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Investing in irrigation development in North West Queensland, Australia*

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This study uses a dynamic multi-regional Computable General Equilibrium model of the Australian economy to examine the impacts of developing irrigated agriculture in remote North West Queensland. A potential investment and operational scenario is implemented using three alternative forecast baselines. In the first run using a business-as-usual baseline, there is a welfare loss from irrigation development, even with an optimistic shift in farm productivity and factor endowments in North West Queensland. In the second run, baseline demand for Australia's exports is assumed to grow at a faster rate and there is a small welfare gain. Simulating climate change impacts on crop yields, the forecast baseline of the third run includes a gradual reduction in farmland productivity in southern Australia. The simulations show the impacts of both supply and demand shifts on the welfare outcome, but on balance, clear welfare gains do not arise from the potential irrigation development.

Key words: Australia, dynamic computable general equilibrium model, forecast baseline, irrigated agricultural development, North West Queensland.

1. Introduction

The Flinders and Gilbert sub-catchments are the subject of the North Queensland Irrigation Agriculture Strategy, jointly funded by the Commonwealth and Queensland Governments (Queensland Government 2010). This paper sets out to estimate potential economic impacts arising from a substantial hypothetical irrigation development of the Flinders–Gilbert sub-catchments. However, not only are the direct output impacts somewhat speculative, but the global economic environment in which the project proceeds is also unknown.

Given these uncertainties and to contextualise the debate, we commence analysis by perusing past efforts to develop the north. Some of the debate surrounding a comparable scheme from half a century ago, the Ord River irrigation project, has resonance in the present setting. In brief, we examine

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both sides of the debate of the time. One analyst at the time in favour of the project was brave enough to imagine how the Ord economy would look far into the future (Cannegieter 1964). This provides a benchmark against which we compare how the local economy of the Ord region looks today. In the leap of faith we require to model the future impacts of the Flinders–Gilbert irrigation development, this comparison of the present Ord region with how it was imagined half a century ago provides some perspective.

Given the remoteness of the region and the consequent costs of sourcing inputs and selling outputs, usual economic analysis is likely to demonstrate welfare losses arising from development of the Flinders–Gilbert scheme. However, in the spirit of Campbell (1962), who noted that different demand conditions will alter returns from a project, we model the scheme using three different baselines which reflect different demand conditions from the perspective of North West Queensland. We do so using a dynamic multi-regional computable general equilibrium (CGE) model.

1.1. Previous attempts to develop agriculture in the north

In the political realm, there are periodic pushes to develop northern Australia. In the late 1950s, the Forster Committee was set up to devise a blue print for the development of agriculture in the Northern Territory. Professor Carl Forster, Dean of the Faculty of Agriculture at Melbourne University, chaired the committee, which also included CSIRO representation. A former farmer, Bert Kelly, a politician who was to become a minister under the Holt and Gorton governments in the late 1960s, joined the committee.

As he went through the process of devising ways of clearing land and choosing crops, Kelly (1978) came to despair of each project. One entailed growing rice on coastal plains. At the time of year when irrigated water was required, it was too salty to use. When the water was fresh, seasonal rainfall rendered it unnecessary. Another scheme aimed to feed cattle during the lengthy dry season on peanut meal. Based on the condition of the cattle, the project worked well. But the costs of producing peanuts exceeded the benefits from fattening cattle. Kelly's experiences led him to conclude the following:

> There is one golden rule we should always remember when developing land and that is never to let the government near it. (Kelly 1978, p. 27).

At this time, construction of the Ord River scheme in the Kimberley region of Western Australia was under way. The merits of the Ord scheme have been debated periodically since its inception. Some motivations concerning the Ord scheme differ from those that apply now to the hypothetical Flinders–Gilbert scheme. In particular, fears of invasion from northern neighbours were still part of the national psyche less than two decades after the end of World War II. Other motivations are as they were then. One example is the vision that the north could become a new food-bowl for domestic and international markets. If anything, this vision has grown with the relative proximity of northern Australian to emerging markets in Indonesia and Asia.

1.2. The debate of the time

The debate among Australian economists concerning the merits of the Ord River scheme began prior to and continued after its opening by Prime Minister Menzies in July 1963. Campbell (1962) recognised that World War II experiences provided a motivation for development of the north on defence grounds. However, at a time when agriculture still accounted for over 12 per cent of gross domestic product (GDP) in Australia (Maddock and McLean 1987) – compared with around 3 per cent now, he noted the declining importance of agriculture in developed economies. He also recognised the potential for productivity gains to maintain the competitiveness of existing farmland, in the face of visions of the cost advantages of farm production in the north. He was also sceptical concerning the likelihood that further development of the north could overcome the cost disadvantages of distance:

Amid his concerns about policy-driven attempts to accelerate economic growth in remote regions, Campbell (1962) outlined five means by which this could occur:

1. expanded demand outside the region for products produced within the region;
2. expanded demand within the region for the products of the region;
3. discovery of previously unknown resources which can be economically exploited;
4. technological change which enhances the comparative advantage of the region relative to other areas in the production of various goods; and
5. purposeful capital investment in the region from outside. (p. 25)

Campbell's five sources of regional economic growth provide a useful framework to which we return later.

National concerns about under-population in the north drove much of Cannegieter's (1964) support for the project. He envisaged that by settling 10,000 people on the Ord River plains over the next century, Australia would demonstrate its commitment to using natural resources in response to 'over-populated Asian countries looking for land of high fertility' (Cannegieter 1964, p. 384). But Musgrave and Lewis (1965) were dismissive of Cannegieter's appeal to the 'pioneering instinct' of Australia reflected in farming developments as a justification for the scheme. Also, Musgrave and Lewis (1965) regarded as absurd the link Cannegieter made between defence benefits and Queensland's sugar industry and the potential for similar benefits arising from the Ord scheme.

1.3. The outcome till now

With hindsight, we align some of the debating points of economists of around 50 years ago with available data on the present day economy of the Ord River region. Cannegieter (1964) envisaged that the Ord scheme would lead to the population of the Wyndham shire (the Wyndham-East Kimberley local statistical area) growing to 10,000 by the year 2060, with agricultural workers exceeding 1000. The region's population passed 8000 in 2011, which aligns reasonably with Cannegieter's projection. But the census of 30 June 2011 indicates that only 4.8 per cent of the local workforce or 179 people were employed in agriculture using a place of residence basis (Table 1). This may understate the contribution to the extent that it excludes seasonal labour, which peaks between May and July, but any upward adjustment is unlikely to result in an annualised full-time equivalent of much more than 100 or so above the employment figure reported in Table 1.

The development of the Argyle diamond mine in the 1980s has made a contribution to broadening of the employment base of the region to include mining (Campbell's point (3)). Point (1) on Campbell's list, expanded demand from outside the region, relates best to tourism, with the Kimberley region developing a reputation for adventure holidays. Transport and accommodation, two tourism-related sectors, have shares of total employment that exceed national shares. The shares are 5.5 per cent for transport versus 4.8 per cent nationally, and 4.2 per cent versus 1.2 per cent for accommodation. These shares provide moderate rather than compelling evidence for the impact of tourism. On the other hand, Hotels and cafes, another tourism-related industry, has an employment share of only 2.6 per cent, below the national share of 5.3 per cent (ABS, 2011 census, unpublished data).

Despite Cannegieter's population projection appearing reasonable, his analysis of the structure of the local economy was incorrect. Mainly, he made

Table 1 Employment in Wyndham-East Kimberley, 2011 census

	No.	%		No.	%
Agriculture	179	4.8	Trade	300	8.0
Beef	80	2.1	Accommodation	157	4.2
Mining	358	9.6	Hotels and cafes	99	2.6
Food Processing	39	1.0	Transport	212	5.7
Mineral processing	27	0.7	Education	357	9.5
Other Manufactures	56	1.5	Health	271	7.2
Utilities	49	1.3	Care Services	141	3.8
Construction	369	9.9	Other Services	1049	28.0
			Total	3743	100.0

Source: ABS (2011) census data.

no allowance for labour-saving technological change over time, so that he equated employment growth with farm output growth. This contrasts with Campbell's analysis, which at least allowed for the possibility that sectors other than agriculture could drive regional economic growth. Healey (1966) accused opponents of northern development of 'economic myopia', appealing to the indirect effects, economic, ethical and political, that might justify the project in the long term. But it seems reasonable to infer that mining has led to development of the north far beyond what could ever be achieved with agriculture. In fairness to analysts of the time, mining's share of GDP in the early 1960s was at a historically low point (Maddock and McLean 1987).

The Kimberley Research Station was established prior to the construction of the Ord River scheme, as scientific feasibility is a necessary part of economic viability. This indicates that at least there was some intent to combine R&D with engineering investments. Despite this, pests and diseases have hindered production over much of the life of the Ord scheme. In some years, cotton production has been damaged by pests. However, the introduction of genetically modified cotton has, over the past decade, overcome pest problems and further problems arising from insecticide resistance.

Even in the case of a crop found suitable in the region, at any time, a chasm may appear between scientific feasibility and economic viability. A case in point is one of the former mainstays of production in the Ord scheme, sugar cane. In 2005, the region produced almost half a million tonnes of sugar cane (ABS 2008). A local sugar mill opened in 1995 (Head 1999) was later mothballed in response to a collapse in sugar prices in 2007–08, in part a consequence of a surging Australian dollar (Webster *et al*. 2009). Sugar cane production in 2010–11 was less than 100 tonnes (Table 2).

A final point regarding the Ord scheme concerns the reporting of outputs. ABS data indicate that beef cattle production still dominates farm production in the Wyndham-East Kimberley region, amounting to around $45 million of output at local prices (ABS 2013). Yet government information on the existing scheme or extensions to it tends to exaggerate the value of output. For example, the Kimberley Development Commission[1] stated that sandalwood output in 2008–09 was $65 million, yet McConnon (2013) reported that harvesting only commenced in 2013. The commission's estimate that other irrigation output in the region totalled $36 million is at least in the same ballpark as available ABS data, which indicate a value of $24 million (Table 2). This is produced on 8500 hectares of irrigated land (ABS 2012b).

2. Regional profile

The geographic focus of this study is the Flinders and Gilbert sub-catchments in North West Queensland, Australia (Figure 1). For the purposes of this

[1] See http://www.kdc.wa.gov.au/Economic-Activity/Agriculture, accessed 3 December 2013.

Table 2 Wyndham-East Kimberley irrigated output, 2010

	Tonnes	$m
Grapefruit	1435	1.9
Mangoes	504	1.9
Pawpaws/papaya	453	0.9
Beans	321	1.7
Chickpeas	607	0.3
Cotton seed	93	0.1
Cotton lint	36	0.1
Lemons/limes	16	0.1
Vegetables for seed	11	0.1
Pumpkins	7538	5.5
Melons	6832	10.0
Sorghum	1135	0.2
Hay	1760	0.1
Maize	1627	0.2
Rice	2208	0.5
Sugarcane	55	0.03
Other	—	0.4
Total	—	24.0

Source: ABS (2012a,b).

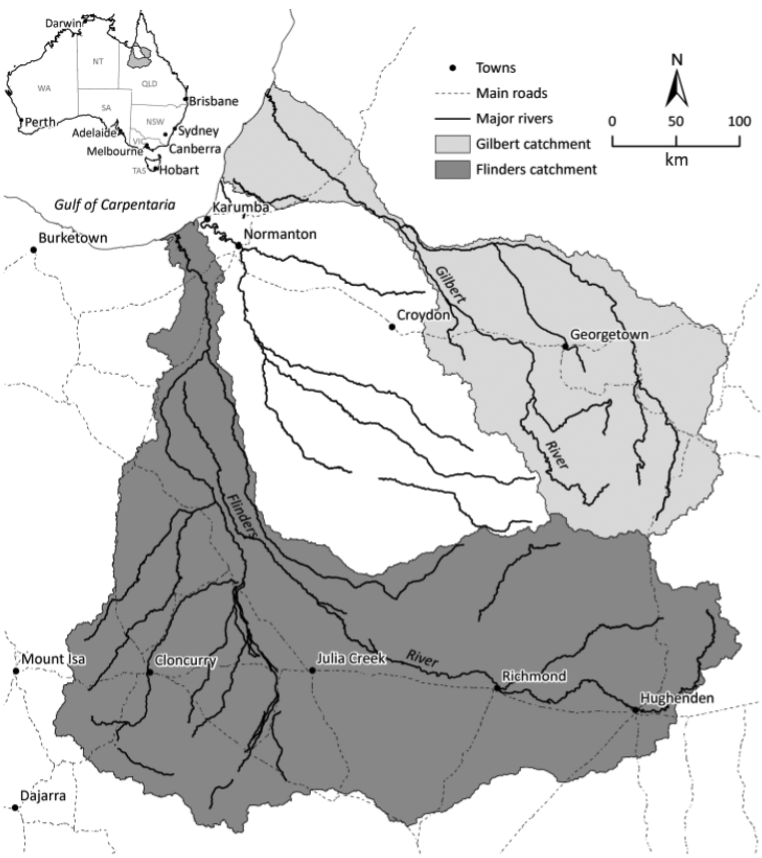

Figure 1 The Flinders and Gilbert sub-catchments, North West Queensland.

analysis, the Flinders and Gilbert sub-catchments are considered to be wholly contained within the North West Queensland Statistical Division.

2.1. The Flinders sub-catchment

The North West Queensland Statistical Division covers 308,098 km^2 and contains the shires of Cloncurry, Flinders, McKinlay, Richmond, Carpentaria, Doomadgee, Mornington and Mount Isa. The first four shires comprise the Flinders sub-catchment. The population of the region was 33,629 in 2010. The Mount Isa shire, to the west of the proposed irrigated areas, contains 21,994 people. Mining and mineral processing are the region's most important activities and are also concentrated in Mount Isa. One quarter of the world's identified lead and zinc deposits are located in this region; rangeland cattle production is the most important industry elsewhere in the region.

The Flinders sub-catchment contains 7100 people. The Great Northern Railway Line, which straddles the sub-catchment area, extends from Mount Isa, west of Cloncurry, to the nearest port at Townsville. Train travel from Mount Isa to Townsville takes 17 hours. Townsville itself is over 1300 km by road north of the state capital, Brisbane. Cloncurry, Julia Creek, Richmond and Hughenden all have commercial airports. The Flinders Highway cuts through the mid-section of the region, running east to west.

In the Cloncurry, Flinders, McKinlay and Richmond shires, beef cattle production accounts for more than one quarter of regional income (authors' estimates from ABS 2011 census and ABS 2012a).

2.2. The Gilbert sub-catchment

The Gilbert sub-catchment lies within the boundaries of both the Far North Statistical Division and the North West Statistical Division, in an area exceeding 100,000 km^2. The Gilbert consists of the shires of Etheridge and Carpentaria with a total population of little more than 3000. Isolation is exacerbated during the wet season when flooding is common.

In the Carpentaria shire, Normanton and Karumba are the principal towns, with the remaining population residing in more remote areas. Normanton serves as a port for the Gulf Region at the head of the Norman River. Established in 1868, Normanton's heyday was attributed to the goldfields at Croydon, but with their expiry, nowadays, the town serves more as a centre of local government and service provider for the Gulf Region (Gulf Regional Planning Advisory Committee 2000). Etheridge Shire includes the towns of Georgetown, Mount Surprise, Forsayth and Einasleigh and has a scattered and very rural population. Pastoral opportunities in the 1860s and the later mining of copper and gold brought settlers, though these activities have long since declined. In the Carpentaria and Etheridge shires, beef cattle accounts for more than 40 per cent of regional income.

3. Methods

3.1. The dynamic TERM model

This study uses direct impacts of the Flinders–Gilbert estimated in a CSIRO study (Brennan McKellar *et al.* 2013) as inputs to a computable general equilibrium model, TERM, to estimate the regional and national impacts of the potential irrigation scheme.

The theory of dynamic TERM is similar to that national dynamic CGE models such as MONASH (Dixon and Rimmer 2002). That is, each industry in TERM chooses inputs of labour, agricultural land, capital and material inputs so as to minimise costs in producing a given level of output. Levels of outputs chosen by the industry satisfy demands, which in turn depend, in the context of internationally traded goods, on global market conditions.

A theoretical modification to this version of TERM concerns land mobility. The industries of cotton, rice, sugar cane, hay and other agriculture are assumed to consist of relatively mobile land and capital. For these sectors, land and capital can switch between farm activities in response to changes in factor rentals, following a constant elasticity of transformation (CET) specification. As beef cattle production is more similar to a perennial crop, relying on a specific form of capital (i.e., the herd), capital and land are modelled as immobile between farm activities. As most hay produced in the region is sold to the beef cattle sector, there is a close link between the beef cattle and hay sectors.

A key feature of the model is its small-region representation. TERM is a bottom-up multi-regional model: that is, supplies, demands, prices and quantities are calculated for each region. In effect, each region in the model is treated as a separate economy, linked to the other regions by trade. The TERM model is documented in detail in Wittwer (2012) and Horridge *et al.* (2005).

The model applied in this analysis is dynamic. In a dynamic model, capital stocks depend on past investments and capital net of depreciation. Stocks of net foreign liabilities are linked to trade balance flows. The dynamic model is run in two modes, forecast and policy. Population, labour force growth, real wage movements, changes in domestic absorption and changes to factor productivities, along with forecast changes in international market conditions, together form a forecast baseline. The underlying forecast baseline may have a critical bearing on the outcome of policy simulations. For example, in the context of the present study, the effect of climate change on agricultural productivity in one region will affect the profitability of agriculture in another region. Results of a policy scenario are reported in detail relative to a business-as-usual baseline.

For the purposes of this analysis, the TERM model master database was aggregated to 25 sectors, including six agricultural sectors and three regions (North-west Queensland, Rest of Queensland, Rest of Australia). The simulations are implemented in North West Queensland. Model experiments are conducted using GEMPACK (Harrison and Pearson 1996) and RunDynam[2] software.

3.2. Summary of scenarios and model shocks

The irrigation development in the Flinders and Gilbert sub-catchments in North West Queensland is modelled in several distinct phases, from the base year of 2011 to 2027:

1. Dam construction phase. Construction takes place between 2015 and 2017 and entails total expenditures over 3 years of storage works and distribution works of \$2.4 billion. There is also an additional investment of \$135 million in road transport infrastructure in the region. This phase is implemented in the model using investment shocks equal to these estimated dollar values.
2. Farm investment and downstream processing phase from 2018 to 2023. Once additional water is available for farming, farm activity increases, and farm investment is permanently elevated. Productivity gains and land endowment shocks are ascribed to farm sectors to reflect the availability of irrigation water. Productivity gains imposed on downstream processing sectors reflect expected gains from scale.
3. A mature phase follows from 2024 onwards, once irrigation and downstream processing have been built up to a full scale.

4. Results

4.1. Dam construction phase (2015–2017)

We start the analysis of the construction phase by concentrating on national impacts in 2015. The direct impact of dam investment is to raise real national investment relative to forecast (Figure 2). In 2015, direct investments in dam construction and roads in North West Queensland total \$760 million. Aggregate national investment in the baseline in 2015 is \$445 billion. Therefore, our estimate of the direct impact of the investments on national investment is an increase of 0.17 per cent ($=0.76/445 \times 100$). The simulated outcome shown in Figure 2 is an increase of 0.165 per cent. Offsetting impacts include small reductions in mining investment in all regions relative to forecast. These small reductions arise because the impact of the direct investment is to raise investment costs faced by other industries, thereby lowering the volume of investment elsewhere relative to forecast.

[2] See http://www.copsmodels.com/gprdyn.htm.

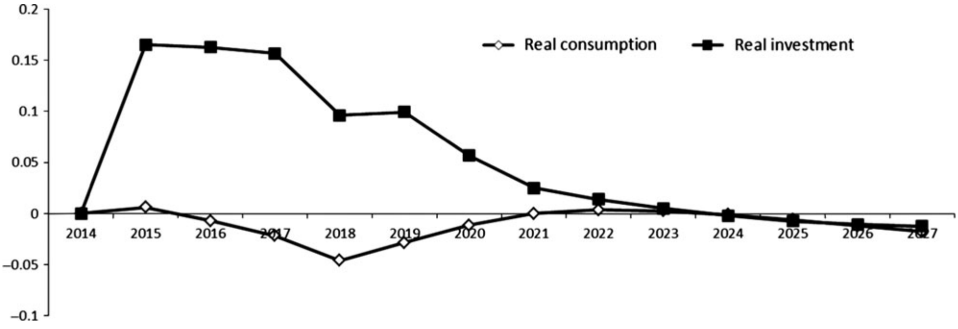

Figure 2 Aggregate consumption and investment for Australia (% deviation from forecast).

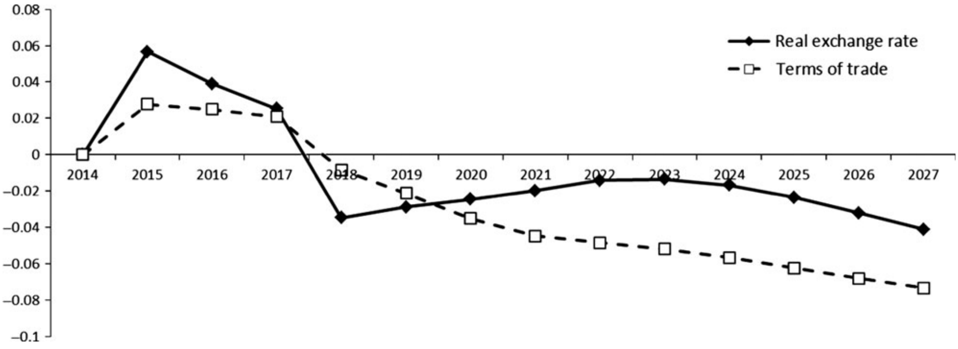

Figure 3 Real exchange rate and terms of trade (% deviation from forecast).

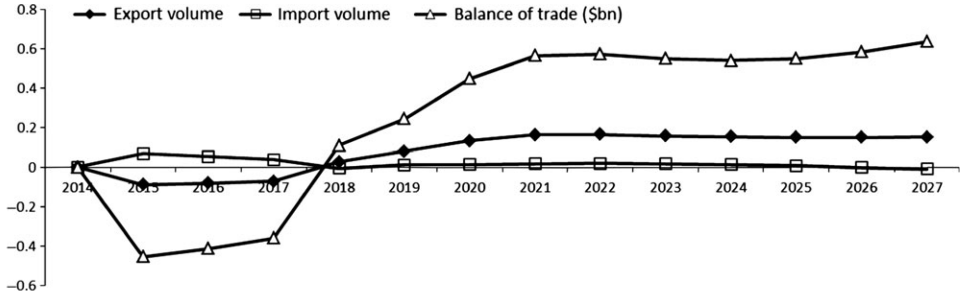

Figure 4 Trade volumes (%) and balance of trade ($bn) (deviation from forecast).

At the national level, for a given level of income, an investment phase diverts output from exports towards investment. Additional domestic demands arising from elevated investment induce a real appreciation of the exchange rate (Figure 3), with a consequent reduction in exports (Figure 4).

Dynamic TERM includes a theory of sluggish labour market adjustment due to sticky wages (Wittwer *et al*. 2005). Therefore, in the initial year of this phase, labour market adjustment is mostly via the quantity of labour hired

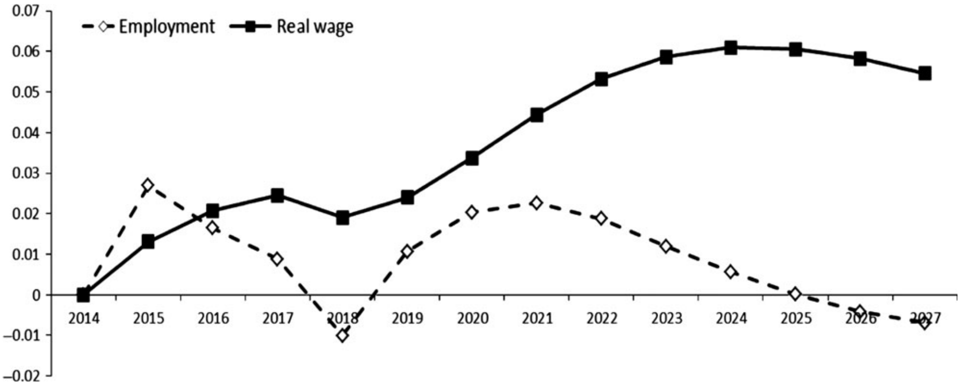

Figure 5 Labour market for Australia (% deviation from forecast).

(employment) with little movement in real wages. A back-of-the envelope analysis of the investment phase impact on the labour market in year 1 relies on terms-of-trade movements to explain the short-term employment increase shown in Figure 5. Assuming that export demand curves are down-sloping and import supplies infinitely elastic, the terms-of-trade rise (that is, the price of exports rises relative to the price of imports) as elevated investment demands reduce export supplies. Next, we examine an expression for the marginal product of labour,

$$\mathrm{MP}_L(K/L) = (w/p_{\mathrm{c}}).(p_c/p_{\mathrm{g}}), \tag{1}$$

in which w is the nominal wage, p_{c} the consumer price and p_{g} the producer price proxied by the economy-wide gross domestic product (GDP) deflator. This expression is a function of the capital-to-labour (K/L) ratio. The marginal product of labour as given by w/p_{g} is divided into two components, w/p_{c}, the sticky real wage as faced by consumers and $p_{\mathrm{c}}/p_{\mathrm{g}}$, the ratio of consumer prices to the GDP deflator. We rearrange (1) to

$$\mathrm{MP}_L(K/L).(p_{\mathrm{g}}/p_{\mathrm{c}}) = w/p_c. \tag{2}$$

As consumption includes imports but not exports, and GDP includes exports but not imports, a rise in the terms-of-trade implies that $p_{\mathrm{g}}/p_{\mathrm{c}}$ must rise. With w/p_{c} fixed or adjusting only slightly in the short term and $p_{\mathrm{g}}/p_{\mathrm{c}}$ rising, the capital-to-labour ratio K/L must fall. As K is fixed in the short term (as it takes time for capital stocks to adjust to changes in rates of return), employment L must rise.

In 2016 and 2017, as real wages keep rising, employment growth is subdued. In 2018, when dam construction has finished and investments in farms, downstream processing and road transport have started, despite the switch to other investments, employment falls below forecast, which is a consequence of wages persisting at 0.02 per cent above forecast nationally (Figure 5).

Although national consumption may rise relative to forecast during any phase of elevated investment, this does not by itself result in a welfare gain. Elevated investment results in imports increasing and the trade balance worsening relative to forecast, and with it, an increase in net foreign debt (Figure 4). Consequently, additional payments must be made to foreigners in later years to service the debt.

4.2. Farm and downstream processing construction phase (2018–2023) and mature phase (2024 and beyond)

The welfare outcome of the project, using Equations (4) and (5) from section 4.3, hinges on the magnitudes of technology and endowment shifts in North West Queensland arising from the development of the irrigation scheme, and on demand shifts for farm outputs produced under the scheme. We can ascribe supply shifts in dynamic TERM through the production function for each industry:

$$Q = f(K, L, \text{Land}, 1/A) \tag{3}$$

where Q is industry output; K is industry capital; L is the quantity of labour hired by the industry; Land is the quantity of agricultural land used by the industry; and $1/A$ is the underlying technology of the industry.

CSIRO developed case studies (Brennan McKellar *et al.* 2013) based on estimates of the water that could be made available through the construction of dams at feasible sites and the construction of distribution networks. Key parameters from the case studies required for this analysis are area by crop, crop yield and price. A non-trivial task is converting estimated output impacts arising from these case studies within the irrigation scheme into endowment and technological gains. The larger these gains, the more likely it is that a positive national welfare outcome will arise from initial investments.

The impact of the investment in dams is treated as an exogenous increase in farmland endowment in North West Queensland in 2018.[3] This reflects that former rangeland is far more productive with the addition of water. From 2018, exogenous increases in investment in farming commence in North West Queensland. These increase capital stocks in farm sectors accompanying the increase in farmland. Four sectors, namely other agriculture (mainly rice and peanuts in North West Queensland in this study), cotton, hay and sugar cane, use mobile land and capital. Total primary factor productivity shocks are ascribed to these four sectors equally. However, with mobile factors, the dollar equivalent of the gains in an individual activity will depend on demand-side changes.

[3] At the same time, effective capital in the utilities sector, used a proxy for dams, is kept constant by matching capital stock increases (implied by the dynamic link between investment and capital) in the Utilities industry with capital productivity deterioration in the sector. This ensures no double counting of additional factors.

Table 3 shows the estimated increases in output arising from the irrigation project at full scale, based on summing the costs and outputs in the case studies undertaken by CSIRO (Brennan McKellar *et al*. 2013). Table 4 shows the dollar extent of the supply shifts attributed to the irrigation investments, with increases in land and capital endowments, plus changes in technology. As is evident from comparing Tables 3 and 4, the endowment and technological shocks ascribed to the model appear to err on the side of optimism. For example, the value of additional mobile factors arising from the irrigation scheme is \$353 million, whereas the value of outputs shown for crops using these mobile factors in Table 3 sums to only \$331 million. Even Table 3 may be optimistic, in that \$331 million is produced with 66,000 hectares of cropping or \$5000 of output per hectare. Table 2 shows that in 2010, the Ord scheme produced \$24 million on 8500 hectares (\$2800 of output per hectare). However, this may not provide a reasonable long-term comparison due to the strength of the Australian dollar in 2010, which diminished the competitiveness of farming and other non-mining trade-exposed sectors. Given that Table 4 uses a value-added basis (i.e., excluding intermediate input costs), it would appear that the model shocks based on Table 4 are twice as large as is appropriate. These supply shocks can be revised in future studies. Moreover, as is discussed in section 4.4, welfare impacts arising from the project also depend on demand conditions.

In the processing and road transport sectors, the additional capital rentals are based on imposed investment shocks. The technological gains are based on judgment but are small relative to the shocks to agriculture.

Table 3 Estimated farm outputs, hypothetical case studies, mature phase

Crop	Hectares	Output (tonnes)	Price (\$/*t*)	Value \$m
Cotton	24,000	50,000	2400	120
Rice	7000	67,200	400	27
Sugarcane	25,000	320,000	530	170
Peanuts	10,000	48,000	300	14
Rhodes Grass fodder	1000	NA	NA	NA
Sorghum fodder	10,000	NA	NA	NA

Sources: http://cottonaustralia.com.au/cotton-library/statistics; http://www.canegrowers.com.au/; Brennan McKellar *et al*. (2013).

Table 4 Endowments and technological change in North West Queensland (\$m 2011 prices, mature phase)

	Capital	Land	Tech	Row total
Mobile factors	206	59	88	353
BeefCattle	4	49	11.5	64.5
GinCotAgSrv	23	—	7	30
MeatProds	4	—	1	5
OtherFood	19	—	34.7	53.7
RoadTrans	16	—	23.7	39.7

4.3. Impacts in North West Queensland

The Flinders–Gilbert irrigation scheme we model involves a substantial transfer of public funding to North West Queensland that is large in comparison with the region's economy. Similarly, the full scale operational phase involves supply shifts that are large at the regional level. Therefore, in the investment phases and the full scale operational phase, regional economic activity rises well above forecast. Figure 6 shows that aggregate consumption remains around 6 per cent or more above forecast in North West Queensland for most of the simulation period. This is equivalent to around $100 million based on 2015 consumption levels.

Figure 7 shows North West Queensland's labour market relative to forecast. Employment peaks in 2015 at 4 per cent or 650 jobs above forecast. The theory of TERM allows real wages in a given region to rise relative to those of other regions in event of the local labour market strengthening, as it does in the present study in the investment phase. As long as labour supply is below labour demand (i.e., employment), there is upward pressure on regional wages. When labour demand falls below supply, there is downward pressure on wages. In the years of the investment phase after 2015, real wages continue to rise so that employment levels move back towards forecast, falling below forecast in 2018 with the end of the dam construction phase. The additional factors and productivity in North West Queensland arising from the Flinders–Gilbert scheme lead to an increase in labour supply of around 0.6 per cent or 100 jobs relative to forecast. Although there may be indirect benefits arising from the project not modelled in this study, the impact on the region, given the level of investment, is small. However, an alternative labour market specification, in which the real wage premium required to attract workers to the region were smaller, would result in a larger regional employment outcome.

4.4. Calculating net national benefits

In later years, national aggregate consumption at the national level dips below forecast as increased payments to foreigners reduce disposable income

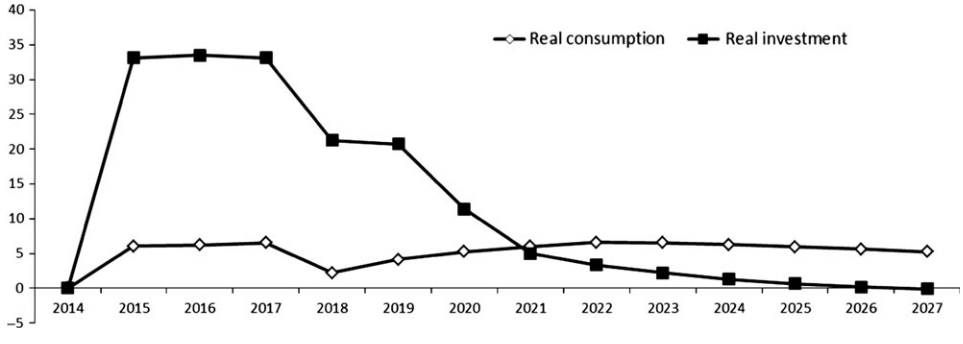

Figure 6 Aggregate consumption and investment in North West Queensland (% deviation from forecast).

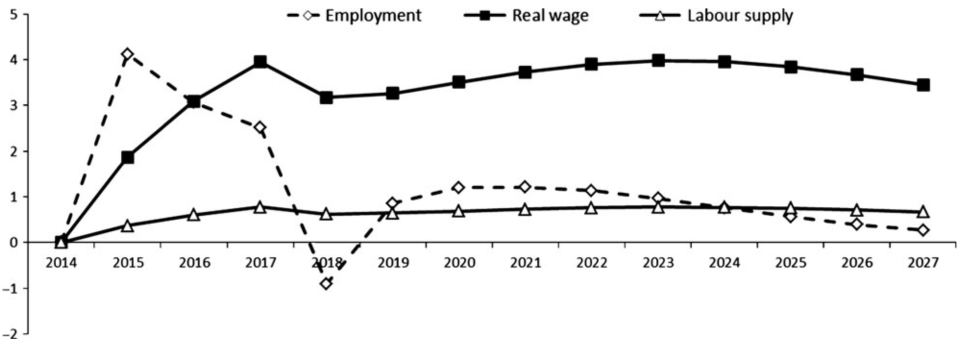

Figure 7 North West Queensland's labour market (% deviation from forecast).

(Figure 2). This reminds us that even with an optimistic set of outward demand shifts in farming sectors in North West Queensland, it is doubtful that the irrigation scheme is welfare enhancing. We can calculate formal welfare (dWELF) at the national level:

$$\text{dWELF} = \sum_d \sum_t \frac{\text{dCON}(d,t) + \text{dGOV}(d,t)}{(1-r)^t} - \frac{\text{dNFL}(z)}{(1-r)^z} \tag{4}$$

where dCON and dGOV are the deviations in real household and government spending in region d and year t; dNFL is the deviation in real net foreign liabilities in the final year (z) of the simulation; and r is the discount rate. One complication in Equation (4) is that the deviation in current consumption is not near zero by 2027. The simulation was projected further out to 2035, by which time, the deviation was still below zero and moving back towards zero. The welfare impact of the final year z was calculated as

$$n \times \sum_d [\text{dCON}(d,z) + \text{dGOV}(d,z)]/(1-r)^z \tag{5}$$

where $n = 0.5$. If the deviation were not trending gradually towards control but instead were constant, n would be set at 1.0.

So that we can compare welfare impacts directly with the annualised numbers shown in Tables 3 and 4, the welfare number obtained from (4) and (5) is multiplied by the discount rate (5%) to obtain an annualised number. In this scenario, the annualised net present value of the welfare impact is *minus* \$69 million.

4.5. Alternative baselines

The modelled magnitude of the net national benefits of the project depends in part on the direct input costs, timing of construction and the magnitude and timing of factor increases and productivity benefits. So far, the Flinders-Gilbert irrigation project does not appear to be welfare-enhancing.

In a dynamic model, the forecast baseline also influences the outcome. Table 3 relies on imposed prices to estimate the value of additional production. Recall from Section 1.2, Campbell's (1962) conditions for realising regional growth: condition (1) concerns expanded demand for a region's products. A change in global agricultural demand or in farm supply conditions in the rest of Australia will alter the returns from the supply shifts ascribed for North West Queensland.

To highlight the importance of model forecasts in influencing the economic viability of an investment project, the second and third scenarios consider two additional forecast baselines. In the second scenario, the investment and productivity gains are imposed on a forecast baseline in which export demand growth is faster than in the main baseline. The third scenario imposes the investment and productivity gains on a forecast baseline in which there is a gradual deterioration of farm productivity in southern Australia relative to the main baseline due to climate change. The second and third baselines each raise the welfare impact arising from the project relative to the first scenario.

In the case of both baselines 2 and 3, there are marked impacts on national agricultural and food processing output relative to the main baseline. Over time, rising export demand growth (baseline 2) is expressed not in rising prices but in rising outputs. That is, rising demand initially raises factor rentals in agriculture and food processing. This induces additional investment, consequent additional capital and additional labour into these sectors, so that over time, supply shifts rather than prices dominate the adjustment to increasing demand. Figure 8 shows the national outputs of agriculture and food processing relative to the first baseline.

In the case of baseline 3, we assume that climate change slows productivity growth in the rest of Australia's farming sector relative to that of the main baseline (i.e., excluding North West Queensland). Each case raises the returns to irrigation investments in North West Queensland. Stronger global demand is the driver in baseline 2. The endowment and productivity increases arising from the irrigation scheme are exogenous. Therefore, growing global demand

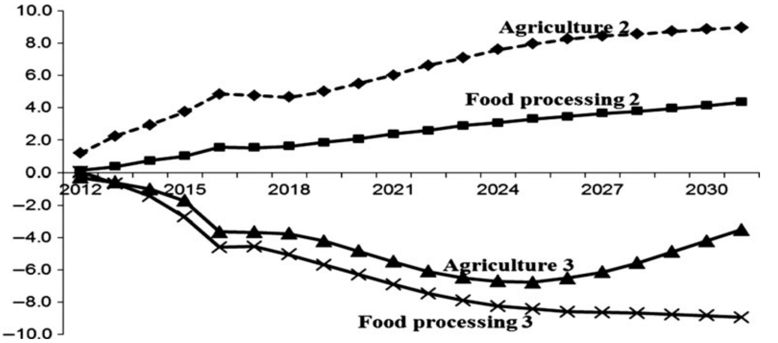

Figure 8 National agricultural and food processing outputs in baselines 2 and 3 relative to the first baseline.

for food products will raise returns to fixed factors (i.e., industry-specific capital imposed through exogenous investment shocks, plus agricultural land and water) arising from the irrigation scheme. Baseline 3 is bad for farming in the rest of Australia, which suffers an inward supply shift relative to the main baseline, but good for returns arising from the irrigation project.

The annualised welfare impact arising from baseline 2 in which baseline export demand growth is faster is *plus* \$115 million. That is, with higher prices for farm products and hence elevated returns from investments in the Flinders and Gilbert valley regions relative to the first baseline, the returns are sufficient to exceed the costs of establishing the irrigation schemes (recalling the optimistic supply shifts shown in Table 4). In the case of baseline 3, in which farm productivity in southern Australia grows at 0.3 per cent per annum less than in the first baseline, the annualised welfare impact is *plus* \$48 million. It is evident that if we halve the agricultural supply shifts shown in Table 4 on the basis that they are somewhat optimistic (so that the shift in mobile factors in the top line of the table reduces from \$354 million to \$176 million), welfare losses would arise from both baselines 2 and 3.

Another dimension of conditionality concerns the discount rate. Long-term projects are more readily justified if the discount rate is lower. A discount rate of 5 per cent is used in this study. As the discount rate falls, returns in later years have a higher weighting in the welfare calculation. Over a long period of time, it may be difficult to justify a lower discount rate than that used in this study, given that Australia's interest rates are currently at 50-year lows.

5. Conclusions

The range in welfare outcomes that arises from varying the forecast baseline shows that the baseline matters in determining the worth of a project in a dynamic CGE model. Climate change, as it affects southern Australia, and rising global demand for agricultural products will improve the welfare outcome relative to the main baseline used in this study. But a revision to the supply shifts imposed in this study on North West Queensland's farm sectors would result in modelled welfare losses in the case of all three baselines.

This study started with an outline of arguments put forward by economists half a century or more ago for and against the Ord River irrigation scheme. Circumstances have changed. Defence of the north is less of an issue now as the social memory of invasions in World War II fades. Environmental considerations now weigh more heavily on major projects in developed countries. This arises not only from impacts on flora and fauna, but also concerns that irrigation developments may alter waterways for the worse, and bring unanticipated salinity and pest and disease problems. It is not as though there is an obligation for a nation to develop every hectare regardless of environmental and climatic conditions. Even in the most densely populated island of Indonesia, namely Java, the western tip of the island remains unpopulated due to its historical vulnerability to tsunamis.

We can reflect that in the half a century since economists debated the merits of the Ord River scheme, mining as a share of GDP in Australia has increased four-fold while agriculture as a share of GDP has fallen to one quarter of what it was then (Maddock and McLean 1987; ABS 2013). It follows that in that time, mining has played a larger role in providing jobs and income for remote communities than farming. Maybe this is misleading, as mining may be at a historical peak that will never again be matched. And agriculture may indeed make a comeback as global market conditions change.

Whereas agricultural economists have consistently argued for higher R&D funding, citing high social returns from R&D investments (Mullen and Cox 1995; Alston *et al*. 2000; Mullen 2007), it is difficult to find support for irrigation developments in the north under present circumstances. There is little evidence that previous irrigation schemes have provided local jobs or made a substantial contribution to regional development. Kununurra on the Ord River comes closest to being a town created and sustained by a remote irrigation scheme, but its growth in the past few decades appears to have relied more on tourism and mining than agriculture.

Maybe, in another half a century, neither irrigation schemes nor mining will be regarded as substantial economic drivers in remote regions. Tourism may continue to grow. One battle ground of recent Federal elections, a national broadband scheme or some technological successor, may grow in importance as a means of lowering the costs of service delivery to remote regions. Perhaps technological advances will do more than ambitious irrigation schemes to alleviate but not eliminate the tyranny of distance in remote regions.

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