Energy-using Consumer Durables in a CGE Model of Taiwan: the case of motor vehicles

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Abstract

To address the durable nature of energy-using appliances acquired by households, this paper applies to motor vehicles the dummy-industry approach that is employed in CGE models to deal with households' consumption of dwellings. In this application, demands for gasoline and motor vehicles become complementary, unlike in conventional CGE models. A petroleum tax simulation is conducted to illustrate the suitability of such treatment for energy-using consumer durables.

1. Introduction

TAIGEM is an environmentally focussed CGE model of Taiwan (Huang, Hsu, Li, Hsu, & Liang, 1998; Lee, Li, Hsu, & Huang, 1998). Like most CGE models, TAIGEM fails to account for the durable nature of energy-using appliances acquired by households. Consequently, it fails to recognise that fuels and appliances are complements in household usage, not substitutes.

This paper describes a modified version of TAIGEM in which households' motor vehicles are treated as durables, using the dummy-industry approach that is employed in CGE models to deal with households' consumption of dwellings. Section 2 outlines the main features of the standard TAIGEM model. Section 3 describes the modifications of the model's theory and data that are required to implement the treatment of motor vehicles as durables. Illustrative simulations, comparing the effects of a petrol tax in the modified and standard versions of TAIGEM, are reported in section 4. Section 5 contains some conclusions and an agenda for further research in this area.

2. The Main Features of the Standard TAIGEM

Apart from its treatment of energy and greenhouse-gas emissions, TAIGEM is a conventional CGE model, based on the ORANI-G specification (Horridge, Parmenter & Pearson, 1998). This section outlines the energy and emissions parts of the model.

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2.1. The "Technology Bundle" Approach for the Electricity Industry

The "technology bundle" approach (Hinchy & Hanslow, 1996; McDougall, 1993a; McDougall, 1993b) emphasises the availability of and substitution possibilities between technologies for production. In TAIGEM, it is applied for the electricity industry, accounting for the substitution between different power-generating technologies.

For Taiwan, we distinguish 10 power-generating industries according to technology and fuel requirement (see Table 1). The 10 power-generating technologies are: (1) Hydro; Steam engines fired by (2) petroleum, (3) coal and (4) natural gas; Combined cycle apparatuses fired by (5) petroleum and (6) natural gas; Gas turbines fired by (7) petroleum and (8) natural gas; (9) Diesel engines; (10) Nuclear power plants.

There is also an end-use supplier (hereafter EUS). The electricity generated flows entirely to the EUS industry. EUS then distributes electricity to the end-users. In the model specification, EUS may substitute between the 10 technologies in response to changes in their production costs[1].

2.2. The Multi-product Oil Refinery Industry

Most TAIGEM industries produce just one commodity. However, we disaggregate the Oil Refinery industry's output into 10 petroleum products: Gasoline, Diesel Fuel, Aviation Fuel, Fuel Oils, Kerosene, Lubricants, Naphtha, Refinery Gas, Asphalt and other Refined Petroleum Products. Production follows a CET (constant elasticity of transformation) function. Output composition varies according to the relative prices of these 10 products.

Table 1 Fuel flows* to the power-generating industries

	Decomposed power-generating industries										Total Electricity Generation
	(1) Hydro	(2) Steam -- Oil	(3) Steam -- Coal	(4) Steam -- Gas	(5) CombCycle -- Oil	(6) CombCycle -- Gas	(7) Gas turbine -- Oil	(8) Gas turbine -- Gas	(9) Diesel	(10)Nuclear	
Coal	0	0	1335	0	0	0	0	0	0	0	1335
Natural gas	0	0	0	2166	0	904	0	30	0	0	3100
Gasoline	2	1	3	1	1	0	0	0	0	5	48
Diesel fuel	0	1957	0	0	1099	0	176	0	71	0	3303
Aviation fuel	0	0	0	0	0	0	0	0	0	0	0
Fuel oils	0	4434	0	0	2490	0	0	0	161	0	7085
Kerosene	0	0	0	0	0	0	0	0	0	0	0
Lubricants	1	0	1	0	0	0	0	0	0	2	15
Naphtha	0	0	0	0	0	0	0	0	0	0	0
Refinery gas	0	0	0	13	0	5	0	0	0	0	18
Asphalt	0	0	0	0	0	0	0	0	0	0	0
Refined Petroleum N.E.C.	0	0	0	0	0	0	0	0	0	0	3
Coal products	0	493	1234	222	296	99	49	54	20	0	2467

* valued at basic price.

2.3. CO_2 Emission Accounting

Usage of 15 commodities will emit carbon dioxide. The 15 commodities are Coal, Coal products, Natural Gas, Gas, 10 Petroleum products, and Non-metallic Minerals (Calcium Carbonate). We

[1] The inter-fuel substitution is also incorporated for non-electricity industries in TAIGEM (Huang, Hsu, Li, Lin, & Liu, 1999). However, we omit it from the simulation for this paper.

assign emission coefficients (CO_2 per dollar) to the individual user's usage of these commodities drawing on data from the national CO_2 inventories.

3. The Modifications to the Standard TAIGEM

Section 3.1 briefly introduces the dummy-industry approach of treating energy-using consumer durables. Section 3.2 describes the adaptation of the data base to the dummy-industry approach.

3.1. The Dummy Industry Approach for Private Transport Services

Like most CGE models, the standard TAIGEM does not treat energy-using consumer durables in the proper way. There is an inconsistency between households' demand for consumer durables (e.g., motor vehicles.) and the fuel for their operation (e.g., gasoline.) (Conrad, 1983; Conrad & Schroder, 1991).

To tackle this problem, we make a new version of TAIGEM (hereafter, version DURA) by applying to the standard TAIGEM model (hereafter, version STD) the dummy-industry approach that is employed in most CGE models and conventional Input-Output accounts to deal with households' consumption of dwellings (Inter-Secretariat Working Group on National Accounts, 1993). In version DURA, the newly established dummy industry, Private Transport Services (hereafter, PTS), provides private transport services for households exclusively, using privately owned motor vehicles as its capital goods and gasoline and other goods as its intermediate inputs. Motor vehicles and gasoline are complements but not substitutes as in version STD.

3.2. The Adaptation of the Data Base

The adaptation of the data base involves moving households' purchases of motor vehicles to become PTS' investment, isolating car operating expenditure to become the PTS' intermediate inputs, and imputing rentals for privately-owned cars. In Figure 1, shaded rows and columns illustrate the major adaptations for the PTS (Private Transport Services) industry. The characteristics of PTS are summarised below.

- PTS only flows to the household sector;
- No import competition faces the PTS industry;
- Gasoline is the essential intermediate input, occupying 30.12% in PTS' total cost;
- The only primary factor - capital rental, takes up 47.40% of PTS' total cost.

After the adaptation, households consume no gasoline and other car-operating goods (e.g., vehicle services). No motor vehicles are purchased by households in version DURA (see Table 2). Furthermore, GDP increases by the amount of the capital rentals of the PTS industry. In the expenditure side, aggregate investment increases by the amount that used to be households' purchases of cars. Aggregate consumption decreases by 136466.5 million dollars, which is the difference between PTS' investment (of cars) and capital rentals (see Table 3).

			Absorption Matrix							
			Producers		Investors		Household	Export	Other	Change in Inventories
		Size	160	**PTS**	160	**PTS**	1	1	1	1
Basic Flows		C×S								
		"Gasoline"×S		**26046** **1028**			***0*** ***0***			
		"MV"×S				**98697** **73733**	***0*** ***0***			
		"PTS"×S	**0** **0**	**0** **0**	**0** **0**	**0** **0**	***190048*** **0**	**0**	**0** **0**	**0** **0**
Margin		C×S×M								n/a
		"PTS"×S×M	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**n/a**
Taxes		C×S								n/a
		"PTS"×S	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**n/a**
Labour		O		**0**						
Capital		1		**90087**						
Land		1		**0**						
Other Costs		I		**0**						
Total Costs		1		***190048***						

C = Number of Commodities (170 + "PTS")
I = Number of Industries (160 + "PTS")
S = 2; Domestic, Imported
O = Number of Occupation Types (6)
M = Number of Commodities used as margins (8)

Figure 1 The adaptation of the TAIGEM data base, adding in the dummy PTS industry

Table 2 The adaptation for household purchases **Unit: $NT million.**

Commodities	Before adaptation	After adaptation
Gasoline	**57249.098**	**0.000**
Diesel Fuel	**320.500**	**0.000**
Lubricants	**1447.100**	**0.000**
Rubber Products	10351.400	3023.940
Hand Tools	1144.200	1121.572
House Electronic products	63626.402	63486.242
Light Equipment	5252.800	4970.011
Video and Radio	58642.203	57706.691
Motor Vehicles	**226553.797**	**0.000**
Insurance	65869.000	59869.102
Vehicle Services	**26236.000**	**0.000**

Table 3 Differences in the components of GDP after adaptation **Unit: $NT million.**

Components of GDP	Before adaptation (A)	After adaptation (B)	Difference (C) = (B) - (A)
GDP from income side	6426111.875	6516199.125	**90087.250**
Land	227240.750	227240.750	0.000
Labour	3699243.000	3699243.000	0.000
Capital rental	1941429.625	2031516.875	**90087.250**
Other costs	294353.656	294353.656	0.000
Indirect Taxes	263844.844	263844.844	0.000
GDP from expenditure side	6426111.414	6516198.664	**90087.250**
Consumption	3765696.500	3629230.000	-136466.500
Investment	1508449.875	1735003.625	226553.750
Government	977115.813	977115.813	0.000
Inventory changes	68509.477	68509.477	0.000
Exports	2776823.500	2776823.500	0.000
Imports	-2670483.750	-2670483.750	0.000

4. An Illustrative simulation

In both versions STD and DURA, a 15% *ad valorem* tax is imposed on all purchases of CO_2-emitting petroleum goods[2], except exports. The effects in the two versions are compared so as to demonstrate the suitability of our treatment for the energy-using consumer durables.

Section 4.1 states the assumptions underlying the simulation. A qualitative analysis common for both versions is made in section 4.2. Predictive differences in the quantitative results between the two versions are pointed out in section 4.3. Quantitative results are compared in section 4.4.

4.1. Assumptions underlying the simulation

The simulations were conducted with a typical long-run comparative static closure. The key assumptions in this closure are as follows:

- Industry-specific rates of return are assumed fixed and capital stocks are free to adjust.
- Aggregate employment is not affected by the imposition of the petroleum tax while the real wage adjusts.
- The ratio of the balance of trade to nominal GDP is constant.
- Industry-specific investment responds to adjustments in capital stocks.
- Aggregate government consumption moves in line with aggregate private consumption in the long run.
- Aggregate private consumption together with aggregate government consumption are regarded as residual in the GDP identity.
- Foreign prices of imports are fixed (small country assumption).
- The number of households is not explained in our model, so it is set exogenous.
- The nominal exchange rate is the numeraire.
- Production technology and consumer tastes are assumed not to be affected by the imposition of the petroleum tax.

4.2. Qualitative analysis

Before we compare the numerical results of the two versions, we analyse qualitatively how the economic agents will respond to the imposition of the petroleum tax.

4.2.1. Macroeconomic aspects

In our closure, the real wage rate is free to adjust to the imposition of the tax, while rates of return are fixed. Because we do not assume tax-revenue neutrality, the rise in producer costs due to the imposition of petroleum tax will drive the real wage downward. As the wage/rental ratio falls, the economy will reduce its capital/labour ratio. Since aggregate employment is assumed fixed, the aggregate capital stock will shrink. As a result, GDP from income side falls.

In the expenditure side, the trade balance moves towards deficit[3] as GDP decreases.

The movement in aggregate consumption (private plus government), as a slack variable to satisfy the GDP identity, is then determined. We use the algebra below based on model equations to illustrate this argument.

From the expenditure side the percentage change in real GDP is computed as

(E. 1) $$\boldsymbol{gdp = S_C{*}c + S_I{*}i + S_B{*}b}$$

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[2] The taxed CO_2-emitting petroleum goods include Gasoline, Diesel Fuel, Aviation Fuel, Fuel Oils, Kerosene, Refined Gas and Other Refined Petroleum products.

[3] According to our data base, there is a trade-balance surplus. In this case, as GDP decreases, the trade surplus decreases, i.e., the trade balance will move towards deficit. If on the other hand there were a deficit in the data, a decrease in GDP would generate a decrease in the deficit, i.e., the trade balance would move towards surplus.

where $\boldsymbol{c}$, $\boldsymbol{i}$ and $\boldsymbol{b}$ are the percentage changes in aggregate consumption, investment and the balance of trade, and S_C, S_I and S_B are the shares of the expenditure categories in GDP.

From the income side the percentage change in real GDP can be written as the weighted sum of percentage changes in primary factor inputs, that is

(E. 2) $$gdp = S_K*k + S_L*l + S_N*n$$

where $\boldsymbol{k}$, $\boldsymbol{l}$ and $\boldsymbol{n}$ are percentage changes in the employment of capital, labour and land, and S_K, S_L and S_N are the shares of the primary factors in real GDP.

According to the closure, $\boldsymbol{l}$ and $\boldsymbol{n}$ equal to zero; and $gdp = b$[4]. As S_B is rather small, $(\frac{1}{1-S_B})$ approximates to unity[5]. We then obtain the following equation:

(E. 3) $$c \cong (\frac{1}{S_C}) *[S_K*k - S_I*i].$$

(E. 3) indicates that the direction of the movement in aggregate consumption depends on the relative contributions[6] of aggregate capital and aggregate investment to GDP.

Note that in the model we split all industries (set IND) into two categories: ENDOGINV and EXOGINV. As a result of the closure setting, the equations about industry investment are as follows.

(E. 4a) $$i(\mathrm{i}) = k(\mathrm{i}),\ \mathrm{i} \in \mathrm{ENDOGINV},$$

(E. 4b) $$i(\mathrm{i}) = i,\quad \mathrm{i} \in \mathrm{EXOGINV},$$

(E. 4c) $$i = \sum_i W_i^I * i(i)\ ,\ \mathrm{i} \in \mathrm{IND},$$

(E. 4d) $$k = \sum_i W_i^K * k(i)\ ,\ \mathrm{i} \in \mathrm{IND},$$

(E. 4e) $$k(\mathrm{i}) = x1tot(\mathrm{i}) - SIGMA1PRIM(\mathrm{i})*[p1cap(\mathrm{i}) - p1prim(\mathrm{i})],\ \mathrm{i} \in \mathrm{IND}$$

In these equations

- $\boldsymbol{i}$(i) and $\boldsymbol{k}$(i) are percentage changes in industry i's investment and capital stock respectively;
- $\boldsymbol{i}$ denotes the aggregate investment;
- W_i^I and W_i^K denote industry i's shares in aggregate investment and capital stock respectively;
- ***x1tot***(i) denotes industry i's activity levels;
- ***SIGMA1PRIM***(i) is the CES substitution elasticity for industry i's demand for primary factors;
- ***p1cap***(i) is the percentage change in industry i's rental price;
- ***p1prim***(i) is the effective price term for factor demand.

The EXOGINV industries are those for which we feel that an arbitrary rule, rather than industry-specific price mechanisms, would best determine investment. In contrast, for the ENDOGINV industries, capital growth rates are related to industry rates of return: $i(\mathrm{i}) - k(\mathrm{i}) = \beta(\mathrm{i})*r(\mathrm{i})$, where β(i) is the industry-specific investment elasticity. $\boldsymbol{r}$(i) is exogenous in this simulation. Hence, $i(\mathrm{i}) = k(\mathrm{i})$ for ENDOGINV industries, while for EXOGINV industries, $i(\mathrm{i}) = i$. Furthermore, the industry shares in aggregate investment and aggregate capital stock - the weights

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[4] Strictly speaking, they are set equal in nominal (rather than real) terms. We ignore the terms of trade effect.

[5] In our data base, SB is 0.016319. $(\frac{1}{1-S_B})$ equals to 1.01659.

[6] Hereafter, contribution of some specific variable denotes the share weighted percentage change in that variable.

used in the calculations of the aggregate investment and the aggregate capital stock - are different from each other. Therefore, the qualitative analysis does not reveal the relative magnitudes of changes in aggregate investment and aggregate capital stock. Hence, although we definitely know that $\boldsymbol{S_K}$ is bigger than $\boldsymbol{S_I}$ [7], we can not be sure of the direction of the movement in aggregate consumption from this qualitative analysis alone. Quantitative results of the magnitudes in the adjustment of aggregate investment and capital stock are necessary to determine the movement of aggregate consumption.

In summary, we expect to see the macro-economy perform in the following way:

- Aggregate capital stock declines in response to a fall in the wage/rental ratio;
- Real GDP falls;
- The balance of trade declines accordingly; and
- The movement of aggregate consumption (private plus government) depends on the relative magnitudes of the movements in aggregate investment and aggregate capital stock.

4.2.2. Responses of economic agents

The decrease in the wage/rental ratio tends to favour labour-intensive industries. Relatively, commodities produced by capital-intensive industries lose their attractiveness in the market. This leads to reductions in capital-intensive industries' production and increases in labour-intensive industries' production. Industries adjust their factor employment accordingly. On the whole, the aggregate capital/labour ratio declines. As aggregate employment is assumed fixed in this simulation, aggregate capital stock must be scaled down. This indicates consistency with the macroeconomic aspects stated above.

4.3. Differences between the two versions of TAIGEM

While the qualitative analysis stated above holds for both versions, we expect to see differences in the magnitudes between the two versions of TAIGEM. As we add a new dummy PTS industry in version DURA, the industry structure shows differences between the two versions of TAIGEM. For example, we expect to see that the aggregate capital stock in version DURA has a bigger movement than in version STD. The underlying justification is that the newly established dummy PTS industry in version DURA is extremely capital-intensive, and also petrol-intensive. The petroleum tax pushes up its production cost and thus output price. The market demand hence decreases. This industry then reduces its activity level and thus capital stock. As this industry occupies a rather big share in aggregate capital stock, aggregate capital stock in version DURA will show bigger movement than in version STD. Hence, we expect to see the dummy PTS industry's behaviour plays a crucial role in the distinction in the results between the two versions.

Secondly, we expect to see version DURA remedy the contradiction in households' demand for gasoline and motor vehicles in the standard TAIGEM. In version STD we specify a Linear Expenditure System for household demand. All commodities are substitutes for each other. Via the substitution effect, we expect to see households increase their purchase of motor vehicles in response to the price increase of gasoline. But in reality gasoline and motor vehicles are complements. In version DURA, less private transport is demanded as the petroleum tax on its most important input, gasoline, pushes up its cost and thus its output price. Households hence substitute away from private transport services. As we specify a Leontief production function for the PTS industry, it will decrease the usage of gasoline and decrease its capital stock, which is solely composed of motor vehicles. Since PTS is one of the ENDOGINV industries, its investment follows the adjustment of its desired capital stock. Therefore, we expect to see consistency in household-induced demand for gasoline and motor vehicles. That is the aim of

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[7] In version STD, the share of aggregate capital in GDP is 30.21% and that of aggregate investment is 23.47%. In version DURA, the share of aggregate capital in GDP is 31.18% and that of aggregate investment is 26.63%.

establishing the dummy PTS industry to remedy the inconsistency in household demand for gasoline and motor vehicles. We will analyse this quantitatively in the next section.

The Oil Refinery industry's product mix depends on the responses of its customers. Households in version STD, the most important gasoline purchaser, will reduce purchases of gasoline, while PTS in version DURA is less elastic in its demand of gasoline. Oil-fired power-generating industries will be substituted away for the increasing costs. Their demands affect the Oil Refinery industry's production decision.

4.4. Quantitative Results

In this section, we investigate the quantitative results to verify the qualitative analysis stated above and to resolve the issues that are indeterminate in the qualitative analysis. We will also compare the magnitudes of the impact on economic variables between the two versions.

We first point out in section 4.4.1 how version DURA remedies the contradiction in households' demand for gasoline and motor vehicles in the standard TAIGEM. Impacts on Oil Refinery industry in the two versions are also compared in section 4.4.2. The impact on the macroeconomic aspects is reported in section 4.4.3.

4.4.1. Households' v.s. PTS' demand for gasoline and motor vehicles

As mentioned in section 4.3, we expect to see that demand for gasoline and motor vehicles are correlated. As shown in Table 4, in the original model the petroleum tax discourages households' consumption of gasoline and diesel fuel (-4.9873% and -3.6303% respectively), while they purchase more motor vehicles (increasing by 0.2308%). On the other hand, in version DURA PTS reduces its consumption of gasoline in accordance with the shrinkage of its capital stock. This is more realistic.

Table 4 Household and PTS demands for gasoline and motor vehicles

(%)	STD / Household demand for	DURA / PTS demand for
Gasoline	-4.9873	-1.3138
Diesel Fuel	-3.6303	-1.3138
Lubricants	-1.2169	-1.3138
Motor Vehicles / Capital stock	**0.2308**	**-1.3138**

4.4.2. Differences in the impact on the Oil Refinery industry

For both versions, the basic price of Fuel Oils decreases while the basic prices of other petroleum products increase due to the petroleum tax (see Table 5). This is because the demand for Fuel Oils is much more elastic than for other petroleum products. Note that the main customers of Fuel Oils are oil-fired power industries. The petroleum tax prompts the End Use Suppliers to substitute away from these technologies. This reflects the more elastic market demand for Fuel Oils. On the other hand, the demanders of other petroleum products have less scope for substitution. Therefore, the petroleum tax will reduce the basic price of Fuel Oils while pushing up the basic prices of other petroleum products.

In comparison, the basic price of gasoline rises more in version DURA. As PTS is the major customer of gasoline[8], its Leontief production function makes the market demand for gasoline less elastic[9] in version DURA than in the original STD model.

[8] Households in version STD, thus PTS in version DURA, consumes 44.80% of the total sales of gasoline
[9] In version STD, households have a Linear Expenditure System for demand; in version DURA, PTS has to purchase a fixed amount of gasoline proportional to its capital stock.

Table 5 The impact on the Oil Refinery industry

	Output of commodities		Basic prices of commodities	
Versions	STD	DURA	STD	DURA
Commodities	(%)	(%)	(%)	(%)
Gasoline	-3.135	-1.158	2.122	4.220
Diesel Fuel	-3.810	-3.210	0.365	-1.073
Aviation Fuel	-0.547	-0.459	8.995	6.054
Fuel Oils	-6.466	-5.575	-6.394	-7.001
Kerosene	-1.876	-1.376	5.437	3.651
Lubricants	-2.298	-1.702	4.320	2.805
Naphtha	-2.902	-2.092	2.733	1.795
Refinery Gas	-2.213	-1.588	4.545	3.099
Asphalt	-1.679	-1.214	5.961	4.075
Refined Petroleum N.E.C.	-2.034	-1.441	5.020	3.483

4.4.3. Macroeconomic aspects

In this section we check that for both versions the qualitative analysis of macroeconomic results is confirmed numerically. As the difference in industry structures between the two versions may account for the difference in the magnitudes of the macroeconomic variables, we will refer to the industrial details. Tables 7 - 17 assist in the comparison for the macroeconomic results.

Subsections 4.4.3.1 and 4.4.3.2 present impacts on the income and expenditure sides of GDP respectively. Subsection 4.4.3.3 presents changes in price indexes. Changes in CO_2 emissions and tax revenue are reported in Subsections 4.4.3.4 and 4.4.3.5.

4.4.3.1. GDP from income side

As shown in Table 6, the wage/rental ratio[10] decreases, by 0.406% in version STD and by 0.384% in version DURA. The aggregate capital stock decreases by 0.058% in version STD and by 0.108% in version DURA. As a result, GDP falls by 0.066% in version STD, and by 0.082% in version DURA. The real wage falls by 0.553% in version STD and by 0.575% in version DURA. These numerical results for both versions conform with the qualitative analysis.

Aggregate capital stock in version DURA decreases nearly twice as much as in version STD, while the wage/rental ratio in version STD declines slightly more than in version DURA. We refer to the industry results to explain this difference.

Comparing the two versions in Table 7, industries apart from the additional PTS in version DURA have similar contributions in both versions to the changes of aggregate capital stock. Besides, the shares of other industries in the aggregate capital stock diminish due to the addition of the extremely capital-intensive PTS industry. This weakens other industries' contributions to the change in the aggregate stock, given the same percentage changes in industry stocks in both versions. Moreover, industries' adjustments in capital stocks are unconstrained and thus independent of each other. Yet, the decreasing wage/rental ratio leads to reduction in their capital stocks. As the wage/rental ratio falls less in version DURA, industry-specific capital stocks shrink less than in version STD. On the whole, industries apart from PTS have similar contributions in both versions to the aggregate capital stock.

The contraction of PTS' capital stock accounts for most of the difference. Suffering from the shrinking market demand due to the petroleum tax, PTS reduces its output and its capital stock accordingly. PTS' basic price increases by 3.0861%; its output and capital stock decrease by 1.3138% and hence, together with a share of 4.4345% in the aggregate capital stock, has a

[10] In percentage change form, the wage/rental ratio equals to the nominal wage minus the rental price of capital.

contribution of -0.0583% to aggregate capital stock. This is approximately the difference in the changes of aggregate capital stock between the two versions.

Among industries listed in these two tables, oil-fired power-generating industries - ComCy_Oil, Steam_Oil, and GasTur_Oil; Fisheries; and Land Transport industries are heavy users of the taxed petroleum goods. Suffering from the petroleum tax, their capital stocks contract. The three oil-fired power-generating industries contract more sharply than others, because the End Use Supplier substitutes away from them. The petroleum tax makes oil-fired power relatively costly.

On the other hand, the model allows smaller substitution possibilities for the products of PTS, Fisheries and Land Transport industries. Their demands are less elastic than the End Use Supplier's demand for the oil-fired electricity. As a result, these industries' production and capital stocks do not contract as much as the oil-fired power industries.

As petroleum-using industries shrink, the Oil Refinery industry also suffers. Its activity level and thus its capital stock decline. In addition, the decreasing wage/rental ratio induces further contraction in its capital stock. In version STD its capital stock contracts more (by 3.8426%) than in version DURA (by 2.6936%). This is because the market demand for gasoline - Oil Refinery industry's most important product - falls less in version DURA than in version STD. The market demand for gasoline is crucial in the Oil Refinery industry's production decision. More discussion about this industry is in section 4.4.2.

4.4.3.2. GDP from expenditure side

Aggregate Investment

Aggregate investment decreases by 0.295% in version STD and by 0.412% in version DURA (see Table 6). We know from the income side of GDP that the aggregate capital stock contracts in both versions. But, capital contracts less than investment in aggregate.

We first discuss the last observation. The differences in weight and the investment rule for the EXOGINV industries count for this observation. To explain the weight effect, we assume that for all industries their investments move with capital stocks. The percentage change of the aggregate investment calculated via (E. 4c) is bigger than that of the aggregate capital stock calculated via (E. 4d), while for all i, $\boldsymbol{k}(\mathrm{i}) = \boldsymbol{i}(\mathrm{i})$. Under this assumption, the weight differences account for the distinction between the percentage changes of the aggregate investment and the aggregate capital stock. Secondly, the investment specification for EXOGINV industries also accounts for this observation. Those oil-fired power industries are included in the EXOGINV. Those industries' capital stocks contract sharply, while their investments are regulated to move with the aggregate investment, which is far smaller than the contraction in their capital stock. On the other hand, those non-oil-fired power industries, favoured by the petroleum tax, increase largely their capital stock, while their investments also move with the aggregate investment. These two effects together contribute to the difference between percentage changes of the aggregate investment and capital stock, with $\boldsymbol{i}$ bigger than $\boldsymbol{k}$ in magnitude for both versions.

Next, we explore the difference in the decrease of the aggregate investment between the two versions. Comparing between the two versions in Table 8, the difference in the contraction of aggregate investment between the two versions comes largely from the newly established PTS industry.

Beyond PTS, the Oil Refinery industry also contributes to this difference. As it is in the set ENDOGINV, its investment contracts with its capital stock. Its investment decreases less sharply (-2.6936%) in version DURA, pulling down aggregate investment by 0.0493%.

The Public Administration Services (PAS henceforth) and the Land Transport industries also have significant contributions to the contraction in aggregate investment. As it is in the set ENDOGINV, the PAS industry's investment moves with its capital stock. Closely related to government consumption, the output of PAS increases as government consumption increases (see Table 6) However, PAS reduces its capital stock and thus its investment, even though its output expands. This arises due to the declining real wage. The PAS industry is fairly labour-intensive. Its cost share of labour is 57.84%, while capital is only of 5.65% in its total cost. The falling real wage prompts PAS to substitute away from capital, and hence its investment decreases. The decrease is smaller in version DURA than in version STD because aggregate private consumption and thus government consumption[11] increases more in DURA. We will discuss aggregate consumption later in this section.

As one of the heavy users of diesel fuel and gasoline, the Land Transport industry[12] suffers increased costs and reduced sales. It reduces its output, capital stock and thus investment[13]. Besides, the substitution effect arising from reduced real wages also contributes to the contraction in the Land Transport industry's capital stock and investment since this industry is also labour-intensive[14]. In comparison, Land Transport industry's investment decreases less in version DURA. Household demand for Land Transport accounts for this difference[15]. As shown in Table 6, aggregate private consumption increases more in version DURA. The reduction in households' demand for Land Transport is hence relatively less. This then leads to less decreases in output and capital stock and hence in investment.

In summary, two forces prompt the Land Transport industry to reduce its capital stock and hence its investment: (1) the real wage decline directly induces reduction of its capital; and (2) the price rise of its output prompts households' substitution away from Land Transport, which in turn reduces its production and hence in capital and investment. These two sorts of substitution effect are common in both versions, while the income effect of household consumption accounts for the difference between them.

Besides, the shares of industries apart from PTS are smaller in the DURA model[16]. This diminishes their contributions to the change in aggregate investment. Overall, PTS' adjustment in investment accounts for most of the difference in aggregate investment between the two versions.

Up to now, we have seen from the income side the contraction in the aggregate capital stock and hence the reduction in GDP in both versions. From the expenditure side, aggregate investment shows even sharper decreases than the aggregate capital stock. Next, we will discuss the impacts on the balance of trade and aggregate consumption.

Trade

As shown in Table 6, aggregate export volumes fall by 0.198% in version STD and by 0.218% in version DURA[17]; aggregate import volumes fall by 0.13% in version STD and by 0.153% in

[11] As mentioned in the qualitative analysis, the movement of aggregate private consumption depends on the relative contributions of aggregate capital and aggregate investment to GDP. Besides, we assume that government consumption moves with aggregate private consumption. So, government consumption increases as aggregate private consumption increases. The detailed discussion about the quantitative result for aggregate private consumption is in section Aggregate Private Consumption.

[12] Diesel fuel contributes 12.05% and gasoline 7.62% to its total cost.

[13] The Land Transport industry is in the set ENDOGINV.

[14] The cost share of labour for the Land Transport industry is 43.49%, while capital is only 12.74% in its total cost.

[15] The household sector is the first-ranked direct-use customer of this industry, therefore household demand will have significant influence on this industry's production. Of Land Transport output, 52% goes to direct use (mostly by households, 31.37%) and 48% is used for margins purposes.

[16] Note that we move households' current purchase of Motor Vehicles in version STD to the dummy PTS' investment in version DURA. This expands economy-wide investment, and hence the shares of the original industries (those other than the dummy PTS) become smaller.

[17] Note that we adopt the small country assumption that the foreign prices of imports are fixed. Hence the shrinkage of exports leads to improvement of the terms of trade.

version DURA. Hence, the trade balance moves towards deficit[18] in both cases. The real exchange rate decreases by 0.146% in version STD and by 0.167% in version DURA.

Note that we assume that the balance of trade moves in line with GDP. Since GDP falls and there is a trade surplus in the data base (see footnote 3), the balance of trade moves towards deficit in both versions. Comparatively, the move toward deficit is bigger in version DURA than in version STD. So is the real appreciation. The rationale is as follows.

Assume first that there is no change in export for both versions. In the results, we observe that import decreases in both versions. Other things being equal, this will lead the trade balance to move towards surplus, which violates our closure specification. Therefore, we must have an appreciation. The appreciation lessens the competitiveness of exports in the world market and also drives up import volumes. In equilibrium, the appreciation results in decreases of both exports and imports, eventually pushing the trade balance towards deficit. This is the common rationale for both versions. As to the comparison, we find a bigger move towards trade deficit and a bigger appreciation in version DURA. The bigger move towards deficit can be explained by the bigger fall in GDP. As to the bigger appreciation in version DURA, following the above rationale, the bigger decrease of imports requires a bigger appreciation to push the trade balance further towards deficit.

We now turn to discuss the bigger decrease of aggregate imports in version DURA. As shown in Table 9, for both versions, the imports of Fuel Oils, Crude Oil and Diesel Fuel are discouraged and make significant negative contributions to aggregate imports. The sizes of these contributions do not vary much between versions.

Crude Oil is the raw material for the production of petroleum goods. Besides, the Oil Refinery industry used to rely heavily on the imported Crude Oil. The petroleum tax discourages the market demand for petroleum goods and thus the domestic production of them. As a result, the import volume of Crude Oil decreases. In comparison, version STD has a bigger decrease. This is because of a bigger reduction in Oil Refinery output -- discussed in section 4.4.2.

As discussed in section 4.4.2, domestically-produced Fuel Oils and Diesel Fuel both show price declines and become cheaper than their import competitors. Besides, their main customers—oil-fired power industries—suffer severe substitution in the impact of the petroleum tax. Hence, the import volume of Fuel Oils and Diesel Fuel decrease sharply.

Imports of Motor Vehicles differ between the two versions, which accounts for the difference in aggregate imports. As see in section 4.4.1, households in version STD buy more motor vehicles (both domestic and imported), while PTS in version DURA reduces its investment in motor vehicles.

Imports of Motor Vehicles increase slightly (0.0156%) in version STD, and make a slight positive contribution to aggregate import volume. This results from the substitution effect in household consumption. Households in version STD use much less gasoline when facing the petroleum tax. On the other hand, they buy more Motor Vehicles (domestically produced and imported). As shown in Table 10, among significant contributions to imports of motor vehicles, household purchases in version STD increase by 0.2526% and contributes 0.1246% to the total increase.

Conversely, imports of Motor Vehicles decrease by 0.9309% in version DURA. Here, the PTS industry reduces its purchase of motor vehicles as investment goods. The petroleum tax imposed on its major intermediate input, gasoline, raises its production cost and thus its output price. The market demand hence declines. This prompts the PTS industry to reduce output and hence its capital stock, which in turn leads to the decrease in its investment. Note that the PTS industry purchases only motor vehicles as its investment goods. In Table 11, we see that the PTS industry

[18] According to our data base, the initial balance of trade is in surplus.

buys 1.2645% less imported motor vehicles, contributing -0.6236% to the decrease in the import volume of motor vehicles.

Thus, increased gasoline prices have opposite effects on Motor Vehicle purchases in the two versions of the model. In both versions, higher gasoline prices reduce gasoline sales. In the standard version, where gasoline and motor vehicles are treated as substitutes, demand for vehicles rises. The modified version, which recognises the complementarity between gasoline and motor vehicles, predicts that motor vehicles sales will fall.

Aggregate Consumption

As seen in Table 6, aggregate private and government consumption[19] both increase, by 0.048% in version STD and by 0.082% in version DURA.

As we mentioned in the qualitative analysis, the movement of aggregate consumption (private plus government consumption) depends on the relative magnitudes of the contributions of aggregate capital and aggregate investment to GDP. Table 12 shows the relative magnitudes of the contributions of aggregate capital and investment in the two versions. In both versions, the contribution of aggregate investment to the decline of GDP is bigger that that of aggregate capital. Following the formula (E. 3) in the qualitative analysis, aggregate consumption will increase. The results in Table 12 support our qualitative analysis.

Aggregate consumption in version DURA increases more than in version STD. The percentage increases in aggregate capital and investment in version DURA are both bigger than in version STD. Furthermore, their shares of GDP in version DURA are also bigger than in version STD. On the other hand, the share of aggregate consumption in GDP in version DURA is relatively smaller[20]. Therefore, the increase of aggregate consumption in version DURA must be bigger than in version STD. In other words, the resources released from the contraction of investment are shifted to aggregate consumption. As the contraction of aggregate investment in version DURA is bigger, aggregate consumption increases more.

4.4.3.3. Price indexes

As a result of the imposition of the petroleum tax, the GDP price index rises in both versions, the rise being greater in DURA than in STD (see Table 6). Table 13 provides a decomposition of the increases in the index in both versions. Among the contributions, the rise in CPI is the major contributor in both versions. In version STD, CPI rises by 0.1948%, with a positive contribution of 0.1141% to the GDP price index. In version DURA, CPI rises by 0.2419%, contributing 0.1347% to the GDP price index. The difference in CPI accounts for the difference in GDP price index between the two versions.

We go on to explore the source for the CPI rise. Table 14 lists significant contribution effects to CPI for both versions. Basically, commodities apart from gasoline and PTS show similar percentage changes in consumer prices. The price of gasoline rises sharply in version STD (8.6206%, see Table 14), contributing 0.1311% to the rise of CPI. In version DURA, the price rise in gasoline does not affect CPI directly in that households consume no gasoline. However, PTS made from gasoline, motor vehicles and other operating goods has a price rise of 3.0861%. With a budget share of 5.2366% in household expenditure, the price rise of PTS contributes 0.1616% to the rise of CPI in version DURA. In other words, the price rise of gasoline is shifted indirectly to CPI through the price rise of the PTS.

[19] Note that we set in the closure that government consumption moves in line with aggregate private consumption. The size of both is given by the trade balance constraint.

[20] As we move household purchase of motor vehicles, which used to be regarded as current consumption, to the PTS dummy industry's investment, the share of aggregate private consumption in GDP decreases in version DURA and aggregate investment has a relatively larger share. The share of aggregate capital also increases because we add in the imputed rentals of the car stock.

Actually, the difference in CPI between both versions comes mainly from the distinction in the price changes of gasoline. The consumption share of gasoline by households (directly or indirectly) is similar in both versions. In version STD, households' budget share of gasoline is 1.5203%. Note that in version DURA households' consumption of gasoline is moved to be one of PTS' intermediate inputs. Referencing the cost share of gasoline of the dummy PTS industry, we can calculate the *indirect* consumption share of gasoline by households in version DURA[21] via multiplying households' budget share of PTS by the dummy PTS industry's cost share of gasoline. The result is 1.5774%[22]. In this way of calculation, the consumption shares of gasoline by households (directly and indirectly) are similar. So, it is the changes in the purchasers' price of gasoline for households in version STD and for PTS in version DURA that contribute to their difference in CPI. Table 14 indicates that the purchasers' price of gasoline for households increases by 8.6206%, contributing a rise of 0.1311% to CPI. Table 15 indicates that the purchaser price of gasoline for PTS increases by 10.1808%, contributing 3.0668% in the rise of its purchaser price. PTS' purchaser price in turn contributes a rise of 0.1616%[23] to CPI.

The changes in the purchaser price of gasoline differ between both versions because of the difference in substitution possibility. Demand for gasoline is less elastic in version DURA. Hence, in version DURA less reduction in gasoline demand contributes to a bigger price increase, while in version STD strong reduction in gasoline demand moderates the price increase.

In contrast to the general price rise induced by the petroleum tax, the government price index falls in both versions (see Table 13). This is not surprising since the government consumption is mainly composed of services from labour-intensive industries. Wages decline in both versions (see Table 6). We list in Table 16 the most significant contributions to government price index in the two versions.

4.4.3.4. CO_2 emissions

The petroleum tax causes CO_2 emissions to decrease by 1.086% in version STD and by 0.864% in version DURA. As can be seen in Table 17, the major source of difference in the CO_2 emission between the two versions lies in the difference between household and PTS emissions. This is because the decrease in gasoline usage in version DURA is smaller.

The Steam_Coal, Steam_Gas and ComCy_Gas electricity-generators contribute significantly to overall CO_2 emissions growth, while CO_2 emissions from Steam_Oil, ComCy_Oil and Diesel reduce greatly and hence help curtail the economy-wide emission. We specified CES substitution between the 10 kinds of raw electricity for the electricity end-use supplier. Hence, demand for Steam_Oil and CombCy_Oil falls since their production costs are relatively higher than other raw electricity generating industries. Hence, CO_2 emissions from the production process in these two industries are largely reduced. On the other hand, Steam_Coal, Steam_Gas and CombCy_Gas are favoured due to their relative lower production costs. Hence, CO_2 emitted from these three industries increases.

Among the users listed in Table 17, households have a contribution of 0.2339% to the reduction of total CO_2 emission in version STD, while in version DURA PTS only helps reduce the total CO_2 amount by 0.0599%. This is the critical point that makes the distinction in the total CO_2 emission between the two versions.

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[21] PTS is only provided for households in version DURA.

[22] Households' budget share of PTS is 5.2366%, while PTS' cost share of gasoline is 30.1234%. Hence, households' budget share of the indirect consumption of gasoline is 1.5774%, similar to the budget share of the direct consumption of gasoline.

[23] We can approximate this contribution effect via multiplying households' indirect consumption share with the price change of gasoline: 1.5774%*10.1808% = 0.1606%.

4.4.3.5. Tax revenue

The petroleum tax increases aggregate indirect tax revenue by around 6.7% in both versions. Among the sources of the tax revenue, tax revenue from production increases by 17.717% in version STD and 19.802% in version DURA. Tax revenue from households increase 6.961% in version STD, but only 0.239% in version DURA. Since we move parts of households' purchases of petroleum goods (those for transport purpose) to PTS in version DURA, households pay fewer taxes in version DURA. On the other hand, version DURA has a higher increase in aggregate tax revenue from production.

Tariff revenue in version STD decreases mainly because of the decrease in local demand for imported Fuel Oils, Diesel Fuel and Crude Oil. In version DURA, the decrease in imported Motor Vehicles makes tariff revenue fall further and hence causes the significant difference between two versions.

In this simulation, we do not impose the petroleum tax on exports. However, tax revenue from exports decreases in both versions. The improvement in terms of trade reduces Taiwanese exports in the world market, and hence tax revenue from exports decreases.

Table 6 Macroeconomic results

	Versions	
Percentage changes of	STD	DURA
Average capital rental	0.047	0.049
Average nominal wage	-0.359	-0.335
Real wage	-0.553	-0.575
Aggregate capital stock	-0.058	-0.108
Aggregate employment*	0	0
Real GDP	-0.066	-0.082
Aggregate real private consumption	0.048	0.082
Total real investment	-0.295	-0.412
Aggregate real government consumption	0.048	0.082
Export volume index	-0.198	-0.218
Import volume index, C.I.F. weights	-0.130	-0.153
Real devaluation	-0.146	-0.167
Terms of trade	0.076	0.074
GDP price index	0.146	0.167
CPI	0.195	0.242
Total nominal supernumerary household expenditure	0.303	0.390
Total CO2 emission	-1.086	-0.864
Aggregate indirect tax revenue	6.727	6.790
Tax revenue from production	17.717	19.802
Tax revenue from households	6.961	0.239
Tariff revenue	-0.081	-0.325
Tax revenue from exports	-0.211	-0.239

* marks exogenous variables.

Table 7 Significant contributions to the change in the aggregate capital stock

	Industry shares (A)		Percentage changes of industry capital stocks (B)		Industry contributions to the aggregate capital stock (C) = [(A)/100]*(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Industries	(%)	(%)	(%)	(%)	(%)	(%)
PTS	**n/a**	**4.4345**	**n/a**	**-1.3138**	**n/a**	**-0.0583**
CombCy_Oil	0.1791	0.1711	-27.9904	-26.0714	-0.0501	-0.0446
Steam_Oil	0.1399	0.1337	-32.5348	-30.3850	-0.0455	-0.0406
Oil Refinery	0.5381	0.5142	-3.8426	-2.6936	-0.0207	-0.0139
Fisheries	1.3033	1.2455	-1.1784	-1.0844	-0.0154	-0.0135
Land Transport	1.4455	1.3814	-0.5571	-0.5130	-0.0081	-0.0071
GasTur_Oil	0.0322	0.0307	-18.1931	-16.5277	-0.0059	-0.0051
GasTur_Gas	0.0042	0.0040	9.8897	9.2045	0.0004	0.0004
EndUseElec	2.5498	2.4368	0.1179	0.1233	0.0030	0.0030
Steam_Gas	0.0560	0.0535	10.5027	9.7213	0.0059	0.0052
CombCy_Gas	0.0839	0.0802	10.8925	10.1007	0.0091	0.0081
Hydro	0.3060	0.2925	11.0151	10.2598	0.0337	0.0300
Nuclear	0.7869	0.7520	10.7157	9.9900	0.0843	0.0751
Steam_Coal	0.8953	0.8556	11.7003	10.9395	0.1048	0.0936

Table 8 Significant contributions to the change in the aggregate investment

	Industry shares (A)		Percentage changes in industry investment (B)		Industry contributions to aggregate investment (C) = [(A)/100]*(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Industries	(%)	(%)	(%)	(%)	(%)	(%)
PTS*	**n/a**	**13.0578**	**n/a**	**-1.3138**	**n/a**	**-0.1716**
Oil Refinery*	2.1044	1.8296	-3.8426	-2.6936	-0.0809	-0.0493
PAS*	20.8208	18.1020	-0.1465	-0.1015	-0.0305	-0.0184
Land Transport*	5.4231	4.7150	-0.5571	-0.5130	-0.0302	-0.0242

* marks an ENDOGINV industry.

Table 9 Significant contributions to the change in aggregate import volume

	Commodity shares (A)		Percentage changes in imports by commodity (B)		Commodity contributions to aggregate import volume (C) = [(A)/100]*(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Commodities	(%)	(%)	(%)	(%)	(%)	(%)
Fuel Oils	0.5278	0.5278	-22.6559	-22.1063	-0.1196	-0.1167
Crude Oil	2.6228	2.6228	-3.7889	-2.6277	-0.0994	-0.0689
Diesel Fuel	0.3391	0.3391	-12.0791	-12.5918	-0.0410	-0.0427
Motor Vehicles	**5.3666**	**5.3666**	**0.0156**	**-0.9309**	**0.0008**	**-0.0500**
Percentage change of the aggregate import volume					-0.1280	-0.1600

Table 10 Significant contributions to the volume change of imported Motor Vehicles (MV) in STD

Imported MV as investment goods of industries:	Industry shares in total MV imports (A)	Percentage changes in industry demand for imported MV as investment goods (B)	Industry contributions to total imports of MV (C) = [(A)/100]*(B)
Oil Refinery	0.6548	-3.8210	-0.0250
Land Transport	3.2059	-0.5348	-0.0171
Fisheries	1.1769	-1.1563	-0.0136
Current purchase by households	**HH purchase share in the total import volume of MV (A)**	**Percentage changes in HH demand for imported MV as current consumption (B)**	**HH contribution to total imports of MV (C) = [(A)/100]*(B)**
Households (HH)	49.3153	0.2526	0.1246

Table 11 Significant contributions to the volume change of imported Motor Vehicles in DURA

Imported MV as intermediate inputs of industries:	Industry shares in total imports of MV (A)	Percentage changes in industry demand for imported MV as intermediate inputs (B)	Industry contributions to total imports of MV (C) = [(A)/100]*(B)
Motor Vehicles	24.0501	-0.8205	-0.197341
Imported MV as investment goods of industries:	**Industry shares in total imports of MV (A)**	**Percentage changes in industry demand for imported MV as investment goods (B)**	**Industry contributions to total imports of MV (C) = [(A)/100]*(B)**
PTS	49.3153	-1.2645	-0.6236
Oil Refinery	0.6548	-2.6435	-0.0173
Land Transport	3.2059	-0.4619	-0.0148
Fisheries	1.1769	-1.0335	-0.0122

Table 12 Effects determining the movement of the aggregate consumption

	Versions	
(%)	STD	DURA
Share of aggregate capital in GDP (Sk/100)	30.2116	31.1764
Percentage change in aggregate capital (x1cap_i)	-0.0582	-0.1079
Contribution of aggregate capital to GDP ((A) = [Sk/100]*x1cap_i)	-0.0176	-0.0336
Share of aggregate investment in GDP (Si/100)	23.4738	26.6260
Percentage change in aggregate investment (x2tot_i)	-0.2953	-0.4117
Contribution of aggregate investment to GDP ((B) = [Si/100]*x2tot_i)	-0.0693	-0.1096
(C) = (A) - (B)	0.0518	0.0760
Share of aggregate consumption in GDP ([Sc + Sg]/100)	73.8053	70.6907
Percentage change in aggregate consumption (x3tot; x5tot)	0.0478	0.0820
Contribution of aggregate consumption to GDP ([[Sc + Sg]/100]*x3tot)	0.0353	0.0580

Table 13 Significant contributions to the change in the GDP price index

	Shares (A)		Percentage changes in (B)		Contributions (C) = [(A)/100]*(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Price indexes for	(%)	(%)	(%)	(%)	(%)	(%)
Aggregate private consumption	58.5999	55.6955	0.1948	0.2419	0.1141	0.1347
Aggregate real investment	23.4738	26.6260	0.0548	0.0511	0.0129	0.0136
Government consumption	15.2054	14.9952	-0.0947	-0.0861	-0.0144	-0.0129
Inventories	1.0661	1.0514	0.0222	0.0213	0.0002	0.0002
Aggregate exports	43.2116	42.6142	0.0760	0.0742	0.0328	0.0316
Aggregate imports (C.I.F.)	41.5568	40.9822	0.0000	0.0000	0.0000	0.0000
Total	100	100			0.1457	0.1672

Table 14 Significant contributions to the change in CPI

	Shares (A)		Percentage changes in (B)		Contributions (C) = [(A)/100] *(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Price indexes of	(%)	(%)	(%)	(%)	(%)	(%)
Gasoline	1.5203	n/a	8.6206	n/a	0.1311	n/a
PTS	n/a	5.2366	n/a	3.0861	n/a	0.1616
Land Transport	2.0886	2.1671	1.3160	1.2316	0.0275	0.0267
Gas	0.6216	0.6450	1.7557	1.7090	0.0109	0.0110
End Use Supplier	1.4624	1.5174	0.7391	0.6986	0.0108	0.0106
Air Transport	1.3864	1.4385	0.6826	0.6885	0.0095	0.0099

Table 15 Decomposition of the changes in purchasers' price of PTS in version DURA

	Cost shares (A)	Percentage changes in purchasers' price of (B)	Contributions (C) = [(A)/100]*(B)
	(%)	(%)	(%)
Gasoline	30.1234	10.1808	3.0668
Diesel Fuel	0.1686	6.2659	0.0106
Lubricants	0.7614	1.6731	0.0127
Rubber Product	3.8556	0.0280	0.0011
Hand Tools	0.0119	0.0481	0.0000
Electric Appliances	0.0737	-0.0072	0.0000
Light Equipment	0.1488	0.0014	0.0000
Video and Radio	0.4922	-0.0037	0.0000
Insurance	3.1570	-0.1313	-0.0041
Vehicle Services	13.8049	-0.0336	-0.0046
Primary Factors (Capital only)	47.4023	0.0075	0.0035

Table 16 Significant contributions to the change in the government price index

	Shares (A)		Percentage changes in (B)		Contributions (C) = [(A)/100]*(B)	
Versions	STD	DURA	STD	DURA	STD	DURA
Price indexes of	(%)	(%)	(%)	(%)	(%)	(%)
Education Training Services	0.1762	0.1762	-0.2671	-0.2431	-0.0471	-0.0428
PAS	0.7767	0.7767	-0.0555	-0.0513	-0.0431	-0.0399
Social Welfare Services	0.0178	0.0178	-0.1711	-0.1436	-0.0030	-0.0026

Table 17 Significant contributions to the change in total CO_2 emissions

	Contributions to total CO_2 emissions	
Versions	STD	DURA
Households	**-0.2339**	
PTS		**-0.0599**
Steam_Coal	2.7665	2.5867
Steam_Gas	0.1367	0.1266
CombCy_Gas	0.0590	0.0547
Diesel	-0.0612	-0.0572
CombCy_Oil	-1.1173	-1.0472
Steam_Oil	-2.2999	-2.1589
Oil Refinery	-0.1066	-0.0781

5. Conclusions and Agenda

The results reported illustrate the suitability of the dummy industry approach in modelling consumer demand for gasoline and motor vehicles in CGE models. Future research includes applying the dummy industry method to other energy-using consumer durables (e.g., electrical appliances).

For short run applications, where capital stocks are fixed, the dummy-industry approach has limitations. Currently, we specify that fuel is used in proportion to the (rigid) stock of consumer durables. We would need to modify this treatment for higher gasoline prices to induce less driving. We should allow for cars to be idle in the short run.

Currently, we assume all cars are equally efficient, regardless of age. In reality, different vintages of car consume gasoline with varying efficiency. The substitution for cars of new technology such as electric vehicles will also be considered.

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