Trade Liberalization in a Small Open Economy: An Application of the Overlapping Generations and Multi-sector Computable General Equilibrium Model to Australia

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Abstract

This paper investigates the effects of trade liberalization on economic performance and welfare in Australia (as a small open economy) by an overlapping generations and multi-sector computable general equilibrium (CGE) model. In this model, decisions of domestic agents, including households, government and producers are both intra- and inter-temporally consistent under the key assumptions that they are endowed with perfect foresight about future prices, all markets are perfectly competitive and production activities are characterized by the technology of constant return to scale.

While the household sector covers several generations and the production sector consists of several industries that can change their behaviors, the government is relatively passive in the model, just performing tax collection and spending, supposed to be predetermined. All imports into Australia are imposed on them a product specific tariff rate while goods leaving Australia are subject to an export duty. Trade liberalization is defined as the reduction in import duty and/or subsidizations. All conditions in the world market, such as price of goods and services and interest rate are exogenous to Australia.

For simplicity, we assume that there is only population growth. As a result, once the economy reaches a steady state equilibrium, all variables measured in per capita term stay unchanged. The economy moves from a steady state equilibrium to a new one if there is a change in exogenous variables. In this research, we focus on examining the effects of trade policy through changes in tariff and/or subsidy rates. Our model explains dynamically how the economy adjusts and incorporates leisure in consumers' utility, making our structure far different from existing CGE models used in international trade.

In general, a fall in import duty has a positive while a reduction in subsidy has negative impact on the Australian economy, for example, welfare, output, labor employment, accumulation of capital stock and trade balance. However, these results are uneven across industries and household generations. Findings of the papers are consistent with mainstream trade theories and realistic facts in Australia, implying the possibility to use the model for policy analyses and prediction. Moreover, the model can be extended in several dimensions to analyze other issues.

Key words: Australia, computable general equilibrium model, overlapping generations, liberalization, multi-sector, subsidy, tariff, trade policy.

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1 Introduction

Australia has moved very quickly towards full liberalization through ambitious engagements in bilateral, regional and global trading frameworks as well as via its unilateral actions. Consequently, it is well integrated to the world economy and is widely recognized as an open country. Market access for Australian exports has been expanded substantially, chances to buy cheap imports have been improved and flows of capital, labors and other production factors into and out of Australia have been facilitated significantly. However, as a small open economy, Australia has become more strongly affected by changes in and shocks from the world market that are external and exogenous to its economy and its domestic firms have had to face more severe competitive pressures. Hence, the commercial policy needs to clarify how the economy reacts to exogenous conditions if further liberalization is carried out. Applied economic models including computable general equilibrium (CGE) models are widely used in policy discussion in Australia.

CGE models have been developed for half of the century. (Dixon 2006) summarizes CGE models have been used to analyze the effects on several economic variables such as welfare, environment, employment, price, distribution after changes in policy, public consumption, taxation, technology and price. The evolution of CGE models has been contributed continuously by theoretical and empirical researches on model specifications and application. Recently, the significant development of CGE models is through large scale computing projects. Regional and even world wide data sets are collected in order to run such models. Starting as static and simple structure models, CGE models were limited to explaining simultaneous facts. For this reason, the extension of CGE models to cover dynamic or inter-temporal decisions in consumption, saving or investment and to incorporate multi-level, multi-sectoral and multi-regional issues has made CGE models become a more realistic and powerful tool in analyzing facts and forecasting the future. Similar to other areas, CGE models used to investigate the effects of trade liberalization have played a more substantial role in research and practical implication, thanks to their ability of incorporating different sources of data and running large scale structure as well as their flexibility in employing theoretical literature. These advantages are especially significant in the age of globalization and regionalization. Though there is splendid CGE model based empirical research concerned with these impacts and most of them come to the conclusion that in general opening policy has positive impact, they are mainly related to the static or atemporal effects. The most fundamental development of the world in the last decade is through the Global Trade Analysis Project (GTAP) which is basically also a static CGE model. In the Australian context, a large proportion of CGE models including large-scale general equilibrium models such as ORANI, MONASH and some econometrically estimated models do not employ a dynamic structure of overlapping generations. As a result, some important trade issues related to the dynamic structure of overlapping generations still await analysis.

In line with the current evolution of CGE models, in this paper, we develop an overlapping generations and multi-sector CGE model for Australia as a small open economy. To our knowledge, this is the first time an overlapping generations (OLG) and multi-sector structure has been combined to investigate the effects of trade liberalization in Australia. Basically, the household sector is populated by several overlapping generations while the production sector includes several industries. Tobin's theory on investment (Hayashi 1982) is used to explain more exactly the investment decision of producers. Hence, we can build up a model for Australia, largely different from recently developed CGE models in Australia and in the world as well.

The model is used to analyze how changes in commercial policy impact our national output, sector specific output, accumulation of the capital stock, labor use, welfare and trading activities such as imports and exports. Moreover, as the model is extended to cover several production sectors and generations, this could help to describe the facts in more detailed at industry and age specific level.

The paper consists of seven parts. The Introduction is followed by Part 2 which describes key points in the commercial policy and trade performance of Australia. Part 3 presents the main structure of the CGE model used for programming and analysis. Part 4 describes how the data is collected, processed and calibrated. Part 5 exhibits the computation algorithm for finding equilibriums. Part 6 shows results of policy simulations. The paper closes up with policy implications and conclusion.

2 Australia and trade liberalization

2.1 Trade performance of Australia

Trade has been widely accepted to be very essential to Australia's economy and its people. Trade can be defined to cover any activities of exchanging consumable goods/services or production factors. Therefore, besides traditional trade in goods and services, flows of capital and labors as well as information (such as intellectual rights, patents...) are also integral parts of modern trade. Since our model is limited to trade in goods and services only, trading of production factors, (such as foreign direct investment or portfolio investment, labor mobility...) are not mentioned in the research.

International trading activities in Australia have continued to grow strongly for the last decade, reaching over $500 billions in recent years. Although trade deficit has dominated in most of years, the trade imbalance is very small, about 2% of total trade volume. Trade generated jobs are estimated to exceed 2 millions.

Table 1 Australia's Trade Performance

	2004-05	2005-06	2006-07	2007-08 A$ million	2008-09	2009-10	% growth 2008-09 to 2009-10	% growth 5 year trend
Export volumes								
Goods	211,048	214,902	218,332	225,259	231,565	247,848	7.0	3.1
Services	44,015	45,462	48,163	51,761	52,877	51,699	-2.2	3.9
Total goods and services	**254,301**	**259,847**	**266,361**	**277,124**	**284,440**	**299,548**	**5.3**	**3.3**
Import volumes								
Goods	170,780	185,297	202,707	228,299	220,650	229,885	4.2	6.3
Services	42,834	43,961	47,403	58,041	56,170	60,759	8.2	8.0
Total goods and services	**213,470**	**229,128**	**249,951**	**286,328**	**276,819**	**290,642**	**5.0**	**6.6**
Total two-way trade volumes								
Goods	381,828	400,199	421,039	453,558	452,215	477,733	5.6	4.6
Services	86,849	89,423	95,566	109,802	109,047	112,458	3.1	6.0
Total goods and services	**467,771**	**488,975**	**516,312**	**563,452**	**561,259**	**590,190**	**5.2**	**4.9**
				Implicit price deflators				
Goods and services								
Total exports IPD	65.7	75.3	80.7	84.1	100.0	84.9	-15.1	6.4
Total imports IPD	89.2	92.1	91.4	90.1	100.0	88.8	-11.2	0.6
				Terms of trade				
Goods and services	73.7	81.8	88.3	93.4	100.0	95.6	-4.4	5.8

(a) For the differences in measuring trade under balance of payments basis vs recorded trade basis refer to this section in the Explanatory notes. (b) Reference year for chain volume measures is 2008-09.

Source: (DFAT 2010a)

China, Japan, United States and the Republic of Korean are the biggest trading partners of Australia. Australia's largest export markets are China, Japan and India (nearly half of total export volume) while Australia's largest import sources are China, US and Japan (one third of total import volume).

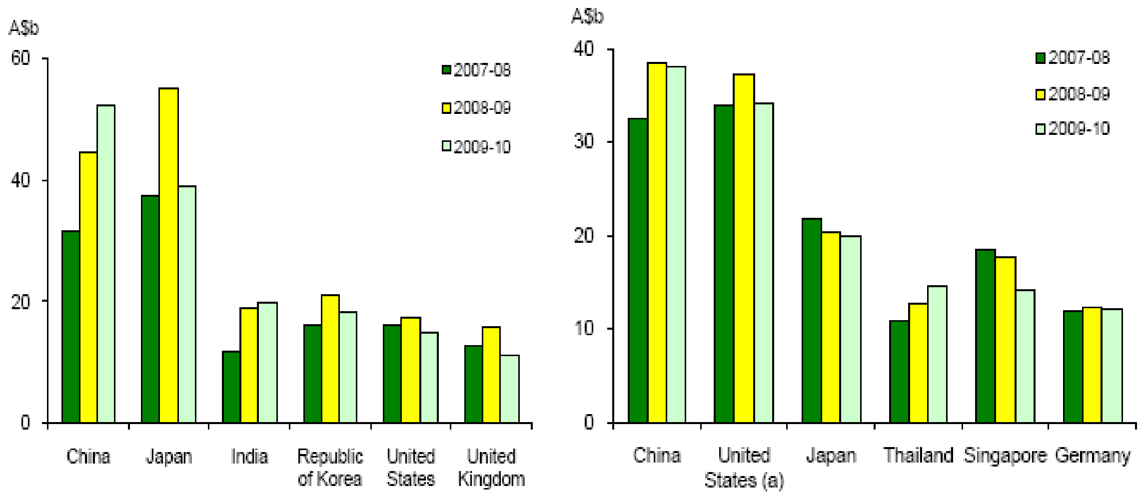

Figure 1 Major goods and services export markets and import sources

Source: (DFAT 2010a)

In the last decade, trade values have increased by around 8-9% annually. The growth rate of exports and imports are almost the same. Except for the year 2009-2010, trade deficits occurred in all periods but were very narrow. Terms of trade have grown at the annual rate of 6% thanks to the rise in export prices, especially those of raw materials.

Australia's principal exports are natural resources (coal, iron ore, gold, natural gas, crude petroleum, aluminum...), some services (education, personal travel) and some agricultural products (beef, wheat...) and major imports are personal travel/transport services, crude petroleum, motor vehicles, refined petroleum, gold and IT equipment. Countries in the Asia – Pacific Economic Forum (APEC) share 70% of Australia's trade volume.

Figure 2: Export and import values of Australia

Source: (DFAT 2010a)

The share of all exportable products except primary products have reduced gradually, reflecting the fact that Australia has become more dependent on natural resources in trading with the rest of the world. Primary products accounted for more than half of total exports. Top major export items are coal, iron ore and concentrates, education related travel service, gold, personal travel services, crude petroleum, natural gas, aluminium and copper ores and concentrates.

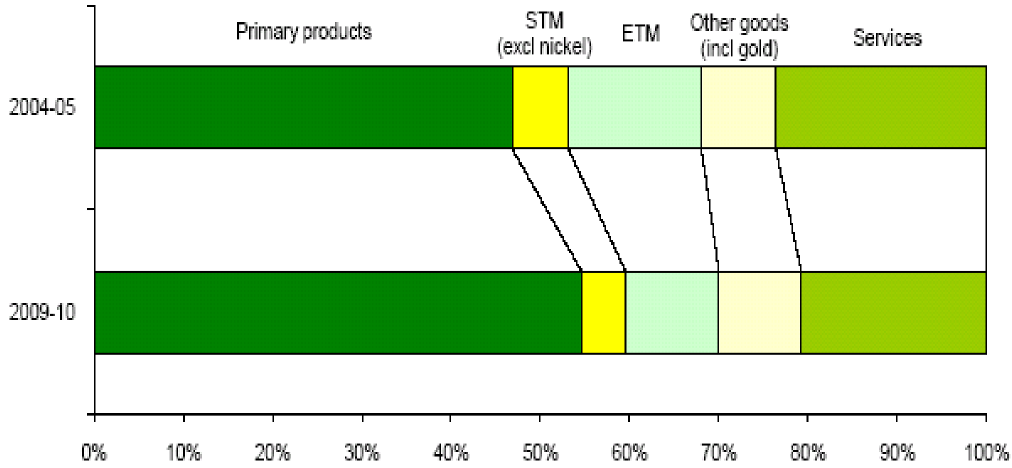

Figure 3: Broad composition of exports: 2004/2005 and 2009/2010

Source: (DFAT 2010a)

In contrast, primary products have a minority share in total imports. Manufactures dominate the basket of imports. In terms of single items, personal travel services, passenger motor vehicles, crude petroleum, refined petroleum, freight transport services are top five imports, which are followed by medicaments, gold, telecommunication equipment and parts, computers and good vehicles.

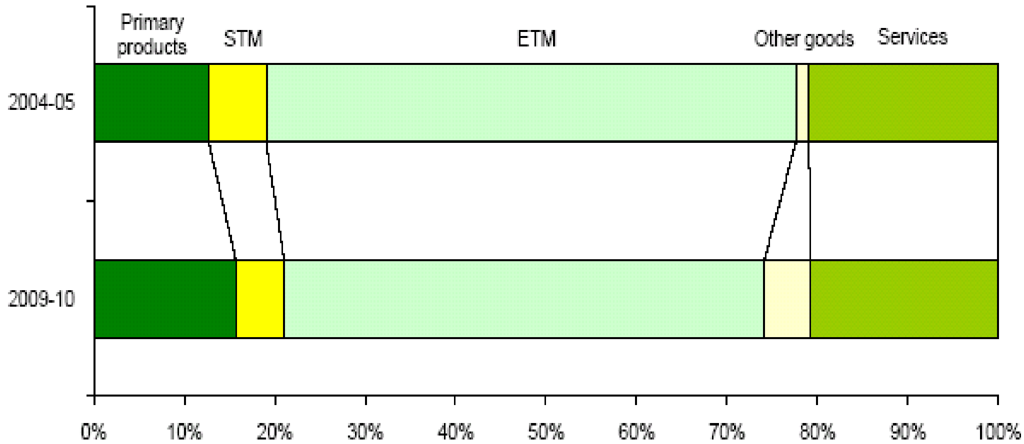

Figure 4: Broad composition of imports: 2004/2005 and 2009/2010

Source: (DFAT 2010a)

Although there is a fall in Australia's share in the world trading volume over the last past decades (mostly caused by substantial expansion of some emerging economies like the Republic of Korea, Taiwan, Singapore, Hongkong and recently China, India and Brazil...), the growth rate of exports and imports of Australia are relatively higher than those of some other developed economies.

2.2 Trade liberalization

Australia has a long history of following an open trade policy although before and after the World War II, Australia was regarded as a country with high rates of protection. Restrictive policy had carried over from the 1920s and the Great Depression years to protect domestic production from external competitions. During the 1950s, the main protection instrument was import licensing, strengthened by higher tariff rates than in any other later periods. Although import licensing measure were ended in 1962, there was no clear evidence about a fall in 1960s in average level of assistance – the indicator made of quantitative restrictions and tariff rates (Lloyd 2006). The decisive move from a protected to an open economy did not take place until the mid of 1970s. Under the pressure of high inflation and economic downturn, the 25% unilateral tariff decrease was implemented in 1973, that was followed by another essential subsequent reductions in tariffs and protection, especially those between the mid 1980s and the late 1990s. Consequently, they have lowered the average rate of protection to less than 5% (CIE 2009). Additionally, non-tariff measures such as quotas, assistance and barriers to some services were lifted year on year. Such changes have stated clearly the movement towards full liberalization of Australia (Leigh 2002).

According to (DFAT 2010b), Australia is now acknowledged internationally as a relatively open economy, with a low level of protection. Australia's trade policy aims to open new markets, reduce barriers to trade and foster market access for Australian goods and services. The Government is also working to improve competition, innovation and productivity within Australia. Australia is committed to fully participate in the global economy and supports an open, transparent and rules-based global trading system. The Government is pursuing improved market access for Australian exporters in global markets through multilateral, regional and bilateral frameworks. At the world level, Australia is an active member in trade negotiations in the World Trade Organization (WTO). At a regional level, the Government actively engages with the Asia-Pacific Economic Cooperation (APEC) forum and the Association of South East Asian Nations (ASEAN). Moreover, the Australian government also undertakes bilateral negotiations with key trading partners through comprehensive Free Trade Agreements (FTA) in order to promote stronger trade and commercial ties between participating countries, and open up opportunities for Australian exporters and investors to expand their business into key markets.

In fact, Australia supports strongly goals of the Doha Round in WTO in order to improve market access for Australia's exports, especially agriculture, industrial goods and services across all countries of the world. Significant initiatives to promote trade liberalization and facilitation have been proposed and actively implemented by Australia within WTO, APEC and some other international and regional forums. By 2010, Australia had signed six Free Trade Agreements (FTA), respectively with New Zealand (very early, 1983), Singapore (2003), Thailand and USA (2005), Chile (2009) and most recently with ASEAN (2010). Additionally, Australia is undertaking numerous FTAs negotiations with China, Japan, Malaysia, the Republic of Korea, Indonesia, the Gulf Cooperation Council (Saudi Arabia, Qatar, Bahrain, Oman, Kuwait, United Arab Emirates), Trans-Pacific Partnership Agreement and Pacific Agreement on Closer Economic Relations (PACER Plus). Once these agreements come into effect, Australia will have easy access to most major markets in the world. At the same time, they will also create good chances for Australian customers and producers to buy good and cheap products from the best providers. Economic benefits, job generation and especially competitiveness, productivity gains are projected to improve significantly after such liberalizing efforts.

Active participation in bilateral and regional liberalization is considered to be a good strategy to reinforce more efficiently multilateral trading systems and improve more quickly markets access to Australian firms and economic benefits to Australian people. Moreover, Australia has pioneered liberalizing the economy by a series of unilateral protection decline.

Consequently, the rate of protection has dropped significantly in the last two decades, making Australia be one of the most competitive markets in the world. According to (WTO 2007), despite the fact that tariffs have remained the substantial instruments of Australia's trade policy, their average rate has fallen dramatically thanks to Australia's unilateral reductions as well as commitments under bilateral, regional or global frameworks. The overall simple average applied Most Favored Nation (MFN) tariff rate was only 3.8% in 2006. Nearly half of all tariff lines are free and nearly 40% bear rates of below 5%. At the same time, assistances provided to encourage domestic production, those are in the form of tariff concessions, tax incentives, grants or concessional loans have been also gradually removed. Details about the structure of import duty and subsidy could be found in the Appendix on Tax Data.

3 Model Specifications

In this paper, we mix the pioneering models developed by (Auerbach and Kotlikoff 1987) and (Keuschnigg and Kohler 1995) to create a distinguished model for Australia. In the former model, that the economy is characterized by an overlapping generations household sector helps to explain more accurately the behavior of the consumers throughout their life time cycle. Hence, it is very useful for investigating consumption side related policies, for example, income tax, superannuation and consumption tax, etc. However, since the entire production sector is represented by a single producer, it fails to predict what would happen to alternative industries in the economy. Some distortions may also occur because of ignoring interactions amongst industries in the economy. In proceeding works, modelers have modified the original model in several dimensions but most of them are in the household sector.

In contrast, the latter model is represented by a multi-industry production sector. Although the household sector is also populated by overlapping cohorts, that they have time invariant death rate and do not retire makes the model not much different from models with a single household. Therefore, despite the possibility to provide industry specific analyses, it still suffers from some distortions. Apart from that, it fails to examine generation specific changes.

For above reasons, the combination of the two models is able to correct their limitations and takes into account their advantages. More importantly, it can help to develop an original model for Australia that can provide more reliable and comprehensive analyses. Accordingly, Australia is regarded as a small open economy which trades with the rest of the world (ROW). This assumption implies that Australia does not have power to affect the world market. Consequently, prices of imported and exported goods are exogenously given to Australia. The domestic interest rate is the same as the world interest rate because of free capital mobility across borders. Like many other models, all markets are perfectly competitive, all agents are price takers. And having perfect foresight, all agents correctly anticipate all future prices, enabling them to make decision for their entire surviving life time span and never have to revise their expectations.

The domestic economy consists of three agents: households, producers and government. The household sector is populated by cohorts who can live for several periods but with uncertain lifespans. Demographic features are assumed to be stationary, implying the cohort shares or age specific proportions in total population are constant over time. The growth rate of population of all age specific cohorts is the same and constant over time. All generations are facing age specific surviving probability to live upon next period of time. Results from the work by (Kudrna and Woodland 2011) are employed to characterize demographic features of the household sector in our model. Retirement is compulsory after households reach a certain age. Households make decisions on consumption and labor supply in order to maximize their expected life time utility.

The production industries are equipped with a constant return to scale technology to combine intermediate inputs and endowment factors, capital and labor to produce goods and services. Capital is produced by combining goods and services while labor is supplied by household sector. Capital is perfectly mobile across countries and industries while labor is only freely mobile across production industries of Australia. Each product is produced by a representative firm that aims at maximizing its present market value. Investment decision of firms is explained by the Tobin's theory of investment (Hayashi 1982).

The government is passive in the model, just performing tax collection, transfer payments, subsidy payment and spending, supposed to be predetermined. The government budget is assumed to be in balance in any period of time. Taxation occurs in the form of commodity use tax, individual income tax, value added output tax, tariffs and export tax. All imports into Australia are imposed a product and use purpose specific import duty while all exports leaving Australia are subject to a product specific export tax. The tax revenues are used to pay for government spending, supposed proportional to value added output and make transfers to households or subsidies to domestic producers.

Australia and ROW are linked through trading activities and capital mobility. Trade imbalance is mirrored by a corresponding balance in the capital account or vice versa. Commercial policy in Australia is represented by the level of tariff rates against imports and subsidy rates for domestic production.

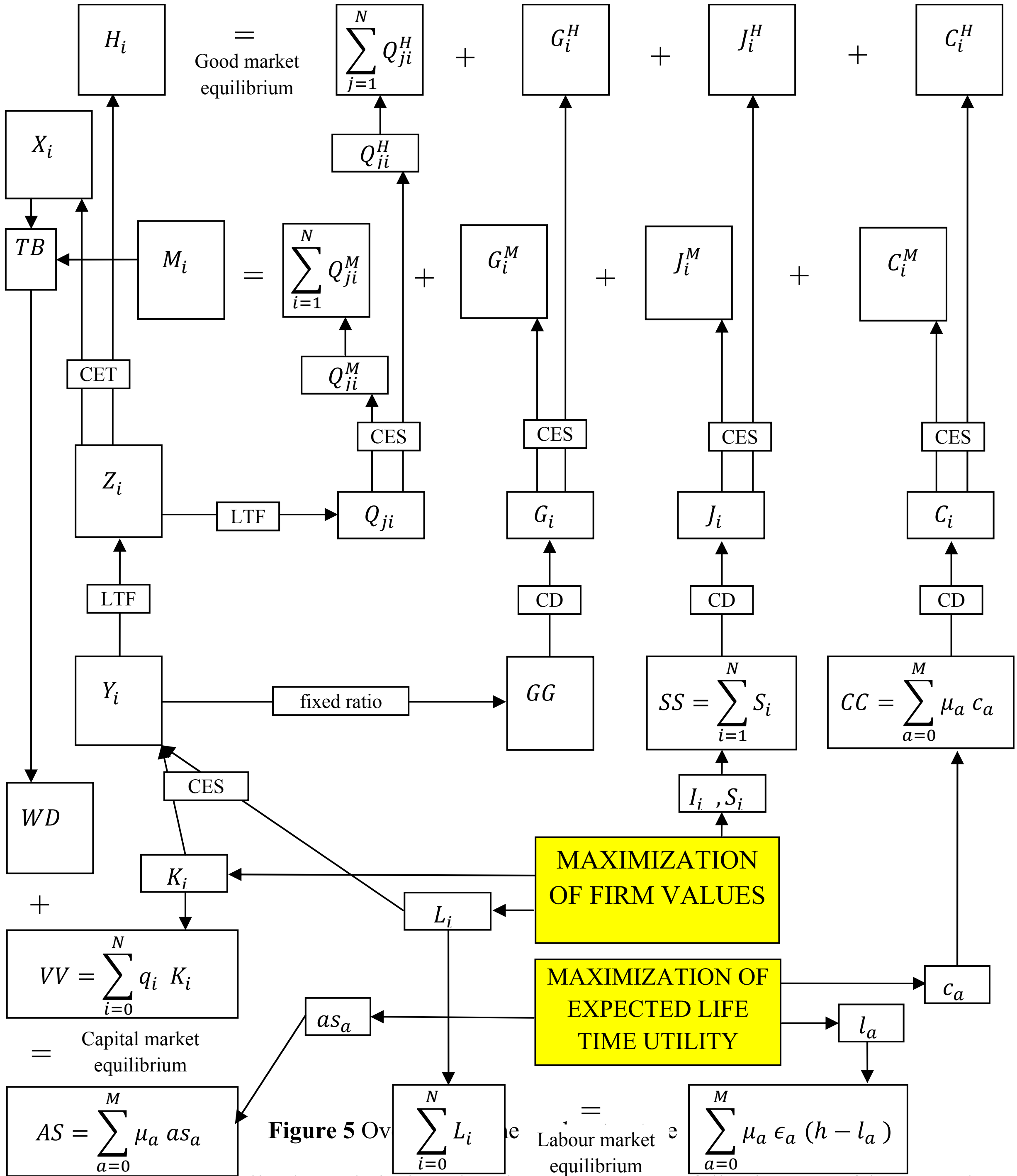

Figure 5 Ov... e ... e

To understand more easily the technical explanation in this paper, following use of letters and subscripts and superscripts to denote variables should be noted. Letters t, s, u are used to denote calendar time. Letters a, b are used to denote age of cohorts. Letters i, j, k are used to denote production sector or product. Additionally, letter U *or* C is used to identify household relevant variables. Letter F is used to identify firm relevant variables. Letter G is used to identify government relevant variables. Letter K is used to identify capital relevant variables. Letters I, J, S are used to identify investment relevant variables. Letter Q is used to identify intermediate input relevant variables. Letter *Z* is used to identify production output relevant variables. Letter *Y* is used to identify value added relevant variables. Letter *H* is used to identify home sold output relevant variables. Letter *M* is used to identify import relevant variables. Letter *X* is used to identify export relevant variables.

For behavioral variables, capital letters are used to denote variables characterizing aggregates (economy, industry, generation or whole population level) while lower case letters are used to denote variables characterizing individual level behaviors (household). For price variables, capital letters are used to denote prices of products while lower case letters are used to denote prices of production factors (interest rate, wage rate, capital shadow price…).

3.1 The household sector

Following (Keuschnigg and Kohler 1995) we model the behavior of households by a multi-level (or nested) structure. The principles from (Auerbach and Kotlikoff 1987) are used to describe decisions of cohorts at the top level but some unrealistic assumptions in the original models are dropped. Specifically, the modeling structure for the household sector by (Kudrna and Woodland 2011) that is a further developed version of (Auerbach and Kotlikoff 1987) is simplified to be used in our model. Accordingly, in any period, there are several coexisting generations of heterogeneous households. All households face lifespan uncertainty. At the end of each period, some fraction of each cohort dies[1] and there appears a newly born generation. Given the survival probabilities and assumption of stationary demographics, the age structure of the population is time invariant. However, the assumption of different income type households in (Kudrna and Woodland 2011) is ignored. It means all individuals have an identical life cycle working capacity profile in our model.

Each household starts life with zero assets and once reaching the maximum age would die without any left assets. If a household dies before the maximum age, their remaining assets would be equally redistributed to surviving households as an accidental bequest.

Given life-time income and price indexes, the objective of the households is to maximize their expected life-time well-being that is the discounted future utilities from consumption and leisure according to a time discount factor and survival probabilities. Retirement is compulsory after households reach a certain age[2]. In our model, households make decision on the number of working hours, consumption expenditure and saving for every year in their life, given the inter-temporal budget constraint and the intra-temporal time constraint. As a result, labor supply is endogenously determined by the households' decision on allocating their time for relaxing and working before the compulsory retirement age (after retirement, entire time is used for leisure). Productivity is age variant, characterized by a hump shaped profile like (Kudrna and Woodland 2011).

3.1.1 The top level

The expected life-time utility of a household who enters the economy in year t is characterized by a time separable and a nested structure:

$$Max: E(U_t\ ) = \frac{1}{1-\frac{1}{\gamma}} \sum_{a=0}^{M} ss_a\ (1+\beta)^{-a+1}\, u_{t,t+a}^{1-\frac{1}{\gamma}} \tag{1}$$

Subject to following life time budget constraint:

[1] Of which all of the oldest generation die

[2] Recently, retirement is optional. But in order to reduce computing burden, we assume that all individuals retire after the age of 65. This simplification does not affect much computing results because the actual proportion of working population who are older than 65 is very small (around 1%) and so ignorable.

$$\sum_{a=0}^{M} \frac{P_{t+a}^{C} c_{t,t+a}}{\left(1+(1-\tau i)r\right)^{a}} \leq \sum_{a=0}^{M} \frac{(1-\tau i)\epsilon_a w_{t+a}\left(h-l_{t,t+a}\right)+tr_{t,t+a}+be_{t,t+a}+ap_{t,t+a}}{\left(1+(1-\tau i)r\right)^{a}} \quad (2)$$

$$c_{t,t+a}, l_{t,t+a} \geq 0;\ h-l_{t,t+a} \geq 0;\ l_{t,t+a}=h\ \forall\ a \geq R \quad (3)$$

(R is the compulsory retirement age, and h is total annual time endowment)

And the asset evolution over life time is given by the law of motion:

$$as_{t,t+a+1} = \left(1+(1-\tau i)r\right)as_{t,t+a} + (1-\tau i)\epsilon_a w_{t+a}\left(h-l_{t,t+a}\right) + tr_{t,t+a} + be_{t,t+a} + ap_{t,t+a} - P_{t+a}^{C} c_{t,t+a} \quad (4)$$

$$as_{t,t} = as_{t,t+M+1} = 0 \quad (5)$$

Where $u_{t,t+a}$is the instantaneous felicity which is generated by a constant elasticity of substitution (CES) combination of the aggregate private consumption commodity, $c_{t,t+a}$ and leisure, $l_{t,t+a}$, $u_{t,t+a} = \left(c_{t,t+a}^{1-\frac{1}{\rho}} + \alpha l_{t,t+a}^{1-\frac{1}{\rho}}\right)^{\frac{1}{1-\frac{1}{\rho}}}$. Taste parameters in the expected utility function are inter-temporal elasticity of substitution (γ), intra-temporal elasticity of substitution (ρ), the subjective rate of time preference (β) and leisure distribution parameter (α). ss_a is the unconditional survival probability or the chance to live upon the age of a, calculated as a product of conditional survival probabilities between any two continuous ages before the age of a, ($ss_a = \prod_{b=0}^{a} s_b$, $s_0 = 1$ and $s_{M+1} = 0$).

The budget constraint implies that total discounted life time consumption cannot exceed total discounted life time income. Accordingly, asset holding of households at the beginning of any year, $as_{t,t+a+1}$ is determined by their asset holding in the previous year, $as_{t,t+a}$, the world interest rate, r , the composite price of the aggregate private consumption commodity, P_{t+a}^{C}, the aggregate private consumption, $c_{t,t+a}$, the flat income tax rate, τi_{t+a}, the wage rate for an effective labor unit, w_{t+a}, total annual time endowment, h, the age specific productivity ϵ_a , the benefit transfer from the government, $tr_{t,t+a}$, the age pension, $ap_{t,t+a}$ and the accidental bequest from left assets of dying households, supposed given to each individual, $be_{t,t+a}$. While age pension is provided only to retired households, being calculated based on the age of recipients (age specific pension coefficient, π_a) and the average wage rate ($ap_{t-a,t} = \pi_a w_t$, $a \geq R$), other benefit transfer payment which represents all other forms of income, welfare or allowance assistance is equally distributed to all working population ($tr_{t-a,t} = tr_t \ \ \forall\ a < R$). This practice reflects the fact that the largest program in the Australian transfer system is the income support for the aged while other programs such as Disability Support Pension, Parenting Payment, Carer Payment, Unemployed Assistance, and some allowances are much smaller and accessible for a wide range of ages (Harmer 2008).

Given the wage rates, interest rates, price of goods, benefit transfers from the government, age pension and tax rates (since we assume all markets are perfectly competitive and agents have perfect foresight), all households determine the level of aggregate private consumption commodity and working time throughout their life time when they start their economic life. The first order necessary condition gives us following relationship amongst aggregate private consumption commodity and leisure over time:

- Euler equation characterizing consumption evolution over time:

$$\frac{\frac{\partial E(U_t\ )}{\partial c^t_{t,t+a+1}}}{\frac{\partial E(U_t\ )}{\partial c^t_{t,t+a}}} = \frac{ss_{a+1}}{\beta} \frac{\frac{P^C_{t+a+1}}{\left(1+\left(1-\tau i\ \ \right)r\ \ \right)}}{P^C_{t+a}} \tag{6}$$

- Relationship between commodity consumption and leisure time allocation before the retirement age:

$$\frac{\frac{\partial E(U_t\ )}{\partial c^t_{t,t+a}}}{\frac{\partial E(U_t\ )}{\partial l^t_{t,t+a}}} = \frac{P^C_{t+a}}{\left(1-\tau i\ \ \right)\epsilon_a\, w_{t+a} hh} \tag{7}$$

Aggregation across households

We assume that aggregate private consumption commodity is homogeneous across individuals. Hence, the total demand for the aggregate private consumption commodity, CC_t is the sum of demand from all cohorts:

$$CC_t = \sum_{a=0}^{M} \mu_a c_{t-a,t} \tag{8}$$

Similarly, total asset holdings held by the household sector in any period, AS_t is the sum of individual assets of all generations:

$$AS_t = \sum_{a=0}^{M} \mu_a as_{t-a,t} \tag{9}$$

Total bequest, BE_t left at the end of period t is the sum of assets from dying population, $BE_t = \sum_{a=0}^{M} \mu_{a+1} be_{t-a,t}$ and is equally distributed to surviving households of this period:

$$BE_t = \sum_{a=0}^{M} \mu_a \left(1-s_{a+1}\right)\left[\left(1+\left(1-\tau i\ \ \right)r\ \ \right)as_{t-a,t} + \left(1-\tau i\ \ \right)\epsilon_a\, w_t\, \left(h - l_{t-a,t}\right) + tr_t + ap_{t-a,t} - P^C_t c_{t-a,t}\right] \tag{10}$$

Where μ_a is the proportion of the generation of age a. Since it is assumed that demographic features are stationary, we have (n is the population growth rate):

$$\mu_{a+1} = \frac{\mu_a s_{a+1}}{1+n} \tag{11}$$

3.1.2 The second level (Intra-temporal allocation)

Total expenditure for private commodity consumption is allocated for particular types of composite commodities. The total aggregate private consumption commodity, CC_t is defined by a nested CES function of industry specific composite commodities, C_{jt}. Accordingly, components are imperfectly substitutable, being determined by their relative price and elasticity of substitution.

$$CC_t = CES\big(C_{1,t}, \dots C_{j,t}, \dots C_{N,t}\big) \tag{12}$$

Given the amount of aggregate private consumption commodity, consumers minimize the cost to pay for it. In this case, we have a static optimization whose solution is the unit cost for CC_t or P_t^C as a dual CES (DCES) function of unit cost of industry specific composite commodities, $P_{i,t}^C$:

$$P_t^C = DCES \quad (P_{1,t}^C, \dots P_{i,t}^C, \dots P_{N,t}^C) \tag{13}$$

Via Shephard's Lemma, the demand for each industry specific composite commodity per unit of aggregate private consumption commodity is derived from its unit cost function:

$$\frac{C_{i,t}}{CC_t} = \frac{\partial P_t^C}{\partial P_{i,t}^C} \tag{14}$$

3.1.3 The third level (home and import allocation)

At the third level, total expenditure for each industry specific composite commodity, $C_{j,t}$ is allocated between home produced, $C_{j,t}^H$, and imported product, $C_{j,t}^M$ through an Armington CES structure:

$$C_{j,t} = CES\big(C_{j,t}^H, C_{j,t}^M\big) \tag{15}$$

Given the amount of industry specific composite commodity, each consumer minimizes the cost to pay for it. Similarly, in this case, we have a static optimization which leads to unit cost function for $C_{j,t}$ or $P_{j,t}^C$ as a dual CES function of price of imported and home produced product, $P_{j,t}^H, P_{j,t}^M$:

$$P_{j,t}^C = DCES \quad \big(P_{j,t}^H, P_{j,t}^M\big) \tag{16}$$

Via Shephard's Lemma, the demand for home produced and imported component per unit of each industry specific composite product is given by:

$$\frac{C_{j,t}^H}{C_{j,t}} = \frac{\partial P_{j,t}^C}{\partial P_{j,t}^H} \tag{17}$$

$$\frac{C_{j,t}^M}{C_{j,t}} = \frac{\partial P_{j,t}^C}{\partial P_{j,t}^M} \tag{18}$$

3.1.4 Aggregation in the household sector

- Total supply of labor is given in any period of time, LL_t^S:

$$LL_t^S = \sum_{a=0}^{M} \mu_a \epsilon_a \ \big(h - l_{t-a,t}\big) \tag{19}$$

- Household sector's total demand for home produced product: $C_{j,t}^H$

- Household sector's total demand for imported product: $C_{j,t}^M$

- Total tax payment to the government by the household sector, TAX_t^C

$$TAX_t^C = \sum_{j=1}^{N} \tau c_{j,t}^C C_{j,t}^H P_{j,t}^H + \sum_{j=1}^{N} (\tau c_{j,t}^C + \tau t_{j,t}^C) C_{j,t}^M P_{j,t}^M + w_t \ \tau i_t \ LL_t \ + \tau i \ \ r \ \ ASS_t \quad (20)$$

Where $\tau c_{j,t}^C$ and $\tau t_{j,t}^C$ are the commodity use tax and the tariff rate imposed upon final private consumption.

- Total benefit transfers received from the government as the sum of benefit transfers to all households:

$$TR_t = \sum_{a=0}^{M} \mu_a tr_{t-a,t} \quad (21)$$

- Total age pensions received from the government as the sum of age pension to all households (retired persons):

$$AP_t = \sum_{a=R}^{M} \mu_a ap_{t-a,t} \quad (22)$$

3.2 The production sector

We assume that there are N production activities in the economy. Each production sector is represented by a representative firm. All of them use a constant return to scale technology and operate in a perfectly competitive environment, implying that producers are price takers. Producers have perfect foresight about future. Each of them produces an industry typical product that can be used for intermediate input, final consumption, capital formulation or export. In order to produce output, firms combine factors of endowment, labor and capital that are aggregated in a value added component and intermediate inputs. The intermediate inputs are aggregates of domestically produced and imported products. The production output of each industry is transformed into domestically usable and exportable product.

Labor is provided by the household sector while capital is provided by the capital producer. Intermediate inputs are provided by industry specific firms or imports. The production process is also modeled by a multi-level structure. Accordingly, given the firms' objective to maximize their present value, decisions of firms are disaggregated into different stages.

Like (Keuschnigg and Kohler 1994), the capital good is identical for all sectors, produced and owned by a unique provider. In any period of time, the producer of capital good meets the investment demand of all firms. After being installed, capital good is immobile across sectors. As a result, the reallocation of capital stock in each industry is implemented through investment adjustment. Different from production industries, capital good provider needs to use only commodities in generating capital good.

We suppose that capital flow is freely mobile across industries and across country borders, resulting in a unique interest rate as the same as the world interest rate. Labor is supposed to be freely mobile only across domestic industries, resulting in an identical wage rate within Australia.

3.2.1 Production output

On the supply side, at the top level, production output of each industry, $Z_{k,t}$ is characterized by fixed input-output coefficients with respect to intermediate inputs, $Q_{jk,t}$ and value added output, $Y_{k,t}$ (Leontief type production function - LTF). This modeling choice for production output is similar to a majority of CGE models which rely on practical data condition provided by Input – Output (IO) tables.

On the use side, a constant elasticity of transformation function (CET) is employed to separate production output into domestically usable product, $H_{k,t}$ and exportable product, $X_{k,t}$. Unlike (Keuschnigg and Kohler 1994) and (Keuschnigg and Kohler 1995) who adopted a partial equilibrium for export[3], we follow the model by (Rutherford and Tarr 2002). Accordingly, production output is regarded as a composite commodity which can be differentiated for home and international market. The shares of domestic and foreign sales are determined by relative difference between domestic and export price. Home and world market sold product so are not identical. In our model, Australian firms are assumed to sell their exported products at the world prices which are given to them. This approach helps to simplify firms' behavior in international market without introducing specific world demand for Australia's exports. In fact, it is used widely, for instance in models by (Goulder and Eichengreen 1992), (Cabalu and Rodriguez 2007), (Yang 2001) and (Konan and Assche 2007).

$$CET(H_{k,t}, X_{k,t}) = Z_{k,t} = LTF(Q_{1k,t}, \dots, Q_{jk,t}, \dots, Q_{Nk,t}; Y_{k,t}) \tag{23}$$

Given the amount of industry specific production output, each firm maximizes the received revenue. Similarly to the case of CES functions of the household sector, in this case, we have a static optimization which leads to unit revenue function for $Z_{k,t}$ or $P_{j,t}^{Z}$ as a dual CET function of exported and home sold price, $P_{j,t}^{H}, P_{j,t}^{X}$:

$$P_{k,t}^{Z} = DCET \quad (P_{j,t}^{H}, P_{j,t}^{X}) \tag{24}$$

Via Shephard's Lemma, the supply of home sold and exported product per unit of each industry specific production output is given by:

$$\frac{H_{k,t}}{Z_{k,t}} = \frac{\partial P_{k,t}^{Z}}{\partial P_{k,t}^{H}} \tag{25}$$

$$\frac{X_{k,t}}{Z_{k,t}} = \frac{\partial P_{k,t}^{Z}}{\partial P_{k,t}^{X}} \tag{26}$$

3.2.2 Value added

3.2.2.1 Value added price

Free entry/exit and perfectly competitive market assumption implies zero profit condition for all producers. In other words, for any production output, total revenue equals total cost. As a result, the price of value added product, $P_{k,t}^{Y}$ is given by:

$$P_{k,t}^{Y} = \frac{P_{k,t}^{Z} - \sum_{j=1}^{N} P_{jk,t}^{Q} \, \varepsilon_{jk}}{\varepsilon_{Yk}} \tag{27}$$

Where $P_{k,t}^{Z}$ is the price or revenue unit cost of production output and $P_{jk,t}^{Q}$ is the price or unit cost of composite intermediate inputs produced by the j^{th} industry and used by the k^{th} industry. ε_{jk} and ε_{Yk}, respectively are fixed intermediate input-output and valued added-output coefficients in Leontief type production output function.

3.2.2.2 Value added output

[3] Keuschnigg's and Kohler's models propose that exported and home sold good are identical and there is a given world demand for exported good

The Leontief type production function makes firm's problems reduce to value added product producing level. Value added product is generated by combining labor and capital in accordance with a CES function, allowing the substitution possibility between employment of labor, $L_{k,t}$ and capital, $K_{k,t}$:

$$Y_{k,t} = CES(K_{k,t}, L_{k,t}) \tag{28}$$

The Tobin's Q theory on investment (Hayashi 1982) is adopted to solve the dynamic decision problem of firms. The purpose of firms is to maximize their present market value, V_k which is defined as the value of all future cash flows, $CF_{k,t}$ discounted at the world interest rate subject to the adjustment cost and capital accumulation conditions.

Since the production function takes the Leontief type, the cash flows of firms are solely determined by decision on value added output ($\tau f_{k,t}$ is the value added output tax):

$$CF_{k,t} = (1+n)^t \left[(1-\tau f_{k,t}) P_{k,t}^Y Y_{k,t} - w_t \ L_{k,t} - P_t^K \left(I_{k,t} + \frac{\sigma}{2} \frac{I_{k,t}^2}{K_{k,t}} \right) \right] \tag{29}$$

As a result, firms' problem reduces to determine just capital stock, labor and investment in each period of time:

$$Max\colon V_k = \sum_{t=0}^{\infty} \frac{CF_{k,t}}{\prod_{s=0}^{t} (1 + r_s)} \tag{30}$$

Subject to the capital depreciation constraint or following law of motion:

$$(1+n) K_{k,t+1} = (1-\delta) K_{k,t} + I_{k,t} \tag{31}$$

And capital adjustment condition which takes the quadratic function form of the investment to capital stock ratio:

$$S_{k,t} = \left(I_{k,t} + \frac{\sigma}{2} \frac{I_{k,t}^2}{K_{k,t}} \right) \tag{32}$$

Where $S_{k,t}$ is the aggregate capital good, $I_{k,t}$ is net investment, σ is investment adjustment cost coefficient. It implies that in order to install an additional capital stock of $I_{k,t}$, the firms have to consume totally $S_{k,t}$ units of aggregate capital good.

The key difference between our model and that of (Keuschnigg and Kohler 1994) is the evolution of capital stock over time. Although the Tobin's Q theory on investment (Hayashi 1982) is employed, too, our model assumes that investment demand can be financed by different sources, rather than rely only on firms' retained earnings.

Firms' decision on employed labor and capital depends on price signals. Firms recruit additionally labor until the marginal rate of return to labor equals the market wage rate:

$$(1-\tau f_{k,t}) P_{k,t}^Y \frac{\partial Y_{k,t}}{\partial L_{k,t}} = w_t \tag{33}$$

Similarly, capital stock and investment are selected to equalize the marginal rate of capital return with shadow price of capital:

$$(1-\tau f_{k,t})P^{Y}_{k,t}\frac{\partial Y_{k,t}}{\partial K_{k,t}}+P^{K}_{t}\frac{\sigma}{2}\frac{I^{2}_{k,t}}{K^{2}_{k,t}}+q_{t+1}(1-\delta)-q_{t}\ (1+r_{t}\ )=0 \tag{34}$$

$$q_{t+1}=\left(1+\sigma\frac{I_{k,t}}{K_{k,t}}\right)P^{K}_{t} \tag{35}$$

Where q_t is the shadow price of capital and P^K_t is the price of aggregate capital good.

The Tobin's Q theorem in (Hayashi 1982) links the firm value to the shadow price of capital and the existing capital stock:

$$V_{k,t}=\ q_t\ K_{k,t} \tag{36}$$

In the steady state, we expect that the shadow price of capital is unchanged. So the firm value grows at the same rate of capital stock. As a result, we have the total value of production firms in the economy, VV_t as the sum of all individual ones:

$$VV_t\ =\sum_{k=1}^{N}V_{k,t} \tag{37}$$

And so is total capital stock in the economy, KK_t :

$$KK_t\ =\sum_{k=1}^{N}K_{k,t} \tag{38}$$

And so is total labor demand in the economy:

$$LL^D_t=\sum_{k=1}^{N}L_{k,t} \tag{39}$$

3.2.3 Investment

Since we assume that aggregate capital good is homogeneous across industries, the economy wide demand for investment is the sum of demand from single industries. Once we know the investment demand in each industry, $I_{k,t}$, we can calculate the required aggregate capital good, $S_{k,t}$ through the capital adjustment condition. Then, the total demand for aggregate capital good is the sum of industry specific ones:

$$SS_t=\sum_{k=1}^{N}S_{k,t} \tag{40}$$

We assume that the capital good in our economy is produced by the capitalist, by combining real commodities with a CES technology. The capital good is supposed to be identical across industries. The role of the capitalist is like an intermediate banker linking the household sector and foreign market with final good producers. Accordingly, the saving of consumers and net foreign asset in any period are mobilized by this capitalist and then used to buy inputs to produce capital good to meet the investment demand of final good producers. The producer of capital good aims at maximizing profit by determining the quantity of inputs used for producing the capital good. Free entry and exit and perfectly competitive market assumptions imply zero profit condition for producing the capital good.

3.2.3.1 The top level

At the top level, total aggregate capital good, SS_t is featured by a CES function to be disaggregated into different industry specific composite commodities, $J_{j,t}$:

$$SS_t = CES(J_{1,t}, \dots, J_{j,t}, \dots J_{N,t}) \tag{41}$$

Given the amount of aggregate capital good, profit maximization goal is obtained by minimizing the cost. In this case, we have a static optimization whose solution is the unit cost function for SS_t, denoted by P_t^K as a dual CES function of unit cost of industry specific composite commodities:

$$P_t^K = DCES \quad (P_{1,t}^K, \dots P_{i,t}^K, \dots P_{N,t}^K) \tag{42}$$

Via Shephard's Lemma, the demand for each industry specific composite commodity per unit of aggregate capital good is derived from its unit cost function:

$$\frac{J_{jt}}{SS_t} = \frac{\partial P_t^K}{\partial P_{j,t}^K} \tag{43}$$

3.2.3.2 The second level

At the second level, total expenditure for each industry specific composite commodity is allocated between home produced and imported product, $J_{j,t}^H, J_{j,t}^M$ through an Armington CES structure:

$$J_{j,t} = CES(J_{j,t}^H, J_{j,t}^M) \tag{44}$$

Given the amount of industry specific composite commodity, the capitalist minimizes the cost to pay for it. Similarly, in this case, we have a static optimization which leads to unit cost function for $J_{j,t}$, $P_{j,t}^K$ is a dual CES function of imported and home produced product:

$$P_{j,t}^K = DCES \quad (P_{j,t}^H, P_{j,t}^M) \tag{45}$$

Via Shephard's Lemma, the demand for home produced and imported product per unit of each industry specific composite commodity is given by:

$$\frac{J_{j,t}^H}{J_{j,t}} = \frac{\partial P_{j,t}^K}{\partial P_{j,t}^H} \tag{46}$$

$$\frac{J_{j,t}^M}{J_{j,t}} = \frac{\partial P_{j,t}^K}{\partial P_{j,t}^M} \tag{47}$$

3.2.4 Intermediate input

Every intermediate input is a composite aggregate of home sold and imported product. Once we have value added output, $Y_{k,t}$, we can easily calculate the quantity of each intermediate input item, $Q_{jk,t}$:

$$Q_{jk,t} = \varepsilon_{jk} Z_{k,t} = \varepsilon_{jk} \frac{Y_{k,t}}{\varepsilon_{Yk}} \tag{48}$$

Armington assumption also is used to identify how firms allocate between home produced and imported component, depending on their relative price. The problem for each firm is to minimize the cost for required quantity of the composite intermediate input.

$$Q_{jk,t} = CES\left(Q^H_{jk,t}, Q^M_{jk,t}\right) \tag{49}$$

Given the amount of industry specific composite input, firms minimize the cost to pay for it. Similarly, in this case, we have a static optimization which leads to unit cost function for $Q_{jk,t}$ or $P^Q_{jk,t}$ as a dual CES function of price of imported and home produced product, $P^H_{j,t}, P^M_{j,t}$:

$$P^Q_{jk,t} = DCES\left(P^H_{j,t}, P^M_{j,t}\right) \tag{50}$$

Via Shephard's Lemma, the demand for home produced and imported product per unit of each industry specific composite input is given by:

$$\frac{Q^H_{jk,t}}{Q_{jk,t}} = \frac{\partial P^Q_{jk,t}}{\partial P^H_{j,t}} \tag{51}$$

$$\frac{Q^M_{jk,t}}{Q_{jk,t}} = \frac{\partial P^Q_{jk,t}}{\partial P^M_{j,t}} \tag{52}$$

3.2.5 Aggregation across production sectors

- Total demand of production sector for home produced product: $\sum_{k=1}^{N} Q^H_{jk,t} + J^H_{j,t}$

- Total demand of production sector for imported product: $\sum_{k=1}^{N} Q^M_{jk,t} + J^M_{j,t}$

- Total tax payment to the government contributed by production sector, TAX^F_t:

$$\begin{aligned} TAX^F_t = {} & \sum_{k=1}^{N} \tau f_{k,t} Y_{k,t} P^Y_{k,t} + \sum_{j=1}^{N}\sum_{k=1}^{N} Q^M_{jk,t}\left(\tau c^Q_{jk,t} + \tau t^Q_{jk,t}\right) P^M_{j,t} + \sum_{j=1}^{N} J^M_{j,t}\left(\tau c^K_{j,t} + \tau t^K_{j,t}\right) P^M_{j,t} \\ & + \sum_{j=1}^{N}\sum_{k=1}^{N} Q^H_{jk,t}\left(\tau c^Q_{jk,t}\right) P^H_{j,t} + \sum_{j=1}^{N} J^H_{j,t}\left(\tau c^K_{j,t}\right) P^H_{j,t} + \sum_{k=1}^{N} \frac{\tau c^X_{k,t} P^X_{k,t} X_{k,t}}{1 + \tau c^X_{k,t} - \tau s^X_{k,t}} \end{aligned} \tag{53}$$

Where $\tau c^Q_{jk,t}$ and $\tau t^Q_{j,t}$ are the commodity use tax and the tariff rate levied against intermediate input consumption; $\tau c^K_{j,t}$ and $\tau t^K_{j,t}$ are the commodity use tax and the tariff rate imposed upon capital good formation; and $\tau c^X_{k,t}$ and $\tau s^X_{k,t}$ are export tax rate and subsidy rate imposed upon exported commodities.

3.3. The government sector

3.3.1 The top level

The government is relatively passive in the model. In order to finance its spending, benefit transfers, age pension to retired individuals and subsidy payments to domestic production and consumption, the government collects taxes from economic agents. To make data sets on tax, duty and subsidy from IO tables usable, we assume that import duties are imposed on all imports while commodity use taxes, τc are levied against any consumption regardless of home produced or imported origins. Subsidy is modeled in the form of support for the consumption of domestically produced products. As a result, regardless of use purposes, such as intermediate inputs or final consumptions (private consumption, capital formation or export), consuming home produced products occurs at a lower price which is paid by the subsidy.

We suppose that government spending value, $GG_t P_t^G$ is exogenously determined, depending on the economy size. Therefore, we take into account the assumption that government expenditure is proportional to total gross domestic product (ϕ). We also suppose that all tax and subsidy rates are also exogenously determined.

$$GG_t P_t^G = \phi \sum_{k=1}^{N} P_{k,t}^Y Y_{k,t} \tag{54}$$

Benefit transfer from the government to the household sector, TR_t is endogenously determined, enabling the government budget to be in balance in any period of time. This assumption is reasonable in the case of Australia because the federal budget exhibits very tiny deficit in most of the last decades and sometimes runs a surplus. At the same time, government debt is targeted to be eliminated in coming years (CA 2006).

$$TR_t = TAX_t^C + TAX_t^F - GG_t P_t^G - AP_t - SUB_t \tag{55}$$

Where: AP_t is total age pension payment to retired households and SUB_t is total subsidy payment to promote consumption of home produced products.

$$SUB_t = \sum_{j=1}^{N} \tau s_{j,t}^C C_{j,t}^H P_{j,t}^H + \sum_{j=1}^{N}\sum_{k=1}^{N} Q_{jk,t}^H \left(\tau s_{jk,t}^Q\right) P_{j,t}^H + \sum_{j=1}^{N} J_{j,t}^H \left(\tau s_{j,t}^K\right) P_{j,t}^H + \sum_{k=1}^{N} \frac{\tau s_{k,t}^X P_{k,t}^X X_{k,t}}{1 + \tau c_{k,t}^X - \tau s_{k,t}^X} \tag{56}$$

Where: Where $\tau s_{j,t}^C$, $\tau s_{jk,t}^Q$ and $\tau s_{j,t}^K$ are the subsidy rate applied for final private consumption, intermediate input use and capital formation, respectively. $\tau s_{k,t}^X$ is subsidy rate for exported commodities.

Like the private consumption, the government consumption is featured by a multi-level structure. A nested CES function is employed to model the demand of the government.

3.3.2 The second level

At the second level, the aggregate government consumption, GG_t is featured by a CES function to disaggregate into different industry specific composite commodities, $G_{j,t}$:

$$GG_t = CES\left(G_{1,t}, \ldots, G_{j,t}, \ldots G_{N,t}\right) \tag{57}$$

Given the amount of aggregate consumption commodity, profit maximization goal is obtained by minimizing the cost. In this case, we have a static optimization whose solution is the unit cost for GG_t or P_t^G as a dual CES function of unit cost of industry specific composite commodities, $P_{j,t}^G$:

$$P_t^G = DCES(P_{1,t}^G, \ldots P_{j,t}^G, \ldots P_{N,t}^G) \tag{58}$$

Via Shephard's Lemma, the demand for each industry specific composite commodity per unit of aggregate government good is derived from its unit cost function:

$$\frac{G_{jt}}{GG_t} = \frac{\partial P_t^G}{\partial P_{j,t}^G} \tag{59}$$

3.3.3 The third level

At the third level, total expenditure for each industry specific composite commodity is allocated between home produced and imported product, $G_{j,t}^H, G_{j,t}^M$ through an Armington CES structure:

$$G_{j,t} = CES\left(G_{j,t}^H, G_{j,t}^M\right) \tag{60}$$

Given the amount of industry specific composite commodity, the government minimizes the cost to pay for it. Similarly, in this case, we have a static optimization which leads to unit cost function for $G_{j,t}$ or $P_{j,t}^G$ as a dual CES function of imported and home produced product:

$$P_{j,t}^G = DCES\left(P_{j,t}^H, P_{j,t}^M\right) \tag{61}$$

Via Shephard's Lemma, the demand for home produced and imported product per unit of each industry specific composite commodity is given by:

$$\frac{G_{j,t}^H}{G_{j,t}} = \frac{\partial P_{j,t}^G}{\partial P_{j,t}^H} \tag{62}$$

$$\frac{G_{j,t}^M}{G_{j,t}} = \frac{\partial P_{j,t}^G}{\partial P_{j,t}^M} \tag{63}$$

3.4 The equilibrium

3.4.1 Transactions with ROW

The Australian market and world market are linked through flows of goods and capital. Trade surplus or deficit is mirrored by current account deficit or surplus, respectively. Capital is freely mobile across countries, resulting in a common interest rate between Australia and the world.

Total export value of Australia to ROW:

$$XX_t = \sum_{k=1}^{N} X_{k,t} P_{k,t}^X \tag{64}$$

Total import value of Australia from ROW:

$$MM_t = \sum_{j=1}^{N} C_{j,t}^M P_{j,t}^M + \sum_{j=1}^{N} Q_{j,t}^M P_{j,t}^M + \sum_{j=1}^{N} J_{j,t}^M P_{j,t}^M + \sum_{j=1}^{N} G_{j,t}^M P_{j,t}^M \tag{65}$$

Because of data limitation, we just model capital flow between Australia and ROW as the result of trade account imbalance. Accordingly, trade deficit or surplus is mirrored by net positive or negative foreign capital inflow respectively.

$$TB_t = XX_t - MM_t \tag{66}$$

The accumulated net foreign capital inflow is total net foreign debt, assumed to be constrained by a transversality condition to avoid debt explosion possibility.

$$(1+n)WD_{t+1} = (1+r_t)WD_t + TB_t \tag{67}$$

$$\lim_{t\to\infty} \frac{WD_t}{\prod_{s=0}^{t}(1+r_s)} = 0 \tag{68}$$

Walras's law is effective, resulting in the equilibrium of all markets: good market, labor market, capital market. In other words, in any period, there exists equilibrium in all markets (all markets are balanced):

3.4.2 Commodity market

$$H_{j,t} = C_{j,t}^H + G_{j,t}^H + J_{j,t}^H + \sum_{k=1}^{N} Q_{jk,t}^H \tag{69}$$

3.4.3 Labor market

Labor is assumed to be homogeneous, mobile across industries but immobile internationally. Hence, total labor supply is determined by decisions of domestic individuals in the model:

$$LL_t^S = \sum_{k=1}^{N} L_{k,t} \tag{70}$$

3.4.4 Asset markets

In any period of time, the total assets holding of the household sector are used to finance world debt and firm values:

$$AS_t = VV_t + WD_t \tag{71}$$

4 Data

To complete modeling the economy, we need values of exogenous parameters characterizing the behavior of economic agents. It is necessary to have several sources of data for this purpose. Some of them can be drawn from related literature (especially parameters in the utility function), some are calibrated to suit the practical conditions (especially parameters in production and intra-generation allocation). The year 2005-2006 is set as the target for the benchmark steady state equilibrium.

4.1 The production sector

The most important data are Input – Output (IO) tables. According to (ABS 2000), IO tables are part of the Australian national accounts, complementing the quarterly and annual series of national income, expenditure and product aggregates. They provide detailed information about the supply and use of products in the Australian economy and about the structure of inter-relationships between Australian industries including input by industry and output by product group; use of domestic production and imports by industry and final demand categories, and taxes, subsidies and margins on supply by product. The Australian Bureau of Statistics (ABS) has completed 22 sets of IO tables for Australia of which the most recent release is for the financial year 2006-2007.

In our model, the financial year 2005-2006 is considered to be the baseline for our artificial economy. Therefore, the IO tables for Australia (2005-2006) are used to calibrate relevant parameters, mostly for the production sector. 2005 – 2006 Australian IO tables are available on the website of the Australian Bureau of Statistics (ABS). The 2005-06 IO tables are the last ones to be produced on a 1993 Australian and New Zealand Industry Classification (ANZSIC93) and 1993 System of National Accounts (SNA93) basis. The structure of the tables, with 109 product and industry groups, and the underlying methodology used in their construction has been kept consistent with the release of 2001-2002 IO tables. There are 39 tables in the 2005-2006 release which contain information about the flows of output, tax, subsidies, margins,… amongst industries and categories of demands. In addition to intermediate inputs, the original tables include final demand components: households consumption, government consumption and gross fixed capital formation (as the sum of gross fixed capital formation of private, public enterprises and general government), and changes in inventories and export. Moreover, compensation of employees, gross operating surplus and mixed income or data on income side are also available. All values are measured at producers' or basic prices in millions of Australian dollars. The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service, minus any tax payable (including deductible value added taxes), and plus any subsidy receivable, as a consequence of production or sale of the unit (ABS 2000).

	Industry uses						Final uses					TOTAL SUPPLY
Industries	1	2	...	108	109	Total industry Use	Household	Government	Capital formation	Inventories	Total final uses	
1												
2												
...												
109												
Total intermediate use												
Compensation of employees												
Gross operating surplus and mixed income												
Net taxes on products												
Net taxes on production												
Competing Imports												
Gross Value Added												
TOTAL USE												

Figure 6 The structure of the Input-Output Tables

Source: (ABS 2010a)

To match this very detailed source of data with our model's dimension, we aggregate components in the full IO tables to form a condensed IO table of 19 industries/products. This concordance work is exactly as the same as the one in (Keuschnigg and Kohler 1994). As a result, the following groups of industries are represented in our model: (i) Agriculture and Forestry; (ii) Mining and Quarry; (iii) Food stuff; (iv) Textile and Clothing; (v) Wood and Wood processing; (vi) Paper and Paper processing; (vii) Petroleum; (viii) Chemical excluding petroleum; (ix) Non-ferrous minerals; (x) Basic metals; (xi) Metal processing; (xii) Energy and Water supply; (xiii) Construction; (xiv) Commerce; (xv) Hotels and Restaurant; (xvi) Transport and Communication; (xvii) Banking, Insurance and Real estate; (xviii) Public service; and (xix) Other services. The components in the first 17 groups can be easily guessed while those in the 18th one are government administration; defense; education; health services and community services and those in the last group consist of motion picture, radio and television services; libraries, museums and the arts; sport, gambling and recreational services; personal services and all others. The sub-industries in each sector can be found in the Appendix on Concordance.

Since we do not explicitly explain how decisions on inventories are made, we distribute this final spending item to other categories of final demand as (Keuschnigg and Kohler 1994) did. Nevertheless, inventories are also redistributed to gross fixed capital formation, besides household and government spending and export. The redistribution shares are proportional to the original values of final demand categories.

Separate information on use and supply of domestic production outputs and imports can be found in Table 5 and Table 3 respectively. The composite use and supply consisting both domestic and imported components can be easily generated by adding Table 3 and Table 5 together.

In Table 5, final consumption data on water transport, air and space transport are not available. However, we can calculate the total final uses for these two forms of transport by subtracting total industry uses from total Australian transport production. Then, weighted average from other forms of transport services are used to allocate total final uses into each final consumption components. In Table 3, final consumption data on water transport, air and space transport are also not available and we omit them because of very small import volume in this industry. Moreover, in our condensed IO table for imports, there appears a negative import value in the transport use by textile and clothing industry. To correct this nonsense value of import, we transfer it to its domestic counterpart and transport import volume used by transport industry. This way helps us to keep total use and total supply of transport and textile and clothing industry equal respectively without affecting much the structure of the original tables.

This aggregation and reallocation process gives us adjusted tables for use and supply of domestic production outputs and imports. The sum of these two tables generates the composite Input – Output Table which consists of both domestic and imported components in any categories of use and supply.

Information on product related taxes and subsidies can be obtained from Table 34, 35, 36, 37 and 38 of which Table 34 provides the net of all product related taxes and subsidies while Table 36 contains import duty and Table 38 is about subsidy. Hence, we can subtract figures in Table 36 and Table 38 from figures in Table 34 to calculate all other product related taxes except import duty, or commodity use tax as we denote in our paper (τc_t). Actually, such type of tax may cover several sub-components, ranging from GST, sales tax to excise tax and other fees… Based on that, we can calculate tariff rate (τt_t), commodity use tax rate (τc_t) and subsidy rate (τs_t) for different types of product in different use purposes by dividing tax revenue against their total sales values at basic prices. Actually, the commodity tax rate, subsidy rate or duty against the intermediate use of a product are different from industry to industry. For exports, commodity use tax is interpreted as export tax ($\tau c_{k,t}^X$) that producers have to pay to the Australian government before selling their products in foreign markets.

Apart from product related taxes, Input – Output Tables contain information on other production tax, which is regarded as tax against value added output production in our model. The other taxes on production are understood as the money enterprises incur as a result of their engagement in the processes of production besides product related taxes. They may consist of taxes payable on the land, fixed assets or labor employed in the production process or on certain activities or transactions. The actual structure for this type of tax is very complicated, that may incur during the production process. Some major items could be listed here such as taxes on payroll or workforce, recurrent taxes on land, buildings or other structures, business and professional licences, taxes on the use of fixed assets, stamp taxes, taxes on pollution and taxes on international transactions (Soriano and Thompson 2006). For simplicity, we assume that it is proportional to value added output. Therefore, the other production tax rate ($\tau f_{k,t}$) for each industry can be easily derived by dividing the tax revenue by its corresponding value added output.

The detailed description on tax data can be found in the Appendix on Tax Data.

Regarding the sources of value added output, IO Tables contain separate rows providing information on compensation of employees, gross operating surplus and mixed income. The former represents value of all entitlements earned by employees, covering wages and salaries and employers' social contributions. Contributions to pension and superannuation funds hence are also parts of compensation of employees. Since our model does not distinguish different sources of labor income, the figures on compensation of employees in IO Tables can be used straight away to reveal how much totally the representative producer in each industry has to pay for the workers and exhibit total wage income received by the household sector. Contribution to pension or superannuation funds can be regarded as a part of labor income that the households do not spend and put in their saving. The latter part of value added output is defined as the surplus accruing from processes of production before deducting interest charges, land rent or other property incomes payable on the financial assets, land or other tangible non-produced assets required to carry on the production. Therefore, this item can be calculated as gross value added minus compensation of employees, minus taxes on production and it is interpreted as the part of value added output generated by capital employment in our model. Like the case of labor employment, because our model does not differentiate types of capital, the figures on gross operating surplus and mixed income are used directly to specify the capital cost firms have to pay in producing valued added output (ABS 2000).

Completing above works, we can achieve a set of data characterizing a steady state equilibrium for our economy, especially the production sector in 2005-2006, such as price indexes (price of goods, services and factors), policy parameters (tax rates), input and output levels, value added, trade volumes, loans to the world...

4.2 The household sector

For the household side, we assume that consumption preference is identical across generations. It means that all generations have the same expenditure proportion of a particular type of good given their different total expenditure. Therefore, what we focus on is to explain how the consumers allocate their income over time. Information from IO table is used to determine how cohorts allocate intra-temporally their income for different types of goods and services. Specifically, we can easily calculate the share of each type of goods and services in final household consumption from IO tables and then use these shares for all generations.

Demographic features are taken from (Kudrna and Woodland 2011). Accordingly, it is assumed that an individual starts their economic life at the age of zero (corresponding to the biological age of 15 – the first age in the labor force) and possibly live till the age of 76 (corresponding to the biological age of 90 – the age at which the number of older persons might be ignorable). The authors use the life tables for men from ABS to calculate conditional survival probabilities (s_b) while the annual population growth rate (n) is constant, equal 0.0145, taken from (Kulish, Smith et al. 2006), which is the average annual growth rate in Australia over the last 10 years. In general, the older a person is, the more likely he/she dies. The age specific productivity (ϵ_a) is calculated based on work by (Reilly, Milne et al. 2005). In our model, these productivities are scaled such that age specific productivity of zero aged household is normalized to unitary. The age profile of working capacity is hump-shaped, reaching the peak at the age of 32 (corresponding to the biological age of 47). The retirement age (R) is set at the age of 52 (corresponding to the biological age of 66), reflecting the fact that the number of working people who are 65 years old or older is very small and thus, ignorable (ABS 2010b).

The age specific pension coefficient (π_a) is assumed to be identical across all retired individuals. In (Kudrna and Woodland 2011), the estimates on age specific pension that are based on Household Income, Labor Data Analysis (HILDA) display clearly that there is a small gap amongst retired generations in terms of their pension. This result is caused by the fact that policy on age pension is not age dependent. In fact, it is calculated based on average wage rate of male employees. In our model, value of these coefficients is adjusted in order to match with the realistic age pension payment in the benchmark year. While total taxation revenue at all government levels (including Commonwealth, State and local governments) is \$298.156 billions (ABS 2010c), total spending value is \$173.345 billions and total subsidy payment is \$9.734 billions (ABS 2009). Hence, total transfer payment (including age pension payment (AP) and other benefit transfer (TR)) is \$115.077 billions. Because age pension payment is \$20.6 billions (ABS 2010d), other benefit transfer is \$94.519 billions.

Additionally, figures from relevant surveys such as labor and consumption expenditure surveys conducted by ABS are used to check whether computing results of our model are practically reasonable.

4.3 Parameterization

Besides the raw database from national accounts, IO tables, labor and household expenditure survey data, it is needed to have value of three types of elasticities and parameters in behaviorial functions:

(i) Elasticities of substitution between commodities or factors in CES functions and elasticities of transformation between export and domestic sales; and share parameters in these functions;

(ii) Household preferences;

(iii) Investment and capital stock related parameters.

While there are external sources for the value of some of the elasticties and parameters (such as elasticity of substitution or transformation), the other ones such as preference or share parameters can be calibrated by using dataset in the benchmark year and external sources of some elasticities and parameters.

4.3.1 External sources of parameters

First and foremost, some parameters are taken from external researches. Elasticities of substitution between commodities or factors in CES functions are also drawn from external sources of information.

At the top levels, the aggregate for final demands (private, government or capital formation aggregate commodity) is modeled as a CES function of industry specific products. Calibrating share coefficients in these functions, we need to know value of the elasticity of substitution amongst industry specific products. In fact, due to the large differences across CGE models in defining such aggregate final demands, there are few researches and sources of information about this type of elasticity. At the same time, their values are much different from each other. For this reason, we follow (Keuschnigg and Kohler 1994) in adopting a Cobb-Douglas function for these final aggregate demand. In other words, the elasticity value equals unitary. This simplification helps us to get share coefficients simply as the proportion of spending on each industry specific product in total expenditure.

Table 2 Elasticity in aggregate goods

Aggregate capital good (ρ_K)	Aggregate private good (ρ_C)	Aggregate government good (ρ_G)
1	1	1

Source: (Keuschnigg and Kohler 1994)

At lower levels in our nested structure, an industry specific commodity is defined as a CES composite of domestic and imported components which are characterized by Armington elasticity. Actually, there are a wide range of choices for this type of elasticity. In (Keuschnigg and Kohler 1994), econometric works for European communities are bases for identifying Armington elasticity in their model. In fact, most of estimates on Armington elasticity are country specific because the databases for estimates are taken from particular countries (a large proportion of them are for the U.S. economy). For this reason, using elasticity for other countries may lead to a reduction in accuracy level of the model.

Recently, GTAP becomes an important source of elasticities because it provides a comprehensive set of elasticities for several countries all over the world and these elasticities are tested in several researches. According to (Dimaranan 2006), sources of elasticities in GTAP are taken from the SALTER model and some recent econometric works such as the one by Hertel (2004). In Australia, CGE models have been used for a long time. Some famous models have been applied not only in Australia but also in some foreign countries such as ORANI, MONASH… Elasticities of substitution are independently estimated in these models and are Australia specific.

In our model, GTAP6 and MONASH model databases are taken into account to specify Armington elasticity of substitution between domestic and imported good. Like the case of IO table, the original database contains product specific parameters. Therefore, we need to aggregate them to match with our model dimension by taking the weighted average of components. While MONASH model provides with Armington elasticities for different commodities and different uses, elasticities in GTAP6 are identical across categories of demand. Therefore, for commodities MONASH model has available data, we use elasticities from MONASH model. For commodities whose Armington elasticities are zero or not available in MONASH model, we replace them by those from GTAP6.

Table 3 Elasticity

		Armington elasticity of substitution between domestic and imported products				Elasticity of transformation between export and home sales	Elasticity of substitution between endowment factors
		Intermediate	Capital	Government	Households		
No.	Industries	ρ_{Qj}	ρ_{Kj}	ρ_{Gj}	ρ_{Cj}	ρ_{Zj}	ρ_{Yj}
1	AgrFor	1.577	1.28	1.667	2.1433	0.56	0.2333
2	MinQuarr	4.635	4.415	6.933	11.75	1.26	0.73
3	Food	1.23	1.3	1.327	1.45	0.56	1.0222
4	Texcloth	2.52	1.84	2.497	3.13	1.26	1.005
5	Wood	1.92	1.67	1.753	1.67	1.26	1.26
6	Paper	1.68	2	2.26	3.1	1.26	1.26
7	Petrol	0.4	0.4	0.4	0.4	1.26	1.26
8	Chemic	1.8	1.5	2.2333	3.4	1.26	1.26
9	Nonferr	0.84	0.68	0.9933	1.46	1.26	1.26
10	Metals	1.25	1.74	2.23	3.7	1.26	1.26
11	MetProc	1.777	1.9967	2.6233	4.0967	1.26	1.26
12	Energy	2.95	2.95	2.95	2.95	1.26	1.26
13	Constr	2.1	2.1	2.1	2.1	1.4	1.68
14	Trade	3.3	3.3	3.3	3.3	1.26	1.68
15	HotRest	4.2	4.2	4.2	4.2	1.26	1.26
16	Transp	0.667	0.6667	0.8889	1.3333	1.68	1.575
17	RealEst	3.8417	3.8417	3.8417	3.8417	1.26	1.26
18	Public	2.8	2.8	2.8	2.8	1.26	1.26
19	OthServ	1.9	1.9	1.9	1.9	1.26	1.26

Source: MONASH and GTAP6 and (DeMelo and Tarr 1992)

Besides Armington elasticities, another type of substitution elasticity is used in value added functions in our model. In GTAP model, value added is generated by three endowment factors, namely capital, labor and land. The substitution possibility amongst them is characterized by a constant elasticity of substitution. Although value added in our model is created by only two factors, capital and labor, elasticity from GTAP model is still usable. We draw values from GTAP model because it covers all industries in our model.

Secondly, for export and domestic sales allocation, there is a limited number of choices. One of the main reasons is the fact that a large part of CGE models adopt other approach in allocating export and domestic sales. The most common method is to consider exported and domestically sold goods are identical. Therefore, for small open economies, export volume depends on the world demand for their export. Parameters of the world demand for export, i.e. price elasticity of the world demand are needed for this type of model. (Keuschnigg and Kohler 1994) and MONASH model also follow this approach in modeling export. Some other works such as (Warr and Lapiz 1994) just estimated elasticity of transformation between export and home sales for some particular industries and countries. In our model, the elasticity of transformation is drawn from (DeMelo and Tarr 1992) because to our knowledge, only this research provides elasticity value for several industries. Although the number of industries in (DeMelo and Tarr 1992) are less than that of our model, we still can make calculation for all industries in our model because most of industries in (DeMelo and Tarr 1992) have the same elasticity of transformation.

4.3.2 Calibration

Once we have enough sources of data and sets of elasticities, we can easily calibrate some behavioral parameters in supply and demand function, specifically, share coefficients or preference parameters.

First and foremost, some household preferences are calibrated to enforce results of our model to be consistent with the benchmark year of 2005-2006. This practice is much different from other CGE models which often take household preferences from external empirical studies, especially the ones from U.S such as (Auerbach and Kotlikoff 1987), (Ballard, Shoven et al. 1985). Values of such parameters in other researches have a wide range of variation (Auerbach and Kotlikoff 1987). In (Kudrna and Woodland 2011), all household preferences are also taken from external sources.

Actually, in order to match household sector with production sector, we have to make all markets (goods market, labor market, asset market) in balance. At the same time, we have to take into account some practical conditions such as government budget balance, hump shaped age profile of consumption and saving and labor force participation rate. Such conditions are maintained if we scarify some degree of freedoms like (Keuschnigg and Kohler 1994) did. In our case, some household preferences are calibrated to meet these conditions. For instance, that consumption expenditure of a typical household is hump shaped with the peak at some age before retirement, asset holdings of a typical household is hump shaped with the peak at the biological age of around 60 (Kudrna and Woodland 2011), labor force participation rate is humped shaped with the peak of about 80% around the biological age of around 40 are milestone to calibrate some utility preferences and demographic features.

Table 4 Some other parameters in utility function

Intra-temporal elasticity of substitution	Subjective rate of time preference	Inter-temporal elasticity of substitution	Leisure preference parameter	Total annual time endowment	Age pension rate	Income tax rate
P	β	γ	α	h	π	τi
3.00	0.007	1.3675	0.1250	47727	107620	0.265

Source: Authors' calculation

Above results are reasonable. For example, inter-temporal elasticity of substitution, γ and leisure preference parameter, α are all in the range adopted by relevant researches (Auerbach and Kotlikoff 1987). At the same time, in a recent review on application of CGE models by (Dixon 2008), it is argued that settings of key parameters should be flexibly adjusted (by sensitivity analyses) rather than be fixed to some external sources. Time-series econometrics estimated parameters seem to be inconsistent with specific simulation contexts.

Regarding the government budget situation, income tax rate (τi) is calibrated so that income tax revenue equals around two thirds of total tax revenue, according to (ABS 2008). Flat pension coefficient (π) is specified to meet the fact that age pension payment is the largest (ABS 2010d).

It is assumed that our economy is in a steady state equilibrium in 2005-2006. Therefore, all data we have from this benchmark year must be consistent with the set of equations characterizing a steady state equilibrium. With our simplification that price of all commodities at the bottom level is unitary in the benchmark year and information on product related taxes, quantity of commodities can be calculated by dividing their monetary value by their tax inclusive price. Based on that, we can use equations for a steady state to calculate their corresponding parameters.

For example, as we partly mentioned above, it is easy to calibrate the product specific share parameters in different types of final aggregate commodity because of the assumption of Cobb-Douglas type function of aggregate commodities. Specifically, share coefficients are simply the proportion of spending on each industry specific product in total expenditure.

Similarly, to calculate the value of share parameter to home and imported product in an industry specific composite good, we can rearrange the corresponding equations to explicitly present this parameter as a function of tax inclusive price of imported and home sold product and spending on imported and home sold product. Since we normalize prices as unitary in the steady state, information on tax is known and all spending values can be obtained from IO tables, we can easily calculate such share parameters.

Regarding fixed coefficients in production output function, they can be calculated straight away by dividing value of intermediate inputs and value added by production output. Productivity coefficient in value added function can also easily obtained since we have data on compensation, gross operating surplus and mixed income as well as value added.

Details on these parameters can be found in the Appendix on Parameters.

Finally, for investment and capital related parameters and value added related functions, despite the fact that there are many external sources of estimates, we calibrate Australian data in order to maintain our model consistent with practical conditions. Besides IO table, we need national accounts which provide information on outputs, capital stock, capital formation cost and capital consumption over time. Based on them, we can calculate ratio of capital formation cost to capital stock.

Table 5 Capital and investment related parameters

Capital formation/Capital stock	Depreciation rate (δ)	Capital adjustment cost coefficient (σ)	Interest rate (r)	Capital shadow price (q)
0.08	0.05	7.4515	0.042	8.9862

Source: (ABS 2010a) and authors' calculation

For investment parameters, depreciation rate of capital stock can be calculated from time series data on capital stock and capital consumption of ABS (ABS 2010a). On average over the last 10 years, the depreciation rate of capital equals 0.05. Combining this result with annual population growth rate, we can calculate the ratio of investment to capital (I/K), equal 0.0645 (equation (2.9)). Using time series data on capital formation cost, we can calculate the ratio of capital formation cost to capital stock value, equal 0.08 on average of the last 20 years. So, it is possible to calculate the capital adjustment cost coefficient (σ) and capital shadow price (q), using equation (2.10) and (2.13) respectively. Then, we can calculate the world interest rate (r) by using equation (2.12). That interest rate equal around 4% is very close to actual world interest rate in last decades (WB 2011).

5. Computation algorithm and benchmark solution

This part explains about techniques used to find steady state equilibrium solutions for our economy and adjustment path between steady states. Results on equilibrium in the benchmark year 2005-2006 are used to test the reliability of the model.

5.1 Equilibrium

5.1.1 Steady state equilibrium

Given tariff rates and values of exogenous variables, all endogenous variables in our model are expected to converge to a stable value in the steady state equilibrium. From above equations for a particular period, we can derive the set of equations for the steady state equilibrium by equalizing values of endogenous variables across different periods of time. The set of these equations for the steady state equilibrium is presented in the Technical Appendix.

Solving this system of equations gives us the solution for a steady state equilibrium of the economy, conditional on given exogenous variables. If there is a change in the trade policy, the economy will move from the initial steady state equilibrium to a new steady state equilibrium. By comparing two steady state equilibriums, we can determine how the economy becomes after a policy change.

However, since we do not know how long it takes the economy to adjust from an initial to a new equilibrium, we cannot determine exactly the welfare effect of the policy on particular living individuals. In other words, households by the time of new equilibrium might not be households of the initial equilibrium time. For this reason, steady state equilibrium computation sometimes is not significant for policy recommendation.

5.1.2 Dynamic adjustment path[4]

Above part helps us to find the steady state equilibrium of the economy at different trading scenarios. Nonetheless, how and how long the economy adjusts from the initial steady state equilibrium to the terminal steady state equilibrium is also our great concern. For simplicity, we assume that the economy is in a steady state equilibrium at the time of the policy change. Unlike steady state equilibrium, all agents experiencing the policy change have to revise their decision. And, of course, the markets in different time periods are related through the dynamics of the saving and investment decisions. The advantage of computing dynamic adjustment path over steady state equilibrium is to clarify clearly the welfare effects on different age groups over their life time.

For household sector, we have to distinguish two groups of cohorts in this case. The first group consists of generations who are still alive at the time of policy change. Therefore, they change their decision for the rest of their life based on new price indexes as the consequence of the new policy. The second group consists of generations who start their economic life when the new policy has been already effective. For production sector, producers have to revise their production decisions based on new price indexes. Consequently, we have a dynamic path of their decisions until the economy reaches a new steady state equilibrium, described by equations in the main text.

Much more complicated than steady state equilibrium, all equations represents the equilibrium in non-steady states. The link between inter-temporal equilibrium is through Euler equations for household sector and capital motion equation for production sector. The size of this system of equations depends on the number of periods the economy requires to adjust from an initial steady state to a new terminal steady state.

5.2 Computation algorithm for steady state equilibrium

To find the solution for the steady state equilibrium or adjustment path, the Gauss-Seidel algorithm is employed as (Auerbach and Kotlikoff 1987) did. In principle, it starts with guessing the initial values for some key endogenous variables. Together with exogenous variables, they are used to solve for all endogenous variables, including the initially guessed key endogenous variables. If the new solution for the initially guessed key endogenous variables is consistent with the initial guess, we can

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[4] In comparison with finding steady state equilibrium, calculation of solutions for dynamic adjustment path requires much more computing jobs. So, the works on dynamic adjustment path will be implemented in our next research.

conclude that a solution for the model has been found. Otherwise, we have to update a new guess for these key endogenous variables, based on information from previous iterations.

For simplicity, we normalize the price of all imported goods and exported goods as numeraires in all periods, $P_{j,t}^M = P_{j,t}^X = 1$.

Interest rate is fixed at the level of the world interest rate, $r_t = r^w$. Hence, all other variables, in any period are in real value, in terms of prices of the world market. At the same time, all aggregate variables are detrended population growth, implying that they are all in per capita terms. Since population size in the benchmark year is normalized to unitary, such variables in other periods are terms per unit of population or equivalent to around 15 million people who are older than 15 years old of the year 2005-2006.

The principle we adopt to find the steady state equilibrium is as follows: (1) Make a guess for the wage rate which is then used as a base to calculate all price indexes in the economy; (2) Calculate all supplies from the view of producers by guessing labor amount used by each industry and using the price indexes; (3) Calculate all demands from the view of consumers by using price indexes and information from the production sector; (4) Check the market clearing condition if demand equals supply.

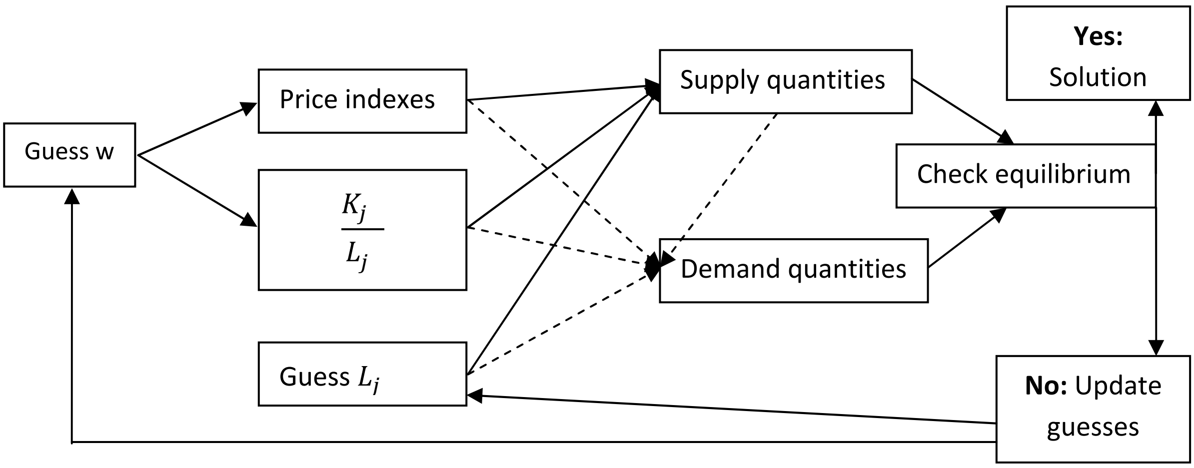

Figure 7 Computation algorithm

And in particular, following steps are implemented to find the steady state equilibrium:

5.2.1 Guess the wage rate, w

Together with the constant interest rate (fixed at the world interest rate), it is possible to calculate agent specific price at different levels, shadow price of capital and ratio of capital to labor ($\frac{K_j}{L_j}$) in each industry by using price index equations, equations on marginal rate of return to production factors:

a. Guess the price of domestically produced product, P_j^H

b. Calculate prices at different levels: All of them can be featured as a function of price of domestically produced goods, P_j^H and price of imported goods, P_j^M (equations 13, 16, 42, 45, 50, 57, 60) or exported good, P_j^X (equations 24, 27) and then shadow price of capital, q (equation 35).

c. Use the equations characterizing the marginal rate of return to capital in each industry (equation 34, which can be rearranged to become a function of $\frac{K_j}{L_j}$) to calculate the ratio of capital stock to labor in each industry, $\frac{K_j}{L_j}$.

d. Use the equations characterizing the marginal rate of return to labor (equation 33, which can be rearranged to become a function of $\frac{K_j}{L_j}$) and results from step (1c) to calculate the corresponding wage rate in each industry, w_j .

e. Check whether the newly found wage in each industry, w_j is consistent with the initially guessed wage rate, w. If yes, move to step 2. If no, come back step (1a) to adjust the price of domestically produced products, P_j^H.

5.2.2 Guess the level of labor employed in each industry, L_j

Together with price indexes from step 1, it is possible to calculate supply of imported and home sold products and demand for investment from the view of producers and demand for imported and home sold products and supply of saving from the view of consumers, respectively. Then we can check the market clearing conditions if demand is as the same as supply:

a. Calculate the capital stock used by each industry, $K_{j,SS}$, by using guessed labor, $L_{j,SS}$ and ratio of capital to labor from step (1c), $\frac{K_j}{L_j}$.

b. Calculate the value added output for each industry, Y_j (equation 28) then production output (equation 23), supply of exportable and home sold product (equation 25, 26), then demand for imported and home sold products used for investment (equations 31, 32, 35, 40, 41, 43, 44, 46, 47), government spending (equations 54, 56, 58, 59, 61, 62) and intermediate inputs (equations 48, 49, 51, 52).

d. Calculate the demand for home sold and imported products of the household sector as the difference between total home sold and total imported product and total demand for home sold and imported goods for investment, government spending and intermediate inputs, respectively (equations 69).

e. Calculate tax revenue and benefit transfer payment, age pension payment and subsidy payment (equations 20, 21, 22, 53, 55, 56), trade balance (equations 26, 64, 65, 66), world debt (equation 67) and total asset holdings (equation and 71).

f. Based on information on transfer payment, age pension payment and price indexes, from the view of consumers, recalculate the demand of the household sector for home sold product, C_j^H, leisure and working decisions (equations 2, 3, 6, 7, 8, 19), and asset holdings (equations 4, 5, 9, 10).

i. Check whether the demands of the household sector from the view of the consumer (obtained from step 2(f)) are as the same as those got from step 2(d). If yes or the number of iterations exceed our predetermined number, we move to step 3. If no, we adjust the guessed labor level, L_j , and come back step 2(a).

5.2.3 Check the balance

If the total asset holdings and total labor supply of the household sector from the view of the consumer (obtained from step 2(f)) are as the same as the ones got from step 2(e) and guessed labor demand respectively.

If yes, we find a solution for the steady state equilibrium of the economy. If no, we adjust the guessed wage rate and start step 1 again.

5.3. The benchmark steady state solution

Characteristics of the benchmark year 2005-2006 are used to run the model. Because model provides results consistent with realistic conditions of this year, it is likely that the model is reliable[5].

5.3.1 The production sector

Table 6: Industry specific share in production output, value added, labor and capital use and capital – labor ratio

Industries	Share in production output value (%)	Share in total value added (%)	Share in total labour use (%)	Share in total capital stock (%)	Capital – labor ratio
AgrFor	2.66	3.09	1.30	5.16	4.60
MinQuarr	5.53	7.31	2.40	13.47	6.51
Food	3.70	2.15	2.11	2.18	1.20
Texcloth	0.40	0.34	0.43	0.21	0.57
Wood	0.52	0.45	0.46	0.44	1.11
Paper	1.55	1.44	1.61	1.26	0.91
Petrol	1.27	0.36	0.13	0.64	5.63
Chemic	1.19	0.78	0.82	0.72	1.02
Nonferr	1.31	1.02	1.16	0.84	0.84
Metals	3.73	1.98	2.45	1.45	0.69
MetProc	3.92	2.65	3.44	1.72	0.58
Energy	2.32	2.49	1.35	3.93	3.38
Constr	11.16	7.036	6.05	8.45	1.62
Trade	11.45	11.24	13.85	7.64	0.64
HotRest	2.76	2.26	2.59	1.90	0.85
Transp	8.48	7.55	6.86	8.27	1.40
RealEst	23.90	28.97	22.96	35.62	1.80
Public	10.52	15.30	24.98	4.21	0.20
OthServ	3.63	3.58	5.04	1.87	0.43
All goods	**28.10**	**24.06**	**17.66**	**32.03**	**1.81**
All services	**71.90**	**75.94**	**82.34**	**67.97**	**0.83**
SUM	**100%**	**100%**	**100%**	**100%**	**1.16**

Source: (ABS 2010a) and authors' calculation

In the benchmark year, total production output value and total value added of Australia is around $1,876 and $888 billions respectively. The largest contributions to total production output value and total value added are given by banking, insurance and real estate sector (23.9%-28.97%), followed by public service sector (10.52%-15.30%) and commerce sector (11.45%-11.24%)... Textile and clothing, petroleum, wood and wood processing and chemical sector have the smallest shares in production output value and value added. At a larger aggregated scale, all good producing industries account for 24% while all services providing industries create 76% of total value added.

Therefore, it is not surprising that in terms of labor and capital employment, banking, insurance and real estate, public service and commerce service are at the top while textile and clothing, petroleum, wood and wood processing and chemical sector are at the bottom. In fact, of $464.511 billions of compensation payment, $116.05, $106.66 and $64.33 billions come from public service, banking, insurance and real estate and commerce, respectively. And of $3274.35 billions of capital

[5] The reliability is then also supported by a sensitivity analysis

stock value, 35.62%, 8.45%, 8.27% and 7.65% are used by banking, insurance and real estate, construction, transport and commerce, respectively.

In terms of factor endowment abundance, Australia as a whole is capital abundant because capital contribution is 1.16 times bigger than labor contribution to total value added. Production of capital intensive goods so is the advantage of Australia. The most capital intensive sectors are mining and quarry, petroleum, agriculture and forestry and energy. And the most labor intensive sectors are public services, other services, textile and clothing and metal processing. Between goods producing and services providing industries, the former is more capital intensive while the latter is more labor intensive.

Table 7: Industry specific share of value added and use purposes in production output

Industries	Value added Contribution (%)	Intermediate use (%)	Final private use (%)	Government use (%)	Capital formation (%)	Export (%)
AgrFor	54.95	61.52	13.99	0.89	5.65	18.37
MinQuarr	62.58	43.79	0.42	0.10	2.62	53.13
Food	27.49	36.54	39.72	0.04	0.43	24.20
Texcloth	39.45	27.61	37.78	0.00	7.56	27.04
Wood	40.60	87.11	2.16	0.00	1.50	9.23
Paper	44.10	73.19	20.28	0.01	1.85	4.66
Petrol	13.46	62.45	25.93	0.00	0.29	13.77
Chemic	31.13	61.42	12.73	4.70	1.46	19.69
Nonferr	36.87	89.46	4.14	0.00	2.11	4.29
Metals	25.16	55.96	1.21	0.00	4.37	38.46
MetProc	32.02	40.51	21.19	0.01	24.17	14.12
Energy	50.74	57.84	29.33	2.10	10.56	0.17
Constr	29.84	37.35	0.38	1.40	60.54	0.33
Trade	46.46	35.85	47.24	0.85	9.13	6.97
HotRest	38.87	27.53	62.85	0.01	0.00	10.27
Transp	42.17	58.55	20.01	4.21	4.92	11.71
RealEst	57.39	63.02	29.43	1.11	4.50	1.99
Public	68.84	8.01	20.07	69.26	0.34	2.33
OthServ	46.74	29.59	45.92	21.99	0.89	1.82
All goods	**40.54**	**52.74**	**15.78**	**0.48**	**6.35**	**24.94**
All services	**50.01**	**43.08**	**27.39**	**12.46**	**13.02**	**4.03**
SUM	**47.34**	**45.80**	**24.12**	**9.10**	**11.15**	**9.91**

Source: (ABS 2010a) and authors' calculation

Total capital stock in the economy values $3274.35 billions or 3.68 times of national value added. Every year, firms spend $261.95 billions on capital formation. This expenditure is transformed into an investment flow to replace the depreciated stock of capital, equivalent to 6.45% of total capital stock. Total value of firms in the economy is estimated at $4848.07 billions.

With respect to contribution of value added to production output, primary and services industries are dominators. The sector with highest share of value added in production output is public service (68.84%), followed by mining and quarry (62.58%), banking, insurance and real estate (57.39%) and agriculture and forestry (54.95%). All of them use relatively less intermediate inputs in their production processes and rely more heavily on the use of labor or capital. The lowest shares of value added in production output occur in petroleum (13.77%) and food stuff industry (27.49%). Between goods producing and services providing industries, the latter ones have a bigger share of value added on average which is mainly caused by their intensive use of labor. The economy-wide data indicates that it is quite balanced between the contribution of intermediate inputs and value added in total domestic production output (52.66% and 47.34% respectively).

With regards to allocation between home and abroad sales, nearly 10% of total production output is used for export in which goods producing industries far exceed services providing industries. The most foreign market oriented sectors are mining and quarry (53.13% of output for export) and basic metals (38.46% of output for export). Both of them are primary industries which rely heavily on the world market in selling their products.

In terms of home use allocation, on the one hand, a majority of industries produce output mainly to meet demands for intermediate inputs (agriculture and forestry, mining and quarry, wood and wood processing, paper and paper processing, petroleum, chemicals, non-ferrous minerals, basic metals, metal processing, energy, transport and real estate). On the other hand, foodstuff, textile and clothing, trade, hotel and restaurant and other services are consumed chiefly by the household sector while most of production output of construction and public services are used for capital formation and government consumption respectively.

5.3.2 The government sector

The actual tiny government budget deficit in Australia is interpreted into the assumption of constant balance between tax revenue and government spending in any period in our model. At the same time, the government consumption value is supposed to be a fixed proportion to GDP or total value added. This proportion (ϕ) in the benchmark year equals 0.1953 and is applied for all other periods. Total government consumption value is \$173.43 billions. Unlike other economic agents, government only consumes domestically produced commodities, except chemicals.

The gap between total tax revenue and government consumption value is allocated as benefit transfer to all households (\$95.693 billions), age pension to retired cohorts (\$20.588 billions) and subsidy (\$9.734 billions).

In terms of sources, of total tax revenue of \$299.45 billions, commodity use tax is \$89.224 billions, income tax is \$182.26 billions, value added output tax is \$27.97 billions and import duty is \$3.24 billions. In terms of payers, producers pay \$66.864 billions while households pay \$232.59 billions.

5.3.3 The household sector

Table 4.3 displays how an average household allocate total consumption expenditure to alternative types of commodity. The household sector as a whole spends \$544.79 billions on goods and services consumption of which 26.68%, 20.52% and 8.26% are spent on banking, insurance and real estate, commerce and public service, respectively.

Table 8 Commodity specific share in final private consumption (%)

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
1.47	0.09	6.59	1.83	0.04	1.39	1.58	1.35	0.38	0.26
MetProc	**Energy**	**Constr**	**Trade**	**HotRest**	**Transp**	**RealEst**	**Public**	**OtherServ**	**Total**
6.63	2.57	0.16	20.52	7.03	6.73	26.68	8.26	6.41	**100%**

Source: (ABS 2010a) and authors' calculation

However, consumption differs from generation to generation. Overall, consumption of a typical household over her lifetime is hump shaped with the peaks around ages before and after the compulsory retirement age. Because of the compulsory retirement assumption, the leisure time in the last working age is essentially smaller than that of the first retirement age. Consequently, all consumers reduce significantly commodity consumption in their first retirement ages as an effort to smooth their felicity over time. The positive effect of full endowment time for leisure is cancelled out by the negative effect of the decline in commodity consumption. Total consumption value of the household sector is $544.79 billions. Asset holdings are also hump shaped with the peak at the biological age of 58. The total asset holding value of the household sector is around $5,310 billions which is stored in the form of firm value and loan to ROW.

Table 9 Final private consumption in industry specific home sold output (%)

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
17.06	0.89	51.77	51.79	2.38	21.27	29.24	15.85	4.33	1.97
MetProc	**Energy**	**Constr**	**Trade**	**HotRest**	**Transp**	**RealEst**	**Public**	**OtherServ**	**Total**
24.67	29.38	0.39	50.76	69.53	22.82	30.01	20.54	46.67	**26.76**

Source: (ABS 2010a) and authors' calculation

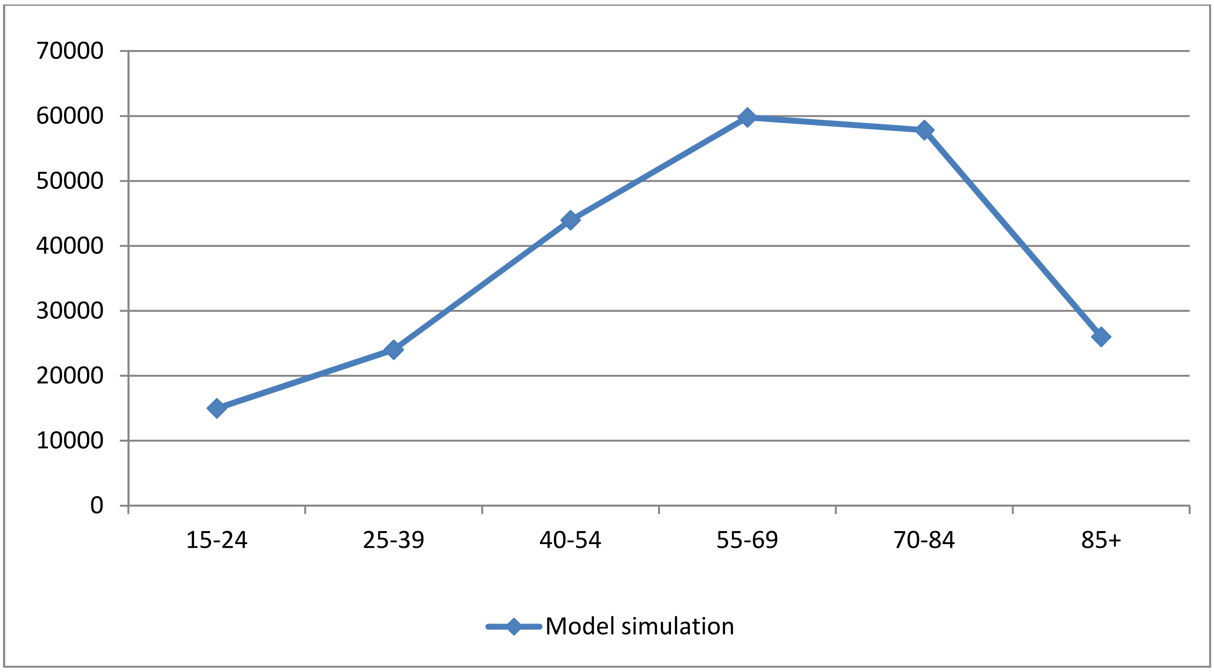

Figure 8 Age specific consumption ($)

Source: Authors' calculation

In general, final private consumption occupies a large proportion of home sold output, 26.75% on average. Production of final consumption oriented industries, including agriculture and forestry, food stuff, textile and clothing, paper and paper processing, petroleum, chemicals, metal processing energy and all services except construction rely much on domestic private demand. Hotel and restaurant service is most while construction and mining and quarry are least dependant on final private consumption. Industries with over half of their home sold output consumed by the household sector are food stuff, textile and clothing, commerce, hotel and restaurant.

Consumer preferences for home sold and imported product vary significantly across types of commodity. On average, the entire household sector allocates 91.05% of their expenditure for home sold product and the remaining, 8.95% for imported product. Commodities with large contribution of imports to final private consumption are textile and clothing (nearly 70%), chemicals (nearly 60%), non-ferrous minerals (nearly 50%) and metal processing (over 50%). Preferences for consumption of services are driven towards domestically provided products.

Table 10 The share of home made product in final private consumption (%)

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
95.41	93.16	84.02	31.33	100.00	85.22	78.30	42.28	53.44	65.63

MetProc	Energy	Constr	Trade	HotRest	Transp	RealEst	Public	OtherServ	Total
47.34	99.91	100.00	99.49	93.03	95.19	99.49	96.40	98.04	91.05

Source: (ABS 2010a) and authors' calculation

In terms of leisure allocation, it reduces continuously in the first 24 years then keeps increasing until reaching full leisure upon the biological age of 66. This is mirrored by a humped shape profile of supply of labor over individual lifetime. On average, the participation rate is 69.67%[6]. The highest participation takes place at the age of 38, equal 79.45%.

The figures below illustrate how good our model results fit with actual observations, specifically in terms of lifecycle participation rates and asset holdings.

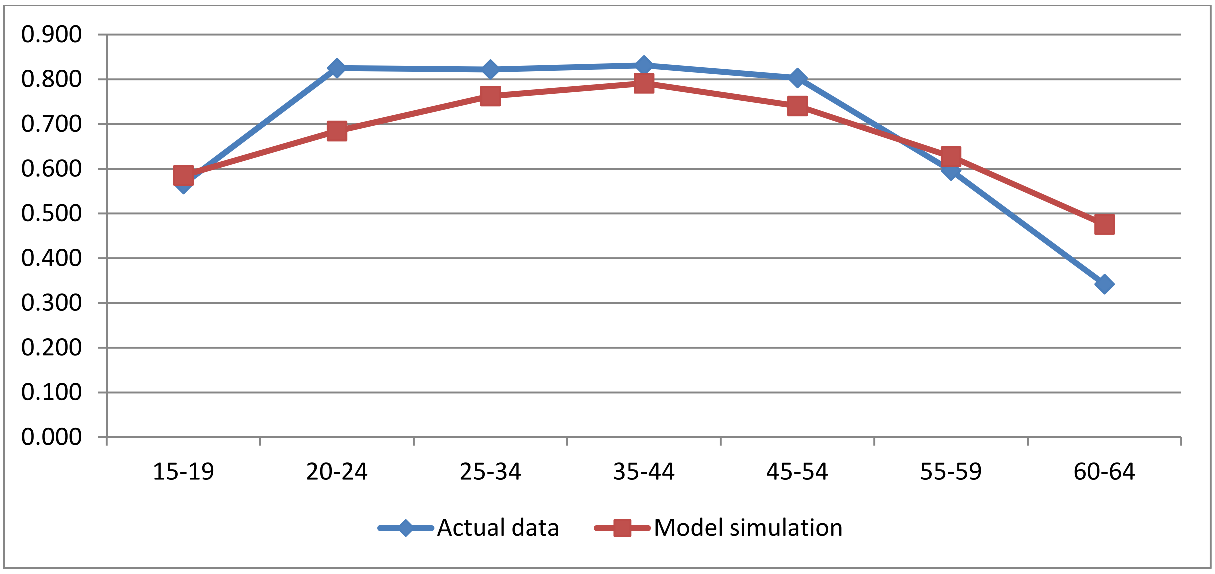

Figure 9 Age specific participation rates

Source: Authors' calculation and (Abhayaratna and Lattimore 2006)

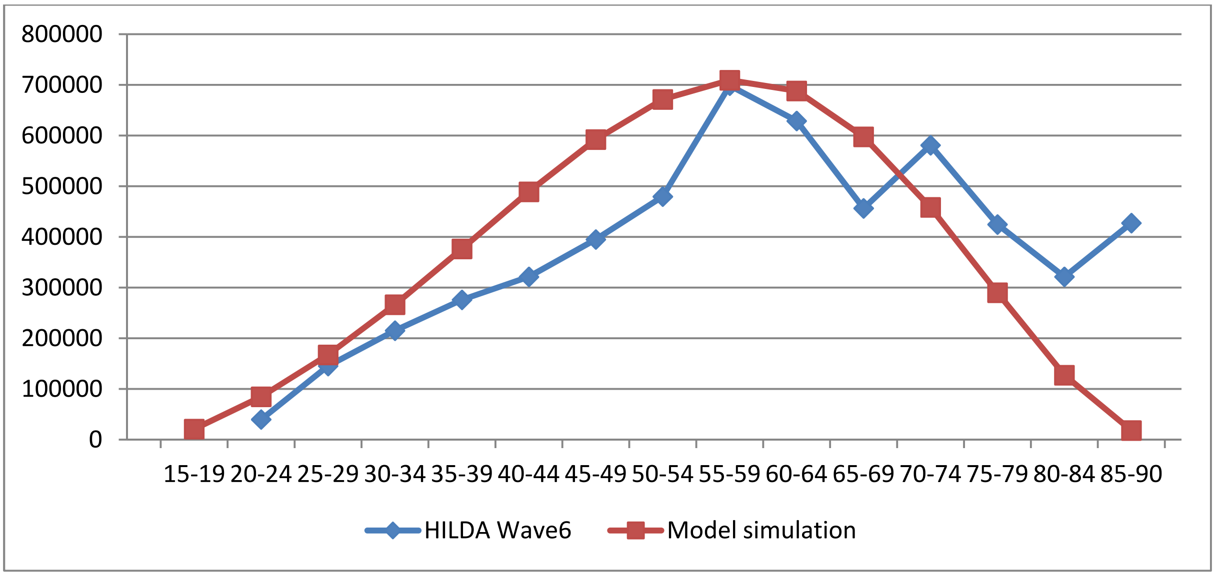

Figure 10 Age specific asset holdings ($)

Source: Authors' calculation and HILDA Wave 6

[6] This average participation rate is slightly higher than actual average because in our model, working force in the age after 65 is not included and our cohort structure is not as the same as the actual data.

5.3.4 Trade performance

In general, Australia is a net importer with total trade volume of $384.30 billions in the benchmark year. The trade deficit is about $12.72 billions, or 3.3% of the total trade volume. This narrow trade deficit represents not only in the benchmark year but also in most of the last decades. Overall, trading performance in Australia is sustainably balanced. Trade deficit is interpreted into the result that total ROW's debt to Australia is around $461.76 billions. This figure does not match the actual condition in which Australia is a net borrower from ROW. However, our model cannot capture accurately both flow of goods and flow of capital at the same time. Therefore, we ignore the unrealistic result on Australia's net foreign asset, just using it to adjust trade in goods and services. To some extent, this experiment is less biased if we take into account the fact that a large part of capital inflows into Australia, especially portfolio investments are not directly related to cross-border flows of goods and services.

Table 11 Commodity specific export and import ($ billion)

Commodities	AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
Export	9.18	55.12	16.77	2.04	0.90	1.36	3.27	4.39	1.05	26.88
Import	1.06	18.23	8.98	9.60	1.53	5.67	9.71	18.20	7.37	10.64

Commodities	MetProc	Energy	Constr	Trade	HotRest	Transp	RealEst	Public	OtherServ	TOTAL
Export	10.39	0.07	0.69	14.97	5.31	18.63	8.94	4.59	1.24	**185.79**
Import	84.38	0.03	0.02	0.54	3.87	6.46	8.38	1.93	1.89	**198.51**

Source: (ABS 2010a) and authors' calculation

In general, Australia is a net exporter of 10 commodities and net importer of 9 commodities. Most of net importing producers are in physical good producing industries while most of net exporting producers are in services providing industries, clearly stating the actuality that services sector is more competitive than non-services sector in Australia. The leading export products are created by the primary sectors. In other words, Australia relies on comparative advantage in services and natural resources in liberalizing the domestic economy and integrating into the world economy.

The largest deficit occurs in metal processing industry (nearly $74 billions). The second largest trade deficit is faced by the chemical sector, at nearly $14 billion. In terms of the import – export ratio, the leading industries are metal processing (8.12 times); non-ferrous minerals (7.01 times); textile and clothing (4.70 times); paper and paper processing (4.17 times); chemical excluding petroleum (4.15 times). They all reflect the fact that manufacturing is not a comparative advantage of Australia. Thus, Australia has spent a large amount on importing manufacturing goods such as transport equipment, especially motor vehicles, electronic equipment, household appliances, production equipment and machinery, furniture, chemical products, papers…

Table 12 Commodity specific trade deficit ($ billion)

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
8.12	36.88	7.79	-7.56	-0.63	-4.31	-6.44	-13.82	-6.32	16.24

MetProc	Energy	Constr	Trade	HotRest	Transp	RealEst	Public	OtherServ	TOTAL
-74.00	0.043	0.67	14.43	1.44	12.18	0.56	2.66	-0.65	**-12.72**

Source: (ABS 2010a) and authors' calculation

The biggest surplus takes place in mining and quarry industry (nearly $37 billions), followed by basic metal industry (over $16 billions). Two other good producing industries with strong competition power of Australia, agriculture and forestry and food stuff also perform significant trade surplus, over and nearly $8 billions respectively. In terms of export – import ratio, except some outliers ((i) construction whose ratio is 40.38 times but not vital because of its low trade volume and limited participating feasibility in the international trade; and (ii) commerce whose ratio is 27.93 times which is mostly caused by its marginal contribution going along with export of manufacturing goods), the leading industries are agriculture and forestry (8.64 times), mining and quarry (3.02 times), transport (2.89 times), basic metals (2.53 times) and energy (2.49 times). This data exhibits the reliance of Australia on natural resources, especially coal, gas and iron and non-ferrous metal ores to promote export activities.

Table 13 Commodity specific export – import ratio

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
8.64	3.02	1.87	0.21	0.59	0.24	0.34	0.24	0.14	2.53
MetProc	**Energy**	**Constr**	**Trade**	**HotRest**	**Transp**	**RealEst**	**Public**	**OtherServ**	**TOTAL**
0.12	2.49	40.38	27.93	1.37	2.89	1.07	2.37	0.66	**0.94**

Source: (ABS 2010a) and authors' calculation

With respect to the use of imports, 57% of nearly $200 billions are utilized for production while 22% and 19% are allocated for final private consumption and capital formation respectively.

Regarding the tariff or import duty rates, the detailed description could be found in the Appendix on Tax Data. But overall, import duty is not an important source of government budget because of relatively low rate on average (1.63% economy wide). Totally, duty revenue is just $3.24 billions in the baseline year. Tariffs are imposed against only imports of physical goods. Two groups of physical goods excluded from import duty are agriculture and forestry and mining and quarry.

6. Policy Simulations

We conduct numerical experiments for the impact of trade liberalization on important macroeconomic variables, welfare, industry specific output, capital stock accumulation, employment, trade performance as well as government budget situation under alternative world market conditions. Such changes are compared with the benchmark references.

Two possible world market conditions are assumed to take place:

(W1) No change in the world prices: The world market conditions are as the same as the time of the benchmark year.

(W2) Change in the world prices: It is projected that price of some primary goods will rise relatively to price of other goods in the long-term due to the depletion of unrecoverable natural resources. Therefore, a circumstance in which the world price of petroleum grows by 50% and price of some raw materials (mining and quarry) grows by 30% is adopted. This scenario is realistic, which has been occurred recently.

Our model is used to find steady state equilibrium associated with each of the above proposed conditions. The steady state equilibrium associated with (W1) has been described in Part 4 and is called the first benchmark equilibrium later on. The steady state equilibrium associated with (W2) is called the second benchmark equilibrium.

Then, following polices are simulated for both of two world market conditions:

(P1) All import duties are unilaterally, immediately and permanently eliminated: As written above, past and current negotiations with most big trading blocs will cause significant reduction in tariff rates in near future. Therefore, it is projected that the current low tariff rates will be further reduced substantially in coming years. A trading scenario in which all tariffs are cleared is a practical assumption, especially after FTA negotiations with big trading partners come into full effect.

(P2) Subsidization is unilaterally, immediately and permanently reduced: In trade negotiations, discrimination between home produced goods and imported goods through subsidization programs is gradually removed. Unlike tariff barriers, countries have more flexibility in using subsidization. In fact, countries are reluctant in removing their subsidization programs because of its substantiality in promoting domestic production, especially for export (Lloyd 2006). Hence, it is unexpected that all subsidies would be eliminated like the case of import duty. Instead, we adopt a realistic proposal that a flat rate decline of 50% is applied to all rates of subsidy.

The model is simulated to find the steady state equilibrium for all possible combinations between policy choices and world market conditions. Then, comparisons between results of different scenarios with their corresponding benchmark equilibrium are made to determine whether our economy is better or worse off and which scenario is most desired. Based on that, optimal policy for different world market conditions could be recommended.

In below parts, we focus on describing what would occur under alternative policies and world price scenarios. Detailed explanation on causes and institutions of such changes could be found in the Appendix.

6.1 Change in the world prices (W2)

6.1.1 Macro results

In general, the economy is better off when there is an increase in the world price of primary goods. Production output, GDP, total stock of capital and real wage rate are expected to increase significantly, around 30%. Australia would become a net exporter in the new price condition with trade surplus of $7 billions. Labor employment would rise, although with much smaller magnitude (3.7%). On average, total equivalent variation transformed welfare of the entire household sector increases by 3.5% in comparison with that in the benchmark year. This result is theoretically and practically consistent because as above analyzed, the Australian economy heavily relies on primary industries thanks to its abundance in natural resources. An increase in price of primary products therefore benefits much Australia as predicted by Hechscher-Ohlin theorem. What have happened actually also support this argument.

Table 14 Change in some key aggregate macro variables under scenario W2

Indicators	W1	W2	Change (%)
Wage rate ($ mills)	1.00	1.25	25.23
Production output value ($ bills)	1875532.13	1891363.34	31.72
GDP ($ bills)	887959	1207056.82	35.94
Capital stock ($ bills)	539503.70	670460.44	24.27
Employed labor	464511.00	481591.59	3.68
Trade balance ($ bills)	-12718.64	6955.99	Deficit to Surplus
Welfare	3622.14	3656.18	3.54

Source: Authors' calculation

6.1.2 Production performance

Table 15 Industry specific changes in production output value, home sold output value, price of home sold products under scenario W2

Industries	Production output value	Home sold output value	Price of home sold products

	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ mills)	W2 ($ mills)	change (%)
AgrFor	49970.00	57177.79	14.42	41002.17	49335.75	20.32	1.00	1.23	22.60
MinQuarr	103744.00	241691.12	132.97	48690.25	73877.42	51.73	1.00	0.95	-4.80
Food	69313.00	78743.78	13.61	53185.24	65035.97	22.28	1.00	1.26	26.14
Texcloth	7552.00	6340.52	-16.04	5509.68	5165.38	-6.25	1.00	1.24	24.01
Wood	9799.00	11936.00	21.81	8894.41	11194.95	25.86	1.00	1.21	20.83
Paper	29128.00	34376.03	18.02	27769.40	33260.00	19.77	1.00	1.18	18.08
Petrol	23764.00	35251.02	48.34	21072.44	27656.77	31.25	1.00	1.07	6.71
Chemic	22271.00	22243.77	-0.12	17885.35	19171.70	7.19	1.00	1.21	20.62
Nonferr	24503.00	30749.42	25.49	23452.36	29813.99	27.13	1.00	1.17	16.97
Metals	69904.00	74105.18	6.01	43020.50	52447.73	21.91	1.00	1.20	19.87
MetProc	73578.00	77307.24	5.07	63184.54	69645.97	10.23	1.00	1.19	19.39
Energy	43518.00	56007.39	28.70	43444.84	55939.54	28.76	1.00	1.16	15.52
Constr	209358.00	298002.73	42.34	208671.52	297351.80	42.50	1.00	1.18	18.41
Trade	214790.00	271752.64	26.52	199884.90	259195.73	29.67	1.00	1.21	20.93
HotRest	51687.00	59402.92	14.93	46725.61	55645.19	19.09	1.00	1.22	22.08
Transp	159094.11	197941.27	24.42	139518.24	182745.83	30.98	1.00	1.22	21.46
RealEst	448215.01	569725.40	27.11	439531.61	562298.15	27.93	1.00	1.19	19.42
Public	197300.00	260689.46	32.13	192715.53	256808.19	33.26	1.00	1.22	22.14
OthServ	68044.00	87098.31	28.00	66945.42	86168.52	28.71	1.00	1.20	20.30
All goods	527044.00	725929.27	37.74	397111.19	492545.16	24.03			
All services	1348488.13	1744612.72	29.38	8932856.57	5072321.93	-43.22			
SUM	1875532.13	2470541.99	31.72	1691104.02	2192758.58	29.66			

Source: Authors' calculation

Generally, the production sector as a whole is better off after the rise in the world price of primary products. Production value, GDP, capital use and labor employment are projected to grow by 31.7%, 35.9%, 24.3% and 3.7% respectively. If the whole production sector is disaggregated by goods and services, both of them would experience a positive change in value added output, capital and labor employment although the changes in the goods producing sector is much stronger than that in the services providing sector.

The industry level disaggregated analyses would produce mixed results. In terms of GDP expansion, all industries except textile and clothing would experience an increase in their valued added of which as expected, mining and quarry would record the biggest rise, followed by petroleum.

Regarding the employment of labor, besides textile and clothing with largest drop in employed labors, agriculture and forestry, food stuff, wood and wood processing, paper and paper processing, chemicals, basic metals, metal processing, hotel and restaurant and transport would also recruit fewer labors. In contrast, as expected, mining and quarry would experience the largest expansion in labor employment.

In terms of capital use, only textile and clothing, agriculture, food stuff, chemicals and metal processing would record a reduction of which textile and clothing have the largest decline. Amongst capital employment increasing industries, mining and quarry would show the highest growth, much higher than the closet followers, petroleum and construction.

Table 16 Industry specific changes in value added, labor and capital employment, and capital – labor ratio under scenario W2

Industries	Value added	Labor use	Capital use	Capital – labor ratio

	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ bills)	W2 ($ bills)	change (%)	W1	W2	change (%)
AgrFor	27457	31134	13.39	6048	5754	-5.07	27863	26953	-3.27	4.61	4.69	1.90
MinQuarr	64928	153565	136.52	11142	21656	92.28	72647	148145	103.92	6.52	6.91	6.05
Food	19055	21676	13.75	9789	8899	-9.24	11748	11577	-1.45	1.20	1.30	8.58
Texcloth	2979	2588	-13.13	2004	1395	-30.64	1145	861	-24.80	0.57	0.62	8.43
Wood	3978	4910	23.42	2142	2101	-2.38	2379	2571	8.05	1.11	1.23	10.68
Paper	12844	15654	21.88	7457	7216	-3.50	6813	7276	6.81	0.91	1.01	10.68
Petrol	3199	4934	54.25	614	747	21.11	3457	4633	34.04	5.63	6.23	10.68
Chemic	6932	7159	3.27	3831	3146	-18.27	3893	3522	-9.54	1.02	1.12	10.68
Nonferr	9034	11825	30.90	5389	5612	3.68	4548	5219	14.76	0.84	0.93	10.68
Metals	17591	20129	14.43	11376	10389	-9.27	7807	7840	0.42	0.69	0.76	10.68
MetProc	23561	25867	9.79	15975	13982	-12.88	9280	8948	-3.58	0.58	0.64	10.68
Energy	22082	29066	31.63	6272	6515	3.55	21211	24309	14.60	3.38	3.74	10.68
Constr	62474	89951	43.98	28114	31516	11.56	45573	58207	27.72	1.62	1.86	14.49
Trade	99801	128670	28.93	64332	65213	1.13	41232	47738	15.78	0.64	0.73	14.49
HotRest	20092	23307	16.00	12030	11073	-8.12	10272	10446	1.69	0.85	0.95	10.68
Transp	67085	84112	25.38	31881	31271	-2.23	44625	49530	10.99	1.40	1.59	13.52
RealEst	257235	328177	27.58	106656	5741	0.66	192175	214104	11.41	1.80	1.99	10.68
Public	135828	182698	34.51	116051	21424	7.12	22734	26953	18.56	0.20	0.22	10.68
OthServ	31804	41634	30.91	23408	8884	4.00	10102	11628	15.11	0.43	0.48	10.68
All goods	213640	328507	53.77	82039	1390	5.95	172792	251854	45.76	2.11	2.90	37.57
All services	674319	878549	30.29	382472	2091	3.19	366712	418607	14.15	0.96	1.06	10.62
SUM	887959	1207057	35.94	464511	7196	3.68	539504	670460	24.27	1.16	1.39	19.87

Source: Authors' calculation

Because of above changes in capital and labor employment, capital – labor ratio is expected to rise in all industries. Between goods producing and services providing sector, the capital – labor ratio of the former would be affected more strongly. The largest change is projected to take place in construction and commerce services while the smallest variation is expected to happen in agriculture and forestry industry and mining and quarry. All other industries would experience the growth in capital – labor ratio by around 10%. Australia would become more capital intensive and most capital intensive industries would expand their production strongly while labor intensive industries (especially unskilled labor intensive industries such as textile and clothing) would contract or grow slightly. This result partly goes along with Hecksher-Ohlin theorem[7] which predicts there is a reduction in labor intensive industries but expansion in capital intensive industries.

Price of all home sold products except mining and quarry is expected to rise after the increase in world prices of primary goods. These results are practical because mining, quarry and petroleum are major inputs to all industries.

Mining and quarry industry is expected to gain most from the world price change with much higher growth rate of GDP and capital and labor use over those of the remaining industries. In contrast, textile and clothing industry would suffer from a big loss with the highest contraction of GDP, employed labor and capital stock.

6.1.3. The government sector

[7] Stolper-Samuelson theorem that predicts the increase in world price of capital intensive goods would lead to a relative expansion in production of capital intensive goods and rental rate of capital.

Since government consumption spending shares a fixed proportion of total GDP in any period, its change would be as the same as the change in GDP, increasing by 35.94%. Specifically, world price changes would cause an increase in government consumption expenditure by 35.94%. Similarly, other benefit transfer payment, age pension payment and subsidy payment also increase, by 19.06%, 25.23% and 41.84% respectively. Tax revenue therefore is also expected to rise by 30.00%.

Table 17 Changes in the government sector under scenario W2

Indicators	W1	W2	Change (%)
Spending ($ bills)	173434.51	235760.11	35.94
Other benefit Transfer ($ bills)	95692.91	113935.40	19.06
Age Pension ($ bills)	20588.00	25782.83	25.23
Subsidy ($ bills)	9734.00	13806.42	41.84
Tax Revenue ($ bills)	299449.42	389284.76	30.00

Source: Authors' calculation

6.1.4 The household sector

Table 19 Changes in the household sector under scenario W2

Indicators	W1	W2	Change (%)
Aggregate private consumption ($ bills)	544789.70	693042.23	27.21
Participation rate (%)	69.67	72.31	3.37
Asset holdings ($ bills)	5309833.04	6708799.83	26.35
Welfare	3622.14	3656.18	3.54

Source: Authors' calculation

Like most of the production industries, the household sector overall would gain after a positive change in price of primary products. Total equivalent variation transformed welfare of the entire household sector is projected to increase by 3.54%. In order to assess the welfare change, we follow (Kudrna and Woodland 2011) in adopting the basis of equivalent variations. Accordingly, the percentage change in equivalent variation transformed welfare is measured by:

$$W = \left[\left(\frac{U_{new}}{U_{initial}} \right)^{\frac{1}{1-\frac{1}{\gamma}}} - 1 \right] \times 100$$

Table 20 Commodity specific changes in final private consumption under scenario W2

Commodities	Consumption of home made products			Consumption of imported products			Consumption expenditure		
	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ bills)	W2 ($ bills)	change (%)	W1	W2	change (%)
AgrFor	6993.09	8789.76	25.69	336.49	534.41	58.82	7329.59	9324.17	27.21
MinQuarr	435.32	592.84	36.19	31.95	1.58	-95.07	467.26	594.42	27.21
Food	27532.28	34410.89	24.98	5237.19	7269.76	38.81	32769.47	41680.65	27.19
Texcloth	2853.48	2572.19	-9.86	6252.96	8929.54	42.81	9106.45	11501.73	26.30
Wood	211.51	269.07	27.21	0.00	0.00	NA	211.51	269.07	27.21
Paper	5907.45	7074.46	19.75	1024.71	1742.08	70.01	6932.16	8816.54	27.18
Petrol	6161.67	7469.64	21.23	1707.94	2536.99	48.54	7869.61	10006.63	27.16
Chemic	2835.59	2710.45	-4.41	3871.11	5813.60	50.18	6706.70	8524.05	27.10
Nonferr	1014.36	1246.13	22.85	883.77	1167.33	32.09	1898.12	2413.46	27.15
Metals	846.03	880.45	4.07	443.03	756.33	70.72	1289.06	1636.78	26.97
MetProc	15589.38	14205.20	-8.88	17344.32	27429.11	58.14	32933.70	41634.31	26.42
Energy	12763.51	16232.02	27.18	11.42	19.27	68.78	12774.93	16251.30	27.21

Commodities	Consumption of home made products			Consumption of imported products			Consumption expenditure		
	W1 ($ bills)	W2 ($ bills)	change (%)	W1 ($ bills)	W2 ($ bills)	change (%)	W1	W2	change (%)
Constr	804.50	1023.43	27.21	0.00	0.00	NA	804.50	1023.43	27.21
Trade	101458.44	128706.35	26.86	520.22	1023.55	96.76	101978.66	129729.91	27.21
HotRest	32487.39	38892.33	19.72	2435.56	5534.14	127.22	34922.95	44426.46	27.21
Transp	31835.92	40362.38	26.78	1608.20	2176.02	35.31	33444.13	42538.39	27.19
RealEst	131902.95	167233.59	26.79	678.36	1426.80	110.33	132581.31	168660.39	27.21
Public	39591.84	49588.85	25.25	1478.81	2658.28	79.76	41070.65	52247.13	27.21
OthServ	31243.22	39603.76	26.76	624.73	935.79	49.79	31867.94	40539.55	27.21
All goods	83143.67	96453.09	16.01	37144.90	56200.02	51.30	120288.57	152653.10	26.91
All services	369324.26	465410.68	26.02	7345.87	13754.58	87.24	376670.14	479165.26	27.21
SUM	452467.93	561863.77	24.18	44490.77	69954.59	57.23	496958.70	631818.36	27.14

Source: Authors' calculation

Additionally, total private consumption spending, labor force participation rate and asset holdings are expected to change positively, by 27.21%, 3.37%% and 26.35% respectively. Expenditure on home sold products increases across commodities except textile and clothing, chemicals and metal processing. Spending on imported products grows across commodities except mining and quarry.

The disaggregation by generation level would produce positive results. It would lead to an increase in all age specific consumptions, participation rates and asset holdings. In terms of consumption, the greatest variation is expected to happen to the youngest generations while the smallest change is expected to happen to the eldest generations. Differently, in terms of participation rate, the biggest and smallest changes are projected to occur to the eldest working and mid-career generations respectively. Regarding asset holdings, the eldest generations would experience the largest variations while other cohorts would see smaller changes. These results reveal the possibility that consumers would relatively save less but consume more in the first half of their life.

6.1.5 Trade performance

In general, trade performance of Australia after the price change would show a mixed result. Although it is projected that instead of being a net imported, Australia would become a net exporter, different results are to happen to goods producing and services providing industry. While the former would record an increase in export value and export-import ratio, the latter is expected to show a decrease. And both of them would import more, increasing by 32% in goods producing sector and 82% in services providing sector. Eventually, goods producing sector is expected to be a net exporter rather than a net importer as before but services providing sector would show a big contraction in its trade surplus by 92.8%.

Table 21 Commodity specific changes in import value, export value, export – import ratio and trade balance under scenario W2

Industries	Export			Import			Export-Import Ratio			Trade Balance		
	W1 ($ bills)	W2 ($ bills)	Change (%)	W1 ($ bills)	W2 ($ bills)	Change (%)	W1	W2	Change (%)	W1 ($ bills)	W2 ($ bills)	Change (%)
AgrFor	9181	8028	-12.55	1062	1499	41.12	8.64	5.37	-37.90	8119	6604	-19.57
MinQuarr	55116	168003	204.82	18235	11096	-39.15	3.02	15.40	409.58	36881	166805	325.44
Food	16772	14256	-15.00	8982	11941	32.95	1.87	1.20	-35.94	7790	2203	-70.29
Texcloth	2042	1175	-42.46	9604	12768	32.94	0.21	0.09	-56.55	-7562	-12849	53.31
Wood	905	741	-18.08	1531	2203	43.89	0.59	0.34	-42.93	-627	-1543	133.35
Paper	1359	1116	-17.85	5672	7571	33.49	0.24	0.15	-38.35	-4313	-6582	49.66
Petrol	3271	9230	182.15	9714	16488	69.73	0.34	0.56	66.60	-6443	-7290	12.65

Industries	Export			Import			Export-Import Ratio			Trade Balance		
	W1 ($ bills)	W2 ($ bills)	Change (%)	W1 ($ bills)	W2 ($ bills)	Change (%)	W1	W2	Change (%)	W1 ($ bills)	W2 ($ bills)	Change (%)
Chemic	4386	3072	-29.95	18202	24180	32.84	0.24	0.13	-47.10	-13816	-21468	52.78
Nonferr	1051	935	-10.97	7370	8870	20.35	0.14	0.11	-25.85	-6319	-8187	25.56
Metals	26884	21657	-19.44	10641	13751	29.23	2.53	1.58	-37.31	16243	8136	-51.33
MetProc	10386	7656	-26.29	84379	120821	43.19	0.12	0.06	-48.37	-73993	-117697	52.94
Energy	72	67	-7.25	29	49	67.51	2.49	1.39	-44.39	43	20	-57.30
Constr	686	651	-5.18	17	32	89.94	40.38	20.18	-50.02	669	636	-7.59
Trade	14970	12612	-15.75	536	1056	97.05	27.93	12.00	-57.03	14434	11698	-19.94
HotRest	5307	4020	-24.26	3867	8690	124.73	1.37	0.46	-66.16	1440	-4602	S to D
Transp	18634	14464	-22.38	6459	8093	25.30	2.89	1.79	-37.90	12175	6548	-47.67
RealEst	8938	7645	-14.47	8382	17917	113.76	1.07	0.43	-59.88	556	-10325	S to D
Public	4591	3887	-15.34	1934	3489	80.43	2.37	1.12	-52.84	2657	413	-85.04
OthServ	1241	1050	-15.37	1894	2794	47.52	0.66	0.38	-42.50	-653	-1753	167.02
All goods	131424	235937	79.52	175421	231237	31.82	0.75	1.03	37.28	-43997	8151	D to S
All services	54368	44329	-18.47	23089	42072	82.22	2.35	1.06	-55.10	31279	2614	-92.79
SUM	185791	280265	50.85	198510	273309	37.68	0.94	1.03	10.36	-12719	10765	D to S

Source: Authors' calculation

Industry level disaggregated results indicate that while all services would become less export oriented, a mixed outcomes would happen to goods producing industries. The increase in price of mining and quarry and petroleum would lead to a reduction in export value of all industries except mining, quarry and petroleum. In contrast, all commodities except mining and quarry are expected to show a rise in import value. This result is an obvious consequence of the increase in price of home produced commodities which shifts the choice towards imported items. Consequently, all industries except mining and quarry would have a worse trade performance, such as reduction in trade surplus, expansion in trade deficit… It is also reflected by the fall in export – import ratio in all sectors except mining and quarry. This result emphasizes the fact that Australia heavily depends on natural resources in promoting trade performance in the case of changes in world market condition. The gain of natural resources based industries goes along with the loss of the remaining industries. Surprisingly, the surplus of mining and quarry alone offsets the deficits of all other producers.

6.2 Tariff elimination (P1)

6.2.1 Macro results

Generally, macro performance is positive if trade liberalization is implemented entirely through tariff elimination. The gross production output, value added (GDP), stock of capital, the number of employed labors and trade balance are projected to improve if tariff abolition is undertaken. For example, in any world market conditions, removal of import duty alone would cause a positive change in production output (0.84% and 1.36% in the W1 and W2 respectively), GDP size (1.06% and 1.63% in the W1 and W2 scenario respectively) and improvement in trade balance (contraction of trade deficit and expansion of trade surplus in the W1 and W2 respectively). Similar results also happen to stock of capital, volume of employed labors…The real wage rate (in terms of the imported or exported goods) is expected to increase slightly by 0.04% in the W1 scenario and 0.47% in the W2 scenario. Importantly, the equivalent variation transformed welfare of the entire household sector is expected to increase slightly in both price scenarios, by 0.05% and 0.06% respectively.

Table 22 Changes in some key aggregate macro variables under the first trade policy P1 (%)

Indicators	P1-W1[1]	P1-W2[2]
Wage rate	0.04	0.47
Production output	0.84	1.36

GDP	1.06	1.63
Capital stock	2.28	2.62
Employed labor	0.74	0.77
Trade balance	-18.01 (Trade deficit falls)	54.75 (Trade surplus rises)
EV Welfare	0.05	0.06

[1]: Comparison against the scenario W1 which presents no change in the world prices

[2]: Comparison against the scenario W2 which presents the change in the world price of primary products

Source: Authors' calculation

If we consider the first commercial policy (P1) as an illustration of free trade between countries, the above results go along with mainstream international trade theory that predicts an increase in both output and welfare.

6.2.2 Production performance

In general, the production sector as a whole would gain if tariff clearance is conducted. Industries are projected to experience bigger variation in W2 to W1. Under W1, production output, GDP, total capital use and total volume of employed labors are expected to grow by 0.84%, 1.06%, 2.28% and 0.74% respectively. Similarly, under W2, they are projected to increase, but with bigger magnitude, by 1.36%, 1.63%, 2.62% and 0.77% respectively. If the whole production sector is disaggregated by goods and services, the same results would occur but the variation in the goods producing sector is much stronger than that in the services providing sector. This result is practically consistent because the former sector relies more on the world market, so benefits more after trade liberalization.

The industry level disaggregated analyses would produce mixed results. All industries except textile and cloth and metal processing would experience an increase in production output while only textile and cloth would see a reduction in value added. As expected, mining and quarry would record the biggest rises, followed by construction. These results are reasonable because textile and cloth and manufacturing industries are less competitive than others.

Regarding the employment of labor, besides textile and clothing with largest drop in employed labors, food stuff and metal processing would also recruit fewer labors in W2 condition while all other industries would employ more labor. In contrast, mining and quarry would experience the largest expansion in labor employment.

In terms of capital use, only textile and clothing would record a reduction. Amongst capital use increasing industries, mining and quarry would show the highest growth, much higher than the closet followers, basic metals.

Because of above changes in capital and labor employment, capital – labor ratio is expected to rise in all industries. Between goods producing and services providing sector, the capital – labor ratio of the former would be affected more strongly. The largest change is projected to take place in construction and commerce services while the smallest variation is expected to happen in agriculture and forestry industry. All other industries would experience the growth in capital – labor ratio by around 1%. Australia would become more capital intensive and most capital intensive industries would expand their production strongly while labor intensive industries (especially unskilled labor intensive industries such as textile and clothing) would contract or grow slightly. Price of all home sold commodities is expected to fall after the abolition of import duty. These results partly go along with Heckshher-Ohlin theorem[8] which predicts there is a reduction in labor intensive industries but expansion in capital intensive industries.

Table 23 Industry specific changes under the first trade policy P1 (%)

[8] Stolper-Samuelson theorem predicts the increase in world price of capital intensive goods would lead to a relative expansion in production of capital intensive goods and rental rate of capital.

Industries	Production output		Home sold output		Price of home sold product		Value added		Labor use		Capital use		Capital – labor ratio	
	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]
AgrFor	0.29	0.44	0.07	0.36	-0.80	-0.37	0.31	0.45	0.79	0.57	1.00	0.81	0.21	0.24
MinQuarr	4.78	4.56	2.66	2.04	-1.67	-1.54	4.87	4.67	5.04	4.41	5.72	5.19	0.65	0.75
Food	0.13	0.21	-0.19	0.12	-0.87	-0.33	0.42	0.48	0.37	-0.01	1.28	1.04	0.91	1.05
Texcloth	-6.91	-7.97	-7.78	-8.32	-1.50	-0.88	-6.09	-7.15	-6.13	-7.59	-5.29	-6.64	0.89	1.03
Wood	0.62	0.91	0.48	0.87	-0.64	-0.24	0.84	1.14	0.70	0.55	1.83	1.85	1.12	1.29
Paper	0.29	0.53	0.22	0.51	-0.59	-0.24	0.53	0.82	0.40	0.24	1.53	1.54	1.12	1.29
Petrol	0.98	1.51	0.78	1.01	-0.75	-0.99	0.97	1.94	0.74	1.25	1.87	2.56	1.12	1.29
Chemic	0.88	0.74	0.55	0.65	-0.73	-0.30	1.13	1.04	1.00	0.45	2.13	1.75	1.12	1.29
Nonferr	0.54	0.99	0.47	0.97	-0.71	-0.36	0.92	1.42	0.80	0.84	1.92	2.15	1.12	1.29
Metals	1.57	1.24	0.21	0.61	-1.53	-0.94	2.27	2.05	2.15	1.48	3.29	2.79	1.12	1.29
MetProc	-0.27	-0.37	-0.55	-0.47	-0.89	-0.45	0.27	0.20	0.17	-0.35	1.29	0.94	1.12	1.29
Energy	0.50	0.95	0.49	0.95	-0.73	-0.41	0.63	1.10	0.43	0.44	1.56	1.74	1.12	1.29
Constr	1.33	1.97	1.33	1.97	-0.68	-0.33	1.57	2.21	1.20	1.33	2.71	3.09	1.50	1.73
Trade	0.41	0.79	0.33	0.78	-0.52	-0.15	0.65	1.07	0.42	0.36	1.92	2.10	1.50	1.73
HotRest	0.33	0.54	0.17	0.50	-0.69	-0.27	0.65	0.87	0.53	0.29	1.65	1.59	1.12	1.29
Transp	0.75	1.07	0.54	1.02	-0.63	-0.25	0.89	1.25	0.59	0.47	2.00	2.09	1.40	1.62
RealEst	0.55	0.98	0.53	0.97	-0.50	-0.15	0.58	1.01	0.41	0.38	1.54	1.68	1.12	1.29
Public	0.81	1.32	0.80	1.32	-0.26	0.15	0.99	1.52	0.92	1.01	2.05	2.31	1.12	1.29
OthServ	0.37	0.79	0.36	0.79	-0.43	-0.05	0.62	1.07	0.53	0.53	1.66	1.83	1.12	1.29
All goods	1.23	1.85	0.31	0.57			1.89	2.60	1.16	1.27	3.25	3.63	2.06	2.34
All services	0.69	1.16	-14.49	-33.52			0.80	1.27	0.65	0.66	1.82	2.02	1.16	1.34
SUM	0.84	1.36	0.57	1.02			1.06	1.63	0.74	0.77	2.28	2.62	1.53	1.84

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Once again, mining and quarry industry is expected to gain most from tariff clearance with much higher growth rate of production output, GDP and capital and labor use over those of the remaining industries. In contrast, textile and clothing industry would suffer from a big loss with the highest contraction of production output, GDP, employed labor and capital stock.

6.2.3 The government sector

Since government consumption spending shares a fixed proportion of total GDP in any period, its change would be as the same as the change in GDP. Specifically, tariff elimination would cause an increase in government consumption expenditure by 1.06% in W1 and 1.63% in W2. However, because of the disappearance of tariff revenue, total tax revenue drops by 0.54% and 0.17% in the scenario W1 and W2 respectively.

Payment for age pension is expected to rise by 0.04% and 0.47% respectively in W1 and W2 scenario. If tariff elimination is implemented alone, it is expected that the government would have to spend more on subsidy payment (1.42% more in W1 and 1.86% more in W2). It could be interpreted as further assistance from the government to promote the competition of domestic producers in a more challenging environment.

Table 24 Changes in the government sector under the first trade policy P1 (%)

Indicators	P1-W1[1]	P1-W2[2]
Spending	1.06	1.63
Other Benefit Transfer	-3.76	-4.28
Age Pension	0.04	0.47
Subsidy	1.42	1.86
Tax Revenue	-0.54	-0.17

[1]: Comparison against the scenario W1 which presents no change in the world prices

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Consequently, payment for other benefit transfer would change in an opposite direction. It is projected to decrease due to tariff elimination, by around 4% as a result of reduction in tax revenue and increase in other spendings of the government.

6.2.4 The household sector

Table 25 Changes in the household sector under the first trade policy P1 (%)

Indicators	P1-W1[1]	P1-W2[2]
Real aggregate private consumption	0.57	0.60
Participation rate	0.76	0.79
Asset holdings	-0.27	0.08
EV Welfare	0.05	0.06

[1]: Comparison against the scenario W1 which presents no change in the world prices

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Similar to the production sector, the household sector overall would get better off if the tariff elimination is simulated. Specifically, equivalent variation transformed welfare of the household sector is projected to increase slightly in all price conditions, by 0.05% in the W1 scenario and 0.06% in the W2 scenario. Like above, we follow (Kudrna and Woodland 2011) in adopting the basis of equivalent variations. This result is consistent with other researches on tariff liberalization in Australia though they do not incorporate leisure in the utility function. Recent researches such as the ones by (Siriwardana 2006a; Siriwardana 2006b) show that welfare of Australia improves after free trade agreement with US, Singapore or Thailand comes into effect. In their model, utility is totally driven by good consumption. As a result, after output expansion, consumption increases and leads to a rise in welfare. In our model, the increase in output and then commodity consumption are associated with an expansion in working time which implies a fall in leisure time. The abolition of import duty would lead to an increase in real private consumption by around 0.6% and participation rate by around 0.8%. The leisure time contraction has a negative impact on utility but is fully offset by the positive effect of commodity consumption rise. Consequently, although it would also lead to an improvement in welfare, its magnitude is smaller than that of other researches. To our knowledge, until now only Keuschnigg and Kohler (Keuschnigg and Kohler 1994; Keuschnigg and Kohler 1995) have examined the effect of tariff liberalization by using multi-sector OLG CGE models that incorporate leisure in consumers' utility. Hence, we have a limited number of relevant models for the purpose of testing our computing results.

Asset holdings of the household sector are expected to change very slightly. In contrast, participation rate in the labor force would rise by around 0.8% in both price conditions.

Table 26 Commodity specific changes in private consumption under the first trade policy P1 (%)

Commodities	Consumption of home made products		Consumption of imported products		Consumption expenditure	
	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]
AgrFor	-0.17	0.15	-1.09	-0.27	-0.22	0.12
MinQuarr	0.93	0.16	-15.78	-15.20	-0.22	0.12
Food	-0.23	0.07	0.89	1.43	-0.05	0.31
Texcloth	-9.85	-11.57	12.66	12.00	5.61	6.73
Wood	-0.22	0.12	NA	NA	-0.22	0.12
Paper	-0.18	0.03	0.03	0.98	-0.15	0.22
Petrol	-0.31	-0.03	0.14	0.57	-0.22	0.12
Chemic	-0.40	-0.80	0.79	1.43	0.29	0.72
Nonferr	-0.65	-0.41	3.05	3.47	1.07	1.46
Metals	-0.25	-0.68	1.45	2.65	0.33	0.86
MetProc	-3.21	-4.47	5.15	5.19	1.19	1.90
Energy	-0.21	0.13	-1.62	-0.67	-0.22	0.12
Constr	-0.22	0.12	NA	NA	-0.22	0.12
Trade	-0.21	0.13	-1.39	-0.21	-0.22	0.12
HotRest	-0.06	0.23	-2.26	-0.63	-0.22	0.12
Transp	-0.20	0.13	-0.41	0.05	-0.21	0.12
RealEst	-0.21	0.13	-1.63	-0.30	-0.22	0.12
Public	-0.20	0.11	-0.66	0.38	-0.22	0.12
OthServ	-0.21	0.13	-0.59	0.08	-0.22	0.12
All goods	-1.12	-0.94	4.82	4.94	0.71	1.22
All services	-0.19	0.13	-1.27	-0.21	-0.22	0.12
SUM	-0.36	-0.05	3.81	3.92	0.01	0.39

[1]: Comparison against the scenario W1 which presents no change in the world price

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

The disaggregation by generation level would produce mixed results. Tariff elimination would lead to an increase in all age specific consumptions and participation rates but a mixed movement in age specific asset holdings. In terms of consumption, the growth rate keeps decreasing as consumers become older, implying a relative decline in saving of young generations. Differently, the growth rate of participation rate is largest before the retirement age and smallest in mid-career ages. The magnitude of the policy's effect on consumption and participation rate is almost the same across two world market conditions. Regarding asset holdings, this liberalization policy is expected to cause a drop in all age specific asset holdings except those of eldest cohorts in the scenario W2. And the greatest variation happens to eldest generations while the smallest change occurs to mid-career ages. The policy is more significant under the W1 condition. Such changes show that households generally work more, consume more but save less during their working ages.

6.2.5 Trade performance

Like the case of change in world price, trade performance of Australia after tariff abolition would show a mixed result. Generally, Australia would improve its trade balance, reducing trade deficit by 18% in W1 condition and increasing trade surplus in W2 condition by 54.75%. Similar variation is projected to occur to both goods producing and services providing industry. The former would record an increase in export value, import value and export – import ratio. As a result, goods producing industry is expected to reduce trade deficit in W1 scenario and expand trade surplus in W2 scenario. The latter is expected to show a rise in export value and export – import ratio but a fall in import value in W1 condition. In W2 condition, all of these indicators of services providing sector would grow. Eventually, services providing industry would lift its trade surplus in both conditions.

Table 27 Commodity specific changes in export value, import value, export – import ratio and trade balance under the first trade policy P1 (%)

Industries	Export		Import		Export-Import Ratio		Trade Balance	
	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]	P1-W1[1]	P1-W2[2]
AgrFor	1.33	0.93	-0.52	0.06	1.86	0.87	1.57	1.13
MinQuarr	6.64	5.67	-2.49	-3.29	9.37	9.27	11.16	6.31
Food	1.17	0.64	1.23	1.70	-0.06	-1.04	1.10	-4.83
Texcloth	-4.56	-6.46	9.12	9.25	-12.54	-14.38	12.82	10.84
Wood	1.94	1.43	3.45	4.14	-1.46	-2.61	5.63	5.52
Paper	1.57	1.06	1.36	1.83	0.21	-0.75	1.29	1.96
Petrol	2.51	3.32	1.63	2.06	0.87	1.24	1.18	0.45
Chemic	2.23	1.34	1.14	1.66	1.08	-0.32	0.79	1.71
Nonferr	2.10	1.79	2.65	3.04	-0.53	-1.21	2.74	3.18
Metals	3.76	2.78	2.05	2.70	1.67	0.07	4.88	2.91
MetProc	1.48	0.56	3.16	3.79	-1.64	-3.11	3.40	4.00
Energy	2.17	1.89	-1.14	-0.12	3.34	2.02	4.38	7.18
Constr	2.99	2.78	0.97	2.19	2.00	0.58	3.04	2.81
Trade	1.51	1.11	-1.36	-0.17	2.92	1.29	1.62	1.23
HotRest	1.76	1.11	-1.95	-0.27	3.78	1.39	11.71	-1.46
Transp	2.25	1.70	0.50	0.85	1.74	0.84	3.18	2.77
RealEst	1.68	1.32	-0.65	0.86	2.35	0.46	36.85	0.51
Public	1.38	0.99	-0.41	0.66	1.80	0.33	2.69	3.90
OthServ	1.34	0.91	-0.02	0.68	1.36	0.23	-2.61	0.54
All goods	4.03	4.52	2.34	3.12	1.65	1.36	-2.70	73.43
All services	1.82	1.35	-0.49	0.57	2.32	0.77	3.53	15.85
SUM	3.38	4.01	2.01	2.72	1.34	1.26	-18.01	54.75

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Industry level disaggregated results indicate that uneven outcomes would happen to specific industries. The import duty elimination would lead to a rise in export value of all industries except textile and clothing. The largest and smallest variation would take place in mining and quarry and food stuff industry respectively. 11 out of 19 industries would import more in both world price scenarios are food stuff, textile and clothing, wood and wood processing, paper and paper processing, petroleum, chemicals, non-ferrous minerals, basic metals, metal processing, construction and transport. The largest and smallest change are expected to textile and clothing and transport respectively. Industries that would experience the drop in import value in both W1 and W2 are agriculture and forestry, mining and quarry, energy, trade and hotel and restaurant. Industries that would face a mixed outcome (import value decrease in W1 but increase in W2) are real estate, public and other services. Consequently, export – import ratio in all services and agriculture and forestry, mining and quarry, petroleum, basic metals and energy would rise. This ratio of textile and clothing, wood and wood processing, non-ferrous minerals and metal processing would decline while that of food stuff, paper and paper processing and chemicals is expected to rise in W1 but fall in W2.

This result emphasizes again natural resources based industries benefit most while labor intensive manufacturing industries loss much if tariff elimination is undertaken. These results go along with Heckscher-Ohlin theorem that predicts that a capital abundant country would specialize in and export capital intensive goods. Actually, most capital intensive commodities would become more export oriented after the tariff elimination is conducted.

6.3 Subsidy reduction (P2)

6.3.1 Macro results

In general, a reduction in subsidy rate would cause a negative macro performance of the Australian economy. The production output, GDP, stock of capital, the number of employed labors and trade balance are all projected to fall if subsidization decline is undertaken. For example, in any world market conditions, reduction of subsidy rate would lead to a negative change in production output (by 2.5% and 3% in W1 and W2 respectively), GDP size (by 2.93% and 3.55% in the W1 and W2 scenario respectively), stock of capital by around 3%, use of labor by around 1% and worsening of trade balance (expansion of trade deficit in the W1 and contraction of trade surplus in the W2). The real wage rate (in terms of the imported or exported goods) is expected to decrease.

Table 28 Changes in some key aggregate macro variables under the second trade policy P2 (%)

Indicators	P2-W1[1]	P2-W2[2]
Wage rate	-1.49	-1.97
Production output	-2.50	-3.04
GDP	-2.93	-3.55
Capital stock	-3.07	-3.48
Employed labor	-1.15	-1.18
Trade balance	23.05 (Trade deficit rises)	-74.99 (Trade surplus falls)
EV Welfare	-0.06	-0.01

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

6.3.2 Production performance

In general, the production sector as a whole would lose if reduction in subsidization is implemented. Like the case of import duty elimination, production industries are projected to experience bigger variation in W2 to W1. Under W1, production output, GDP, total capital use and total volume of employed labors are expected to drop by 2.5%, 2.93%, 3.07% and 1.15% respectively. Similarly, under W2, they are projected to fall, with bigger magnitude, by 3.04%, 3.55%, 3.48% and 1.18% respectively. If the entire production sector is disaggregated by goods and services, the same results would occur but the variation in the goods producing sector is much stronger than that in the services providing sector.

Unlike the case of tariff elimination, the industry level disaggregated analyses are quite similar across particular industries. In terms of GDP expansion, all industries would experience a decline in their valued added of which mining and quarry would record the biggest fall, followed by petroleum and basic metals. The smallest change is to happen to textile and clothing industry. Similarly, in terms of capital use, all production sectors would record a reduction. Amongst them, mining and quarry would show the highest drop, followed also by petroleum and basic metals. The least variation is expected to take place in textile and clothing, too.

Table 29 Industry specific changes under the second trade policy P2 (%)

Industries	Production output		Home sold output		Home sold price change		Value added change		Labor use change		Capital use change		Capital – labor ratio change	
	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]
AgrFor	-1.04	-1.29	-0.97	-1.33	0.24	-0.20	-1.76	-2.01	-1.01	-0.87	-1.30	-1.20	-0.30	-0.33
MinQuarr	-5.32	-5.49	-3.58	-3.69	1.54	1.21	-6.43	-6.61	-5.27	-5.03	-6.15	-6.01	-0.92	-1.04
Food	-1.03	-1.20	-1.17	-1.44	-0.40	-0.86	-1.62	-1.80	-0.12	0.19	-1.41	-1.27	-1.29	-1.45
Texcloth	-0.18	-0.13	-0.66	-0.62	-0.79	-1.15	-0.73	-0.76	0.78	1.24	-0.50	-0.20	-1.27	-1.43
Wood	-2.77	-3.20	-2.88	-3.33	-0.55	-0.93	-3.19	-3.65	-1.58	-1.54	-3.14	-3.30	-1.59	-1.79
Paper	-1.78	-2.05	-1.84	-2.12	-0.63	-0.99	-2.16	-2.49	-0.55	-0.38	-2.13	-2.16	-1.59	-1.79
Petrol	-4.46	-6.04	-3.84	-4.72	0.56	0.89	-5.18	-7.08	-3.48	-4.92	-5.01	-6.62	-1.59	-1.79
Chemic	-1.58	-1.76	-1.84	-2.06	-0.59	-0.94	-2.06	-2.31	-0.43	-0.19	-2.01	-1.97	-1.59	-1.79
Nonferr	-2.60	-3.15	-2.64	-3.21	-0.39	-0.77	-3.23	-3.82	-1.64	-1.74	-3.20	-3.49	-1.59	-1.79
Metals	-2.77	-2.88	-2.59	-3.10	0.20	-0.35	-3.93	-4.09	-2.37	-2.04	-3.92	-3.79	-1.59	-1.79
MetProc	-3.21	-3.36	-3.25	-3.48	-0.53	-0.93	-3.80	-4.01	-2.25	-1.97	-3.80	-3.72	-1.59	-1.79
Energy	-2.20	-2.71	-2.20	-2.71	-0.17	-0.54	-2.62	-3.12	-0.91	-0.91	-2.48	-2.68	-1.59	-1.79
Constr	-3.19	-3.90	-3.19	-3.91	-0.36	-0.73	-3.63	-4.35	-1.71	-1.90	-3.79	-4.23	-2.11	-2.37
Trade	-1.86	-2.30	-1.96	-2.41	-0.64	-1.03	-2.35	-2.82	-0.60	-0.55	-2.69	-2.91	-2.11	-2.37
HotRest	-1.19	-1.23	-1.34	-1.38	-0.67	-1.06	-1.60	-1.66	0.02	0.47	-1.56	-1.33	-1.59	-1.79
Transp	-3.30	-3.41	-2.30	-2.89	0.34	-0.22	-4.09	-4.21	-2.28	-1.87	-4.21	-4.05	-1.98	-2.23
RealEst	-2.06	-2.46	-2.09	-2.49	-0.67	-1.05	-2.18	-2.59	-0.51	-0.42	-2.09	-2.20	-1.59	-1.79
Public	-2.48	-3.04	-2.53	-3.09	-1.04	-1.48	-2.79	-3.38	-1.28	-1.39	-2.84	-3.15	-1.59	-1.79
OthServ	-1.92	-2.35	-1.94	-2.37	-0.75	-1.15	-2.37	-2.83	-0.81	-0.79	-2.38	-2.56	-1.59	-1.79
All goods	-2.82	-3.55	-2.38	-2.77			-3.82	-4.71	-1.87	-2.11	-3.94	-4.55	-2.11	-2.49
All services	-2.37	-2.83	-29.06	-67.42			-2.65	-3.11	-1.00	-0.97	-2.67	-2.83	-1.69	-1.87
SUM	-2.50	-3.04	-2.32	-2.81			-2.93	-3.55	-1.15	-1.18	-3.07	-3.48	-1.95	-2.32

[1]: Comparison against the scenario W1 which presents no change in the world prices

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Regarding the employment of labor, except textile and clothing with growth in employed labors, all other production industries would recruit fewer labors in both of the world market conditions. Amongst them, the highest movement would be experienced by mining and quarry and petroleum.

Because of above changes in capital and labor employment, capital – labor ratio is expected to decline in all industries. Between goods producing and services providing sector, the capital – labor ratio of the former would be affected more strongly. The largest change is projected to take place in construction and commerce services while the smallest variation is expected to happen in agriculture and forestry industry. All other industries would experience the growth in capital – labor ratio by around 1-2%. Australia would become less capital intensive and most capital intensive industries would reduce their production strongly while labor intensive industries (especially unskilled labor intensive industries such as textile and clothing) would contract slightly. Price of all home produced commodities except mining and quarry and petroleum is expected to fall after the reduction in subsidy rate.

Unlike the case of import duty elimination, mining and quarry industry is expected to lose most after subsidization reduction with much higher dropping rate of GDP and capital and labor use over those of the remaining industries. In contrast, textile and clothing industry would suffer from a smallest loss with the tiniest contraction of GDP, employed labor and capital stock.

6.3.3 The government sector

Table 30 Changes in the government sector under the second trade policy P2 (%)

Indicators	P2-W1[1]	P2-W2[2]
Spending	-2.93	-3.55
Other benefit Transfer	4.34	5.32
Age Pension	-1.49	-1.97
Subsidy	-53.07	-53.52
Tax Revenue	-2.14	-2.62

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Since government consumption spending shares a fixed proportion of total GDP in any period, its change would be as the same as the change in GDP. Specifically, subsidization reduction would cause a decline in government consumption expenditure by around 3%. Because of the negative change in production performance, tax revenue is projected to drop by 2.14% and 2.62% in W1 and W2 respectively. It is projected to increase due to the fall in subsidy rates, by around 4-5%. Payment for age pension is expected to drop by 1-2%. If subsidization reduction is undertaken, it is unsurprised that the government would decrease significantly subsidy payment, by around 53% in both world price scenarios. Consequently, payment for other benefit transfer would change in an opposite direction in comparison with other components.

6.3.4 The household sector

Table 31 Changes in the household sector under the second trade policy P2 (%)

Indicators	P2-W1[1]	P2-W2[2]
Real aggregate private consumption	-0.84	-0.81
Participation rate	-1.18	-1.23
Asset holdings	-1.01	-1.35
EV Welfare	-0.06	-0.01

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Like the production sector, the household sector overall would get worse off if subsidization reduction is simulated. Specifically, equivalent variation transformed welfare of the household sector is projected to decrease slightly in all price conditions, by 0.06% and 0.01% in W1 and W2 respectively. Like above, we follow (Kudrna and Woodland 2011) in adopting the basis of equivalent variations. In our model, the decline in output and then real private commodity consumption are associated with a contraction in working time which implies a rise in leisure time. Specifically, real private consumption and participation rate in the labor force would decline by about 0.8%. The leisure time increase has a positive impact on utility but cannot exceed the negative effect of commodity consumption fall. Consequently, it would lead to a tiny decrease in welfare. Asset holdings of the household sector are also expected to decline in all price scenarios, by around 1%.

Table 32 Commodity specific changes in private consumption under the first trade policy P2 (%)

Commodities	Consumption of home made products		Consumption of imported products		Consumption expenditure	
	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]
AgrFor	-1.12	-1.40	-0.84	-1.62	-1.10	-1.42

Commodities	Consumption of home made products		Consumption of imported products		Consumption expenditure	
	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]
MinQuarr	-2.29	-1.45	15.12	12.21	-1.10	-1.41
Food	-1.07	-1.35	-1.25	-1.73	-1.10	-1.41
Texcloth	0.08	0.52	-1.60	-1.93	-1.07	-1.38
Wood	-1.10	-1.41	NA	NA	-1.10	-1.41
Paper	-0.91	-1.01	-2.22	-3.05	-1.10	-1.41
Petrol	-1.56	-1.79	-1.64	-2.08	-1.58	-1.87
Chemic	-0.29	0.13	-1.69	-2.13	-1.10	-1.41
Nonferr	-1.02	-1.24	-1.20	-1.59	-1.10	-1.41
Metals	-1.29	-0.98	-0.75	-1.91	-1.10	-1.41
MetProc	-2.95	-2.64	-0.39	-1.31	-1.60	-1.76
Energy	-1.67	-1.98	-0.32	-1.36	-1.67	-1.98
Constr	-1.10	-1.41	NA	NA	-1.10	-1.41
Trade	-1.09	-1.40	-2.55	-3.71	-1.10	-1.41
HotRest	-0.96	-1.00	-3.06	-4.33	-1.10	-1.41
Transp	-3.67	-3.97	-0.18	-0.68	-3.50	-3.80
RealEst	-1.09	-1.39	-2.97	-4.30	-1.10	-1.41
Public	-1.04	-1.28	-2.89	-3.89	-1.10	-1.41
OthServ	-1.29	-1.59	-1.58	-2.24	-1.29	-1.60
All goods	-1.49	-1.56	-0.97	-1.65	-1.33	-1.60
All services	-1.31	-1.59	-2.23	-3.48	-1.33	-1.64
SUM	-1.35	-1.58	-1.18	-2.01	-1.33	-1.63

[1]: Comparison against the scenario W1 which presents no change in the world prices

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

The disaggregation by generation level would produce mixed results. Subsidization reduction would lead to a fall in all age specific consumptions and participation rates but a mixed movement in age specific asset holdings. In terms of consumption, the contraction rate keeps decreasing as consumers become older, implying a relative decrease in saving of young generations. The contraction rate of participation rate is largest in eldest working ages and smallest in mid-career ages. The magnitude of the policy's effect on consumption and participation rate is almost the same across two world market conditions. Regarding asset holdings, this liberalization policy is expected to cause a drop in all age specific asset holdings except those of some eldest cohorts in the scenario W1. And the greatest variation happens to eldest cohorts while the smallest fall occurs to youngest ages. The policy is more significant under the W2 condition. Such changes show that households generally work less, consume less and save less throughout their working lifetime.

6.3.5 Trade performance

Different from the case of change in world price and import duty elimination, trade performance of Australia after subsidy reduction changes in an opposite way. Generally, this policy would worsen Australian trade balance, increasing trade deficit by 23.05% in W1 condition and decreasing trade surplus by 74.99% in W2 condition. Export value, import value and export-import ratio would all drop in both of the world market price scenarios.

Table 33 Commodity specific changes in export value, import value, export – import ratio and trade balance under the second trade policy P2 (%)

Industries	Export		Import		Export-Import Ratio		Trade Balance	
	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]	P2-W1[1]	P2-W2[2]
AgrFor	-1.35	-1.02	-0.74	-1.39	-0.61	0.37	-1.43	-0.94
MinQuarr	-6.85	-6.28	0.28	-0.70	-7.11	-5.63	-10.38	-6.68
Food	-0.55	-0.10	-1.27	-1.68	0.73	1.61	0.28	8.09
Texcloth	1.13	2.01	-1.71	-2.02	2.89	4.12	-2.47	-2.43
Wood	-1.67	-1.26	-3.31	-4.03	1.70	2.89	-5.67	-5.43
Paper	-0.43	0.10	-2.18	-2.75	1.79	2.93	-2.74	-3.24
Petrol	-7.47	-9.01	-0.32	-0.58	-7.18	-8.48	3.32	10.14
Chemic	-0.51	0.06	-2.41	-2.93	1.95	3.08	-3.02	-3.37
Nonferr	-1.77	-1.49	-2.34	-2.72	0.58	1.26	-2.43	-2.86
Metals	-3.04	-2.33	-2.39	-3.06	-0.67	0.75	-3.47	-1.07
MetProc	-2.58	-1.92	-2.43	-3.11	-0.16	1.23	-2.40	-3.19
Energy	-2.67	-2.35	-0.61	-1.75	-2.07	-0.61	-4.04	-3.93
Constr	-2.35	-2.21	-3.89	-5.28	1.60	3.25	-2.31	-2.05
Trade	-0.52	-0.10	-2.59	-3.77	2.13	3.81	-0.44	0.23
HotRest	0.17	1.03	-3.55	-4.80	3.86	6.13	10.16	-9.82
Transp	-7.79	-6.98	-1.08	-1.43	-6.79	-5.62	-11.36	-14.02
RealEst	-0.59	-0.14	-4.31	-5.77	3.89	5.97	55.52	-9.95
Public	-0.19	0.22	-3.26	-4.30	3.16	4.73	2.03	39.91
OthServ	-0.50	-0.03	-1.95	-2.63	1.48	2.67	-4.71	-4.20
All goods	-4.08	-5.14	-1.91	-2.63	-2.21	-2.58	4.57	-128.74
All services	-2.95	-2.25	-2.96	-4.35	0.00	2.20	-2.95	36.95
SUM	-3.75	-4.68	-2.03	-2.90	-1.75	-1.84	23.05	-74.99

[1]: Comparison against the scenario W1 which presents no change

[2]: Comparison against the scenario W2 which presents only the change in the world price of primary products

Source: Authors' calculation

Similar variation is projected to occur to both goods producing and services providing industry. The former would record a decrease in export value, import value and export – import ratio by 4.08%, 1.91% and 2.63% respectively in W1 and 5.14%, 2.63% and 2.58% respectively in W2. As a result, goods producing industry is expected to enlarge trade deficit by 4.57% in W1 scenario and contract trade surplus by 128.74% in W2 scenario. The latter is expected to show a fall in export value (by 2.95%), import value (by 2.96%) and export – import ratio (by 0.00%) in W1 condition. In W2 condition, while export and import value would decline by 2.25% and 4.35% respectively, export – import ratio grows by 2.2%. Eventually, services providing industry would reduce its trade surplus by 2.95% in W1 but increase its trade surplus by 36.95% in W2 condition.

Industry level disaggregated results indicate that uneven outcomes would happen to specific industries. The subsidization reduction would lead to a fall in export value of all industries except textile and clothing and hotel and restaurant in W2 condition. The largest variation would take place in mining and quarry, petroleum and transport while the smallest change would happen to public services. It is not a surprise if we know that highest subsidy rate is given to petroleum and transport.

All industries except mining and quarry would import less in both world price scenarios. The largest and smallest changes are expected to occur to real estate and petroleum respectively. Consequently, export – import ratio in food stuff, textile and clothing, wood and wood processing, paper and paper processing, chemicals, non-ferrous minerals, construction, commerce, hotel and restaurant, real estate, public services and other services would rise. This ratio of mining and quarry, petroleum, energy and transport would decline while that of agriculture and forestry, basic metals and metal processing is expected to fall in W1 but rise in W2. This result emphasizes again natural resources based industries are more vulnerable while labor intensive manufacturing industries are less affected if subsidization reduction is undertaken.

6.4 Sensitivity analysis

In order to test the reliability of the model, it is needed investigate whether computed results are sensitive to specification of some parameters from external sources. Like any other nested structured CGE models, we focus on Armington elasticities of substitution between home produced and imported commodities, elasticities of transformation between home sales and export and elasticities of substitution between factors of productions in value added function. Higher and lower values for such elasticities are used to examine how much the economy differs from the benchmark case after a new scenario is simulated. Particularly, new values of elasticities are assumed to be 29% lower and 25% higher than the original values. The former shows the possibility in which the economy is less sensitive to external conditions while the latter indicates the possibility in which the economy is more vulnerable to world scenarios. Based on that, we can also calculate the remaining parameters to characterize the benchmark year of 2005-2006. Next, without losing the generality, we simulate the change in the world price of primary products, mining and quarry and petroleum (W2) and elimination of all tariffs (P1-W1) for the economy. How the economy varies in the new sets of parameters is compared against the results in part 1. Actually, the movement direction of variables in the new specifications of parameters are as the same as the benchmark case. Moreover, the variation magnitudes are relatively close across contexts. Therefore, we can conclude that the model is reliable and could be used for further analyses. Particular changes of some key variables in different settings of parameters are shown in the below table.

Table 34 Changes of some key variables under scenario W2 and P1-W1 in different specifications of elasticities[1]

Variables	W2 (%)			P1-W1 (%)		
	Original	Low	High	Original	Low	High
Asset holdings	26.3	25.31	27.44	-0.27	-0.31	-0.26
Capital stock	24.27	15.52	33.45	2.28	1.76	2.72
Labor use	3.68	2.67	4.67	0.74	0.65	0.81
Participation rate	3.68	2.75	4.8	0.76	0.67	0.83
Wage rate	25.23	23.95	26.62	0.04	0.01	0.06
Equivalent variation transformed welfare	3.54	3.55	3.49	0.05	0.08	0.03
Production output	31.72	26.78	37.10	0.84	0.55	1.09
GDP	35.94	29.88	42.38	1.06	0.75	1.31
Trade balance	Deficit to surplus	Deficit to surplus	Deficit to surplus	-18.01	-12.82%	-22.58

[1]: Comparisons against the benchmark year

Source: Authors' calculation

7. Conclusion

If further trade liberalization is implemented through tariff elimination, Australia would be better off overall. Not only macro economic indicators, industry specific performance and welfare are also expected to improve significantly in any world market conditions. Textile and clothing and some labor intensive industries would suffer from the greatest loss while natural resources based industries would benefit most. In contrast, if subsidy reduction is undertaken, Australia would be negatively affected both at macro and disaggregated industry and generation level.

Therefore, the optimal liberalization policy for Australia in coming years is to remove tariff barriers and maintain current subsidization measures. If possible, Australia should swap subsidization reduction by further decline of import duty in negotiations with its trading partners.

In addition to trade policy, the model could be used to examine effects of other policies, for example, income tax, consumption tax, social security programs as well as investigate impacts of some external conditions such as exchange rate and world interest rate…

Despite some positive aspects, there are some limitations to the employment of the model. For example, liberalization of trade in services is investigated only through subsidization policy and flows of capital, especially FDI are not explicitly described. Imperfect competition, economies of scales and productivity change have not been included. Trade liberalization is analyzed only via unilateral actions of Australia. The overlapping generation structure is utilized to investigate only the allocation between commodity consumption and relax time. The age specific preferences of commodity consumption are still omitted, making analyses on product and industry specific changes less reliable. This shortage can be handled by collecting more data on age specific features.

For these reasons, the model can be further improved in several dimensions. And if so, the prediction and implication power of the model will be enhanced significantly.

A. Appendix

A.1 Technical Appendix

A.1.1 Basic Functions

A.1.1.1 Leontief function (LTF):

$$LTF(x_1, \dots, x_i, \dots, x_n) = Min(\frac{x_1}{\varepsilon_1}, \dots, \frac{x_i}{\varepsilon_i}, \dots, \frac{x_n}{\varepsilon_n})$$

Where ε_i is the Leontief fixed coefficient associated with quantity variable x_i, $i \in N$

Dual Leontief function (DLTF):

$$DLTF(P_1, \dots, P_i, \dots, P_n) = \sum_{i=1}^{n} \varepsilon_i \; P_i$$

Where P_i is the price variable associated with quantity variable x_i, $i \in N$

A.1.1.2 Constant elasticity of substitution (CES) function

$$CES(x_1, \dots, x_i, \dots, x_n) = \left[\sum_{i=1}^{n} \theta_i \; x_i^{1-\frac{1}{\rho}}\right]^{\frac{1}{1-\frac{1}{\rho}}}$$

Where:

θ_i : the share coefficient associated with variable x_i, $i \in N, \sum_{i=1}^{n} \theta_i = 1$

ρ: the elasticity of substitution amongst variables, $\rho > 0$

Dual constant elasticity of substitution (DCES) function

$$DCES(P_1, \dots, P_i, \dots, P_n) = \left[\sum_{i=1}^{n} \theta_i^{\frac{1}{\rho}} P_i^{1-\frac{1}{\rho}}\right]^{\frac{1}{1-\frac{1}{\rho}}}$$

Where P_i is the price variable associated with quantity variable x_i, $i \in N$

A.1.1.3 Constant elasticity of transformation (CET) function

$$CET(x_1, \dots, x_i, \dots, x_n) = \left[\sum_{i=1}^{n} \theta_i \; x_i^{1+\frac{1}{\rho}}\right]^{\frac{1}{1+\frac{1}{\rho}}}$$

Where:

θ_i : the share coefficient associated with variable x_i, $i \in N, \sum_{i=1}^{n} \theta_i = 1$

ρ: the elasticity of substitution amongst variables, $\rho > 0$

Dual constant elasticity of transformation (DCET) function

$$DCET(P_1, \dots, P_i, \dots, P_n) = \left[\sum_{i=1}^{n} \theta_i^{\frac{1}{\rho}} P_i^{1+\frac{1}{\rho}}\right]^{\frac{1}{1+\frac{1}{\rho}}}$$

Where P_i is the price variable associated with quantity variable x_i, $i \in N$

A.1.2 Solutions for the household sector

Following (Auerbach and Kotlikoff 1987), we can solve for decisions of the household sector once all exogenous variables are known.

$$Max: E(U_t) = \frac{1}{1-\frac{1}{\gamma}} \sum_{a=0}^{M} ss_a\,(1+\beta)^{-a}\, u_{t,t+a}^{1-\frac{1}{\gamma}}$$

$$u_{t,t+a} = (c_{t,t+a}^{1-\frac{1}{\rho}} + \alpha l_{t,t+a}^{1-\frac{1}{\rho}})^{\frac{1}{1-\frac{1}{\rho}}}$$

Subject to following life time budget constraint:

$$\sum_{a=0}^{M} \frac{P_{t+a}^{C} c_{t,t+a}}{\left(1+(1-\tau i)r\right)^{a}} \le \sum_{a=0}^{M} \frac{(1-\tau i)\epsilon_a\, w_{t+a}\,\left(h - l_{t,t+a}\right) + tr_{t,t+a} + ap_{t,t+a} + be_{t,t+a}}{\left(1+(1-\tau i)r\right)^{a}}$$

The first order conditions give us Euler equations characterizing the evolution of consumption (equation (6) in the main text):

$$\frac{\frac{\partial E(U_t)}{\partial c_{t,t+a+1}^{t}}}{\frac{\partial E(U_t)}{\partial c_{t,t+a}^{t}}} = \frac{ss_{a+1}}{\beta} \frac{\frac{P_{t,t+a+1}^{C}}{\left(1+\left(1-\tau i_{t+a+1}\right)r\right)}}{P_{t,t+a}^{C}}$$

More specifically,

$$\frac{ss_{a+1}(1+\beta)^{-a-1}\left[c_{t,t+a+1}^{1-\frac{1}{\rho}} + \alpha l_{t,t+a+1}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{t,t+a+1}^{-\frac{1}{\rho}}}{ss_{a}(1+\beta)^{-a}\left[c_{t,t+a}^{1-\frac{1}{\rho}} + \alpha l_{t,t+a}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{t,t+a}^{-\frac{1}{\rho}}} = \frac{\frac{P_{t+a+1}^{C}}{\left(1+\left(1-\tau i\right)r\right)^{a+1}}}{\frac{P_{t+a}^{C}}{\left(1+\left(1-\tau i\right)r\right)^{a}}}$$

$$\frac{ss_{a+1}\left[c_{t,t+a+1}^{1-\frac{1}{\rho}}+\alpha l_{t,t+a+1}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{t,t+a+1}^{-\frac{1}{\rho}}}{(1+\beta)\quad\left[c_{t,t+a}^{1-\frac{1}{\rho}}+\alpha l_{t,t+a}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{t,t+a}^{-\frac{1}{\rho}}}=\frac{P_{t+a+1}^{C}}{\left(1+\left(1-\tau i\quad\right)r\quad\right)P_{t+a}^{C}}$$

The intra-allocation between consumption and leisure time before retirement:

$$\frac{c_{t,t+a}^{-\frac{1}{\rho}}}{\alpha l_{t,t+a}^{-\frac{1}{\rho}}}=\frac{P_{t+a}^{C}}{\left(1-\tau i\quad\right)\epsilon_{a}\, w_{t+a}}$$

So, we have:

$$l_{t,t+a}=\left(\frac{\alpha P_{t+a}^{C}}{\left(1-\tau i\quad\right)\epsilon_{a}\, w_{t+a}}\right)^{\rho} c_{t,t+a}$$

Substitute it back to (6) we have:

$$c_{t,t+a+1}=\left(\frac{(1+\beta)P_{t+a+1}^{C}}{s_{a+1}\left(1+\left(1-\tau i\quad\right)r\quad\right)P_{t+a}^{C}}\right)^{-\gamma}\frac{v_{t,t+a+1}}{v_{t,t+a}}c_{t,t+a}$$

Where:

$$v_{t,t+a}=[1+\alpha^{\rho}(\frac{P_{t+a}^{C}}{\left(1-\tau i\quad\right)\epsilon_{a}\, w_{t+a}})^{\rho-1}]^{\frac{\rho-\gamma}{1-\rho}}$$

A.1.3. Inclusion of tax, duty and subsidy in aggregate price indexes

In our model, like quantity variables, prices also have a nested structure. Therefore, price index of any aggregate commodity can be expressed as a function of grass-root prices or price of home sold product, imported or exported single products as well as commodity use tax, import duty and subsidy.

For nested CES structure:

The intermediate level or price of industry specific composite good (? represents C, K, Q or G):

$$P_{j,t}^{?}=\left\{\theta_{j}^{?,H^{\rho?_j}}\left[\left(1+\tau c_{j}^{?}-\tau s_{j}^{?}\right)P_{j,t}^{H}\right]^{1-\rho?_j}+(1-\theta_{j}^{?,H})^{\rho?_j}\left[\left(1+\tau c_{j}^{?}+\tau t_{j}^{?}\right)P_{j,SS}^{M}\right]^{1-\rho?_j}\right\}^{\frac{1}{1-\rho?_j}}$$

The top level or price of aggregate good: (? represents C, K or G):

$$P_t^? = \left(\sum_{j=1}^{N} \theta_j^{C\,\rho?}\left[P_{j,t}^?\right]^{1-\rho?}\right)^{\frac{1}{1-\rho?}}$$

For CET structure:

$$P_{k,t}^Z = \left[\left(\theta_k^Z\right)^{-\rho Z_k}\left(P_{k,t}^H\right)^{1+\rho Z_k} + \left(1-\theta_k^Z\right)^{-\rho Z_k}\left(\frac{P_{k,t}^M}{1+\tau c_k^X - \tau s_j^X}\right)^{1+\rho Z_k}\right]^{\frac{1}{1+\rho Z_k}}$$

Therefore, above the grass-root level, all price indexes are inclusive of taxes, duties and subsidies.

A.1.4. Equations for steady state equilibrium

A.1.4.1 Household sector

$$\frac{ss_{a+1}\left[c_{a+1,SS}^{1-\frac{1}{\rho}} + \alpha l_{a+1,SS}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{a+1,SS}^{-\frac{1}{\rho}}}{(1+\beta)\left[c_{a,SS}^{1-\frac{1}{\rho}} + \alpha l_{a,SS}^{1-\frac{1}{\rho}}\right]^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} c_{a,SS}^{-\frac{1}{\rho}}} = \frac{P_{SS}^C}{\left(1+(1-\tau i\quad)r\quad\right)P_{SS}^C} \tag{S1}$$

$$l_{a,SS} = \left(\frac{\alpha P_{SS}^C}{(1-\tau i\quad)\epsilon_a\, w_{SS}}\right)^{\rho} c_{a,SS}\ \ if\ a \le R \tag{S2}$$

$$l_{a,SS} = h\ if\ a \ge R \tag{S3}$$

$$CC_{SS} = \sum_{a=0}^{M} \mu_a c_{a,SS} \tag{S4}$$

$$as_{a+1,SS} = \left(1+(1-\tau i\quad)r\quad\right)as_{a,SS} + (1-\tau i\quad)\epsilon_a\, w_{SS} hh\left(h - l_{a,SS}\right) + tr_{a,SS} + be_{SS} + ap_{SS} - P_{SS}^C c_{a,SS} \tag{S5}$$

$$AS_{SS} = \sum_{a=0}^{M} \mu_a as_{a,SS} \tag{S6}$$

$$\begin{aligned} BE_{SS} &= \sum_{a=0}^{M} \mu_{a+1} be_{SS} \\ &= \sum_{a=0}^{M} \mu_a\,(1-ss_{a+1})\left[\left(1+(1-\tau i\quad)r\quad\right)as_{a,SS} + (1-\tau i\quad)\epsilon_a\, w_{SS} hh\left(h-l_{a,SS}\right) + tr_{a,SS} \right. \\ &\quad \left. + ap_{SS} - P_{SS}^C c_{a,SS}\right] \end{aligned} \tag{S7}$$

$$C_{iSS} = \frac{\theta_i^{C\,\rho C} P_{SS}^C CC_{SS}}{\left[P_{SS}^C\right]^{\rho C} \sum_{j=1}^{N} \theta_j^{C\,\rho C}\left[P_{jSS}^C\right]^{1-\rho C}} \tag{S8}$$

$$P_{SS}^C = \left(\sum_{j=1}^{N} \theta_j^{C\,\rho C}\left[P_{j,SS}^C\right]^{1-\rho C}\right)^{\frac{1}{1-\rho C}} \tag{S9}$$

$$C_{j,SS}^{M}=\frac{(1-\theta_j^{C,H})^{\rho C_j}C_{j,SS}P_{j,SS}^{C}}{\left[\left(1+\tau c_j^C+\tau t_j^C\right)P_{jSS}^{M}\right]^{\rho C_j}\left\{\theta_j^{C,H\,\rho C_j}\left(1+\tau c_j^C-\tau s_j^C\right)P_{j,SS}^{H\;1-\rho C_j}+(1-\theta_j^{C,H})^{\rho C_j}\left[\left(1+\tau c_j^C+\tau t_j^C\right)P_{j,SS}^{M}\right]^{1-\rho C_j}\right\}}\quad (S10)$$

$$C_{j,SS}^{H}=\frac{\theta_j^{C,H\,\rho C_j}C_{j,SS}P_{j,SS}^{C}}{\left[\left(1+\tau c_j^C-\tau s_j^C\right)P_{j,SS}^{H}\right]^{\rho C_j}\left\{\theta_j^{C,H\,\rho C_j}\left(1+\tau c_j^C-\tau s_j^C\right)P_{j,SS}^{H\;1-\rho C_j}+(1-\theta_j^{C,H})^{\rho C_j}\left[\left(1+\tau c_j^C+\tau t_j^C\right)P_{j,SS}^{M}\right]^{1-\rho C_j}\right\}}\quad (S11)$$

$$P_{j,SS}^{C}=\left\{\theta_j^{C,H\,\rho C_j}\left[\left(1+\tau c_j^C-\tau s_j^C\right)P_{j,SS}^{H}\right]^{1-\rho C_j}+(1-\theta_j^{C,H})^{\rho C_j}\left[\left(1+\tau c_j^C+\tau t_j^C\right)P_{j,SS}^{M}\right]^{1-\rho C_j}\right\}^{\frac{1}{1-\rho C_j}}\quad (S12)$$

$$TAX_{SS}^{C}=\sum_{j=1}^{N}\tau c_j^C C_{j,SS}^{H}P_{j,SS}^{H}+\sum_{j=1}^{N}\left(\tau c_j^C+\tau t_j^C\right)C_{j,SS}^{M}P_{j,SS}^{M}+\ w_{SS}\tau i\quad LL_{SS}+\tau i\quad r_{SS}AS_{SS}\quad (S13)$$

$$LL_{SS}=\sum_{a=0}^{M}\mu_a\epsilon_a\ \left(h-l_{a,SS}\right)\quad (S14)$$

$$TR_{SS}=\sum_{a=0}^{M}\mu_a\,tr_{a,SS}\quad (S15)$$

$$AP_{SS}=\sum_{a=0}^{M}\mu_a\pi_a\ w_{SS}\quad (S16)$$

A.1.4.2 Production sector

$$Z_{k,SS}=\frac{A_k\left(\theta_k^Y K_{k,SS}^{1-\frac{1}{\rho_k^Y}}+\left(1-\theta_k^Y\right)L_{k,SS}^{1-\frac{1}{\rho_k^Y}}\right)^{\frac{1}{1-\frac{1}{\rho_k^Y}}}}{\varepsilon_{Yk}}\quad S(17)$$

$$Q_{jk,SS}=\varepsilon_{jk}Z_{k,SS}\quad (S18)$$

$$X_{k,SS}=\frac{\left(\frac{P_{k,SS}^{X}}{1+\tau c_k^X-\tau s_j^X}\right)^{\rho Z_k}Z_{k,SS}P_{k,SS}^{Z}}{(1-\theta_k^Z)^{\rho Z_k}\left[(\theta_k^Z)^{-\rho Z_k}(P_{k,SS}^{H})^{1+\rho Z_k}+(1-\theta_k^Z)^{-\rho Z_k}\left(\frac{P_{k,SS}^{X}}{1+\tau c_k^X-\tau s_j^X}\right)^{1+\rho Z_k}\right]}\quad (S19)$$

$$H_{k,SS}=\frac{(P_{k,SS}^{H})^{\rho Z_k}Z_{k,SS}P_{k,SS}^{Z}}{(\theta_k^Z)^{\rho Z_k}\left[(\theta_k^Z)^{-\rho Z_k}(P_{k,SS}^{H})^{1+\rho Z_k}+(1-\theta_k^Z)^{-\rho Z_k}\left(\frac{P_{k,SS}^{X}}{1+\tau c_k^X-\tau s_j^X}\right)^{1+\rho Z_k}\right]}\quad (S20)$$

$$P_{k,SS}^{Z}=\left[\left(\theta_k^Z\right)^{-\rho Z_k}(P_{k,SS}^{H})^{1+\rho Z_k}+(1-\theta_k^Z)^{-\rho Z_k}\left(\frac{P_{k,SS}^{M}}{1+\tau c_k^X-\tau s_j^X}\right)^{1+\rho Z_k}\right]^{\frac{1}{1+\rho Z_k}}\quad (S21)$$

$$P_{k,SS}^{Y}=\frac{P_{k,SS}^{Z}-\sum_{j=1}^{N}P_{j,SS}^{Q}\,\varepsilon_{jk}}{\varepsilon_{Yk}}\quad (S22)$$

$$S_{k,SS} = \left(I_{k,SS} + \frac{\sigma}{2} \frac{I_{k,SS}^2}{K_{k,SS}} \right) \tag{S23}$$

$$(\delta + n) K_{k,SS} = I_{k,SS} \tag{S24}$$

$$(1 - \tau f_k\ ) P_{k,SS}^Y \left(1 - \theta_k^Y\right) A_k \left(\theta_k^Y K_{k,SS}^{1-\frac{1}{\rho_k^Y}} + \left(1 - \theta_k^Y\right) L_{k,SS}^{1-\frac{1}{\rho_k^Y}} \right)^{\frac{\frac{1}{\rho_k^Y}}{1-\frac{1}{\rho_k^Y}}} L_{k,SS}^{-\frac{1}{\rho_k^Y}} = w_{SS} \tag{S25}$$

$$(1 - \tau f_k\ ) P_{k,SS}^Y \theta_k^Y A_k \left(\theta_k^Y K_{k,SS}^{1-\frac{1}{\rho_k^Y}} + (1 - \theta_k^Y) L_{k,SS}^{1-\frac{1}{\rho_k^Y}} \right)^{\frac{\frac{1}{\rho_k^Y}}{1-\frac{1}{\rho_k^Y}}} K_{k,SS}^{-\frac{1}{\rho_k^Y}} + P_{SS}^K \frac{\sigma}{2} \frac{I_{k,SS}^2}{K_{k,SS}^2} = \left(r_{SS} + \delta\right) q_{SS} \tag{S26}$$

$$P_{SS}^K (1 + \sigma\delta) = \ q_{SS} \tag{S27}$$

$$II_{SS} = \sum_{k=1}^{N} I_{k,SS} \tag{S28}$$

$$SS_{SS} = \sum_{k=1}^{N} S_{k,SS} \tag{S29}$$

$$KK_{SS} = \sum_{k=1}^{N} K_{k,SS} \tag{S30}$$

$$V_{k,SS} = \ q_{SS} K_{k,SS} \tag{S31}$$

$$VV_{SS} = \sum_{k=1}^{N} V_{k,SS} \tag{S32}$$

$$J_{j,SS} = \frac{{\theta_j^K}^{\rho K} SS_{SS} P_{SS}^K}{\left(P_{j,SS}^K\right)^{\rho K} \sum_{i=1}^{N} {\theta_i^K}^{\rho K} \left(P_{i,SS}^K\right)^{1-\rho K}} \tag{S33}$$

$$P_{SS}^K = \left[\sum_{j=1}^{N} {\theta_j^K}^{\rho K} \left(P_{j,SS}^K\right)^{1-\rho K} \right]^{\frac{1}{1-\rho K}} \tag{S34}$$

$$J_{j,SS}^H = \frac{{\theta_j^{K,H}}^{\rho K_j} J_{j,SS} P_{j,SS}^K}{\left[\left(1 + \tau c_j^K - \tau s_j^K\right) P_{j,SS}^H\right]^{\rho K_j} \left\{ {\theta_j^{K,H}}^{\rho K_j} \left[\left(1 + \tau c_j^K - \tau s_j^K\right) P_{j,SS}^H\right]^{1-\rho K_j} + \left(1 - \theta_j^{K,H}\right)^{\rho K_j} \left[\left(1 + \tau c_j^K + \tau t_j^K\right) P_{j,SS}^M\right]^{1-\rho K_j} \right\}} \tag{S35}$$

$$J_{j,SS}^M = \frac{\left(1 - \theta_j^{K,H}\right)^{\rho K_j} J_{j,SS} P_{j,SS}^K}{\left[\left(1 + \tau c_j^K + \tau t_j^K\right) P_{j,SS}^M\right]^{\rho K_j} \left\{ {\theta_j^{K,H}}^{\rho K_j} \left[\left(1 + \tau c_j^K - \tau s_j^K\right) P_{j,SS}^H\right]^{1-\rho K_j} + \left(1 - \theta_j^{K,H}\right)^{\rho K_j} \left[\left(1 + \tau c_j^K + \tau t_j^K\right) P_{j,SS}^M\right]^{1-\rho K_j} \right\}} \tag{S36}$$

$$P_{j,SS}^K = \ \left\{ {\theta_j^{K,H}}^{\rho K_j} \left[\left(1 + \tau c_j^K - \tau s_j^K\right) P_{j,SS}^H\right]^{1-\rho K_j} + \left(1 - \theta_j^{K,H}\right)^{\rho K_j} \left[\left(1 + \tau c_j^K + \tau t_j^K\right) P_{j,SS}^M\right]^{1-\rho K_j} \right\}^{\frac{1}{1-\rho K_j}} \tag{S37}$$

$$Q^{H}_{jk,SS} = \frac{\theta_{jk}^{Q,H\,\rho Q_j} P^{Q}_{jk,SS} Q_{jk,SS}}{\left[\left(1+\tau c^{Q}_{jk}-\tau s^{Q}_{jk}\right) P^{H}_{jk,SS}\right]^{\rho Q_j} \left\{\theta_{jk}^{Q,H\,\rho Q_j}\left[\left(1+\tau c^{Q}_{jk}\right) P^{H}_{jk,SS}\right]^{1-\rho Q_j} + (1-\theta^{Q,H}_{jk})^{\rho Q_j}\left[\left(1+\tau c^{Q}_{jk}+\tau t_{jk,SS}\right) P^{M}_{jk,SS}\right]^{1-\rho Q_j}\right\}} \quad \text{(S38)}$$

$$Q^{M}_{jk,SS} = \frac{(1-\theta^{Q,H}_{j})^{\rho Q_j} P^{Q}_{jk,SS} Q_{jk,SS}}{\left[\left(1+\tau c^{Q}_{jk}+\tau t^{Q}_{jk}\right) P^{M}_{jk,SS}\right]^{\rho Q_j} \left\{\theta_{jk}^{Q,H\,\rho Q_j}\left[\left(1+\tau c^{Q}_{jk}-\tau s^{Q}_{jk}\right) P^{H}_{jk,SS}\right]^{1-\rho Q_j} + (1-\theta^{Q,H}_{jk})^{\rho Q_j}\left[\left(1+\tau c^{Q}_{jk}+\tau t^{Q}_{jk}\right) P^{M}_{jk,SS}\right]^{1-}} \quad \text{(S39)}$$

$$P^{Q}_{jk,SS} = \left\{\theta_{jk}^{Q,H\,\rho Q_j}\left[(1+\tau c^{Q}_{jk}-\tau s^{Q}_{jk}) P^{H}_{jk,SS}\right]^{1-\rho Q_j} + (1-\theta^{Q,H}_{jk})^{\rho Q_j}\left[(1+\tau c^{Q}_{jk}+\tau t^{Q}_{jk}) P^{M}_{jk,SS}\right]^{1-\rho Q_j}\right\}^{\frac{1}{1-\rho Q_j}} \quad \text{(S40)}$$

$$Q^{H}_{j,SS} = \sum_{k=1}^{N} Q^{H}_{jk,SS} \quad \text{(S41)}$$

$$Q^{M}_{j,SS} = \sum_{k=1}^{N} Q^{M}_{jk,SS} \quad \text{(S42)}$$

$$\begin{aligned} TAX^{F}_{SS} = {} & \sum_{k=1}^{N} \tau f_k \left[A_k \left(\theta^{Y}_{k} K_{k,SS}^{1-\frac{1}{\rho^{Y}_{k}}} + (1-\theta^{Y}_{k}) L_{k,SS}^{1-\frac{1}{\rho^{Y}_{k}}}\right)^{\frac{1}{1-\frac{1}{\rho^{Y}_{k}}}}\right] + \sum_{j=1}^{N}\sum_{k=1}^{N} Q^{M}_{jk,SS}\left(\tau c^{Q}_{jk}+\tau t^{Q}_{jk}\right) P^{M}_{j,SS} \\ & + \sum_{j=1}^{N} J^{M}_{j,SS}\left(\tau c^{K}_{j}+\tau t^{K}_{j}\right) P^{M}_{j,SS} + \sum_{j=1}^{N}\sum_{k=1}^{N} Q^{H}_{jk,SS}\left(\tau c^{Q}_{jk}\right) P^{H}_{j,SS} + \sum_{j=1}^{N} J^{H}_{j,SS}\left(\tau c^{K}_{j}\right) P^{H}_{j,SS} \\ & + \sum_{k=1}^{N} \frac{\tau c^{X}_{k} P^{X}_{k,SS} X_{k,SS}}{1+\tau c^{X}_{k}-\tau s^{X}_{j}} \end{aligned} \quad \text{(S43)}$$

A.1.4.3 Government sector

$$TAX_{SS} = TAX^{C}_{SS} + TAX^{F}_{SS} \quad \text{(S44)}$$

$$SUB_{SS} = \sum_{j=1}^{N} \tau s^{C}_{j} C^{H}_{j,SS} P^{H}_{j,SS} + \sum_{j=1}^{N}\sum_{k=1}^{N} Q^{H}_{jk,SS}\left(\tau s^{Q}_{jk}\right) P^{H}_{j,SS} + \sum_{j=1}^{N} J^{H}_{j,SS}\left(\tau s^{K}_{j}\right) P^{H}_{j,SS} + \sum_{k=1}^{N} \frac{\tau s^{X}_{k} P^{X}_{k,SS} X_{k,SS}}{1+\tau c^{X}_{k}-\tau s^{X}_{k}} \quad \text{(S45)}$$

$$P^{G}_{SS} GG_{SS} = \phi \sum_{k=1}^{N} P^{Y}_{k,SS} A_k \left(\theta^{Y}_{k} K_{k,SS}^{1-\frac{1}{\rho^{Y}_{k}}} + (1-\theta^{Y}_{k}) L_{k,SS}^{1-\frac{1}{\rho^{Y}_{k}}}\right)^{\frac{1}{1-\frac{1}{\rho^{Y}_{k}}}} \quad \text{(S46)}$$

$$P^{G}_{SS} GG_{SS} + TR_{SS} + AP_{SS} + SUB_{SS} - TAX_{SS} = 0 \quad \text{(S47)}$$

$$G_{j,SS} = \frac{\theta_{j}^{G\,\rho G} P^{G}_{SS} GG_{SS}}{\left(P^{G}_{j,SS}\right)^{\rho C} \sum_{i=1}^{N} \theta_{i}^{G\,\rho G} \left(P^{G}_{i,SS}\right)^{1-\rho G}} \quad \text{(S48)}$$

$$P_{SS}^{G} = \left[\sum_{j=1}^{N} \theta_j^{G\,\rho G} \left(P_{j,SS}^{G}\right)^{1-\rho G}\right]^{\frac{1}{1-\rho G}} \tag{S49}$$

$$G_{j,t}^{H} = \frac{\theta_j^{G,H\,\rho G_j} GX_{j,t}}{\left(P_{j,t}^{H}\right)^{\rho G_j}\left[\theta_j^{G,H\,\rho G_j}\left(P_{j,t}^{H}\right)^{1-\rho G_j} + \left(1-\theta_j^{G,H}\right)^{\rho G_j}\left(P_{j,t}^{M}\right)^{1-\rho G_j}\right]} \tag{S50}$$

$$G_{j,SS}^{M} = \frac{\left(1-\theta_j^{G,H}\right)^{\rho G_k} P_{j,SS}^{G} G_{j,SS}}{\left(P_{j,SS}^{M}\right)^{\rho G_j}\left[\theta_j^{G,H\,\rho G_j}\left(P_{j,SS}^{H}\right)^{1-\rho G_j} + \left(1-\theta_j^{G,H}\right)^{\rho G_j}\left(P_{j,SS}^{M}\right)^{1-\rho G_j}\right]} \tag{S51}$$

$$P_{j,SS}^{G} = \left[\theta_j^{G,H\,\rho G_j}\left(P_{j,SS}^{H}\right)^{1-\rho G_j} + \left(1-\theta_j^{G,H}\right)^{\rho G_j}\left(P_{j,SS}^{M}\right)^{1-\rho G_j}\right]^{\frac{1}{1-\rho G_j}} \tag{S52}$$

A.1.4.4 Equilibrium

$$\sum_{k=1}^{N} P_{k,SS}^{M} X_k - \sum_{k=1}^{N} P_{k,SS}^{M} M_{k,SS} = TB_{SS} \tag{S53}$$

$$(n - r_{SS})WD_{SS} = TB_{SS} \tag{S54}$$

$$H_{j,SS} = C_{j,SS}^{H} + Q_{j,SS}^{H} + J_{j,SS}^{H} + G_{j,SS}^{H} \tag{S55}$$

$$M_{j,SS} = C_{j,SS}^{M} + Q_{j,SS}^{M} + J_{j,SS}^{M} + G_{j,SS}^{M} \tag{S56}$$

$$AS_{SS} = VV_{SS} + WD_{SS} \tag{S57}$$

$$LL_{SS} = \sum_{k=1}^{N} L_{k,SS} \tag{S58}$$

$$P_{j,SS}^{M} = P_{j,SS}^{X} = 1 \tag{S59}$$

$$r_{SS} = r^{W} \tag{S60}$$

A.2. Aggregation concordance

Table A1 Industries/Commodities in the model

Ref. No.	Name of 19 industries/commodities	Briefs
1	Agriculture and Forestry	AgrFor
2	Mining and Quarry	MinQuarr
3	Food stuff	Food
4	Textile and Clothing	Texcloth
5	Wood and Wood processing	Wood
6	Paper and Paper processing	Paper
7	Petroleum	Petrol
8	Chemicals excluding Petroleum	Chemic
9	Non-ferrous minerals	Nonferr
10	Basic metals	Metals
11	Metal processing	MetProc

Ref. No.	Name of 19 industries/commodities	Briefs
12	Energy and Water supply	Energy
13	Construction	Constr
14	Commerce	Trade
15	Hotels and Restaurants	HotRest
16	Transport and Communication	Transp
17	Banking, Insurance and Real Estate	RealEst
18	Public service	Public
19	Other services	OthServ

Table A2 Industries/Commodities in the IO Tables

IO Code	Industries/Commodities in the IO Table	Concordance	IO Code	Industries/Commodities in the IO Table	Concordance
0101	Sheep	1	2701	Iron and steel	10
0102	Grains	1	2702	Basic non-ferrous metal and products	10
0103	Beef cattle	1	2703	Structural metal products	10
0104	Dairy cattle	1	2704	Sheet metal products	10
0105	Pigs	1	2705	Fabricated metal products	10
0106	Poultry	1	2801	Motor vehicles and parts; other transport equipment	11
0107	Other agriculture	1	2802	Ships and boats	11
0200	Services to agriculture; hunting and trapping	1	2803	Railway equipment	11
0300	Forestry and logging	1	2804	Aircraft	11
0400	Commercial fishing	1	2805	Photographic and scientific equipment	11
1101	Coal	2	2806	Electronic equipment	11
1201	Oil and gas	2	2807	Household appliances	11
1301	Iron ores	2	2808	Other electrical equipment	11
1302	Non-ferrous metal ores	2	2809	Agricultural, mining and construction machinery, lifting and material handling equipment	11
1400	Other mining	2	2810	Other machinery and equipment	11
1500	Services to mining	2	2901	Prefabricated buildings	11
2101	Meat and meat products	3	2902	Furniture	11
2102	Dairy products	3	2903	Other manufacturing	11
2103	Fruit and vegetable products	3	3601	Electricity supply	12
2104	Oils and fats	3	3602	Gas supply	12
2105	Flour mill products and cereal foods	3	3701	Water supply; sewerage and drainage services	12
2106	Bakery products	3	4101	Residential building construction	13
2107	Confectionery	3	4102	Other construction	13
2108	Other food products	3	4201	Construction trade services	13
2109	Soft drinks, cordials and syrups	3	4501	Wholesale trade	14
2110	Beer and malt	3	4502	Wholesale mechanical repairs	14
2113	Wine, spirits and tobacco products	3	4503	Other wholesale repairs	14

IO Code	Industries/Commodities in the IO Table	Concordance	IO Code	Industries/Commodities in the IO Table	Concordance
2201	Textile fibres, yarns and woven fabrics	4	5101	Retail trade	14
2202	Textile products	4	5102	Retail mechanical repairs	14
2203	Knitting mill products	4	5103	Other retail repairs	14
2204	Clothing	4	5701	Accommodation, cafes and restaurants	15
2205	Footwear	4	6101	Road transport	16
2206	Leather and leather products	4	6201	Rail, pipeline and other transport	16
2301	Sawmill products	5	6301	Water transport	16
2302	Other wood products	5	6401	Air and space transport	16
2303	Pulp, paper and paperboard	6	6601	Services to transport; storage	16
2304	Paper containers and products	6	7101	Communication services	16
2401	Printing and services to printing	6	7301	Banking	17
2402	Publishing; recorded media and publishing	6	7302	Non-bank finance	17
2501	Petroleum and coal products	7	7401	Insurance	17
2502	Basic chemicals	8	7501	Services to finance, investment and insurance	17
2503	Paints	8	7701	Ownership of dwellings	17
2504	Medicinal and pharmaceutical products, pesticides	8	7702	Other property services	17
2505	Soap and other detergents	8	7801	Scientific research, technical and computer services	17
2506	Cosmetics and toiletry preparations	8	7802	Legal, accounting, marketing and business management services	17
2507	Other chemical products	8	7803	Other business services	17
2508	Rubber products	9	8101	Government administration	18
2509	Plastic products	9	8201	Defence	18
2601	Glass and glass products	9	8401	Education	18
2602	Ceramic products	9	8601	Health services	18
2603	Cement, lime and concrete slurry	9	8701	Community services	18
2604	Plaster and other concrete products	9	9101	Motion picture, radio and television services	19
2605	Other non-metallic mineral products	9	9201	Libraries, museums and the arts	19
			9301	Sport, gambling and recreational services	19
			9501	Personal services	19
			9601	Other services	19

A.3. Parameters

Table A3 Fixed coefficients in Leontief production output function and Productivity coefficient in value added function

θ_{QHjk}	Ref. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Y	A
No.	**Briefs**	**AF**	**MQ**	**Food**	**TC**	**Wood**	**Paper**	**Petrol**	**Chem**	**Nonfe**	**Metals**	**MetP**	**Ener**	**Con**	**Trad**	**HoRe**	**Tran**	**Real**	**Public**	**Other**	**VA**	**TFP**
1	**AgrFor**	0.37	0.00	0.56	0.14	0.23	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.00	0.00	0.04	1.65	1.07
2	**MinQua**	0.00	0.14	0.01	0.00	0.00	0.01	0.78	0.02	0.15	0.34	0.00	1.02	0.02	0.06	0.01	0.00	0.00	0.01	0.01	1.25	1.14
3	**Food**	0.07	0.00	0.23	0.10	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.01	0.01	0.06	0.30	0.00	0.01	0.01	0.07	0.70	1.79
4	**Texcloth**	0.00	0.00	0.00	0.22	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.02	0.87	1.75
5	**Wood**	0.00	0.00	0.00	0.00	0.24	0.01	0.00	0.00	0.01	0.00	0.04	0.01	0.15	0.00	0.00	0.00	0.00	0.01	0.01	1.27	1.77
6	**Paper**	0.00	0.00	0.04	0.03	0.02	0.33	0.00	0.03	0.03	0.00	0.01	0.02	0.04	0.05	0.03	0.02	0.03	0.06	0.08	1.80	1.79
7	**Petrol**	0.04	0.03	0.00	0.00	0.01	0.01	0.06	0.03	0.04	0.01	0.01	0.18	0.06	0.02	0.01	0.07	0.01	0.01	0.02	0.33	1.37
8	**Chemic**	0.07	0.01	0.01	0.02	0.05	0.08	0.04	0.27	0.24	0.01	0.03	0.13	0.08	0.01	0.01	0.00	0.01	0.02	0.05	0.75	1.80
9	**Nonferr**	0.01	0.00	0.04	0.01	0.02	0.05	0.00	0.05	0.31	0.01	0.04	0.09	0.46	0.01	0.01	0.01	0.00	0.01	0.02	1.55	1.79
10	**Metals**	0.01	0.02	0.02	0.01	0.05	0.02	0.00	0.03	0.06	0.25	0.22	0.11	0.41	0.01	0.01	0.02	0.01	0.02	0.03	0.51	1.76
11	**MetProc**	0.02	0.02	0.01	0.02	0.03	0.02	0.01	0.01	0.03	0.01	0.23	0.20	0.20	0.08	0.02	0.08	0.02	0.10	0.09	0.86	1.75
12	**Energy**	0.03	0.02	0.02	0.02	0.04	0.05	0.01	0.03	0.14	0.04	0.03	1.60	0.04	0.03	0.07	0.04	0.04	0.05	0.06	8.70	1.53
13	**Constr**	0.02	0.05	0.01	0.01	0.03	0.01	0.06	0.01	0.02	0.01	0.01	0.92	2.81	0.05	0.06	0.07	0.06	0.08	0.02	3.27	1.73
14	**Trade**	0.15	0.05	0.15	0.15	0.16	0.16	0.05	0.15	0.16	0.06	0.22	0.43	0.35	0.17	0.21	0.20	0.09	0.11	0.22	1.61	1.80
15	**HotRest**	0.01	0.00	0.03	0.01	0.01	0.03	0.02	0.02	0.02	0.01	0.01	0.05	0.00	0.02	0.00	0.02	0.04	0.02	0.05	1.13	1.78
16	**Transp**	0.11	0.06	0.17	0.10	0.24	0.25	0.04	0.15	0.29	0.09	0.09	0.39	0.34	0.29	0.11	0.24	0.16	0.19	0.34	1.13	1.78
17	**RealEst**	0.09	0.09	0.08	0.08	0.19	0.34	0.09	0.17	0.25	0.09	0.19	0.93	1.03	0.40	0.22	0.26	1.02	0.30	0.60	3.28	1.74
18	**Public**	0.00	0.00	0.01	0.01	0.01	0.03	0.01	0.02	0.01	0.00	0.01	0.06	0.04	0.01	0.01	0.03	0.04	0.09	0.04	3.74	1.48
19	**OthServ**	0.00	0.00	0.01	0.00	0.01	0.02	0.00	0.01	0.01	0.00	0.01	0.05	0.04	0.02	0.10	0.01	0.06	0.05	0.29	2.64	1.69

Source: Calibrated

Table A4 Share parameters in top aggregate goods

		Share parameters in capital good	**Share parameters in private good**	**Share parameters in government good**
No.	**Industries**	θ_{Kj}	θ_{Cj}	θ_{Gj}
1	AgrFor	0.0108	0.0137	0.0026
2	MinQuarr	0.0105	0.0014	0.0006
3	Food	0.0011	0.0824	0.0002
4	Texcloth	0.0027	0.0224	0.0000
5	Wood	0.0006	0.0004	0.0000
6	Paper	0.0035	0.0149	0.0000
7	Petrol	0.0003	0.0247	0.0000
8	Chemic	0.0012	0.0149	0.0223
9	Nonferr	0.0028	0.0045	0.0000
10	Metals	0.0127	0.0027	0.0000
11	MetProc	0.2180	0.0691	0.0000
12	Energy	0.0175	0.0254	0.0053
13	Constr	0.5035	0.0015	0.0169
14	Trade	0.0748	0.1912	0.0105
15	HotRest	0.0000	0.0756	0.0000

		Share parameters in capital good	Share parameters in private good	Share parameters in government good
No.	**Industries**	θ_{Kj}	θ_{Cj}	θ_{Gj}
1	AgrFor	0.0108	0.0137	0.0026
16	Transp	0.0299	0.0631	0.0387
17	RealEst	0.1050	0.2496	0.0288
18	Public	0.0026	0.0762	0.7879
19	OthServ	0.0024	0.0665	0.0863

Source: Calibrated

Table A5 Share parameters of home made products in composite commodities and capital stock in value added

		Capital good	Private good	Government good	Value added	Production output
Ref. No.	**Briefs**	θ_{KHj}	θ_{CHj}	θ_{GHj}	θ_{Yj}	θ_{Zj}
1	AgrFor	1.0000	0.8046	1.0000	0.9980	0.0661
2	MinQuarr	0.7475	0.5553	1.0000	0.9053	0.5249
3	Food	1.0000	0.7566	1.0000	0.4670	0.1170
4	Texcloth	0.7074	0.4177	1.0000	0.2957	0.3127
5	Wood	1.0000	1.0000	1.0000	0.4434	0.1401
6	Paper	0.5862	0.6365	1.0000	0.4056	0.0836
7	Petrol	1.0000	0.9607	1.0000	0.7429	0.2170
8	Chemic	1.0000	0.4750	0.3908	0.4261	0.2468
9	Nonferr	0.8024	0.5168	1.0000	0.3905	0.0784
10	Metals	0.7979	0.5397	1.0000	0.3522	0.4078
11	MetProc	0.3999	0.4816	1.0000	0.3227	0.1925
12	Energy	1.0000	0.9143	1.0000	0.6585	0.0061
13	Constr	1.0000	1.0000	1.0000	0.4942	0.0166
14	Trade	1.0000	0.8317	1.0000	0.3600	0.1138
15	HotRest	1.0000	0.6495	1.0000	0.3927	0.1599
16	Transp	1.0000	0.8992	1.0000	0.4758	0.2231
17	RealEst	0.7263	0.7977	1.0000	0.5391	0.0447
18	Public	1.0000	0.7639	1.0000	0.1674	0.0491
19	OthServ	0.9764	0.8865	1.0000	0.2734	0.0455

Source: Calibrated

Table A6 Share parameter of home made products in intermediate inputs

θ_{QHjk}	**Ref. No.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
No.	**Briefs**	**AF**	**MQ**	**Food**	**TC**	**Wood**	**Paper**	**Petrol**	**Chem**	**Nonfe**	**Metals**	**MetP**	**Ener**	**Con**	**Trade**	**HoRe**	**Tran**	**Real**	**Public**	**Other**
1	**AgrFor**	0.96	0.94	0.921	0.95	0.996	0.97	0.00	0.772	0.743	0.922	0.845	0.848	0.607	0.919	0.881	0.893	0.81	0.91	0.819
2	**MinQua**	0.62	0.72	0.657	0.67	0.608	0.646	0.48	0.671	0.65	0.563	0.576	0.72	0.662	0.495	0.643	0.653	0.659	0.66	0.611
3	**Food**	0.93	0.87	0.796	0.99	0.941	0.876	0.972	0.788	0.954	0.951	0.908	0.875	0.863	0.848	0.814	0.849	0.822	0.81	0.848
4	**Texcloth**	0.46	0.51	0.451	0.42	0.461	0.384	0.478	0.43	0.395	0.448	0.466	0.416	0.518	0.508	0.365	0.438	0.454	0.43	0.455
5	**Wood**	0.58	0.63	0.589	0.51	0.704	0.733	0.618	0.582	0.594	0.616	0.669	0.741	0.744	0.654	0.704	0.717	0.75	0.71	0.661
6	**Paper**	0.77	0.6	0.815	0.86	0.43	0.464	0.742	0.779	0.707	0.704	0.808	0.791	0.777	0.798	0.807	0.847	0.862	0.79	0.839

7	**Petrol**	0.74	0.7	0.947	0.96	0.865	0.953	0.616	0.91	0.972	0.896	0.982	0.87	0.683	0.878	0.941	0.854	0.9	0.87	0.903
8	**Chemic**	0.55	0.55	0.627	0.55	0.502	0.457	0.463	0.52	0.478	0.513	0.554	0.389	0.578	0.527	0.622	0.594	0.541	0.51	0.478
9	**Nonferr**	0.78	0.73	0.813	0.77	0.782	0.671	0.702	0.776	0.876	0.79	0.666	0.722	0.902	0.711	0.736	0.574	0.728	0.57	0.613
10	**Metals**	0.78	0.7	0.832	0.66	0.71	0.736	0.965	0.711	0.693	0.783	0.719	0.621	0.774	0.722	0.548	0.784	0.71	0.58	0.579
11	**MetProc**	0.49	0.45	0.679	0.74	0.761	0.634	0.88	0.508	0.536	0.553	0.444	0.472	0.573	0.48	0.529	0.551	0.444	0.47	0.41
12	**Energy**	0.9	0.93	0.922	0.91	0.927	0.924	0.924	0.92	0.941	0.929	0.924	0.927	0.916	0.935	0.925	0.919	0.907	0.93	0.919
13	**Constr**	0.96	0.95	1.00	1.00	0.968	0.983	0.944	1.00	0.985	1.00	1.00	0.992	1.00	0.976	0.94	0.97	0.982	0.98	0.982
14	**Trade**	0.95	0.92	0.954	0.95	0.931	0.925	0.968	0.954	0.93	0.945	0.956	0.931	0.946	0.925	0.957	0.925	0.901	0.95	0.939
15	**HotRest**	0.61	0.64	0.671	0.69	0.641	0.609	0.557	0.633	0.659	0.64	0.643	0.638	0.607	0.6	0.671	0.626	0.661	0.62	0.633
16	**Transp**	1.00	0.99	0.998	1.00	0.998	1.00	0.985	0.996	0.998	0.996	0.99	0.981	0.998	0.995	0.993	0.991	0.961	0.97	0.985
17	**RealEst**	0.68	0.7	0.695	0.69	0.709	0.708	0.694	0.705	0.692	0.725	0.713	0.715	0.727	0.723	0.729	0.72	0.728	0.72	0.715
18	**Public**	0.71	0.8	0.759	0.73	0.753	0.79	0.76	0.758	0.762	0.779	0.76	0.748	0.859	0.801	0.75	0.812	0.765	0.79	0.739
19	**OthServ**	0.93	0.92	0.974	0.94	0.981	0.947	0.992	0.948	0.963	0.962	0.973	0.891	0.913	0.955	0.959	0.941	0.74	0.91	0.805

Source: Calibrated

A.4. Data on taxes, import duty and subsidy

Australian taxes and subsidies consist of several types and have a complicated structure. The calculation methods are also a complexity. Because of limited data condition on taxes and in order to make computation jobs possible, we simplify tax and subsidy policy to be used in our model. Accordingly, based on available relevant data from Input – Output Tables, only product provision or use related taxes (τc_t), subsidy rate (τs_t), value added output production taxes (τf_t), personal income tax (τi_t) and of course, import duty (τt_t) are taken into account.

A.4.1. All product related taxes except import duty

Information on product provision or use related taxes and subsidies can be obtained from Table 34, 35, 36, 37 and 38 of which Table 36 contains import duty while Table 34 provides the net of all product supply or use related taxes and subsidies and Table 38 is about subsidy.

Table 34 reveals the net taxes, which is taxes less subsidies, associated with the provision of domestic and imported products to intermediate usage and final use categories. Major contributors are goods and services (GST) taxes, sales tax, excises and levies (most importantly excices and levies on crude oil and LPG) and taxes on international trade (export related taxes and import duties). For GST taxes, the rate of 10% is applied on the supply of most goods and services to final private consumption.

Table 36 exhibits separately the duty, mostly imports duty associated with the provision of domestic and imported products to intermediate usage and final use categories. Table 38 provides data on subsidy to consumption of each commodity and use purpose.

Hence, we can subtract figures in Table 36 and Table 38 from figures in Table 34 to calculate all other product related taxes except import duty, or commodity use tax as we denote in our paper (τc_t). Based on that, we can calculate tariff rate (τt_t), subsidy rate (τs_t) and commodity use tax rate (τc_t) for different types of product in different use purposes by dividing tax revenue or subsidy value against their total sales values at basic prices. Actually, the commodity use tax rate, subsidy rate or duty against the intermediate use of a product is different from industry to industry. For exports, commodity use tax is interpreted as export tax ($\tau c_{k,t}^{X}$) that producers have to pay for the Australian government before selling their products in foreign markets.

In our model, product related taxes or commodity use tax rate, subsidy rate and import duty go directly to the bottom level of our CES or CET price structure, being added to the basic price of goods and services. As a result, any price indexes above the bottom level are inclusive of product related taxes and subsidy. For example, the top aggregate private consumption price (P_t^C) are the net price paid by households before consumption.

In general, the commodity tax rate for the entire economy is 4.15% but it is different across use purposes. This tax rate is 2.05%, 9.85% and 5.81% against intermediate use, final private consumption (very close to flat GST rate of 10%) and capital formation respectively. The highest commodity tax rate at 47.16% is faced by petroleum industry, mostly caused by high excise tax against petroleum products, then followed by food and stuff industry (18.28% - which is chiefly caused by high excises against consumption of alcohol drinks and tobacco), textile and clothing (14.43%), hotel and restaurant (11.94%) and finally, the lowest commodity tax rate at 0.24% is given to public services industry which are mainly contributed by government conducted activities of services.

In consumption as intermediate inputs, petroleum and food and food stuff face highest rate and other service, 41%, 5.6% and 2.6% respectively while all of the remaining products are subject to very tiny rates, all below 1%.

In final private consumption, very high product related tax rate against petroleum, mining and quarry, food, textile and clothing are also caused by very high excise or mining tax against some of their components such as fuel, alcohol drinks, tobacco…

In capital formation, real estate and paper have highest rate, 33.1% and 13.7%.

Table A7 Commodity use tax rates

No.	Briefs	Industry Supply	HH Cons	Capital formation	Export	Final use	TOTAL
1	AgrFor	0.0056	0.0185	0.0034	0.0238	0.0183	0.0105
2	MinQuarr	0.0032	0.6424	0.0000	0.0011	0.0062	0.0046
3	Food	0.0564	0.3669	0.0000	0.0400	0.2574	0.1828
4	Texcloth	0.0003	0.2678	0.0516	0.0000	0.2092	0.1443
5	Wood	0.0030	0.0637	0.0024	0.0000	0.0109	0.0039
6	Paper	0.0011	0.1670	0.1372	0.0000	0.1394	0.0372
7	Petrol	0.4096	0.7260	0.0000	0.2662	0.6048	0.4716
8	Chemic	0.0005	0.2003	0.0000	0.0000	0.0879	0.0335
9	Nonferr	0.0014	0.2614	0.0100	0.0000	0.1374	0.0170
10	Metals	0.0020	0.1191	0.0006	0.0000	0.0049	0.0031
11	MetProc	0.0003	0.1379	0.0396	0.0075	0.0692	0.0430
12	Energy	0.0026	0.0949	0.0000	0.0022	0.0660	0.0293
13	Constr	0.0021	0.0000	0.0407	0.0000	0.0394	0.0255
14	Trade	0.0019	0.0213	0.0000	0.0044	0.0162	0.0111
15	HotRest	0.0012	0.1795	0.0000	0.0697	0.1658	0.1194
16	Transp	0.0007	0.0792	0.0000	0.0080	0.0415	0.0174
17	RealEst	0.0254	0.0257	0.3312	0.0293	0.0629	0.0391
18	Public	0.0001	0.0113	0.0186	0.0015	0.0026	0.0024
19	OthServ	0.0255	0.1404	0.0470	0.1338	0.0958	0.0743
	Industry	0.0205	0.0985	0.0581	0.0146	0.0599	0.0415

Source: (ABS 2009) and authors' calculation

For export tax, six industries do not have to pay tax (textile and clothing, wood and wood processing, chemicals, nonferrous mineral, metals and construction) and all nine remaining industries have to pay an industry specific export tax rate. The highest export tax rate at 26.62% is faced by petroleum industry, followed by other services (13.38%) and hotel and restaurant (6.97%). The economy wide export tax rate is very small, at 1.46%.

Above tax rates are interpreted into total product related tax revenue except duties of $86 billions in the benchmark year of which $20, $49.46, $14 and $27 billions come from intermediate use, final private consumption, capital formation and export, respectively. In terms of commodities, the biggest contributors are food and stuff ($12.7 billions), real estate ($10.5 billions).

A.4.2 Subsidy

In our model, subsidy is also a part of trade policy. Trade liberalization requires gradual abolition of subsidization programs to support domestic producers. This practice implies there is no discrimination between local and foreign firms, assuring fair competition in the market. There are many forms of subsidization, such as tariff concessions, tax incentives, grants, concessional loans or export assistance (WTO 2007). Because we don't have enough data, a single aggregate subsidy is proposed to include all forms of subsidization. According to (ABS 2000), product specific subsidies are regarded as negative taxes and so, if buyers buy some products which attract a subsidy, the amount of subsidy is deducted from taxes on products paid by them. In IO tables, subsidies are shown to be associated with the supply of domestic and imported products to intermediate or final usage. Since the amount of subsidies associated with supply of imported products is very small and negligible, it is reasonable to assume that subsidies associated only with supply of home produced products. This simplification is consistent with the goal of Australia's subsidization policy to support domestic production (WTO 2007). In our model, subsidy rate is calculated by dividing the amount of subsidies by their corresponding sales values at basic prices.

Table A8 Subsidy rate

No.	Briefs	Industry Supply	HH Cons	Capital formation	Export	Final use	TOTAL
1	AgrFor	0.0004	0.0000	0.0000	0.0000	0.0000	0.0003
2	MinQuarr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	Food	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	Texcloth	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	Wood	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	Paper	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	Petrol	0.2768	0.0211	0.0000	0.0507	0.0299	0.1841
8	Chemic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	Nonferr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	Metals	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	MetProc	0.0000	0.0232	0.0236	0.0082	0.0198	0.0118
12	Energy	0.0116	0.0125	0.0000	0.0136	0.0087	0.0104
13	Constr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	Trade	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	HotRest	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	Transp	0.0104	0.0537	0.0000	0.0561	0.0426	0.0237
17	RealEst	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	Public	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	OthServ	0.0055	0.0044	0.0036	0.0042	0.0030	0.0038
	Industry	**0.0064**	**0.0055**	**0.0020**	**0.0072**	**0.0042**	**0.0052**

(Source: (ABS 2009) and authors' calculation)

The production of six commodities (agriculture and forestry, petroleum, metal processing, energy, transport and other services) receives subsidy from the Government. The subsidy rate for the whole econmy is 0.52% in which the highest rate is for consumption of petroleum (18.41%) and transport (2.4%). The largest subsidy is given to consumption of petroleum ($4.4 billions) and transport ($3.8 billions) in the total subsidy payment of $9.7 billions. In terms of use purpose, most of subsidy is provided to intermediate input use ($5.5 billions). $2.5 and $1.3 billions are for final private consumption and export promotion respectively.

A.4.3. Import duty

Open trade policy has been followed by Australia for a long time, being targeted at opening new markets, reducing barriers and improving market access for Australian goods and services. At the same time, domestic market is also liberalized gradually for foreign goods and services. In fact, the Australian government has engaged in several trade liberalization negotiations (eg., in the World Trade Organization (WTO), Asia-Pacific Economic Cooperation (APEC) forum and the Association of South East Asian Nations (ASEAN) and some bilateral Free Trade Agreements...). As a result, Australia is globally recognized as a deeply open economy with low level of trade protection (ABS 2010c).

In fact, there are two main types of trade barriers against imports of goods and services, tariff and non-tariff barriers. While the former can be easily quantified and is mostly used against import of goods, it is very hard to do the same job with the latter which cover a wide range of measures against import of both goods and services. In modern international trading context, non-tariff measures are major trade barriers employed by countries. Both tariff and non-tariff barriers may vary amongst different sources and types of imports. For these reasons, numerical economic models including CGE models often use tariff barriers rather than non-tariff ones in measuring trade openness degree although a comprehensive and accurate indicator must cover both. In some models, tariff equivalent measures can be calculated for non-tariff barriers. Nonetheless, this calculation requires a lot of works and its accuracy is still controversial.

Table A9 Tariff rate

No.	Briefs	Industry Supply	Private consumption	Capital formation	Final use	TOTAL
1	AgrFor	0.0000	0.0000	0.0000	0.0000	0.0000
2	MinQuarr	0.0000	0.0000	0.0000	0.0000	0.0000
3	Food	0.0180	0.0142	0.0000	0.0142	0.0158
4	Texcloth	0.0544	0.1077	0.0380	0.1066	0.0889
5	Wood	0.0195	0.0000	0.0000	0.0000	0.0196
6	Paper	0.0117	0.0055	0.0000	0.0043	0.0100
7	Petrol	0.0004	0.0000	0.0000	0.0000	0.0003
8	Chemic	0.0073	0.0104	0.0000	0.0060	0.0068
9	Nonferr	0.0276	0.0349	0.0226	0.0327	0.0284
10	Metals	0.0194	0.0178	0.0206	0.0189	0.0194
11	MetProc	0.0132	0.0311	0.0183	0.0224	0.0191
	Industry use	**0.0120**	**0.0370**	**0.0183**	**0.0266**	**0.0185**

(Source: (ABS 2009) and authors' calculation)

Indeed, Australia has a complicated structure of protection barriers that can take several different forms such as tariff, quota, subsidy, import/export licensing, anti-dumping measures, and technical regulations, etc... Of course, it is impossible to quantify and incorporate all forms of protection into a single model. Moreover, the intra-industry structure of CGE requires a lot of data dimensions for any type of barrier that is practically infeasible. Therefore, we concentrate only on tariff barriers and ignore all other types of protection in our model. Import duty data can be taken from relevant IO tables. Similar to other countries, import duties in Australia are levied against tradable goods only (agricultural, primary and manufacturing commodities). Although services sector and some non-tradable good producing industries (ie., energy) also perform import and export activity, their nature is much different from that of producing sector. And because protection measures against import of services and non-tradable goods are all non-tariff, trade restriction against them is not analyzed by our model.

In our paper, the trade policy is partly reflected through the tariff rate for different use purposes and products (besides subsidization). In general, Australia is a largely liberalized economy with low tariff rates on average. If we use import weighted average method, the average tariff rate of Australia is 1.85% in the benchmark year 2005-2006. However, import duty is uneven across commodities and use purposes.

In 2005-2006 (the year considered to be the benchmark for our economy), the average tariff rate against imports used for intermediate input, investment and private consumption is 1.20%, 1.83% and 3.70%. However, trade barriers are applied against only 9 out of 11 tradable commodities: food stuff, textile and clothing, wood and wood processing, paper and paper processing, petroleum, chemicals excluding petroleum, non-ferrous minerals, basic metals, metal processing. The industry with highest protection is textile and clothing, followed by non-ferrous minerals and basic metals.

In our model, import duty is used to measure liberalization level. This practice is reasonable since tariffs have been still considered to be essential trade barriers in Australia (WTO 2007). Table 34 contains information on import duty revenue while Table 3 provides information on import values for all groups of products and purposes of use. Dividing numbers in the former table by their corresponding numbers in the latter table gives us import duty rate or tariff rate (τt_t) against different types of product in different use purposes. Obviously, import duty varies across different types of product. Moreover, it is interesting that for a specific type of product, import duty can change between use purposes because we do not process the data at tariff line level. Commodities in our model are aggregate of sub-items whose structure may change across use purposes. Moreover, it is partly caused by the fact that import duty may change from trading partner to trading partner (some get more favorable treatments than the others when sell their products in Australia) and product to product. In addition, for a specific product, different use purpose may lead to a change in sources of import. For example, the use of imported food stuff for agricultural production is in favor of goods from country A while for mining and quarry production, it is in favor of goods from country B. That import duty against imported food stuff is different between those from country A and B makes the tariff rate against food stuff is different from their use in agriculture to mining and quarry. At the same time, all goods and services in our model are aggregated from several single components. Structure of an aggregated good can be different from use purpose to use purpose which is explained carefully in Part III. Data.

In our model, we do not distinguish sources of import or all trading partners of Australia are treated as a whole as the rest of the world. In general, import duty in Australia is very low, just 1.85% on average in 2005-2006. Nevertheless, imports used as intermediate input faced lower duty (1.20%) than when they are used for capital formation (1.83%) or final private consumption (3.70%). Only nine out of eleven tradable commodities in our model are imposed import duty. Agricultural, forestry, mining and quarry products are exempted from tariff barriers. The highest protection is given to textile and clothing industry with the average tariff rate of 8.89%, followed by non-ferrous minerals (2.84%), wood and wood processing (1.96%), basic metals (1.94%), metal processing (1.91%), food stuff (1.58%), paper and paper processing (1.00%), chemicals excluding petroleum (0.68%) and finally petroleum (0.03%).

Above tax rates are interpreted into total duty revenue of $3.24 billions in the benchmark year of which $1.18, $1.37 and $0.69 billions come from intermediate use, final private consumption and capital formation, respectively. Amongst industries, the largest contributions are given by the imports of metal processing ($1.61 billions) and textile and clothing ($0.85 billions).

Low import duties in most sectors have reflected clearly open trade strategy of Australia. Current negotiations and some other plans are about to clear all tariff rates expectedly in coming time. It is argued that because of already low duty, there is a little room for the trade policy to have large impact on the economy. This argument is reasonable if we consider tariff rate reduction as the main target of trade liberalization and the little actual changes in trading performance of Australia in the last few years.

A.4.4 Other production tax

Table A10 Other production tax rate

AgrFor	MinQuarr	Food	Texcloth	Wood	Paper	Petrol	Chemic	Nonferr	Metals
3.58%	0.82%	3.43%	4.57%	2.31%	3.06%	1.59%	3.56%	3.44%	2.80%
MetProc	Energy	Constr	Trade	HotRest	Transp	RealEst	Public	OtherServ	**TOTAL**
3.32%	1.18%	1.53%	5.25%	2.65%	3.71%	3.77%	2.29%	3.12%	**3.15%**

(Source: (ABS 2009) and authors' calculation)

Apart from above product related taxes or subsidy, Input – Output Tables contain information on other production tax, which is regarded as tax against value added output production in our model. The other taxes on production are understood as the money enterprises incur as a result of their engagement in the processes of production besides product related taxes. They may consist of taxes payable on the land, fixed assets or labor employed in the production process or on certain activities or transactions. The actual structure for this type of tax is very complicated, that may incur during the production process. Some major items could be listed here such as taxes on payroll or workforce, recurrent taxes on land, buildings or other structures, business and professional licences, taxes on the use of fixed assets, stamp taxes, taxes on pollution and taxes on international transactions (Soriano and Thompson 2006). For simplicity, we assume that it is proportional to value added output. Therefore, the value added tax rate ($\tau f_{k,t}$) for each industry can be easily derived by dividing revenue of tax on production by value added output, covering all kinds of tax that firms have to pay in their production processes. On average, this tax rate is 3.15% for the whole economy. Similar to product related tax, value added production tax rate varies across industries of which the highest rate of 5.25% is faced by trade industry and the lowest rate of 0.82% is given to mining and quarry industry.

Above tax rates are interpreted into total other production tax or value added output tax revenue of $28 billions in the benchmark year of which the largest contributions come from banking, insurance and real estate ($9.71 billions), commerce ($5.24 billions) and transport ($2.49 billions).

A.4.5 Income tax

In addition to revenue from product and production related taxes, the government budget is significantly contributed by income tax revenue. Actually, income tax has a very complicated structure. In our model, it is simplified as a flat rate against all sources of income of the household sector including wage income and investment income. This flat income tax rate is calculated to get the targeted share of income tax revenue in total tax revenue. Actually, income tax revenue contributes nearly two thirds of total tax revenue or equivalent to $182.3 billions in the benchmark year. Two main types of income tax used in Australia are personal income tax and corporate profit tax. In general, the latter one is set at the rate of 30%. Because of zero profit condition assumption in our model, corporate profit tax is not analyzed directly. In contrast, we assume that all sources of income are taxed at personal level. This simplification is still practically reasonable if we take into account the fact that corporate profits are basically owned by and eventually would be distributed to individuals (ie, in the forms of dividend) and this source of income is included in gross operating surplus and mixed income in Input - Output tables. Therefore, income tax in our model can be interpreted as a combination of both personal income and corporate profit tax and the rate is selected to reflect the practical condition that income tax revenue share around two thirds of total tax revenue. The income tax rate is calculated to be 26.5% across the entire economy.

A.5 Intuitions for results caused by tariff and subsidy changes

A.5.1 Intuitions for results caused by tariff changes

Generally, a reduction in tariff upon import of a particular product has several impacts which occur in different levels. It is assumed that tariff reduction is imposed on imported product i.

$$\tau t_i \downarrow \rightarrow (1+\tau t_i)P_i^M \downarrow \rightarrow D_i^M \uparrow, D_i^H \downarrow, P_i \downarrow \rightarrow D_i \uparrow$$

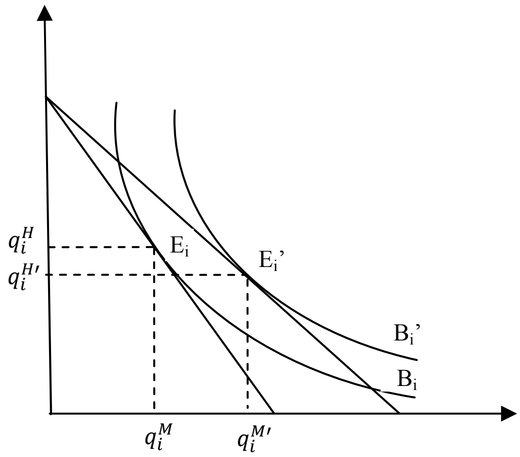

Figure A.5.1 Substitution between home made and imported product that is imposed lower duty

First, at the bottom levels, local price index of imported product that is imposed lower duty falls, creating chances for local buyers to purchase more imported quantity given their previous income. Since imported and home made component in the same type of commodity are related through an Armington structure, they are good substitutes for each other. In our model, that the Armington elasticities in all categories of demand are greater than unitary implies the substitution between home made and imported product is elastic. Therefore, within the commodity whose imported component is imposed lower tariff, the demand for imported product rises but the demand for home made product drops as the consequence of substitution effect[9]. As a result, composite price index of the commodity whose imported component is imposed lower tariff decreases, too, regardless of their use purposes or categories of demand[10]. Next, because alternative composite commodities are combined through a CES structure, the demand for the commodity whose imported component is imposed lower tariff expands relatively in comparison with the demand for the remaining commodities as the consequence of substitution effect.

Second, in production, industrialists substitute imported products with lower duty for their home made counterparts in intermediate inputs and capital formation. So both of the cost of intermediate inputs and value added reduce. The LTF structure employed in production implies there is a reduction in total production cost. Consequently, it is expected to cause an expansion in production capacity of all producers. Therefore, local industries which do not have to face further competition from imported products are projected to increase their production capacity. Because industry specific production

[9] The income effect is available but it is totally offset by the substitution effect as the consequence of elastic substitution between home made and imported product. For this reason, the income effect is ignored here.

[10] Consist of final private consumption, government consumption, capital formation and intermediate input

outputs in our model are separated into home sold and exported product through a CET structure, it is obvious that both quantity of home sold and exported product rise. The increase in quantity of exported product is larger than that of home sold product because the world price of exported products is given meanwhile the demand for home sold products is downward sloping. A part from the change in quantity, the price of home sold product of these industries reduces. Eventually, the top price index of aggregate commodities in all categories of demand reduces, too.

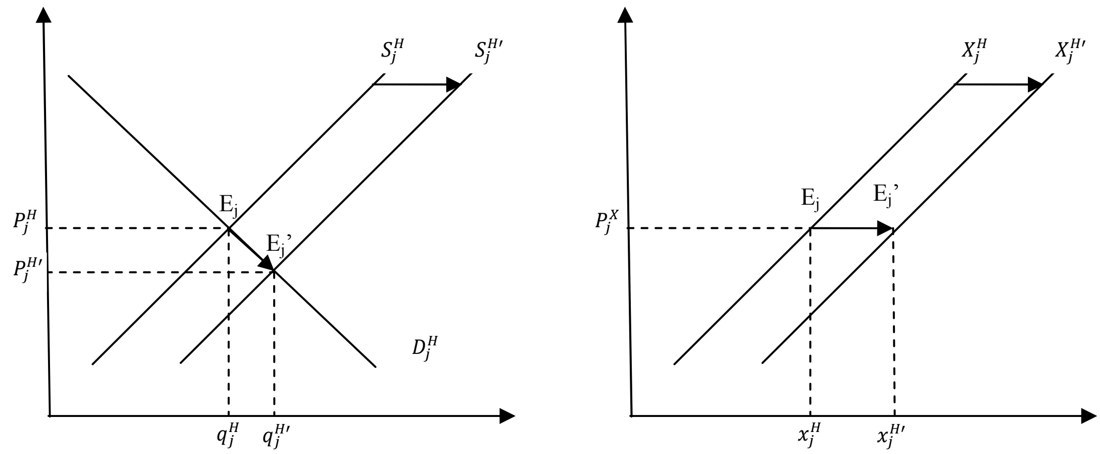

Figure A.5.2 Change in the industry whose competing import is not imposed lower duty

Whereas the industry whose direct competing import is imposed lower duty would experience different results. Although this industry also expands its production capacity like the others, that buyers in all categories of demand substitute imported product for its home sold product creates a large drop in its domestic demand. Since the drop in domestic demand far exceeds the rise in supply, this industry would face a big fall in its home sold price and quantity. And despite the increase in exported quantity like other industries, this industry still experience a reduction in production output as well as value added. It is reasonable also because in most industries, the share of domestic sales in total production output is much larger than that of export[11].

Generally, because the total increase in output of expanding industries exceeds the reduction in output of the contracting industry, a tariff cut is projected to lead to a net positive change in output of the whole economy.

Because of the reduction in price index of all industry specific home sold products, the price index at composite commodity level and top aggregate level in all categories of demand further decreases, so deepening production capacity expansion above. Moreover, it can create some substitution effect between imported and home made products in all categories of demands. But in this round, the income effect is significant as the consequence of output expansion. Therefore, the demand for alternative home made and imported products depends on specific characteristics of buyers. In our model, value added and intermediate inputs are combined through a LTF technology to generate industry specific production output. Since price index of value added and intermediate inputs all fall, it is certain that price index of industry specific production outputs reduces, too, of which the largest drop obviously occurs to industries whose competing import has to pay lower duty.

[11] The industry with largest share of export is mining and quarry (around 50%).

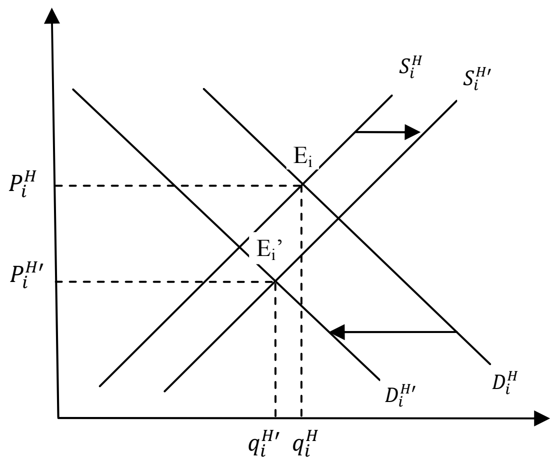

Figure A.5.3 Change in industries whose competing import is imposed lower duty

Table A.5.1 Elasticity of industry specific GDP to alternative tariffs in 2010 – 2011[1]

Tariff upon	AgrFor	MiQuar	Food	Texclot	Wood	Paper	Petro	Chemi	Nonfer	Metal	MetPro
AgrFor	0.1396	-0.0008	1.0374	0.7686	0.0465	-0.2139	-0.0010	-0.3304	-0.8264	-0.7000	-4.5696
MinQuarr	-0.0524	0.0217	-2.5373	-6.7924	-1.0764	-0.9789	-0.0045	-2.7588	-2.8467	-2.1661	-34.8060
Food	-0.0301	-0.0015	2.2392	0.3055	-0.2086	-0.2785	-0.0009	-0.3281	-1.0593	-0.8528	-5.6236
Texcloth	-0.0349	-0.0054	-1.0183	51.8910	-0.4566	-0.5190	-0.0010	-1.3099	-1.4504	-1.5986	-10.9807
Wood	-0.0114	-0.0013	-0.5951	-1.7096	10.2194	-0.5445	-0.0018	-1.2003	-1.8007	-1.9723	-9.5613
Paper	-0.0047	-0.0001	-0.0069	-0.1569	-0.2384	2.2006	-0.0011	-0.4971	-1.1202	-0.9125	-6.4944
Petrol	-0.0013	0.0020	-0.2550	-0.8177	-0.2454	-0.2507	-0.0027	-0.5661	-0.9243	-0.8015	-7.7328
Chemic	-0.0223	-0.0044	-0.8747	-2.0028	-0.3852	-0.5534	-0.0019	8.8098	-1.7473	-1.9943	-12.4172
Nonferr	-0.0112	-0.0013	-0.3061	-1.2150	-0.4448	-0.3763	-0.0018	-0.9773	4.5409	-1.6461	-10.9366
Metals	-0.0281	-0.0129	-1.3569	-3.9287	-0.8209	-0.6871	-0.0026	-1.8582	-2.4458	3.0723	-17.9212
MetProc	-0.0146	-0.0055	-0.7296	-2.2593	-0.8466	-0.4743	-0.0016	-1.3588	-2.2468	-3.3791	4.9349
Energy	-0.0011	0.0009	-0.0774	-0.2740	-0.2036	-0.1886	-0.0012	-0.4143	-0.7944	-0.6085	-5.6984
Constr	-0.0064	0.0020	-0.4120	-1.2519	-0.4978	-0.4065	-0.0020	-0.9942	-1.7829	-1.6583	-12.0471
Trade	-0.0005	0.0005	0.0072	0.0874	-0.2405	-0.2441	-0.0011	-0.3429	-0.9658	-0.8569	-6.4829
HotRest	-0.0122	-0.0007	-0.8465	-0.0654	-0.1946	-0.2086	-0.0008	-0.2948	-0.8482	-0.7701	-5.2570
Transp	-0.0041	0.0002	-0.1362	-0.4978	-0.2290	-0.2533	-0.0015	-0.4521	-1.0750	-0.9271	-7.7437
RealEst	-0.0010	0.0010	-0.0243	-0.0998	-0.2023	-0.1755	-0.0010	-0.3244	-0.8249	-0.7023	-5.4291
Public	-0.0024	0.0012	-0.1476	-0.5323	-0.2944	-0.3125	-0.0014	-0.5743	-1.2210	-1.0771	-8.5865
OthServ	-0.0034	0.0008	0.0388	0.0132	-0.2337	-0.2117	-0.0010	-0.3660	-0.9429	-0.8650	-6.0299
Total GDP	-0.0035	0.0018	-0.2554	-0.7067	-0.2884	-0.2822	-0.0015	-0.6054	-1.1773	-1.0040	-8.9548

[1] All the numbers in the table are 1000 times smaller

Source: Authors' calculation

However, the change in commodity specific imports is much more complicated. After a tariff reduction, it is certain that import of product that is imposed lower tariff expands rapidly but the movement direction of other imports varies across remaining products. It is worth noting that the demand for composite commodities whose competing import is not imposed lower duty rises and price of home made products reduces in all categories of demand. Obviously, the demand for home made products increases. However, that the demand for their corresponding imported products rises or drops depend on the magnitude of the income effect and the substitution effect. Consequently, it is undetermined about the change in import volume in alternative categories of demand. Moreover, in comparison with output, import volume is less sensitive to the change in import duties. This finding can be illustrated clearly by the results on elasticity of commodity specific imports to tariff change. Accordingly, a reduction in tariff imposed on a particular product might have different effects on imports of other products. Except reduction in tariff imposed on mining and quarry and petroleum has a negative and positive impact on imports of all remaining products respectively, tariff reform upon imports of all other products would show a mixed results.

Table A.5.2 Elasticity of commodity specific import to alternative tariffs in 2010 – 2011[2]

Tariff upon	AgrFor	MiQuar	Food	Texclot	Wood	Paper	Petro	Chemi	Nonfer	Metal	MetPro
AgrFor	-6.3600	0.0031	1.4042	1.7047	0.0008	-0.0178	0.0000	0.7389	-0.2612	0.0497	1.4379
MinQuarr	0.0300	-0.0726	1.3161	3.2233	0.2869	0.2607	0.0007	1.0623	0.5259	3.9555	16.1998
Food	0.0260	0.0025	-27.8512	1.3807	-0.0408	0.0777	-0.0003	0.3336	-0.1037	-0.0253	-0.2304
Texcloth	0.0106	0.0019	0.4803	-58.9652	-0.0816	0.0350	-0.0005	0.1433	-0.3211	-0.2241	-1.4001
Wood	-0.0009	0.0014	-0.1386	-0.3907	-54.3765	0.1691	-0.0014	-0.1118	-1.1895	-0.8010	-3.8762
Paper	0.0004	0.0016	0.1842	0.4894	-0.0154	-12.9081	-0.0009	0.2065	-0.3807	-0.5533	-4.8237
Petrol	-0.0056	0.0020	-0.5845	-1.7407	-0.3566	-0.3463	-0.0123	-0.7354	-1.2409	-1.1625	-12.7658
Chemic	0.0146	0.0017	0.1313	0.1156	-0.1148	-0.0099	-0.0010	-11.4995	-0.0704	-0.5980	-5.6828
Nonferr	-0.0065	0.0014	-0.1955	-0.7096	-0.2994	-0.1527	-0.0012	0.0810	-23.3816	-1.0656	-7.0764
Metals	-0.0016	0.0072	-0.0909	-0.3260	-0.2372	-0.2012	-0.0010	-0.3534	-1.0187	-23.0115	-1.2069
MetProc	0.0022	0.0042	0.0153	0.0019	-0.1011	-0.1763	-0.0013	-0.2776	-0.7103	-0.1546	-34.8046
Energy	0.0213	0.0078	0.9374	2.3434	0.1111	0.1189	0.0000	0.8548	0.2644	1.1647	6.1920
Constr	-0.0016	0.0112	-0.4579	-0.8185	0.0145	-0.2199	-0.0017	-0.2845	-0.3327	0.3355	-9.7063
Trade	0.0288	0.0076	1.6085	3.5412	0.1104	0.4023	-0.0002	0.7476	0.1311	0.7051	6.3856
HotRest	0.0649	0.0106	4.4571	4.4821	0.1104	0.4803	-0.0004	1.0706	0.3797	1.0670	6.9715
Transp	-0.0006	0.0010	0.0037	-0.0988	-0.1693	-0.1336	-0.0006	-0.2383	-0.6322	-0.5514	-4.9065
RealEst	0.0198	0.0084	0.9495	2.2084	-0.0343	0.0756	-0.0013	0.3631	-0.5192	0.2228	2.3040
Public	0.0169	0.0051	1.0004	2.6332	-0.1052	0.1166	-0.0009	0.3396	-0.5042	-0.0766	-1.1607
OthServ	0.0148	0.0033	0.5399	1.3783	-0.1181	0.0251	-0.0007	0.0947	-0.5085	-0.2011	-2.7708
Total Import	-0.0253	-0.0032	-0.9647	-2.4483	-0.4903	-0.4362	-0.0014	-1.0566	-1.3255	-1.1029	-14.9218

[2] All the numbers in the table are 1000 times smaller

Source: Authors' calculation

In comparison with output and import volume, the influences of tariff cut on utility are much less significant, that is caused by the role of leisure in utility and income earning.

On the one hand, leisure can be treated as a kind of non-traded commodity whose price is estimated by the wage rate or the income amount consumers have to give up in order to obtain a unit of leisure. In our model, commodity consumption and leisure are related also through a CES structure which implies the substitutability between them. As above analysed, a tariff reduction leads to a decrease in price index of aggregate private consumption commodity. Consequently, as usual, consumers substitute consumption of commodity for leisure.

On the other hand, different from the case of two normal commodities whose substitution effect dominates income effect, the substitution of commodity consumption for leisure has a strong income effect that is caused by the direct link between leisure and working time. The substitution of commodity consumption for leisure implies an increase in supply of labour.

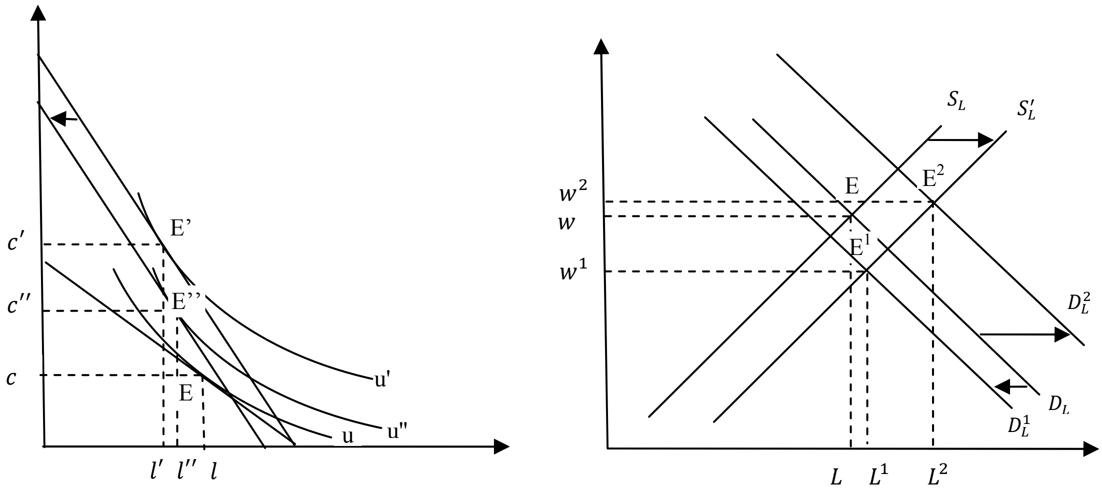

Figure A.5.4 Substitution between commodity consumption and leisure and change in the labour market

Table A.5.3 Vectors of elasticity of welfare to tariff rates $\frac{\partial U/U}{\partial t/t}$

	1996-1997	**1997-1998**	**1998-1999**	**1999-2000**	**2003-2004**	**2004-2005**	**2005-2006**	**2009-2010**	**2010-2011**	**2014-2015**	**2015-2016**
AgrFor	0.18E	0.18E	0.18E	0.17E	0.16E	0.15E	0.15E	0.15E	0.14E	0.14E	0.14E
MinQuarr	-0.09E	-0.09E	-0.09E	-0.10E	-0.09E	-0.09E	-0.09E	-0.09E	-0.09E	-0.09E	-0.09E
Food	2.98E	2.95E	2.90E	2.76E	2.56E	2.44E	2.32E	2.20E	2.08E	2.04E	2.00E
Texcloth	-60.95E	-45.80E	-31.87E	-8.75E	-10.23E	1.02E	9.61E	14.88E	16.61E	15.52E	13.22E
Wood	-7.87E	-7.88E	-7.65E	-7.12E	-7.28E	-7.08E	-6.77E	-6.59E	-6.42E	-6.59E	-6.42E
Paper	4.59E	4.57E	4.52E	4.47E	3.72E	3.69E	3.61E	3.60E	3.60E	3.59E	3.59E
Petrol	-0.08E	-0.08E	-0.08E	-0.06E	-0.04E	-0.04E	-0.03E	-0.03E	-0.03E	-0.03E	-0.03E
Chemic	1.78E	1.75E	1.73E	1.79E	0.61E	0.80E	1.85E	1.82E	1.79E	1.77E	1.75E
Nonferr	-20.32E	-20.20E	-20.08E	-19.53E	-19.66E	-18.80E	-17.08E	-16.83E	-16.73E	-16.73E	-16.73E
Metals	-28.88E	-28.94E	-29.00E	-28.80E	-27.41E	-26.25E	-22.77E	-22.22E	-21.67E	-21.68E	-21.70E
MetProc	-565.11E	-530.01E	-492.46E	-409.24E	-410.97E	-364.92E	-319.00E	-274.64E	-231.15E	-231.32E	-231.49E

$E = 10^{-6}$

Source: Authors' calculation

At the same time, because of the reduction in the price index of the capital good, in order to generate value added which is a CES combination of capital and labour, producers would substitute capital for labour, implying a decrease in demand for labour. The computation results reveal this situation very clearly that given a reduction in any tariff, all industries in Australia would become more capital intensive. It is the main reason why there is a drop in value added price of all industries. In addition to the substitution effect, because of the drop in production costs, firms expand their production, implying an increase in demand for labour. The net effect on demand for labour depends on the difference between the substitution effect and the production expansion effect. As a result, it may lead a rise or fall in wage rate and quantity of employed labour as well. If the substitution effect dominates the production expansion effect, the demand for labour shifts downward, leading a fall in wage rate. Therefore, the income of the household sector decreases, making the positive effect of the reduction in price of commodities on utility less significant. Oppositely, if the production expansion effect exceeds the substitution effect, there would be an increase in employed labour. As a result, it can be concluded that utility is less elastic to tariff change in comparison with output and import volume.

In addition to direct changes to producers and consumers, it is expected that there is a negative impact on the government budget because of the disappearance of import duty revenue. Because of the output expansion and real wage increase, the government would spend more, pay more for subsidy and age pension. As a result, there is a big fall in other benefit transfer to the consumers that negatively influence the utility of households. However, it is still offset by the positive consumption expansion effect.

A.5.2 Intuitions for results caused by subsidy changes

In our model, subsidy is used to encourage domestic production, including those for exports. Accordingly, buyers of home made products are provided with price assistance. Subsidy could be regarded as a negative consumption tax. If products are exported, producers get additional payment to their selling price from the government. Similarly to the case of tariff reduction, a fall in subsidy for a particular home made product is expected to cause changes at several levels. We can reemploy the institutions used above to explain the causes of the effects of subsidy reduction. Once again, it is assumed that the subsidy toward the consumption and export of product i is halved.

$$\tau s_i \downarrow \rightarrow (1-\tau s_i)P_i^H \uparrow \rightarrow D_i^H \downarrow, D_i^M \uparrow, P_i^H \downarrow$$

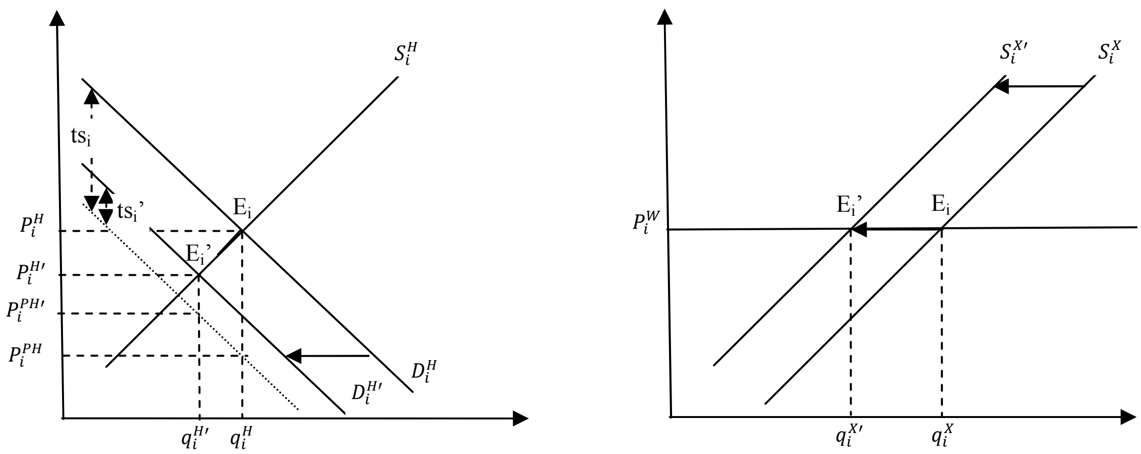

Figure A.5.5 Change in the industry whose product is given lower subsidy

In principle, a decline in subsidy makes all of the variables in the economy except price indices change in the opposite direction with the case of tariff reduction.

In the first stage, there is a relative fall in demands for the product with lower subsidy in comparison with other products. After the decline in demands, there is a reduction in the price index of the home made product with lowered subsidy but an increase in its corresponding net purchasing price. Because of higher production cost, all producers contract their production capacity, implying a reduction in all supplies. As a result, all other industries would experience a fall in output.

In the proceedings stages, arguments similar to the above part can be utilized to explain why there would be a fall in welfare, labour force participation rate and other variables.

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