A SIMPLE DYNAMIC INDUSTRY SPECIFIC PE MODEL WITH FLEXIBLE CAPITAL AND WAGES

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Abstract

In this paper, we derive a simple, industry specific, dynamic partial equilibrium model. We do this by introducing inter-temporally flexible capital and wages to the single period partial equilibrium model in Desai, Hallren and Kobza (2019). This type of modification is similar to the evolution of the World Bank's 1-2-3 atemporal CGE model into the 1-2-3-T dynamic CGE model. This type of model is advantageous when the policy shock of interest occurs over multiple time periods and at differing intensity over time. To demonstrate the performance of this dynamic model we analyze the effect of COVID-19 on Japan's tourism industry. In this example, we find that while demand for domestic tourism output recovers somewhat slowly, the level of employment quickly returns to the no COVID-19 counterfactual level. The adjustment that allows for this outcome is the downward flexibility in Japanese wages. We discuss the plausibility of this outcome given the particular features of Japan's labor system.

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1 Introduction

Dynamic PE models are a useful tool for exploring both the short- and long-term adjustments of an industry to a policy shock. Moreover, we can analyze the speed of adjustment to a policy change, something that is not possible with a single period, atemporal, model. Perhaps more useful is that we can use dynamic PE models to estimate the economic effects of policy changes that phase-in, and potentially phase-out, over a transition period.

In this paper, we introduce a World Bank 1-2-3-T style CES Armington supply chain PE model with inter-temporally flexible wages and supply of capital. As with all dynamic recursive CGE models, our model solves a single period form of the model within a given time period, and the dynamics are introduced through factor accumulation across periods via a linking, or transition, function. (Pratt, Black and Swann (2013)) Because these models are a series of single period models linked across time periods by transition functions, agents are myopic with respect to future events and policy shocks always arrive as a surprise. Unlike the dynamic GTAP model or the World Bank's 1-2-3-T dynamic CGE models, where each period is linked via an investment rule, we introduce rules for capital and wage adjustment across periods.

We utilize work by the World Bank, the Global Trade Analysis Project (GTAP), and Japan's National Graduate Institute for Policy Studies (GRIPS) as the basis for our industry specific dynamic PE model because these frameworks are flexible and widely accepted in the literature.[1] Because our goal is to develop a tool to analyze narrowly defined industries and product groups where information on investment spending is limited or unavailable, we have to develop linking equations related to wage and capital adjustment that rely only on industry specific data.

With respect to labor, we assume that in the short-run, within a period, wages are sticky.

[1]For a detailed description of relevant dynamic recursive CGE models see: Ianchovichina and McDougall (2018), Devarajan and Go (1998), and Hosoe (2014).

Therefore, shocks to the model do not affect the general equilibrium, intra-period price of labor. Across time-periods, we allow wages to be flexible. Using guidance from the USAGE and MONASH models, we allow for wages to rise or fall depending on whether labor demand is above or below the business as usual (BAU) baseline. (Dixon and Rimmer (2008)) In the long-run, we assume that wages adjust such that demand for labor is mean reverting to the exogenous long-run supply, which is assumed to be equal to the BAU baseline.

The question is, how much do wages respond to shocks to demand for labor and how quickly does labor demand return to the long-run supply? Put concretely, if labor demand is X% above the BAU value, how much of that translates into higher wages? For the past twenty years, the Center for Policy Analysis (CoPS) has calibrated the wage adjustment elasticity such that labor demand returns to the exogenous long-run supply amount within five periods after a shock to labor demand. (Dixon and Rimmer (2008) and Dixon, Rimmer and Tran (2019))

For capital, we also use an approach where the only parameter that needs to be estimated or calibrated relates to the speed of adjustment. For capital, we assume that the supply of capital is fixed within a period such that shocks to demand translate only into changes in the rental rate of capital. Further, we assume that capital will flow into and out of the industry until in the long-run the rental rate of capital returns to the initial equilibrium rate. In other words, the industry is sufficiently small such that no shock to the industry will have a general equilibrium effect on the global price of capital. Put technically, we assume that the capital market is mean reverting in the rental rate.

Between periods, capital flows into and out of the industry according to Newton's Law of Cooling.[2] Therefore, the parameter of interest is the rate of convergence between the demand for capital at the current rental rate and the demand for capital at the initial equilibrium

[2]Other uses of Newton's Law of Cooling to describe mean reverting processes include monetary economics.(see Todorovic, Tomic, Denic, Petkovic, Kojic, Petrovic and Petkovic (2018))

rental rate. To ensure full long-term adjustment, we have to deviate slightly from Newton's Law of Cool equation. [3]

The paper proceeds as follows. In section 2, we derive the World Bank 1-2-3-T style, vertically integrated, industry specific model, and the transition functions that describe the inter-temporal adjustments to wages and capital. In section 3, we discuss COVID-19 in Japan and its effects on tourism. In section 4, we present the results. Section 5 concludes.

2 1-2-3-T Style Armington CES Supply Chain Model

2.1 Intra-Period Framework

We start by presenting a vertically integrated, single period CES Armington model. Since our derivation closely follows Armington (1969), Francois and Hall (1997), Hosoe, Gasawa and Hashimoto (2015), Hallren and Riker (2018) and Desai et al. (2019), we do not cover each step. The model assumes that final demand consumers maximize utility from consumption, producers are profit maximizers, markets are perfectly competitive, goods are differentiated by country of origin, country varieties are imperfect substitutes, all markets clear in equilibrium, and the zero-profit condition holds in equilibrium.

Figure 1 illustrates the conceptual structure of our single country, industry specific model. In this model, consumers in the domestic market (D) maximize a CES utility function from consuming final demand products from three country groups: foreign countries subject to a policy change (S), foreign countries that are not subject to a policy change (N), and the domestic market (D). Product varieties are differentiated by country or region of origin in a nested manner. First, buyers differentiate product varieties as domestic and imports. Next, the buyers differentiate import varieties by region or country of origin. Consumers substitute

[3]This approach follows from the endogenous growth literature's treatment of capital or technology absorption.

between product varieties at a constant rate at each tier: between imports and the domestic variety (σ_{FD}) and among import varieties ($\sigma_{FD,IM}$).[4]

Given the Armington CES demand assumption, equation (1) represents the demand for the final goods variety (j).

$$q_{FD,j} = Q_{FD}(b_{FD,j}) \left(\frac{P_{FD}}{p_{FD,j}}\right)^{\sigma_{FD}} for\ j \in \{D, M\} \tag{1}$$

The parameter b_j in equation (1) represent factors that shift the demand curves. When the initial equilibrium prices are normalized to one, these parameters are calibrated to the initial market share of each variety j. The sum of the market shares in the initial equilibrium are equal to one.

Demand for each import variety (h) is described by equation (2):

$$q_{FD,h} = q_{FD,M}(b_{FD,M,h}) \left(\frac{p_{FD,M}}{p_{FD,h}}\right)^{\sigma_{FD,M}} for\ h \in \{S, N\} \tag{2}$$

Here the parameter $b_{FD,M,h}$ has the same interpretation as above, except that this parameter is equal to variety h's share of final demand imports consumed in the domestic market.

Prices in these and all equations are buyers' prices (market prices), inclusive of tariffs and taxes. Therefore, the producer price for each foreign variety (S and N) is $\frac{p_{FD,h}}{1+\tau_{FD,h}}$.

For simplicity, we assume that the supply functions for the S and N varieties of the FD goods are constant price elastic.

[4] This type of nested CES demand is a common in the CGE literature (see Ianchovichina and McDougall (2018), Devarajan and Go (1998), and Hosoe (2014).) However, setting the foreign-foreign elasticity at twice the value of the foreign-domestic elasticity (the ad-hoc "Rule of Two"), while also common, lacks strong econometric support in the literature. The most recent research on this topic indicates that the foreign-foreign elasticity is likely larger than the foreign-domestic elasticity for many products but does not support the "Rule of Two." Feenstra, Luck, Obstfeld and Russ (2018) Therefore, economists should conduct econometric analysis of the products under investigation, as well as, ex-post sensitivity analysis.

$$q_{FD,h} = a_{FD,h} \left(\frac{p_{FD,h}}{1+\tau_{FD,h}} \right)^{\epsilon_{FD,h}} for\ h \in \{S, N\} \tag{3}$$

The $\epsilon_{FD,h}$ parameter is a constant price elasticity of supply, and the $a_{FD,i}$ parameter represents factors that shift the supply curves. The equation for the supply curve assumes a specific functional form (in this case, it is log-linear), and it is tailored to the industry by fitting the supply shift parameter to industry data. The calibrated values of the supply shifters reflect a variety of factors, including the level of production capacity and input costs.

By contrast, domestic output (Z) is produced by combining value added (VA) and intermediate (INT) inputs via Cobb-Douglas production technology.[5] Country D converts output into two distinct consumer varieties via Constant Elasticity of Transformation (CET) technology, one variety for export to the rest of the world (ROW) at the constant world price and the other for domestic consumption. Therefore, the supply function for these two varieties is:

$$q_{FD,k} = Q_Z \delta_k \left(\frac{P_Z}{p_{FD,k}} \right)^{-\rho} for\ k \in \{D, ROW\} \tag{4}$$

Here Q_Z is total domestic production of the final demand product. The δ's represent the share of output (Z) dedicated to each market (D and ROW) in the initial equilibrium. They sum to 1. $p_{FD,k}$ is the price of each variety of domestic output, and P_Z is the price index of output. The parameter ρ is the constant elasticity of transformation and is the rate at which output can be converted between market varieties.

We assume that domestic output is small relative to the world market such that changes in exports to the world market do not change the world price. Consequently, the world price is exogenous.[6]

[5] We choose Cobb-Douglas technology because it is consistent with national account input-output tables in value, not quantity, form.

[6] We could relax this assumption. However, we would then need to specify a global demand function or industry specific trade balance closure.

Given the CES demand structure in the final goods market, the FD consumer price indices are

$$P_{FD} = \left(\sum (b_{FD,j}) p_{FD,j}^{1-\sigma_{FD}}\right)^{\frac{1}{1-\sigma_{FD}}} \; for \; j \in \{D, M\} \tag{5}$$

$$p_{FD,M} = \left(\sum (b_{FD,M,h}) p_{FD,M,h}^{1-\sigma_{FD,M}}\right)^{\frac{1}{1-\sigma_{FD,M}}} \; for \; h \in \{S, N\} \tag{6}$$

Total domestic industry demand, itself, adjusts to changes in the industry average price. This reflects movement in consumption between industries. Here total demand in the industry, Q_{FD}, is

$$Q_{FD} = k_A P_{FD}^{\theta} \tag{7}$$

The variable P_{FD} is a price index for the final demand product of the industry in the national market, and the parameter k_A represents the initial national aggregate industry expenditure (Y_0) at the baseline calibrated price, $P_{FD} = 1$. The parameter θ is the price elasticity of total demand in the industry.

Country D's firms produce output (Z) by combining value added and intermediate inputs via Cobb-Douglas technology. Given this assumption, the factor demand functions for the two composite inputs (VA and INT) are

$$Q_i = \frac{\beta_i P_Z}{P_i} Q_Z \; for \; i \in \{INT, VA\} \tag{8}$$

Here β_{VA} and β_{INT} are the cost share parameters for the composite value added input and composite intermediate input, respectively, in the initial equilibrium. We assume constant returns to scale such that $\beta_{VA} + \beta_{INT} = 1$.

Given these demand equations and the zero profit condition, the price of domestic output is equal to its unit cost function.

$$P_Z = \prod P_i^{\beta_i} \ for \ i \in \{INT, VA\} \tag{9}$$

Country D produces a composite value added input (VA) using fixed expenditure shares of each available value added factor. That is domestic firms combine value added factors (f), labor (L) and capital (K), into an aggregate value added input (VA) via a Cobb-Douglas production function. The resulting factor demand function for each value added input is

$$q_f = \frac{\beta_f P_{VA}}{p_f} Q_{VA} \ for \ f \in \{L, K\} \tag{10}$$

Here p_f is the factor price for value added factor (f, $w = p_L$, $r = p_K$); P_{VA} is the price of the composite value added input, which is determined by the unit cost function; and β_f is the cost share parameter for the value added factor (f). We assume constant returns to scale such that $\sum \beta_f = 1$.

In our model, we assume that the supply of labor is perfectly elastic. (i.e. Firms can hire as many workers as required at the prevailing wage (w).) By contrast, we assume that the supply of capital in the industry is perfectly inelastic. Therefore, the price of capital (r) responds to changes in demand such that the market clears.

Given the Cobb-Douglas technology, the unit cost function for the composite value added input is

$$P_{VA} = w^{\beta_L} r^{\beta_K} \tag{11}$$

Because of the perfect competition assumption, the unit cost function determines the price of the aggregate VA input in lieu of a supply curve.

Country D producers combine intermediate inputs from the different countries via CES technology into a composite intermediate input INT for production of the final demand product. As in the final demand portion of the model, buyers of intermediate goods exhibit nested CES demand. The resulting demand functions are

$$q_{INT,j} = Q_{INT}(b_{INT,j}) \left(\frac{P_{INT}}{p_{INT,j}} \right)^{\sigma_{INT}} \quad for\ j \in \{D, M\} \tag{12}$$

$$q_{INT,h} = q_{INT,M}(b_{INT,M,h}) \left(\frac{p_{INT,M}}{p_{INT,h}} \right)^{\sigma_{INT,h}} \quad for\ h \in \{S, N\} \tag{13}$$

The preference parameters, $b_{INT,j}$ and $b_{INT,M,h}$, have the same interpretation as the corresponding parameters in the final demand node of the model.

The unit cost of the composite intermediate input is the CES price index. Given the zero profit condition, equations (14) and (15) determine the prices of the composite intermediate inputs, in lieu of a supply function.

$$P_{INT} = \left[\sum (b_{INT,j}) p_{INT,j}^{1-\sigma_{INT}} \right]^{\frac{1}{1-\sigma_{INT}}} \quad for\ j \in \{D, M\} \tag{14}$$

$$p_{INT,M} = \left[\sum (b_{INT,M,h}) p_{INT,h}^{1-\sigma_{INT,M}} \right]^{\frac{1}{1-\sigma_{INT,M}}} \quad for\ h \in \{S, N\} \tag{15}$$

The consumer prices for the two varieties of intermediate products are $p_{INT,i}$. The producer price of the domestic variety is the same as the consumer price. However, for the two foreign varieties, the producer prices are $\frac{p_{INT,h}}{1+\tau_{INT,h}}$. The trade cost factor $\tau_{INT,h}$ is equal to the ad valorem equivalent rate of the import tariff and international transport costs on imports for each variety (h).

Each variety of intermediate inputs (D, S, and N) are supplied via a constant price elasticity supply function:[7]

[7] It is not difficult to extend the model to include imperfect competition, but in this case the producers have cost curves but not supply curves. The models in Khachaturian and Riker (2016) and Barbe, Chambers,

$$q_{INT,i} = a_{INT,i} \left(\frac{p_{INT,i}}{1+\tau_{INT,i}} \right)^{\epsilon_{INT,i}} \quad for\ i \in \{D, S, N\} \tag{16}$$

The parameter $\epsilon_{INT,i}$ is the constant price elasticities of supply for each variety i, and $\alpha_{INT,i}$ represents factors that shift each supply curve. The equations for the supply curves assume a specific form (in this case, they are log-linear), and they are tailored to the industry by fitting the supply shift parameters to industry data. The calibrated values of the supply shifters reflect a variety of factors, including the level of production capacity and input costs.

We calibrate the model to the initial equilibrium conditions by setting all prices to 1 and adjusting the shift parameters in the demand equations to the initial FD and INT country variety market shares, setting the productivity terms equal to the cost shares in the VA factor demand equations, and equating shift parameters in the supply equations to the relevant initial quantities supplied.

2.2 Inter-Period Dynamics of Capital and Wages

In the labor market, we assume that in the short-run (i.e. each period of the model) the wages are sticky. Consequently, the level of employment adjusts in response to demand shocks. In between periods, wages are flexible. In particular, wages adjust in response to deviations of total labor demand in the economy from the BAU level. To accomplish this, we utilize the wage adjustment process from the ORANI and MONASH models. (Dixon and Rimmer (2008)) The ORANI and MONASH models employ long-term wage flexibility via the following inter-temporal equation:

$$\left(\frac{w_t}{w_t^*} - 1 \right) = \sigma_w \left(\frac{Q_{L,t-1}}{Q_{L,t-1}^*} - 1 \right) + \left(\frac{w_{t-1}}{w_{t-1}^*} - 1 \right) \tag{17}$$

The term $Q_{L,t}^*$ is the economy-wide level of employment in the BAU scenario in period t,

Khachaturian and Riker (2017) include monopolistic competition, for example.

and w_t^* refers to the price of labor (wages) in period t in the BAU scenario. In many cases, the BAU scenario is such that the industry is static in all factor prices over the period of analysis. Therefore, given that we calibrate the model to the initial equilibrium by setting prices equal to 1, then the wage adjustment equation can be simplified as.

$$w_t = \sigma_w \left(\frac{Q_{L,t-1}}{Q^*_{L,t-1}} - 1 \right) + w_{t-1} \tag{18}$$

The term σ_w is the elasticity of wages. This term controls how much of a deviation of total economy-wide employment above or below the BAU forecast is translated into a change in wages from the BAU wage rate.[8] However, in the ORANI and MONASH models the elasticity's value is set such that employment returns to the BAU scenario level after five years (i.e. five periods). (Dixon and Rimmer (2008)) Implicitly, this formulation assumes that the BAU scenario level of employment represents an exogenous long-run labor supply and that the total economy-wide level of employment is mean reverting to the long-run supply. For this reason, the natural bounds of the elasticity of wages parameter are [0,1].[9]

This model is designed for analysis of narrowly defined industries or product groups that utilize a relatively small share of total labor supply. Therefore, $Q_{L,t}$ evolves according to the following equation where s_L represents the share of total labor used in the industry of analysis in period 0 in the BAU scenario.

$$Q_{L,t} = q_{L,t} + (1 - s_L) * Q^*_{L,0} \tag{19}$$

As for capital, within a period we hold it's endowment fixed such that the rental rate of

[8]In this equation, the model treats positive and negative shocks to employment symmetrically, with respect to inter-temporal wage adjustment. This might not always be an appropriate assumption for every industry and country. Symmetry allows for simpler model specifications. However, evidence suggests economic agents to do not respond symmetrically to positive and negative price shocks. (For example see:Enders and Granger (1998), Hung (2009), Ball and Mankiw (1994), and Edwards and Levy-Yeyati (2005))

[9]If the parameter is much larger than 1, then demand for labor will not mean revert to the long-run labor supply quantity but rather wildly oscillate around this long-run equilibrium value.

capital adjust in response to demand shocks. Inter-temporally, capital will flow into and out of the market according to Newton's law of Cooling:

$$q_{K,t} = q_{K,t-1}(\bar{r}) + \left(q_{K,t-1} - q_{K,t-1}(\bar{r})\right) e^{-\sigma_K} \tag{20}$$

In equation (20), the supply of capital at the beginning of period t is equal to the quantity demanded of capital at the original price of capital at the end of the last period plus the difference between the endowment of capital at the end of last period and the quantity demanded at the original rental rate of capital. The difference portion of the equation is multiplied by an exponential decay term, where σ_K is a positive, capital adjustment elasticity parameter to be calibrated. σ_K controls the speed of adjustment and should be calibrated based on industry specific information. The underlying assumptions are that the long-run price of capital is exogenous, capital flows in and out of the industry until the price of capital returns to the initial equilibrium (i.e. long-run equilibrium) rental rate, and the adjustment process follows exponential decay.

3 COVID-19 and Tourism

Japan's first case of the novel coronavirus 2019 (COVID-19) occurred on January 9, 2020. (Mainichi Shimbun (2020)) As of July 20, 2020, Japan had 25,096 cumulative confirmed cases of COVID-19, with 4,348 hospitalization and and 985 deaths. (MHLW (2020)) While the number of cases per 100,000 has been relatively modest in Japan, relative to other OECD countries, the shock to Japan's economy in 2020 is projected to be minus 6%. (IMF (2020)) Moreover, Japan's Center for Economic Research forecasts that Japan's economic will not return to pre-COVID-19 levels (2018) until 2024. (Nikkei Shimbun (2020)). Several factors drive this forecast, Japan's declining population, the on-going US-China trade war, and the precipitous fall in foreign consumer demand. (IMF (2020), Nikkei Shimbun (2020), NHK

(2020))

No where are the effects of Japan's declining population and the rise of foreign demand more apparent than Japan's tourism sector. Over the period 2011 - 2019, the number of visitors to Japan grew at an average annual rate of 22.7%. (JTB (2020)) Over the same period, the foreign demand share in the sector increased from 3.7% to 17.3%. (MLIT Tourism) However, on April 3, 2020, Japan imposed an emergency global ban on foreign tourist, with few exceptions, to prevent the spread of COVID-19 from overseas arrivals. (Japan Times (2020)) Consequently, the number of foreign tourists arrivals dropped from 2.6 million in January to 1,700 in May, a 99.9% decrease from the same month last year.(JTB (2020)) This translated into a 41.6% decline in consumption expenditures by foreign tourists to Japan in Q1, compared to the same time last year. (Japan Tourism Agency (2020a))

A few days later on April 7th, the Japanese government declared a state of emergency due to the rapid rise in COVID-19 infections in February and March. (Mainichi Shimbun (2020)) During the state of emergency, which was lifted on May 25th, the Japanese government asked its citizens to refrain from unnecessary travel. While the request to refrain from unnecessary travel was not mandatory, ridership on trains in Tokyo and Osaka were below 40% of pre-COVID-19 levels (early January to early February), indicating general adherence to the request.(MLIT (2020)) Additionally, Q1 expenditures by domestic Japanese tourists were down 21% from the same time the previous year. (Japan Tourism Agency (2020a))

We use this event as an illustrative test case for our dynamic PE model. To do this, we use Japan's tourism satellite accounts to populate an industry specific social accounting matrix for our dynamic model. The Japanese tourism agency publishes an annual input-output data for the broad tourism sector by activity (e.g. transportation, food and beverage, goods consumption, accommodations, etc.) by consuming agent (e.g. domestic tourist, foreign tourist, government, etc.) (Japan Tourism Agency (2020b)) In our example, we aggregate all activities into a composite tourist sector.

Using the 2017 Japan Tourism Satellite Account from Japan Tourism Agency (2020b), we construct a composite Japanese tourism industry. We set the valued added and intermediate input cost shares and foreign-domestic market shares equal to those reported for the aggregate agriculture sector. We set our industry price elasticity of demand equal to -1, consistent with Cobb-Douglas preferences across industries. We set our domestic-import (macro) Armington elasticity to 1.9 in the final demand node and 2 in the intermediate input node. These are the average values reported in the GTAP-9 database for final demand recreational goods and services and intermediate inputs, respectively. (Hertel, McDougall, Narayanan G. and Aguiar (2008)) The elasticity of transformation of domestic output between the domestic and export variety we set to 2, the default value from Hosoe (2014). Table 1 reports these and the remaining model parameters.[10]

The 2017 Japan Tourism Satellite Account table is the most recent year available. Therefore, for the input cost shares, 2017 serves as our benchmark year. However, using expenditure survey data (Japan Tourism Agency (2020a)), we are able to update our domestic spending by Japanese tourists at home and abroad and in-bound domestic (i.e. in Japan) spending by foreign tourist data to 2019. To update the data on spending on imported tourist goods and services (i.e. spending by outbound Japanese tourists), we multiplied the number outbound Japanese tourists by the average spending per-person in 2017, the most recent year of data available.

In our model, wages adjust such that in the long-run demand for labor returns to the long-run supply, which we assume to be equal to the BAU forecast. One important part of this adjustment equation is the share of labor employed in the industry under investigation. Using the most recent Japanese Input-Output table (2015), we determine that about 2% of Japanese labor is employed in the broad tourism sector. (eSTAT (2015))

[10] Although we specify nested Armington demand functions in our model, the SAM in Hosoe (2014) does not breakout imports by source country. Therefore, we only treat all imports as subject imports.

For this test case, we utilizes a flat baseline forecast for our no COVID-19 counterfactual scenario. We assume that the tourism expenditures over the next decade are the same in every year as total expenditures in 2019. After we establish the baseline forecast, we apply shocks to both foreign and domestic demand for tourism goods and services. On the foreign (i.e. export) demand side, we shock the model with a 86% reduction, relative to 2019, in foreign tourist demand in year 1. We assume that foreign demand returns to 20% , 50%, and 75% of initial 2019 demand in years 2, 3, and 4 of the simulation. In years 5 and afterward, we assume demand returns to the baseline level. On the domestic demand side, we introduce a 50% reduction in year 1, relative to 2019, in final demand tourism goods and services.

Because COVID-19 is introduced in the model as an exogenous shock to domestic and foreign demand for Japanese tourist services and asymmetrically impacts the two, one of the main parameter of interests is the export variety - domestic variety CET elasticity. This parameter governs how quickly the economy shifts tourism goods and services from inbound foreign tourists to domestic Japanese tourists. Therefore, we run our experiment over five values of this parameter: 2, 4, 6, 8, and 10.

We simulate our experiment over a number of iterations of the model to test how sensitive the results are to different speeds of adjustment in the capital and labor markets. For each value added input, we adjust the relevant adjustment elasticity until we identify that value that generates full adjustment within 5 periods after the shock. We report the dynamic results only for the scenario with this parameterization. Typically, this is easy to do when the policy shock occurs at one period in time. In our application, the demand shock occurs in period 1 and phases out of the following three periods. Therefore, to identify the adjustment elasticities that allow for adjustment within 5 periods, we conduct a series of one period policy shock experiments.

4 Results

4.1 Speed of Adjustment

To identify the appropriate speed of adjustment elasticities for wages and capital supply, we shock the model with a 30% tariff on subject final demand imports of tourism goods and services. Conceptually this is a bit unrealistic because this would be something akin to an exit tax on Japanese outbound tourists. However, this one time policy change is merely applied for calibration purposes.

Figure 2 shows the response of the price of capital to the tariff shock under four sets of wage and capital adjustment elasticities. As we increase the capital adjustment elasticity, the price of capital more quickly returns to the BAU value (i.e. the initial equilibrium value). When the elasticity is zero the supply is fixed across all periods, and the price of capital only adjusts in response to changes in demand for capital. At a value of 0.1, the market price does not return to the initial rental rate within 10 periods of the policy shock. When the elasticity is 0.5 the price returns to within half a percent of the initial rental rate five periods after the shock. At a value of 10, the price of capital returns to the BAU value within one period. Applying the rule of thumb from CoPS (Dixon and Rimmer (2008)), we use 0.5 as our capital adjustment elasticity.[11]

As with capital, we use the the rule of thumb from CoPS (Dixon and Rimmer (2008)) and select the wage adjustment elasticity that returns the level of employment to the BAU value within five periods after a shock. Normally, this calibration method would be done by applying the shock to the full-economy model and adjusting the wage elasticity until this condition is satisfied. However, we have only developed an industry specific model without consideration to its relationship to a corresponding CGE model. Therefore, for illustrative

[11] Dixon and Rimmer (2008) note that when setting the speed of adjustment it is important to match the slope of the inter-temporal capital supply curve to relevant econometrically estimated values.

purposes we show how demand for labor in a CGE model, with identical cost and market shares to our PE model, responds to the tariff shock across the four sets of wage and capital elasticities. (Figure 3) Across all cases, employment initially increases sharply in response to the import shock. In all four cases, employments falls back to the BAU value as the price of labor rises. As expected, as we increase the wage adjustment elasticity, the rate at which employment returns to the BAU level accelerates. With a value of 15, employment reaches nearly zero five periods after the shock. We use this value for our wage adjustment elasticity.

4.2 Dynamic Model Results

Before we run the experiment, we first construct a business as usual (BAU) baseline forecast of how the industry would have involved without the shock. For simplicity, we construct a naive forecast where the industry would have remained static at the initial equilibrium in the absence of the shock.[12] The results of the model are all interpreted as percent deviations from the BAU forecast.

We conducted our experiment using the capital and wage adjustment elasticities calibrated above. Additionally, we test how sensitive the results are to Japanese producers' abilities to shift tourism goods and services between in-bound foreign tourists and domestic Japanese tourists. We do this by repeating the experiment over a range of export-domestic CET elasticities. Overall, we find that the results are not very sensitive to the value of this elasticity over the standard range, the default value of 2 up to a value of 10. To highlight this point, we show the two extreme cases in the exposition of our results.

In figure 4, we present the evolution of domestic (Japanese) real output of tourism goods and services. Additionally, in the lower panel of the same figure, we illustrate how the

[12] Another common naive BAU forecast is to assume that the industry supply, demand, and supply all inputs grow at a common, for example the rate of population growth. This ensures that although the industry is expanding, all prices and market shares are static at the initial equilibrium level. In a backward casting exercise, the BAU cause would be observed industry data.

composite price of these goods and services moves over the 10 periods following the demand shocks. Both results are in percent change deviation from the BAU baseline forecast. Domestic (Japanese) output, which is sold to either Japanese tourists or in-bound foreign tourists, drops by 40% in year 1 but quickly recovers in year 2 to just 10% below the BAU level. By year 4, output is almost fully recover and thereafter output is slightly above the BAU level. In part, this is because the overall price of tourism output remains below the the BAU level even after demand recovers. In both cases, the output and prices return to the BAU path more quickly when the export-domestic CET elasticity is higher. This makes sense given that a higher value means that producers are able to more quickly shift output between in-bound foreign tourists and domestic tourists. Therefore, domestic producers are better able to take advantage of the asymmetry in the speed of recover of domestic versus export demand. However, the difference in the results is quite small.

Figure 5 summarizes the evolution of the dominant wage rate and industry employment, in percent deviation from the BAU level, over the course of the experiment. In the year 1, industry employment falls by 60% relative to the BAU counterfactual. However, employment fully recovers to the counterfactual level by the next year and then rises above the BAU level in years 2 and 3. Employment remains above the counterfactual level throughout the experiment. What drives this rapid recovery in employment is the downward flexibility in wages. In year 2, wages fall between 17 and 18%, before beginning a slow return to the BAU level. While the trajectory of wages after year 3 is the same across all values of the export-domestic CET elasticity, the level of wages relative to the BAU level and the speed of recovery are sensitive to the elasticity value. Initially, the difference is as much as two percentage points in years 3 through 5. However, the difference diminishes afterwards.

Since 2006, Japanese overall total cash compensation has never experience a year-on-year change of negative 18%. (JILPT (2020)) The largest year-on-year decline was slightly under 8% in 2009. (JILPT (2020)) However, some components of compensation such as regular bonuses and over-time payments have fallen by more than 18%. (JILPT (2020), JILPT (2019)) Additionally, some industries have experienced negative shocks to total compensation of nearly 18%, year-on-year. (JILPT (2020)) Certain features of Japan's compensation system, such as semi-annual bonuses worth typically three to four months of salary, are well known to give Japanese wages considerable negative and positive flexibility. (Freeman and Weitzman (1987) and Japan Visa (2018)) Therefore, while overall economy wide wages have never fallen in one year as much as our model predicts, the Japanese labor system does seem to exhibit enough downward flexibility in wages that such a one year change is not impossible.

Figure 6 shows the response of the domestic tourism capital market to the demand shocks. Initially, the price of capital in the tourism market sharply declines by nearly 60% in response to the negative demand shock. However, by the next period the price of capital rises above the no COVID-19 BAU baseline level. The price of capital remains above the baseline forecast throughout the remainder of the simulation. This occurs because the supply of capital in the tourism industry adjusts somewhat slowly. Inter-temporally, the supply of capital in the industry adjusts so that the price returns to the economy-wide equilibrium price. However, supply is fixed within each period and adjusts with a lag to changes in demand. Therefore, the supply of capital stays below the counterfactual level and only returns to the BAU baseline around period 10. These results are insensitive to the export-domestic CET elasticity.

In terms of real quantity consumption of tourism goods and services by Japanese consumers, demand initially falls by 40% below the BAU baseline in period 1. (Figure 7) However, real demand fully recovers by the next period. While not shown, the underlying dynamics are as follows. Real demand for tourism imports (i.e. outbound Japanese tourism) initially declines and stays slightly below the no COVID-19 counterfactual level by about 2% for each of the first three periods following the demand shock and about 0.5% thereafter.

By contrast, real demand for domestic Japanese tourism by Japanese tourists is about 3% above the BAU baseline for periods 2 through 4 and about 0.5% each period thereafter. This shift away from outbound tourism to domestic tourism is the result of a decline in domestic tourism goods and services relative to imported tourism due to the sharp and prolonged decline demand by in-bound foreign tourists.

5 Conclusions and Areas for Future Research

In this paper, we derive a simple, industry specific, dynamic partial equilibrium model. We do this by introducing inter-temporal capital supply and wage adjustment to a single period partial equilibrium model. This type of modification is similar to the evolution of the World Bank's 1-2-3 model into the 1-2-3-T model. This type of model is helpful for analyzing shocks that phase-in, or phase-out, over time. Moreover, dynamic models give us a better sense of the response over time by an industry to a shock, of any duration. As illustrated in this example case, demand for Japanese output of goods and services recovers somewhat quickly after the initial demand shock, through stays slightly below the BAU forecast. The speed of recover is driven by the magnitude of the shock to in-bound foreign tourism demand (i.e. exports) and the downward flexibility of Japanese wages. Given the historical variance in Japanese wages, it is likely that the downward flexibility predicted by the model is the upper bound of what is possible in the Japanese labor market.

While a dynamic model is convenient in this type of application, nothing comes for free; the information burden of the dynamic model is considerably greater than for the single period model. In particular, we have to gather specific information about how wages and capital supply respond inter-temporally to demand shocks. Fortunately, there is deep literature on the topics of BAU baseline construction, model calibration, parameterization, and sensitivity analysis. (See Dixon and Rimmer (2008), Ianchovichina and Walmsley (2012))

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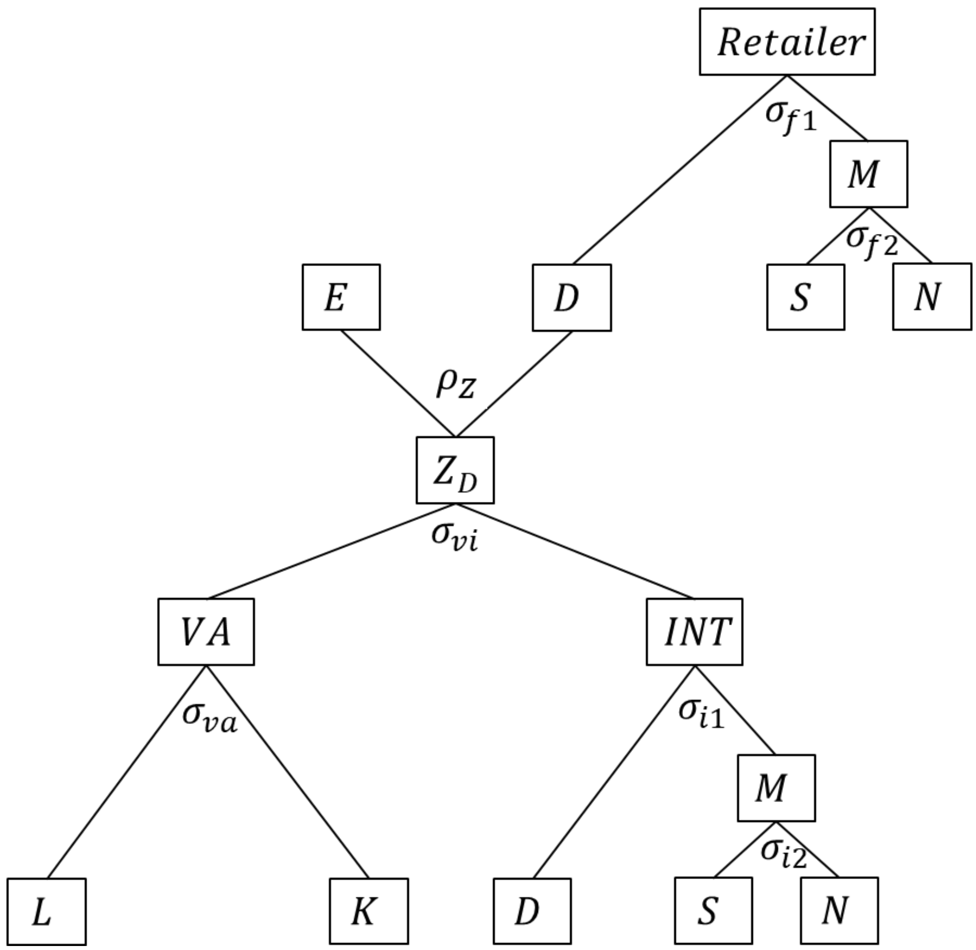

Figure 1: Model Conceptual Diagram

Table 1. Model Data and Parameters

Expenditures (Billion Yen)	
Domestic Consumption	¥23,086.50
Outbound Consumption (Imports)	¥ 4,813.50
Inbound Consumption (Exports)	¥ 3,510.11
Market Shares	**Case 1**
Final Demand	
Domestic	86.80%
Imports	13.20%
Intermediate Inputs	
Domestic	95.10%
Imports	4.90%
Cost Shares	
Intermediate Inputs Share of Output	49.44%
Value Added Share of Output	50.56%
Labor Share of VA	58.60%
Capital Share of VA	41.40%
Parameters	
Industry Price Elasticity	-1
Final Demand Armington	1.90
Intermediate Armington	2.00
Supply Elasticities	
Foreign Final Demand	100
Intermediate Domestic	4
Intermediate Final Demand	100

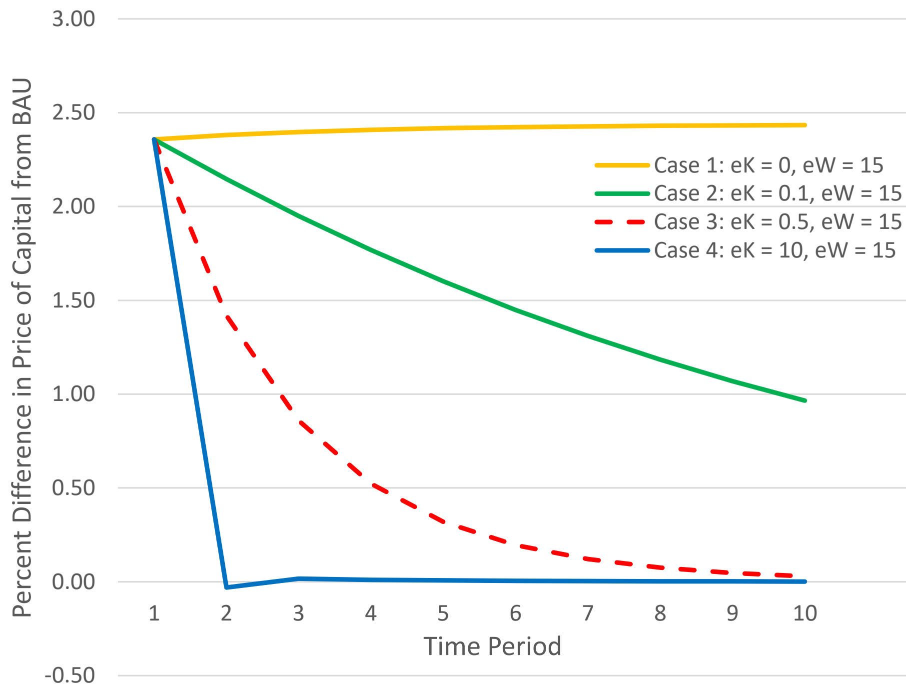

Figure 2: Evolution of Price of Capital

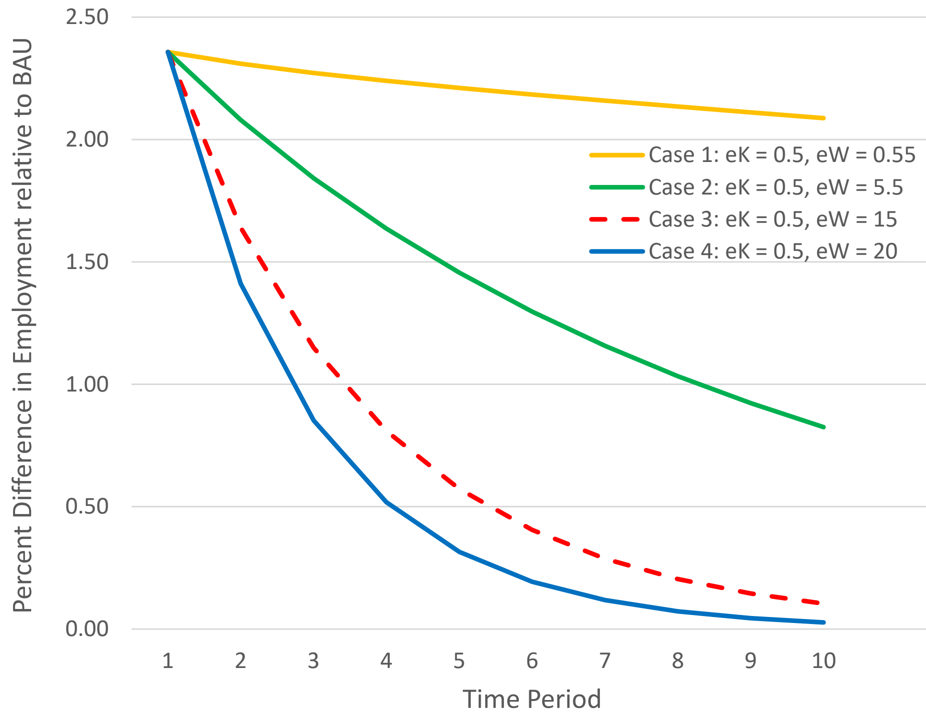

Figure 3: Evolution of Employment

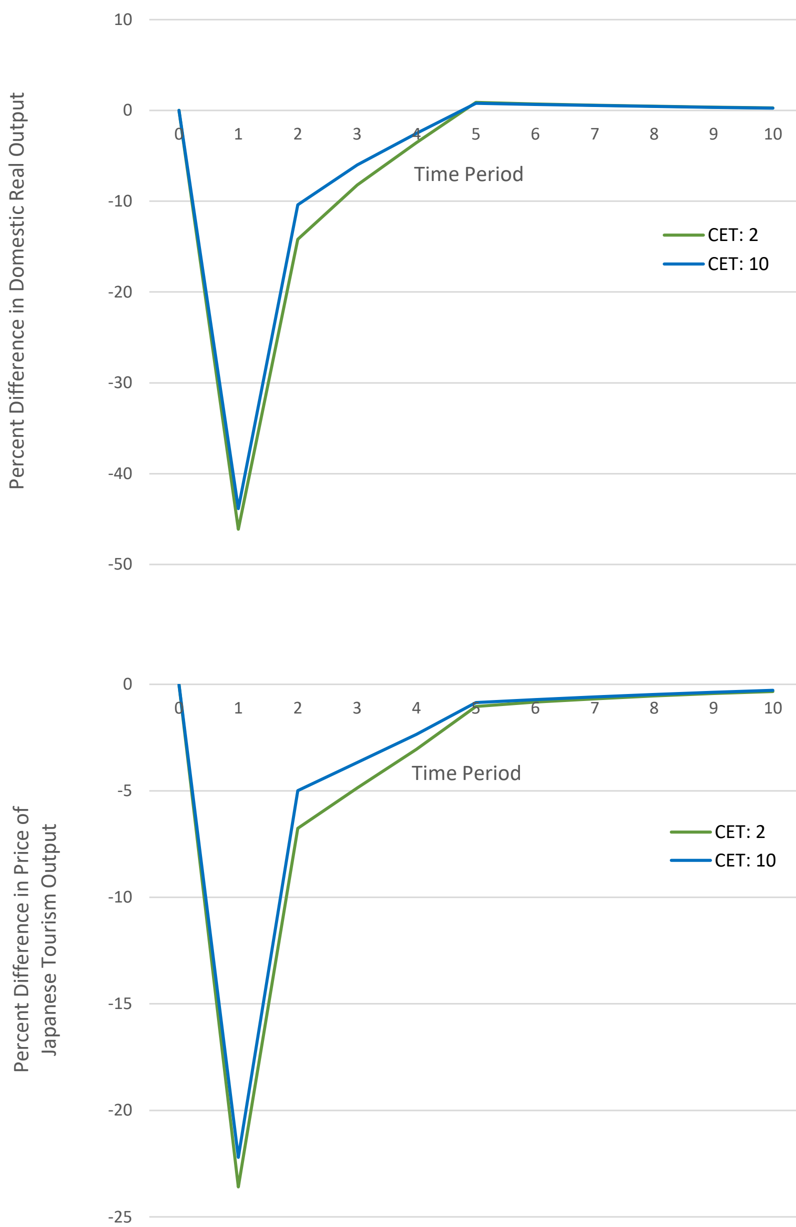

Figure 4: Evolution of Domestic Output in Quantity and Price Relative to the BAU Forecast

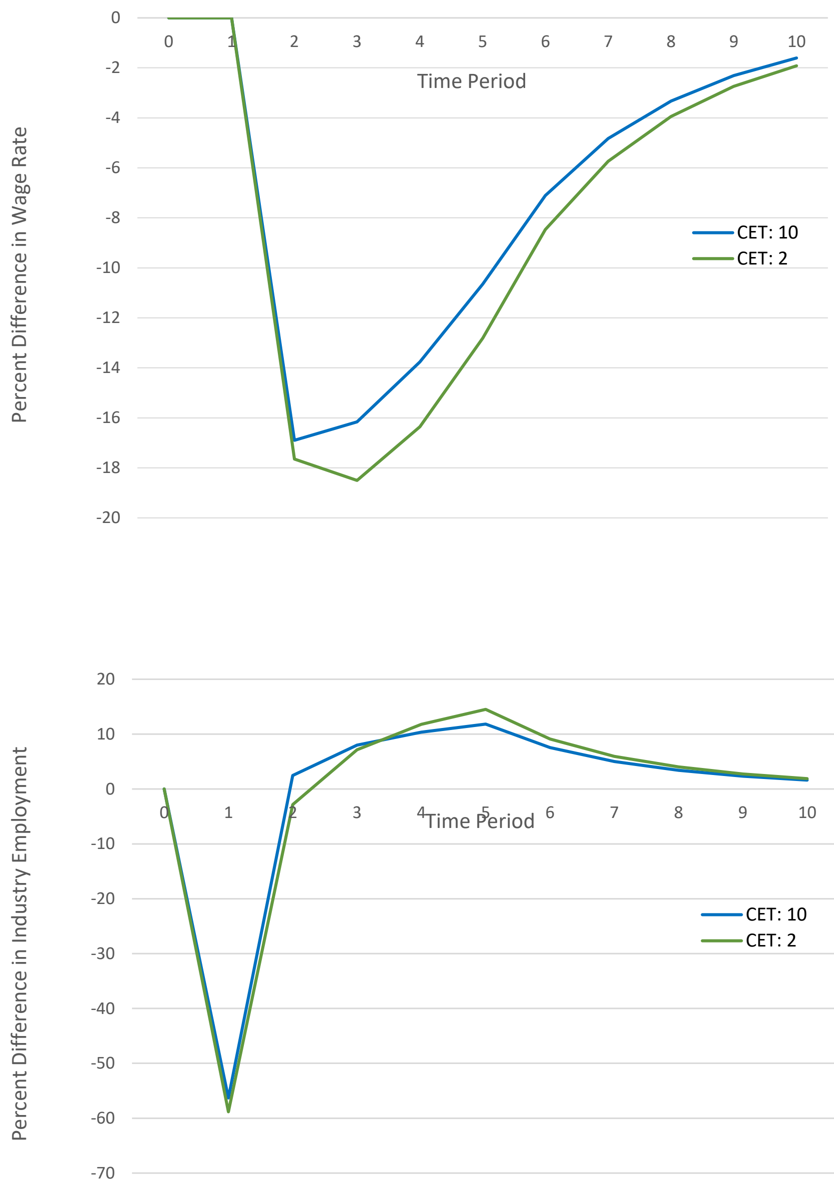

Figure 5: Evolution of Wages and Employment Relative to the BAU Forecast

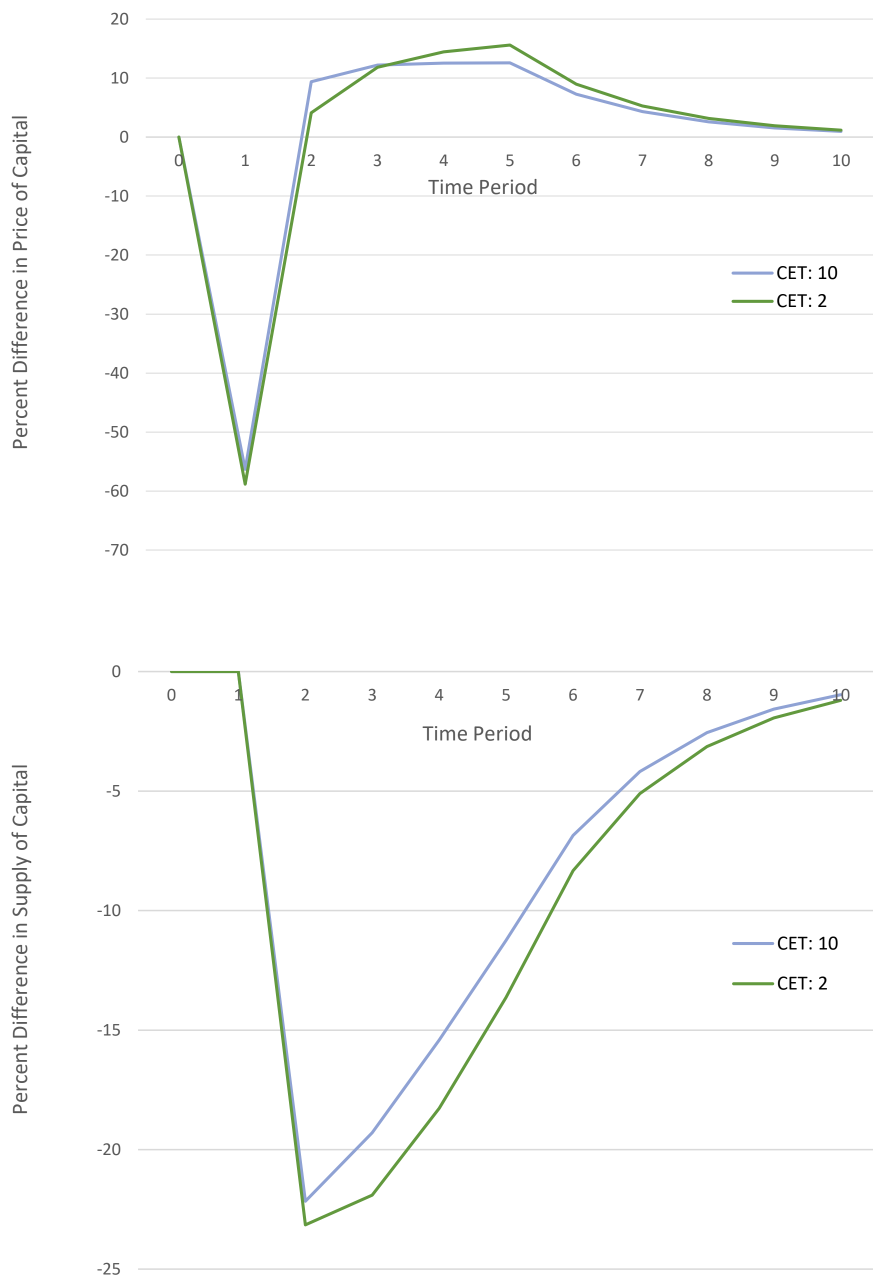

Figure 6: Evolution of Price and Supply of Capital Relative to the BAU Forecast

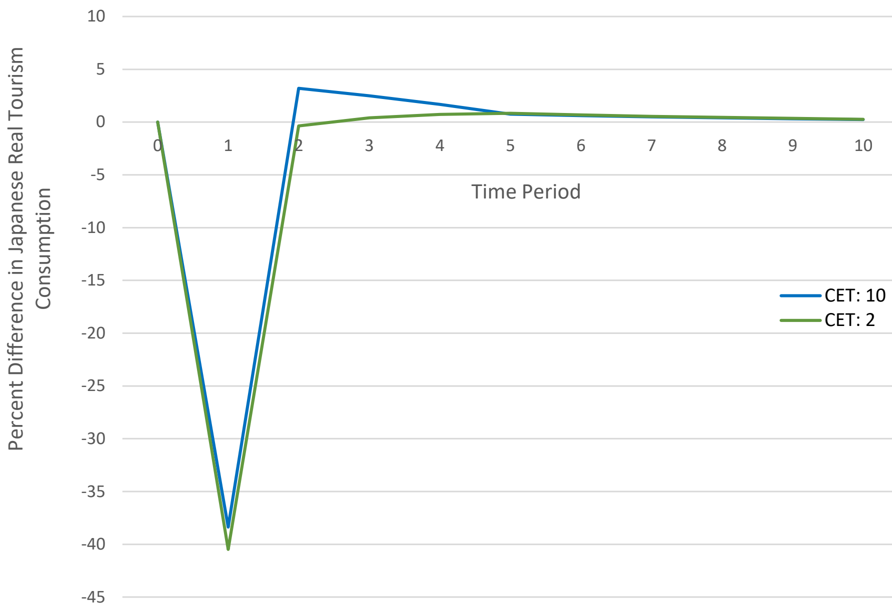

Figure 7: Evolution of Japanese Real Demand for Tourism Goods and Services Relative to the BAU Forecast