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U.S. trade indicators and epidemics: Lessons from the 2003 SARS outbreak

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Abstract

We revisited the 2003 outbreak of Severe Acute Respiratory Syndrome (SARS-2003) and its role in two U.S. indicators – U.S. merchandise exports to countries in the East Asia Pacific (EAP) region and domestic U.S. jobs supported by these exports. We employed a quasi-experimental approach where SARS-2003 average treatment effects were derived from comparing before-2003 and after-2003 differences in indicator trends for EAP countries that experienced the bulk of 2003 epidemic transmission (China, Taiwan, Hong Kong and Singapore) and EAP countries that did not, controlling for observed and unobserved country heterogeneity that might concurrently determine trends in trade. The SARS-2003 outbreak was associated with a USD 29 billion relative reduction in U.S. merchandise exports to the group of high-burden SARS countries, with a corresponding relative loss of 61,200 U.S. jobs. These effects were largely explained by a slowdown in exports from the U.S. manufacturing sector (USD 24.9 billion). No significant post-2003 effects were estimated for either exports or jobs, indicating a relatively quick rebound.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Office of the Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services.

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1. Introduction

In 2003, an outbreak of Severe Acute Respiratory Syndrome (SARS-2003) caused over 8,000 illnesses and nearly 800 deaths, largely concentrated in four countries in the East Asia and Pacific (EAP) region – China, Taiwan, Hong Kong and Singapore (WHO, 2003). Estimates of the regional economic damage attributed to the outbreak approached USD 40 billion, reflecting epidemic-related declines in tourism, retail and capital flows (Lee and McKibbin, 2004; Beutels et al., 2008; Keogh-Brown and Smith, 2008). In the United States, the public health impact of SARS-2003 was limited to 29 confirmed cases with no recorded deaths (CDC, 2003). Since the direct health impact of the 2003 SARS outbreak within the U.S. was minimal, it is plausible to presume that its economic relevance to the U.S. would have been correspondingly negligible, but the question has not been examined empirically.

Existing evidence on the impact of distant epidemics is sparse. To the best of our knowledge, only one previous study has explored trade as a mechanism through which public health emergencies might reverberate to the economies of unaffected countries (Kostova et al., 2019). On that occasion, we documented a link between select U.S. trade indicators and the 2014 West Africa Ebola outbreak, where the year of peak Ebola transmission, 2014, was associated with a USD 1.08 billion relative reduction in U.S. merchandise exports to Ebola-affected countries, and with relative losses in exports-supported U.S. jobs that exceeded 1,200 in 2014 and 11,000 in 2015. However, it is not clear if such findings might generalize across different epidemic events. The contribution of the present note is the following. It explores the consistency of previously published implications linking distant epidemic events to economic outcomes in the U.S. by extending the 2014 Ebola analysis to a different period and geography, the 2003 SARS outbreak. In this context, we assess the role of SARS-2003 in the volume of U.S. exports to EAP countries that bore the brunt of the outbreak, and in the number of U.S. jobs supported by these exports. By evaluating potential linkages between U.S. indicators and geographically distant epidemics, this analysis explores a layer in the complex web of interactions between global health and the economy, informing the relevance of global health security efforts.

2. Methods

We analyzed trends in two indicators: U.S. merchandise exports to EAP countries from 1990 to 2015 (USDC), and the number of U.S. jobs supported by these exports from 1999 to 2015 (Rasmussen and Xu, 2016). These indicators were used as outcomes in difference-in-differences models where SARS-2003 average treatment effects were derived from comparing before-2003 and after-2003 outcomes trends in four EAP countries that were heavily affected by the epidemic and 27 EAP countries that were not, employing a framework previously described in the context of the 2014 Ebola epidemic (Kostova et al., 2019). In addition to the inclusion of country fixed effects, country-specific heterogeneity that may independently influence trends in trade and thus interfere with the parallel trends assumption was addressed by employing country-specific time trends and a number of relevant macroeconomic controls, described below. The model was specified as follows:

$$Y_{jt} = \beta_0 + \beta_1 SARS_j + \beta_2 2003 + \beta_3 Post2003 + \beta_4 SARS_j * 2003 + \beta_5 SARS_j * Post2003 + \beta_6 X_{jt} + \gamma_{0j} + \tau_j T + \varepsilon_{jt} \quad (1)$$

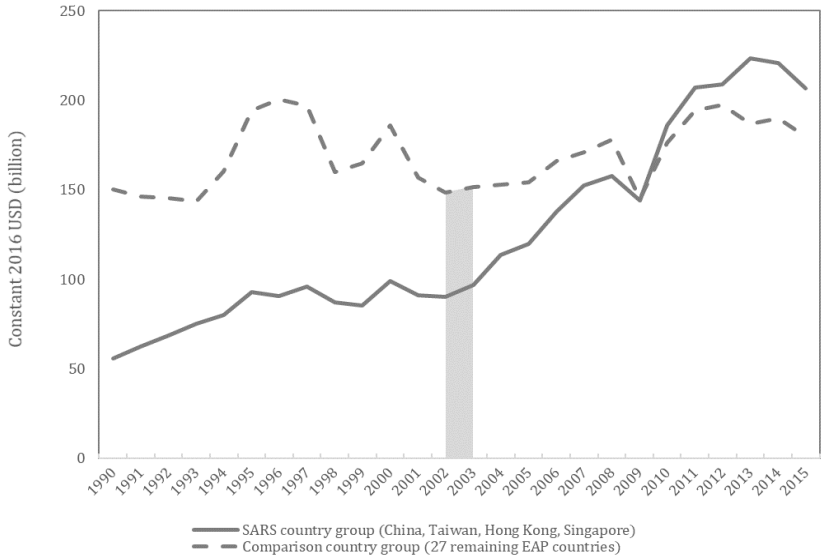
where Y_{jt} denotes the evaluated outcome (U.S. exports or exports-supported jobs) for country *j* in

year *t*; $SARS_j$ is a binary indicator equal to 1 if country *j* is one of the four primary SARS-afflicted EAP countries (China, Taiwan, Hong Kong, Singapore) and zero if country *j* is among the remaining 27 countries in the region; *2003* is a binary indicator for the peak year of SARS transmission; *Post2003* is a binary indicator for the period thereafter. X_{jt} is a vector of control variables that may influence trade patterns: the relative annual income and relative price level indicators for partner countries (country real gross domestic product (GDP) per capita relative to U.S. GDP and country CPI relative to U.S. CPI, respectively), and an indicator of the strength of the U.S. dollar relative to other major world currencies (the real trade-weighted USD index). Within-country fluctuations in unobservable factors that might confound the estimation were addressed by including country fixed effects, γ_{0j}, and country-specific linear time trends, $\tau_t T$, denoting the interaction terms between country dummy variables and a time trend. The model in Equation (1) was estimated separately for each outcome using ordinary least squares with clustering of the standard errors by country. A number of robustness checks, including propensity score weighting and placebo models, were used to test model validity, as described in the subsequent section.

3. Results

We first examined the unadjusted trends in U.S. exports to countries in the EAP region as defined by World Bank regional definitions (Figure 1). Prior to 2003, early patterns across country groups exhibited similar fluctuations, with both trends rising during the late 1990s, dipping during the 1998 recession, recovering by 2000 and falling in the aftermath of the 2001 terrorist attacks. By the time of the 2003 SARS outbreak, U.S. exports were on the rebound for both country groups, while after the outbreak their trends showed increased divergence as the aggregate value of U.S. exports to the SARS country group outpaced other countries in the region (Table I).

Figure 1. Aggregate U.S. merchandise exports to countries in the East Asia and Pacific (EAP) region, 1990-2015, by SARS country group.



Note: The comparison country group includes Australia, Brunei, Cambodia, Fiji, Indonesia, Japan, Kiribati, Laos, Malaysia, Marshall Islands, Macao, Micronesia, Mongolia, Myanmar, New Zealand, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, South Korea, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, Vietnam.

Table I. Sample descriptive values of U.S. merchandise exports and U.S. jobs, by SARS country group.

	SARS country group (China, Taiwan, Hong Kong, Singapore)		Comparison country group (27 remaining EAP countries)		China	
	2003	2015	2003	2015	2003	2015
Total value of U.S. merchandise exports, constant 2016 USD (billions)	96.70	206.88	151.58	179.91	36.51	116.48
Agriculture and livestock products (% of merchandise exports)	8.2%	10.0%	8.3%	8.6%	14.7%	14.9%
Oil, gas, minerals and ores (% of merchandise exports)	0.3%	1.3%	0.6%	1.7%	0.6%	1.9%
Manufacturing products (% of merchandise exports)	88.2%	83.9%	89.8%	88.0%	77.7%	77.3%
Other (% of merchandise exports)	3.3%	4.8%	1.3%	1.7%	7.0%	6.0%
Total number of U.S. jobs supported by exports	577,198	976,711	971,378	931,856	229,387	601,410

Sources: Author calculations using data from the U.S. Department of Commerce, International Trade Administration, Trade Policy Information System; and Rasmussen and Xu (2016).

Table II. Unadjusted and regression-adjusted average annual differences in U.S exports and U.S. exports-supported jobs between pre-2003 and 2003, by SARS country group.

	1990-2002	2003	Unadjusted difference	p-value	Adjusted difference§	p-value
U.S. exports, annual country average value, constant 2016 USD (billions)						
SARS country group (China, Taiwan, Hong Kong, Singapore)	20.66	24.18	3.52	0.416	-7.46**	0.001
Comparison country group (27 remaining EAP countries)	6.37	5.61	-0.76	0.790	-0.21	0.821
	1999-2002	2003	Unadjusted difference	p-value	Adjusted difference	p-value
U.S. jobs, annual country average number						
SARS country group (China, Taiwan, Hong Kong, Singapore)	147,541	144,300	-3,241	0.917	-21,122***	0.000
Comparison country group (27 remaining EAP countries)	43,234	35,977	-7,257	0.727	-5,824	0.136

Notes: * Statistically significant at the 10% level, ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.
§ Estimates obtained from difference-in-differences linear models with controls for U.S. currency value index, country GDP per capita relative to U.S., country CPI relative to U.S., country fixed effects and country-specific time trends.

To tease out SARS-2003 effects from the contemporaneous dominating influence of observed and unobserved factors that shape international commerce, we employed a regression model estimating the covariate-adjusted change in U.S. exports in 2003 and thereafter for the group of primary SARS countries (China, Taiwan, Hong Kong, Singapore) relative to 27 remaining EAP countries, after controlling for country heterogeneity through country fixed effects and country-specific time trends. The regression-adjusted annual difference between the pre-SARS period (1990-2002) and year 2003 revealed a statistically significant reduction in the average 2003 U.S. exports to SARS-affected countries but no significant reduction for unaffected EAP countries (Table II).

Table III shows the estimated 2003 average treatment effects on exports to countries in the SARS country group relative to the group of comparison EAP countries. The average relative reduction in U.S. exports associated with the 2003 outbreak was estimated to be USD 7.245 billion (95% confidence interval (CI) 2.570-11.920 billion) per country, for a total of USD 29 billion (CI 10.280-47.680 billion) for the afflicted group of countries. Most of this reduction (86%) was estimated to have occurred in the U.S. manufacturing sector, whereas the U.S. agricultural sector and other sectors were not significantly affected. The corresponding relative loss of U.S. jobs was approximately 15,300 (CI 2,500-28,000) per country, for a total of approximately 61,200 (CI 10,000-112,000) jobs that would have occurred in the absence of the 2003 outbreak. The estimator of average treatment effects on either exports or jobs after 2003 was not statistically significant, indicating that outbreak-associated losses might not have persisted after the end of the outbreak.

Table III. Estimates from difference-in-differences models of U.S. merchandise exports to East Asia Pacific countries.

	U.S. merchandise exports[§]					U.S. jobs[§§]
Covariate name	Total	Agricultural & livestock	Oil, gas, minerals & ores	Manufacturing	Other	
SARS country	8.244**	3.077***	0.327***	4.313*	0.508	-320,348.1***
	(3.304)	(0.548)	(0.077)	(2.254)	(0.472)	(16,417.8)
2003	-0.211	-0.012	-0.036	-0.192	0.030	-5,824.5
	(0.925)	(0.069)	(0.032)	(0.835)	(0.025)	(3,799.9)
Post-2003	-1.284	-0.383	-0.074	-0.774	-0.045	-8,632.3*
	(2.081)	(0.281)	(0.052)	(1.793)	(0.103)	(4,625.9)
SARS country*2003	-7.245***	-0.646	-0.165	-6.238***	-0.198*	-15,297.5**
	(2.289)	(0.464)	(0.166)	(1.728)	(0.115)	(6,261.3)
SARS country*Post-2003	0.241	0.205	-0.036	-1.013	1.073	-4,263.7
	(3.026)	(0.386)	(0.036)	(2.024)	(0.911)	(8,633.6)
N	729	729	729	729	729	516

Notes: The SARS country group includes four countries experiencing 95% of SARS-2003 cases: China, Taiwan, Hong Kong, Singapore. The comparison group includes 27 remaining East Asia Pacific countries with limited or no SARS transmission (Australia, Brunei, Cambodia, Fiji, Indonesia, Japan, Kiribati, Laos, Malaysia, Marshall Islands, Macao, Micronesia, Mongolia, Myanmar, New Zealand, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, South Korea, Thailand, Timor-Leste, Tonga, Tuvalu, Vanuatu, Vietnam)

Estimates obtained from linear models with clustering by country. All models include country fixed effects and control for country-specific time trends (not shown). All models control for U.S. currency value index, partner country GDP per capita relative to U.S., partner country CPI relative to U.S. (not shown). Standard errors in parentheses.

§ Models of U.S. exports are based on data for 1990-2015. Coefficients represent average annual change per country, in constant 2016 USD (billions), from a unit change in the corresponding indicator.
§§ Model of U.S. jobs is based on data for 1999-2015. Coefficients represent the annual change in the average number of jobs per country from a unit change in the corresponding indicator.
* Statistically significant at the 10% level, ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.

To explore the validity of the estimation approach, we conducted a number of robustness checks, whose results are listed in Table IV. First, we tested the assumption of comparability between the SARS country group and the comparison country group by employing a version of the model with propensity score weighting - an approach where the groups are balanced across a set of characteristics through a propensity scoring adjustment (Stuart et al., 2014). This model confirmed the implications of our original estimates, while also spreading out the estimated SARS effects over a longer time period. Next, we employed a falsification test where we artificially shifted the outbreak year to 2000, a "placebo" year without major health or other disruptions. This test revealed that SARS countries experienced no significant difference in exports trends compared to other EAP countries in the placebo year, strengthening the assumption that the original estimates were not a reflection of a preexisting pattern. Finally, we employed a falsification test where we artificially assigned a "placebo" SARS-2003 status to EAP countries that in fact reported zero SARS cases – Cambodia, Myanmar, Laos and Japan. This test confirmed that no concurrent 2003 effects were observed for the placebo countries, strengthening the assumption that the original estimates were not a spurious regional change in exports that merely coincided with the outbreak. The robustness checks help to support the implications of the baseline analysis.

Table IV. Summary of estimates from robustness checks.

	Main model	Robustness check: use propensity score weighting of country groups	Robustness check: introduce pseudo-SARS timing that precedes the actual outbreak	Robustness check: introduce pseudo-SARS countries
Covariate name	(1)	(2)	(3)	(4)
SARS country group	8.244**	4.066*	8.935**	69.034***
	(3.304)	(2.186)	(3.691)	(2.399)
2003	-0.211	-0.061	2.362*	0.324
	(0.925)	(1.070)	(1.174)	(0.700)
Post-2003	-1.284	-1.822	0.901	0.551
	(2.081)	(2.052)	(1.759)	(1.590)
SARS country group * 2003	-7.245***	-5.845***	-8.007	-4.254
	(2.289)	(1.425)	(6.856)	(3.752)
SARS country group * Post-2003	0.241	-2.989*	-11.324*	-4.329
	(3.026)	(1.581)	(5.555)	(3.350)
N	729	729	729	625

Notes:
(1) Main DD model. Same as reported in Table III.
(2) DD model same as main model where observations in each country group are weighted using propensity scores, increasing group similarity on a set of observed characteristics including country GDP per capita, country consumer price index, and country population.

(3) DD model where a pseudo-outbreak year is set to 2000.
(4) DD model where a pseudo-SARS country group is set to four countries with no recorded 2003 SARS cases: Cambodia, Myanmar, Laos, Japan.
Estimates obtained from linear models with clustering by country. All models include country fixed effects and control for country-specific time trends (not shown). All models control for U.S. currency value index, partner country GDP per capita relative to U.S., partner country CPI relative to U.S. (not shown). Standard errors in parentheses.
* Statistically significant at the 10% level, ** Statistically significant at the 5% level, *** Statistically significant at the 1% level.

4. Concluding remarks

This study is the first to assess the link between the 2003 SARS epidemic and select U.S. indicators, indicating that a regional public health emergency may influence economic outcomes in unaffected countries by inhibiting international trade. We estimated that the 2003 outbreak of SARS in the EAP region was associated with a relative reduction in U.S. exports to SARS-afflicted countries compared to unafflicted countries in the region, and with a corresponding loss in U.S.-based jobs. These findings are consistent with the conclusions from a prior analysis of the 2014 Ebola outbreak in West Africa, reinforcing the implication that distant epidemics have the capacity to influence U.S. indicators even when they remain localized, at least for their duration.

In 2003, as today, the largest share of U.S. merchandise exports to China came from the manufacturing sector (e.g. vehicles, aircraft), which was also the sector that experienced the largest relative slowdown in exports during the SARS outbreak. Smaller shares belonging to the U.S. agricultural and other sectors were not significantly affected by the outbreak, pointing to vulnerabilities specific to manufacturing exports. In a hopeful sign, outbreak-specific effects appeared to wane after 2003, indicating a potential for relatively quick trade recovery following health shocks as aggregate demand rebounds in importing countries.

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