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Sectoral analysis of an Australia–India free trade agreement

Sang-Wook (Stanley) Cho[a*] and Gordon Yoon[b]

[a]*School of Economics, University of New South Wales, Sydney, NSW 2052, Australia;* [b]*Land & Economic Development, Department of Lands, Planning and the Environment, Northern Territory Government, Darwin, Australia*

This paper analyses potential sectoral effects of Australia and India signing a free trade agreement. We construct a static applied general equilibrium model, and using a social accounting matrix, we calibrate it to match the Australian data sector by sector. We then perform a numerical experiment of removing all import tariffs between Australia and India. Additionally, we compare this benchmark case with one scenario where the tariffs are partially eliminated, and another scenario with more realistic trade elasticities. We quantify how trade liberalisation leads to falling consumer prices in the import sectors, increased production in the export sectors and aggregate welfare gains. Our analysis indicates a social welfare gain of around 0.4% which is robust to different estimates of trade elasticities, or in the case in which perhaps more realistically reflecting the recent episodes of free trade agreement we partially remove bilateral trade barriers.

Keywords: calibrated general equilibrium model; trade liberalisation; free trade agreement; social accounting matrix

JEL Classification: D58, F14, F15

1. Introduction

In the recent years, a wave of trade liberalisation episodes have gained momentum around the world, despite challenges from the recent global financial crisis in 2008. Australia is no exception to this proliferating trend as there have been or are currently under negotiations for bilateral free trade agreements (FTAs). Dating back to 1983, with its first FTA with New Zealand, Australia has liberalised trade with Singapore (2003), Thailand and the United States (2005), Chile and Malaysia (2009), and more recently with Brunei, Burma, the Philippines and Vietnam (2010). More potential FTAs are under negotiation including China, India, Indonesia, Japan and South Korea. In this paper, we study the impact of a potential FTA between Australia and India with specific attention to different production and consumption sectors of the Australian economy.[1]

The wide consensus among economists is that free trade generates *aggregate* welfare gains through efficient reallocation of resources, and production, reduction of prices and exposure to foreign competition. In *aggregate* terms, economies open benefit from doing so. Numerous studies in the literature have addressed this issue, assessing the qualitative and quantitative impact of trade liberalisation at the aggregate level. Examples, among many, include the works of Brown and Stern (1995) and Sobarzo (1995) which analyse the effects of the North American Free Trade Agreement on the economies of Canada, Mexico and the United States. In the Australian context, Siriwardana (2007) studies the impact of

*Corresponding author. Email: s.cho@unsw.edu.au

the recent FTA between Australia and the United States and Siriwardana (2006a) evaluates Australia's FTAs with the United States, Singapore and Thailand.[2] Sectorally, more specific questions arise. What are the effects on the disaggregated production structure of the economy? Which sectors' output will expand or contract? Will exports or imports of a particular sector increase or decrease? What are the magnitudes of these changes? What will happen to the prices that domestic consumers face? What will happen to the welfare of the consumers as trade is liberalised? What are some fiscal implications for the government? This paper aims to provide quantitative answers to most of these questions.

To address these important policy issues, we construct a standard static applied general equilibrium model (AGEM) which has been the standard yet sophisticated theoretical and empirical model widely adopted to assess the impact of these reforms, since it also captures all the complicated linkages between the various agents that comprise an economy. By using an AGEM, we are also able to conduct sensitivity analyses and perform additional experiments that explore the implications of alternative trade liberalisation arrangements. Using several data sources, we calibrate the main characteristics that define the behaviour of the agents in the model to match the Australian economy. Once the model has been constructed and all its parameters have been calibrated, we conduct a simple experiment, labelled as the 'benchmark' experiment, that consists of Australia and India simultaneously eliminating the tariffs that they impose on their respective imports. We then track the changes in production and consumption patterns and identify different policy implications regarding welfare changes using real income indices for not only the aggregate economy, but also for the private and public sectors.

We find that the aggregate impacts are quantitatively similar to those reported by CIE (2008). For example, trade liberalisation with India leads to a higher increase in overall imports than in exports, where the imports are projected to increase by 3.20% compared to by 1.61% in the exports. Higher trade facilitates Australian production, and we report an increase of 0.31% and 0.57% for the total domestic and final production, respectively. In addition, higher production demand leads to an increased demand for factor inputs which leads to a slight increase in the rental rate (0.02%) and the wage rate (0.17%). In line with CIE (2008), we also find that the Australian dollar appreciates and the terms-of-trade improves. In terms of welfare and policy implications, we find that the aggregate consumer welfare increases by 0.31%, while the government welfare increases by 0.74%. Consumer welfare gain is possible due to an increase in the household disposable income and a decrease in the prices that domestic consumers face. On the other hand, despite tariff revenue losses, government welfare increases as higher production and consumption leads to a larger tax base. The increase in government welfare can be used as an argument for the government to provide subsidy and transfers to those sectors that might potentially lose from the trade reform. Coupled with increases in both the consumer and the government welfare, the social welfare also increases by 0.41%.

For our sectoral analysis, we find that the consumption goods prices fall in the main import sectors with relatively high tariff rates such as the textiles and machinery sectors. However, quantitatively, the magnitude of the price decline is small, with a 0.20% fall in the textiles sector and 0.17% fall in the machinery sector. This is partly due to the fact that imports from India comprise less than 1% of the total imports of Australia. As for domestic production, trade liberalisation results in a large production increase in the fuel sector which is the second largest export item for Australia, by a magnitude of 10.71%. It is interesting to note that trade liberalisation causes sectoral production shifts with more resources (capital and labour) shifting away from all other sectors in favour of the fuel sector, as all other disaggregated sectors show a small decline in production, including the mining sector. For

international trade, exports to India show an explosive growth of 470.30% in the fuel sector, and an overall increase in exports to India by 33.24%. Sector by sector, exports become more heavily concentrated in the fuel and other primary sectors. Imports, on the other hand, increase in every sector with the largest jump in imports occurring in the textiles sector by an order of 466.13%. On average, imports from India increase by a sizeable 285.22%.

To complement our benchmark analysis, we perform several additional numerical experiments. In the benchmark numerical experiment, bilateral tariffs between Australia and India were instantaneously removed. However, more realistically, the countries involved follow a carefully sequenced transition where they gradually lower tariff rates, perhaps due to some sectors being politically or socially more sensitive to liberalisation. Hence, we conduct a numerical experiment to assess the implications of a 'partial' liberalisation, where we calculate the tariff elimination rate sector by sector based on the recent episodes of FTAs signed by Australia. The qualitative implications from the partial liberalisation are similar to the benchmark case, but quantitatively, the magnitude is smaller in terms of prices, production and trade volume. As far as welfare is concerned, it is interesting to find that we attain the same social welfare gain from partial liberalisation as compared to a 'full' liberalisation benchmark case.

In another experiment, we note that all the elasticities of substitution (for both imports and exports) were assumed to be the same across sectors in the benchmark scenario. We perform a sensitivity analysis with differentiated values for the import elasticities of substitution for each sector, and explore the implications on prices and welfare. Following Cho and Díaz (2008), we take one set of estimates from Hummels (2001) and another from Rolleigh (2008). The quantitative implications are further amplified for sectors with higher elasticities of substitution. For example, Rolleigh (2008) reports the parameter ρ_m that governs the import elasticities of substitution to be 0.95 in the fuel sector. Compared to the benchmark case where $\rho_m = 0.8$ for all sectors, the price fall in the fuel sector is 4.5 times larger than the magnitude under the benchmark case. In addition, the trade volumes are sensitive to the choice of elasticities of substitution. As for the welfare impact, social welfare gains in the benchmark results are quite robust as sector-by-sector elasticities of substitution, by both Hummels (2001) and Rolleigh (2008), do not quantitatively change the magnitude of welfare changes obtained in the benchmark simulation.

The rest of this paper is organised as follows. Section 2 presents an overview of bilateral trade relationship between Australia and India. Section 3 presents the general equilibrium model, and Section 4 details the sectoral disaggregation and the calibration of the model. Section 5 shows the benchmark results, while the results of our policy experiments are shown in Section 6. The conclusions of the study are presented in Section 7.

2. Background

The trading relationship between Australia and India is important to both countries and is growing rapidly. India has grown faster than any of the other top 30 markets over the past five years. It is also the fastest growing major export market – with both goods and services exports increasing by an annual average of over 32% in the last five years. In 2009, merchandise exports to India have grown strongly to an estimated US$14.5 billion which would place India as Australia's fourth largest merchandise export market after China, Japan and South Korea. On the other hand, imports from India in 2009 was around US$2.0 billion, making Australia's trade surplus with India the second largest only after Japan. As a fraction of total merchandise trade, India accounted for 8.1% of Australia's exports and 0.9% of its imports.

Table 1. Top 10 Australian exports to India and Indian tariffs.

Top exports	HS code	Value (million US$)	Tariff rate
Precious/semi-precious stones	71	3481.6	12.5%
Mineral fuels, oils and distillation	27	2096.0	52.4%
Ores, slag and ash	26	1016.7	5.0%
Wool products	51	125.2	13.5%
Lead and articles	78	88.4	12.5%
Nuclear machinery and appliances	84	79.3	12.2%
Edible vegetables and roots	07	76.8	30.0%
Copper and articles	74	64.4	12.5%
Aluminium and articles	76	59.6	12.5%
Iron and steel	72	55.9	20.0%

In terms-of-trade composition, Australia is basically an exporter of mining products and fuel products with mining and fuel exports alone taking almost 90% of the Australian exports to India. On the other hand, Australia mainly imports machinery equipment, mining products and textile products. Table 1 and Table 2 contain more detailed information regarding the composition of top imports and exports for Australia (taken from UN Comtrade) as well as respective bilateral tariff rates (simple average) for 2007.

Finally, it is important to note that Australia has a relatively low tariff rate schedule. The average tariff rates on agricultural and manufacturing goods stand at 1.4% and 4.1%, respectively, with the weighted average tariff rate implied by the data around 2.41%. However, there are some sectors that are more protected than others, such as textiles (HS code 63), and iron and steel (HS code 73) with implied tariff rates of 6.2% and 5.3%, respectively. On the other hand, India's tariff rates are much higher than those of Australia, with the average tariff rate for manufacturing goods around 12.1% and for agricultural goods around 40.8%. The manufacturing sector continues to be protected by relatively high tariff barriers, especially in textiles and clothing (22.5%), and automobiles (33.6%). While the weighted average tariff rate is around 23.4%, some sectors are subject to tariff rates as prohibitive as 52%. The two biggest Australian exports to India, precious and semi-precious stones (HS code 71) and mineral fuels, oils and distillation items (HS code 27) are subject to tariff rates of 12.5% and 52.4%, respectively. Our tariff rates are comparable to the average unweighted tariff rate of 3.2% and 17.6% for Australia and India, respectively, as reported by CIE (2008).

Table 2. Top 10 Australian imports from India and Australian tariffs.

Top imports	HS code	Value (million US$)	Tariff rate
Precious/semi-precious stones	71	150.1	1.7%
Electrical machinery and equipment	85	149.4	1.8%
Nuclear reactors and machinery	84	68.6	3.3%
Iron or steel	73	62.3	5.3%
Made-up textile articles	63	42.7	6.2%
Organic chemicals	29	42.3	1.8%
Articles of leather	42	41.7	4.5%
Coffee, tea and spices	09	41.5	0.0%
Vehicles other than railway	87	37.2	0.0%
Pharmaceutical products	30	33.3	0.0%

3. The model

3.1. *Overview*

The model we use is a standard static applied general equilibrium model that follows the tradition of Shoven and Whalley (1984). We disaggregate the Australian economy into seven sectors: mining, fuel, other primary, textile, machinery, other manufactures and services.[3] There are several agents in the Australian economy: households, different types of producers through inter-industry linkage, a domestic government and foreign trade partners. For the foreign sector, we distinguish India and the rest of the world (ROW) as distinct trade partners. We provide a more detailed explanation of their features below.

3.2. *Domestic production firms*

We assume that the final goods are produced combining a locally produced component and imported components. The former is produced by domestic production firms. They use intermediate inputs from all sectors in fixed proportions, and also combine capital and skilled and unskilled labour using a Cobb–Douglas technology for output. The production function of a domestic firm producing good i is

$$y_{i,d} = \min\left\{\frac{x^d_{1,i}}{a^d_{1,i}}, \ldots, \frac{x^d_{i,i}}{a^d_{i,i}}, \ldots, \frac{x^d_{n,i}}{a^d_{n,i}}, \beta_i k_i^{\alpha_i} \ell_i^{1-\alpha_i}\right\}, \tag{1}$$

$\forall i = 1, \ldots, n \in \mathsf{G_P}$, the set of production goods; $y_{i,d}$ is the output of the domestic firm i, $x^d_{m,i}$ is the amount of intermediate inputs of good m used in the production of good i, $a^d_{m,i}$ is the unit-input requirement of intermediate good m in the production of good i, and k_i and ℓ_i are, respectively, the capital and labour inputs used to produce good i.

3.3. *Final production goods firms*

The firm that produces final production good i combines the domestic component with the imported goods using an Armington aggregation technology:

$$y_i = \gamma_i \left[\delta_{i,d} y_{i,d}^{\rho_{m,i}} + \sum_{f \in \mathsf{T}} \delta_{i,f} y_{i,f}^{\rho_{m,i}}\right]^{\frac{1}{\rho_{m,i}}}, \tag{2}$$

where $\sigma_{m,i} = 1/(1 - \rho_{m,i})$ is the elasticity of substitution between domestic and imported goods (note that we allow for possibly different elasticities of substitution for different production goods), y_i is the output of final good i, $y_{i,d}$ is the domestic component in final good i and $y_{i,f}$ is the imported component from each of the trade partners. Note that when $\rho_{m,i} \to 0$, the production function takes a standard Cobb–Douglas form, i.e. $y_i = \gamma_i \left[y_{i,d}^{\delta_{i,d}} \times \prod_{f \in \mathsf{T}} y_{i,f}^{\delta_{i,f}}\right]$. Finally, imports of good i from country f are subject to an *ad valorem* tariff rate $\tau_{i,f}$. Our choice of the Armington aggregator form is motivated by the fact that it is the most extensively used in the literature and we would like our model structure (and the results generated by it) to be comparable with the wide majority of previous studies.

3.4. *Consumption goods firms*

We assume that the goods that the households purchase are different from the goods that production firms purchase in their intra-industries transactions. In particular, the goods that consumers purchase have a very high service component embedded in them. Therefore, we assume that consumers purchase goods that we label as 'consumption goods'. The consumption goods firms combine the final production goods using a fixed-proportion technology:

$$y_{i,c} = \min\left\{\frac{x^c_{1,i}}{a^c_{1,i}}, \cdots, \frac{x^c_{i,i}}{a^c_{i,i}}, \cdots, \frac{x^c_{n,i}}{a^c_{n,i}}\right\}, \tag{3}$$

where $\{1, 2, \ldots, n\} \in \mathsf{G_c}$, the set of consumption goods. We make an additional assumption that $x^c_{i,j} = 0$ for $i \neq j$, *services*. This implies that for consumption good i, the firm only uses as inputs final goods of its own sector and services.

3.5. *Investment good firm*

In a dynamic model, agents save in order to enjoy consumption in the future. In our static set-up, we introduce an investment good in order to account for the savings observed in the data. That is, agents derive utility from consuming the investment good, just as they derive utility from the consumption goods. Investment good y_{inv} is produced by a firm that combines the final goods as intermediate inputs using a fixed-proportion technology, as shown below:

$$y_{\text{inv}} = \min\left\{\frac{x_{1,\text{inv}}}{a_{1,\text{inv}}}, \cdots, \frac{x_{i,\text{inv}}}{a_{i,\text{inv}}}, \cdots, \frac{x_{n,\text{inv}}}{a_{n,\text{inv}}}\right\}. \tag{4}$$

The investment good is sold to the households, government and foreigners, such that in our model the aggregate savings are equated to the aggregate investment.

3.6. *Consumers*

Household preferences are represented by a Cobb–Douglas utility function defined over the consumption goods and savings (or the investment good). The problem of a representative household is

$$\max \sum_{i\in\mathsf{G_C}} \theta_i \log c_i + \theta_{\text{inv}} \log c_{\text{inv}} + \sum_{f\in\mathsf{T}} \theta_{\text{inv},f} \log c_{\text{inv},f} \tag{5}$$

$$\text{s.t.} \sum_{i\in\mathsf{G_C}} p_{c,i} c_i + p_{\text{inv}} c_{\text{inv}} + \sum_{f\in\mathsf{T}} e_f \bar{p}_{\text{inv},f} c_{\text{inv},f} = (1-\tau_d)(w\bar{\ell} + r\bar{k}),$$

where c_i is the consumption of good i by the household, $p_{c,i}$ is the price of consumption good i, τ_d is the direct tax rate imposed on the household income, w and r are, respectively, the wage rate for labour and the rental rate of capital, and $\bar{\ell}$ and $\bar{k}$ are, respectively, the endowments of labour and capital.

Since this is a static set-up, we model household savings as purchases of the investment good. Thus, c_{inv} represents the purchases of the investment good, and p_{inv} is the price

of the investment good. Additionally, if Australia is running a trade surplus with a trade partner, we model this as household purchase of a foreign investment good (i.e. Australian households are saving abroad). Then, $c_{\text{inv},f}$ represents the purchases of the investment good from country f, $\bar{p}_{\text{inv},f}$, its price (which is assumed to be exogenous), and e_f is the bilateral real exchange rate.

3.7. *The government*

A look at the national accounts shows that the government makes purchases of goods and services and also that it runs fiscal surpluses or deficits. To account for these observations, we follow the standard practice in the literature[4] and assume that, in the model, the government is an agent that enjoys utility from consuming the production goods and the investment good. Purchases of these goods must be financed by the revenues collected from direct and indirect taxes and tariffs imposed on imports.

The problem of the government is then

$$\max \sum_{i\in \mathsf{G_P}} \theta_i^g \log c_i^g + \theta_{\text{inv}}^g \log c_{\text{inv}}^g \tag{6}$$

$$\text{s.t.} \sum_{i\in \mathsf{G_P}} p_i c_i^g + p_{\text{inv}} c_{\text{inv}} = \tau_d(w\bar{\ell} + r\bar{k}) + \sum_{i\in \mathsf{G_P}} t_{p,i}\, p_{d,i}\, y_{i,d} + \sum_{i\in \mathsf{G_C}} t_{c,i}\, p_{c,i}\, y_{i,c} + \sum_{f\in \mathsf{T}} \sum_{i\in \mathsf{G_P}} \tau_{i,f} e_f \bar{p}_{i,f} y_{i,f}.$$

The left-hand side of the budget constraint of the government includes the purchases of final goods and the investment good. The right-hand side of the equation includes the tax and tariff revenues: the first term is the direct taxes collected from the households' income; the second and third terms are the revenues collected from taxing the domestic and consumption goods firms, respectively; and the last term represents the tariff revenues collected. Note that we are not imposing any exogenous conditions to the government's budget constraint which implies that the government can run budget surplus or deficits.

3.8. *Foreign trade partners*

In our model, Australia trades with two trade partners: India and the ROW. We denote the set of trade partners by $\mathsf{T} = \{\text{Ind},\ \text{ROW}\}$. In each one of these trade partners $f \in \mathsf{T}$ there is a representative household that purchases imported goods $x_{j,f}$ ($j \in \mathsf{G_P}$) from Australia, and consumes their local good $x_{f,f}$. The problem of the representative household in the foreign country f is

$$\max \left[\sum_{j\in \mathsf{G_P}} \theta_{j,f} x_{j,f}^{\rho_x} + \theta_{\text{inv},f} x_{\text{inv},f}^{\rho_x} + \theta_{f,f} x_{f,f}^{\rho_x} \right]^{-\frac{1}{\rho_x}} \tag{7}$$

$$\text{s.t.} \sum_{i\in \mathsf{G_P}} (1+\tau_i^f) p_i x_{i,f} + p_{\text{inv}} x_{\text{inv},f} + e_f x_{f,f} = e_f I_f\,,$$

where τ_i^f is the *ad valorem* tariff rate that country f imposes on the imports of good i, ρ_x is the parameter that determines the exports elasticity of substitution σ_x (i.e. $\sigma_x = 1/(1-\rho_x)$), e_f is the bilateral real exchange between Australia and country f, and I_f is the exogenous income of the household in country f. As we model Australia as a small open economy, it cannot affect world prices and therefore the foreign prices and foreign income are given exogenously. However, we let the balance of payments to be endogenously determined through the bilateral exchange rates and allow for possible trade deficits or surpluses. If a particular trade partner is running a trade surplus with Australia, we model these savings as foreign purchases of the Australian investment good $x_{\text{inv},f}$. Vice versa, if Australia runs a trade surplus with a trade partner j, these surpluses are considered as Australian purchases of a foreign investment good $c^j_{\text{inv},f}$.

3.9. *Definition of equilibrium*

An equilibrium for this economy is a set of prices for the domestic goods $\{p_{i,d}\}_{i\in \mathsf{G_p}}$; prices for the final goods $\{p_i\}_{i\in \mathsf{G_p}}$; a price for the investment good p_{inv}; prices for the consumption goods $\{p_{c,i}\}_{i\in \mathsf{G_c}}$; factor prices w, r; bilateral exchange rates $\{e_f\}_{f\in \mathsf{T}}$; foreign prices $\{\bar{p}_{i,f}\}_{i\in \mathsf{G_p},\ f\in \mathsf{T}}$; a consumption plan for the household $\{c_i, c_{\text{inv}}, c_{\text{inv},f}\}_{i\in \mathsf{G_c},\ f\in \mathsf{T}}$; a consumption plan for the government $\{c_i^g, c_{\text{inv}}^g\}_{i\in \mathsf{G_p}}$; a consumption plan for the household in country f $\{x_{i,f}, x_{\text{inv},f}, x_{f,f}\}_{i\in \mathsf{G_p},\ f\in \mathsf{T}}$; a production plan for the domestic good i firm $(y_{i,d}, x^d_{1,i}, \ldots, x^d_{n,i}, k_i, \ell)$; a production plan for the final good i firm $(y_i, y_{i,d}, \{y_{i,f}\}_{f\in \mathsf{T}})$; a production plan for the investment good firm $(y_{\text{inv}}, x_{1,\text{inv}}, \ldots, x_{n,\text{inv}})$; a production plan for the consumption good i firm $(y_{i,c}, x^c_{1,i}, \ldots, x^c_{n,i})$; such that, given the tax rates and the tariff rates:

(1) The consumption plan $\{c_i, c_{\text{inv}}, c_{\text{inv},f}\}_{i\in \mathsf{G_c},\ f\in \mathsf{T}}$ solves the problem of the household.
(2) The consumption plan $\{c_i^g, c_{\text{inv}}^g\}_{i\in \mathsf{G_p}}$ solves the problem of the government.
(3) The consumption plan $\{x_{i,f}, x_{\text{inv},f}\}_{i\in \mathsf{G_c}}, x_{f,f}$ solves the problem of the representative household in country f.
(4) The production plan $(y_{i,d}, x^d_{1,i}, \cdots, x^d_{n,i}, k_i, \ell_i)$ satisfies

$$y_{i,d} = \min\left\{\frac{x^d_{1,i}}{a^d_{1,i}}, \cdots, \frac{x^d_{i,i}}{a^d_{i,i}}, \cdots, \frac{x^d_{n,i}}{a^d_{n,i}}, \beta_i k_i^{\alpha_i}\ell_i^{1-\alpha_i}\right\} \quad \text{and}$$

$$(1+t_{p,i})p_{i,d}y_{i,d} - \sum_{j\in \mathsf{G_p}} p_j x^d_{j,i} - w\ell_i - rk_i \le 0, \ = 0 \ \text{ if } \ y_{i,d} > 0.$$

(5) The production plan $(y_i, y_{i,d}, \{y_{i,f}\}_{f\in \mathsf{T}})$ satisfies

$$p_i y_i - p_{i,d}y_{i,d} - \sum_{f\in \mathsf{T}}(1+\tau_{i,f})e_f\bar{p}_{i,f}y_{i,f} \le 0, \ = 0 \ \text{ if } \ y_i > 0,$$

where $y_{i,d}$ and $\{y_{i,f}\}_{f\in \mathsf{T}}$ solve

$$\min \ (1+t_{p,i})p_{i,d}y_{i,d} + \sum_{f\in \mathsf{T}}(1+\tau_{i,f})e_f\bar{p}_{i,f}y_{i,f}$$

$$\text{s.t.}\ \ \gamma_i \left[\delta_{i,d} y_{i,d}^{\rho_{m,i}} + \sum_{f \in \mathsf{T}} \delta_{i,f} y_{i,f}^{\rho_{m,i}} \right]^{\frac{1}{\rho_{m,i}}} = y_i \,.$$

(6) The production plan $(y_{\text{inv}}, x_{1,\text{inv}}, \ \ldots\ , x_{n,\text{inv}})$ satisfies

$$y_{\text{inv}} = \min \left\{ \frac{x_{1,\text{inv}}}{a_{1,\text{inv}}}, \ \cdots\ , \frac{x_{j,\text{inv}}}{a_{i,\text{inv}}}, \ \cdots\ , \frac{x_{n,\text{inv}}}{a_{n,\text{inv}}} \right\} \ \text{and}$$

$$p_{\text{inv}} y_{\text{inv}} - \sum_{j \in \mathsf{G_p}} p_j x_{j,\text{inv}} \leq 0, = 0 \ \text{ if } \ y_{\text{inv}} > 0 \,.$$

(7) The production plan $(y_{i,c}, x_{1,i}^c, \ldots, x_{n,i}^c)$ satisfies

$$y_{i,c} = \min \left\{ \frac{x_{1,i}^c}{a_{1,i}^c}, \ \cdots\ , \frac{x_{i,i}^c}{a_{i,i}^c}, \ \cdots\ , \frac{x_{n,i}^c}{a_{n,i}^c} \right\} \ \text{and}$$

$$(1 + t_{c,i}) p_{i,c} y_{i,c} - \sum_{j \in \mathsf{G_p}} p_j x_{j,i}^c \leq 0, \ = 0 \ \text{ if } \ y_{i,c} > 0$$

(8) The factor markets clear:

$$\sum_{i \in \mathsf{G_p}} \ell_i = \bar{\ell}, \qquad \sum_{i \in \mathsf{G_p}} k_i = \bar{k} \,.$$

(9) The goods markets clear:

$$y_i = \sum_{j \in \mathsf{G_p}} x_{j,i}^d + \sum_{j \in \mathsf{G_c}} x_{j,i}^c + x_{j,\text{inv}} + c_i^g + \sum_{f \in \mathsf{T}} x_{i,f} \,,$$

$$y_{i,c} = c_i \,,$$

$$y_{\text{inv}} = \sum_{j \in \mathsf{H}} c_{\text{inv}}^j + c_{\text{inv}}^g + \sum_{f \in \mathsf{T}} x_{\text{inv},f} \,.$$

(10) The balance of payments condition for each trade partner country f is satisfied:

$$\sum_{i \in \mathsf{G_p}} e_f \bar{p}_{f,i} y_{i,f} + \sum_{j \in \mathsf{H}} e_f \bar{p}_{\text{inv},f} c_{\text{inv},f}^j = \sum_{i \in \mathsf{G_p}} p_i x_{i,f} + p_{\text{inv}} x_{\text{inv},f} \,.$$

Table 3. Sectoral disaggregation of the Australian economy.

Seven sectors	Input–output sectors
Mining	Iron and non-ferrous metal ores, other mining, services to mining, iron and steel
Fuel	Coal, oil and gas, petroleum and coal products
Other primary	Sheep, grains, beef, dairy, fishing, pigs, poultry, other agriculture, meat products, forestry, services to agriculture, dairy, fruit and vegetable, oils and fats, cereal foods, bakery, confectionery, other food products, soft drinks, beer, wine, spirits and tobacco
Textile	Textile fabrics and products, clothing, footwear, knitting products, leather products
Machinery	Motor vehicles, ships, aircraft, railway, photography, household appliances, electronics, other electrical equipment, agricultural, mining and construction machinery, other machinery and equipment
Other manufactures	Sawmill products, other wood products, pulp, paper, printing, publishing, paints, basic chemicals, furniture, pharmaceuticals, detergents, cosmetics, other chemical products, rubber, plastic, glass, ceramics, cement, other concrete, structural metal, sheet metal, other non-metallic mineral products, fabricated metal, basic non-ferrous metals, prefabricated buildings, other manufacturing
Services	Electricity, gas, water, residential building construction, other construction, construction trade, wholesale trade and mechanical repairs, other wholesale repairs, retail trade and mechanical repairs, road and rail and water and air transport, other retail repairs, accommodation, services to transport, communication, banking, non-bank finance, insurance, services to finance, dwellings, other property services, computer services, legal and business services, other business services, defence, government administration, education, health, radio and television services, community services, arts, recreational services, personal services, other services

4. Calibration

We calibrate the parameters of the model so that, in equilibrium, the agents of the model replicate the same transactions that their counterparts in the real world perform which helps us trust the policy implications that it generates.

4.1. *Sectoral disaggregation*

As mentioned earlier, the main objective of this paper is to quantify the impact of trade liberalisation reforms on the different productive sectors. Thus, an important factor in this analysis is to find the correct level of sectoral disaggregation. We use a variety of criteria to determine the specific sectors. In particular, we consider the relative importance of a sector in the total economy, the level of tariff protection that the sector enjoys, the differential between India's tariff rate and the Australian tariff rate, the relative importance of the sector in the total imports or exports, and the historical importance of some particular sectors, detailed, for example, in Trade Policy Review (2007) for Australia and India, produced by the WTO. The sectoral disaggregation of seven sectors we choose for Australia is shown in Table 3.

First, we separate the mining sector as it accounts for more than 60% of Australian exports to India as well as more than 20% of Australian imports from India. In terms of the HS code, the mining sector would include: precious/semi-precious stones (HS code 71), ores, slag and ash (HS code 26), and iron and steel (HS code 72). Our second disaggregated sector is the fuel sector as it is not only the second biggest export sector for Australia

(29% of Australian exports to India), but also one of the most protected sector in the Indian economy with tariff rates higher than 50%. Other primary industries are all grouped into 'Other primary' and this sector also enjoys a high level of protection in India. As for manufacturing sectors, we take out the textiles sector as it is not only one of the main imports from India (around 17.5% of total imports from India), but also the sector that is most heavily protected in Australia, with average tariff rates more than twice the industry average. In terms of the HS code, the textiles sector would include: leather articles (HS code 42), wool and animal hair (HS code 51), and other made-up textile articles (HS code 63). Next, the machinery sector was extracted due to its importance in the imports of Australia as well as its relatively high tariff rates. In the HS code, the machinery sector would include: nuclear machinery and appliances (HS code 84) and electrical machinery and equipment (HS code 85) which are the second and third largest import items from India, respectively. The remaining manufacturing sectors were grouped into 'Other manufactures'.

4.2. *Social accounting matrices*

The construction of an applied general equilibrium model requires that all the parameters that govern the preferences of the agents and the technologies of the firms, as well as the different tax rates and tariff rates must be numerically specified. In order to calibrate the parameters, we use a social accounting matrix (SAM) for Australia. Most of the parameters, such as the input shares and total factor productivity scale parameters in the production functions and the parameters in the agents' utility functions, can be directly calibrated from the SAM using the optimality and market clearing conditions. Appendix 1 contains the values of the calibrated parameters in the model economy.

A SAM is a record of all the transactions that take place in an economy, typically during a one-year period. It provides a snapshot of the structure of production, where the rows record the receipts of a particular agent and the columns represent the payments made by the agents. Depending on the data availability, it can provide a very disaggregated level of institutional detail, with different types of firms, levels of government, households that differ in basic demographic characteristics and several trade partners. The use of SAMs can be traced back to Quesnay (1759) and more recently to Stone (1947), the architect of the United Nations System of National Accounts. Given the richness of information contained in them, SAMs have been commonly and extensively used in applied general equilibrium models designed to analyse policy reforms (see e.g. Kehoe 1996).

Since a SAM for Australia is not readily available, we construct one ourselves that would suit the level of disaggregation that our analysis requires, using the latest available input–output table for the year 2005 and combining it with additional data from a variety of sources. Our SAM is presented in Appendix 2.

4.3. *Other parameters*

For those parameters that cannot be calibrated from the data, we explain below how we choose those values.

4.3.1. *Trade partners' income*

The incomes of the trade partners are extracted from the *International Financial Statistics* published by the International Monetary Fund, and we use gross domestic product (GDP) as our measure of income. In the data, the GDP of India and Australia in 2008 is $1.24 and

Table 4. Tariff rates.

Sector	Australian tariffs (τ_i)	Indian tariffs (τ_i^{IND})	ROW tariffs (τ_i^{ROW})
Mining	1.16%	10.92%	0.03%
Fuel	0.03%	52.38%	0.76%
Other primary	1.46%	30.00%	21.98%
Textile	10.64%	13.49%	7.72%
Machinery	2.16%	12.19%	2.23%
Other manufactures	1.87%	12.50%	0.57%
Services	0.00%	0.00%	0.00%

$1.07 trillion dollars (USD), respectively. Taking the global GDP as $62.25 trillion dollars, the GDP of the 'ROW' is calculated as $59.94 trillion dollars.

4.3.2. *Tariff rates*

The tariff rates that Australia imposes on the imports from its trade partners are extracted directly from the SAM. To determine the tariff rates that the trading partners impose on imports from Australia, the most recent editions of the *Trade Policy Reviews* by WTO (2007a, 2007b) are used. To determine the tariff rates imposed by the 'ROW', we assume that the tariffs from the ROW are a simple average of the tariffs imposed by top 10 bilateral trading partners of Australia.[5] The tariff rates imposed by Australia and its trading partners are shown in Table 4. Note that our effective tariff rates in the service sector is zero which is different from CIE (2008) that introduces some positive tariff rates in the service sector.

4.3.3. *Elasticities of substitution*

Given the static nature of our model, the elasticities of substitution for exports and imports cannot be calibrated directly from the SAM. Instead, we set different sets of values for these parameters. For our 'benchmark' case, we set $\rho_{m,j} = 0.8 \ \ \forall j \in \mathsf{G_p}$, and $\rho_x = 0.9$, implying elasticities of import and export substitution of 5 and 10, respectively. Additionally, we take two sets of values from the literature, one from Hummels (2001) and the other from Rolleigh (2008). In his article, Rolleigh (2008) calibrates these parameters by choosing the value of the elasticities to match the sectoral gross output mark-ups in the United States. On the other hand, Hummels (2001) constructs a multisectoral trade model and empirically estimates the relationship between freight rates and distance between trade partners and uses this relation to infer the elasticities of substitution for different production sectors in the United States. As we are currently not aware of any estimates in the Australian context, we use those results from these two sets of parameters in our sensitivity experiments. The values used are shown in Table 5.

Note that Rolleigh (2008) only provides estimates for the elasticities of substitution of manufacturing industries. As a result, we use the same value of $\rho_{m,j}$ for the other primary goods as the one used in Hummels (2001). Moreover, when any sector in our disaggregation does not exactly correspond to a sector in either Rolleigh or Hummels (e.g. in the case of 'Other manufactures'), we arrange their disaggregation to fit ours by taking simple averages of the corresponding elasticities of substitution. Finally, for all cases, the export elasticity of substitution ρ_x is fixed to be 0.9.

Table 5. Import elasticities of substitution ($\rho_{m,j}$).

Sector	Hummels (2001)	Rolleigh (2008)
Mining	0.73	0.89
Fuel	0.50	0.95
Other primary	0.78	0.78
Textile	0.86	0.92
Machinery	0.87	0.81
Other manufactures	0.79	0.88
Services	0.80	0.80

5. Benchmark results

This section presents the results from the benchmark simulation which examines the aggregate as well as sectoral impact of FTA between Australia and India where bilateral tariffs are instantaneously eliminated.[6]

5.1. *Aggregate macroeconomic and welfare impact*

Table 6 below shows the per cent change in aggregate production and aggregate exports and imports for Australia as well as changes in different aggregate prices upon removal of the tariff barriers.

As projected, trade liberalisation with India leads to higher exports and imports for Australia. In the aggregate, exports increase by 1.61%, while the magnitude of increase in imports is twice the size at 3.20%. Higher increases in imports over exports are also documented in CIE (2008), although the magnitude is smaller at 0.8% and 0.5%, respectively. Higher trade volumes also benefit the production side, as we note that the total domestic production increases by 0.31%, while the total final production increases further by 0.57%. The numbers are comparable or even higher than the results provided by CIE (2008) that projected an increase in real GDP of 0.33% in the year following liberalisation. In terms of prices,[7] trade liberalisation leads to slight increases in the rental rate of capital and the wage rate which reflects higher demand for factor inputs. Finally, the terms of trade improve significantly with India and modestly with the ROW. The changes in the terms of trade are consistent with the report by CIE (2008) which also predicts an appreciation of the Australian dollar.

Table 6. Effect of trade liberalisation on aggregate variables.

	% change
Total exports	1.61
Total imports	3.20
Total domestic production	0.31
Total final production	0.57
Rental rate (r)	0.02
Wage (w)	0.17
Terms-of-trade (with India)	28.15
Terms-of-trade (with the ROW)	0.09

Table 7. Effect of trade liberalisation on welfare.

Institution	Change in welfare
Consumer welfare	0.31%
Government welfare	0.74%
Social welfare	0.41%

5.1.1. *Welfare*

In this section, we examine the impact of trade liberalisation on the Australian national welfare. For welfare analysis, we construct a real income index that uses both the consumer real income index and the government real income index to look at the aggregate welfare index which provides a richer layer of policy implication for the aggregate as well as disaggregated sectors. The consumer real income index is given by $\prod_j c_j^{\theta_j}$, where j ranges over the consumption goods and the investment good. Similarly, the government real income index is given by $\prod_j c_{g,j}^{\theta_{g,j}}$, where j ranges over the production goods and the investment good consumed by the government. The social real income index is defined as $\prod_j \mathbb{C}_j^{\Theta_j}$, where $\mathbb{C}_j = c_j + c_{g,j}$ and $\Theta_j = \frac{c_j + c_{g,j}}{\sum_j c_j + \sum_j c_{g,j}}$. This equivalent variation will measure how much additional income consumers would require under the base prices in order to achieve the same level of utility as in the base simulation.

It is interesting to note that both the government and the consumers gain from the trade liberalisation. The former is attributed to higher government tax revenues from increases in domestic production, despite tariff revenue losses (by a magnitude of 1.20%), whereas the latter gain is a result of lower prices of imports (as shown in the fall of consumption goods prices in Section 5.2.1) and increases in disposable income by the households (as shown in the increase in the rental rate and wages). In the aggregate, the overall social welfare increases by 0.41%, as shown in Table 7. Our quantitative results are comparable to the welfare gain reported by CIE (2008) which projects 3.1% increase in real consumption over a 20 year period.

5.2. *Sectoral impact*

5.2.1. *Consumption goods prices*

Table 8 below shows the per cent change in the price of consumption goods after Australia and India sign an FTA. Generally, in terms of overall changes, there is a small decrease in the consumption goods prices from the trade liberalisation, primarily in the main import

Table 8. Effect of trade liberalisation on consumption goods prices.

Sector	Price change
Mining	−0.04%
Fuel	−0.08%
Other primary	−0.01%
Textile	−0.20%
Machinery	−0.17%
Other manufactures	−0.08%
Services	0.05%

Table 9. Effect of trade liberalisation on domestic production.

Sector	% change
Mining	−1.70
Fuel	10.71
Other primary	0.01
Textile	−1.08
Machinery	−0.29
Other manufactures	−1.02
Services	0.08

sectors. The fall in the consumption goods prices will benefit the consumers and play a role in the consumer welfare gain as shown previously. Quantitatively, since the imports from India take a small fraction of the total imports in Australia, the magnitude of fall in the consumption goods prices is small. The largest fall takes place in the textiles sector that had the highest level of protection among the primary and manufacturing sectors, followed by the machinery sector which was the biggest import sector from India.[8]

5.2.2. *Domestic production*

Table 9 below shows the per cent change in the domestic production for different sectors in Australia. The largest increase in domestic production takes place in the fuel sector with an increase of 10.71%. The sectoral shift in production patterns from trade liberalisation is evident in the case of Australia as the export-intensive fuel sector absorbs more resources (including capital and labour) away from the rest of the economic sectors.

5.2.3. *International trade*

Table 10 and Table 11 show the per cent change in exports and imports for Australia, respectively. The average exports of all primary and manufactured goods to India increase by 33.24%. On a disaggregate level, the exports to India increase in the fuel and other primary sectors, with the largest gain shown in the fuel sector with an increase of around 470%. This reflects the fact that the two sectors were the most heavily protected sectors in India prior to liberalisation. All other sectors, on the other hand, exhibit large decrease in exports to India, indicating sectoral shifts in exports similar to domestic production. In contrast, the exports to the ROW decrease by 0.44%, on average, with not much significant changes sector by sector.

Table 10. Effect of trade liberalisation on exports.

Sector	% change (India)	% change (ROW)	% change (total)
Mining	−76.29%	−0.43%	−5.04%
Fuel	470.30%	0.01%	28.64%
Other primary	15.63%	−0.72%	0.27%
Textile	−69.68%	1.25%	−3.07%
Machinery	−73.02%	1.11%	−3.40%
Other manufactures	−72.55%	0.06%	−4.36%
Services	−91.66%	−1.32%	−6.82%

Table 11. Effect of trade liberalisation on imports.

Sector	% change (India)	% change (ROW)	% change (total)
Mining	260.09	−1.22	0.89
Fuel	282.80	11.12	13.33
Other primary	271.75	0.50	2.70
Textile	466.13	−0.74	3.05
Machinery	283.03	0.06	2.36
Other manufactures	275.18	−0.61	1.62
Services	246.76	0.79	2.78

The imports from India, on the other hand, record a significant increase of the order of 285.22% with increases taking place in all disaggregated sectors which reflects favourable terms of trade for Australia, reported in the previous section. On a sectoral level, the largest increase in imports takes place in the textiles sector which reflects the high trade barriers set by Australia. Unlike exports, imports from the ROW show a small increase of 0.90%. It is interesting to note that, by sector, the imports in the fuel industry from the ROW jump by more than 11%. Our results confirm those reported by CIE (2008), where Australia is projected to experience an increase in imports for all sectors, while the signs are mixed in the exports.

Finally, in order to quantify the magnitude of trade creation, we find that the total bilateral trade flow volumes for Australia with India and the ROW increase by 67.37% and 0.30%, respectively. Combining all trade partners together, Australia trades 2.47% more in the global economy.

6. Numerical experiments

With the benchmark simulation as a reference, we conduct several numerical experiments in this section, each of which explores the implications on prices, production, trade and welfare.

6.1. *Partial liberalisation*

First, we look at a case that we label as 'partial' liberalisation. In the benchmark numerical experiment, bilateral tariffs between Australia and India were instantaneously removed. However, in reality, trade liberalisation takes place over a transition period. Perhaps, more realistically, the countries involved follow a carefully sequenced time agenda where they gradually lower tariff rates. For a recent Australian experience, Siriwardana (2007) mentions that 86% of all import commodities became tax-free when the FTA with the United States came into effect in 2005, with the rest of the tariff barriers scheduled to be removed over 17 years. In order to simulate this gradual liberalisation, we look at the most recent cases of countries that signed FTAs with Australia: New Zealand, Malaysia, Singapore and Thailand. For each country, we calculate the tariff elimination rate[9] which corresponds to our disaggregated sectors, and apply the average rate to the potential FTA with India. Table 12 summarises the tariff elimination rates applied for the disaggregated sectors which are used to simulate the partial liberalisation scenario.[10]

Table 12. Tariff elimination rate.

Sector	Elimination rate
Mining	52.17%
Fuel	100.00%
Other primary	90.24%
Textile	69.16%
Machinery	85.25%
Other manufactures	86.37%

6.1.1. *Consumption goods prices*

Table 13 below shows the per cent change in the price of consumption goods shortly after Australia and India sign an FTA. Similar to the full liberalisation case, there is a small decrease in the consumption goods prices from the trade liberalisation. Since imports from India take a small fraction of the total imports in Australia, the magnitude of fall in the consumption goods prices is quantitatively small. The largest fall still takes place in the textiles sector which had the highest level of protection among primary and manufacturing sectors, followed by the machinery sector which was the biggest import sector from India.

6.1.2. *Domestic production*

Table 14 below shows the per cent change in the total sectoral domestic production for Australia. The largest increase in domestic production takes place in the fuel sector with an increase of 11.26%. Compared to the case of full liberalisation, the increase in the domestic production of the fuel sector is larger under partial liberalisation. This is due to the fact that under the partial liberalisation, some sectors have higher tariff elimination rates than others. The sectoral shift in domestic production from trade liberalisation is more evident in the case of Australia as the export-intensive fuel sector experiences higher production at the expense of the rest of the economic sectors.

6.1.3. *International trade*

Table 15 and 16 show the per cent changes in exports and imports for Australia under partial liberalisation. The average exports of all primary and manufactured goods to India increase by 31.45%. On a disaggregate level, the exports to India increase only in the fuel sector with an increase of around 493%. All other sectors, on the other hand, show a significant decrease in exports to India, indicating sectoral shifts in exports. Interestingly, exports of

Table 13. Effect of partial liberalisation on consumption goods prices.

Sector	Price change
Mining	−0.04%
Fuel	−0.08%
Other primary	−0.01%
Textile	−0.17%
Machinery	−0.16%
Other manufactures	−0.08%
Services	0.04%

Table 14. Effect of partial liberalisation on domestic production.

Sector	% change
Mining	−1.82
Fuel	11.26
Other primary	−0.29
Textile	−1.01
Machinery	−0.27
Other manufactures	−1.04
Services	0.07

Table 15. Effect of partial liberalisation on exports.

Sector	% change (India)	% change (ROW)
Mining	−85.18	−0.41
Fuel	492.86	0.03
Other primary	−9.92	−0.67
Textile	−79.10	0.92
Machinery	−76.54	1.07
Other manufactures	−75.89	0.08
Services	−91.83	−1.24

other primary goods decrease under the partial liberalisation. In contrast, the overall exports to the ROW decrease by 0.41% without significant changes sector by sector.

The total imports from India, on the other hand, record a sizeable increase of 269.40% with increases in imports in all disaggregated sectors. On a sectoral level, the largest increase in imports takes place in the textiles sector which reflects the high trade barriers set by Australia. Unlike exports, imports from the ROW show a small increase of 0.91%.

Finally, in order to quantify the magnitude of trade creation, we found that the total bilateral trade flow volumes for Australia with India and the ROW increase by 63.68% and 0.32%, respectively. Combining all trade partners together, Australia trades 2.37% more in the global economy.

6.1.4. *Welfare*

In this section, we examine the impact of the partial trade liberalisation on the Australian national welfare. It is interesting to note that the consumer welfare gain from the partial

Table 16. Effect of partial liberalisation on imports.

Sector	% change (India)	% change (ROW)
Mining	242.97	−1.37
Fuel	277.24	11.65
Other primary	260.90	0.17
Textile	372.92	−0.66
Machinery	269.74	0.06
Other manufactures	263.07	−0.66
Services	239.97	0.74

Table 17. Effect of partial liberalisation on welfare.

Institution	Change in welfare
Consumer welfare	0.31%
Government welfare	0.75%
Social welfare	0.41%

liberalisation remains unchanged from that of full liberalisation, while the government welfare gain is slightly higher under the partial liberalisation. The overall social welfare gain at 0.41% is also identical to the full liberalisation scenario, as shown in Table 17.

6.2. *Sector-by-sector elasticity of import substitution*

A potential problem with the Armington aggregator specification is that the elasticities of substitution cannot be calibrated directly from the data sources, but instead need to be assigned exogenously, and in the benchmark simulation, all the elasticities of substitution (for both imports and exports) were assumed to be uniform across sectors. To overcome this caveat, we conduct several sensitivity analyses to check for the robustness of the benchmark results by allowing the Armington elasticities of import substitution to be differentiated by sector. For sectoral import elasticities, we take the estimated numbers from Hummels (2001) and Rolleigh (2008), as shown in Table 5.

6.2.1. *Consumption goods prices and domestic production*

Table 18 and Table 19 show the per cent changes in the price of consumption goods and total domestic production when the Armington elasticities of import substitution are differentiated sector by sector, rather than set uniformly for all sectors at $\rho_{m,j} = 0.8 \quad \forall j$. When we take sector-by-sector elasticities given by Hummels (2001), the quantitative implications are not significantly different from the benchmark results as the average of ρ_m for the main import sectors is 0.76 for Australia. With the values given by Rolleigh (2008), however, the average elasticities are higher around 0.86.

At disaggregated levels, the higher the elasticities of substitution, the larger the corresponding impact on the price of consumption goods. Hence, with parameters estimated by Rolleigh (2008), the magnitude of price declines in the fuel sector and the textiles sector is 9.0 and 2.2 times larger than those estimated by Hummels (2001). We note that under

Table 18. Effect of full liberalisation on consumption goods prices ($\sigma_{m,i} \neq \sigma_{m,j}$).

Sector	% change (Hummels)	% change (Rolleigh)
Mining	−0.01	−0.03
Fuel	−0.04	−0.36
Other primary	0.01	0.02
Textile	−0.30	−0.65
Machinery	−0.23	−0.12
Other manufactures	−0.08	−0.06
Services	0.07	0.05

Table 19. Effect of full liberalisation on domestic production ($\sigma_{m,i} \neq \sigma_{m,j}$).

Sector	% change (Hummels)	% change (Rolleigh)
Mining	−1.66	−1.94
Fuel	12.47	12.39
Other primary	0.13	0.78
Textile	−2.08	−7.24
Machinery	−1.35	−0.32
Other manufactures	−1.03	−1.37
Services	0.02	−0.02

different elasticity parameters suggested by Rolleigh (2008), the biggest changes in price occur in the textile and the fuel sectors. As for domestic production, the largest increase still takes place in the fuel sector, while most resources are taken away from the textiles sector as production decreases by an order as much as 7.24% in the case of Rolleigh (2008).

6.2.2. *International trade*

Table 20 and Table 21 show the per cent changes in the volume of exports and imports for Australia using elasticities given by Hummels (2001) and Rolleigh (2008). The average exports of all primary and manufactured goods to India increase by 49.24% under Hummels (2001) and a sizeable 124.40% under Rolleigh (2008). On a disaggregate level, the exports to India increase in the fuel sector and other primary sector. The increase in exports in the fuel sector is as large as 867.18% under Rolleigh (2008). In contrast, the overall exports to the ROW decrease by 0.69% and 0.06% under Hummels (2001) and Rolleigh (2008), respectively.

The imports from India, on the other hand, record a significant increase by 410.02% under Hummels (2001) and by an explosive 973.94% under Rolleigh (2008). The latter figure is as large as 3.5 times the benchmark scenario. Imports from the ROW show a small increase between 0.68% and 0.87%.

Finally, in order to quantify the magnitude of trade creation, we find that the total bilateral trade flow volumes for Australia with India and the ROW increase by 98.24% and 0.07%, respectively, under Hummels (2001). The corresponding figures for Rolleigh (2008) are staggering at 239.49% with India and at 0.46% with the ROW. Combining all

Table 20. Effect of full liberalisation on exports ($\sigma_{m,i} \neq \sigma_{m,j}$).

	India		ROW	
Sector	Hummels	Rolleigh	Hummels	Rolleigh
Mining	−73.41%	−60.96%	−0.84%	−0.58%
Fuel	583.23%	867.18%	−0.59%	2.88%
Other primary	29.83%	89.98%	−0.99%	−1.11%
Textile	−65.57%	−47.65%	2.12%	6.03%
Machinery	−69.43%	−55.77%	1.74%	0.53%
Other manufactures	−69.17%	−54.75%	−0.20%	0.04%
Services	−90.63%	−86.30%	−1.50%	−1.62%

Table 21. Effect of full liberalisation on imports ($\sigma_{m,i} \neq \sigma_{m,j}$).

	India		ROW	
Sector	Hummels	Rolleigh	Hummels	Rolleigh
Mining	146.54%	561.19%	−1.18%	−0.84%
Fuel	80.56%	5761.38%	12.74%	13.14%
Other primary	213.37%	165.30%	0.70%	1.39%
Textile	987.03%	3749.95%	−1.64%	−7.42%
Machinery	614.12%	216.46%	−0.80%	0.22%
Other manufactures	233.13%	499.83%	−0.53%	−0.58%
Services	226.93%	170.19%	0.83%	0.84%

Table 22. Effect of full liberalisation on welfare ($\sigma_{m,i} \neq \sigma_{m,j}$).

Institution	% change (Hummels)	% change (Rolleigh)
Consumer welfare	0.32%	0.31%
Government welfare	0.79%	0.72%
Social welfare	0.43%	0.41%

trade partners together, Australia trades 3.25% more under Hummels (2001) and 8.19% more under Rolleigh (2008).

6.2.3. *Welfare*

In this section, we examine the impact of the trade liberalisation on the Australian national welfare. It is interesting to note that despite changes in the elasticities which result in large swings in trade volumes, welfare gains do not change much compared to the benchmark case for both types of elasticities chosen. The changes in social welfare are shown in Table 22.

7. Conclusion

This paper analyses the potential sectoral effects of trade liberalisation. We use a calibrated applied general equilibrium model as our tool of analysis and apply it to the special case of Australia and India signing an FTA as it provides a natural case of a small open economy being opening up to a fast-growing economy. Our structural model also enables us to simulate alternative policy reforms such as a 'partial' liberalisation scenario and more realistic trade elasticities, and compare the quantitative effects of these trade-liberalisation policies on the prices of disaggregated sectors as well as social welfare.

The predictions of the model are consistent with trade-liberalisation experiences observed in the past, with domestic production increasing in the export sectors and prices falling in the import sectors. Australian exports to India record moderate increases and become heavily concentrated in fuel exports, while imports show much significant growth, especially in those sectors that were originally more protected.

The impact on the national welfare is small but positive with a larger welfare increase for the government than for the aggregate consumers. The magnitude of welfare increase is also robust to different estimates of import elasticities.

As any model, our model abstracts from several important issues. Among others, due to the static nature of the model, this paper is not designed to capture the dynamic aspects of trade-liberalisation policies, and thus, some important dimensions of trade-liberalisation reforms, such as capital flows, foreign direct investment and productivity gains and losses across sectors, are beyond the scope of this paper. Adding dynamic features would help our model to shed light on these issues and capture the long-term effects that these types of trade-liberalisation reforms encompass. Another interesting extension would be to quantify the distributional impact of these trade-liberalisation reforms on different household groups in Australia: high-skilled households versus low-skilled ones, or comparisons on the welfare gains of urban versus rural households. Cho and Díaz (2011) conduct a distributional analysis combining household expenditure survey results into an applied general equilibrium framework, taking the case of Slovenia's ascension into the European Union. Adding distributional features to our model would further enrich our welfare analysis. Finally, another important issue that our experiment does not address explicitly regarding the FTA deals the rules of origin requirements which might mitigate the quantitative impact of our simulations. In fact, according to Brenton and Manchin (2003), countries usually stipulate highly technical rules of origin to prevent trade deflection, where goods from non-participating countries initially enter through the low-tariff free-trade partners and then redirected to circumvent the payment of customs duties. The textiles sector is a fine example which entails strict requirements for such rules of origin. For this reason, Jayasuriya and Panza (2011) also suggest that the nature of rules of origin plays a critical role in understanding the impact of FTAs. Tackling these issues in a general equilibrium set-up raises several exciting questions for future research.

Notes

1. In August 2008, a feasibility study of the free trade agreement between Australia and India has been published at the Department of Foreign Affairs and Trade, and since then the two countries have progressed to the current negotiation phase (CIE 2008).
2. There are also studies on the possible trade liberalisation between Australia, India and South Africa. See Siriwardana (2006b) and Siriwardana (2009).
3. A detailed description of the industries included in each sector is provided in the next section.
4. See, for example, Whalley (1982) or Kehoe (1996).
5. The top 10 trading partners of Australia, excluding India, are China, Germany, Japan, Korea, Malaysia, New Zealand, Singapore, Thailand, the United Kingdom and the United States.
6. While our analysis is of comparative statics nature, our general equilibrium model structure allows the government budget and the balance of payments to be endogenously determined, while the existence of an investment good firm will equate aggregate savings and investment. Thus, our results are long-run simulations.
7. We normalise prices according to a price index based on consumption weights. That is, $\sum_{i \in \mathsf{G_C}} \theta_i p_{c,i} = 1$ which implies that changes in prices would then be termed changes in the real prices.
8. Note that the service sector, where tariff removal does not take place, will experience a modest gain in consumption goods prices.
9. Tariff elimination rate on a sector is calculated as the difference in the sum of tariff rates between 2005 and 2010 divided by the sum of tariff rates on a sector in 2010.
10. Note that in the 'full' liberalisation benchmark scenario, the elimination rate is 100% for all sectors.

Notes on contributors

Sang-Wook (Stanley) Cho is a senior lecturer at the School of Economics, University of New South Wales. He received his PhD degree from the University of Minnesota. His research interests are in dynamic macroeconomics and international economics.

Gordon Yoon is an economic and market analyst at the Land & Economic Development, Department of Lands, Planning and the Environment. He holds a bachelor degree in commerce (Honours in economics) from the University of New South Wales. His research interests include macroeconomics, international economics, housing market and government policy.

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Appendix A. Calibrated parameters

Table A1. Preference parameters (θ) – aggregate consumer and government.

	Consumer	Government
Mining	0.0000	0.0000
Fuel	0.0177	0.0000
Other primary	0.1040	0.0019
Textiles	0.0304	0.0000
Machinery	0.0562	0.0000
Other manufactures	0.0537	0.0249
Services	0.4898	0.7090
Investment goods	0.2480	0.2643

Table A2. Domestic goods firm parameters (α, β).

	α	β
Mining	0.6680	5.3637
Fuel	0.8487	6.0043
Other primary	0.6307	13.1214
Textiles	0.3987	110.2586
Machinery	0.2943	27.3712
Other manufactures	0.4123	12.7100
Services	0.4297	3.0269

Table A3. Armington aggregators (γ, δ).

	γ	δ_{dom}	δ_{India}	δ_{ROW}
Mining	2.0361	0.5760	0.0910	0.3331
Fuel	1.8664	0.6630	0.0279	0.3091
Other primary	1.9819	0.5793	0.1084	0.3122
Textiles	2.6781	0.4092	0.1996	0.3912
Machinery	2.6322	0.4037	0.2079	0.3884
Other manufactures	2.3001	0.4956	0.1347	0.3697
Services	1.8284	0.6147	0.1066	0.2787

Appendix 2. Social accounting matrix (unit: million AU$)

		PRODUCTION							CONSUMPTION							Labour	Capital	Consumption	Government	Investment	Exports (total)	Exports (ROW)	Exports (India)	TOTAL
		Mining	Fuel	Other Agriculture	TCF	Machinery	Other Manufacture	Service	Mining	Fuel	Other Agriculture	TCF	Machinery	Other Manufacture	Service									
PRODUCTION	Mining	14906	2856	287	26	4904	21560	4709	3	0	0	0	0	0	0	0	0	0	0	878	15467	14525	942	65595
	Fuel	3708	19789	2385	52	166	2808	23093	0	9082	0	0	0	0	0	0	0	0	0	0	27027	25381	1645	88109
	Other Agriculture	84	27	57299	1258	38	1961	25419	0	0	60206	0	0	0	0	0	0	0	372	5466	23792	22344	1448	175921
	TCF	121	47	523	5291	266	1432	5110	0	0	0	18634	0	0	0	0	0	0	0	2108	2576	2419	157	36109
	Machinery	1451	1773	1826	0	24051	1233	49092	0	0	0	0	30502	0	0	0	0	0	0	69825	9647	9060	587	189399
	Other Manufacture	2832	1698	11277	349	7417	58441	80379	0	0	0	0	0	27715	0	0	0	0	4823	8727	26784	25153	1631	230441
	Service	14458	17850	54056	15275	65593	68073	150406	0	316	5720	600	4363	3452	275577	0	0	0	137475	140222	44646	41928	2718	998084
CONSUMPTION	Mining	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
	Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11239	0	0	0	0	0	11239
	Other Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65926	0	0	0	0	0	65926
	TCF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19281	0	0	0	0	0	19281
	Machinery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35635	0	0	0	0	0	35635
	Other Manufacture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34064	0	0	0	0	0	34064
	Service	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	310449	0	0	0	0	0	310449
VA - Labour		6793	2785	9045	277	5431	17021	365316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	406668
VA - Captal		13668	15625	15446	184	2265	11943	275283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	334413
Household		0	0	0	0	0	0	0	0	0	0	0	0	0	0	406668	334413	0	0	7698	0	0	0	748779
Government		190	9629	14324	4185	6361	3263	365	0	1841	0	46	770	2896	34872	0	0	114969	0	0	0	0	0	193911
Direct Tax		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114969	0	0	0	0	0	114969
Indirect Taxes		104	9825	14186	3205	4788	2463	365	0	1841	0	46	770	2896	34872	0	0	0	0	0	0	0	0	75361
Tariffs (total)		86	4	138	980	1573	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3581
Tariffs (ROW)		85	4	137	972	1560	794	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3552
Tariffs (India)		1	0	1	8	13	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29
Capital		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	149514	51241	0	34169	34169	0	234924
Imports (total)		7383	15832	9454	9212	72907	42708	18913	0	0	0	0	0	0	0	0	0	7698	0	0	0	0	0	184107
Imports (ROW)		7323	15704	9377	9137	72316	42362	18760	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	174979
Imports (India)		60	128	77	75	591	346	153	0	0	0	0	0	0	0	0	0	7698	0	0	0	0	0	9128
TOTAL		65596	88109	175921	36109	189399	230441	998084	3	11239	65926	19281	35635	34064	310449	406668	334413	748779	193911	234924	184107	174979	9128	1783658