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Tariffs and steel: US safeguard actions*

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A multiproduct spatial equilibrium model of world steel trade is presented in this paper. The model is used to analyse the impacts of the safeguard trade barriers brought about by the USA in order to protect their domestic industry from the so-called unfair competition. Emphasis is placed on the likely effect on the Australian industry and possible policy responses available to the industry. A case study is made of Australia's three largest export products; namely, slab, hot-rolled and cold-rolled steel, which share some substitutability in supply and demand because of the nature of the industry. As a result of the safeguard barriers to steel trade, world steel prices fell and trade shifted away from the USA to other importing regions.

Key words: spatial equilibrium model, steel, trade.

1. Introduction

Trade protection is viewed as an inefficient means to achieve a domestic policy outcome. Trade policies aimed at protecting or improving domestic employment and encouraging structural reform rarely succeed because of a lack of consideration given to other sectors of the economy. The benefits from trade to both importing and exporting countries are significant, with many countries advocating free trade to achieve maximal benefits. It is, therefore, surprising that a country such as the USA, a supporter of free trade in the manufacturing sector, has advocated a policy restricting trade to achieve a domestic policy outcome.

On 6 March 2002, President George W. Bush announced a series of punitive barriers on steel imported into the USA. The measures included a range of tariffs on processed steel products, which had the potential to affect Australia's exports to the USA by $US400 million (Davis and Collins 2002). For Australia, the USA represents the largest export market (Ferber 2002). Australia's largest steel export to the USA – slab steel which represent 50 per cent of total exports – was relatively unaffected with the implementation of a global tariff-free quota of 5.4 million tonnes. A concession on Australian hot-rolled steel products (Australia's second largest steel export) was granted with 250 kt of exports exempted from the new barriers. Recently, the World Trade Organization has ruled the safeguard measures illegal; however, the US

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government has rejected the finding. It is unclear whether the USA will remove the tariffs, or face retaliation from steel exporting nations.

President Bush blamed trade-distorting subsidies from steel-producing nations for the increase in imports to the USA. Bush reasoned that the subsidies provided to overseas steel producers have led to excess capacity in the global steel industry, with excess stocks being 'dumped' on the US market (Bush 2002). The temporary protection measures were aimed at restoring market forces in the US steel market, allowing the US steel producers to restructure their operations. The plan included a retraining package and assistance to help firms with health care costs, a major source of inefficiency in the steel industry (Bush 2002).

The aim of this paper is to report how the US safeguard tariffs and quotas have affected the importation of steel products from Australia and other world steel industries. This paper is a case study of the use of trade policy to achieve a domestic policy objective. The structure of the paper is as follows: an overview of the history and supposed motives behind the current protectionist measures imposed by the USA is presented in section 2; in section 3, details of the spatial equilibrium used to model the industry are given; in section 4, modelling results are presented; and policy implications are discussed in sections 5 and 6. The impacts measured are the changes in volume and direction of trade flows caused by the implementation of the barriers and the changes in consumer and producer surplus.

2. Protection in the USA

The steel industry is comprised of different enterprises that produce finished steel mill products and semifinished slabs, blooms and billets from iron ore, steel scrap, or both (Crandall 1981). The output takes the form of carbon, alloy, or stainless steel. Carbon steel comprises the bulk of world steel production. The major consumers of steel goods are the construction and automotive industries (Crandall 1981).

The steel production process is described in Crandall (1981). Slab steel is a primary form of steel. Iron ore is processed to form molten steel, which is used to produce slabs, blooms and billets. Hot-rolled and cold-rolled products are finished steel products that use slab steel and other semifinished products as their input.

An integrated steel manufacturing plant uses a blast furnace to convert iron ore into pig iron, which is then reduced to steel, typically in an oxygen blown converter. These large plants typically use a highly unionised workforce and as part of the conditions negotiated, pay generous benefits to retired employees (Crandall 1996). These plants in the USA face domestic and international competitive pressures. Their higher labour and production costs have caused smaller domestic mini-mill producers and foreign imports to capture one-quarter of the US market (Anon 2002).

A mini-mill is a steel manufacturing plant that uses scrap steel, melted down and reformed into new hot-rolled and flat steel products. Mini-mills expanded their market share from 5 per cent in 1970 to 35 per cent in 1996 (Crandall 1996). This growth was attributed to a sharp decline in scrap steel prices and relatively low production costs.

The cost advantage of mini-mills has arisen from two sources, lower fixed costs and lower labour costs. For the industry, the United Steelworkers Association estimates benefits paid to union workers are close to $US1 billion annually, on average, $US9 per tonne produced (Hufbauer and Goodrich 2002). Furthermore, it is estimated that higher capital costs incurred by integrated steel producers, mean that fixed costs per tonne of hot-rolled steel produced are $US130 for integrated producers, compared with $US30 for mini-mills (Hufbauer and Goodrich 2002). This cost disadvantage is partly offset by higher variable costs for mini-mills (Hufbauer and Goodrich 2002).

The USA became a net steel importer in 1959 and, with the emergence of Japan as a major exporter of steel products, imports gained greater penetration into the US market. From 1967 to 1968, a fall in demand for locally produced steel caused by supply uncertainty led to the formation of the Voluntary Restraint Agreements with Japan and the European Community (Jones 1983). These agreements placed voluntary restraints on steel exports to the USA. After the failure of the Voluntary Restraint Agreements (see Jones 1983), the USA, in 1979, introduced the Trigger Price Mechanism, which defined a series of dumping reference prices.

In 1982 the Trigger Price Mechanism was replaced, in part, by an agreement between the European Community and the USA to limit imports into the USA (Jones 1983). Furthermore, the USA negotiated seven new Voluntary Restraint Agreements with importing countries in an effort to stem fears of antidumping actions by the US producers (Howell *et al.* 1988).

This further intervention failed to solve the problems of the US steel industry as imports from non-agreement nations increased (Howell *et al.* 1988). Government intervention in the US steel industry can be seen as a case of policy persistence. Continued government intervention leads to a change in decision-making as decision makers alter their behaviour believing government support will be provided in hard times (Coate and Morris 1999). The recent safeguard actions by the USA can be seen as a further extension of a problem that first appeared in the 1960s and one which has been exacerbated by subsequent government intervention in the steel trade.

Job losses between 1997 and 2001 from 29 US steel firms (estimated to be 10 370 jobs by Hufbauer and Goodrich 2002) and the declining importance of the steel industry in the US economy (1.5% of workers in 1950 to 0.1% in 2002; Henwood 2002) have placed pressure on governments to lessen the hardship from plant closures. In 2001, the US International Trade Commission found that steel imports were causing injury to the domestic industry, which, under Section 201 of US trade law, provides sufficient justification for the US authorities to introduce trade barriers of any sort considered appropriate (Maurer and Lynch 2002). The full range of trade barriers is presented in Table 1.

3. Modelling of steel trade

Tariffs and effective quotas generally reduce the total welfare in the economy. Tariffs raise the domestic price and provide a more favourable environment for domestic industries to compete with imports (Pindyck and Rubinfeld 1998). Tariffs are generally a tax on imports.

Tariffs placed by small importing nations (those which cannot influence world price) reduce total welfare. Tariffs generate distributional effects. There is a transfer of surplus

Table 1 Restrictions on Australian steel exports to the USA

Product	Remedy	Year 1 (%)	Year 2 (%)	Year 3 (%)
Slabs	TRQ†	30	24	18
Hot-rolled coil for re-rolling by steelscape	Exemption	250 kt	250 kt	250 kt
Other hot-rolled sheet and coil	Tariff	30	24	18
Cold-rolled sheet and coil	Tariff	30	24	18
Plate	Tariff	30	24	18
Coated sheet	Tariff	30	24	18
Tin mill products	Tariff	30	24	18
Hot-rolled bar, cold-finished bar	Tariff	30	24	18
Rebar	Tariff	15	12	9
Certain welded tubular products	Tariff	15	12	9
Stainless rod and bar	Tariff	15	12	9
Stainless wire	Tariff	8	7	6
Pipe and tube fittings and flanges	Tariff	13	10	7

†TRQ, tariff rate quota; 30 per cent tariff applies to tonnages in excess of country quota in year 1, 24 per cent in year 2 and 18 per cent in year 3; kt, thousand tonnes. Source: USITC and Whitehouse web sites.

from consumers to producers and from consumers to government (tariff revenue); both these effects do not represent a fall in efficiency (Tisdell 1982). A transfer of consumer surplus to production cost occurs along with an area of forgone surplus, as consumers re-allocate budgets in response to changed relative prices; these represent a fall in efficiency and welfare, respectively.

In the case of the steel safeguard barriers, a series of *ad valorem* tariffs applied. The economic impacts and consequences of these *ad valorem* tariffs are similar to a fixed rate tariff. The *ad valorem* tariff is set as a per cent of the international price, causing high prices to be skewed away from the world price, while low prices are less affected (Houck 1986).

An *ad valorem* tariff is depicted in Figure 1. The *ad valorem* tariff (θ) is applied on the import price (Market A's price). The non-tariff barrier transfer price between markets (given costless transfer) is given by the 45° line. The imposition of a tariff creates a

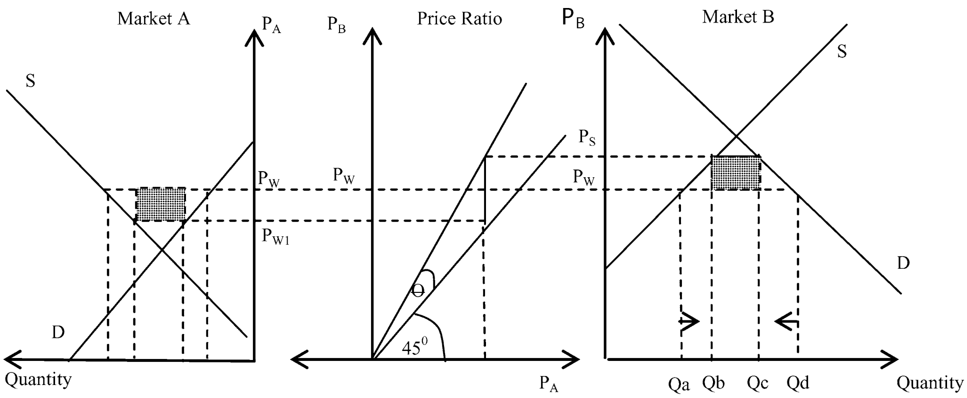

Figure 1 Effect of an *ad valorem* tariff. P_w is world price, P_s is support price and other variables as defined in the text.

wedge between the two prices, causing the price in Market B to rise, while the price falls in Market A. Tariff revenue collected is shown by the hatched regions in Figure 1. The revenue is collected from both markets, with the share determined by the relative elasticities. The tariff induces change in relative prices with an increase in domestic production at the cost of production in the exporting nation ($Q_d - Q_a < Q_c - Q_b$). Furthermore, the demand quantity falls in the importing nation, yet increases in the exporting nation.

Quotas restrict the quantity of imported product to the domestic market. With the implementation of an effective quota, the increase in domestic price causes domestic production to increase from the free trade level. The increase in output represents a shift in the resources used in the domestic economy away from more efficient uses, resulting in an efficiency loss similar to that seen for a tariff.

An import quota has significant external effects if the importing country is large. The change in excess demand causes the world price to fall and the domestic price to rise. The fall in world price and rise in domestic price means that the imposing country is able to extract a level of quota rent from world producers. The collection of quota revenue will be similar to that seen in Figure 1 and depends on the relative elasticities. However, the feedback of the fall in the world price to the domestic market will not occur.

A tariff quota (or tariff rate quota) was imposed on Australian steel exports. A tariff quota is comprised of two parts, a 'within-quota' tariff and 'out-of-quota' tariff. The within-quota tariff applies to the goods imported within the quota. The out-of-quota tariff is the tariff rate applied to any goods imported over and above the set quota.

The effect of a tariff quota with a prohibitive out-of-quota tariff is shown in Figure 2. A zero tariff is applied to the first 'quota' units, with an out-of-quota tariff of 'θ' (an *ad valorem* tariff), resulting in a stepped price ratio (assuming no transport costs). The

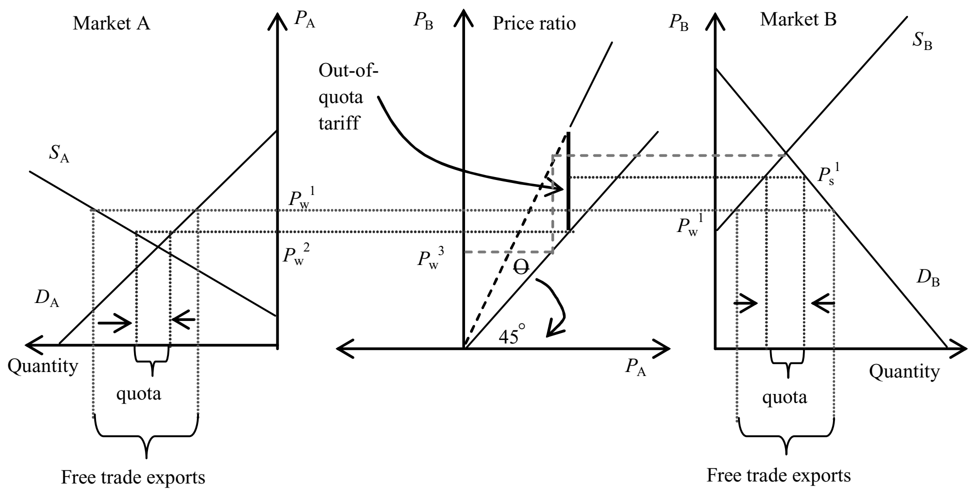

Figure 2 Tariff rate quota (no trade over the quota setting). D_i is demand in region i ($i = $ A, B), S_i is supply in region i, P_w^j is world price and P_s is support price.

effect on the domestic economy is the same as with a quota, with one difference. A standard quota allows no feedback of the world price change to the domestic market; however, with a tariff quota there is an opportunity for a change in the world price to feedback to the domestic market. If the price were to fall below P_w^3 in Figure 2, some units would be imported with the out-of-quota tariff applied. The result is a lower domestic price and increased imports.

4. Spatial equilibrium model

A spatial equilibrium model was used to evaluate the impacts of the US safeguard measures on steel trade. A spatial equilibrium model was first constructed by Enke (1951) and mathematically solved by Samuelson (1952) and Takayama and Judge (1971). Such models can be formulated with either prices or quantities as the dependant variables (Krishnaiah and Krishnamoorthy 1990). The approach uses either a welfare-based objective function, or a net revenue function, which equals zero at the competitive equilibrium. The simplest form of a spatial equilibrium model is constructed under the assumption of perfect competition, where supply, demand and transfer costs are known (Batterham and MacAulay 1994).

When world price is below the autarky price, the excess demand function is positive, indicating that domestic demand is greater than domestic supply. When the world price is above the autarky price, the excess supply function is positive, indicating that the domestic supply is greater than demand.

Where the excess demand and supply curves intersect, the quantity and direction of trade is determined with the flow of goods from region 1 to region 2, x_{12} (Figure 3). With zero transfer costs, the trade equilibrium would be given by the intersection of the excess demand and excess supply curves. In Figure 3, transfer costs are given by t_{12} ($t_{12} > 0$), with the resulting price lower in the exporting market and higher in the importing market.

Samuelson (1952) provided a means to solve complex spatial models using the concepts of consumer and producer surplus and a mathematical programing formulation. Samuelson described the 'net social pay-off' from trade as the benefit to producers from the exporting countries and the benefit to consumers in the importing countries

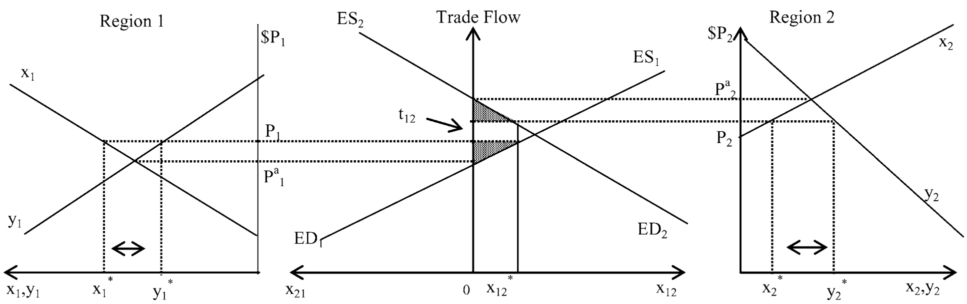

Figure 3 Trade between two regions. x_i is supply in region i, y_i is domestic demand in region i ($i = 1, 2$), ES_i is excess supply from region i, ED_i is excess demand from region i, t_{12} is transfer cost from region 1 to region 2, x_{ij} is exports from region i to region j ($j = 1, 2$), P_i is price in region i and P_i^a is autarky price for region i.

less the transfer costs (the shaded area in Figure 3). The equilibrium is defined as the point where the net social payoff is maximised.

The shaded areas above the excess supply and below the excess demand functions show the welfare effects from trade (Figure 3). Trade causes welfare changes as prices rise for the exporting region and fall for the importing region. As such there are associated changes in producer and consumer surplus. As prices rise for the exporter, producer surplus increases and consumer surplus falls. The opposite is true for an importing nation.

The approach used in this study draws on the quadratic programming model developed by Takayama and Judge (1971) and that used by Batterham and MacAulay (1994). Takayama and Judge (1971) showed that the Samuelson model, based on a social welfare function, could be solved using what was termed 'net social monetary gain' as the objective function (referred to as the 'net revenue' function in Batterham and MacAulay 1994).

The net social revenue solution is depicted in Figure 4. Under perfect competition, a transfer services demand function can be implicitly derived from the vertical difference between the excess supply and excess demand functions. The difference between the excess supply and excess demand functions is the difference in the autarky prices

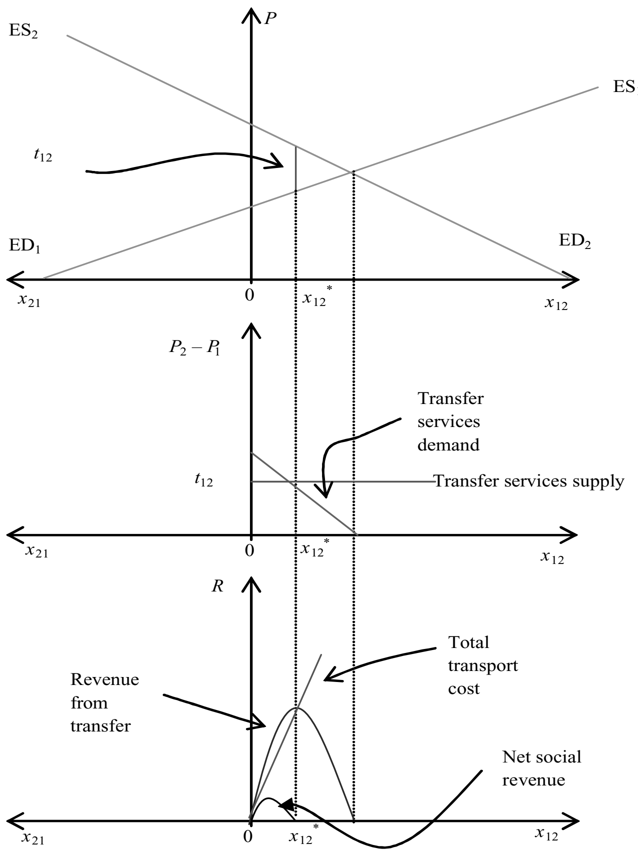

Figure 4 Representation of a net social revenue solution.

between the regions, with trade occurring as long as transfer costs do not exceed the difference between the curves. The vertical distance between the curves is the 'willingness to pay' for transfer services, the demand for transfer services. Total revenue from transfer services is equal to the total traded volume multiplied by transfer costs. Under perfect competition, the set of price and transfer cost relationships is required to hold so that the net social revenue is zero. As such, the model's objective function is maximised to give a zero value.

There are three sets of equilibrium conditions essential to the spatial equilibrium model. First, differences in prices between markets must be less than or equal to the transfer costs (Samuelson 1952). This is an arbitrage condition and is an extension of the *law of one price*. It assumes the products from each region are perfect substitutes that compete in perfectly competitive markets. Second, demand in any region, y_j, is equal to local production, x_j, plus imports $\sum_j x_{ij}$. Third, the supply, x_i, is equal to exports, $\sum_i x_{ij}$, plus demand, y_i. The spatial model allows for no excess demand to exist, but does allow excess supply if a slack variable is included in the model (MacAulay 1976).

The price-orientated spatial equilibrium used differs from the quantity-oriented spatial model as outlined by Martin (1981). Although in both models the returns from trade are maximised (Batterham and MacAulay 1994), price-orientated spatial equilibrium models reach equilibrium through solution for price levels, which give rise to quantities produced and traded as the Lagrangian multipliers or the dual variables. However, in the quantity formulation, the solution is for quantities that subsequently lead to equilibrium prices as the dual variables.

4.1 Empirical model

A spatial equilibrium model requires data on consumption, production, exports and imports. These data are combined with elasticities to estimate the supply and demand functions for the regions in the model. The data sources are the International Iron and Steel Institute (2002), American Iron and Steel Institute (2002), Ferber (2002) and International Trade Commission (2002). The data were used to develop a global balance sheet for steel production for 1999 as this was the most current year in which a full dataset was available. As such, the results obtained are based on changes from the 1999 levels. However, export levels to the USA remained stable from 1999 to 2002 (US Census Bureau 2001).

The demand for slab steel is a derived demand, so the elasticity is a function of the final product and the marketing margin involved. The elasticity at the derived level is less than the elasticity at the retail level as the derived price is lower than the retail price (Tomek and Robinson 1990).

The steel industry uses many industry-specific inputs (even labour because of the specialised nature of skills required). It is assumed that factors are mobile up and down the production process – that is, from coated products to hot rolled to slab. Although there is a large capital expenditure required to move into finished products, and there is a large capacity of many integrated steel producers responsible for producing much of the semifinished products (Crandall 1981), the factor substitution elasticities between products are assumed equal, because the inputs used in the production are similar for the different types of steel.

Information on supply elasticities were unavailable, causing these elasticities to be estimated. Supply for steel products was assumed to be relatively elastic for all steel products. Slab steel supply was assumed to be more elastic as it is a primary product, while the elasticity of the further processed steel was assumed to be more inelastic. Elasticities for the 'Rest of World' region were assumed to be more elastic than for the other nations. Furthermore, a sensitivity analysis, conducted due to these uncertainties, showed the results were stable to changes in elasticities. A just-in-time supply also was assumed. This approach ignores inventories, but based on data and other studies (see Jondrow *et al.* 1982), the assumption may not be unreasonable for imported steel.

4.1.2 Model structure

The products chosen were slab steel, hot-rolled steel and coated sheet steel because of their significance to the Australian industry. The countries included in the study were Australia, the USA, Japan, Rest of World importing nations and Rest of World exporting nations.

As production and consumption of steel can substitute between products, as would occur with changes in relative prices caused by inconsistent trade barriers, substitution coefficients were estimated. These coefficients were calculated for each steel product and indicated whether producers would respond to the tariffs by sending alternate products into the USA. The substitution of one steel product for another for both supply and demand functions were estimated and inserted into the model (the cross-coefficients were included in the Ω and H matrices, see MacAulay 2002). The calculation of the coefficients for each region is as follows:

$$\text{Demand:} \quad \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix}, \tag{1}$$

where y_i is demand for good i, α_i is the intercept for demand i and β_{ij} is the cross-coefficient of demand for good i given the price of good j. These coefficients were required for the spatial equilibrium model. It was assumed that the cross-price elasticity for good 1 given the price of good 2 was equal to the cross-price elasticity for good 2 given the price of good 1 (symmetry). The definition of the relationship between β_{ij} and the cross-price elasticities is:

$$\begin{bmatrix} \mathrm{E}_{11} & \mathrm{E}_{12} & \mathrm{E}_{13} \\ \mathrm{E}_{21} & \mathrm{E}_{22} & \mathrm{E}_{23} \\ \mathrm{E}_{31} & \mathrm{E}_{32} & \mathrm{E}_{33} \end{bmatrix} = \begin{bmatrix} 1/y_1 & & \\ & 1/y_2 & \\ & & 1/y_3 \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \begin{bmatrix} P_1 & & \\ & P_2 & \\ & & P_3 \end{bmatrix}. \tag{2}$$

The solution to Equation (1), in terms of α_i using Equation (2) is:

$$\begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} = [(1 - \mathrm{E}_{11} - \mathrm{E}_{12} - \mathrm{E}_{13})\ (1 - \mathrm{E}_{21} - \mathrm{E}_{22} - \mathrm{E}_{23})\ (1 - \mathrm{E}_{31} - \mathrm{E}_{32} - \mathrm{E}_{33})] \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} \tag{3}$$

and β_{ij}:

$$\begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} = \begin{bmatrix} 1/P_1 & & \\ & 1/P_2 & \\ & & 1/P_3 \end{bmatrix} \begin{bmatrix} y_1 & & \\ & y_2 & \\ & & y_3 \end{bmatrix} \begin{bmatrix} \mathrm{E}_{11} & \mathrm{E}_{12} & \mathrm{E}_{13} \\ \mathrm{E}_{21} & \mathrm{E}_{22} & \mathrm{E}_{23} \\ \mathrm{E}_{31} & \mathrm{E}_{32} & \mathrm{E}_{33} \end{bmatrix}. \tag{4}$$

The advantage of incorporating cross-price terms into the spatial model is that it allows the three demand and supply equations to act in a dependent manner. This modification means the spatial model can be used to evaluate any range of substitute and complementary goods by allowing price changes from a policy shock to be determined for the full range of goods.

Tariffs were incorporated into the spatial equilibrium model through the arbitrage conditions (Takayama and Judge 1971; Koo and Larson 1985; MacAulay 1992). The application of an *ad valorem* tariff is analogous to the incorporation of an exchange rate. Essentially, the *ad valorem* tariff increases the costs of transfer from one region to the other (MacAulay 1992). Tariffs are incorporated into the model by means of a converter matrix R_τ (MacAulay 1992). The arbitrage condition matrix (see MacAulay 2002 for a general formulation) then becomes:

$$[R_\tau G_y' \quad G_x'] \begin{bmatrix} \rho_y \\ \rho_x \end{bmatrix} \le T, \tag{5}$$

where R_τ is in a $(n^2 \times n^2)$ matrix. For example, if a tariff rate τ_{ij} is applied on the trade flow from region i to j, then R_τ is a $[n^2 \times n^2]$ matrix for n regions and has ϕ_{ij} terms on the main diagonal for those trade flows with tariffs (see MacAulay 1992).

In the model, the *ad valorem* tariffs were applied to the steel demand price in the USA. With a tariff level equal to τ_{12} levied on the price of steel products exported from country 1 to country 2, the arbitrage condition becomes:

$$(1 - \tau_{12})\rho_1 - \rho^2 \le t_{12}. \tag{6}$$

Australia successfully negotiated an exemption for 250 kt of hot-rolled sheet imports. This exemption was incorporated into the model. A within-quota tariff of 0 per cent was applied to the first 250 kt of hot-rolled sheet exported to the USA, and an 'above-quota' tariff of 30 per cent. The incorporation of a quota was done by separating the trade flows into the USA into a within-quota trade flow with no tariff and a quota imposed, and an out-of-quota trade flow with the full tariff rate applied. Slab steel was subject to a global quota of 5.4 million tonnes, which was implemented in the model in a similar way.

Transfer costs for the model were estimated by means of unit value differentials. The differential chosen was calculated as the US domestic price less the export unit value. This choice was because of the difficulties in obtaining transfer costs, as transfer costs were unavailable for the specific products examined. The price differences between export unit values and the US domestic price did correspond with the trade flows, so that the net exporting regions – Australia and Japan – had lower export unit values than the US domestic price.

The difference in export unit values and the US domestic price includes not only the transfer costs but may also include other factors. If exports are concentrated towards a higher or lower value subproduct, then the export unit value will be skewed towards the higher or lower price range. This may exaggerate or underestimate the transfer cost. Notwithstanding this discrepancy, as well as other factors influencing the US domestic price, the transfer costs obtained were the best available given the dataset.

4.2 Results

The results obtained from the spatial equilibrium model are presented in this section. The results are discussed in terms of changes in prices, quantities and economic surplus. In order to calculate the changes in producer and consumer surplus, a line integral was required. As the demand and supply equations were specified as a function of own and cross-prices of the goods in the model, the demand and supply functions were a plane in a three-dimensional space. The calculation used to determine the consumer (CS) and producer surplus (PS) for industry 1 is shown in Equation (7):

$$\begin{aligned}\mathrm{CS}_1 &= \left(\frac{\alpha_1}{\beta_{11}}\bar{P}_2\bar{P}_3 + \frac{\beta_{12}}{2\beta_{11}}\bar{P}_2^2\bar{P}_3 + \frac{\beta_{13}}{2\beta_{11}}\bar{P}_2\bar{P}_3^2\right)\\ \mathrm{PS}_1 &= \left(\frac{\alpha_1}{\beta_{11}}\bar{P}_2\bar{P}_3 + \frac{\beta_{12}}{2\beta_{11}}\bar{P}_2^2\bar{P}_3 + \frac{\beta_{13}}{2\beta_{11}}\bar{P}_2\bar{P}_3^2\right),\end{aligned} \tag{7}$$

where β_{ji} is the cross-price coefficients of good j for price of good i, β_{ii} is the own price coefficient for good i, α_i is the demand intercept of good i and $\bar{P}_i$ is the equilibrium price of good i.

This calculation is an adaptation of the calculation used in MacAulay (1976) with the use of a line integral set out in Spiegel (1968) and Stewart (1995). A problem with using line integrals to determine consumer and producer surplus is that they are path-dependant (see MacAulay 1976); however, for the purpose of this study, the cross-coefficients in the demand and supply equations were symmetric; as such the choice of path makes no difference.

4.2.1 Prices

As a result of the US safeguards, the estimated prices for all products in countries other than the USA fell as shown in Table 2. The largest fall in price occurred for

Table 2 Changes in prices paid/received ($US/tonne)

Product	Country	Pre	Post	Change	Percentage change
Slab	Australia	209	207.53	−1.47	−0.701
	USA	230	247.42	17.42	7.572
	Japan	217	215.53	−1.47	−0.675
	Rest of World†	230	228.53	−1.47	−0.637
	Rest of World‡,§	228	226.53	−1.47	−0.643
Hot rolled	Australia	290	286.20	−3.80	−1.310
	USA	352	390.49	38.49	10.934
	Japan	280	276.20	−3.80	−1.357
	Rest of World†	352	348.20	−3.80	−1.079
	Rest of World‡,§	306	302.20	−3.80	−1.241
Coated sheet	Australia	653	640.11	−12.78	−1.957
	USA	677	760.55	83.55	12.341
	Japan†	650	637.22	−12.78	−1.965
	Rest of World	677	664.22	−12.78	−1.887
	Rest of World‡,§	675	662.22	−12.78	−1.893

†Rest of World importing nation; ‡Rest of World exporting nation; §supply price.

coated sheet steel, in which all countries, with the exception of the USA, experienced a fall of $US12.78. Despite the uniform drop in absolute price across nations other than the USA, the relative changes differed within nations. The relative differences in prices allowed producers (in the model) to substitute between different production activities, changing the direction and composition of exports. For the USA, the price levels for all products increased. The smallest increase was seen for slab steel as the barriers placed on this product were the least restrictive.

A quasi-rent was generated for both the slab and hot-rolled steel product quotas, the quotas were binding. The quasi-rent estimated for Australian exports of slab and hot-rolled steel was equal to $US18.88 and $US42.28 per tonne, respectively. The global slab steel quota had an associated rent of $US18.88 per tonne. No nation expanded beyond the quota with the full 30 per cent tariff rate.

4.2.2 Production

Total world trade in steel products fell from a pre-safeguard level of 38.6 million tonnes of steel to 30.9 million tonnes, close to a 20 per cent fall in world trade for the three products examined. Total exports to the USA, post the safeguard actions, represented 5.75 million tonnes (the summed quota levels), a fall from 7.1 million tonnes. Changes in production and consumption are shown in Table 3.

Total production of slab steel increased by over 61 000 tonnes (an increase of 0.01%) as a result of the measures. The reason for this is linked to the trade diversion effects caused by the measures, for instance, much of the slab steel originally exported to the USA was redirected to the Rest of World importing nation. Producers shifted production away from the hot-rolled and coated sheet products and into slab steel production, as the slab steel price was the least affected by the move. As such, total production for hot-rolled and coated sheet products fell globally in response to the safeguard measures, with production of slab steel increasing.

Table 3 Production and consumption (million tonnes)

Region	Product	Production Pre	Production Post	Production Change	Consumption Pre	Consumption Post	Consumption Change
Total	Slab	587.47	587.53	0.06	587.47	587.53	0.06
	Hot rolled	376.19	376.10	−0.08	376.19	376.10	−0.09
	Coated sheet	77.90	77.72	−0.19	77.90	77.72	−0.18
	Total	1041.56	1041.35	−0.21	1041.55	1041.35	−0.20
Australia	Slab	8.054	8.07	0.01	6.51	6.51	0.00
	Hot rolled	3.81	3.81	−0.01	3.29	3.30	0.01
	Coated sheet	0.646	0.64	0.00	0.11	0.11	0.00
	Total	12.51	12.51	0.00	9.91	9.93	0.02
USA	Slab	94.425	94.29	−0.13	100.52	99.05	−1.47
	Hot rolled	62.58	63.91	1.33	67.54	64.16	−3.38
	Coated sheet	18.813	19.45	0.64	20.92	19.45	−1.47
	Total	175.82	177.66	1.84	188.98	182.66	−6.32
Japan	Slab	94.877	95.14	0.27	89.29	89.23	−0.06
	Hot rolled	51.31	51.20	−0.11	33.919	34.08	0.16
	Coated sheet	11.298	11.21	−0.09	7.74	7.82	0.08
	Total	157.49	157.55	0.07	130.95	131.14	0.18
Rest of World	Slab	390.11	390.02	−0.09	391.15	392.73	1.58
	Hot rolled	258.48	257.19	−1.29	271.44	274.56	3.12
	Coated sheet	47.15	46.41	−0.73	49.12	50.33	1.21
	Total	695.74	693.62	−2.12	711.70	717.62	5.92

For the USA, the price of hot-rolled and coated sheet products rose by a greater per cent than seen for slab steel. This change in relative prices created a shift in production away from slabs. Interestingly, mini-mill producers who produce such products will benefit from this increase in price. The higher price received for the transformed products could create a situation where mini-mills increase their market share to the disadvantage of integrated producers. This response would undermine the purpose of the safeguard policy.

Exports to the USA fell significantly in the three products examined as a result of the safeguard measures. Total imports fell by an average of 71 per cent for all steel products examined in the study. The reduction in imports equated to a fall in market share from 7.5 per cent to 3.3 per cent for the products examined. Changes in imports are presented in Table 4.

Table 4 Imports to the USA (million tonnes)

	Australia			Japan			ROW†		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
Slab	0.44	0.35	−0.09	0.32	0.15	−0.17	6.33	5.25	−1.07
Hot rolled	0.24	0.25	0.01	0.21	0.00	−0.21	4.51	0.00	−4.51
Coated sheet	0.01	0.00	−0.01	0.17	0.00	−0.17	1.94	0.00	−1.94

†Rest of World importing nation.

Table 5 Changes in economic surplus ($US millions)

Region	Industry	Change in producer surplus	Change in consumer surplus
Total	Slab	15.17	−34.74
	Hot rolled	15.18	−22.61
	Coated sheet	15.30	−21.23
	Total	45.65	−78.58
	Total change in surplus		−32.92
Australia	Slab	−1.24	3.72
	Hot rolled	−1.97	2.72
	Coated sheet	−1.49	2.13
	Total	−4.70	8.57
	Total change in surplus		3.87
USA	Slab	20.64	−45.85
	Hot rolled	21.87	−31.28
	Coated sheet	20.26	−26.96
	Total	62.78	−104.08
	Total change in surplus		−41.31
Japan	Slab	−1.74	4.39
	Hot rolled	−1.95	2.71
	Coated sheet	−1.50	2.02
	Total	−5.20	9.12
	Total change in surplus		3.92
Rest of World	Slab	−2.49	3.01
	Hot rolled	−2.77	3.24
	Coated sheet	−1.97	1.57
	Total	−7.23	7.82
	Total change in surplus		0.59

4.2.3 Economic surplus

The effects of the safeguard measures on consumer and producer surplus are shown in Table 5. For all nations except the USA, producer surplus fell and consumer surplus increased. The net effect in the Rest of World region was the smallest, as consumers benefited from the redirected cheaper imports, while producers lost export markets and local sales. The driver for this result was the partial nature of the analysis.

The results for Australia and Japan are similar and show that total surplus actually increased. The cause of this increase in total surplus was because of the redirection of exports away from the USA to the Rest of World importing region and a shift in the composition of production away from highly protected products. An assumption of the spatial equilibrium model is that producers, by ignoring the differences in relative transfer costs, can costlessly shift exports from one region to the other. As a result, the most viable option for producers in Australia and Japan was to seek alternate markets. As the elasticity of demand in the Rest of World importing region was relatively more elastic, the lower price led to greater demand, meaning this region was able to absorb the shift in exports.

For the USA, the implementation of the safeguard measures led to a net loss in surplus. The measures did increase domestic production and increased producer surplus. Despite this, the impact on the US consumers was great, meaning that the surplus gained for producers was outweighed by the loss incurred by consumers.

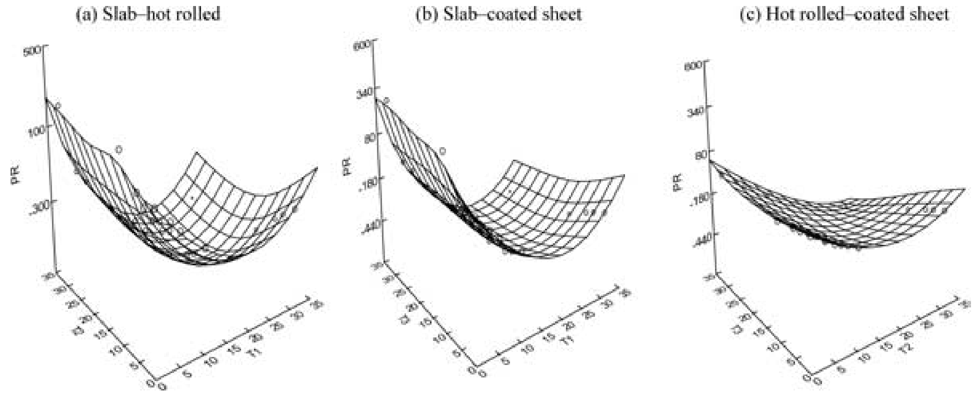

Figure 5 Policy response surfaces for producer revenue in Australia. PR, producer revenue change in $US100 000; T1, slab tariff level; T2, hot-rolled tariff level.

5. Policy responses

Policy response surfaces were formulated in order to examine alternative responses of Australian steel producers. The policy response surfaces were mapped by means of a set of varying tariff levels. As there were three products examined, three different policy response surfaces were estimated, slab–hot rolled, slab–coated sheet and hot rolled–coated sheet. The policy response surfaces map differing levels of Australian producer revenue for a range of tariff levels between 0 and 30 per cent. The tariffs used to map changes in producer revenue were combinations of 30, 10, 5, 3 and 0 per cent for each product (given no concessions).

The producer revenue surface for slab–hot rolled is shown in Figure 5a, where producer revenue is graphed as change in revenue from the no tariff situation. From Figure 5a, it can be seen that relaxation in the slab tariff (T1) would have more benefit to Australian producers than relaxations in other tariffs. Even with a zero tariff level on hot-rolled steel, the gain to Australian producers is marginal (given a 30% tariff on slab steel).

With tariff-free imports of slab or hot-rolled steel into the USA, Australian producers would benefit through the ability to take advantage of the higher domestic price. Combinations of tariffs for slab steel at 10 per cent and above yielded a negative result for Australian producers independent of the hot-rolled steel tariff. The policy surface estimated for slab–coated sheet products is shown in Figure 5b. The results are similar to those seen for the slab–hot-rolled policy response functions as tariff-free access, for slab steel yields the greatest benefits for producers. In the case of hot rolled–coated sheet, tariff-free access for either coated sheet or hot-rolled steel would still mean that the Australian steel industry would be worse off than with the zero tariff position. With zero tariff access for hot-rolled steel and a full tariff rate on coated sheet, Australian producers are only marginally better off (Figure 5c).

An implication from the above analysis is that the best outcome for Australian producers is to have some form of preferential access to the US market, assuming the concession was given on slab steel (from the consumers' point of view, the best position for Australia is opposite to this and would be at the lowest points in Figure 5a–c). This conclusion appears obvious, but the implications of the cross-elasticities signalling that the products were in some way substitutes for the purpose of the study, mean that only one product would need to have tariff-free access into the US market for benefits to flow to the producers of the other products in the study. The increase in price received in Australia would also place upward pressure on the prices of the other goods. The concept of total elasticity is a useful way to envisage the overall effect (Tomek and Robinson 1990).

6. Concluding comments

The impacts of the safeguard measures on the world steel industry can be viewed through examining changes in producer and consumer surplus. It was seen from the results that the initial position was more efficient for the global steel market because of the negative change in total surplus that has occurred with the safeguard tariffs. It can be said that free trade provides greater overall benefits, while trade protection leads to short-term benefits for protected steel producers.

Total surplus for the global steel market is seen to fall by $US32.92 million because of the imposition of the safeguard actions. Benefits for steel producers in the USA (measured in the form of producer surplus) increased by $US62.78 million, with losses in consumer surplus equal to $US104.08 million. As such, a more efficient policy to enable the US steel industry to restructure would be one aimed at market reforms, and not trade protection.

A figure excluded from the change in producer and consumer surplus is the transfer that occurs with the impositions of tariffs and quotas. The US government may receive an income stream from these protection measures depending on the structure of the quota. The USA is a large importer, and as such, can benefit from the imposition of trade barriers. The effect of the trade-distorting measures used – tariffs and quotas – led to a fall in world price. This fall allows the US government to capture some surplus from the world steel market. With the inclusion of the surplus from quota revenue, the US economy would actually gain (quasi-quota rent can be viewed as a surplus transfer) equal to $US77.69 million.

The benefits to the steel market would only increase if the quota revenue were transferred to this market (which may be the case). If this quasi-rent is placed into treasury, depending on the structure of the quota, the revenue collected may go to other causes, leading to a net loss in the market. This rent also ignores administration costs, which are usually high with quotas due to difficulties in collection. With appropriate permit controls, it is possible that the quota rent may not be collected by the USA, and in fact be collected by world exporters, or importing firms depending on the degrees of market power or levels of regulation.

The trade protection measures used by the USA were supposed to provide an environment in which domestic steel producers could expand output, increase revenues and provide the means to allow for structural reform. The higher price levels encourage increases in production, requiring a shift in resources away from other sectors of the US economy, where these resources would have been better used given world prices. If it was viewed by the US government that this policy was best – either the costs to the market are worth paying, or that government revenue is favoured over outlays – the response by the steel industry may not be what the government is after. It has been seen throughout history that the US government has intervened in the steel market whenever steel producers were affected adversely by imports. This continual intervention has meant that steel producers have relied on the government if the economic situation turned against them. This policy has caused unproductive practices and large excess capacity to remain in the industry. The question becomes, would this be any different this time?

The results obtained from the analysis of the safeguard actions show an unequal increase in the price of the examined steel products within the USA, skewed towards coated sheet and hot-rolled steel. Both integrated steel producers and mini-mills produce these two products. The safeguard policy was primarily aimed at the larger integrated producers because of their political significance and the fact that it was these producers that were most under threat from the surge in imports. With the higher prices favouring the products that mini-mills produce, the safeguard barriers may not help the integrated producers, but allow mini-mills to capture more of the US market at the expense of the integrated producers.

The results obtained here differed to those which were seen in the world steel market because of the partial equilibrium nature of the analysis. In reality, the effect of China's strong growth fuelled world demand for steel during the period of safeguard tariffs, causing world prices to increase. As such, exporting nations did not have to face lower steel prices as a result of the safeguard measures as they were able to shift exports towards China.

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