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## Potential Impacts of the SARS Outbreak on Taiwan's Economy\*

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### Abstract

In addition to describing the history of severe acute respiratory syndrome (SARS) in Taiwan, the government's measures to contain the outbreak, and the actual economic impacts of SARS on Taiwan's economy, this paper presents the results of a multiregional computable general equilibrium model (Global Trade Analysis Project model version 6.2) that predicts the outbreak's consequences to 31 service and manufacturing sectors in Taiwan and to the GDP of 16 regions. The results of a short-term outbreak (less than 1 year), taking into account capital accumulation, are compared with those of a longer outbreak (more than 1 year). The losses to GDP are also predicted for the cases in which (1) China provides complete information on its SARS cases and (2) it fails to fully disclose the progress of the outbreak there to the international community. For a short-term outbreak, the simulation predicts losses to GDP of the service and manufacturing sectors of 0.67 percent in Taiwan, 0.20 percent in mainland China, and 1.56 percent in Hong Kong. If SARS is a long-run phenomenon, a lack of transparent disclosure about the progress of SARS on the part of the Chinese authorities could cause an additional 1.6 percent decline in China's GDP, according to the simulation.

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### 1. Introduction

The outbreak of severe acute respiratory syndrome (SARS), which first occurred in November 2002 in southern China, subsequently infected thousands of people in 32 countries/regions. SARS is medically regarded as an atypical strain of pneumonia because it causes the lungs to swell and compress against the chest, making breathing

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difficult. Without treatment, SARS patients face a high risk of death. According to statistics released by the World Health Organization (WHO), as of 7 August 2003 there were 8,422 reported cases of SARS, and the total number of deaths was 916 (WHO 2003). More than 90 percent of these cases were reported in Asia.

Taiwan was reportedly first hit by SARS on 17 March 2003.<sup>1</sup> On 22 April 2003 another outbreak was reported in a Taiwanese hospital, which led to the quarantine of thousands of patients and hospital staff. The outbreak's main economic impact has been on the tourism industry. Few people wanted to travel and thereby risk being infected with SARS or quarantined on their return home. Consumer spending was also hit as people began to shun public places such as department stores and restaurants. The impacts of this alarming epidemic have been short and sharp, but fear of SARS, particularly the uncertainty about whether it is permanently under control, could still damage Taiwan's economy further. If another SARS outbreak were to occur, the full cost of SARS to Taiwan would depend on how long the outbreak lasted and how far it spread.

Current estimations of the loss to Taiwan's GDP as a result of the 2003 SARS outbreak range from around 0.1 percent to 1.75 percent, depending on the type of model used and its assumptions. Using a macroeconomic model based on quarterly data, Chou and Peng (2003) predicted that if SARS were controlled by the end of June 2003, then Taiwan would see only a 0.2 percent decline in GDP growth for the whole year, but that this estimate could easily rise to a 0.8 percent decline if SARS were to last until the end of 2003. Using the input-output table approach, Wu (2003) predicted a 1.75 percent decline in Taiwan's GDP for the whole year. These studies did not consider, however, the consequences to Taiwan of the disease's impacts on the economies of mainland China and Hong Kong. The trade activities of these areas are closely related to those of Taiwan, and a shock to their trade or investment is likely to affect Taiwan as well. Most of the data on SARS and Taiwan's economy for the second quarter of 2003 (when the disease was at its peak) has now been compiled, so we are able to evaluate more accurately the potential overall impacts of SARS on the Taiwanese economy.

This study uses a multiregional computable general equilibrium (CGE) model. We set up simulations of a short-run (static) shock to the services sector and a short-run (static) shock to the services and manufacturing sectors. Thereafter, using the global bank assumption of the Global Trade Analysis Project (GTAP) model, we take into

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<sup>1</sup> The first reported case of SARS in Taiwan came 20 days after the date of onset of the first probable case in Taiwan reported by WHO.

account capital accumulation with (and without) a specific country risk. This risk reflects the state of foreign direct investment in mainland China and depends on China's attitude toward quickly communicating the true extent of the SARS outbreak to the international community.

## 2. Development and containment of SARS in Taiwan

Table 1 shows WHO data on SARS cases in 32 countries/regions. As of 7 August 2003, the countries and regions worst hit by the SARS epidemic were mainland China (5,327 reported probable cases), Hong Kong (1,755 cases), Taiwan (665 cases), Canada (251 cases), and Singapore (238 cases). Taiwan ranked third out of 32 countries/regions in the cumulative number of probable SARS cases that were reported to WHO. Of the total number of people reported to have been infected with the SARS virus in Taiwan, 475 recovered and 180 died. Eighty-six health care workers were affected. Taiwan was declared free of the virus by WHO on 5 July 2003, 20 days after the onset date of the island's last probable SARS case, which was reported on 15 June 2003.<sup>2</sup>

The first reported case of SARS in Taiwan was a Taiwanese businessman who had contracted the disease on a visit to mainland China. The patient was subsequently released from the National Taiwan University Hospital, fully recovered from the disease, but members of his family and hospital staff contracted SARS through contact with him. From the initial reported case on 17 March 2003 until 21 April 2003, the SARS outbreak in Taiwan seemed to have been contained: there was no evidence of SARS' having spread and no reported deaths resulting from the virus.

A subsequent outbreak of the disease at the Taipei Municipal Ho-Ping Hospital brought about the closure of the hospital, and more than a thousand patients and hospital staff were quarantined. The number of reported probable cases rose from 29 on 22 April 2003 to 37 on 23 April 2003, and then climbed dramatically to 100 by 2 May 2003, an alarming increase over such a brief period that represented an average daily growth rate of 7.1 percent. As the trend in figure 1 demonstrates, it seemed clear at that time that the SARS outbreak had not yet reached its peak in Taiwan.

On 10 May 2003, the Taipei city government sealed the Huachang Public Housing Complex in Wanhua district after SARS was suspected to be the cause of death of a

<sup>2</sup> The incubation period of the SARS virus is 10 days, but for safety reasons WHO requires that an area be free of new cases for 20 days before it can be removed from WHO's list of areas with local transmission.

**Table 1. Summary of SARS cases by country/region (1 November 2002 to 7 August 2003)**

	Cumulative number of cases	Number of cases that recovered	Number of deaths	Number of HCWs affected	Date of onset of first probable case	Date of onset of last probable case
China	5,327	4,949	349	1,002	16 November 2002	25 June 2003
Hong Kong	1,755	1,448	300	386	5 February 2003	31 May 2003
Taiwan	665	475	180	86	25 February 2003	15 June 2003
Canada	251	200	41	108	23 February 2003	12 June 2003
Singapore	238	205	33	97	25 February 2003	5 May 2003
Vietnam	63	58	5	36	23 February 2003	14 April 2003
United States	33	26	0	1	9 January 2003	13 July 2003
Philippines	14	12	2	4	25 February 2003	5 May 2003
Germany	9	9	0	1	9 March 2003	6 May 2003
Mongolia	9	9	0	1	31 March 2003	6 May 2003
Thailand	9	7	2	1	11 March 2003	27 May 2003
France	7	6	1	2	21 March 2003	3 May 2003
Australia	6	6	0	0	24 March 2003	1 April 2003
Malaysia	5	3	2	0	14 March 2003	22 April 2003
Italy	4	4	0	0	12 March 2003	20 April 2003
United Kingdom	4	4	0	0	1 March 2003	1 April 2003
India	3	3	0	0	25 April 2003	6 May 2003
Republic of Korea	3	3	0	0	25 April 2003	10 May 2003
Sweden	3	3	0	0	—	—
Indonesia	2	2	0	0	6 April 2003	17 April 2003
Brazil	1	1	0	0	3 April 2003	3 April 2003
Macao	1	1	0	0	5 May 2003	5 May 2003
Colombia	1	1	0	0	2 April 2003	2 April 2003
Finland	1	1	0	0	30 April 2003	30 April 2003
Kuwait	1	1	0	0	9 April 2003	9 April 2003
New Zealand	1	1	0	0	20 April 2003	20 April 2003
Republic of Ireland	1	1	0	0	27 February 2003	27 February 2003
Romania	1	1	0	0	19 March 2003	19 March 2003
Russian Federation	1	0	0	0	5 May 2003	5 May 2003
South Africa	1	0	1	0	3 April 2003	3 April 2003
Spain	1	1	0	0	26 March 2003	26 March 2003
Switzerland	1	1	0	0	9 March 2003	9 March 2003
Total	8,422	7,442	916	1,725	—	—

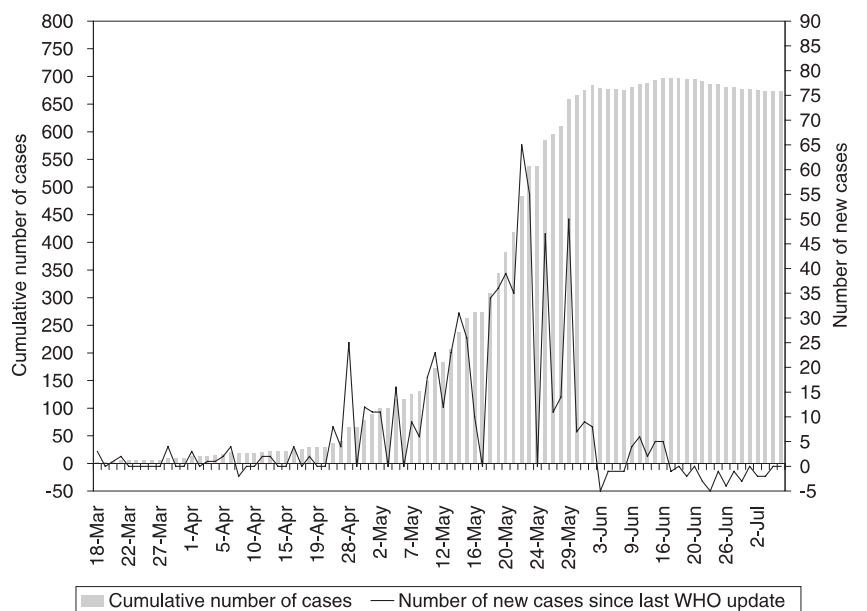
Source: World Health Organization (2003). Available at [http://www.who.int/csr/sars/country/en/country2003\\_08\\_15.pdf](http://www.who.int/csr/sars/country/en/country2003_08_15.pdf)

Note: HCWs = health care workers. The number of infected HCWs in Thailand and France includes those HCWs who were exposed to SARS cases that originated outside of Thailand and France.

man at the complex. The SARS outbreak was becoming more serious in Taipei. Officials could not trace the sources of infection for a large number of people—an alarming sign that the disease was getting out of control. Meanwhile, the situation at the Chang Gung Memorial Hospital in Kaohsiungin was worsening. Hospital staff had mistakenly placed suspected SARS cases (people who had visited Taipei's Jen Chi Hospital) into a regular ward. Three physicians who had taken care of a suspected SARS case were placed in isolation on 11 May 2003. SARS also made inroads into the eastern Taiwan areas of Hualien and Ilan counties and the offshore islands of Penghu County on 17 May 2003.

While outbreaks in other parts of the world were being brought under control, Taiwanese health authorities reported escalating numbers of cases of SARS and forced more hospitals to close their doors in the second half of May. The cumulative number of reported probable cases jumped from 264 on 15 May 2003 to 676 on 31 May

Figure 1. Cumulative number of reported probable cases of SARS in Taiwan



Source: Center for Disease Control, Taiwan.

Note: A negative number of new cases indicates that some of the new probable cases from the previous tally turned out not to be cases of SARS.

2003. Over the same period, the number of deaths caused by the SARS virus climbed from 30 to 81. One spokesperson said at the time, "The SARS outbreak is the most serious health care crisis that Taiwan has ever seen. The magnitude of the outbreak is even more grave than that of the enterovirus outbreak in 1998, which claimed the lives of 78 children."<sup>3</sup>

There were flaws in hospital procedures in Taiwan in regard to the SARS outbreak, including insufficient vigilance and poor reporting. In spite of good medical laboratories and clinical treatment, Taiwan needed to strengthen its disease control, particularly in hospital emergency rooms. Indeed, the SARS outbreak could have been brought under complete control in only 4 to 5 weeks if there had been no mass in-hospital transmission and the public had followed preventive measures.<sup>4</sup> With ad-

<sup>3</sup> This quotation, by Lee Ming-liang, vice convener of the Cabinet's SARS prevention committee, is taken from the 20 May edition of the *Taipei Times*.

<sup>4</sup> Guidelines for such preventive measures were released by the Center for Disease Control, Department of Health, Republic of China, and are available at <http://www.cdc.gov.tw/>

**Table 2. Comparison of aircraft movement, airline passengers, and hotel occupancy rates in Taiwan between the first and second quarters of 2003**

	Average number of total flights per day	Number of passengers			Hotel occupancy rate
		Daily average	Arrivals	Departures	
First quarter 2003	630	211,191	2,876,807	2,904,950	61.69
Second quarter 2003	444	89,145	1,174,668	1,228,472	31.19
Change (number)	-186	-122,046	-1,702,139	-1,676,478	-30.50
Change (%)	-29.5	-57.8	-59.2	-57.7	-49.44

Source: Department of Statistics, Ministry of Transportation, Republic of China.

vice from WHO and the U.S. Center for Disease Control, Taiwan eventually managed to contain the SARS outbreak by mid-June 2003. With a decline in the number of cases, WHO lifted its warning against nonessential travel to and from Taiwan on 17 June 2003, and on 5 July 2003 it removed Taiwan from the list of areas with recent local SARS transmission. Taiwan was the last area to be removed from this global list.

The containment of the SARS virus on 5 July 2003 marks a significant milestone; however, based on what we know about other members of the coronavirus family, SARS could be a seasonal disease. Taiwan's government warned the public to remain alert to the possibility that SARS might recur in winter 2003 or early in 2004. Hospitals will need to be vigilant against SARS, and residents have been encouraged to take the necessary preventive measures.

### 3. Economic impacts of SARS and Taiwan's response

#### 3.1 Economic impacts

The businesses in Taiwan that suffered most from the SARS outbreak belonged to the airline and tourism-related sectors. Nearly 30 percent of the international flights were canceled, with a daily reduction of about 122,000 passengers in the second quarter of 2003 (table 2). Outbound travel was reduced by 57.7 percent, and inbound passenger traffic was down by 59.2 percent. The average occupancy rate of hotels in Taiwan fell by 30 percent in March, and recreational businesses also suffered severely. The GDP of the air transport sector and the eating and drinking places sector dropped 22.7 percent and 13.1 percent, respectively, compared with the same period a year earlier. Securities and futures, and real estate sectors, which are sensitive to consumer sentiment, fell by 26.1 percent and 7.7 percent, respectively.

sarsen/Guideline-e-rev.doc The guidelines consist of procedures for reporting and categorization, epidemic investigation, self-initiated health monitoring and home quarantine, infectious disease treatment, contagion control, testing for SARS, control of prevention materials (e.g., masks), and international exchange of information.

**Table 3. Changes in service sector GDP in Taiwan (2003:Q2)**

Sector	Year-on-year change (%)	Amount of GDP in 2003:Q2		
		(NT\$ million at 1996 prices)	Share (%)	Contribution (%)
	(1)	(2)	(3)	(4) = (1) × (3)/100
Service sectors (total)	0.22	1,508,590	100.00	0.21
Trade and eating and drinking places	-1.02	397,193	26.66	-0.27
Wholesale trade	-1.78	93,076	6.30	-0.11
Retail trade	-0.62	159,168	10.64	-0.07
Retail sale of general merchandise	-0.81	26,115	1.75	-0.01
Foreign trade	3.94	88,749	5.67	0.22
Eating and drinking places	-13.11	30,107	2.30	-0.30
Transport, storage, and communications	1.60	200,098	13.08	0.21
Land transport	-6.29	37,785	2.68	-0.17
Water transport	8.98	18,517	1.13	0.10
Air transport	-22.68	13,057	1.12	-0.25
Transport service, storage, and warehousing	-3.21	25,569	1.75	-0.06
Communication	-3.21	93,237	6.40	-0.21
Finance, insurance, and real estate	2.98	500,697	32.30	0.96
Financing	9.98	186,730	11.28	1.13
Securities and futures	-26.07	15,595	1.40	-0.37
Insurance	3.32	67,572	4.34	0.14
Real estate	-7.68	13,946	1.00	-0.08
Dwellings	0.95	216,863	14.27	0.14
Business services	2.13	58,977	3.84	0.08
Community, social, and personal services	1.47	212,625	13.92	0.20
Producers of government services	1.93	230,270	15.01	0.29
Other producers, import duties, and value-added tax	-0.99	117,263	7.87	-0.08
Less: imputed bank services charge	9.34	208,620	12.68	1.18

Source: Directorate General of Budget, Accounting, and Statistics, Republic of China.

Note: The share of each service sector is expressed as a percentage of the total services. GDP is calculated from the data for the second quarter of 2002.

The GDP of the services sector as a whole grew by only 0.2 percent, which was relatively low in comparison with its growth during the previous 3 years (table 3).

As the SARS epidemic caused people to curb their spending and prevented buyers from attending trade fairs at home and in China, export orders grew at their slowest pace in more than a year. For the first time in 14 months, factories saw a fall in their levels of production. The GDP of the electrical and electronic machinery sector, the share of which had previously accounted for 32 percent of Taiwan's manufacturing GDP, fell by 2.7 percent. The effects were also severely felt in non-heavy industrial products such as processed foods, textiles and clothing, leather and fur products, wood and bamboo products, plastic products, and nonmetallic mineral products, all of which had been in decline over recent years. Total manufacturing fell (table 4).

As shown in table 5, Taiwan's economy as a whole fell by 0.08 percent in the second quarter of 2003. This was the first period of negative growth since the onset of the

Table 4. Changes in Taiwan's manufacturing GDP by sector (2003:Q2)

Sector	Year-on-year change (%)	Amount of GDP in 2003:Q2		
		(NT\$ million at 1996 prices)	Share (%)	Contribution (%)
	(1)	(2)	(3)	(4) = (1) × (3)/100
Total manufacturing sectors	-0.04	647,774	100.00	-0.04
Food products	-6.07	29,808	4.90	-0.30
Tobacco	-17.49	3,628	0.68	-0.12
Textiles and clothing	-12.45	22,526	3.97	-0.49
Wearing apparel and accessories	-14.02	4,962	0.89	-0.12
Leather and fur products	-3.86	2,818	0.45	-0.02
Wood and bamboo products	-9.28	1,935	0.33	-0.03
Furniture and fixtures	-11.95	3,397	0.60	-0.07
Pulp, paper, and paper products	0.40	12,500	1.92	0.01
Printing and processing	2.18	5,728	0.87	0.02
Chemical materials	0.66	52,883	8.11	0.05
Chemical products	7.65	16,444	2.36	0.18
Petroleum and coal products	13.02	46,286	6.32	0.82
Rubber products	9.19	6,821	0.96	0.09
Plastic products	-7.44	29,889	4.98	-0.37
Nonmetallic mineral products	-2.48	20,209	3.20	-0.08
Basic metals	1.99	53,905	8.16	0.16
Fabricated metal products	1.89	39,276	5.95	0.11
Machinery and equipment	7.64	34,744	4.98	0.38
Electrical and electronic machinery	-2.72	200,248	31.76	-0.86
Transport equipment	7.54	41,675	5.98	0.45
Precision instruments	9.86	6,833	0.96	0.09
Other industrial products	3.18	11,247	1.68	0.05

Source: Directorate General of Budget, Accounting, and Statistics, Republic of China.

Note: The share of each manufacturing sector as a percentage of the sum of all manufacturing sectors is calculated from the data for the second quarter of 2002.

global recession and the terrorist attack on the United States in September 2001, when Taiwan's GDP and the growth of many sectors fell (in 2001:Q2, 2001:Q3, and 2001:Q4). After the containment of the SARS outbreak in July 2003, the economy rebounded, and it is currently expected to grow steadily.

### 3.2 Government policies

On 1 May 2003, President Chen Shui-bian warned Taiwan's citizens that they should prepare for a long fight against the SARS outbreak. He announced the immediate need for the island to build up an internationally standardized epidemic control system and make comprehensive efforts to contain the outbreak.<sup>5</sup> The president put forward the following five guidelines aimed at defending Taiwan from the many effects that the SARS outbreak had inflicted on the island's citizens:

1. Medical authorities would fully implement quarantine measures to prevent the spread of SARS.

<sup>5</sup> In "Prepare for Long Fight, Chen Says," *Taipei Times*, 2 May 2003. Available at <http://www.taipeitimes.com/News/taiwan/archives/2003/05/02/204317>



**Table 5. Quarterly growth rate of Taiwanese GDP, by industry (percentage, 2000:Q1–2003:Q2)**

GDP growth rates (%) year on year							
	Real GDP	Manufacturing sector	Service sector	Agriculture sector	Mining sector	Water and electricity sector	Construction sector
2000							
Q1	7.94	9.98	8.58	1.62	-15.82	7.14	-8.48
Q2	5.10	6.27	5.65	0.52	-7.38	6.38	-7.13
Q3	6.73	10.67	5.66	1.95	0.85	6.93	-2.92
Q4	3.82	2.64	4.74	0.73	2.35	8.20	-3.18
2001							
Q1	0.61	-1.22	1.63	-0.95	-1.61	5.89	-6.36
Q2	-3.26	-6.74	-1.37	-1.58	-16.12	1.45	-12.47
Q3	-4.42	-9.79	-1.28	-1.33	-9.44	0.49	-17.88
Q4	-1.58	-4.52	0.55	-4.07	-4.71	-2.76	-13.29
2002							
Q1	0.94	1.38	1.33	2.96	1.34	-1.94	-9.64
Q2	3.67	7.32	2.64	2.78	8.38	3.51	-4.68
Q3	5.21	8.61	3.95	5.93	5.64	2.77	1.17
Q4	4.52	7.50	3.29	7.19	-5.84	4.18	2.42
2003							
Q1	3.53	7.83	2.23	-1.54	-16.76	3.70	-0.38
Q2	-0.08	-0.04	0.22	0.12	-20.66	1.46	-6.23

Source: Directorate General of Budget, Accounting, and Statistics, Republic of China.

2. A SARS task force would be established with medical experts from the Department of Health and the National Health Research Institutes.
3. Government agencies would provide twice-daily updates of the available information on SARS prevention to help calm the public's fears about the virus.
4. The government would make regular reports to the foreign representative offices and embassies in Taiwan about the latest SARS developments.
5. The government would provide necessary relief funds to compensate those industries that suffered losses from SARS, including tourism, transportation, and recreation-related businesses.

The government would also, under the guidelines, undertake supplementary measures to reinforce the medical health and security of Taiwanese businesspeople in mainland China, as well as measures to encourage Taiwanese businesspeople to relocate their China-based industries to Taiwan. Furthermore, Taiwan would reinforce its collaboration with the health authorities in Hong Kong and mainland China.

In consequence of the severity of the situation, the Taiwan legislature promptly completed both the second and third readings of the special regulations (the five guidelines listed above) within a single day to demonstrate their willingness to cooperate with the nationwide effort to contain the SARS outbreak. A special fund totaling NT\$50 billion was proposed to subsidize SARS-related medical expenses and

to mitigate the economic impacts on local industries. The bill proposing the fund also stipulated that the government must compensate the families of nurses who gave their lives in fighting the epidemic. This compensation would take the form of subsidies for the educational expenses of the victims' children. The bill, which was part of the special regulations, also stated that the government must ensure the protection of both the working rights and the members of the families of quarantined people, and that necessary measures should be undertaken to compensate hospitals and clinics that were shut down temporarily as a direct result of SARS. The National Science Council launched a NT\$38 million project to study clinical symptoms, seek methods of diagnosis and treatment, develop technologies for rapid detection, and create vaccines and medicines.

President Chen Shui-bian later presented the Executive Yuan with a NT\$300 billion budget that expanded public construction and public services over the subsequent 3 years to buffer the impact of the SARS epidemic. A final measure included in the special regulations was that any person suspected of having the SARS virus who subsequently and deliberately transmitted the virus to any other person could face a period of 3 years in jail or a maximum fine of NT\$500,000.

#### **4. Simulations using the GTAP model**

##### **4.1 Methodology**

The 0.08 percent fall in Taiwan's GDP in the second quarter of 2003 was caused not only by the outbreak of SARS, but also by the structural changes and cyclical pattern of the Taiwanese economy. We conduct a computable general equilibrium analysis to identify the impacts of SARS on Taiwan's economy. Exports from Taiwan to mainland China and Hong Kong currently account for one-third of the island's total exports, and the largest proportion of Taiwan's foreign direct investment (FDI) is targeted at these areas. Thus the economic impacts on Taiwan as a direct result of the SARS outbreak cannot be effectively estimated without taking the situations in both mainland China and Hong Kong into account. We therefore utilize a multiregional CGE model, the GTAP model version 6 with the GTAP database version 5. The data are aggregated into 16 regions and 31 sectors. A detailed description of the model's structure can be found in Hertel (1997).<sup>6</sup>

We carry out short-run and long-run simulations. For the short-run simulations (in which the SARS outbreak lasts 1 year or less), we fix the capital stock for each re-

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<sup>6</sup> Modifications of the model in newer versions can be found at the GTAP home page (<http://www.gtap.agecon.purdue.edu/>).

gion. For the long-run simulations (in which the SARS outbreak continues for longer than 1 year), we use the steady-state approach discussed by Francois, McDonald, and Nordstrom (1996) to take account of the linkages among investment, production capacity, and growth. In the short run, a change in investment has only demand-side effects, whereas in the long run a change in investment will affect the steady-state capital stock.

#### 4.2 Foreign direct investment

From an investor's point of view, a commitment by the Chinese government to transparency reduces that country's risk factor. For instance, a recent Deutsche Bank survey on investor attitudes toward FDI in mainland China found that the number of respondents who were concerned about policy risks arising from the Chinese government's handling of the SARS situation had climbed to 58 percent prior to 20 April 2003 but had subsequently fallen to 33 percent when remedial measures were eventually taken (Ma 2003). Following Malcolm's (1998) treatment of country risks, our model adopts the setup of Weng, Hsu, and Hsu (2002), using a coefficient for investment attractiveness as a means of adjusting a country's expected return on capital. Thus, in our model:

$$RORE(r) = RORG/INVATT(r),$$

where  $RORE(r)$  is the expected return on capital in region  $r$ ,  $RORG$  is the global level of return on capital, and  $INVATT(r)$  is the investment attractiveness coefficient in region  $r$ . As long as a country has greater investment attractiveness than competing countries, it will attract more foreign investment, even if the expected return on capital is the same as that in the competing countries. The value of this investment attractiveness coefficient is estimated and calibrated from a regression analysis described in Chou et al. (2002).

#### 4.3 Simulation design

Table 6 shows the basic scheme of our simulations. Scenario 1 considers only the impacts on the service sectors in terms of the short-run losses, as currently being observed over the whole year (2003). Scenario 2 includes the impacts on both the service sectors and manufacturing sectors, in terms of losses in 2003. Scenario 3 takes into account capital accumulation and a shock on total factor productivity as a long-run phenomenon (i.e., the SARS outbreak lasts over 1 year) and includes the effect of a positive change in the transparency policy of mainland China. Scenario 4 is similar to scenario 3, but it assumes nontransparent reporting of the SARS outbreak by the Chinese authorities. Because the SARS outbreak spanned almost a full quarter, we divide our simulation results by 4 to assess the impact in a quarter with unemployment (CGE models typically assume full employment).

**Table 6. Simulation design**

	Short-run simulations (static)		Long-run simulations (steady state)	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Service sectors	✓	✓	✓	✓
Manufacturing sectors		✓	✓	✓
Foreign direct investment				
Transparent reporting of SARS outbreak by China			✓	
Nontransparent reporting of SARS outbreak by China				✓

**Table 7. Hypothetical changes in Taiwan's household consumption and exports, by sector (percentage)**

Sector	Household consumption (%)	Exports (%)
Agriculture and mining	0.50	5.32
Food processing	0.48	-3.39
Textiles		-9.27
Wearing apparel	-5.82	-8.14
Leather products	—	-6.60
Wood products	2.60	-7.62
Paper products and publishing	—	0
Petroleum and coal products	—	0
Chemical, rubber, and plastic products	—	8.09
Mineral products	—	-3.99
Ferrous metals	—	-2.20
Metals	—	-2.96
Metal products	—	-4.24
Motor vehicles and parts	—	16.47
Transport equipment	—	0
Electronic equipment	—	3.62
Machinery and equipment	—	4.00
Other manufacturing	—	19.58
Construction	—	—
Public utilities	0.80	—
Trade	—	—
Land transportation	-6.29	—
Water transportation	8.98	—
Air transportation	-22.68	—
Communications	-3.21	—
Financial services	6.00	—
Insurance	3.32	—
Business services	2.13	—
Recreational and other services	-13.16	—
Public administration, defense, education, and health	1.91	—
Dwellings	2.60	—

*Note:* A dash indicates the model predicts that the sector was not affected by the SARS outbreak.

The hypothetical changes in Taiwan's household consumption and exports, shown in table 7, are calculated from the news reports about industrial responses to the SARS outbreak. Household consumption, for example, is likely to fall by 22.68 percent in the air transportation sector and by 6.29 percent in the land transportation sector. Increases are expected in household consumption of agricultural products, food and food products, public administration (including health care), and housing because of the strong demand for medical treatment and related activities. The data in table 7 are adjusted to account for the effects of the disease in mainland China

Table 8. Predicted percentage changes in GDP caused by SARS

Areas	Short-run simulations		Long-run simulations	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Taiwan	-0.55	-0.67	-2.05	-1.64
China	-0.13	-0.20	-0.18	-1.80
Hong Kong	-1.68	-1.56	-4.43	-3.88
Japan	-0.02	0.01	0.14	0.92
South Korea	-0.02	0.03	0.06	0.44
Indonesia	0	0.01	0.09	0.36
Malaysia	-0.06	-0.02	-0.14	0.29
Philippines	0.01	0.04	0.07	0.38
Singapore	-1.30	-1.07	-1.86	-1.34
Thailand	0	0	0.08	0.91
Vietnam	0.01	0.06	-0.05	0.30
Southeast Asia	0.01	0.02	0.11	0.27
Australia and New Zealand	-0.01	0.01	0.05	0.74
NAFTA	-0.03	-0.01	0.06	1.00
European Union	-0.01	0.01	0.14	0.96
Rest of the world	-0.01	0.01	0.09	0.49

*Note:* The short-run simulations predict changes to GDP resulting from a SARS outbreak that is contained in less than 1 year. The long-run simulations predict changes to GDP resulting from a SARS outbreak that lasts for over 1 year. Scenario 1 = impact on service sectors of a short-term outbreak; scenario 2 = impact on service and manufacturing sectors of a short-term outbreak; scenario 3 = impact of long-term SARS outbreak on service and manufacturing sectors if China engages in transparent reporting of SARS cases; and scenario 4 = impact of long-term SARS outbreak on service and manufacturing sectors if China fails to report the true extent of its SARS cases to international authorities.

and Hong Kong, given their regional differences (e.g., size of the country and industrial structure) and differences in the extent of the SARS outbreak. The figures in table 7 are then imposed on the model as the shocks of the SARS outbreak from Taiwan, China, and Hong Kong.

#### 4.4 Simulation results

Table 8 shows the results of the simulations under the four scenarios defined in table 6. For scenario 1 (a static analysis), the changes to GDP as a result of a short-term SARS outbreak in 2003 are a reduction of 0.55 percent in Taiwan, a 0.13 percent decline in mainland China, and a significant fall of 1.68 percent in Hong Kong. In all four scenarios, the main impacts occur in the service sectors. Scenario 2 includes the impacts on the service sectors and manufacturing sectors in terms of short-run losses over 2003 (also a static analysis), and the simulation predicts a 0.67 percent decline in Taiwan, a 0.20 percent decline in mainland China, and a fall of 1.56 percent in Hong Kong. If a SARS outbreak were to last a year or more (considered a permanent or long-run phenomenon), and we take the effects on capital accumulation into account (scenario 3), then the negative impacts on GDP would rise to 2.05 percent for Taiwan and 4.43 percent for the worst case, Hong Kong, while remaining about the same for mainland China (0.18 percent). The model also predicts that the GDP loss for China would be considerably worse if the government did not improve its disclosure of the overall SARS situation in the mainland (scenario 4 in

**Table 9. Predicted percentage changes in Taiwan's output caused by SARS**

Sector	Short-run simulation		Long-run simulation	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Agriculture and mining	-0.19	-0.20	-0.64	-0.42
Food processing	-0.28	-0.32	-0.89	-0.70
Textiles	-0.41	-0.48	-1.98	-1.84
Wearing apparel	-0.43	-0.04	-3.50	-2.95
Leather products	-0.56	-0.61	-2.12	-1.80
Wood products	-0.56	-0.67	-1.69	-0.97
Paper products and publishing	-0.56	-0.70	-1.93	-1.61
Petroleum and coal products	-0.53	-0.67	-2.05	-1.74
Chemical, rubber, and plastic products	-0.54	1.94	-1.72	-1.53
Mineral products	-0.54	-0.68	-1.97	-1.57
Ferrous metals	-0.55	-0.68	-2.82	-2.45
Metals	-0.54	-0.67	-2.48	-2.42
Metal products	-0.57	-0.64	-3.70	-3.25
Motor vehicles and parts	-0.51	-2.50	-4.29	-3.87
Transport equipment	-0.52	-0.66	-3.13	-2.67
Electronic equipment	-0.50	0.48	-1.50	-0.87
Machinery and equipment	-0.50	-0.63	-1.99	-1.65
Other manufacturing	-0.52	-0.62	-2.24	-1.58
Construction	-0.50	-0.60	-1.76	-1.26
Public utilities	-0.41	-0.50	-1.96	-1.61
Trade	-0.53	-1.05	-2.24	-1.83
Transportation	-4.89	-5.00	-3.09	-2.67
Water transportation	-0.47	-0.59	-0.85	-0.39
Air transportation	-7.46	-7.56	-4.83	-4.32
Communications	2.24	2.14	-1.29	-0.83
Financial services	-0.45	-0.55	-2.02	-1.59
Insurance	-0.53	-0.64	-2.12	-1.66
Business services	0.21	0.14	-1.72	-1.23
Recreational and other services	-2.02	-2.14	-3.14	-2.71
Public administration, defense, education, and health	-0.02	-0.16	-1.88	-1.47
Dwellings	-0.33	-0.40	-1.74	-1.34

*Note:* The short-run simulations predict changes to GDP resulting from a SARS outbreak that is contained in less than 1 year. The long-run simulations predict changes to GDP resulting from a SARS outbreak that lasts for over 1 year. Scenario 1 = impact on service sectors of a short-term outbreak; scenario 2 = impact on service and manufacturing sectors of a short-term outbreak; scenario 3 = impact of long-term SARS outbreak on service and manufacturing sectors if China engages in transparent reporting of SARS cases; and scenario 4 = impacts of long-term SARS outbreak on service and manufacturing sectors if China fails to report the true extent of its SARS cases to international authorities.

table 8). No such corresponding losses would be expected, however, for Taiwan or Hong Kong. Other Asian countries are also predicted to suffer declines in GDP resulting from the SARS outbreak (e.g., Malaysia and Singapore), although South Korea, Vietnam, and Southeast Asia as a whole might see some slight gains in GDP. Countries other than China fare better in scenario 4 than in scenario 3 because nontransparent reporting of the outbreak by the Chinese authorities would lead to investment's being redirected to these areas.

Table 9 shows that most sectors in Taiwan (except communications and business services) would suffer from decreased output in the short-run scenarios, but all sectors in Taiwan are expected to suffer losses if the SARS outbreak lasts for more than a year.

## 5. Conclusions

The worldwide influenza epidemic of 1918–19 caused the death of 40 million people, but we are confident that such a devastating outcome from SARS has been avoided. Our analysis indicates that the impact of any SARS outbreak on the Taiwanese economy is contingent on the way that the SARS situation is dealt with in mainland China and Hong Kong, given Taiwan's proximity and continuing business relationships with these seriously affected areas.

We find that the GTAP multiregional CGE model predicts that Taiwan will suffer only moderately from a SARS outbreak, compared with the losses in mainland China, Hong Kong, and even Singapore. This is mainly because of the importance of the tourism industry in these three most-affected areas. Compared with other industries, tourism by its nature involves many more personal interactions, and thus a higher likelihood of spreading the virus.

The accurate and timely reporting of SARS cases is crucial to controlling the international spread of the virus. Such transparency by a country will affect the ability of that country to attract FDI. Incorporating this idea into the model simulations, we find that a lack of transparent reporting by China will cause an additional 1.6 percent loss in GDP in the long run. Those countries that have dealt effectively with the SARS outbreak might gain some degree of international competitiveness because of their increased attractiveness to FDI.

The current fear is that a recurrence of SARS will seriously damage the economy in Taiwan. Prompt effective actions by the government will, no doubt, reduce the costs and help revive the economy sooner.

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