The Australian Journal of
Agricultural and Resource Economics

Journal of the Australian Agricultural and Resource Economics Society

Australian Journal of Agricultural and Resource Economics, 58, pp. 111–129

Assessing the trade-offs of increased mining activity in the Surat Basin, Queensland: preferences of Brisbane residents using nonmarket valuation techniques*‡

Jill Windle and John Rolfe†

The mining boom in Australia since 2003 has produced significant economic benefits for regional, State and National economies, creating new job opportunities and revenue flows. Despite the contribution of the resources sector to economic growth, questions are frequently raised about the concomitant negative social, economic and environmental impacts. The Surat Basin in southern Queensland is a traditional agricultural region with a small but growing coal mining sector and a rapidly developing liquefied natural gas industry (mainly associated with extracting coal seam gas). In this paper, the preferences of residents in Brisbane, the State capital, are explored in relation to the relative importance of social, economic and environmental impacts of the resource boom in the Surat Basin. A choice modelling experiment was conducted to assess the trade-offs Brisbane residents would make (in monetary terms) between the economic benefits and the associated costs of increased mining activity on local communities. The results identify the strength of concerns about community and environmental impacts and can potentially be used to help evaluate the net benefits of resource development.

Key words: choice modelling experiment, coal mining, coal seam gas, impact assessment, regional development.

1. Introduction

In Australia, mining, energy extraction and minerals processing make a significant contribution to National and State economies, creating new job opportunities and revenue flows (Garton 2008; Lim *et al*. 2009; Corden 2012). The recent mining boom that has occurred in Australia from 2003 (phase 1) and 2009 (phase 2) has led to the overlapping occurrence of an unprecedented number of new mine developments, expansion of existing mines and exploration, with most activity concentrated in Western Australia and Queensland (BREE 2012; Penney *et al*. 2012). The depth of the supply

* The research outlined in this paper was funded through the Minerals Futures Collaboration Cluster under the CSIRO Minerals Down under National Research Flagship. The contribution of Daniel Gregg for the experimental design is gratefully acknowledged.

‡ This article has been processed and accepted for publication under the previous editorial team of Allan Rae, Ross Cullen and Geoff Kerr.

† Jill Windle (email: j.windle@cqu.edu.au) and John Rolfe are with Centre for Environmental Management, CQUniversity, Rockhampton, Queensland, Australia.

doi: 10.1111/1467-8489.12025

chains involved and the diversity of locations of mining workforces mean that the economic benefits of resource projects are widely spread, leading to increases in employment and income across diverse areas (Hajkowicz *et al.* 2011; Rolfe *et al.* 2011). However, despite the contribution of the resources sector to regional, State and National economies, questions are often raised about potential negative social, economic and environmental impacts (Rolfe *et al.* 2007; Solomon *et al.* 2008).

At a macro level, negative economic impacts on nonmining sectors of the economy are commonly known as Dutch disease (Corden 2012). In Australia, higher resource prices and exports contributed to an appreciation of the exchange rate of about 35 per cent between 2005 and 2011 (Corden 2012), while the Reserve Bank lifted interest rates to dampen the economy (Richardson 2009). As well, bottlenecks in infrastructure and competition for key inputs, such as construction workers and materials, put upwards pressure on prices in factor markets and restricted growth (Goodman and Worth 2008; Norman 2009; Grudnoff 2012). Microeconomic forms of Dutch disease from resource developments can also occur at the local level. Negative economic effects can be identified in resource towns through mechanisms such as higher prices in housing and labour markets, where competition from the resources sector reduces the viability of firms in other sectors competing for factor inputs (Rolfe *et al.* 2007; Lockie *et al.* 2009; Petkova-Timmer *et al.* 2009; Ivanova and Rolfe 2011).

A range of different concerns about the social impacts of resource developments on communities have been identified, with key ones, including demographic change, changes in community structure and cohesion, lack of adequate human services, lack of affordable housing, inadequate supply of community infrastructure, threats of increased crime and loss of community identity (Rolfe *et al.* 2007; Solomon *et al.* 2008; Lockie *et al.* 2009; Petkova-Timmer *et al.* 2009; Franks *et al.* 2010; Carrington and Pereira 2011). Changes in work shift patterns to block shifts and increased use of fly-in/fly-out workforces are contributing factors to some of the impacts (Rolfe *et al.* 2007; Petkova-Timmer *et al.* 2009), while the cyclical nature of commodity cycles and variations in mining activities impact on community stability (Lockie *et al.* 2009).

Environmental issues remain a key concern around many resource developments (Goodman and Worth 2008; Lockie *et al.* 2009), although the impact assessment process used to assess and approve new projects is arguably more thorough in relation to environmental issues than to social and economic issues. While the Australian States and Territories have primary responsibility for evaluating the potential impacts of projects, the jurisdiction of the Commonwealth Government is also triggered (through the *Environmental Protection and Biodiversity Conservation Act 1999*) when larger or more sensitive environmental impacts might occur.

The issues around the economic, social and environmental impacts of resource developments and the processes used to evaluate and manage them can be demonstrated with the Surat Basin in southern Queensland. This is a traditional agricultural region with a small but growing coal mining sector and a rapidly developing liquefied natural gas industry (mainly associated with extracting coal seam gas). Growth projections based on a medium-level scenario for potential resource development in the Surat Basin estimate that by 2031 (Queensland Government 2010):

1. Production of coal and coal seam gas is expected to increase tenfold.
2. The gross regional product will double.
3. Employment in the area will increase by an additional 12,500 full-time equivalent positions.
4. Population growth is projected to increase by 44 per cent.

The emergence of a new resource industry (coal seam gas), the rapid pace of development and the intersection of the resources sector with a number of small agriculturally based towns across the regional area mean that the Surat Basin provides a case study region where there is potential for different economic, environmental and social impacts to occur. At the State level, the economic value of new resource developments involve increased production, income and employment, but at the cost of potential economic, social and environmental impacts, largely in the regional area. While the impact assessment process for individual projects can address specific environmental, social and economic impacts, broader questions about the net benefits of development strategies and what their impacts are in a welfare economics framework are currently lacking.

This paper reports on the results of a choice modelling experiment conducted to assess the preferences of Brisbane residents (the State capital) for different economic, social and environmental impacts of increased mining activity on local communities in the Surat Basin. The results identify the strength of concerns about community and environmental impacts and can potentially be used to help evaluate the net benefits of resource development.

The paper is structured as follows. In Section 2, background details are presented about the Surat Basin case study and the issues of most concern are identified, and in Section 3, design details of the valuation survey are provided. Results are presented in Section 4, and discussion and conclusions in the final section.

2. Case study details

The Surat Basin region lies to the west of Brisbane in southern Queensland (Figure 1). It covers an area of approximately 110,000 square kilometres and encompasses three regional local government areas. The majority (78 per cent) of the 199,000 population are concentrated in the Toowoomba Regional Council area; 16 per cent live in the Western Downs Regional Council area (Dalby region), and 6 per cent live in the Maranoa Regional Council area (Roma region).

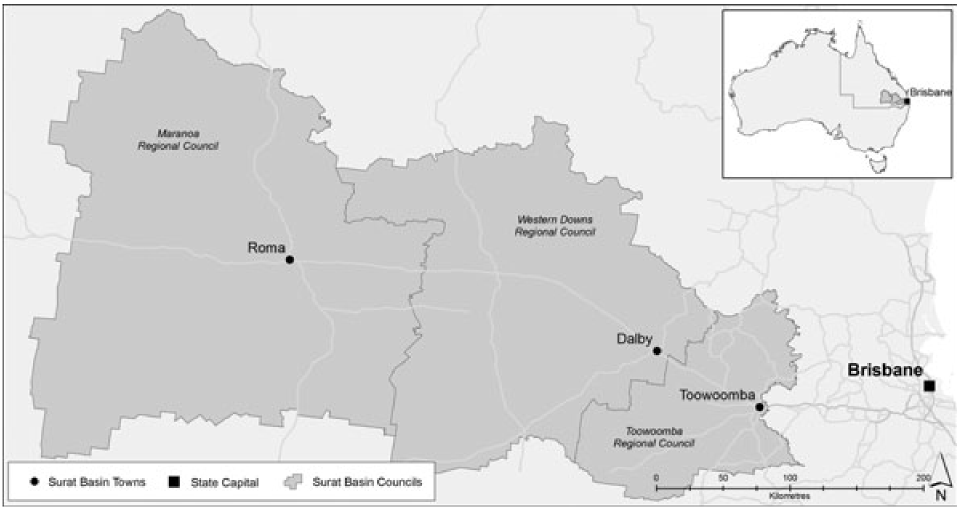

Figure 1 The Surat Basin in southern Queensland.

Although a small number of coal mines have been operational in the region, agriculture has traditionally been the backbone of the regional economy. In the east, fertile soils support significant agricultural production. Further west, the landscape becomes drier and agriculture relies on grazing and dry land cropping. The region is sparsely populated (declining towards the west reflecting the smaller economic base), and until the recent increase in mining activity, employment opportunities in the smaller towns have generally been declining.

The Surat Basin shares many characteristics with the neighbouring Bowen Basin, in central Queensland, where the impacts of the rapid expansion in coal mining activities have already been examined in a number of case studies (Rolfe *et al*. 2007; Lockie *et al*. 2009; Petkova-Timmer *et al*. 2009; Ivanova and Rolfe 2011). Schandl and Darbas (2008) identified the following social and economic issues as important to local Surat residents:

1. The loss of affordable housing.
2. The lack of skilled local labour.
3. The potential increase in social dysfunction.
4. The risk that the currently diverse economic base could be undermined if mining became the dominant economic activity.

Concerns about environmental impacts also exist. To extract coal seam gas, a hole is drilled into the coal seam and a mixture of gas and water is extracted. However, there is limited scientific knowledge about groundwater systems and the level of connectedness between underground water aquifers. This means it is difficult to quantify the risks about

1. The extent to which extractions of water in one area may impact on another area (water supply issues).

2. The potential for cross-contamination between aquifers of potentially harmful chemicals that either occur naturally and/or are associated with the drilling and process of extraction (water quality issues).

In addition, coal mining generates large quantities of wastewater with high concentrations of salt and sodium levels. While restrictions and conditions apply to the treatment and disposal of wastewater (Queensland Government 2011), it is not clear exactly how effectively the problem will be managed.

Little is known about how the broader (Queensland) community views the trade-offs of mining development in the Surat Basin. To address the issue, a survey, including nonmarket valuation experiments, has been conducted with people living in Brisbane, the State's major population base and capital city, located outside the Surat Basin. Although the economic benefits of increased mining activity will also flow to Brisbane (Rolfe *et al*. 2011),[1] it is very unclear how Brisbane residents feel about the negative aspects of mining that might impact on local communities. Furthermore, it is not clear whether Brisbane residents are prepared to sacrifice some of the wealth from resource developments to reduce negative impacts, and if so, how they would make the trade-offs.

3. The choice modelling valuation survey

The economic impacts of mining operations are usually estimated by applying market related data to assess potential changes in output, employment and incomes. However, people may also hold nonmarket values for better social outcomes in regional areas, even if they do not live in the region. For example, people living in urban centres have been shown to have significant values to maintain viable rural communities through employment opportunities and regional incomes (eg. Bennett *et al*. 2004) and for more environmental protection in terms of mine site rehabilitation (eg. Burton *et al*. 2012). The preferences that people have for these types of outcomes are not reflected in market transactions and hence need to be assessed with specialist nonmarket valuation techniques such as choice modelling.

3.1. Mining nonmarket valuation studies

A wide literature search only identified four studies where nonmarket valuation experiments have been conducted to assess the impacts of increased mining activity on rural communities. Spyce *et al*. (2012) report the use of a

[1] It has been estimated that the employment multiplier effect means that for each new job created locally, there will be 2.3 new jobs generated in local communities; 3.3 extra jobs for the whole region (including Toowoomba, the regional centre); and 4.0 extra jobs in Brisbane and southeast Queensland (adapted from Rolfe *et al*. 2011).

choice experiment in the Yukon in northern Canada to assess community preferences for trade-offs between land use, as recent increases in mining and energy projects are transforming the region. Respondents were asked to indicate their preferences for different development scenarios that had varying impacts on jobs, moose populations, fish catch rates and the population of the regional area. Regression models were applied (welfare estimates were not calculated) with results indicating that conservation scenarios were ranked higher than development scenarios, but with considerable heterogeneity associated with the former. They also found that residents did not discount the future, highlighting the importance of intergenerational equity in resource development decisions. They did not find evidence of development thresholds or limits of acceptable change.

In New South Wales, Australia, two choice modelling valuations have been conducted to estimate the nonmarket impacts associated with an expansion in underground coal mining activity (Gillespie Economics 2009; Gillespie and Kragt 2012). In both studies, respondents were selected from the local region where the mine was located as well as from the broader State-wide community. Respondents were faced with trade-offs between positive and negative impacts, which incorporated social, environmental and economic issues. Random parameter logit models were developed to calculate willingness-to-pay (WTP) estimates (Table 1). The results indicated that both local and nonlocal respondents were WTP to avoid adverse environmental impacts (on waterways and vegetation) as well as to avoid adverse impacts on Aboriginal cultural heritage sites (Gillespie Economics 2009; Gillespie and Kragt 2012). Respondents were also WTP to ensure the flow of employment benefits occurred into the future (extending the period of time that the mine will provide jobs). In the Gillespie Economics (2009) study, values were also elicited from the samples to avoid rural families being displaced due to mine proximity and increased noise and dust. The latter two results highlight the

Table 1 Attributes and WTP estimates in the NSW coal mining studies

Gillespie Economics (2009)		Gillespie and Kragt (2012)	
Cost (lump sum payment)	WTP/hshld	Cost (annual 20 year payment)	WTP/hshld
Impact on mine site EEC†	−\$0.41/ha	Length of stream affected	\$3.74/km
Area of EEC planted in region	\$0.10/ha	Area of upland swamp affected	\$0.34/ha
Area of existing EEC protected in the region	\$0.28/ha		
Impact on highly significant Aboriginal sites	\$29.71/site	Number of aboriginal sites affected	\$0.27/site
Impact on rural families in the small rural community	\$33.88/family		
Number of years that the mine will provide 975 jobs	\$27.13/year	Years that the mine will provide 320 jobs	\$5.94/year

†Ecologically endangered vegetation communities.

importance of nonuse values that some respondents have for socio-economic factors affecting rural communities.

Ivanova and Rolfe (2011) report the application of a choice experiment in Moranbah, a coal mining town in the Bowen Basin in central Queensland, Australia. In that study, local residents were asked about the expansion of coal mining in their area and their preferences for future development options for the town. Four potential impact attributes were included as categorical variables in the experiment with a cost attribute as an annual cost (reduced income) for an unspecified period. The preference data were analysed using multinomial logit models and the results indicated that local residents did not have significant WTP to either avoid a 25 per cent increase in housing prices/rentals in the next 5 years or to achieve a 25 per cent decrease. They had significant WTP ($475/year) to avoid water restrictions on households but not to avoid restrictions on town parks and gardens. There was significant WTP ($494/year) to have a buffer between the mine and town that eliminated noise, vibration and dust, but not for partial remediation. Residents were also concerned about the composition of the labour force and whether people lived in the local community or were commuters living in workcamps, with a current level mix of 20 per cent in housing and 80 per cent in workcamps. There was significant WTP both to avoid a situation with 100 per cent of new employment in workcamps ($1720/year) and to increase the proportion housed in the local community to 80 per cent ($1434/year).

3.2. Survey design

The aim of the present research was to identify how the largest population group in Queensland; residents of Brisbane, viewed the potential social, environmental and land use change impacts of rapid resource developments in the Surat Basin. Four particularly important issues were identified from focus groups with Brisbane residents:

1. Increased employment opportunities in local communities (and by inference the flow-on effects in Brisbane).
2. Higher housing prices (and housing shortages) in local communities.
3. Pressures on local businesses in the nonmining sector (rising wage rates and labour shortages).
4. Potential environmental impacts.

However, discussions also identified considerable variation in community views about the impacts associated with rapid mining developments, with some people favouring developments because of the benefits, while others viewed developments as a negative because of the costs involved.

The four issues outlined above were incorporated as attributes in the choice modelling experiment. There were some challenges associated with converting concerns about environmental issues into a choice attribute. Environmental concerns were primarily focussed on water quality issues, but there was considerable uncertainty both about the potential impacts that might occur, as well as the likelihood of occurrence. Consequently, the attribute was described in terms of 'more independent monitoring activity' which would help in early detection if any environmental issues did occur, as well as ensure industry compliance.

A fifth attribute representing cost was included, with the payment vehicle described in general terms as potentially an increase in either taxes, rates or prices, to avoid possible payment vehicle bias that might be associated with a more specific description. Background information in the survey had explained how people in Brisbane would receive a larger share of some benefits of mining in the Surat Basin compared to people in small rural communities through flow-on employment benefits. This provided the rationale for asking Brisbane residents whether they were WTP to change the level of impact on the local community, and the extent they were prepared to trade-off the benefits of increased employment and income opportunities.

The different outcomes were predicted to occur in 5 years time (2016) with the term of the annual payment limited to the same period. Details of the background information presented to respondents are provided as a Data S1. An example choice set is shown in Figure 2, and attribute details are outlined in Table 2.

A D-efficient experimental design (D = 0.0001) was created using ©Ngene software with a Bayesian design strategy (Scarpa and Rose 2008) used to create 24 choices sets. These were blocked into four versions so that each respondent was assigned a random block of six choice sets.

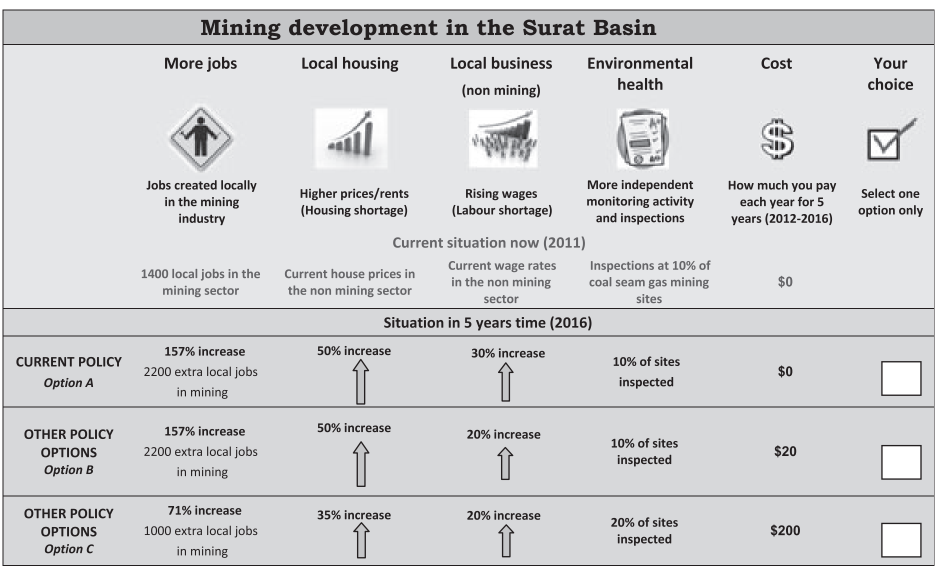

Figure 2 Example choice set.

Table 2 Choice set attribute descriptions and levels

Title	Description	Current levels (2011)	Levels in 5 years time (2016)	
			Status quo option	Alternative options
More jobs	Number of jobs created locally (in the Surat Basin) in the mining industry	1400 jobs	2220 extra jobs	2220, 1600, 1000 extra jobs
Local housing	Higher housing prices (housing shortages)	Current prices	50% increase	50%, 35%, 20% increase
Local business	Rising wage costs (labour shortages) in the nonmining sector	Current wage rates	30% increase	30%, 20%, 10% increase
Environmental monitoring	More independent monitoring activity and inspections	Inspections at 10% of coal seam gas mining sites	10% of sites inspected	10%, 20%, 30% of sites inspected
Cost	How much you pay each year for 5 years (2012–2016)	\$0	\$0	\$20, \$50, \$100, \$200

Table 3 Sample characteristics of Brisbane respondents

	Sample	Population†
Gender		
Female	54%‡[b]	50%
Age		
Average (years)	45 years‡[t]	43 years
Education		
Postschool qualification	69%‡[b]	59%
Tertiary degree	39%‡[b]	25%
Income (gross)		
Less than \$25,999 per year	17%[b]	17%
\$26,000 – \$41,599 per year	17%[b]	18%
\$41,600 – \$62,399 per year	19%[b]	21%
\$62,400 – \$88,399 per year	18%[b]	17%
\$88,400 – \$103,999 per year	13%‡[b]	8%
\$104,000 – \$155,999 per year	11%‡[b]	15%
\$156,000 or more per year	5%[b]	6%

†Australian Bureau of Statistics 2006 Census.
‡Indicates a statistical difference between the sample and the population when applying: *b* = the normal approximation to the bionomial test or *t* = independent samples t-test.

4. Results

A total of 1208 responses were collected from Brisbane respondents in February 2012. The socio-demographic characteristics of survey respondents are presented in Table 3. The sample had a higher proportion of females and people with higher education levels than occurs in the general population.

Before the valuation data were analysed, two groups of responses were identified and removed from the data set. The first group was identified as being strategic responses rather than reflecting respondents' true WTP. These responses were revealed in another section of the survey with an open-ended maximum WTP contingent valuation question (the details of which are not reported in this paper). Responses were identified as being strategic if the maximum stated WTP to avoid environmental losses was equal to, or greater than, half the respondent's stated average weekly income. A total of 52 strategic responses (4.3 per cent) were identified and removed.

The second group of responses was identified as being protest votes, that is, these respondents did not agree with the context of the valuation scenario, so their stated zero WTP was unlikely to be a reflection of their true WTP. These responses were identified in a follow-up question after the choice sets. A total of 113 responses (9.4 per cent) were identified as protest votes and were also deleted from any further analysis. The remaining 1043 responses were included in the choice modelling analysis.

Choice experiments have their theoretical foundation in random utility theory. The probability that a particular alternative is chosen from a set of alternatives can be estimated using different econometric models (Louviere *et al.* 2000). The random parameter logit (RPL) model has grown in popularity as it avoids the independence of irrelevant alternatives property of the conditional logit model, allows for random taste variations and can incorporate correlations in unobserved factors over choice alternatives (Hensher *et al.* 2005; Colombo *et al.* 2009). The typical formulation of the RPL model decomposes utility into an unobserved, preference heterogeneity component and a deterministic component, the latter representing the utility of a respondent choosing a particular alternative in a choice situation as a function of that alternative's attributes. Random parameters included in the model vary among the sample population with a density function (with a specified distributional form) that captures individual deviations from the mean. Latent class (LC) models have also been developed to represent heterogeneity by assigning individuals into behavioural groups or latent segments. Preferences in each latent or unobserved class are assumed homogeneous; but preferences, and hence utility functions, can vary between segments (Colombo *et al.* 2009).

In this study, both RPL and LC models were developed using Nlogit5 (Econometric Software 2012) to examine respondents' preferences. Models 1 and 2 were specified with, respectively, utility as a linear and as a nonlinear function of the attributes. These models were specified as RPL models to account for both the panel nature of the data and for unobserved heterogeneity between respondents. In the nonlinear model (Model 2), the levels for the nonlinear attributes were dummy-coded as separate variables. The base, or status quo, level for each attribute was omitted so that parameter estimates represent preferences for changes from the base. A third model was defined as a LC model. This model allows the identification of multiple 'classes' of respondents who have heterogeneous preferences towards the attributes.

In the first two cases, the choice data were analysed with random parameter logit (RPL) models to account for both the panel data set and the unobserved heterogeneity between respondents.[2] In the RPL models (Models 1 and 2), all attributes were included as random parameters with a normal distribution. This was considered the most appropriate distribution to apply to a population sample, and prior testing indicated little improvement when other distributions were applied. Both RPL models were estimated with 1000 halton draws.

The same socio-economic variables used to compare the characteristics of the sample with that of the population were included in the model to determine the relative importance of sampling biases. All variables (see Table 4 for details) were interacted with the ASC.

Table 4 Model variables

Main variables	Description
Main attributes	
JOBS	More jobs (no. of jobs)
JOBS1600	Dummy-coded 1 = 1600 extra jobs
JOBS1000	Dummy-coded 1 = 1000 extra jobs
HOUSING	Local housing – higher prices (% increase)
HOUSE35%	Dummy-coded 1 = 35% increase in house prices
HOUSE20%	Dummy-coded 1 = 20% increase in house prices
BUSINESS WAGE	Local business – rising wage costs (% increase)
WAGE20%	Dummy-coded 1 = 20% increase in wages
WAGE10%	Dummy-coded 1 = 10% increase in wages
ENV MONITORING	Independent water/environmental monitoring activity (% increase in sites monitored)
MONITOR20%	Dummy-coded 1 = 20% increase in independent monitoring
MONITOR30%	Dummy-coded 1 = 30% increase in independent monitoring
COST	Annual household payment for 5 years ($)
ASC + Socio-demographic variables	
ASC	Alternative specific constant = 1 for the status quo alternative
AGE	Age in years
GENDER	Male = 1; Female = 0
EDUCATION	Dummy-coded 1 = tertiary education
INCOME	Information collected in a seven category format representing different ranges in annual income (Table 2). The midpoint of each category was applied in the analysis as follows: 1 = $13,000; 2 = $41,600; 3 = $62,400; 4 = $88,400; 5 = $104,000; 6 = $114,400; 7 = $156,400
SURAT	Respondents were asked whether they had family or friends living in the Surat region. Coded 1 = yes; 0 = no

[2] Generalised mixed logit models were also estimated, but it was not possible to fit models with a sufficiently large number of Halton draws, and there was too much variation in model outputs at low numbers of draws.

Table 5 Random parameter logit model results

	Model 1		Model 2	
	Coefficient	SE	Coefficient	SE
Random parameter means				
LOCAL JOBS	0.00002	0.0001	—	—
JOBS1600	—	—	−0.4050***	0.1205
JOBS1000	—	—	−0.5951***	0.1056
HOUSING	−0.0465***	0.0034	—	—
HOUSE35%	—	—	0.7329***	0.1386
HOUSE20%	—	—	1.0080***	0.1309
BUSINESS WAGE	0.0126**	0.0052	—	—
WAGE 20%	—	—	−0.9350***	0.1660
WAGE 10%	—	—	−0.7959***	0.1214
ENV MONITORING	0.0581***	0.0061	—	—
MONITOR20%	—	—	1.1515***	0.1532
MONITOR30%	—	—	1.6221***	0.1500
COST	−0.0208***	0.0012	−0.0343***	0.0021
Random parameter standard deviations				
LOCAL JOBS	0.0010***	0.0001	—	—
JOBS1600	—	—	1.4313***	0.2200
JOBS1000	—	—	1.6773***	0.1501
HOUSING	0.0419***	0.0041	—	—
HOUSE 35%	—	—	1.3651***	0.1710
HOUSE 20%	—	—	2.0718***	0.1482
BUSINESS WAGE	0.0700***	0.0073	—	—
WAGE 20%	—	—	1.4444***	0.2287
WAGE 10%	—	—	1.3266***	0.1677
ENV MONITORING	0.1104***	0.0081	—	—
MONITOR 20%	—	—	0.1074	0.2436
MONITOR 30%	—	—	2.2220***	0.1745
COST	0.0210***	0.0013	0.0390***	0.0024
Nonrandom parameters				
ASC	−1.1691***	0.3970	0.3698	0.3220
AGE	−0.0140**	0.0062	−0.0200***	0.0050
GENDER	0.7965***	0.1908	0.5640***	0.1504
EDUCATION	−0.0230	0.1940	−0.1251	0.1561
INCOME	−1.2E-06	2.5–06	−5.2E–06**	2.0E–06
SURAT	−0.6063***	0.2112	0.3698	0.3220
Model statistics				
Observations	6258	—	6258	—
Log likelihood	−4853	—	−5005	—
AIC	1.556	—	1.607	—
McFadden R^2	0.294	—	0.272	—
χ^2	4044	—	3741	—

Significance levels are *10%, **5% and ***1%.

Details of the first two models are outlined in Table 5. As expected, higher levels of local employment, lower levels of increased housing costs and higher levels of environmental monitoring were all preferred. Respondents had positive preferences for higher wage rates in the region which suggested they viewed higher wage rates as a benefit for local employees rather than a cost for local business operators.

Apart from two exceptions, all parameter means and standard deviations were significant, confirming the heterogeneity in preferences. In Model 1, the standard deviation, but not the parameter mean for LOCAL JOBS was significant, indicating that while there was significant heterogeneity in preferences, the mean estimate of the distribution was not significant. In Model 2, the parameter mean, but not the standard deviation for the 20 per cent level of ENV MONITORING was significant, indicating that there was significant preferences for higher levels of ENV MONITORING, but there was no significant heterogeneity across respondents.

In both models, GENDER and AGE were significant influences on choices with males being more likely to select the status quo option and older people more likely to select one of the alternatives. However, there was some difference between Models 1 and 2 in the significance of the ASC and some socio-demographic variables. This suggests that different factors were influential in preference trade-offs when the attributes were treated as a continuous variable (Model 1) compared to the trade-offs between the different levels of different attributes (Model 2). The influence of being connected through family or friends with the Surat Basin (SURAT) became insignificant in the nonlinear model interpretation. Two other changes provide some indication that Model 2 represents a more appropriate interpretation of the data. First, the ASC is not significant in Model 2, indicating that the variables included in the model specification explain preferences towards the status quo option. Second, INCOME is significant in Model 2 but not in Model 1, indicating that respondents were more aware of their budgetary limitations and possibly less likely to be making strategic choices when considering the trade-offs at a more detailed level.

The WTP estimates (Table 6) were calculated using the mean parameter coefficients[3] with confidence intervals estimated using the Krinsky and Robb (1986) procedure.

The results from Model 1 indicate Brisbane households were WTP each year for 5 years, \$0.11 for each additional 100 local jobs created, \$2.24 to avoid a 1 per cent increase in housing cost, \$0.61 for a 1 per cent increase in local wages and \$2.80 for a 1 per cent increase in independent water/environmental monitoring. The confidence intervals for JOBS ranged from negative to positive levels signifying the heterogeneity of preferences for this attribute (revealed in more detail in the latent class model below).

The proportional difference between attribute levels were constant, with the second level double that of the first. If preferences followed a linear pattern, then WTP changes would also be expected to double. This was not the case for Model 2, where preferences for JOBS, HOUSING and ENV MONITORING were less than 50 per cent higher for the second level compared with the first, and preferences for the second level of BUSINESS WAGE were lower. These nonlinear preferences demonstrate diminishing

[3] As noted by a reviewer, this does not account for preference heterogeneity,

Table 6 WTP estimates and confidence intervals from Models 1 and 2

	Description	WTP (CI)†
JOBS	Unit (100 jobs) increase in local jobs	\$0.11 (−\$0.52: \$0.73)
JOBS1600	600 fewer jobs (from 2200 to 1600 jobs)	−\$11.80 (−\$18.81: −\$5.19)
JOBS1000	1200 fewer jobs (from 2200 to 1000 jobs)	−\$17.34 (−\$23.52: −\$11.42)
HOUSING	Unit (%) increase in local house prices	−\$2.24 (−\$2.66: −\$1.86)
HOUSE35%	15% reduction (from 50% to 35% price increase)	\$21.36 (\$13.56: \$29.03)
HOUSE20%	30% reduction (from 50% to 20% price increase)	\$29.38 (\$21.57: \$37.16)
BUSINESS WAGE	Unit (%) increase in wage rates for local business	\$0.61 (\$0.16: \$1.12)
WAGE20%	10% reduction (from 30% to 20% wage increase)	−\$27.25 (−\$37.8: −\$17.51)
WAGE10%	20% reduction (from 30% to 10% wage increase)	−\$23.20 (−\$30.62: −\$16.31)
ENV MONITORING	Unit (%) increase in sites monitored	\$2.80 (\$2.21: \$3.46)
MONITOR20%	10% increase (from 10% to 20% of sites monitored)	\$33.56 (\$25.45: \$41.90)
MONITOR30%	20% increase (from 10% to 30% of sites monitored)	\$47.27 (\$38.22: \$57.31)

†Confidence intervals estimated using 1000 draws with the Krinsky and Robb (1986) procedure.

marginal benefits in attribute improvements and suggest that there are limits to the extent Brisbane residents are WTP to mitigate some of the potential impacts of mining and to achieve better outcomes in the Surat Basin.

The third, latent class model was developed to identify groups of respondents, where respondents in each group have similar responses, and the groups differ in the trade-offs made between attributes. A five class model was developed on the basis that it provided the best model fit while ensuring a minimum class size of 10 per cent. None of the socio-demographic variables were significant for any of the classes, and for purposes of clarity, an attributes-only model is presented in Table 7.

The different class structures identified in the model are indicative of the heterogeneity in the way that respondents viewed the attributes (in positive or negative terms) as well as in the trade-offs they made between attributes.

The only attribute that was significant and positive in all classes was the ENV MONITORING attribute. This indicates a consistency across classes for higher monitoring efforts, compared to the status quo. COST was significant in four classes (83 per cent of respondents), HOUSING in three classes (58.4 per cent of respondents), and JOBS and BUSINESS in two classes (38.4 per cent of respondents). JOBS and BUSINESS were seen as positives in Class 2 and as negatives in Class 5, indicating that respondents in

Table 7 Latent class model highlighting the different preference trade-offs

	Class 1	Class 2	Class 3	Class 4	Class 5
Membership probability	0.245	0.225	0.199	0.171	0.159
COST	−0.188 (0.041)***	−0.015 (0.002)***	−0.004 (0.001) ***	0.001 (0.001)	−0.028 (0.005)**
JOBS (‘00s)	−0.037 (0.048)	0.070 (0.014) ***	−0.017 (0.012)	−0.018 (0.011)	−0.058 (0.017) **
HOUSING (%)	0.025 (0.020)	−0.026 (0.005) ***	−0.099 (0.008) ***	−0.006 (0.006)	−0.075 (0.011) ***
BUSINESS (%)	0.045 (0.030)	0.021 (0.007) ***	0.002 (0.008)	−0.007 (0.009)	−0.028 (0.016) *
MONITORING (%)	0.115 (0.039) ***	0.039 (0.007) ***	0.019 (0.009) **	0.166 (0.015) ***	0.116 (0.019) ***
Model statistics					
Observations	6258	—	—	—	—
Log likelihood	−4815	—	—	—	—
AIC	1.548	—	—	—	—
McFadden R^2	0.300	—	—	—	—
χ^2	4120	—	—	—	—

Note Standard errors in parenthesis. Significance levels are *10%, **5% and ***1%.

Class 5 were prepared to trade-off employment gains and wage increases in favour of changes in other attributes.

5. Discussion and conclusions

The results reported in this paper have demonstrated that Brisbane residents are concerned about different issues and impacts associated with increased coal and gas mining activity that affect local communities in the Surat Basin. The key methodological contribution of the research is to demonstrate that the issues and impacts associated with mining developments can be assessed in a welfare economics framework with the aid of nonmarket valuation techniques, as distinct from the more traditional impact assessment and political economy approaches. These results support the findings of Gillespie Economics (2009) and Gillespie and Kragt (2012) that distant populations hold quantifiable nonuse values to reduce the adverse impacts of increased mining activity in local areas and on local communities. They are also consistent with other studies that have identified how urban residents have strong preferences (nonuse values) to maintain the viability of rural communities (eg. Bennett *et al*. 2004).

However, the results from Model 2 suggest that although Brisbane residents are WTP to reduce the adverse impacts of mining activity on rural communities, there are limits to this support. Preferences are not linear, and although residents value higher levels of impact reduction, diminishing returns are evident at higher levels. The results are consistent with the broad thrust of resource approvals granted by governments, which allow new projects subject to planning and approval processes.

It is often difficult to define the costs and benefits of economic development in a rural area and to identify how they might be viewed by separate communities (ie. local/regional; rural/urban) and by different members within a community. The results of the choice modelling experiment identified heterogeneity within the Brisbane community in preferences for the different choice attributes and in the trade-offs made between them. The most preference heterogeneity was manifest in preferences for the JOBS and BUSINESS attributes. The aggregate sample analysis indicated respondents had positive preferences for increased levels of local employment and for higher local wage rates (Model 2), but the results of the latent class model indicated that some people in the community had positive preferences while others had negative preferences.

The ENV MONITORING attribute was associated with the strongest (always significant) and most consistent (higher levels of environmental monitoring were always preferred) preferences. Environmental issues associated with coal seam gas mining activity receive wide spread media coverage in Australia, so the significance of this attribute may be driven by combinations of awareness and concern. While increased independent monitoring activity may not result in a specific environmental outcome, it provides more insurance against adverse impacts, particularly in a situation surrounded in uncertainty. Preferences for increased monitoring to guard against risks of future adverse effects are akin to option and quasi-option values, so their significance in this study suggests that Brisbane residents may have some precautionary values around development that encompasses environmental risks.

Over the past few decades, resource economists have addressed concerns about adverse environmental impacts by developing nonmarket valuation techniques that allow more comprehensive assessment of projects in a cost–benefit framework, even when nonuse values are involved. The analysis provided in this paper shows that the same approach can be extended to assess other impacts on communities and have demonstrated that outside populations may have significant values for community protection. The analysis provided in this paper extends other economic valuation studies that have determined monetary values for different environmental impacts, employment opportunities and some social impacts of extending the life of underground coal mines (Gillespie Economics 2009; Gillespie and Kragt 2012) and for future development options in a small coal mining town (Ivanova and Rolfe 2011). Together the results of these studies provide useful information about the strength of concerns about community and environmental impacts and can potentially be used to help evaluate the net benefits of resource development.

References

Bennett, J., van Bueren, M. and Whitten, S. (2004). Estimating society's willingness to pay to maintain viable rural communities, *Australian Journal of Agricultural and Resource Economics* 48(3), 487–512.

Bureau of Resource and Energy Economics (BREE) (2012). *Mining Industry Major Projects April 2012*. Bureau of Resource and Energy Economics, Canberra.

Burton, M., Zahedi, S. and White, B. (2012). Public preferences for timeliness and quality of mine site rehabilitation: the case of bauxite mining in Western Australia, *Resources Policy* 37 (1), 1–9.

Carrington, K. and Pereira, M. (2011). Assessing the social impacts of the resources boom on rural communities, *Rural Society* 21(1), 2–20.

Colombo, S., Hanley, N. and Louviere, J. (2009). Modelling preference heterogeneity in stated choice data: an analysis for public goods generated by agriculture, *Agricultural Economics* 40, 307–322.

Corden, M. (2012). The Dutch Disease in Australia: policy options for a three speed economy. Working Paper No. 5/12, Melbourne Institute Working Paper Series. The University of Melbourne, Melbourne.

Econometric Software (2012). *Nlogit 5*. Econometric Software Inc, Castle Hill.

Franks, D., Brereton, D. and Moran, C. (2010). Managing the cumulative impacts of coal mining on regional communities and environments in Australia, *Impact Assessment and Project Appraisal* 28(4), 299–312.

Garton, P. (2008). *The Resources Boom and the Two-Speed Economy*. Economic Roundup, Issue 3. Australian Treasury, Canberra.

Gillespie Economics (2009). *Proposed Warkworth Extension. Choice Modelling Study of Environmental, Cultural and Social Impacts*. Report Prepared for Warkworth Mining Ltd., Gillespie Economics, Sydney.

Gillespie, R. and Kragt, M. (2012). Accounting for nonmarket impacts in a benefit-cost analysis of underground coal mining in New South Wales, Australia. *Journal of Benefit-Cost Analysis* 3(2), article 3.

Goodman, J. and Worth, D. (2008). The minerals boom and Australia's 'resource curse', *Journal of Australian Political Economy* 61, 201–219.

Grudnoff, M. (2012). *Job Creator or Job Destroyer? An Analysis of the Mining boom in Queensland*. Technical Brief No. 36. The Australia Institute, Melbourne.

Hajkowicz, S., Heyenga, S. and Moffat, K. (2011). The relationship between mining and socio-economic wellbeing in Australia's regions, *Resources Policy* 36, 30–38.

Hensher, D.A., Rose, J.M. and Greene, W.H. (2005). *Applied Choice Analysis: A Primer*. Cambridge University Press, Cambridge.

Ivanova, G. and Rolfe, J. (2011). Assessing development options in mining communities using stated preference techniques, *Resources Policy* 36(3), 255–264.

Krinsky, I. and Robb, A. (1986). On approximating the statistical properties of elasticities, *Review of Economics and Statistics* 68, 715–719.

Lim, G.C., Chua, C.L., Claus, E. and Tsiaplias, S. (2009). Review of the Australian economy 2008-09: recessions, retrenchments and risks, *The Australian Economic Record* 42, 1–11.

Lockie, S., Franettovich, M., Petkova-Timmer, V., Rolfe, J. and Ivanova, G. (2009). Coal mining and the resource community cycle: a longitudinal assessment of the social impacts of the Coppabella coal mine, *Environmental Impact Assessment Review* 29, 330–339.

Louviere, J.J., Hensher, D.A. and Swait, J.D. (2000). *Stated Choice Methods: Analysis and Applications*. Cambridge University Press, Cambridge.

Norman, K. (2009). Rule of law and the resource curse: abundance versus intensity, *Environmental and Resource Economics* 43, 183–207.

Penney, K., Melanie, K., Stark, C. and Sheales, T. (2012). Opportunities and challenges facing the Australian resources sector, *Australian Journal of Agricultural and Resource Economics* 56(2), 152–170.

Petkova-Timmer, V., Lockie, S., Rolfe, J. and Ivanova, G. (2009). Mining developments and social impacts on communities: Bowen Basin case studies, *Rural Society* 19(3), 211–228.

Queensland Government (2010). *Surat Basin Future Directions Statement*. Queensland Government, Brisbane.

Queensland Government (2011). *Salt and Brine Management, in Coal Seam gas Production, Fact Sheet*. Queensland Department of Environmental and Resource Management, Brisbane.

Richardson, D. (2009). *The Benefits of the Mining Boom: Where Did They Go?* Technical Brief No. 3. The Australia Institute, Melbourne.

Rolfe, J., Miles, B., Lockie, S. and Ivanova, G. (2007). Lessons from the social and economic impacts of the mining boom in the Bowen Basin 2004–2006, *Australasian Journal of Regional Studies* 13(2), 134–153.

Rolfe, J., Gregg, D., Ivanova, G., Lawrence, R. and Rynne, D. (2011). The economic contribution of the resources sector by regional areas in Queensland, *Economic Analysis and Policy* 41(1), 15–36.

Scarpa, R. and Rose, J. (2008). Design efficiency for non-market valuation with choice modelling? How to measure it, what to report and why, *Australian Journal of Agricultural and Resource Economics* 52(3), 253–282.

Schandl, H. and Darbas, T. (2008). *Surat Basin Scoping Study. Enhancing Regional and Community Capacity for Mining and Energy Driven Regional Economic Development*. Report to the Southern Inland Queensland Area Consultative Committee and Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. CSIRO Sustainable Ecosystems, Canberra.

Solomon, F., Katz, E. and Lovel, R. (2008). Social dimensions of mining: research, policy and practice challenges for the minerals industry in Australia, *Resources Policy* 33, 142–149.

Spyce, A., Weber, M. and Adamowicz, V. (2012). Cumulative effects planning: finding the balance using choice experiments, *Ecology and Society* 17(1), 22.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Data S1. Information presented to survey respondents before completing the choice sets.