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An *Ex post* Evaluation of Economic Impacts of SARS on Taiwan Using a Dynamic Computable General Equilibrium Model

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Abstract

The outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003 has resulted in significant losses to the tourism and tourism-related industries in China, Hong Kong, Singapore, and Taiwan. Through the inter-industry feedback effects, the economic impacts of SARS not only affect the tourism-related services industries, but also other industries and the whole economy. There have been a number of *ex ante* studies that have quantified the potential impacts of SARS on Taiwan's economy (e.g., Chou et al. 2003, Wu et al. 2003). This article provides an *ex post* economy-wide assessment of the SARS impacts on Taiwan. The model used is Taiwan General Equilibrium Model (TAIGEM), a dynamic, computable general equilibrium (CGE) model of the Taiwan's economy, which is derived from the Australian ORANI model and the MONASH model (Dixon, Parmenter, Sutton and Vincent, 1982; Dixon and Rimmer, 2002). The input-output database was compiled from the 160-sector Use Table of the 1999 Taiwan's Input-Output Tables.

To provide an *ex post* evaluation, we use historical closure and *ex post* closure (a closure similar to decomposition closure) originally from MONASH innovations. Comparisons with other *ex ante* SARS impact assessments are also provided. Results indicate that only a few industries like medicines, medical health services and precision instruments would

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benefit from SARS, while almost all other industries in Taiwan suffered with output losses as well as employment and welfare reductions. Loss to gross domestic product (GDP) of Taiwan is estimated to be between 0.84 and 1.61 percent which is much bigger than those predicted by the previous *ex ante* studies.

Keywords: SARS, *Ex Post* Analysis, Computable General Equilibrium

1. Introduction

The ex ante analysis emphasizes on predicting the future economic status or the economic impact of specific events and polices, while the ex post analysis emphasizes on evaluating the specific events and policies which had already happened. Before proceeding the ex ante analysis of predicting the economic impact of specific events, accurately forecasting which were involving the setting of lots relative prediction values of exogenous variables were needed. Due to the time lag of the data, the setting of those exogenous variables was usually hard to access, unless some estimations or assumptions had made. And those assumptions do affect the accuracy of the analysis results.

However, when proceeding the ex post analysis of evaluating the economic impact of specific events, most of the exogenous variables was known through accessing some published data. There is no need to estimate or assume. But, there is still a challenge of proceeding the ex post analysis, the impact of one specific event were usually mixed with others. It's crucially important to decompose the impact of one single event from the historical simulation. Based on the ex ante idea which were originally from Dixon an Rimmer (2002), this article used the Severe Acute Respiratory Syndrome (SARS) event which burst out in March, 2003 as a example, tried to evaluate the impact of SARS event from a ex post point of view and compared with other ex ante SARS impact assessments.

Wu, C.S. et al. (2003) used the Macro econometric model and Input-output analysis as the method of evaluating the impact of SARS event, also used several investigation as the data source. (e.g., "Investigation of SARS impact on business services" from EOA and "The economic impact of SARS event on Taiwan" from Chamber of Commerce and some other investigation data from National Federation of Industries, Tourism bureau, Ministry of Finance etc.) Wu, C.S. et al. assumed the impact of SARS event were from March to August, severest on May ,weaken as time goes by. The setting of SARS impact from demand side mainly focus on private consumption, private investment, exports and imports etc. While the setting of industrial impact focus on industrial total output, value-add and number of employees.

From estimation of demand side, the research results showed that the growth rate of real gross domestic product shrank 1.172%, private consumption suffered the most, dropped 1.094%, private investment reduced 0.065%, exports and imports were barely affected, only down by 0.013%. Among the private consumption, the Recreation, Entertainment, Education and Cultural Services were the most damaged which dropped 0.392%, then followed by Transport and Communication, Food, down by 0.215% and 0.200% respectively. From industrial aspect, the results showed the growth rate of real GDP reduced 0.872%, also represented for the loss of 84.5 billion $NT value-add. The number of employees dropped 0.675% which were equal to 68 thousand people. Among all industries, Air transportation suffered the most which lost 15.5 billion $NT value-add, followed by Tourism services and Hotel services which were lost 13.1 and 11.1 billion $NT value-add respectively.

Wu, R.I. et al. (2003) also used Input-out model analysis method and evaluated the impact of SARS. By given some assumed impact setting, the influences of domestic consumption, production, exports etc. were estimated through the computation of industrial interaction effect. Also, the impact of SARS on real GDP and the number of employees could be estimated through the calculation of the value-add ratio and the coefficients of of labor input. The results showed under the first scenario which the outbreak of SARS could be controlled well in the mid of May, the growth rate of real GDP dropped 0.2%, the number of employees reduced 0.38% which compared with last year. While the second scenario which the outbreak of SARS could not be controlled well until the end of June, the growth rate of real GDP shrank 0.57%, the number of employees dropped 0.38%. In the third scenario which the influences of SARS last 6 month until the end of September, the growth rate of real GDP dropped severely 1.56%, the number of employees reduced 3.03% compared with last year. Among all the industries, air transportation, travel services and hotel services which were relative to domestic consumption suffered the most. The manufacturing industries suffered less due to the less industrial interaction effect.

Besides references mentioned above, Chou et al. (2003) used the Macro econometric quarterly model and the input-output model as the method of evaluating the impact of SARS. First, Chou et al. evaluated the economic status which excluded the aid of government budget on SARS events by using the Macro econometric quarterly Model which data source were based on the prediction of Taiwan macro economic published by Directorate-General of Budget, Accounting and Statistics (DGBAS) in August, 2003. Then, by comparing with the prediction of Taiwan macro economic published by Directorate-General of Budget, Accounting and Statistics (DGBAS) in February, 2003 while the SARS hadn't happened, the net impact of SARS could be estimated. The results appeared, without the aid of government budget on SARS, the growth rate of real GDP in second quarter of the year 2003 dropped 0.45%, while growth rate in 2003 were 2.97%. Among the composition of real GDP, the private consumption dropped 1.84% in the second quarter of the year 2003, then rebound with the growth 2.2% in the half year, while the growth rate in 2003 were 0.88%. The domestic investment dropped 15.76% severely in the second quarter of the year 2003, while growth rate of the whole year were 1.61%. The exports and imports of second quarter in 2003 were 3.16% and -1.38% respectively, while growth rate of the whole were 7.11% and 5.08%.

The net impact of SARS events were severest in the second quarter of 2003, it caused the real GDP of second quarter dropped 3.51%, while the growth rate of whole year reduced 0.71%. Also, the private consumption and investment dropped 4.19% and 16.9% in second quarter respectively. And the growth rate of 2003 were 1.7% and 4.91%. Besides, the exports and imports dropped 2.12% and 4.87% in the second quarter of 2003 respectively were also affected. In the whole year of 2003, exports slightly increased 0.43%, while imports decreased 2.42%. Using the monetary value in 1997 as base, the net impact of SARS events caused 90.1 billion $NT loss in real GDP in the second quarter of 2003 and 64.5 billion $NT loss in real

GDP in the year 2003. The loss of imports, private investment and private consumption which were 68.6 billion $NT, 59.3 billion $NT and 46.2 billion $NT respectively were also crucial in the second quarter of 2003. In the whole year of 2003, the significant loss of imports and private consumption were 122.4 billion $NT, 95.9 billion $NT respectively, while the exports increased 39.1 billion $NT.

The summary of results which mentioned above revealed in Table 1. While without considering the inconsistence of scenario setting, (e.g., the lasting time of the influence of SARS.) the impact of SARS were severest in the research of Wu, C.S. et al. (2003) which cause the real GDP dropped 1.172%, modest in the research of Wu, R.I. et al. (2003) which cause the real GDP reduced 0.57%. However, the net impact of SARS which presented by Chou et al.(2003) by excluding the aid of government budget on SARS events caused the real GDP shrank 0.71%. In short, the impact of SARS on real GDP were probably between -0.5% to -1% which were quite match with the gap of real GDP -0.62% in the economic prediction published by DGBAS in February and August, 2003.

As for the research method, Wu, C.S. et al.(2003) and Wu, R.I.et al.(2003) both used the Macro Econometric Model for evaluating the Macro economics impact of SARS and the Input-output Model for evaluating the impact of the total output of individual industries and the number of employee from a ex ante viewpoint. Comparing with the previous reference, this article use the Computable General Equilibrium (CGE) Model which integrated the Micro and Macro Economic impact effects in one Model and considered the endogeny of price and the restriction of limited resources. Though, Chou et al.(2003) claimed the research were a ex post analysis, according to the idea of Dixon an Rimmer (2002), the complete ex post analysis needed a precise historical simulation as a base, then through the process of calibration which based on historical simulation, the results of calibration (e.g. calibrated technology and taste variable) will take into the setting of ex post analysis.

This article used two mechanism: Historical simulation and decomposition-like simulation of Taiwan General Equilibrium Model-Dynamic (TAIGEM-D^{i}) Model to evaluate the Macro and Micro economics impact of SARS events which burst out in Taiwan, March 2003 and compared with previous references from a ex post viewpoint. The Database were the Input-output table of Taiwan in 1999, the number of sectors were 170.

The first section of this article is the introduction, Second section is the framework for ex post analysis. Third section is the simulation specification which specified the detail setting of SARS impact and historical and ex post simulation. Fourth section is the simulation results and analysis which described the results of historical and ex post simulation and compared with other references. The Final section is the conclusion.

2. Framework for *Ex post* Analysis

According to framework and application of MONASH Model which developed by

Monash University in Australia, the setting of simulation included four kind of closures rules: Historical and decomposition closures which were ex post analysis, Forecasting and policy closure which were Ex ante analysis. In the next section, we will introduce those four closures and the ex post closure which are the most important closure in this article.

2.1 Historical and decomposition closures

The historical and decomposition simulation both simulated the events which had happened, but the function of these two simulations is quite different. The historical simulation replicates the historical economic path by using the past data. And through the process of replication, the technology and taste variables which are endogenous in the model can be solved. And the technology and taste variables can be the benchmark of setting the technology and taste variables in the forecasting, also they are the important information in proceeding decomposition simulation. Besides, updating the input-output table is another main objective of historical simulation. Generally, the process of accomplishing an input-output table are quite long and it requires lots of manpower and money. The time lag problem of input-output table are unavoidable. Through the process of historical simulation, the input-output table can be updated more easily.

Unlike the historical simulation, decomposition simulation decompose the effect into different parts. In decomposition closure, the exogenous variable (e.g. policy variable, technology variable, taste variable, international variable) can be considered as independently determined and can be thought of as having their own effects on endogenous variable such as incomes, consumption, exports, imports, outputs, employment and investment.

Besides the differences mentioned above, the setting of closures of historical and decomposition closure are also different. The setting of closures is the process of setting the exogenous and endogenous variables for simulation. The closures vary between simulations. In the historical closures, there are two types of variables in the exogenous set: observables and assignables. Observables are those for which movements can be readily observed from statistical sources for the period of interest. Historical closures vary between applications depending on data availability. Assignable variables are naturally exogenous (and are therefore exogenous in decomposition closures as well as historical closures). The key feature of a assignable variable in an historical simulation is that its movement ca be assigned a value without contradicting anything that we have observed about the historical period or wish to assume about that period. In the decomposition closure we include in exogenous set all naturally exogenous variables, i.e., variables not normally explained in a CGE model. These may be observable variable such as tax rates or unobservables such as technology and preference variables.

Table 2 gives some examples of the partitioning of variables in the historical and decomposition closures. There are four kinds of variable sets: $X(H\overline{D})$, $X(\overline{H}D)$, $X(HD)$,

$X(\overline{HD})$. H denotes exogenous in the historical closure. $\overline{H}$ denotes endogenous in the historical closure and D and $\overline{D}$ denotes exogenous and endogenous in the decomposition closure. Thus, for example, $X(HD)$ consists of those variables that are exogenous in both historical and decomposition closures.

By the partitioning of variables, it gives some insights about the relationship between historical and decomposition closures. Variables in $X(\overline{HD})$ are demands for intermediate inputs and demands for margins services (e.g. road transport) to facilitate commodity flows from producers to users. In the absence of end-of-period tables, movements in these variables are not readily observable or assignable and are normally explained in CGE models. Examples of variables in $X(HD)$ include population size, foreign currency prices of imports and policy variables such as tax rates, tariff rates and public consumption. Values of these variables are readily observable and are not normally explained in CGE model.

$X(\overline{H}D)$ contain the same number of variables as $X(H\overline{D})$ with each variables in $X(H\overline{D})$ having a corresponding variable in $X(\overline{H}D)$. And tables 2 shows examples of corresponding pairs. In historical simulation we use shifts in household preferences to accommodate observations on consumption by commodity, shifts in commodity-specific intermediate input-saving technical change to accommodate observations on total intermediate usage by commodity, etc.

In general, we use historical closure in estimating changes in technology and tastes. Then, decomposition analysis gives us a basis for assessing the relative importance to the industry of changes in policy variables, technology variables, taste variables and international variables. The relationship between our historical and decomposition simulations is illustrated in Figure 2.

2.2 Forecasting and policy closures

The relationship between forecasting and policy simulations is similar to that between historical and decomposition simulations. Historical simulations provide values for exogenous variables in corresponding decomposition simulations. Similarly, forecasting simulations provide values for exogenous variables in corresponding policy simulations. However there is one key difference between the relationships. An historical simulation and the corresponding decomposition simulation produce the same solution. This is because all the exogenous variables in the decomposition simulation have the values they had (either endogenously or exogenously) in the historical simulation. In a policy simulation, most , but not all, of the exogenous variables have the values they had in the associated forecast simulation. The policy variables of interest are set at values that are different from those they had in the forecasts. Thus policy simulations generate deviations from forecasts.

Producing the prediction value of various economic variables and establishing the base scenario of future economic status are the main purpose of forecasting simulation. And analyzing the impact which caused by the variation of policy are the main purpose of policy

simulation. Forecasting closures are similar in nature to historical closures. Instead of exogenizing everything that we know about the past, in forecasting closures we exogenize everything that we think we know about the future. (such as exports of agricultural and mineral products, tourism exports and macro variables) To allow these variables to be exogenous we need to endogenize numerous naturally exogenous such as the positions of foreign demand curves, the positions of domestic exports supply curves and macro coefficients, e.g., the average propensity to consume. Because we know less about the future than the past, forecasting closures are more conventional than historical closures. In forecasting closures, taste and technology are exogenous.

Policy closures are similar to decomposition closures. In policy closures naturally endogenous variables (such as exports of agricultural and mineral products, tourism exports and macro variables) are endogenous. They must be allowed to respond to the policy change under consideration. Correspondingly, in policy closures naturally exogenous variables (such as the positions of foreign demand curves, the positions of domestic export supply curves and macro coefficients) are exogenous. They are set at the values revealed in the forecasts. The relationship between the forecast and policy simulations is illustrated in Figure 3. Giving the base scenario which provided by forecasting simulation, the results of policy simulation can be computed by modifying some variables in the forecasting simulation. Then comparing the results of forecasting and policy simulation, the deviations are the effects which caused by policy shock.

2.3 Ex post closure

The ex post simulation are the counter-factual simulation which evaluate the effect if some policy or events had not happened. The relationship between ex post and historical simulation are similar to the relationship between forecasting and policy simulation. Historical simulations provide values for exogenous variables in corresponding ex post simulations. Then, ex post simulation modified some exogenous variables. Thus, ex post simulations generate deviations from historical simulation.

The closures of ex post simulation are similar to policy simulation. The exogenous variable of ex post simulation can partition into two parts. One is the variables which provided by historical simulations. (e.g. policy variable)The other is the variables which modified and differed from historical simulations. (e.g., technology variable, taste variable, international variable, macro variables.) The relationship between ex post and historical simulation are illustrated in Figure 4.

In brief, the historical and decomposition simulation, the forecasting and policy simulation, or the ex post simulation are similar to each other to some degree. Historical simulation provides the values for exogenous variables in corresponding decomposition and ex post simulations. And the values for exogenous variables in policy simulation are also provided by forecasting simulation. Their relationships are quite similar. The key difference

between the forecasting and historical simulation is that historical simulation and the corresponding decomposition simulation produce the same solution, and forecasting simulation and the corresponding policy simulation don't. And Like forecasting and the corresponding policy simulation, the historical and the corresponding ex post simulation don't produce the same solution. That's because policy and ex post simulation both modified the exogenous variable which accessed from their corresponding simulation.

3. Simulation specification

By giving the main industries impact effects which caused by SARS events, this article evaluated the "Ex post" economic impacts of SARS events by using the CGE Model. There are two simulation which need to specify : historical and ex post simulation. First, we focus on the shocks setting of SARS impacts. Then, we explain the closure and shocks of historical and ex post simulation.

3.1 Industries impacts setting of SARS

Because his article are the ex post analysis which evaluate the impacts of events what had happened, the historical data are accessible. We use the historical data as base of the setting of shocks, and modified the shocks according to the difference of each industry. While the influences of SARS event are mainly on the confidence of consumers, the willing of the investment which can't evaluate, the replacement index of evaluating the impact of SARS are needed. We use the sales value of each industry which are connected to he confidence of consumers and the willing of the investment. The data sources of sales value are from the Journal of Financial Statistics which published by Ministry of Finance.

We defined the influence period of SARS were the Second season of 2003. That's because after the first patient got the SARS disease in March 2003, this disease burst out quickly in the mid of April as the group infection happened in Taipei Municipal Hoping Hospital. However, in the mid of June, there is no more newly infected patient, the spread of this disease are under control. In the early of July, Taiwan got eliminated from list of SARS infection area of World Health Organization.

In the process of setting the shocks of SARS impact, first, we considered the variation of sales value in second season as the impacts of SARS event by comparing with the average sales value in second season last years. Then, by weighting each season, we computed SARS impact of the whole year. Second, in order to eliminate the effects which caused by the variation of price, we deflated the impacts of SARS by using the consumer price index of Taiwan. Finally, we got the SARS impact of the whole year to each industry.

Besides, by considering the differences and growth trends of each industry, we used three scenarios to compare with the sales value of second season 2003: the average of sales value in the second season of past five years (1998-2002), past three years (2000-2002) and last year

(2002). The impact of SARS got more severe as the comparing period got shorter.

The influences of SARS mainly focused on the services and other relative manufacture industries. So we chose some of the services and other relative manufacture industries, according to the classification of 170 sectors input-out table in 1997 and other research report which evaluate the impacts of SARS. The services sectors which we chose included the hotel services, travel agency services, air transportation, other land transportation, railroad vehicle transportation, radio, television & movies services, water transportation, recreational & cultural services, services incidental to transport, restaurant services and medical & health services. The manufacture sectors included precision instruments & apparatus, medicines, cleaning preparations and cosmetics.

Classified by the severe degree of SARS impact in each scenario, the red zone are the industries which affected by the SARS impact the most, the impact on sales value are below -5%. The Yellow zone are industries which affected by the SARS impact moderately , the impact on sales value were between -5% ~ 0%. The green zone are the industries which benefited by the SARS, the impact on sales value are greater than 0%. Table 3 illustrated the impact setting of SARS under different scenario.

3.2 Historical simulation specification

As illustrated in the second section, the historical simulation not only were that revealed the historical path of past economics and estimated the technology and taste variables, but also updated the input-output table. Since the original data in the model were the 160 sectors and 160 commodities input-output table in 1994, the industrial structure of original data were far from now. The update of input-output table were needed before the simulation begin.

The database of the TAIGEM-D model can be separate into three parts: input-output table, variables of the dynamic mechanism equation, elasticity data. First, we replaced the original input-output with the 170 sectors and 182 commodities input-output table in 1999. Second, by using the original elasticity data as a base, the number of sectors in elasticity data expanded to 170 in order to accommodate the number of sectors of new input-output table. In the Final step, it’s the update of the variables of the dynamic mechanism equation. The variables of the dynamic mechanism equation included capital stocks, rate of return and investment coefficient. We used the capital stocks which were from the journal of income statistic in 1999 to update the original capital stocks. And the rate of return of each industry which based on the original data in 1994 modified with the variation of interest.

In the historical simulation, there were two ways to update the historical data: one was updated data year by year, the other was updated the data across a period of time (e.g., form 1999 ~ 2002.) This article used the second method which was the same with the way historical simulation in MONASH model. Besides, the historical simulation of this article separated into two parts: First part was from 1999 to 2002 and used the database which solved as the base data of next year. Second part was from 2002 to 2003. The endogenous variable

which solved in this part of historical simulation can be provided for the ex post simulation later. The relationship between two parts of historical simulation are illustrated in Figure 5.

In the closure of historical simulation, the exogenous included the variables of Macro economics and micro economics. The variables of Macro economics included private consumption expenditure, gross fixed capital formation, government consumption expenditure, exports and imports of goods and services, GDP deflator, exchange rate, export price deflator, import price deflator, annual rate of employed persons, number of household and trend of employment etc. By setting the value of those exogenous variables, we can calibrate the corresponding endogenous variables which can provide for ex post simulation. The above data were mainly from the Journal of Quarterly National Economic Trends which published by statistical bureau. Table 4 illustrated the annual rate of change of those exogenous variables. And the variables of Micro economics included the industrial output of those services and manufacture sectors which were illustrated in 3.1. We used the sales values which were form the Journal of Financial Statistic to update the output of those industries in 2003. Table 5 illustrated the output growth rate of each industry in 2003 while those industries suffered by the impact of SARS events.

3.2 Ex post simulation specification

Before explain the ex post simulation specification, let's focus on the feature of TAIGEM-D model. The model was comprised of enormous equation and the setting of closure was quite important in the model. Under general circumstance, all exogenous variables had the corresponding endogenous variables. e.g. the exogenous variables in historical simulation, private consumption expenditure, gross fixed capital formation, government consumption expenditure, exports and imports of goods and services, etc. Each variable had the corresponding endogenous variables which reflected the impact affected by exogenous variable. While swapped all the endogenous variables as exogenous variables and given the value of endogenous variables which solved in historical simulation, then re-run the simulation again.

The value of endogenous variables would be the same with the value of exogenous variables which we specified in the historical simulation. The ex post simulation didn't just swap all the endogenous variables which solved in historical simulation as exogenous variables. It swapped some of them and modified some exogenous variables. The only difference between historical simulation and ex post simulation was the modified exogenous variables, the value of rest exogenous variables were the same with the value of endogenous variables which solved in historical simulation. So the deviation from historical paths caused by ex post simulation shock was the influences of modified exogenous variables.

As mentioned before, there were two kinds of exogenous variables of ex post closures. One was the exogenous variables which modified. In this case, we modified the output of those industries which suffered by the impact of SARS by given the output which were under

the circumstance SARS event didn't happen. By reducing the impact of SARS event, the impacts on macro economics and those industries which didn't directly suffered by SARS event could be evaluated. The growth rates of those industries which suffered by the impact of SARS event under the circumstance SARS event didn't happen were illustrated in Figure 6. Those value could be calculated by subtracting the growth rate of output in 2003 (Figure 5) with the impact of SARS event on growth rate of output (Figure 3).e.g. the growth rate of output in 2003 of Air Transportation was 1.9% while the impact of SARS event was -15.14% (under the scenario of 2002), then the growth rate of output of Air Transportation under the circumstance SARS event wasn't happen was 17.04%.

The other kind of exogenous variables were the corresponding variables of exogenous variables in historical simulation, e.g. shifts in macro functions. And the macro variables which were exogenous in historical simulation were all endogenized in order to reflect the effect of the modified exogenous variables, e.g. private consumption expenditure, gross fixed capital formation, government consumption expenditure, exports and imports of goods and services. Besides, the output variables of those industries which didn't directly suffered by the impact of SARS event were also endogenized order to reflect the effect of the modified exogenous variables.

4. Simulation Results and Analysis

The results of historical and ex post simulation in this section were solved by using the TAIGEM-D model and GEMPACK software[ii]. And the results and analysis in this section were illustrated in two partitions. First, the results of Macro variables in historical simulation should match with the data which published by statistical bureau. And the value of those corresponding variables of macro variables can provide for the next ex post simulation. Second part was the results and analysis of ex post simulation.

4.1 Historical Simulation Results and Analysis

The reason of proceeding the historical simulation was not only revealed the historical path of economics and updated the original database of TAIGEM-D model from 1999 to 2003 but also solved the value of corresponding variables of macro variables in order to provide for the next ex post simulation.

By setting the value of those exogenous variables which mentioned in last section, including private consumption expenditure, gross fixed capital formation, government consumption expenditure, exports and imports of goods and services, GDP deflator, exchange rate, export price deflator, import price deflator, annual rate of employed persons, number of household and trend of employment etc., the growth rate of GDP in 1999-2002 and 2002-2003 can be solved. The results illustrated in Table 7. The growth rates of GDP in 1999-2002 and 2002-2003 were 7.28% and 3.23 respectively. It seemed quite same with the

value announced by statistical bureau, 7.27% and 3.24%.

And the value of corresponding variables of macro variables which included private consumption expenditure, gross fixed capital formation, government consumption expenditure, exports and imports of goods and services illustrated in Table 8. The value of corresponding variables would be used in ex post simulation.

4.2 Ex post Simulation Results and Analysis

In the results of ex post simulation, we discussed each different macro and micro variables one by one. First, the results of macro variables which illustrated in table 9 showed that the growth rate of real GDP in 2003 should achieve 4.07% ~ 4.85% under the circumstance the SARS event didn't happed. The SARS event caused the growth rate of real GDP drop 0.84% ~ 1.61%. And the impact of SARS event was the most severe in the scenario of 2002, modest in the scenario of 1998-2002. Comparing the results with previous research, Wu, C.S. et al. (2003) estimated the impact of SARS event on real GDP was -0.87% ~ -1.17%. And the Estimation of Wu, R.I. et al. (2003) was modest than our results, the influences on real GDP was -0.57% under the scenario which the outbreak of SARS could not be controlled well until the end of June.

While the growth rate of private consumption was between 1.95% ~ 2.84% under the circumstance which SARS event wasn't happen. Comparing the actual growth rate in 2003, the impact of SARS event on private consumption was between -2.02% ~ -1.13%. The influence was quite huge and only less than the influence on exports of goods and services. Among all scenarios, the impact was most severe in the scenario of 1998 ~ 2002. And the growth rate of gross fixed capital formation was between -2.09% ~ -2.33% under the circumstance which SARS event wasn't happen. The results showed no huge difference between each scenario and the actual growth rate of gross fixed capital formation in 2003. The influence on gross fixed capital formation was between -0.58% ~ -0.82%, however the influence wasn't the same with our expectation. This reason might be the increasing of government investment in 2003 for solving the problem of unemployment. Though the private investment shrank by the impact of SARS event, the increasing of government investment compensated the gap caused by the lost of private investment.

The results showed the impact on exports was larger than on imports. Under the circumstance which SARS event wasn't happen, the growth rate of exports of goods and services was between 12.87% ~ 15.83%. And the impact of SARS event on exports was between -4.22% ~ -7.18%, the most severe in the scenario of 2002. The influence on imports wasn't severe and was between -0.11% ~ -0.27%. The growth rate of imports was between 4.99% ~ 5.15% under the circumstance which SARS event wasn't happen. And the impact on annual rate of employed persons was between -2.62% ~ -3.12%, the most severe in the scenario of 2002. From the results of macro economics mentioned above, the impact caused by SARS event was the most severe on exports and private consumption, the modest on

imports.

In the results of micro economics, we only showed the results in the scenario of 2002. The results illustrated in table 10. Besides minor industry and service sectors e.g. other fabrics, other products for medical use, cleaning preparations and cosmetics, precision instruments & apparatus, medical & health services, most of the sectors suffered the damage caused by SARS event. Among all sectors, the output of air transportation (-15.14%), travel agency services (-14.66%), hotel services (-13.78%) and consulting services (-12.74%) suffered the most. The influences on the employments of those sectors were also severe. Other transportation, services and commercial sectors, such as railroad vehicle transportation (-3.31%), other land transportation (-7.24%), water transportation (-4.97%), services incidental transport (-2.81%), wholesale trade (-3.94), retail trade (-3.58%), international trade (-5.57%), advertising services (-5.20%), radio, television & movies services (-4.20%), recreational and cultural services (-3.43%) were also suffered the damage of SARS event on output. Those sectors which benefited from the impact of SARS event included other fabrics (2.29%), other products for medical use (7.18%), cleaning preparations and cosmetics (6.29%), precision instruments & apparatus (1.46%), medical & health services (2.45%). The output of cleaning preparations and cosmetics, other products for medical use and precision instruments & apparatus sectors increased during the period of SARS burst, that's because those sectors produced the products which used for preventing the spread of SARS disease. And the other fabrics sector included the non-woven cloth sub-sector which produced the material of mask. The precision instruments & apparatus sector also included the medical instruments & apparatus sub-sector which produced the essential medical instruments such as thermometer. The reason that the output of medical & health services sector increased might be the frequency of visiting the doctor during the period of SARS events increased which were due to the awareness of the importance of health.

5. Conclusions

Before proceeding the ex ante simulation, precise forecasting which involving lots prediction of exogenous variables was needed. Usually, due to the time lag problem, the setting of those exogenous variables was hard to access, unless some assumptions had made. And those assumptions do affect the accuracy of the analysis results. However, while proceeding the ex post simulation, most of the exogenous variables was known. There is no need to estimate or assume. But, It's crucially important to decompose the impact of one single event from the historical simulation.

Comparing the previous research, this article used two mechanism: Historical simulation and decomposition-like simulation (ex post simulation) of Taiwan General Equilibrium Model-Dynamic (TAIGEM-D) Model to evaluate the Macro and Micro economics impact of SARS events which burst out in Taiwan, March 2003. Before the ex post simulation, we used

the historical simulation as a base which the SARS event had happened. Then, by proceeding the counter-factual simulation which assumed the SARS event hadn’t happened, the difference of result between two simulations was the ex post influence of SARS event.

The results illustrated that the impacts on real GDP were -0.84%, -1.14%, -1.61% under scenario of the average of 1998 ~ 2002, the average of 2000 ~2002, 2002 respectively. The impacts of SARS event on real GDP was between -0.84% ~-1.61% and was severe than the previous research. And the impacts of SARS event on micro economics showed the hotel services, travel agency services, air transportation, consulting services were the most severe damaged sectors. However, other fabrics, other products for medical use, cleaning preparations and cosmetics, precision instruments & apparatus, medical & health services sectors benefited from the SARS event.

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Table 1 Results of relative SARS research Unit:% , Million NT

Wu, C.S. et al. (2003)		Wu, R.I.. et al. (2003)		Chou et al. (2003)	
Industry Side					
Real GDP(%)	**-0.872**%	**Real GDP** (%)	**-0.57**%	**Real GDP** (%)	**-0.71**%
Total Output	**-144716**	**Total Output**	**-129380**	**Total Output**	**-64500**
Travel agency services	**-9379**	Agriculture	**-496**	Private consumption	**-95900**
Hotel services	**-21657**	Mining	**-246**	Growth rate (%)	**-1.70**%
Passenger transportation	**-8202**	Manufacture	**-70518**	Private investment	**-44600**
Freight transportation	**-15108**	Other services	**-58120**	Growth rate (%)	**-4.91**%
Car renting services	**-1228**	Hotel services	**-4918**	Exports	**-39100**
Movies services	**-5458**	Travel agency services	**-1811**	Growth rate (%)	**0.43**%
Beauty salon	**-14577**	Air transportation	**-12595**	Imports	**-22400**
Restaurant services	**-17338**	Restaurant services	**-6070**	Growth rate (%)	**-2.42**%
Air transportation	**-31472**	Medical insurance services	**-6138**		
Interior Design services	**-13292**	Retail trade	**-14751**	Growth rate of CPI (%)	**-0.53**%
Exhibition services	**-46**				
Lighting fixture export services	**-6960**				
Demand Side					
Real GDP (%)	**-1.172**%				
Private Investment (%)	**-0.065**%				
Exports & Imports (%)	**-0.013**%				
Private consumption (%)	**-1.094**%				
Beverage consumption	**-0.078**%				
Clothing consumption	**-0.116**%				
Household equipment consumption	**-0.022**%				
Food consumption	**-0.215**%				
Medical and Health consumption	**-0.098**%				
Recreational consumption	**-0.392**%				
Transportation & communication consumption	**-0.200**%				

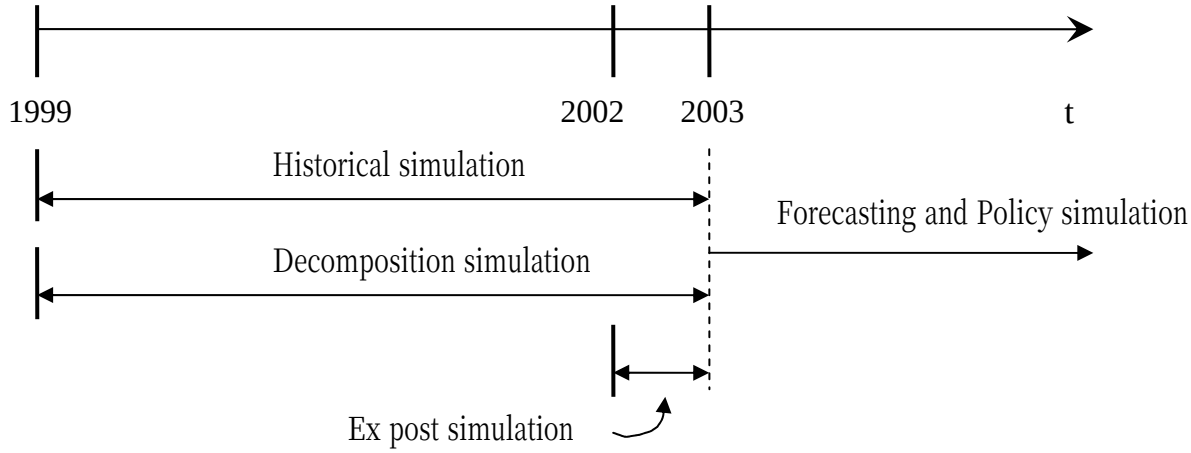
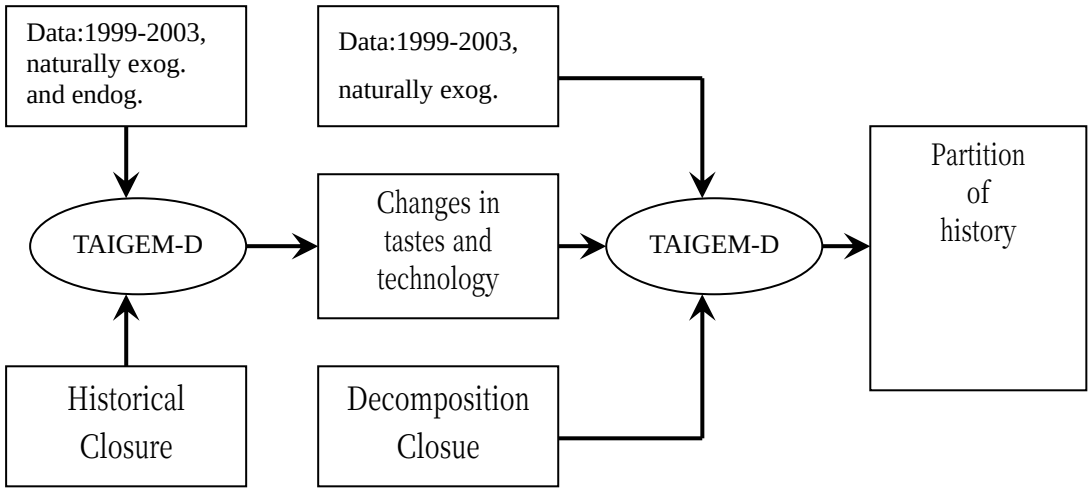


Figure 1. Relationship between each simulation

Table 2 Categories of Variables in the Historical and Decomposition Closures

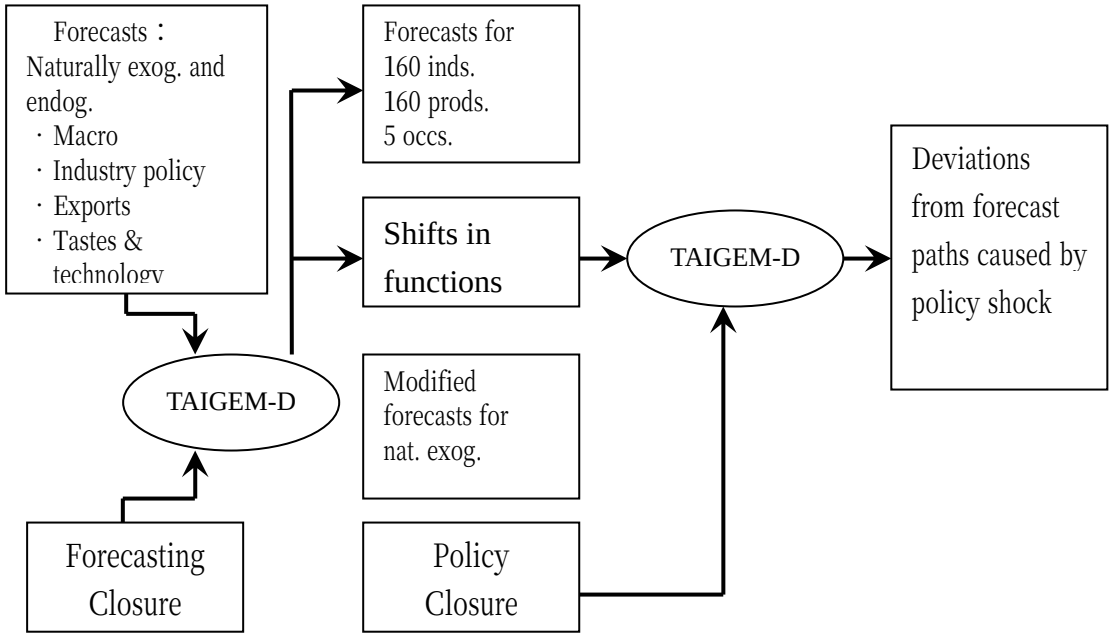
Selected components of $X(H\overline{D})$	**Corresponding components of** $X(\overline{H}D)$
Consumption by commodity	Shifts in household preferences
Total intermediate usage by commodity (deduced from information on outputs, imports and final usage)	Intermediate-input-saving technical change
Employment and capital inputs by industry	Primary-factor-saving technical change and capital/labour bias in technical change
Imports by commodity	Shifts in import/domestic preferences
Producer prices by industry	Rates of return on capital or markups on costs
Export volumes and f.o.b. prices	Shifts in foreign demand and domestic supply functions
Macro variables, e.g. aggregate consumption	Shifts in macro functions, e.g. the average propensity to consume
Selected components of $X(HD)$	
Population	
C.i.f. import prices in foreign currency	
Policy variables, e.g. tax and tariff rates, and public consumption	
Selected components of $X(\overline{HD})$	
Demands for intermediate inputs and margin services	

Date Sources:Dixon and Rimmer (2002)



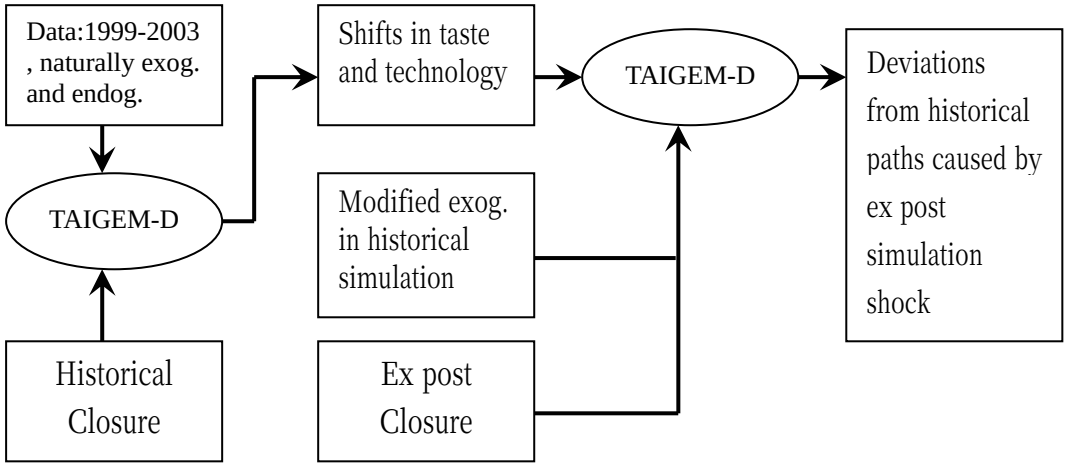
Data Source：Modified by Dixon and Rimmer (2002)

Figure 2. The relationship between Historical and Decomposition Closure



Data Source：Modified by Dixon and Rimmer (2002)

Figure 3. The relationship between Forecasting and Policy Closure



Data source：Dixon and Rimmer (2002)

Figure 4. The relationship between Historical and Ex post Closure

Table 3 The impact of SARS on industry output under different scenario Unit:%

Scenario	2002	2000-2002 Average	1998-2002 Average
Red Zone (Below -5%)			
Hotel Services	-13.78	-14.85	-12.58
Travel Agency Services	-14.66	-14.62	-11.62
Air Transportation	-15.14	-14.50	-11.10
Other Land Transportation	-7.24	-7.13	-7.40
Railroad Vehicle Transportation	-3.31	-6.11	-5.75
Yellow Zone (-5% ~ 0%)			
Radio, Television & Movies Services	-4.20	-6.29	-4.20
Water Transportation	-4.97	-3.97	-2.55
Recreational and Cultural Services	-3.43	-4.65	-2.97
Services Incidental Transport	-2.81	-1.29	-0.72
Restaurant Services	-1.11	-1.25	-1.65
Green Zone (Greater than 0%)			
Precision Instruments & Apparatus [a]	1.46	1.23	1.04
Medical & Health Services	2.45	1.57	1.30
Other fabrics [b]	2.29	1.92	1.22
Other products for medical use	7.18	5.68	4.33
Cleaning Preparations and Cosmetics [c]	6.29	6.21	5.55

Note:a. Precision Instruments & Apparatus included Medical instruments & apparatus, Scientific measuring instruments, Photographic instruments, Optical instruments, Spectacles, Clocks & watches, Other precision instruments & apparatus.

b. Other Fabrics included Silk, linen & other fabrics, Textile products for industrial purpose, Non-woven cloth, Other misc. fabrics, Scarp & waste.

c. Cleaning Preparations and Cosmetics included Cleaning preparation, Cosmetics.

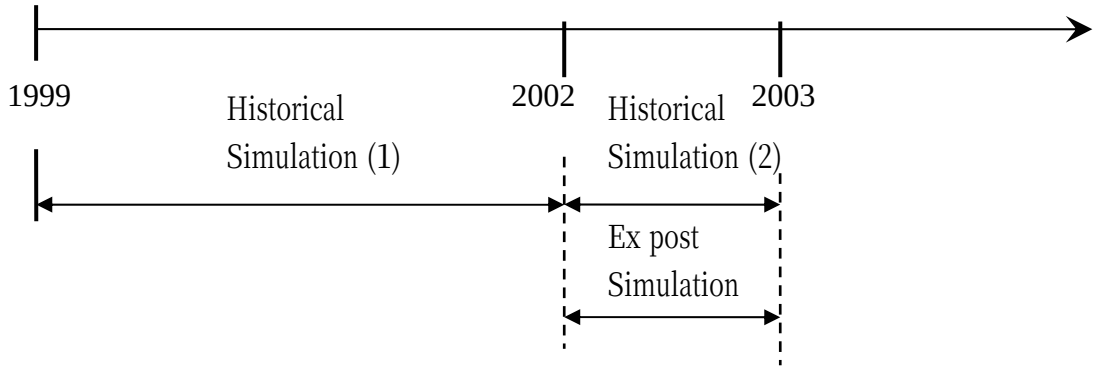


Figure 5 The relationship between Historical and Ex post Closure

Table 4 Annual Growth rate of macro Variables in historical simulation Unit:%

	Historical Simulation (1)			Historical Simulation (2)	
	2000	2001	2002	**1999-2002**	**2002-2003**
Private consumption expenditure	4.93	1.04	1.99	**8.12**	**0.82**
Gross fixed capital formation	8.61	-20.61	-2.13	**-15.62**	**-2.91**
Government consumption expenditure	0.55	-1.02	-0.20	**-0.68**	**0.65**
Exports of goods and services	17.55	-7.77	9.98	**19.23**	**8.65**
Imports of goods and services	14.53	-13.87	5.84	**4.40**	**4.88**
GDP deflator	-1.73	0.57	-1.01	**-2.17**	**-1.90**
Exchange rate	5.16	6.00	-0.66	**10.74**	**-2.82**
Export price deflator	-0.23	-0.25	-1.45	**-1.92**	**-0.87**
Import price deflator	3.98	-0.93	-0.58	**2.42**	**2.98**
Number of household	2.28	1.80	1.80	**7.85**	**1.80**
Annual rate of employed persons	1.14	-1.15	0.76	**3.24**	**1.07**
Trend of employment	1.00	1.00	1.00	**1.00**	**1.00**

Table 5 Growth rate of each sector in 2003 Unit:%

Red Zone (Below -5%)	
Hotel Services	-3.12
Travel Agency Services	0.14
Air Transportation	1.90
Other Land Transportation	0.14
Railroad Vehicle Transportation	-7.32
Yellow Zone (-5% ~ 0%)	
Radio, Television & Movies Services	2.21
Water Transportation	0.66
Recreational and Cultural Services	16.34
Services Incidental Transport	3.48
Restaurant Services	1.56
Green Zone (Greater than 0%)	
Precision Instruments & Apparatus	7.92
Medical & Health Services	-1.01
Other fabrics	6.98
Other products for medical use	7.00
Cleaning Preparations and Cosmetics	21.50

Table 6 Growth rate of each sector (No SARS Impact) Unit:%

Scenario	2002	2000-2002	1998-2002
Red Zone (Below -5%)			
Hotel Services	10.66	11.73	9.46
Travel Agency Services	14.81	14.77	11.76
Air Transportation	17.04	16.40	13.00
Other Land Transportation	7.38	7.27	7.53
Railroad Vehicle Transportation	-4.01	-1.21	-1.57
Yellow Zone (-5% ~ 0%)			
Radio, Television & Movies Services	6.41	8.50	6.41
Water Transportation	5.63	4.63	3.21
Recreational and Cultural Services	19.77	20.99	19.31
Services Incidental Transport	6.29	4.77	4.20
Restaurant Services	1.25	1.39	1.79
Green Zone (Greater than 0%)			
Precision Instruments & Apparatus	6.46	6.69	6.88
Medical & Health Services	-3.46	-2.58	-2.31
Other fabrics	4.69	5.06	5.76
Other products for medical use	-0.18	1.32	2.67
Cleaning Preparations and Cosmetics	15.21	15.29	15.94

Table 7 Macro economics results of historical simulation Unit:%

	1999-2002	2002-2003
Growth rate of real GDP (Actual value)	7.27	3.24
Growth rate of real GDP	7.28	3.23
Private consumption expenditure	8.12	0.82
Gross fixed capital formation	-15.62	-2.91
Government consumption expenditure	-0.68	0.65
Exports of goods and services	19.23	8.65
Imports of goods and services	4.40	4.88

Table 8 Results of corresponding variables of macro variables Unit:%

	2002-2003
Private consumption expenditure	-1.92
Gross fixed capital formation	50.41
Government consumption expenditure	-0.17
Exports of goods and services	1.11
Imports of goods and services	1.31

Table 9 Macro economics results of ex post simulation Unit:%

	His. Sim.	Ex post Simulation			Impact of SARS		
Scenario		2002	2000-2002	1998-2002	2002	2000-2002	1998-2002
Real GDP	3.24	4.85	4.38	4.07	-1.61	-1.14	-0.84
C	0.82	2.84	2.36	1.95	-2.02	-1.54	-1.13
I	-2.91	-2.09	-2.27	-2.33	-0.82	-0.64	-0.58
X	8.65	15.83	14.82	12.87	-7.18	-6.17	-4.22
M	4.88	5.15	4.99	5.12	-0.27	-0.11	-0.24
Employment	1.07	4.19	3.84	3.69	-3.12	-2.77	-2.62

Table 10 Micro economics results of ex post simulation (scenario: 2002) Unit:%

	Historical .Simulation (2003)		Ex post simulation (2003)		Impact of SARS	
	Output	Employment	Output	Employment	Output	Employment
Agriculture	-1.27	-5.80	0.82	-7.08	-2.09	1.28
Light Industries	2.13	-1.15	9.56	7.11	-7.43	-8.26
Other fabrics	6.98	5.53	4.69	-0.89	2.29	6.42
Other products for medical use	7.00	7.37	-0.18	-8.43	7.18	15.80
Cleaning Preparations and Cosmetics	21.50	29.95	15.21	15.83	6.29	14.11
Precision Instruments & Apparatus	7.92	9.37	6.46	2.95	1.46	6.42
Heavy Industries	1.76	-3.34	7.83	2.40	-6.08	-5.74
Electricity, Water, Gas	1.96	-3.42	6.72	3.61	-4.76	-7.03
Transportation, Storage, Communication	1.63	-4.04	8.05	2.07	-6.42	-6.11
Railroad Vehicle Transportation	-7.32	-8.97	-4.01	-8.51	-3.31	-0.46
Other Land Transportation	0.14	-6.97	7.38	-1.20	-7.24	-5.77
Water Transportation	0.66	-1.02	5.63	3.92	-4.97	-4.94
Air Transportation	1.90	-3.70	17.04	19.21	-15.14	-22.91
Services Incidental Transport	3.48	0.92	6.29	0.95	-2.81	-0.03
Travel Agency Services	0.14	-3.82	14.81	13.85	-14.67	-17.67
Finance, Insurance, Real Estate	2.39	-5.90	6.37	-1.49	-3.98	-4.41
Finance	2.70	-4.86	8.24	0.57	-5.54	-5.44
Securities & Futures	2.78	-2.15	6.83	-0.15	-4.05	-2.00
Insurance	0.97	-2.97	6.14	1.02	-5.16	-3.99
Real Estate Services	-5.04	-37.13	-0.98	-31.49	-4.06	-5.64
Business	0.71	-3.70	4.84	-1.72	-4.13	-1.98
Wholesale Trade	0.21	-2.76	4.15	-1.21	-3.94	-1.55
Retail Trade	1.45	-3.72	5.03	-2.53	-3.58	-1.19
International Trade	-0.32	-5.08	5.25	-0.39	-5.57	-4.69
Other Services	2.15	-1.82	6.07	-0.40	-3.93	-1.42
Restaurant Services	1.56	-3.00	2.67	-5.27	-1.11	2.27
Hotel Services	-3.12	-9.26	10.66	7.53	-13.78	-16.79
Consulting Services	14.73	14.75	27.47	28.85	-12.74	-14.11
Advertising Services	1.35	-2.83	6.54	0.34	-5.20	-3.17
Medical & Health Services	-1.01	-5.50	-3.46	-12.64	2.45	7.14
Radio, Television & Movies Services	2.21	-5.01	6.41	-2.73	-4.20	-2.28
Recreational and Cultural Services	16.34	4.99	19.77	6.06	-3.43	-1.07

Note

[i] The detail of TAIGEM-D Model and its application were in Li et al.(2003).
[ii] The detail of GEMPACK was in Harrison and Pearson (1996).