/ measuring wellbeing

Governments, especially in developing countries, tend to focus on objective indicators of wellbeing (which are often collected in censuses), while paying little attention to indicators of subjective wellbeing (Diener and Suh, 1997; Abdallah et al., 2011; Rablen, 2012). Subjective indicators could, also be easily collected in censuses and are thus not necessarily more 'costly' or 'difficult' to obtain than objective indicators. Numerous researchers have argued that subjective wellbeing cannot, and should not, be ignored (e.g. Dale, 1980; Veenhoven, 2002; OECD, 2013). This study adds new evidence that it is necessary to use subjective indicators, as a complement to objective indicators, if seeking a true and comprehensive picture of wellbeing.

First, objective indicators are not always as 'objective' as some believe: they may simply reflect the preferences and value judgements (about what is 'important' enough to be measured) of the researchers who select the indicators, instead of reflecting the preferences and value judgements of the general public (Veenhoven, 2002; Rablen, 2012). In such situations, objective indicators might be judiciously selected to portray a desired picture, and may not reflect the true wellbeing of the broader population. In contrast, subjective indicators reflect people's thoughts and emotions (Rablen, 2012), which can provide a mechanism through which public opinion to be expressed. Building this mechanism by which people's voices can be expressed and taken into account may improve monitoring systems – be those related to a particular industry, or those simply monitoring the socio-economic system more broadly.

Moreover, evident from this study, and consistent with other findings (e.g. Emmons and Diener, 1985), objective wellbeing indicators do not always accurately reflect subjective assessments. For the wellbeing factors considered here, it seems that objective indicators of some life domains may work as better 'proxies' for subjective wellbeing than others (e.g. income and air quality). Some objective indicators are not good predictors of subjective wellbeing (e.g. a bigger house does not necessarily indicates high satisfaction with housing).

Notably, the relationship between objective and subjective measures of wellbeing can be mediated by sociodemographic factors (e.g. younger people seem to require more household income to be satisfied with income). Evident from this study, it is thus correct to say that improvements in household income (or reduction in PM_{10}) will be accompanied by improvements in people's satisfaction with their income (or air quality). But it does not mean people who have high income (or good air quality) will be more satisfied with their income (or air quality) than others with lower income (or with poor air quality).

The relationship between OWB and SWB thus depends on the nature of wellbeing factors, the particular objective indicators used, the sociodemographic factors and the cultural contexts. Using objective indicators only to inform and guide policy, may thus omit important aspects of wellbeing, especially when single, aggregated measures mask differences within regions (Schneider, 1975) and are not able to reveal information about people's preference. Consequently, monitoring programs that use only objective indicators may not be able to adequately monitor wellbeing.

Thus it is necessary to consider when objective indicators do, and do not, consistently reflect subjective assessments, and thus when they can (or cannot) be used to inform public policy. For those wellbeing factors where objective indicators can predict subjective indicators (income and air quality, in this case), it is likely appropriate to choose either one or the other. For those wellbeing factors where objective indicators do not necessarily predict subjective indicators (housing, in this case), it may be important to include both types of indicators to deliver a comprehensive picture of wellbeing. For intangible factors, such as trust and perceived street safety, which are difficult to be measured by objective indicators (Veenhoven, 2002), it is better to use subjective indicators than to follow current practice, which is to ignore that which cannot be measured objectively.

More importantly, this study offers an empirical approach to examine the relationship between objective and subjective indicators of wellbeing, using regression and controlling for sociodemographic factors. Using this approach, future studies can also examine the relationship between objective and subjective indicators for other wellbeing factors. By doing so, more empirical results, which can be used for the reference of public policy will accumulate. This enables researchers or decision makers to decide when (in which regions, and for which domains) it may be appropriate to use only objective indicators, when it may be appropriate to use subjective indicators, and when it might be necessary to use both.

7.5.2 Methodological contributions to the impact assessment literature

As discussed in section 2.2.1.2, common methods for assessing the impacts of mining (including EIA, SIA and EcIA) struggle to adequately assess (in terms that can be compared in a quantitative way) the impacts of mining projects. Of particular relevance are the difficulties of accounting for the non-market impacts of mining, and of reliably and fairly identifying the magnitude or direction of the trade-off or net impact. This study demonstrates that the concept and measurement of subjective wellbeing and the LS approach can at least partially address the problem, and could be used to complement traditional impact assessment approaches.

As most previous research that has used the LS approach has been undertaken in developed countries, this study also provides accountability for using the LS approach in developing countries. To the best of my knowledge, this study is also the first one to use the LS approach to assess the impacts of mining on satisfaction with life domains, and also on GLS. Importantly, this study illustrats that, not only can the LS approach capture the impacts of mining on a diverse range of wellbeing factors, but it can quantify those non-market impacts in a way that allows one to compare their relative magnitude, and it can also measure the magnitude of the impacts in monetary terms. The LS approach thus could be used alongside other impact assessments and/or to support assessments of eco-compensation.

Impact assessment practitioners can develop or take from the literature a list of suitable wellbeing factors that might be affected by the targeted projects. Data relating to people's subjective satisfaction with those factors, and perceptions of the importance of those factors to overall wellbeing, can be collected from the different areas to facilitate the comparison, or even in the same area before and after a certain project start up. If the cause-effect relationship between the targeted project and certain outcome need to be clarified, data on people's perceived impacts of the project can also be collected. Then an action list which identifies the most important/dissatisfying or most strongly affected wellbeing factors can be developed to inform the mitigation policy.

If seeking to determine whether the project incurs a 'net benefit' (i.e. if the benefits outweigh the costs), then the LS approach can be used. The LS approach, which has been successfully used to assess the 'value' of numerous different non-market goods in a variety of contexts (see section 2.2.2.2.), can assess the net impact (on satisfaction with particular life domains and on GLS) of numerous simultaneous and related changes. This information could be added to information generated by more traditional assessment approaches (which are well suited to a detailed analysis of particular impacts). With the capacity to measure non-market impacts, it also enables one to use coefficients from the LS equations to estimate the required 'compensation' for loss of broad range of intangible factors. As discussed in section 6.4.3, when the LS approach used for policy of compensation, endogeneity issues should be considered and controlled to generate estimation with more confidence.

The framework suggested by Noronha (2001) integrated multiple domains that coal mining might impact (environmental, economic, social and political), used both objective and subjective indicators and calculated net impact using mainly market-based approaches. This is an advance, given the fact that current studies use mainly objective wellbeing factors, cost-benefit analysis and only involve limited life domains. This study confirms that it is necessary and useful to explore multiple life domains using both objective and subjective indicators. More importantly, it demonstrated that using subjective data can help quantify the non-market impacts and identify a defensible trade-off.

The approaches demonstrated in this study are better viewed as complementing rather than replacing more traditional mining impact assessments. The mixed approaches used here might be integrated in the existing framework of mining impact assessment and eco-compensation to facilitate more comprehensive mining impact assessment.

7.6 Implications for future research

Future studies are needed to expand some results and to overcome some of the difficulties encountered in this study.

First, future studies could explore the relationship between objective and subjective indicators across other domains, and in other social/culture contexts. The heterogeneity issues could be addressed by future studies using objective data with higher resolution (e.g. objective indicators of air quality at individual level). With the accumulation of empirical evidence on the relationship between objective and subjective indicators in more life domains, policy makers can be better informed when to use either of them, when to use both and which is important for the development of regional policy.

Second, while this study has demonstrated that it is, in principle, possible to use the LS approach to generate estimates of the 'compensation' likely required to maintain people's GLS at a consistent level even when confronted by numerous impacts from mining, the empirical estimates presented here are not robust enough to be used with certainty. Endogeneity is a difficult issue when using the LS approach, and may bias compensation estimates (MacKerron and Mourato, 2009; Ferreira and Moro, 2010). This study was only an exploratory study with a relatively small sample and non-time-series data. It thus did not address endogeneity issues. If practitioners intend to use the LS approach to generate estimates of compensation in 'live' settings, they may need control for this problem – and more research that identifies appropriate instruments (or alternative methods) to do so is needed.

Third, much research raises concerns about the potential 'unsustainability' of mining (Vincent, 1997), which might be considered in future studies. The economy, and infrastructure in remote mining areas, to some degree rely on mining companies. When resources are exhausted and mines shut down, the benefits associated with mines, such as jobs or services maintained by mining companies, may disappear (Warhurst and Noronha, 1999). Fears about that happening in the future, may affect the wellbeing of people today (The international wellbeing group, 2013; OECD, 2011). This study did not consider this issue, but future research which further develops "suitable indicators for describing the evolution of stocks of different types of capital (natural, economic, human and social)" (deemed still lacking (OECD, 2011, p. 6)) for consideration individually (as in Chapter 4), or for incorporation into LS studies (as per chapter 6) could add much extra depth and a broader perspective to the issues considered in this thesis.

Lastly, this study uses aggregated wellbeing data at individual level and treats those aggregated measures as if they measure the wellbeing of communities (characterized by different intensities of coal mining), like many other studies did (e.g. Schneider,1975; Oswald and Wu, 2010). Some researchers "have highlighted the need to expand analysis beyond the individual to the wider contexts of the community and the social interactions that they involve" (Gibbs et al., 2015, p. 6), because the sum of the individual at the micro level does not necessarily equal the value at a macro ('whole of community') level (Hancock et al., 1999 and Sirgy, 2011, cited by Gibbs et al., 2015, p. 6). While the situated, dynamic and context-dependent nature of social interaction should be asserted when investigating community wellbeing, the current methods of analysis, such as standard survey and subsequent statistical techniques, are not quite yet able to capture the embeddedness of individuals within the social network (Gibbs et al., 2015). Future studies are also needed to explore the 'whole of community' approaches, which might be used to compare to individualistic approaches, to see where there are substantial difference.

7.7 Concluding comments

This research set out to further our understanding of the impacts of coal mining on the 'wellbeing' of those living in host communities. It used a variety of different methods and measures – providing a comprehensive overview of impacts on life domains and on life overall. A clear and consistent message emerges: coal mining has multiple impacts across multiple domains – negative impacts on the environment, economy, and society; positive impacts on living conditions. It has net negative impacts for those immediately adjacent to coal mine, especially those who live adjacent to coal mines but are not dependent upon coal mining for household income.

Overall, this study illustrates that wellbeing (particularly subjective wellbeing) is an appropriate lens through which to view and assess mining impacts and to inform mitigation policies. It adds empirical evidence that subjective indicators can complement the traditionally used objective indicators to provide a more comprehensive policy reference. It demonstrates simple but effective approaches to identifying policy priorities for impact mitigation and a more sophisticated approach to assess net impact in monetary terms. These approaches can address some of difficulties that prevent existing approaches from comprehensively assessing the numerous and varied impacts of mining, thus helping to generate a valid and defensible impact and eco-compensation assessment method for the mining industry. Although still imperfect, with future refinement and research, the methods demonstrated here offer a new way for thinking about and assessing multiple 'impacts', not just in the context of mining, but likely in many other situations.

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Appendix A: Questionnaire

Appendix A – 1: Questionnaire

	How satisfied are you with those factor?							How important are those factors to your life?							How coal mining affect those factors?							
	Strongly dissatisfied	Dissatisfied	Slightly Dissatisfied	Neutral	Slightly Dissatisfied	Dissatisfied	Strongly dissatisfied	Very unimportant	Unimportant	Slightly disagree	Neutral	Slightly important	Important	Very important	Strongly negative	Negative	Slightly negative	No impacts	Slightly positive	Positive	Strongly positive	I don't know
Health situation																						
6.Physical health of yourself	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7.Mental health of yourself	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8.Physical health of your family	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9.Mental health of your family	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Income																						
10. Family income level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11.Personal income level	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Don't fill this if you don't have personal income																					

	How satisfied are you with those factor?							How important are those factors to your life?							How coal mining affect those factors?							
12.Difference between my income level and others living in your village/town/city	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Job or something you can live on																						
13.Salary or money you earn form your job or business [24]	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
	Don't fill this if you don't have job or business																					
14.Other aspects of job apart from financial aspects	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Living standards																						
15.The house/apartment you are living	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
16.Water supply	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
17.Electricity supply	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
18.Other infrastructure (transportation and communication)	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Natural environment																						

[24] During the survey, it is found out that salary was the decisive factor for job satisfaction. Also, there is not much variation on the answers relating to 'other aspects of job', thus wellbeing factor 14 was excluded from the analysis. The answer relating to 'salary', 'personal income' and 'family income' are highly correlated. Meanwhile, comparing to 'salary' and 'personal income', questions about 'family income' have the least missing values, thus only 'family income' was used in the analysis.

	How satisfied are you with those factor?			How important are those factors to your life?			How coal mining affect those factors?			
19.Total air quality[25]	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
20.Cleanliness of the air (whether the air make you sick)	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
21. Dust in the air	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
22. Safety of drinking water	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
23. Safety of surface water	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
Price level										
24. House price level	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
25.The current price of necessity (food, cloth, transportation)	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
26.Inflation rate	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□
Education										
27.The education opportunity	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□ □ □	□	□ □ □	□

[25] Questionnaire for this study, initially, asked about people's satisfaction dust in the air, air cleanliness, smell of the air, the amount of smoggy days. After the pilot survey, "smell of the air", and "the amount of smoggy days" were deleted, as rural respondents, generally did not encounter bad smell and smoggy days. Satisfaction with air quality as a whole were also asked after pilot test.

	How satisfied are you with those factor?			How important are those factors to your life?			How coal mining affect those factors?			
28.The quality of education (amount and quality of schools)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
Personal relationships										
29.The relationship status with your family	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
30.Relationship with your close friends, relatives and neighbour	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
31.Social participation (political activity, sports, donation, volunteer, club, religion and so on)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
Social trust and justice										
32.People in the community can trust each other(no cheating and stealing)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
33.People in the community help each other (carry bag for strange senior people)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
34.People in the community can be honest to each other	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐

	How satisfied are you with those factor?			How important are those factors to your life?			How coal mining affect those factors?			
35.People in the community can count government or police when they need	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
36.Income fairness	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
Safety										
Physical safety in the place you are living (don't worry someone harm you)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
The illegal behaviour your property have encountered (stealing, rob, cheating)	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐ ☐ ☐	☐	☐ ☐ ☐	☐
39.										
40.										
41.										

Are there other things important to you which we haven't listed? Please add to the blank and fill the form like other factors.

Background information

42. Gender: ☐Male ☐female

43. Age: ☐ 18–25 ☐ 26–35 ☐ 36–45 ☐46–55 ☐56–65 ☐above 65

44. How many people, including yourself, normally live in your household?

Adults____ children (16 and younger) ____

45. Marriage status

☐Married ☐ Never Married ☐ Divorced Widowed ☐Separated but not divorced

46. The highest level of education of yourself:

☐Primary school ☐ Secondary school ☐High school ☐University ☐Other (please specify)

47. Which of the following categories applies to you?

☐Full time paid employment ☐Part time paid employment ☐Casual employment

☐Unemployment ☐Full time study ☐Part time study

48. Please indicate which of the following industries is the main source of your household's income?

☐Agriculture, forestry, animal husbandry or fishing ☐ Mining ☐ Manufacturing

☐Produce and supply of electricity, gas and water ☐Construction ☐Retail

☐Transportation, warehousing and postal industry

☐Information transferring, IT service and software industry ☐ Financial industry

☐ Accommodation cafes and restaurants ☐Real estate industry ☐Leasing and business service

☐ Research, technique service and geological exploration ☐ Education

☐Communal facilities management ☐Culture, sports and entertainment

☐Public health, social security and social welfare ☐ Public administration and social organization

49. On average, how much pre–tax income does your household earn each year?

☐Below 10,000 ☐10,000 – 20,000 ☐20,000 – 30,000 ☐40,000 – 50,000 ☐50,000 –60,000 ☐60,000 – 70,000 ☐70,000 – 80,000 ☐ 80,000 – 90,000 ☐90,000 – 100,000 ☐100,000 – 110,000 ☐110,000 – 120,000 ☐above 120,000 ☐Prefer not to say ☐ I don't know

50. I spend___hours per week on work, and ___hours per week on leisure, entertainment or sports per week.

51. The number of rooms per person have in average in my dwelling is_

52. I ☐have / ☐don't have flush toilet or bathroom in my dwelling.

53. How far is the following activity related to coal mining from your dwelling? Unit: km

	0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100
Coal mining										
Railway mainly for coal transportation										
Coal stockpile										
Waste from coal										

54. Which direction is the following activity related to coal mining from your dwelling?

	north	northeast	northwest	South	Southeast	southwest	west	east
Coal mining								
Railway mainly for coal transportation								
Coal stockpile								
Coal gangue								

55. How are you satisfied with your life as a whole, on a scale from 0 to 100?

Appendix A – 2: Information sheet

INFORMATION SHEET

PROJECT TITLE: "Coal Mining and Human Wellbeing"

You are invited to take part in a research project about coal Ming and Well–being. The study is being conducted by **Qian Li** will contribute to the **degree** in **PhD** at James Cook University.

If you agree to be involved in the study, you will be invited to complete a questionnaire, which asks you about your assessment of your own life satisfaction. The questionnaire should only take 10 minutes to complete.

Taking part in this study is completely voluntary and you can stop taking part in the study at any time without explanation or prejudice.

Your responses and contact details will be strictly confidential. The data from the study will be used in research publications and reports. You will not be identified in any way in these publications.

If you have any questions about the study, please contact **– Qian Li and David King.**

Principal Investigator:

Qian Li

School of Education

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Phone: 4781 4877

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Supervisor: (If applicable) or Co–Investigator Details:

Name: David King

School: School of earth and environment

James Cook University (or other institution)

Phone: (07) 4781 4430

Email: david.king@ jcu.edu.au

If you have any concerns regarding the ethical conduct of the study, please contact:
Human Ethics, Research Office
James Cook University, Townsville, Qld, 4811
Phone: (07) 4781 5011 (ethics@jcu.edu.au)

Appendix B: Comparison of income between the (coal) mining industry and other industries

Table 1 statistical tests between family income of coal mining industry and other industries

Location	Proportion of family income sourced from coal mining	Average family income		Result from Mann–whitney Test	
		Coal mining	Non–coal mining	P–Value (2–sided)	P–Value (1–sided)
Rural With	32.10%	39237	31210	0.0368	0.0184
Rural Close	16.20%	41071	31084	0.0122	0.0061
Urban Close	14.80%	42895	31667	0.6408	0.3204
Urban Far	0.00%				
Rural Far	0.00%				

Table 2 Average wages of mining industry and other industries

Industry	Average Wages of Fully Employed (yuan)	
	Non–private Units	Private Units
Total	47417	27580
Farming, Forestry, Animal	29807	21064
Husbandry and Fishery		
Mining	**69039**	**37694**
Manufacturing	36876	27348
Production and Supply of Electricity, Heat, Gas and Water	64507	27199
Construction	38119	29185
Wholesale and Retail Trade	33075	25978
Transport, Storage and Post	55385	22411
Lodging and Catering Services	23251	20577
Information Transmission, Software and Information Technology Services	51171	21177
Banking and Insurance	73675	34975
Real Estate Trade	34579	31987
Lease and Business Services	32218	19582
Scientific Research and Technical Services	51611	26056
Water, Environmental Protection and Public Facility Management	24091	20260
Resident Services, Repair and Other Services	28473	20070
Education	42430	20985
Health Care and Social Work	37245	21526
Culture, Sports and Recreation	36502	19786
Public Management, Social Security and Social Organization	37866	
Share Controlled by State	57557	

Source: Selected from Statistical Yearbook of Shanxi, 2014

Note: Average wages of mining industry are highlighted in red. Only wage of mining industry, rather than wage of coal mining industry, is available in the Statistical Yearbook of Shanxi. Since coal mining is dominant (mining) industry (see Table 3.2), the information here can be treated as a reference for coal mining industry.

Appendix C: The relationship between objective and subjective wellbeing indicators

Appendix C–1: The relationship between actual family income and satisfaction with income

Table 1 Ordinal regression results (Total sample population)

SatIncome	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
income	2.42E–05	3.10E–06	7.78	0	1.81E–05	3.02E–05
schooling	–0.032	0.028	–1.130	0.257	–0.086	0.023
adult	–0.052	0.057	–0.920	0.358	–0.163	0.059
children	–0.103	0.089	–1.150	0.250	–0.278	0.072
age	0.023	0.008	2.830	0.005	0.007	0.038
female	–0.290	0.170	–1.710	0.088	–0.624	0.043
NotPartnered	0.298	0.265	1.120	0.261	–0.221	0.816
emp1	1.442	0.361	4.000	0.000	0.735	2.149
emp2	0.014	0.234	0.060	0.953	–0.444	0.472
emp3	0.383	0.382	1.000	0.316	–0.366	1.132
emp4	0.198	0.202	0.980	0.327	–0.198	0.594

Table 2 Ordinal regression results (Urban Close)

SatIncome	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
income	1.73E–05	6.01E–06	2.88	0.004	5.50E–06	2.91E–05
schooling	–0.120	0.081	–1.480	0.139	–0.279	0.039
adult	0.272	0.117	2.320	0.021	0.042	0.502
children	0.380	0.362	1.050	0.294	–0.331	1.092
age	0.044	0.031	1.430	0.154	–0.017	0.104
1.female	0.310	0.431	0.720	0.473	–0.536	1.156
1.NotPartnered	1.338	0.774	1.730	0.084	–0.182	2.858
1.emp1	1.792	1.414	1.270	0.205	–0.985	4.570
1.emp2	1.185	0.866	1.370	0.172	–0.517	2.887
1.emp3	0.371	0.700	0.530	0.596	–1.003	1.745
1.emp4	0.918	0.513	1.790	0.074	–0.091	1.926

Table 3 Ordinal regression results (Rural With)

SatIncome	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
income	2.35E–05	9.15E–06	2.57	0.01	5.56E–06	4.15E–05
schooling	–0.021	0.058	–0.360	0.721	–0.135	0.093
adult	–0.212	0.101	–2.100	0.036	–0.411	–0.013
children	–0.142	0.167	–0.850	0.397	–0.471	0.187
age	0.005	0.014	0.340	0.732	–0.023	0.033
1.female	–0.305	0.307	–0.990	0.321	–0.907	0.298
1.NotPartnered	–0.005	0.538	–0.010	0.993	–1.063	1.053
1.emp1	2.262	0.575	3.930	0.000	1.132	3.393
1.emp2	–0.198	0.352	–0.560	0.573	–0.890	0.493
1.emp3	0.730	0.747	0.980	0.329	–0.739	2.198
1.emp4	0.431	0.426	1.010	0.312	–0.405	1.267

Table 4 Ordinal regression results (Rural Close)

SatIncome	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
income	3.21E–05	1.06E–05	3.02	0.003	1.13E–05	0.000053
schooling	–0.037	0.049	–0.750	0.452	–0.132	0.059
adult	0.030	0.096	0.310	0.757	–0.159	0.218
children	–0.078	0.151	–0.520	0.605	–0.376	0.219
age	0.012	0.013	0.940	0.346	–0.013	0.037
1.female	–0.421	0.324	–1.300	0.194	–1.058	0.215
1.NotPartnered	–0.698	0.466	–1.500	0.135	–1.614	0.219
1.emp1	1.453	0.680	2.140	0.033	0.117	2.789
1.emp2	0.558	0.479	1.170	0.244	–0.382	1.498
1.emp3	1.017	0.619	1.640	0.101	–0.198	2.232
1.emp4	0.184	0.367	0.500	0.616	–0.536	0.904

Table 5 Ordinal regression results (Urban Far)

SatIncome	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
income	6.29E–05	1.72E–05	3.66	0	2.91E–05	9.66E–05
schooling	–0.107	0.180	–0.590	0.553	–0.461	0.247
adult	–0.441	0.368	–1.200	0.231	–1.163	0.282
children	–0.332	0.694	–0.480	0.632	–1.695	1.030
age	0.094	0.047	2.000	0.046	0.002	0.186
1.female	–0.753	0.876	–0.860	0.390	–2.474	0.968
1.NotPartnered	5.421	1.617	3.350	0.001	2.245	8.597
1.emp1	–1.954	2.848	–0.690	0.493	–7.548	3.640
1.emp2	–1.894	1.652	–1.150	0.252	–5.139	1.350
1.emp3	–6.011	1.332	–4.510	0.000	–8.628	–3.394
1.emp4	–2.008	1.106	–1.820	0.070	–4.179	0.164

Table 6 Ordinal regression results (Rural Far)

SatIncome	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
income	0.000033	9.18E–06	3.59	0	0.000015	0.000051
schooling	0.014	0.121	0.110	0.909	–0.223	0.251
adult	–0.272	0.286	–0.950	0.343	–0.834	0.291
children	–0.745	0.358	–2.080	0.038	–1.448	–0.042
age	0.080	0.031	2.550	0.011	0.018	0.141
1.female	0.076	0.632	0.120	0.905	–1.165	1.316
1.NotPartnered	1.680	1.290	1.300	0.193	–0.854	4.215
1.emp1	0.699	0.859	0.810	0.416	–0.988	2.386
1.emp2	–1.277	1.096	–1.170	0.244	–3.430	0.875
1.emp3	–0.586	1.131	–0.520	0.605	–2.807	1.636
1.emp4	0.000	0.666	0.000	1.000	–1.307	1.308

Appendix C–2: The relationship between PM_{10} and satisfaction with air quality

Table 7 Ordinal regression results (Total sample population)

SatAir	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
PM_{10}	–0.021	0.002	–9.030	0.000	–0.025	–0.016
schooling	–0.073	0.028	–2.590	0.010	–0.129	–0.018
adult	0.139	0.059	2.360	0.018	0.023	0.255
children	0.000	0.088	0.000	0.996	–0.172	0.173
age	0.003	0.008	0.440	0.662	–0.012	0.019
female	0.096	0.173	0.560	0.578	–0.242	0.435
NotPartnered	–0.085	0.261	–0.320	0.745	–0.596	0.426
emp1	0.157	0.364	0.430	0.666	–0.556	0.869
emp2	0.182	0.244	0.750	0.455	–0.296	0.660

Table 8 Ordinal regression results (Rural With)

SatAir	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
PM_{10}	–0.002	0.004	–0.600	0.551	–0.010	0.005
schooling	–0.015	0.054	–0.270	0.785	–0.121	0.091
adult	0.123	0.097	1.270	0.205	–0.067	0.313
children	0.070	0.216	0.320	0.746	–0.354	0.494
age	–0.007	0.015	–0.450	0.656	–0.035	0.022
1.female	–0.248	0.345	–0.720	0.473	–0.926	0.430
1.NotPartnered	0.620	0.666	0.930	0.352	–0.688	1.928
1.emp1	–1.382	0.892	–1.550	0.122	–3.134	0.369
1.emp2	–0.554	0.463	–1.200	0.232	–1.465	0.356
1.emp3	0.343	0.876	0.390	0.696	–1.377	2.063
1.emp4	0.014	0.389	0.040	0.971	–0.751	0.778

Table 9 Ordinal regression results (Rural Close)

SatAir	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
PM_{10}	–0.014	0.005	–3.110	0.002	–0.023	–0.005
schooling	–0.077	0.063	–1.230	0.221	–0.200	0.046
adult	0.072	0.112	0.640	0.524	–0.149	0.292
children	0.009	0.133	0.070	0.946	–0.252	0.270
age	0.024	0.015	1.520	0.128	–0.007	0.054
1.female	–0.322	0.323	–1.000	0.319	–0.958	0.313
1.NotPartnered	0.130	0.452	0.290	0.773	–0.757	1.017
1.emp1	–0.926	0.689	–1.340	0.179	–2.279	0.427
1.emp2	0.324	0.438	0.740	0.460	–0.536	1.183
1.emp3	1.551	0.482	3.220	0.001	0.605	2.497
1.emp4	0.135	0.383	0.350	0.724	–0.617	0.888

Appendix C–3: The relationship between objective indicators of housing and satisfaction with housing

Table 10 Ordinal regression results (Total sample population)

SatHouse	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
1.bathroom	0.921	0.278	3.320	0.001	0.377	1.466
1.flushingToilet	0.141	0.275	0.510	0.609	-0.399	0.680
roomPerPerson	0.265	0.121	2.200	0.028	0.029	0.502
schooling	-0.044	0.028	-1.560	0.118	-0.100	0.011
adult	0.048	0.058	0.830	0.405	-0.065	0.162
children	0.068	0.089	0.760	0.450	-0.108	0.243
age	0.019	0.008	2.390	0.017	0.003	0.034
1.female	-0.302	0.170	-1.770	0.076	-0.635	0.032
1.NotPartnered	-0.192	0.261	-0.740	0.461	-0.703	0.319
1.emp1	0.544	0.362	1.500	0.133	-0.165	1.252
1.emp2	-0.262	0.240	-1.090	0.275	-0.733	0.209
1.emp3	0.662	0.366	1.810	0.070	-0.055	1.380
1.emp4	0.212	0.202	1.050	0.294	-0.184	0.608

Table 11 Ordinal regression results (Urban close)

SatHouse	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
1.bathroom	0.384	1.089	0.350	0.725	–1.756	2.524
1.flushingToilet	1.448	0.982	1.470	0.141	–0.482	3.377
roomPerPerson	–0.207	0.366	–0.570	0.572	–0.925	0.512
schooling	–0.073	0.073	–0.990	0.320	–0.216	0.071
adult	–0.022	0.152	–0.140	0.885	–0.320	0.276
children	0.316	0.355	0.890	0.374	–0.382	1.014
age	0.081	0.039	2.070	0.039	0.004	0.157
1.female	–0.269	0.521	–0.520	0.606	–1.292	0.755
1.NotPartnered	0.704	0.785	0.900	0.370	–0.837	2.246
1.emp1	0.568	1.575	0.360	0.719	–2.526	3.662
1.emp2	–0.438	1.130	–0.390	0.698	–2.657	1.781
1.emp3	0.907	0.718	1.260	0.207	–0.502	2.317
1.emp4	–0.089	0.622	–0.140	0.887	–1.311	1.134

Table 12 Ordinal regression results (Rural with)

SatHouse	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
1.bathroom	1.162	0.428	2.710	0.007	0.321	2.004
1.flushingToilet	–0.562	0.405	–1.390	0.165	–1.357	0.233
roomPerPerson	0.228	0.276	0.830	0.409	–0.314	0.770
schooling	–0.055	0.058	–0.950	0.343	–0.168	0.058
adult	–0.176	0.092	–1.910	0.057	–0.358	0.005
children	–0.106	0.164	–0.650	0.518	–0.429	0.216
age	0.018	0.014	1.310	0.190	–0.009	0.046
1.female	–0.230	0.302	–0.760	0.446	–0.823	0.363
1.NotPartnered	0.317	0.560	0.570	0.571	–0.782	1.416
1.emp1	0.931	0.711	1.310	0.191	–0.465	2.326
1.emp2	–0.517	0.384	–1.350	0.178	–1.271	0.237
1.emp3	0.924	0.645	1.430	0.153	–0.344	2.191
1.emp4	0.221	0.389	0.570	0.570	–0.543	0.985

Table 13 Ordinal regression results (Rural close)

SatHouse	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
1.bathroom	0.889	0.454	1.960	0.051	–0.002	1.780
1.flushingToilet	0.994	0.585	1.700	0.090	–0.155	2.143
roomPerPerson	0.282	0.250	1.130	0.261	–0.210	0.773
schooling	0.007	0.051	0.140	0.885	–0.094	0.109
adult	0.184	0.109	1.680	0.093	–0.031	0.398
children	0.195	0.131	1.490	0.138	–0.063	0.454
age	0.008	0.014	0.610	0.542	–0.019	0.036
1.female	–0.286	0.336	–0.850	0.394	–0.946	0.373
1.NotPartnered	–0.926	0.355	–2.610	0.009	–1.623	–0.229
1.emp1	0.140	0.641	0.220	0.828	–1.120	1.399
1.emp2	0.002	0.489	0.000	0.997	–0.959	0.963
1.emp3	0.494	0.679	0.730	0.467	–0.839	1.827
1.emp4	0.012	0.358	0.030	0.974	–0.691	0.714

Table 14 Ordinal regression results (Urban far)

SatHouse	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
1.bathroom	1.451	1.966	0.740	0.461	–2.411	5.313
1.flushingToilet	3.971	3.101	1.280	0.201	–2.121	10.064
roomPerPerson	0.234	1.025	0.230	0.819	–1.778	2.247
schooling	–0.324	0.325	–1.000	0.320	–0.961	0.314
adult	0.980	0.544	1.800	0.072	–0.089	2.050
children	–0.734	0.539	–1.360	0.174	–1.792	0.324
age	–0.014	0.062	–0.230	0.817	–0.135	0.107
1.female	–1.001	0.989	–1.010	0.312	–2.944	0.943
1.NotPartnered	0.910	2.094	0.430	0.664	–3.203	5.024
1.emp1	3.602	3.336	1.080	0.281	–2.951	10.156
1.emp2	–0.129	3.331	–0.040	0.969	–6.672	6.415
1.emp3	0.998	2.021	0.490	0.621	–2.971	4.968
1.emp4	3.450	1.669	2.070	0.039	0.170	6.729

Table 15 Ordinal regression results (Rural far)

SatHouse	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
roomPerPerson	–0.365	0.717	–0.510	0.611	–1.774	1.043
schooling	–0.109	0.112	–0.970	0.330	–0.328	0.111
adult	0.034	0.337	0.100	0.920	–0.628	0.695
children	–0.060	0.390	–0.150	0.879	–0.826	0.707
age	0.020	0.027	0.720	0.475	–0.034	0.073
1.female	–0.784	0.749	–1.050	0.296	–2.255	0.687
1.NotPartnered	0.001	1.194	0.000	1.000	–2.346	2.347
1.emp1	1.463	1.228	1.190	0.234	–0.949	3.874
1.emp2	–0.714	0.909	–0.780	0.433	–2.500	1.073
1.emp3	1.017	1.216	0.840	0.403	–1.372	3.407
1.emp4	0.583	0.742	0.790	0.433	–0.875	2.041

Appendix C– 4: The relationship between objective and subjective indicators of education

Table 16 OLS regression results – with dependent variable being subjective measures of respondent satisfaction with education opportunity (Total sample population)

SATeduopp	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
schooling	-0.011	0.030	-0.380	0.706	-0.069	0.047
children	-0.007	0.093	-0.070	0.940	-0.190	0.176
adult	0.019	0.061	0.310	0.755	-0.100	0.138
age	-0.015	0.008	-1.850	0.066	-0.031	0.001
female	-0.126	0.182	-0.690	0.489	-0.482	0.231
NotPartnered	-0.456	0.275	-1.660	0.098	-0.996	0.085
emp1	0.186	0.361	0.510	0.608	-0.524	0.895
emp2	0.071	0.248	0.290	0.774	-0.416	0.558
emp3	-0.251	0.408	-0.620	0.538	-1.053	0.550
emp4	-0.275	0.217	-1.270	0.204	-0.701	0.150
_cons	4.817	0.584	8.250	0.000	3.669	5.964

Table 17 OLS Regression results – with dependent variable being subjective measures of respondent satisfaction with education quality (Total sample population)

Q281eduqua	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
schooling	-0.043	0.028	-1.500	0.135	-0.098	0.013
adult	0.021	0.058	0.360	0.716	-0.093	0.136
children	-0.154	0.089	-1.730	0.085	-0.330	0.021
age	-0.015	0.008	-1.870	0.062	-0.030	0.001
female	-0.438	0.174	-2.520	0.012	-0.780	-0.096
NotPartnered	-0.264	0.263	-1.000	0.316	-0.782	0.253
emp1	0.234	0.346	0.680	0.500	-0.446	0.914
emp2	-0.085	0.238	-0.360	0.720	-0.552	0.382
emp3	-0.117	0.391	-0.300	0.765	-0.884	0.651
emp4	-0.158	0.208	-0.760	0.447	-0.566	0.250
_cons	5.441	0.560	9.720	0.000	4.342	6.540

Appendix D: Ordinal regression – Impacts of coal mining on subjective wellbeing

Appendix D–1: Ordinal regression – Impacts of coal mining on satisfaction with different life domains

Table 1 Satisfaction with human capital – Urban areas

MFhumcap	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.056	0.373	0.150	0.882	-0.677	0.788
1.miningincome	-0.048	0.640	-0.070	0.940	-1.304	1.209
income	0.000	0.000	2.360	0.018	0.000	0.000
children	0.037	0.253	0.150	0.883	-0.460	0.535
adult	0.073	0.126	0.580	0.559	-0.174	0.320
age	0.046	0.024	1.890	0.059	-0.002	0.094
1.female	0.358	0.405	0.880	0.378	-0.438	1.154
1.NotPartnered	1.189	0.578	2.060	0.040	0.053	2.326
schooling	-0.019	0.056	-0.330	0.741	-0.129	0.092
1.emp1	0.274	1.018	0.270	0.788	-1.725	2.274
1.emp2	-0.065	0.666	-0.100	0.922	-1.374	1.244
1.emp3	-0.453	0.647	-0.700	0.484	-1.724	0.819
1.emp4	0.447	0.489	0.910	0.361	-0.514	1.408

Table 2 Satisfaction with human capital – Rural areas

SAThumcap	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	0.174	0.226	0.770	0.441	–0.269	0.617
1.FarCoal	0.339	0.271	1.250	0.211	–0.192	0.870
1.miningincome	0.534	0.389	1.370	0.170	–0.230	1.298
1.withminy	–0.373	0.472	–0.790	0.430	–1.301	0.554
income	0.000	0.000	3.180	0.002	0.000	0.000
children	–0.063	0.102	–0.620	0.534	–0.264	0.137
adult	0.037	0.069	0.540	0.593	–0.098	0.171
age	0.016	0.008	1.890	0.060	–0.001	0.033
1.female	–0.200	0.223	–0.900	0.369	–0.639	0.238
1.NotPartnered	–0.338	0.327	–1.030	0.301	–0.981	0.304
schooling	–0.026	0.033	–0.770	0.439	–0.090	0.039
1.emp1	0.455	0.417	1.090	0.276	–0.364	1.273
1.emp2	–0.527	0.286	–1.840	0.066	–1.088	0.034
1.emp3	0.077	0.476	0.160	0.872	–0.859	1.012
1.emp4	0.149	0.244	0.610	0.542	–0.331	0.629

Table 3 Satisfaction with environment – Urban areas

MFenvi	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	1.264	0.500	2.530	0.012	0.281	2.247
1.miningincome	0.898	0.488	1.840	0.066	-0.060	1.856
income	0.000	0.000	0.610	0.539	0.000	0.000
children	-0.315	0.266	-1.180	0.238	-0.838	0.209
adult	-0.096	0.188	-0.510	0.611	-0.464	0.273
age	0.011	0.020	0.550	0.585	-0.029	0.051
1.female	-0.593	0.465	-1.280	0.202	-1.506	0.320
1.NotPartnered	-0.380	0.492	-0.770	0.440	-1.347	0.587
schooling	0.032	0.068	0.470	0.642	-0.102	0.166
1.emp1	1.831	0.747	2.450	0.015	0.364	3.297
1.emp2	0.711	0.709	1.000	0.317	-0.682	2.103
1.emp3	1.133	0.524	2.160	0.031	0.105	2.161
1.emp4	-0.262	0.514	-0.510	0.611	-1.272	0.749

Table 4 Satisfaction with environment – Rural areas

MFenvi	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	-0.796	0.241	-3.300	0.001	-1.270	-0.322
1.FarCoal	2.424	0.324	7.480	0.000	1.787	3.060
1.miningincome	-0.204	0.380	-0.540	0.592	-0.950	0.543
1.withminy	0.063	0.453	0.140	0.889	-0.827	0.953
income	0.000	0.000	-0.240	0.809	0.000	0.000
children	-0.027	0.091	-0.300	0.767	-0.205	0.152
adult	0.051	0.065	0.790	0.431	-0.076	0.178
age	0.013	0.008	1.540	0.125	-0.004	0.029
1.female	0.072	0.191	0.380	0.707	-0.304	0.448
1.NotPartnered	0.400	0.298	1.340	0.180	-0.185	0.984
schooling	-0.106	0.034	-3.160	0.002	-0.173	-0.040
1.emp1	-0.382	0.363	-1.050	0.293	-1.096	0.332
1.emp2	0.034	0.244	0.140	0.889	-0.446	0.514
1.emp3	1.169	0.454	2.570	0.010	0.276	2.062
1.emp4	0.160	0.244	0.650	0.513	-0.320	0.640

Table 5 Satisfaction with economy – Urban areas

MFeco	Coef. Std. Err.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.453	0.464	0.980	0.330	-0.459	1.364
1.miningincome	0.095	0.503	0.190	0.850	-0.893	1.083
income	0.000	0.000	2.800	0.005	0.000	0.000
children	0.293	0.317	0.920	0.356	-0.329	0.915
adult	0.259	0.222	1.170	0.244	-0.177	0.696
age	0.008	0.021	0.400	0.691	-0.033	0.049
1.female	0.117	0.405	0.290	0.773	-0.679	0.912
1.NotPartnered	-0.429	0.471	-0.910	0.363	-1.354	0.496
schooling	-0.004	0.065	-0.050	0.957	-0.131	0.124
1.emp1	-0.456	0.999	-0.460	0.649	-2.419	1.508
1.emp2	1.006	0.804	1.250	0.211	-0.573	2.585
1.emp3	1.745	0.597	2.920	0.004	0.572	2.917
1.emp4	0.100	0.509	0.200	0.845	-0.900	1.100

Table 6 Satisfaction with economy – Rural areas

MFeco	Coef. Std. Err.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	-0.340	0.244	-1.390	0.164	-0.820	0.139
1.FarCoal	0.593	0.263	2.250	0.025	0.076	1.109
1.miningincome	-0.121	0.401	-0.300	0.763	-0.908	0.666
1.withminy	0.825	0.481	1.720	0.087	-0.120	1.770
income	0.000	0.000	4.650	0.000	0.000	0.000
children	0.051	0.088	0.580	0.563	-0.122	0.225
adult	-0.071	0.059	-1.200	0.230	-0.187	0.045
age	0.020	0.009	2.100	0.036	0.001	0.038
1.female	-0.149	0.207	-0.720	0.470	-0.556	0.257
1.NotPartnered	0.205	0.291	0.700	0.482	-0.367	0.777
schooling	-0.041	0.029	-1.410	0.160	-0.098	0.016
1.emp1	0.276	0.379	0.730	0.467	-0.469	1.021
1.emp2	-0.223	0.267	-0.840	0.404	-0.747	0.301
1.emp3	0.309	0.412	0.750	0.453	-0.500	1.119
1.emp4	-0.169	0.250	-0.670	0.500	-0.660	0.322

Table 7 Satisfaction with social capital – Urban areas

Mfsocap	Coef. Std. Err.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.368	0.507	0.730	0.468	-0.628	1.365
1.miningincome	-0.366	0.552	-0.660	0.508	-1.451	0.719
income	0.000	0.000	0.770	0.442	0.000	0.000
children	0.186	0.243	0.760	0.445	-0.292	0.663
adult	-0.024	0.126	-0.190	0.851	-0.272	0.224
age	0.002	0.018	0.100	0.921	-0.033	0.036
1.female	-0.376	0.378	-0.990	0.320	-1.117	0.366
1.NotPartnered	-0.068	0.485	-0.140	0.889	-1.020	0.885
schooling	-0.082	0.062	-1.320	0.189	-0.204	0.040
1.emp1	1.593	0.916	1.740	0.083	-0.207	3.394
1.emp2	0.019	1.069	0.020	0.986	-2.082	2.119
1.emp3	0.891	0.638	1.400	0.163	-0.362	2.144
1.emp4	0.238	0.472	0.500	0.614	-0.689	1.164

Table 8 Satisfaction with social capital – Rural areas

Mfsocap	Coef. Std. Err.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.368	0.507	0.730	0.468	-0.628	1.365
1.miningincome	-0.366	0.552	-0.660	0.508	-1.451	0.719
income	0.000	0.000	0.770	0.442	0.000	0.000
children	0.186	0.243	0.760	0.445	-0.292	0.663
adult	-0.024	0.126	-0.190	0.851	-0.272	0.224
age	0.002	0.018	0.100	0.921	-0.033	0.036
1.female	-0.376	0.378	-0.990	0.320	-1.117	0.366
1.NotPartnered	-0.068	0.485	-0.140	0.889	-1.020	0.885
schooling	-0.082	0.062	-1.320	0.189	-0.204	0.040
1.emp1	1.593	0.916	1.740	0.083	-0.207	3.394
1.emp2	0.019	1.069	0.020	0.986	-2.082	2.119
1.emp3	0.891	0.638	1.400	0.163	-0.362	2.144
1.emp4	0.238	0.472	0.500	0.614	-0.689	1.164

Table 9 Satisfaction with institutional capital – Urban areas

SATinscap	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.474	0.422	1.120	0.262	–0.355	1.303
1.miningincome	0.099	0.488	0.200	0.840	–0.860	1.058
income	0.000	0.000	1.020	0.307	0.000	0.000
children	–0.350	0.349	–1.000	0.316	–1.034	0.335
adult	0.161	0.130	1.240	0.216	–0.094	0.415
age	0.028	0.024	1.190	0.234	–0.018	0.074
1.female	–0.246	0.423	–0.580	0.561	–1.077	0.584
1.NotPartnered	–0.443	0.651	–0.680	0.497	–1.723	0.837
schooling	–0.063	0.063	–0.990	0.324	–0.187	0.062
1.emp1	0.517	1.035	0.500	0.618	–1.516	2.550
1.emp2	–0.456	1.086	–0.420	0.675	–2.590	1.678
1.emp3	2.279	0.681	3.350	0.001	0.942	3.616
1.emp4	0.622	0.518	1.200	0.230	–0.395	1.640

Table 10 Satisfaction with institutional capital – Rural areas

MFinscap	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	-0.367	0.240	-1.530	0.126	-0.838	0.103
1.FarCoal	-0.983	0.290	-3.380	0.001	-1.553	-0.412
1.miningincome	0.037	0.359	0.100	0.918	-0.668	0.742
1.withminy	0.335	0.437	0.770	0.444	-0.524	1.194
income	0.000	0.000	2.290	0.023	0.000	0.000
children	-0.120	0.090	-1.330	0.185	-0.298	0.058
adult	-0.014	0.065	-0.220	0.830	-0.142	0.114
age	0.007	0.009	0.740	0.463	-0.011	0.025
1.female	-0.242	0.190	-1.270	0.203	-0.616	0.131
1.NotPartnered	-0.263	0.296	-0.890	0.376	-0.845	0.320
schooling	-0.079	0.031	-2.590	0.010	-0.139	-0.019
1.emp1	0.110	0.378	0.290	0.771	-0.632	0.852
1.emp2	-0.109	0.279	-0.390	0.695	-0.657	0.439
1.emp3	0.830	0.401	2.070	0.039	0.042	1.619
1.emp4	0.115	0.230	0.500	0.619	-0.338	0.568

Table 11 Satisfaction with living conditions – Urban areas

MFlivcon	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	0.474	0.422	1.120	0.262	-0.355	1.303
1.miningincome	0.099	0.488	0.200	0.840	-0.860	1.058
income	0.000	0.000	1.020	0.307	0.000	0.000
children	-0.350	0.349	-1.000	0.316	-1.034	0.335
adult	0.161	0.130	1.240	0.216	-0.094	0.415
age	0.028	0.024	1.190	0.234	-0.018	0.074
1.female	-0.246	0.423	-0.580	0.561	-1.077	0.584
1.NotPartnered	-0.443	0.651	-0.680	0.497	-1.723	0.837
schooling	-0.063	0.063	-0.990	0.324	-0.187	0.062
1.emp1	0.517	1.035	0.500	0.618	-1.516	2.550
1.emp2	-0.456	1.086	-0.420	0.675	-2.590	1.678
1.emp3	2.279	0.681	3.350	0.001	0.942	3.616
1.emp4	0.622	0.518	1.200	0.230	-0.395	1.640

Table 12 Satisfaction with living conditions – Rural areas

MFlivcon	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	-0.367	0.240	-1.530	0.126	-0.838	0.103
1.FarCoal	-0.983	0.290	-3.380	0.001	-1.553	-0.412
1.miningincome	0.037	0.359	0.100	0.918	-0.668	0.742
1.withminy	0.335	0.437	0.770	0.444	-0.524	1.194
income	0.000	0.000	2.290	0.023	0.000	0.000
children	-0.120	0.090	-1.330	0.185	-0.298	0.058
adult	-0.014	0.065	-0.220	0.830	-0.142	0.114
age	0.007	0.009	0.740	0.463	-0.011	0.025
1.female	-0.242	0.190	-1.270	0.203	-0.616	0.131
1.NotPartnered	-0.263	0.296	-0.890	0.376	-0.845	0.320
schooling	-0.079	0.031	-2.590	0.010	-0.139	-0.019
1.emp1	0.110	0.378	0.290	0.771	-0.632	0.852
1.emp2	-0.109	0.279	-0.390	0.695	-0.657	0.439
1.emp3	0.830	0.401	2.070	0.039	0.042	1.619
1.emp4	0.115	0.230	0.500	0.619	-0.338	0.568

Appendix D–2: Ordinal regression – Impacts of coal mining on global life satisfaction

Table 13 Global life satisfaction – Urban areas

LS	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.FarCoal	-0.462	0.428	-1.080	0.280	-1.302	0.378
1.miningincome	-0.698	0.576	-1.210	0.226	-1.829	0.433
income	0.000	0.000	2.880	0.004	0.000	0.000
children	0.370	0.230	1.610	0.108	-0.082	0.823
adult	0.016	0.135	0.120	0.904	-0.248	0.281
age	0.024	0.018	1.330	0.184	-0.011	0.059
1.female	-0.657	0.457	-1.440	0.152	-1.555	0.242
1.NotPartnered	-0.259	0.675	-0.380	0.702	-1.584	1.067
schooling	0.080	0.062	1.300	0.194	-0.041	0.201
1.emp1	1.305	0.732	1.780	0.075	-0.133	2.743
1.emp2	0.240	0.847	0.280	0.777	-1.424	1.905
1.emp3	0.204	0.871	0.230	0.815	-1.508	1.915
1.emp4	0.244	0.626	0.390	0.697	-0.986	1.475

Table 14 Global life satisfaction – Rural areas

LS	Coef.	Linearized Std. Err.	t	P>t	[95% Conf. Interval]	
1.WithCoal	-0.339	0.235	-1.450	0.149	-0.800	0.122
1.FarCoal	0.186	0.305	0.610	0.542	-0.414	0.786
1.miningincome	-0.079	0.354	-0.220	0.824	-0.774	0.616
1.withminy	1.020	0.459	2.220	0.027	0.119	1.922
income	0.000	0.000	4.070	0.000	0.000	0.000
children	-0.012	0.101	-0.110	0.909	-0.209	0.186
adult	-0.056	0.066	-0.850	0.397	-0.186	0.074
age	0.010	0.010	1.010	0.311	-0.009	0.029
1.female	-0.521	0.213	-2.450	0.015	-0.939	-0.103
1.NotPartnered	0.196	0.358	0.550	0.584	-0.507	0.899
schooling	-0.009	0.034	-0.270	0.789	-0.077	0.059
1.emp1	0.839	0.373	2.250	0.025	0.106	1.571
1.emp2	-0.154	0.290	-0.530	0.596	-0.724	0.416
1.emp3	0.330	0.615	0.540	0.592	-0.878	1.538
1.emp4	0.087	0.235	0.370	0.712	-0.376	0.549