Agricultural Land Retirement for Biodiversity: The Australian Wool Industry*

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Abstract

In this paper we use a Computable General Equilibrium (CGE) model to examine the economic implications of agricultural land retirement from wool production for biodiversity in Australia. Our CGE model incorporates specific-factors in production to generate short-run and long-run results. We show that the potential welfare gains from the agricultural land retirement policy are significant. The magnitude of these gains depends on the assumed elasticity of demand for wool, the temporal specification of the model, and the degree of slippage that occurs. However, the welfare gains result from a positive terms-of-trade effect. We discuss the implications of this result for land retirement in light of the WTO rules concerning the entry of policy into the Green Box.

J.E.L. Classification Codes: C68, Q21, Q24

Keywords: land retirement, wool, slippage, specific-factors

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1 Introduction

The Australian government has a stated objective of ensuring that a comprehensive, adequate and represented system of protected areas that contain samples of all regional ecosystems be established. To ensure that this objective is met the National Reserve System Program was introduced. Between 1996 and 2001 this program received $85 million (Australian) to support the purchase of land for inclusion in the National Reserve System (NRS). However, recent changes to the allocation of the environmental budget significantly reduce the funding made available for acquiring land to enter into the NRS (Commonwealth of Australia, 2002). These budgetary changes raise important questions regarding the ability of government in Australia to meet NRS objectives.

In previous research Hone et al. (1999) and Fraser and Hone (2001) have argued that agricultural land retirement offers a means by which to achieve NRS objectives cost effectively. They draw a comparison between the imposition of an optimal export tax on wool and agricultural land retirement from wool production. This line of reasoning is as follows. Australian wool accounts for almost three quarters of all world wool production. Assuming that Australia has a degree of market power as a result of its large share of production, it follows that an export tax on wool would yield welfare gains for Australia as a result of a positive terms-of-trade effect. Agricultural land retirement is also a form of supply restriction and as such reducing the land area devoted to the production of wool would yield a positive terms-of-trade effect.

The comparison between an optimal export tax and a land retirement option arises because much of the land currently used in the production of wool is under-represented in the NRS. This is particularly the case in the Pastoral zone in Australia which contains many ecologically significant ecosystems providing habitat that support rare and endangered native wildlife (ANZECC and ARMCANZ, 1999). In our model we are able to focus on agricultural land retirement in the Pastoral zone because production is disaggregated into the three main agricultural zones: Pastoral, Wheat-Sheep and the High Rainfall. Also the broad policy implications are of direct relevance to land retirement policies used in the U.S. (Conservation Reserve Program) and the E.U. (Set-Asides).

This paper makes several contributions to the literature on the economic evaluation of land retirement. First, by employing a Computable General Equilibrium (CGE) model, we can extend the ideas and results presented in Hone et al. (1999) and Fraser and Hone (2001) which employed partial equilibrium models to derive welfare estimates. Hertel (1993) and Peterson et al. (1994) provide strong arguments in favour of employing CGE models when undertaking policy analysis. Our welfare estimates can be considered as lower bounds because we do not explicitly include non-market estimates for biodiversity. Instead we take it as given that these estimates are significant as indicated by non-market valuation studies in Australia (e.g., Rolfe et al., 2000).

Second, by employing an innovative specific-factors representation of wool production we are able to examine differences between the short- and long-run results. As we show there are significant differences in the results generated. For example, our welfare estimates differ significantly between long- and short-run as do the effects of slippage resulting from the land retirement policy.

Third, the CGE model and dataset we employ allows us to consider regional effects of various alternative forms of land retirement policy. This is important given the different regional responses in previous studies of land retirement (e.g., Wu, 2000). The regional aggregation also allows us to model alternative assumptions regarding multi-commodity production.

Fourth, we quantify the degree of slippage from the introduction of the land retirement policy. These results add to a small but important literature in agricultural policy design and implementation. Because of the industry and commodity disaggregation in the CGE model, we are also able to examine: (i) slippage due to substitution of labour and capital for retired land, (ii) slippage due to substitution of land used in production of commodities other than wool, and (iii) slippage due to changes in the world price of wool.

Finally, our analysis draws attention to the interpretation of the criteria used to assess the trade impact of agricultural policy to be allowed into the Green Box. We argue that the Green Box criteria are too simple and that greater use should be made of policy specific conditions.

The paper is organized as follows. In Section 2 we begin by briefly describing the wool industry in Australia, and explain why it is reasonable to assume that some degree of market power exists. In Section 3 we review the existing literature that has examined agricultural land retirement. The literature we consider includes policies such as EU Set-Aside which is entirely supply-restriction oriented, as well the US Conservation Reserve Program (CRP) which has a dual focus of resource management and supply restriction. In Section 4 we describe the CGE model and dataset used, including a description of the industry and commodity aggregations and relevant model parameters. In Section 5 we describe results. There are a number of important policy implications stemming from our results and we examine these in Section 6. Finally, concluding comments are presented in Section 7.

2 The Australian Wool Industry

The production of wool in Australia is undertaken in three zones - Pastoral, Wheat-Sheep and High Rainfall. The Pastoral zone covers the arid and semi-arid parts of central Australia where wool is the main form of output. The Wheat-Sheep zone includes central NSW and southern western Queensland. This region is the main dry land cropping area as well as being an important beef production area. Thus, when primary commodity prices fluctuate it is common to observe changes in the mix of outputs in this region. The High Rainfall zone contains farms that generally run cattle in combination with sheep. The sheep are used to produce both wool and prime lambs.

While there are significant climatic variations between the zones, the type of wool produced is relatively homogeneous. ABARE farm survey data between 1992-93 and 2000-01 indicates that the average micron size of wool sold in all zones was between 21 and 23.[1] In terms of the quantity of wool produced in 1999-2000 the average kg per farm was 18,497 in the Pastoral zone, 7,191 in the Wheat-Sheep zone and 6,365 in the High Rainfall zone. Despite these differences in farm production the average cut per sheep is very similar in all zones, roughly four kg greasy.

Some 98% of raw and semi-processed wool produced in Australia is exported (Ashton et al. 2000). 64% is exported in greasy form while the remainder is subject to relatively low value adding. Australia exported $3.9 billion dollars worth of wool in 2001 (ABARE, 2001). In 2000-01 Australian exports accounted for 74% of world raw wool exports. The next largest producer was New Zealand with 15% (ABARE, 2001a). However, wool can be considered a differentiated product in terms of its potential uses in production. Beare and Zwart (1990) observe that the physical characteristics (i.e., micron size) of wool are important in determining end use. New Zealand wool is coarse and is used in non-apparel production. Australian wool is much finer and is used in apparel production. Thus, Australian and New Zealand wools can be considered different products providing further support for the argument that Australian could exert some market power.

3 Agricultural Land Retirement

The economics literature on agricultural land retirement is diverse. This is because agricultural land retirement is employed in a diverse set of policies e.g., Set-Aside in the

[1]Summary information from ABARE can be accessed via AgSurf at the ABARE website.

EU, the Conservation Reserve Program (CRP) in the US. Within this literature two key issues have emerged: First, the magnitude of benefits resulting from the introduction of a land retirement policy, and second, the potential reduction in benefits as a result of slippage.

3.1 Benefits of Land Retirement

The benefits resulting from land retirement policies are well documented in the literature. For example, Ribaudo et al. (1994) estimated the benefits that would arise when a land retirement policy was used as a means to reduce agricultural non-point source pollution. They employed the US Agricultural Resource Model, a static mathematical programming model, to simulate various land retirement scenarios. This model assumed that demand for output is negatively sloped, output prices are endogenous, and that all agricultural production is consumed within the US. The structure of this model meant that the various land retirement scenarios yielded a net reduction in consumer-plus-producer surplus. Only when the non-market benefits of land retirement (i.e., reduced soil erosion, water quality, wildlife habitat) were included did net benefits become positive.

Another example is the literature directly related to our paper is Fraser and Hone (2001). They examined the potential benefits of retiring agricultural land in the Pastoral zone of Australia for biodiversity employing a simple partial equilibrium model. Fraser and Hone found that for various estimates of the elasticity of demand for Australian wool (between 0.5 and 1.5), a 10% reduction in land devoted to wool production in the Pastoral zone yielded increased industry profits of between $7 and 17 million Australian per annum. Implicit in these results is the fact that as Australians consume virtually no wool, the reduction in consumer surplus from a price increase is zero.

3.2 Slippage

There are several reasons to be skeptical regarding the magnitude of many of the benefit estimates in the literature. As Wu (2000) argues land retirement policies such as the CRP are frequently subject to problems of slippage which reduce the size of the benefits generated. In the case of the CRP Wu estimates that existing benefit estimates need to be reduced by at least 10% to take account of slippage effects.

Slippage can be defined as follows:

$$\text{slippage} = 100 * \left[\frac{\%\text{ reduction in land use} - \%\text{ reduction in production}}{\%\text{ reduction in land use}}\right]$$

So for example, if a 10% land retirement scheme is introduced and we only see a 4% reduction in output, this indicates 60% slippage.

In the literature various reasons for slippage have been advanced. Hoag et al. (1993) identify three sources of slippage. First, a farmer may be able to obtain productivity gains on the land that is not taken out of production because of the allocation of fixed resources such as labour. Second, a farmer may wish to intensify production because of the incentives he now faces. The change in incentives occurs because most land retirement schemes offer financial incentives to induce participation. Third, there may be land-quality slippage, due to the fact that the farmer will initially retire the least productive land from production. Hoag et al. identify two ways in which this can occur: Either at the individual farm level or at the regional level where there are differences in participation rates.

Wu (2000) provides a slightly different justification for the existence of slippage. He identifies two sources: An output price effect and an input substitution effect. The output price effect can lead to slippage as the reduction in output associated with the given level of land retirement causes a supply shortage which leads to an increase in the output price. This increase in the output price gives an incentive to farmers to decrease output by less than the amount of land retirement. The input substitution effect contributes to slippage since other inputs in variable supply can be substituted for the land being retired, again implying that output will fall by less than the amount of land retirement. Wu's sources encompass those identified by Hoag et al.

Part of the theoretical literature has identified heterogeneous land quality as an important source of slippage for research. For example, Rygnestad and Fraser (1996) have examined how set-aside in the EU may be subject to slippage as a result of land heterogeneity. Fraser (2001) models how slippage that results from land heterogeneity can be minimized using a principal-agent model.

Another facet of the theoretical literature considers how to design policy to minimize the effects of slippage. Wu et al. (2001) examine how the design of policy to achieve environmental protection and resource conservation needs to take account of the effects of policy slippage. Specifically, when the demand for a commodity affected by the land retirement policy is not perfectly elastic it is necessary to consider the general equilibrium effects of endogenous price changes. They demonstrate that as a result of the existence of slippage, environmental policy needs to carefully design the objectives of policy implementation.

The applied literature has attempted to quantify the extent and form of slippage.

Hoag et al. (1993) measure land-quality slippage at the farm level, a topic that has been the subject of much theoretical research. They found that slippage does occur but that the "worst-land-out-first" scenario is far less important than the emphasis placed upon it by many researchers. In fact the most important source of slippage according to Hoag et al. are interregional differences in participation. As a result they argue that land retirement policy needs to offer incentives that take account of regional differences so that potential policy slippage can be minimized.

In a study of land retirement in the US under the CRP Wu (2000) finds that there are regional differences in the degree of slippage and that the potential net benefits of the CRP are lower than claimed in previous research. He found that for every 100 acres of land retired, twenty acres of non-cropland is converted. So there is a change in the mix of agricultural production as a result of slippage. An interesting aspect of this study is that because of its cross-sectional nature Wu argues that he only captures the input substitution effects and not the output price effects of land retirement, and as a result underestimates the magnitude of slippage. The input substitution effects are assumed to capture the conversion of non-cropland into cropland, thereby reducing the actual area of land retired from production.

4 General Equilibrium Model

In this section we describe the model we employ to conduct our analysis of the the land retirement policy. We begin by describing the data we use. Next we describe the production and then consumption parts of the model. We also explain detail how we model specific factors and the importance of multi-commodity industries to the results generated.

4.1 Data

The data set we use is an aggregated version of the Monash model, described in Dixon and Rimmer (2002). The Monash model is a dynamic GE model of Australian production and trade, disaggregated to 113 industries and 117 commodities. We are primarily interested in the agriculture sector, especially those industries involved with wool production and usage, we aggregate industries and commodities associated with mining (6 industries and commodities), processed foods (12 industries and commodities), manufactures (44 industries and commodities), and services (30 industries and commodities) to reduce the dimensionality of the model.[2] The Monash model also contains information about levels and rates of return on investment by industry and commodity. Since we are interested in comparative static experiments, we employ a static GE model, using data for 1994, and treat all investment activity as exogenous. The model is solved using GAMS/MPSGE, described in Rutherford (1998).

Before describing the structure of production, we note that wool resporesent only a small portion of total production in Australia, and as such we can anticipate that the overall welfare effects of any land retirement policy will be small.

4.2 Production Sector

4.2.1 Factors of Production

Commodities are produced using three primary factors (land, labour, and capital) and intermediate inputs. The primary factors are assumed to be internationally immobile and fully employed in Australia in equilibrium. Land is only used in the production of primary agricultural commodities, and is treated as factor-specific to these industries.

Typically, short-run and long-run responses to comparative static experiments with CGE models are generated by benchmarking the model to different Armington trade elasticities. The Armington elasticities measures the degree of substitutability between domestic and imported goods. Smaller values are presumed in the short-run, and larger values in the long-run.

In this paper we use a specific-factors approach to contrast short-run and long-run comparative statics results. The use of the specific-factors approach to represent differences between long- and short-run results is not uncommon in the literature (e.g., Mayer, 1974, Mussa, 1974 and Schweinberger, 2002). There is also empirical evidence highlighting the importance of specific-factors in production (e.g., Grossman and Levinsohn, 1989 and Hiscox, 2002).

We model specific-factors in a manner different to that generally employed in the literature. We take as the motivation for our model the observations of Bhagwati and Srinivasan (1983), who note that the all-factors-specific model (Haberler, 1950) and the one-specific-factor model (Jones, 1971) are special cases. The approach we adopt is to consider a particular share of labour and capital to be specific in the short-run. We then

[2]The industry and commodity aggregations are available from the authors on request. The complete concordance between the industry and commodity classifications in the Monash model and those used in this paper are reported in the Appendix, available from `http://www.business.latrobe.edu.au/staffhp/rwhp/research.htm`. A more detailed description of each of the Monash industries and commodities is available from the Centre of Policy Studies web page at `http://www.monash.edu.au/policy/techdoc.htm`.

reduce this share to zero to arrive at our long-run specification which is equivalent to the Heckscher-Ohlin model. Formally, we assume that a share λ_i of capital and labour used for production in industry i is specific, while the remainder, $1 - \lambda_i$, is mobile. In the long-run, $\lambda_i \to 0$, but, in the short-run, industries face production costs which they treat as sunk. In the short-run we set λ_i equal to 25% for both capital and labour. We present results which show what happens if λ_i is less than 25%. It is also clear from our analysis what are the implications if λ_i is greater than 25%.

As indicated, our approach to modelling specific-factors is different to that generally employed in the CGE literature. For example, Warr (2001) and Dufournaud et al. (2000) assume that land is specific to agriculture. However, they also model capital as an industry-specific fixed factor. This implies that changes in relative prices will not result in a reallocation of this specific factor in the short-run. As a result both argue that their comparative statics relate to the medium term - two to four years. We view this as being too restrictive, especially as we wish to use the specific factors structure to model temporal comparative statics.

Blake et al. (1999) take an approach similar to that employed here by assuming that 50% of all factors used in production are specific. All factors in this case include land which we assume is a fixed factor. However, we agree with sentiments expressed by Blake et al. who argue that their approach yields a model that better reflects reality. Interestingly, although they compare results for their specific-factors specification to a scenario in which all factors, including land, are freely mobile between sectors, they do not make any observations regarding the temporal dimension of these results. Also it is unusual to model land as a mobile factor in the long-run in as much as it is normally assumed to be specific to agriculture at all times.

4.2.2 Production Function

For each industry i, commodities (y_i) are produced using intermediate inputs from sector j (x_{ij}) and primary inputs: land (H_i), labour (L_i), and capital (K_i). We assume that production technology displays constant returns to scale, and is represented by nested CES production functions of the form:

$$y_i = \left[\sum_j \delta_j x_{ij}^{\frac{\rho_i - 1}{\rho_i}} + \delta_{VA} VA_i^{\frac{\rho_i - 1}{\rho_i}} \right]^{\frac{\rho_i}{\rho_i - 1}} \qquad (1)$$

$$\text{where} \quad VA_i = \left[\alpha_L L_i^{\frac{\gamma_i - 1}{\gamma_i}} + \alpha_K K_i^{\frac{\gamma_i - 1}{\gamma_i}} + \alpha_{\bar{H}} \overline{H}_i^{\frac{\gamma_i - 1}{\gamma_i}} + \alpha_{\bar{L}} \overline{L}_i^{\frac{\gamma_i - 1}{\gamma_i}} + \alpha_{\bar{K}} \overline{K}_i^{\frac{\gamma_i - 1}{\gamma_i}} \right]^{\frac{\gamma_i}{\gamma_i - 1}} \qquad (2)$$

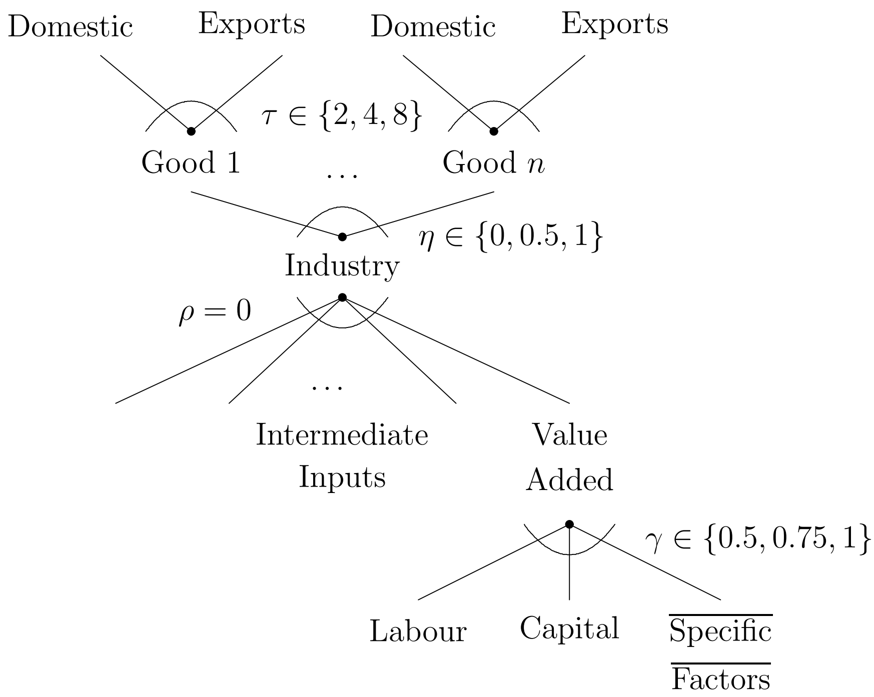

Figure 1: Structure of Production of Output

where x_{ij} is the amount of good j used in production of good i and a $^{-}$ denotes usage of specific factors. In non-wool producing industries the elasticity of substitution between primary inputs γ_i is set equal to unity. For wool production we set γ_i equal to 0.75. This value is consistent with the CGE literature (Adams, 1987, Dufournaud et al., 2000, and Warr, 2001) and estimates generated by econometric research of wool production in Australia (e.g., Wall and Fisher, 1987). Given the potential importance of this parameter in the model we undertake sensitivity analysis on this parameter such that we allow it to take the values $\gamma_i \in \{0.5, 0.75, 1\}$.

All intermediate inputs x_{ij} and the aggregate value added VA_i are combined using fixed-coefficients production technology, so $\rho_i \rightarrow 0 \; \forall \; i$. The structure of production employed in the model is shown in Figure 1. The top nest shows how output of any commodity is either exported or consumed within Australia, according to the transformation elasticity τ. We employ a central case value of $\tau = 4$, and conduct sensitivity analysis allowing it to take values $\tau \in (2, 4, 8)$. Finally, we assume all markets are perfectly competitive, with free entry and exit of firms, so economic profits are equal to zero in all industries in equilibrium. Producers take all output and input prices as given, and these are all normalized to unity in the initial equilibrium.

Commodity	Pastoral	Wheat Sheep	High Rain	Northern Beef	Milk Cattle	Cane, Fruit, Nuts	Other Farming
	Commodity, by Industry						
Wool	15.9	50.0	34.1	0.0	0.0	0.0	0.0
Sheep	6.5	56.6	36.9	0.0	0.0	0.0	0.0
Wheat	4.0	94.1	1.9	0.0	0.0	0.0	0.0
Barley	3.1	85.7	11.3	0.0	0.0	0.0	0.0
Other Grains	2.4	75.2	22.4	0.0	0.0	0.0	0.0
Meat Cattle	8.4	33.4	27.3	24.2	6.7	0.0	0.0
Milk Cattle	0.1	6.9	2.4	0.0	90.6	0.0	0.0
Cane, Fruit, Nuts	0.0	0.3	0.5	0.0	0.0	99.2	0.0
Other Farming	1.2	4.1	5.6	0.0	0.0	0.0	89.1
	Industry, by Commodity						
Wool	43.8	19.8	31.9	0.0	0.0	0.0	0.0
Sheep	4.6	5.7	8.8	0.0	0.0	0.0	0.0
Wheat	8.1	27.2	1.3	0.0	0.0	0.0	0.0
Barley	3.0	11.9	3.7	0.0	0.0	0.0	0.0
Other Grains	2.6	11.3	7.9	0.0	0.0	0.0	0.0
Meat Cattle	33.7	19.3	37.3	100.0	10.7	0.0	0.0
Milk Cattle	0.2	2.5	2.1	0.0	89.3	0.0	0.0
Cane, Fruit, Nuts	0.0	0.1	0.3	0.0	0.0	100.0	0.0
Other Farming	4.1	2.1	6.8	0.0	0.0	0.0	100.0

Table 1: Production of multi-commodity industries (%)

4.3 Multi-Commodity Industries

An important feature of the Monash model is that it reflects multi-commodity production by primary agricultural industries. For example, the commodity Wool is produced by three distinct industries or zones: Pastoral; Wheat-Sheep; and High Rainfall. These industries produce different commodities such as wool, sheep, wheat, barley, and other primary agricultural commodities. The upper part of Table 1 gives the share of production of each primary commodity by industry, while the lower part shows the share of production of each industry, by commodity. For example, the Pastoral zone produces 15.9% of wool in Australia by value, and wool accounts for 43.8% of total production (by value) in this zone. Multi-commodity production in these industries is reflected by the nest immediately above each industry in Figure 1. Output can be transformed into different commodities according to the transformation elasticity $\eta \in (0, 0.5, 1)$.

In order to avoid unrealistic output responses in production of agricultural commodities (especially wool), and to ensure that our model specification is consistent with prevailing institutional features, we modify the multi-commodity production structure as follows. In the Pastoral zone we model wool as a separate production activity, because wool produced in this region is typically produced on farms that are on leasehold land. The leases only allow for the production of wool from running sheep (Productivity Commission, 2002).

In the Wheat-Sheep and High Rainfall zones, wool is frequently produced as part of a multi input-output system. That is, sheep and hence wool are part of a system that includes broadacre crops normally farmed in some sort of rotation. This characteristic of the production system is useful, as it allows us to identify how different specifications of production systems contribute to slippage when we consider the effects of a land retirement policy across all wool producing zones.[3] In particular we consider two versions of the 10% land retirement policy across all wool producing zones. First, land which is used to produce agricultural commodities (see Table 1) other than wool cannot be substituted for land retired from wool production. Second, producers in the Wheat-Sheep and High Rainfall zones can take land out of wheat production, for example, and use this land to substitute for the land retired from wool production.

4.4 Final Consumption and Trade

Final goods are consumed by industry as intermediate inputs, and by the public and private sector. To simplify the analysis, we aggregate together the public and private sectors, and assume the existence of a single representative consumer who owns all primary factors of production, and supplies all land, labour and capital to the production sector. The representative consumer maximizes utility represented by a Cobb-Douglas utility function:

$$U = \prod_i z_i^{\theta_i} \quad \forall\, i, \quad \sum_i \theta_i = 1, \tag{3}$$

where z_i is consumption of commodity i by the representative consumer in Australia. Because we employ a Cobb-Douglas utility function the elasticity of substitution in consumption is equal to one.

In the Monash model, Australia produces, imports and exports all goods, so there is cross-hauling in all goods. Trade must be balanced, so in equilibrium, Australia's exports of each commodity must equal total imports from Australia by the rest of the

[3] We are able to consider the input substitution effect. In our model this derives from the substitution of labour and capital for retired land. This is different to the substitution effect identified in Wu (2000) because in our model land is exogenous whereas Wu models land as endogenous.

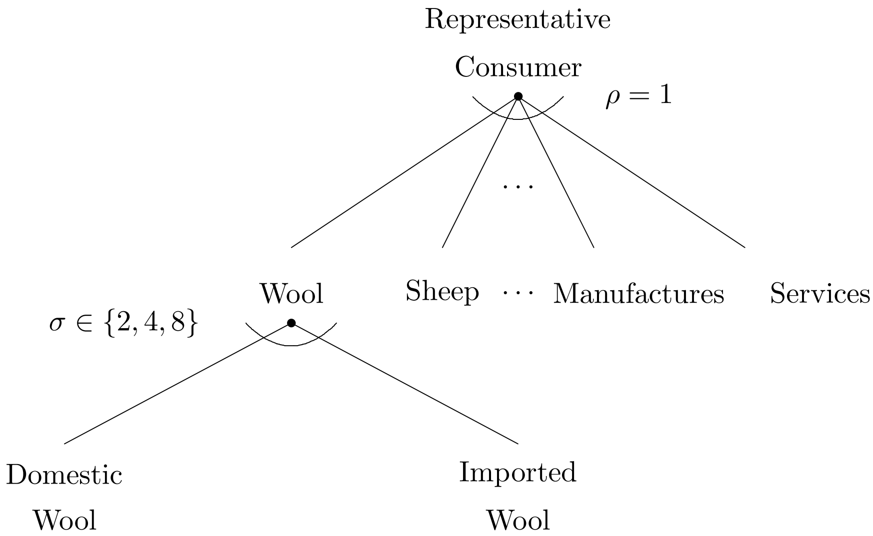

Figure 2: Structure of Consumption in the BEDS

world (ROW). Trade is accommodated using the so-called Armington assumption. The same goods produced in Australia and imported from the ROW are imperfect substitutes for one another.

$$z_i = \left[\gamma_d y_i^{\frac{\sigma_i - 1}{\sigma_i}} + \gamma_f m_i^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}} \qquad \forall\ i, \tag{4}$$

where m_i are imports of commodity i. The central case value for the substitution elasticity between domestic and imported goods is set at $\sigma_i = 4$, implying that Australia's (uncompensated) elasticity of demand for imports is approximately equal to 4.[4] We conduct sensitivity analysis around this parameter, allowing it to take values $\sigma \in (2, 4, 8)$. This Armington function is illustrated in the lower part of Figure 2 for wool, with a corresponding description of the structure of consumption goods applying for all other goods.

Finally, Australian exports are consumed by the rest-of-the-world, which is presumed to have an infinitely elastic demand for all Australian exports except wool. As Australian wool accounts for a large share of world trade, we presume that Australia has some amount of market power. Thus, we benchmark the model to an elasticity of demand for wool which is finite. Haszler et al. (1996) provide a summary of empirical evidence of the own price demand elasticity for wool. In the short-run many estimates are inelastic, frequently less than -0.5. In the long-run there are estimates in excess of

[4]See Mansur and Whalley (1984) p.106-7, for a description of the relationship between domestic/import substitution elasticities and the (uncompensated) import demand elasticity.

-1.5. The estimates reported in the literature have lead researchers to assume that the own price demand elasticity for Australian wool is -1. However, in the trade literature it is frequently argued that estimates of export demand elasticities are biased toward -1 (see Athukorala and Riedel, 1991). For this reason many CGE modellers argue for elasticity values greater than those in the econometric literature. For example, Warr (2001) argues that long-run export demand elasticities for Thai rice are at best only lower bound estimates. Therefore, given the evidence on own price demand elasticities of wool we employ a range of estimates in our analysis. We assume a lower bound of $\epsilon = -1.5$ and an upper bound of $\epsilon = -4.5$. By noting how the results of a given land retirement policy differ for different values of the export demand elasticity for Australian wool ϵ, we can highlight the importance of the output price effect on slippage, since smaller values of ϵ will result in larger changes in the output price of wool.

5 Results

We present results for two agricultural land retirement policies: A 10% reduction in land devoted to wool production in the Pastoral zone and a 10% reduction in all agricultural zones. Our results focus on the impacts on terms-of-trade, welfare and output of wool and other agricultural commodities.

5.1 10% Land Retirement: Pastoral Zone Only

To begin with, we suppose that 10% of the land used to produce wool in the Pastoral zone is retired. The terms-of-trade effects of this policy scenario are illustrated in Figure 3. The real exchange rate measures the real price of imports relative to the real price of exports, so in the short-run (when the multiplier on specific factors is 1), the land retirement policy has a positive effect on Australia's terms-of-trade. This terms-of-trade effect is more favourable the less elastic is the export demand for Australian wool. Also note that in the long-run (as the multiplier on specific factors goes to 0), this positive terms-of-trade effect is relatively constant for the most inelastic specification of the export demand elasticity for Australian wool, but for larger values of ϵ, the terms-of-trade effect becomes less favourable in the long-run.

The corresponding welfare effects of the 10% reduction in land in the Pastoral zone are presented in Figure 4. Note that for all chosen values of the rest-of-world export demand elasticity for wool, this policy leads to an improvement in welfare. The welfare change is larger the more market power Australia has on world wool markets, and the

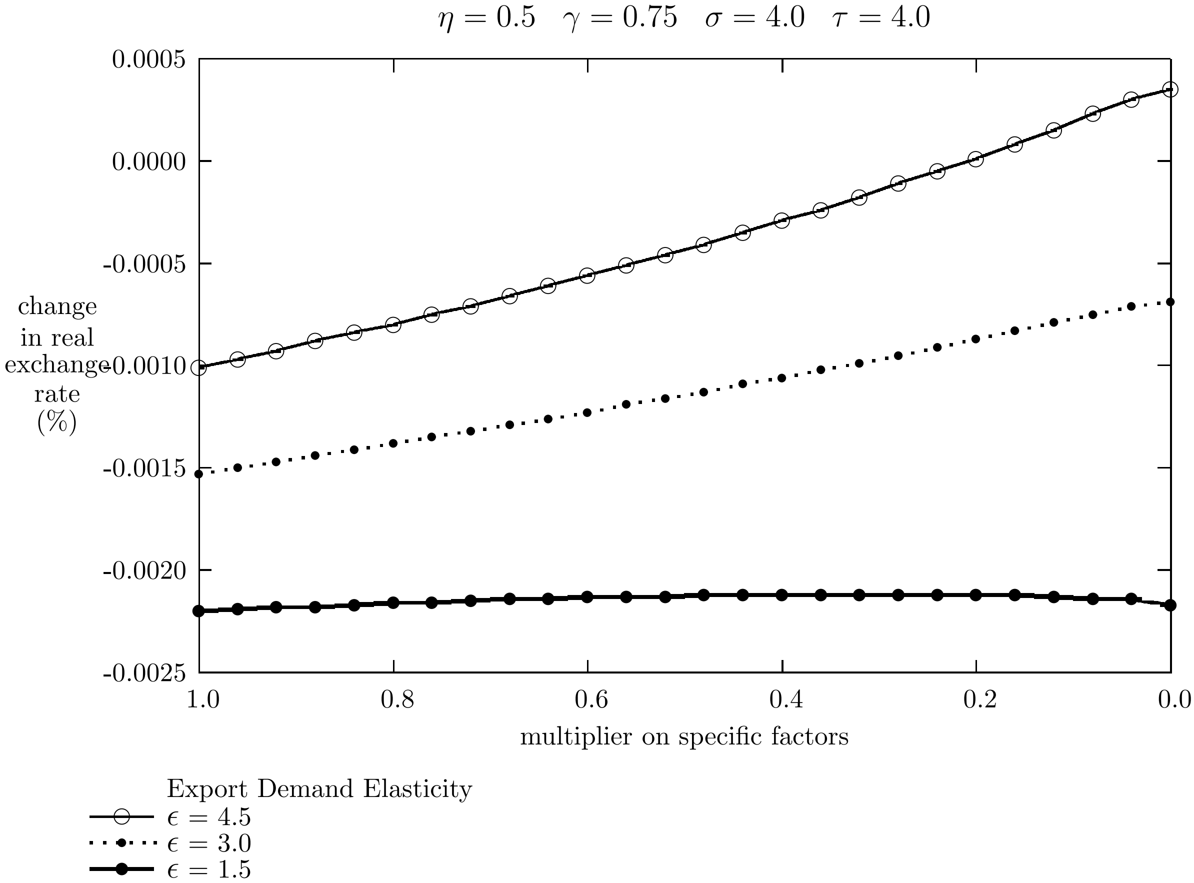

Figure 3: Terms-of-trade effects of a 10% land retirement scheme in the Pastoral zone

greater the degree of intersectoral factor mobility (i.e., in the long-run). The magnitude of the welfare gains are significantly different (between 3 and 4 times higher) depending on the degree of factor mobility. These welfare estimates are consistent with the estimates of Hone et al. (1999). While our long-run estimates are somewhat lower than those in Hone et al., this can be explained by the fact that they assumed an export demand elasticity between 0.5 and 1.5.[5] It is worth reiterating that these welfare results represent lower-bound welfare estimates, since the land which is retired is presumed to become completely unproductive. Of course, there may be some productive use of retired land, due to enhanced biodiversity, tourism, etc.

[5]The relevant comparison is between the results in Hone et al. and our long-run estimates because the partial equilibrium models used in Hone et al. implicitly assumes long-run behaviour with regard to resource allocation.

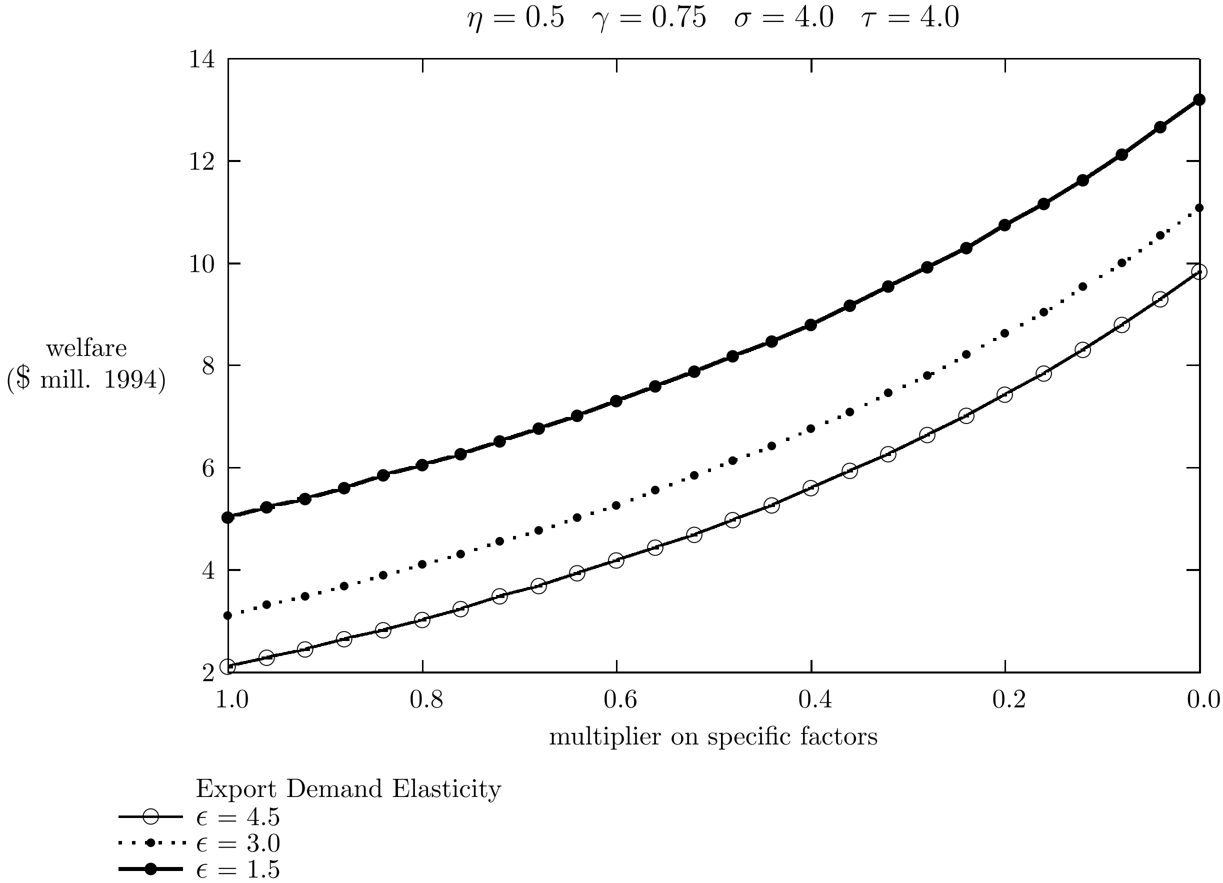

Figure 4: Welfare effects of a 10% land retirement scheme in the Pastoral zone

Slippage

To identify the extent of slippage due to the 10% land retirement policy in the Pastoral zone, we need to look at the change in the price of wool and the change in production of wool in the Pastoral zone, given in Figure 5.

The first-order effect of the land retirement policy is a decrease in wool production in the Pastoral zone. Because Australia has market power on world wool markets, this leads to an increase in the price of wool. As shown in the lower panel of Figure 5, this increase in the price of wool is greater the more inelastic is the demand for Australian wool, and is larger in the long-run. How this output price effect contributes to slippage is evident in the upper panel in Figure 5. Slippage in the Pastoral zone varies between 55.9% and 53.6% (4.41% and 4.64% reduction in wool production) in the short-run and 22.1% and 13.8% (7.79% and 8.62% reduction in wool production) in the long-run, depending on whether the export demand for Australia's wool is relatively elastic ($\epsilon = 4.5$) or relatively inelastic ($\epsilon = 1.5$), respectively. Not surprisingly, slippage is greater the more market

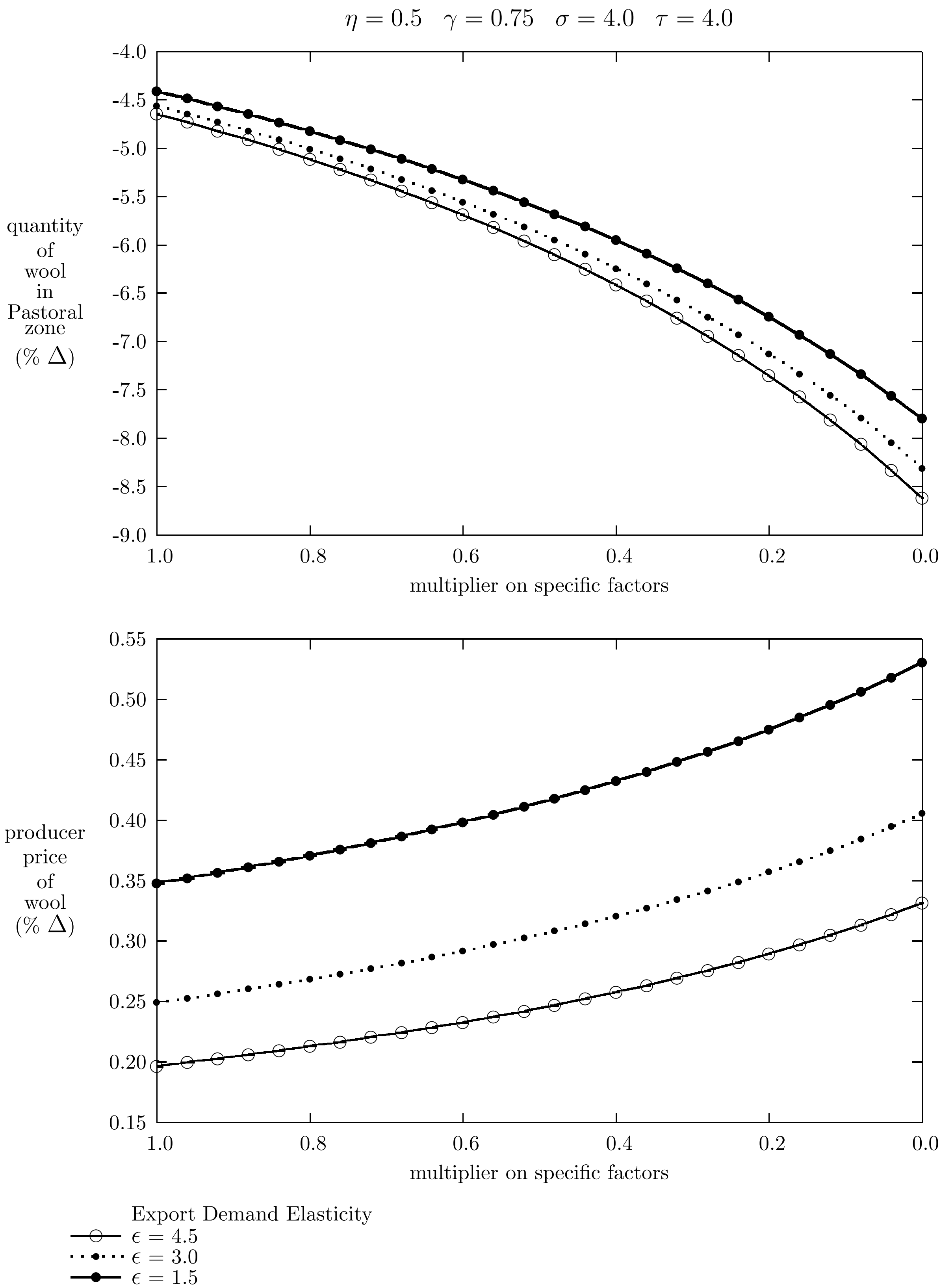

Figure 5: Effects of a 10% land retirement scheme in the Pastoral zone on production and price of wool

power Australia has on world wool markets. But the increase in intersectoral factor mobility has a more dramatic effect on slippage. In the short-run, the land retirement policy leads to a decrease in wool production, which decreases the productivity of the remaining specific factors in wool production. As factors become more mobile in the long-run, labour and capital which were specific to wool production will move to more productive uses, leading to larger decreases in wool production, so slippage is much smaller in the long-run when all labour and capital is mobile.

5.2 10% Land Retirement: All Wool-Producing Sectors

We now examine what happens when we extend the 10% land retirement policy beyond the Pastoral zone so that 10% of the land used to produce wool in all three wool producing zones is retired. As previously explained we examine two alternative model structures. We begin by assuming that wool is produced as part of a multi commodity system in the Wheat-Sheep and High Rainfall zones.

Figure 6 illustrates how Australia's terms-of-trade respond to this land retirement policy for different specifications of the export demand elasticity for Australian wool.

In all cases the real exchange rate depreciates, which is equivalent to a deterioration of Australia's terms-of-trade. The deterioration of the terms-of-trade is worse the more elastic is the demand for Australia's wool exports (the larger is the export demand elasticity for wool) and is worse in the long-run compared to the short-run. It is also worth noting that these terms-of-trade effects differ significantly from those in the previous experiment where land was retired only in the Pastoral zone. Instead of the small positive terms-of-trade effects in the previous experiment, we now see relatively large negative terms-of-trade effects. As a result, we would expect to see relatively larger and negative welfare effects from the 10% land retirement policy in all wool producing zones. These welfare effects are illustrated in Figure 7.

The reason why the first-order effects of the land retirement policy in all wool producing zones is significantly more negative is because much more land is now being retired. As shown in Table 1, the Pastoral zone accounts for only a small share (15.9%) of Australian wool production. In the initial equilibrium, the value of land retired in the Pastoral zone is \$6.15 million, while the value of land retired in the Wheat-Sheep and High Rainfall zones is \$30.54 and \$21.38 million, respectively.

However, to fully explain this decrease in welfare due to extension of the land retirement policy to all wool producing zones, we need to consider slippage effects of this

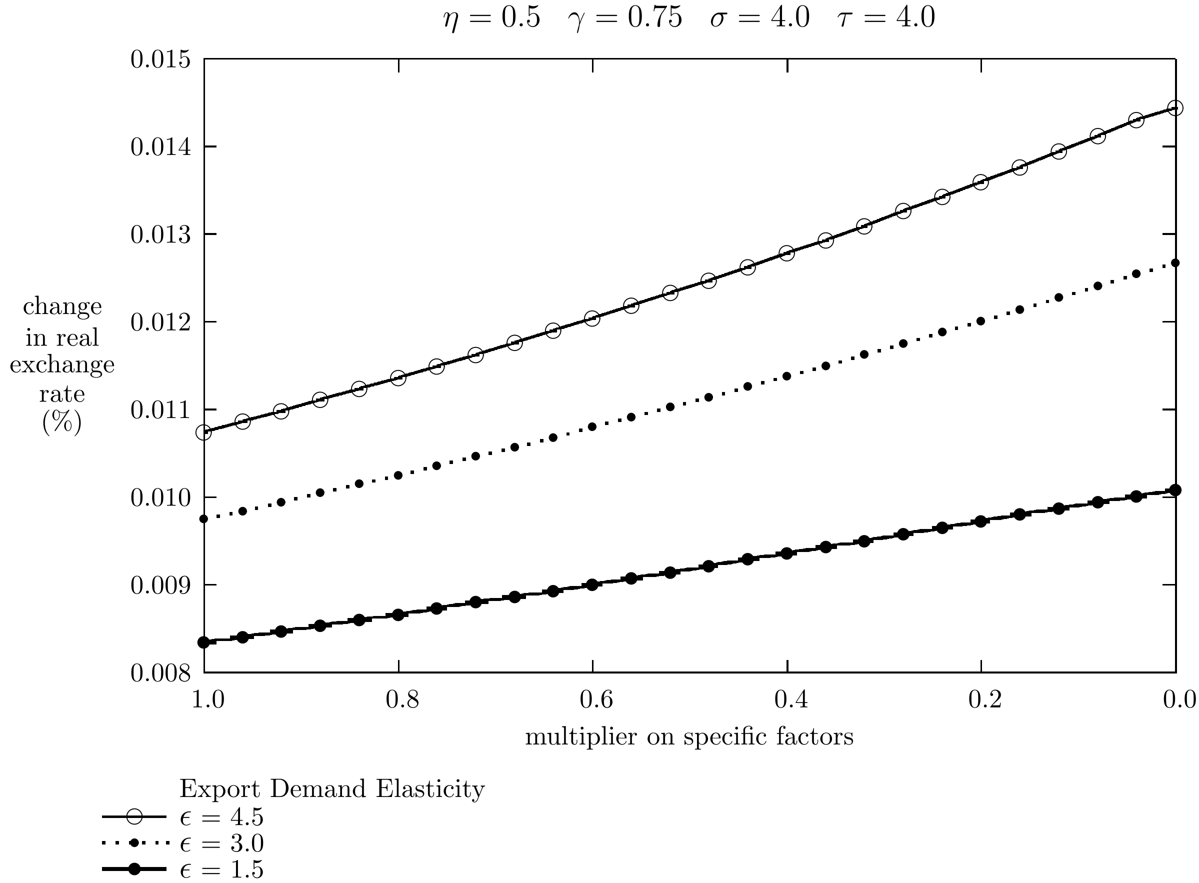

Figure 6: Terms-of-trade effects of a 10% land retirement scheme in all wool producing zones

land retirement policy. To this end, we examine the intermediate case where the export demand elasticity for Australian wool is set to $\epsilon = 3$, and isolate the input substitution effect on slippage. Figure 8 reports the overall welfare effects of the 10% land retirement policy when wool is produced as a separate commodity only in the Pastoral zone, but also shows the welfare effects of the land retirement policy when wool is produced as a separate commodity in all wool producing zones. In this latter case, land which was used to produce other agricultural commodities cannot be substituted for land retired from wool production in the Wheat-Sheep and High Rainfall zones.

When wool is produced as a separate commodity in all wool producing zones (hollow circles in Figure 8), producers in the Wheat-Sheep and High Rainfall zones cannot substitute land used to produce other agricultural commodities for land retired from wool production, so this line shows the welfare results of the 10% land retirement policy absent the input substitution effect. Clearly, including this input substitution effect (filled circles in Figure 8) leads to a significant reduction of welfare. To see how this input

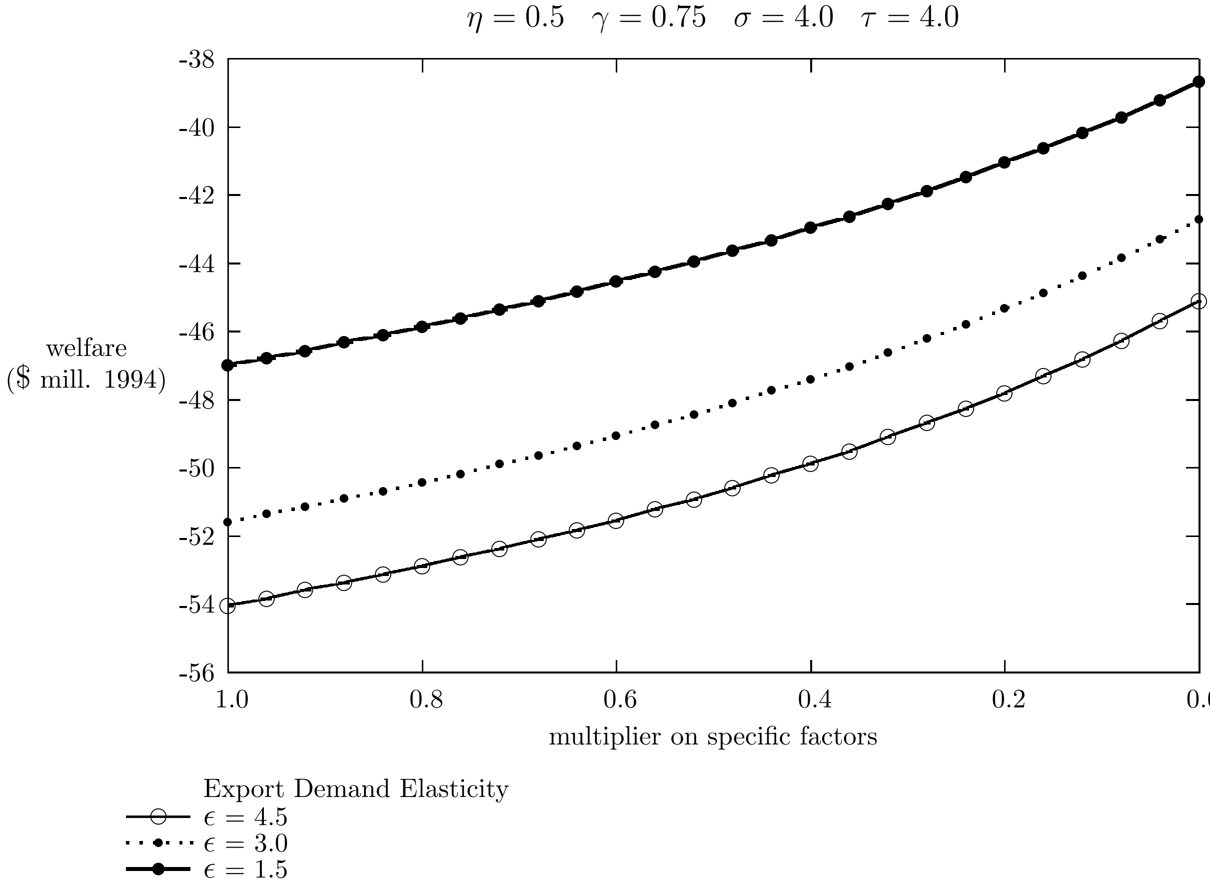

Figure 7: Welfare effects of a 10% land retirement scheme in all wool producing zones

substitution effect contributes to slippage, consider the effects of the land retirement policy on the price of wool and wool production by industry, illustrated in Figure 9.

When we ignore the input substitution effect, the land retirement policy leads to an increase in the price of wool (hollow circles in the bottom panel of Figure 9), which causes slippage of approximately 54% (45%) in the short-run (long-run) in the Wheat-Sheep (-4.68% change in wool production in short-run, -5.50% in the long-run) and High Rainfall zones (-4.48% in short-run, -5.44% in the long-run in High Rainfall). Slippage is much larger in the Pastoral zone, because wool accounts for a much larger share of production in the Pastoral zone (-2.00% change in wool production in short-run, -1.27% in the long-run).

When we include the input substitution effect in the Wheat-Sheep and High Rainfall zones, we get the full effect of the land retirement policy on wool production. Since the initial effect of the land retirement policy is an increase in the price of wool, producers in the Wheat-Sheep and High Rainfall zones have an incentive to switch land used

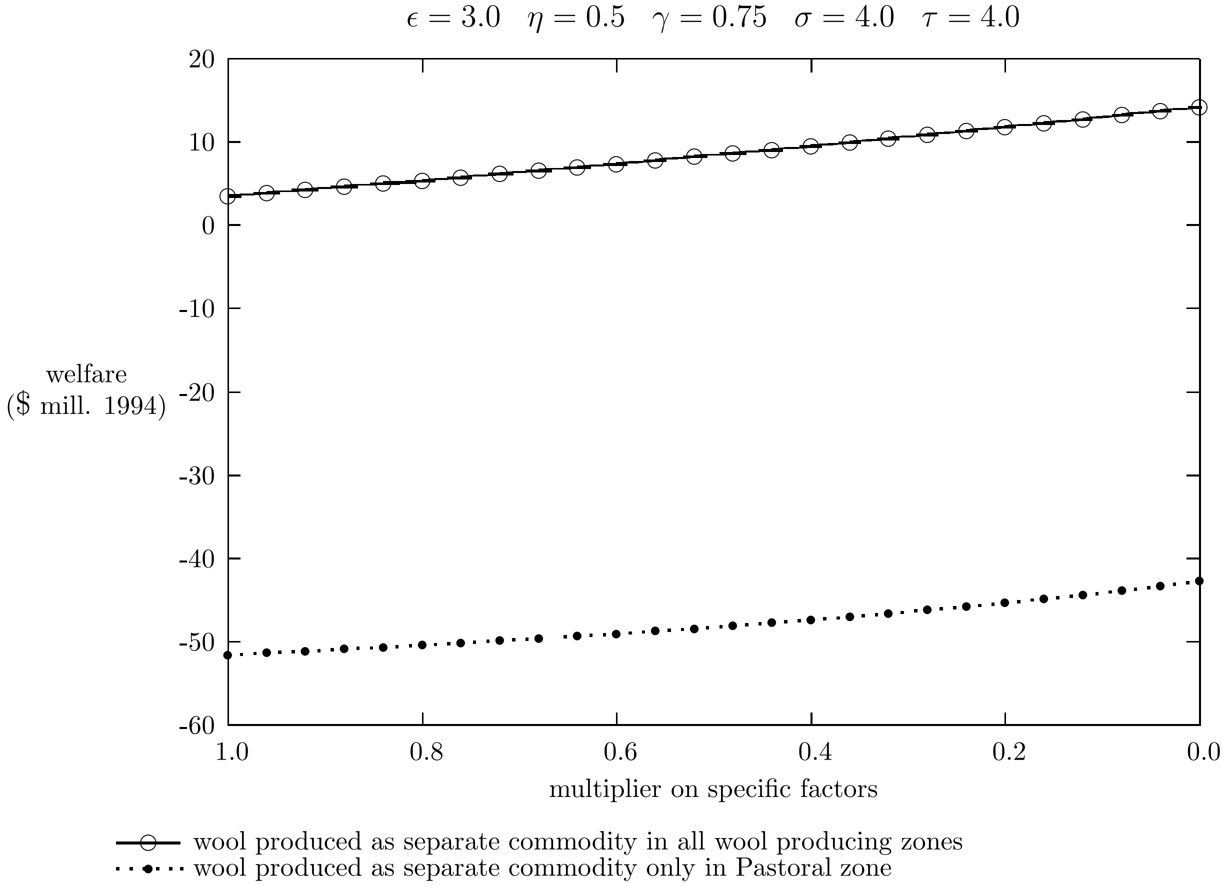

Figure 8: Welfare effects of a 10% land retirement scheme in all wool producing zones

to produce other agricultural commodities into wool production. This leads to a large increase in slippage in these two zones, to 94% in the Wheat-Sheep zone (-0.62% average change in production) and 86% in the High Rainfall zones (-1.35% average change in production). These smaller decreases in wool production by the two large wool producing zones in Australia cause the price of wool to rise by a much smaller extent in equilibrium (filled circles in the bottom panel of Figure 9), so that slippage in the Pastoral zone is much smaller (60% (-3.98% change in production) in the short-run and 34% (-6.65% change in production) in the long-run).

The implication of this analysis is that a 10% land retirement policy in all wool producing zones produce greater increases in welfare if the input substitution effect can be effectively avoided. If producers in the Wheat-Sheep and High Rainfall zones have the ability to substitute land used to produce other agricultural commodities for land retired from wool production, the slippage effects in these zones will result in a welfare loss of $40-50 million. However, if the land retirement policy can be constructed to effectively

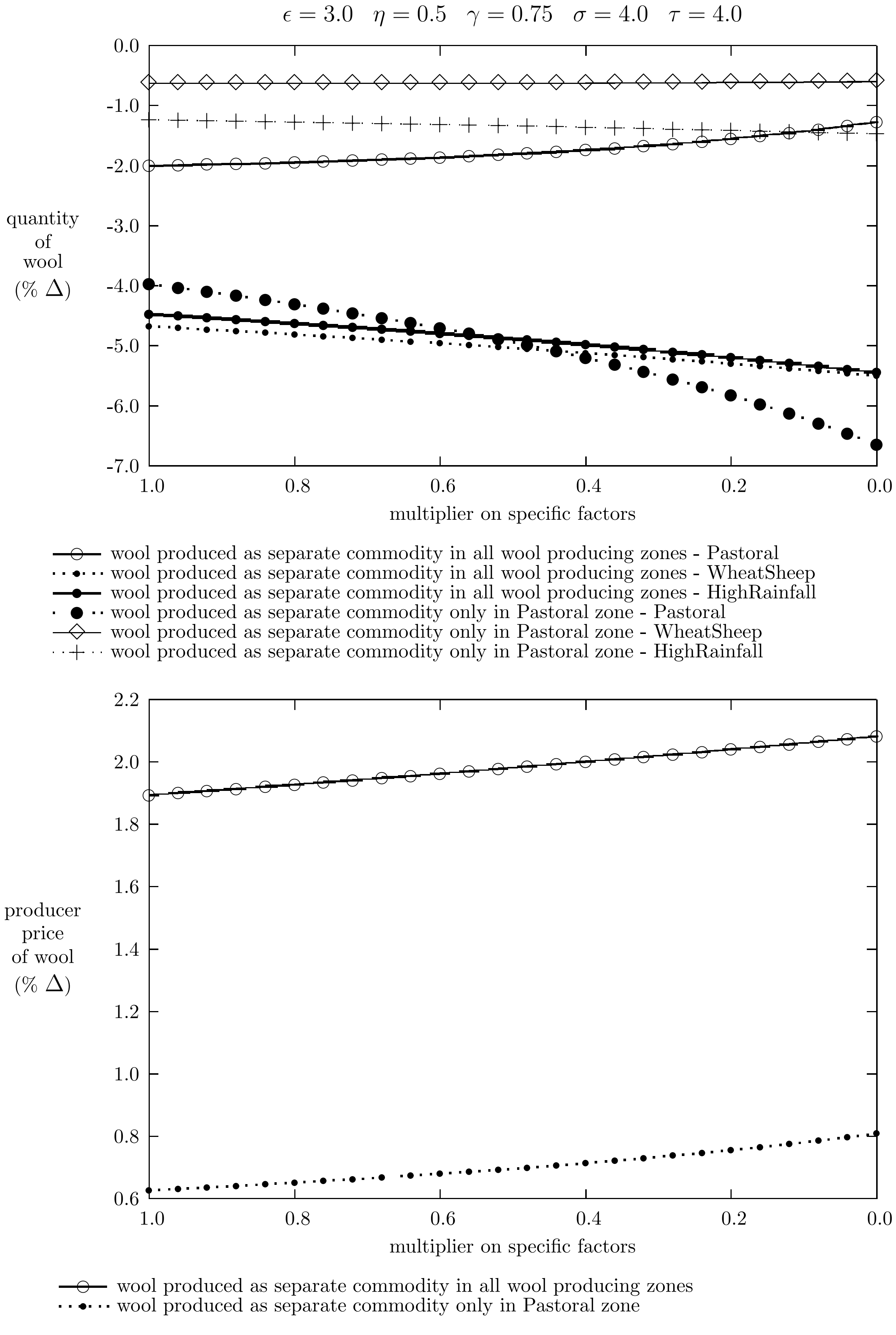

Figure 9: Effects of a 10% land retirement scheme in all wool producing zones on production and price of wool

remove this input substitution effect (by imposing penalties for switching land out of production of other agricultural commodities for land retired from wool production), then the land retirement policy should yield welfare gains. On the other hand, if the large slippage effects due to input substitution in the Wheat-Sheep and High Rainfall zones cannot be avoided, these results indicate that in the case of wool production and NRS enlargement a policy that targets the Pastoral zone is to be preferred.

6 Policy Implications

The agricultural land retirement policy analyzed in this paper clearly has terms-of-trade effects. As a result it is necessary to consider whether the land retirement proposal is consistent with the GATT (1994) Agreement on Agriculture and the rules governing agricultural trade. Given that the main objective of the proposed agricultural land retirement policy is to ensure that the desired level of land be placed in the NRS to achieve biodiversity objectives it is reasonable to consider it a type of agri-environmental policy. As such this policy is potentially eligible to be placed in the Green Box. The Green Box broadly encompasses policies judged less trade distorting and which are generally beyond challenge in trade negotiations. As a result there are obvious reasons why a country would like to see its policies accommodated within the Green Box.

To have a policy accepted into the Green Box requires that general criteria are satisfied. The general criteria require policy to, *"have no, or at most minimal, trade-distorting effects or effects on production."* (GATT, 1994, p. 56). Since the introduction of the Green Box there has been research that has focused on the interpretation of the general criteria and the implications for the design and evaluation of agri-environmental policies. This research has yielded some interesting policy propositions of direct relevance to the results presented in this paper.

In particular there are opposing views expressed about trade effects. Edwards and Fraser (2001) disagree with the general criteria of using the absence of trade-distorting effects as being a condition for a policy to qualify for inclusion in the Green Box. They argue: *"A clear distinction needs to be made between trade effects that result from policies that are welfare-enhancing and from those that are rent seeking."*(p. 323). In sharp contrast, Peterson et al. (2002) argue that, *"global efficiency requires either all trading nations are "small" or large countries are willing to ignore the terms-of-trade effects in setting environmental policy."* (p. 433). They arrive at this result by assessing the efficiency of policy in terms of global welfare. But as Edwards and Fraser argue these terms-of-trade effects are simply a result of a correct realignment of production and consumption by taking account of an existing externality. To make this point they explain how legitimate agri-environmental policy alters the mix of agricultural production and in so doing is potentially in breach of the general criteria.

However, if we accept the views of Peterson et al. (2002) then the proposed Pastoral zone land retirement scheme would appear to be potentially in breach of the general criteria (see Figure 3). Such a decision would necessarily involve a judgement of the relative size of the terms-of-trade effect arising from the land retirement policy. In light of the opposing views with respect to the terms-of-trade effect it is preferable to consider policy in terms of stated objectives, and the likelihood that the policy will achieve these objectives. Edwards and Fraser (2001) and Paarlberg et al. (2002) have proposed conditions to sharpen the focus of the Green Box criteria which will assist in identifying legitimate policies.

7 Conclusion

In this paper we have used a Computable General Equilibrium model of the Australian economy to examine the economic implications of a 10% agricultural land retirement policy to help extend the National Reserve System (NRS). We examine two policy options. The first targets land in the Pastoral zone used to produce wool. We find that there are significant welfare gains as a result of this policy, although the magnitude of these gains changes significantly depending on the modelling assumptions we employ. The second examines a 10% land retirement policy in all agricultural zones. In contrast this policy yields large negative welfare results because for all agricultural commodities other than wool producers are assumed to be price takers. Thus, any reduction in supply as a result of land retirement does not yield a commensurate increase in price.

From a policy perspective it is the results for the Pastoral zone that are more important. This is because the NRS needs to be extended in the Pastoral zone because many important ecological systems are under represented. The main results we find for this policy option are as follows.

First, the greater the degree of market power in wool that is assumed as reflected by the choice of export demand elasticity for wool, the greater the welfare gains. In this paper we have employed a range of export demand elasticity values that may be considered by some to be too conservative. As a result the welfare estimates we produce can be considered to be lower bound estimates. In addition our estimates do not include the resulting welfare gains from the provision of biodiversity.

Second, the welfare gains are lower in the short-run compared to the long-run. This temporal effect is revealed as a result of the way in which we employ specific-factors to model the long and short run.

Third, there are significant slippage effects. We have been able to establish these results without needing to explicitly incorporate land heterogeneity into the model. We have also been able to demonstrate the importance of input substitution in contributing to slippage and the welfare gains produced. A 10% land retirement policy in all wool-producing zones in Australia can yield positive welfare effects if the negative effects of slippage due to substitution of land from production of other agricultural commodities for retired land can be avoided.

Finally, we have examined the compatibility of the land retirement policy for biodiversity objectives with respect to current rules concerning agricultural policy. Although there is reason to be concerned about the acceptability of the policy as a Green Box policy it is unlikely that the proposed land retirement option would be subject to challenge from other countries as long as the biodiversity objectives of policy are clearly stated and seen to be being achieved.

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