The Economic Effects of COVID-19 Containment Measures

AEA MEETINGS

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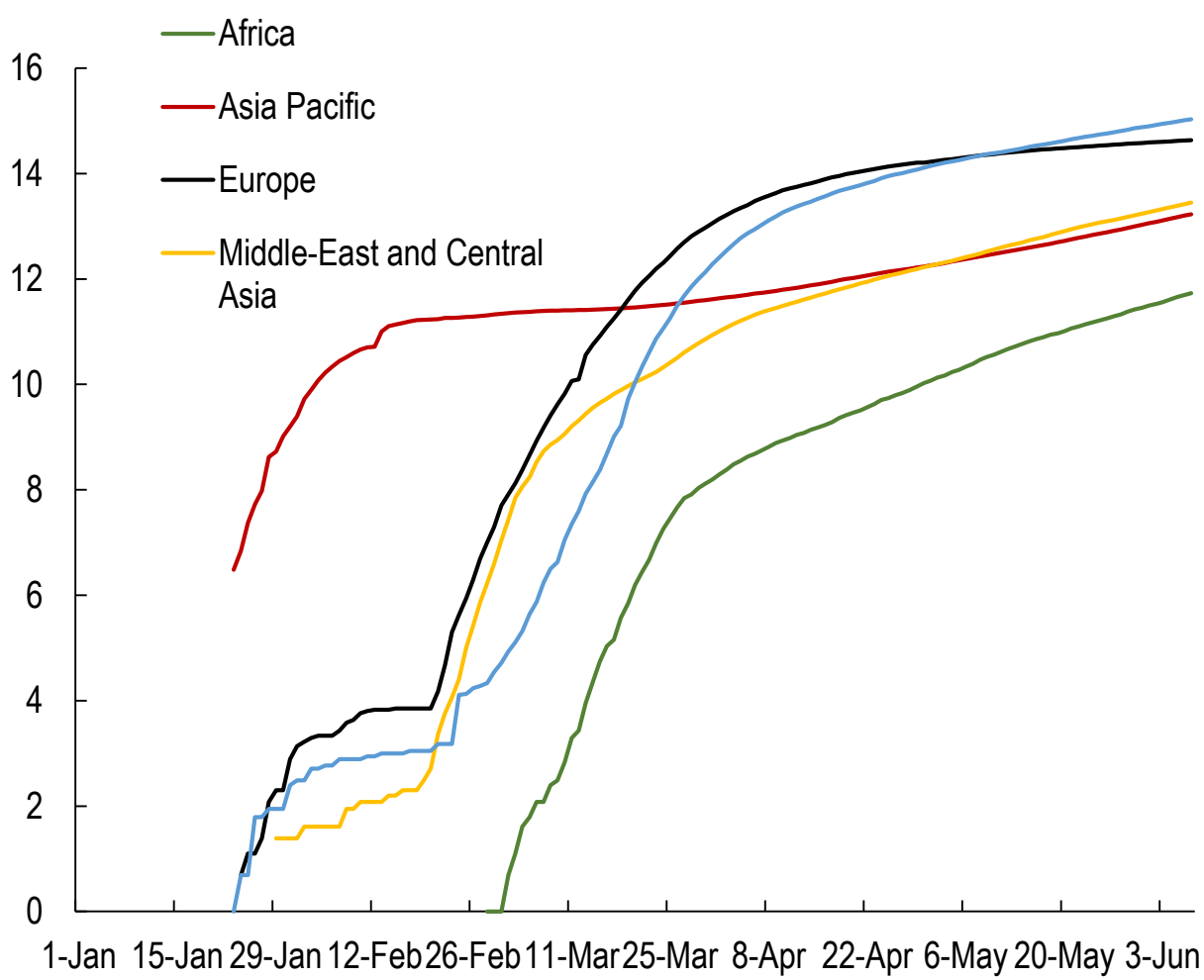
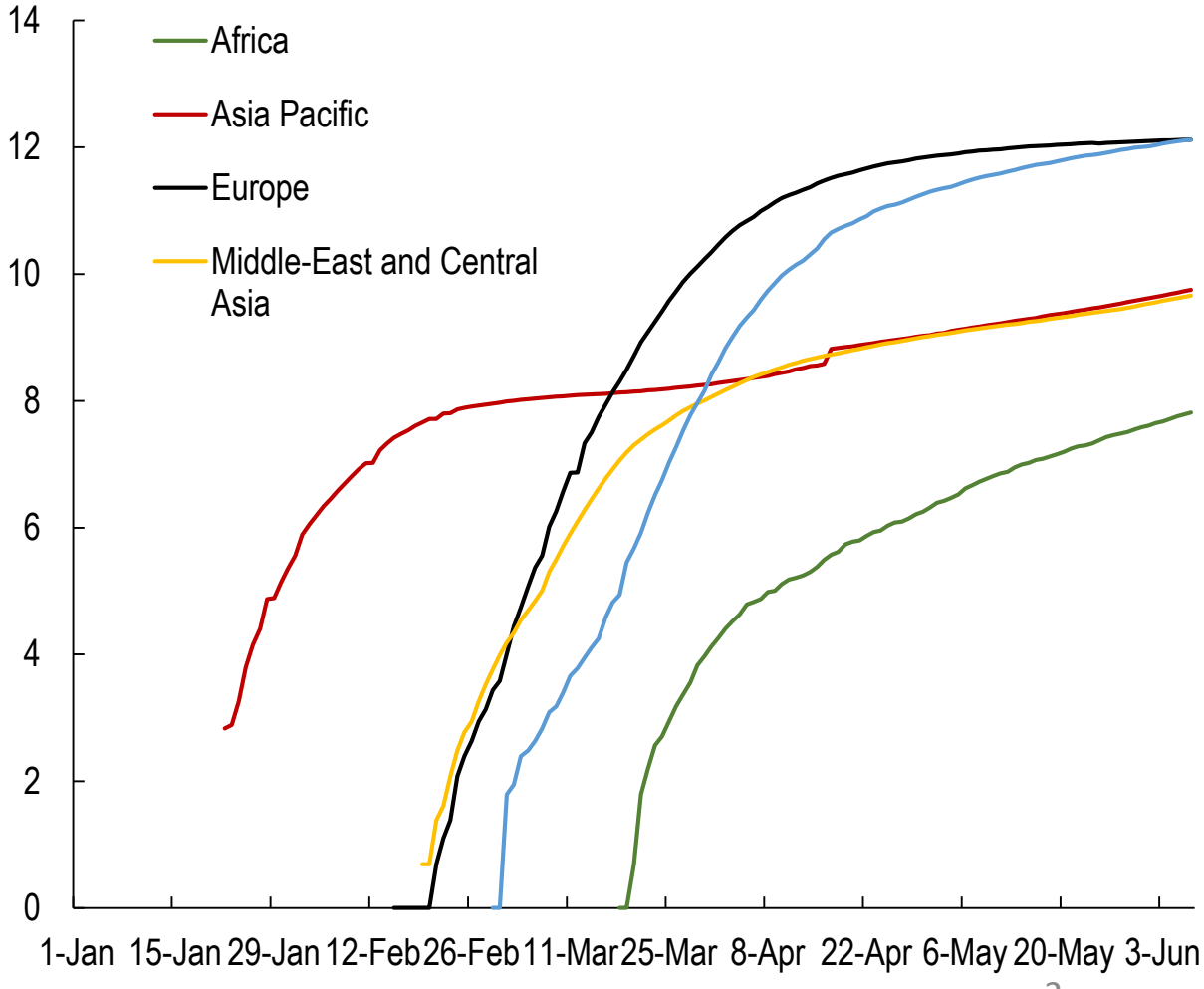
COVID-19 has spread to more than 200 countries and territories…

COVID-19 Infections, by Region
(logs)



Sources: JHU Coronavirus Resources Center, OxCGRT, and IMF staff calculations

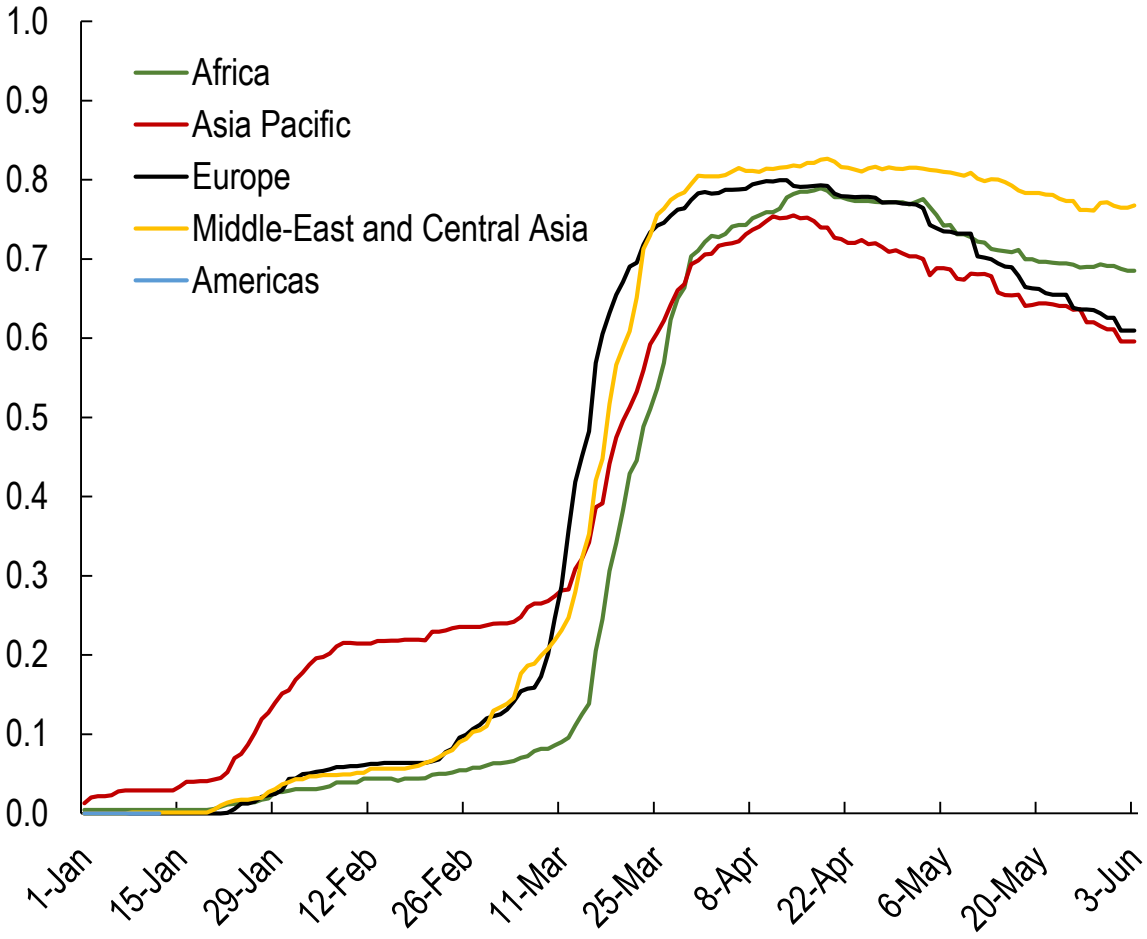
COVID-19 Fatalities, by Region
(logs)



Sources: JHU Coronavirus Resources Center, OxCGRT, and IMF staff calculations

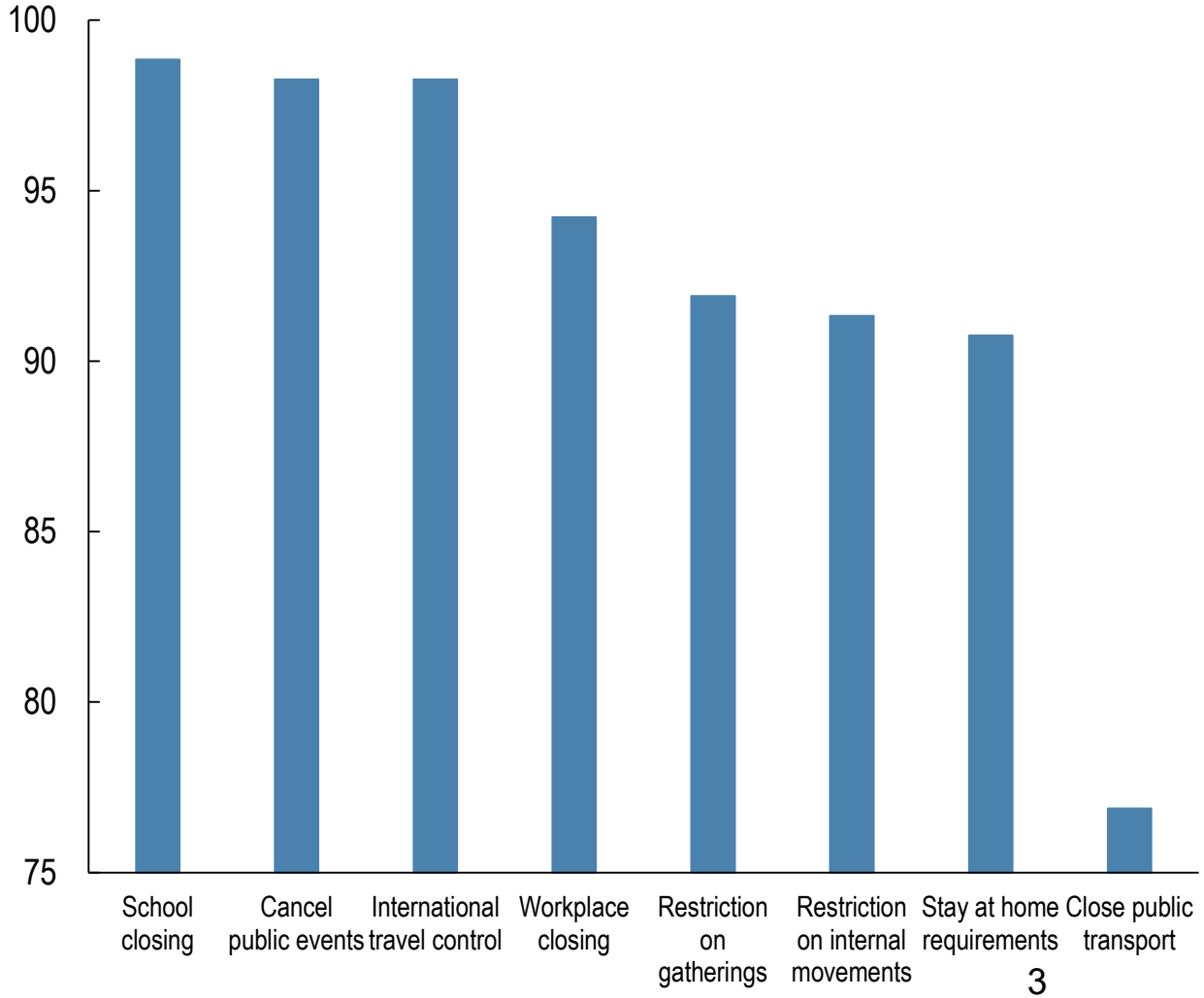
…prompting them to enact containment and mitigation measures…

Stringency of Containment Measures
(0 to 1, 1 = strictest)



Sources: OxCGRT, and IMF staff calculations

Containment Measures Implemented by Countries, by Type
(percent)



Sources: OxCGRT, and IMF staff calculations.

Research questions

- What have been the economic effects of containment measures?
- Has macroeconomic stimulus mitigated these effects?
- How do these effects vary across containment measures?

Data

- **COVID-19 infections and deaths** from the COVID-19 Dashboard from the Coronavirus Resource Center of Johns Hopkins University, for 208 countries.

- **COVID-19 containment measures** from Oxford's COVID-19 Government Response Tracker (OxCGRT) for 151 countries. Cross checked with SPR policy dataset.

- **High-frequency indicators of economic activity:**
  - **Nitrogen Dioxide (NO2)** emissions from Air Quality Open Data Platform, for 62 countries.
  - Domestic and international flight from FlightRadar24, for over 200 countries.
  - Maritime indices of imports and exports from Cerdeiro, Komaromi, Lui and Saeed (2020), for 22 countries.
  - Energy consumption from ENSTOE, for 35 countries.
  - Retail and transit mobility, from Google's Mobility Reports, for 75 countries.

- **Macro policy measures** from the IMF's policy tracker for 195 countries:
  - Fiscal stimulus: announced and implemented fiscal packages.
  - Monetary policy actions: changes in policy rates implemented in response to the COVID-19 pandemic.

Nitrogen Dioxide (NO2) Emissions and economic activity (yearly historical data 1990-2018)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
GDP growth	0.341**	0.326*	0.307*						
	(2.147)	(1.942)	(1.865)						
Manufacturing VA growth				0.130***	0.134***	0.135***			
				(3.347)	(3.426)	(3.334)			
IP growth							0.203*	0.201**	0.206**
							(2.028)	(2.166)	(2.381)
Time trend	-0.001***	-0.001	0.000	-0.002***	-0.001**	-0.001	-0.002**	0.000	0.001
	(-3.353)	(-1.520)	(0.770)	(-3.352)	(-2.086)	(-1.046)	(-2.348)	(0.638)	(0.919)
Average temperature		-0.012***	-0.011**		-0.011***	-0.011**		-0.010**	-0.012**
		(-3.285)	(-2.521)		(-3.151)	(-2.628)		(-2.214)	(-2.537)
Urban population		-0.004			-0.004			-0.011**	
		(-1.335)			(-1.324)			(-2.088)	
Population Density			-0.001*			-0.001*			-0.002**
			(-1.920)			(-1.896)			(-2.097)
Income per-capita			0.000			0.000			-0.000
			(0.065)			(0.108)			(-1.200)
Log GDP			-0.056						
			(-1.601)						
Log Manufacturing VA						0.005			
						(0.295)			
Log IP									-0.042
									(-1.356)
Constant	-0.005	0.350*	1.763*	0.004	0.380*	0.101	0.006	0.913**	0.558**
	(-0.529)	(1.898)	(1.825)	(0.500)	(1.838)	(0.195)	(0.399)	(2.509)	(2.511)
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.061	0.082	0.086	0.051	0.074	0.076	0.058	0.100	0.092
Observations	929	863	828	852	789	775	623	568	566
No. of countries	36	36	36	36	36	36	30	30	30

Note. NO2 emission is thw dependent variable. Standard errors clustered at the country level in parentheses.
*** $\rho<0.01$, ** $\rho<0.05$, *** $\rho<0.1$.

Nitrogen Dioxide (NO2) Emissions and economic activity (monthly post-COVID data)

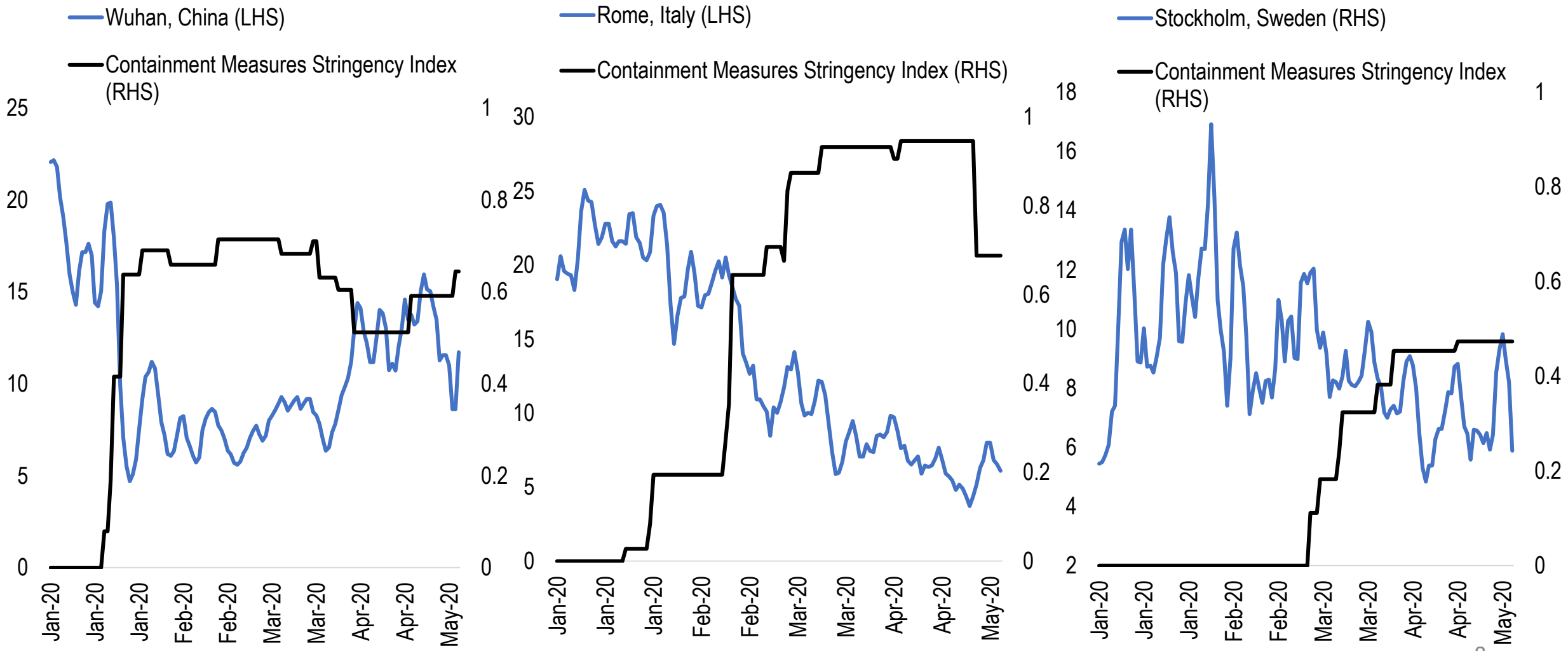
	Industrial Production (percent)	NO_2 emissions (percent)
Variables		
NO_2 emissions (percent)	0.015** (0.006)	
Industrial Production (percent)		0.27* (0.151)
Constant	0.004*** (0.0003)	0.023*** (0.001)
Observations	421	421
R-Squared	0.016	0.005
Number of countries	38	38

Note. NO2 emission as dependent variable. Standard errors clustered at the country level in parentheses.
*** $\rho<0.01$, ** $\rho<0.05$, *** $\rho<0.1$.

Lockdowns and Nitrogen Dioxide (NO2) Emissions

NO2 Emissions and Stringency Indices, Selected Cities

(log (LHS), levels(RHS))



Sources: Air Quality Open Data Platform, OxCGRT, and IMF staff calculations.

Identification strategy

- **Establishing causality** is difficult because countries have introduced containment measures in response to the spread of the virus.

- **We try to address reverse-causality/endogeneity** by controlling for the change in the number of infected cases (deaths) the day before the implementation of containment measures.
  - Given implementation lags, the use of daily data allow us to control for the endogenous response of containment measures to the spread of the virus.
  - We control for other NPIs (masks, public campaigns, contract tracing and testing)
  - To account for country-specific (exponential) evolution of the pandemic, we also control for country specific linear, quadratic and cubic time trends.

- **Mobility and announcement/expectations** do not drive our results
  - Containment measures were announced before being implemented and therefore anticipated.
  - We control for changes in mobility
  - We examine the effect of travel restrictions—which are not preceded by changes in mobility and introduced in response of foreign outbreak

Empirical Framework

Local Projection methods by Jordà (2005) to estimate the dynamic cumulative effect of containment measures on the number of confirmed COVID-19 cases and deaths:

$$\Delta d_{i,t+h} = u_i + \theta_h c_{i,t} + X'_{i,t}\Gamma_h + \sum_{\ell=1}^{\mathcal{L}} \psi_{h,\ell}\Delta d_{i,t-\ell} + \varepsilon_{i,t+h} \qquad (1)$$

Where:

- $\Delta d_{i,t+h} = d_{i,t+h} - d_{i,t+h-1}$ and $d_{i,t}$ is the log NO2 emission (other economic indicators), in country i at date t
- $c_{i,t}$ denotes the Containment Stringency Index
- u_i are country-fixed effects to account for time-invariant country-specific characteristics
- X is a vector of control variables which includes lags of containment, mobility, other NPIs daily temperature and humidity levels, in addition to country-specific linear, quadratic and cubic time trends

Impulse response functions computed using the estimated coefficient θ_h.
Equation 1 is estimated for each day *h*=0,..,30
Robust standard errors clustered at the country level

Empirical Framework

Interactions to allow response to vary with countries characteristics estimated using smooth transition autoregressive model of Granger and Terävistra (1993)

$$\Delta d_{i,t+h} = u_i + \theta_h^L F(z_{i,t}) c_{i,t} + \theta_h^H (1 - F(z_{i,t})) c_{i,t} + X'_{i,t}\Gamma_h + \sum_{\ell=1}^{\mathcal{L}} F(z_{i,t})\, \psi_{h,\ell} \Delta d_{i,t-\ell} +$$

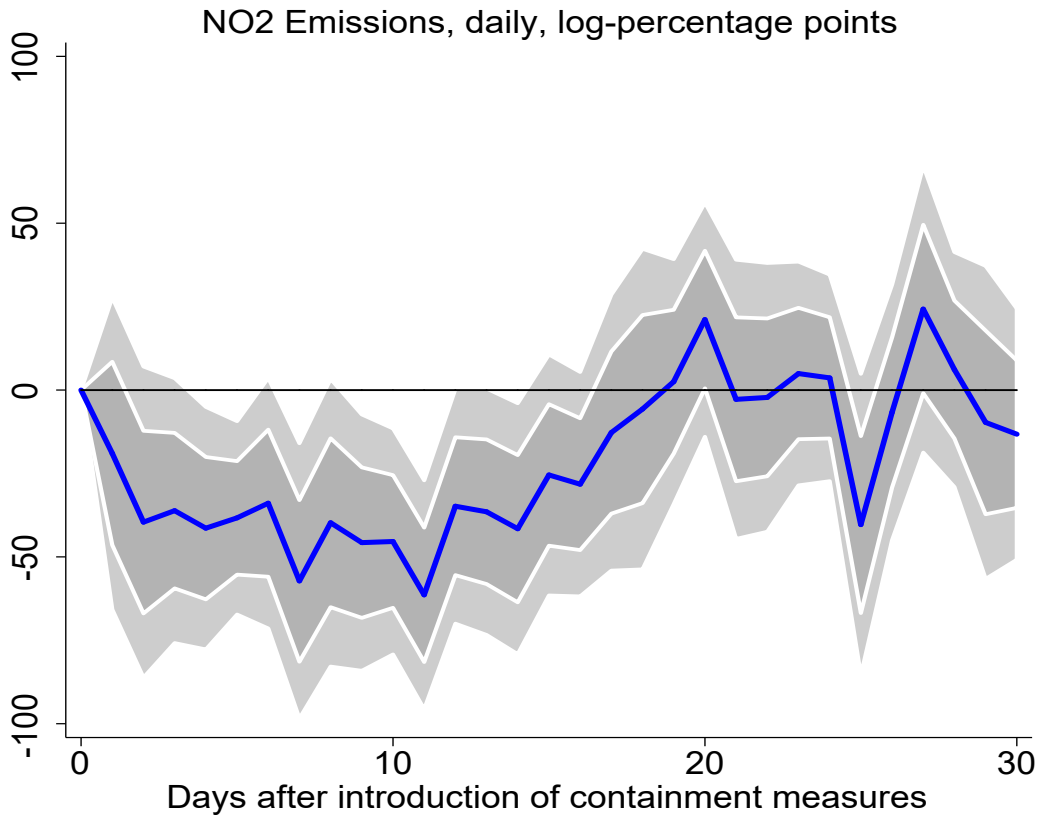
$$\sum_{\ell=1}^{\mathcal{L}} (1 - F(z_{i,t})) \psi_{h,\ell} \Delta d_{i,t-\ell} + \varepsilon_{i,t+h}$$

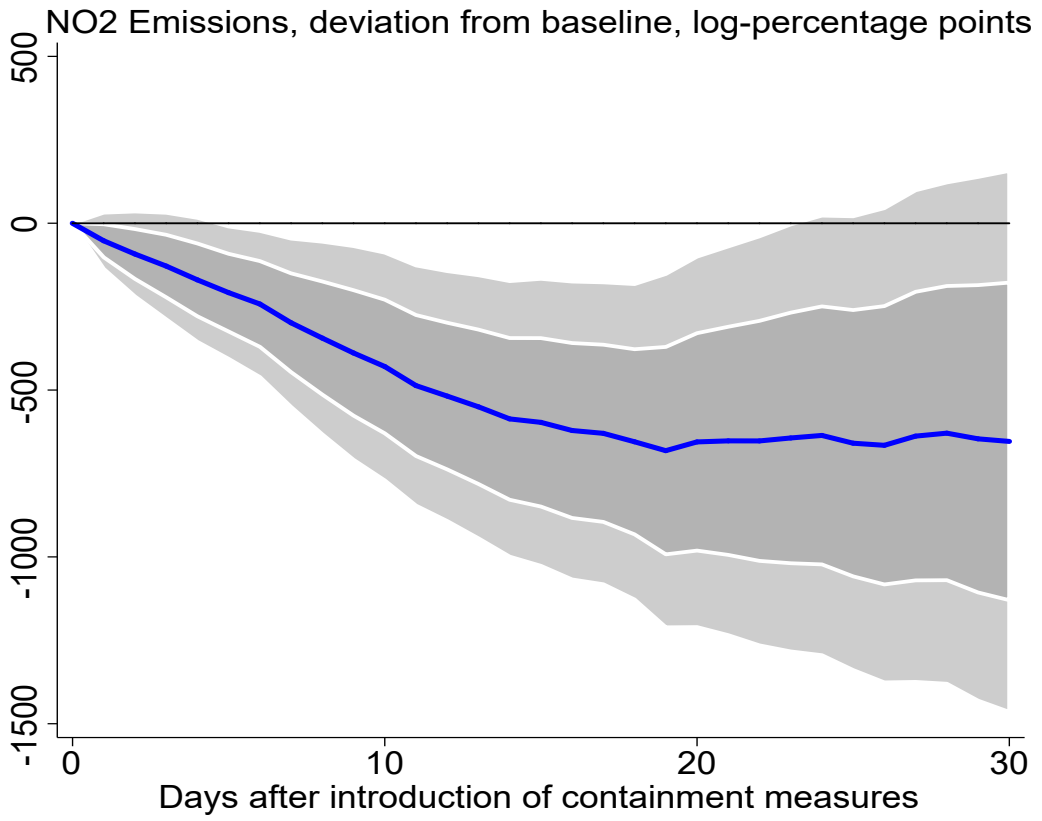
$$\text{with } F(z_{it}) = exp^{-\gamma z_{it}}/(1 - exp^{-\gamma z_{it}}), \quad \gamma > 0 \qquad (2)$$

where *z* is the country-specific stimulus, normalized to have zero mean and a unit variance.

- Weights assigned to each regime vary between 0 and 1 according to the weighting function $F(.)$, so that $F(z_{it})$ can be interpreted as the probability of being in a given "state" of the economy.
- The coefficients θ_h^L and θ_h^H capture the impact of containment measures at each horizon *h* in cases of very low levels of *z* ($F(z_{it}) \approx 1$ when *z* goes to minus infinity) and very high levels of *z* ($1 - F(z_{it}) \approx 1$ when z goes to plus infinity), respectively.

Effect of containment measures on NO2 emissions

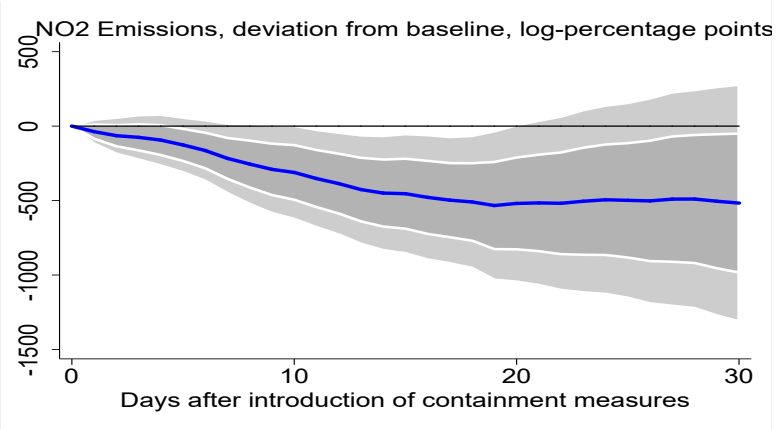




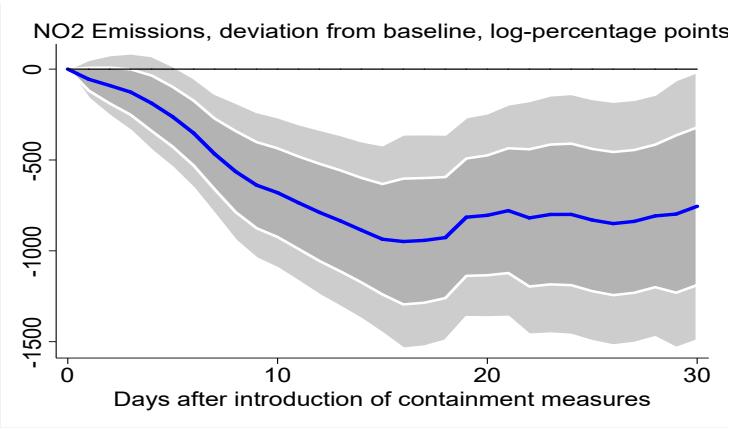
Note. Impulse response functions are estimated for a sample of 50 countries using daily data from January 1, 2020. The graph shows the response and confidence bands at 90 and 95 percent. The horizontal axis shows the response x days after the containment measures.

Robustness checks

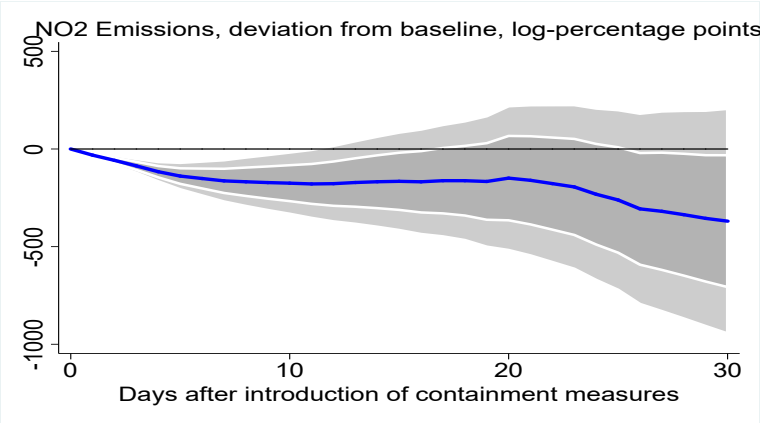
(a): With Time-Fixed Effects



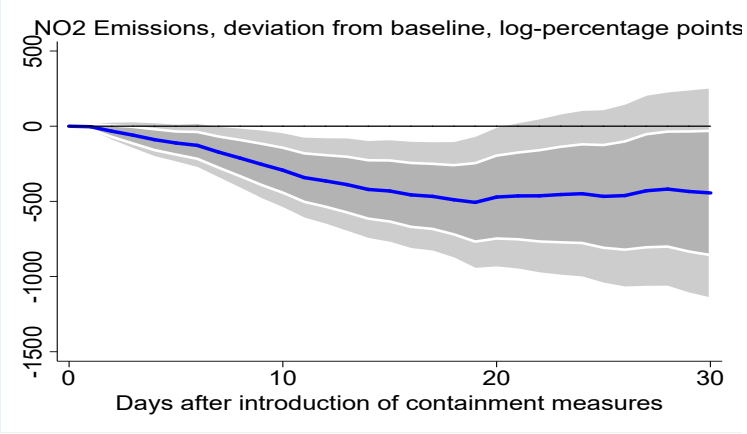
(b): With data restricted to lockdown periods onl



(c): With leads of Stringency Index



(d): With Contemporaneous NO_2 emissions



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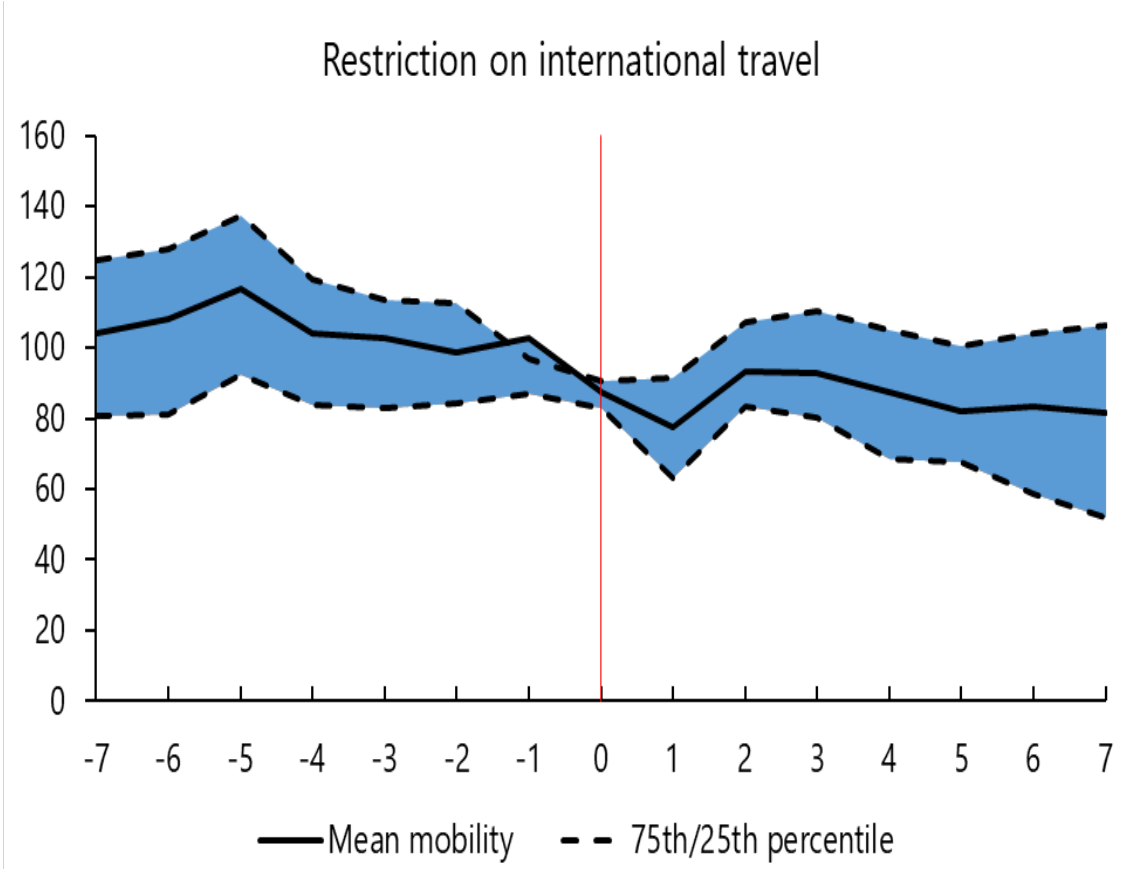
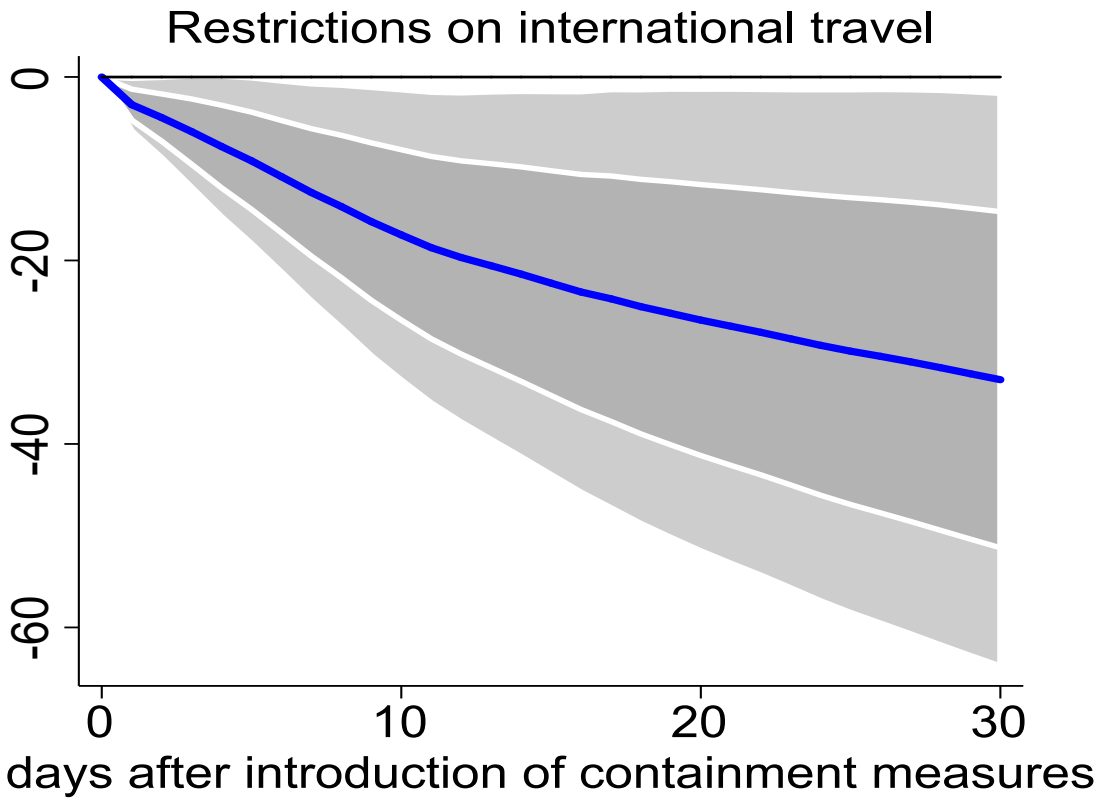
Effect of international travel restrictions on NO2

Mobility and International travel restrictions



Sources: Apple Mobility Indices, OxCGRT Stringency Index and IMF Staff calculations. An index =100 suggest no decline in mobility compared to trend. X-axis denote days.

International travel restrictions and NO2



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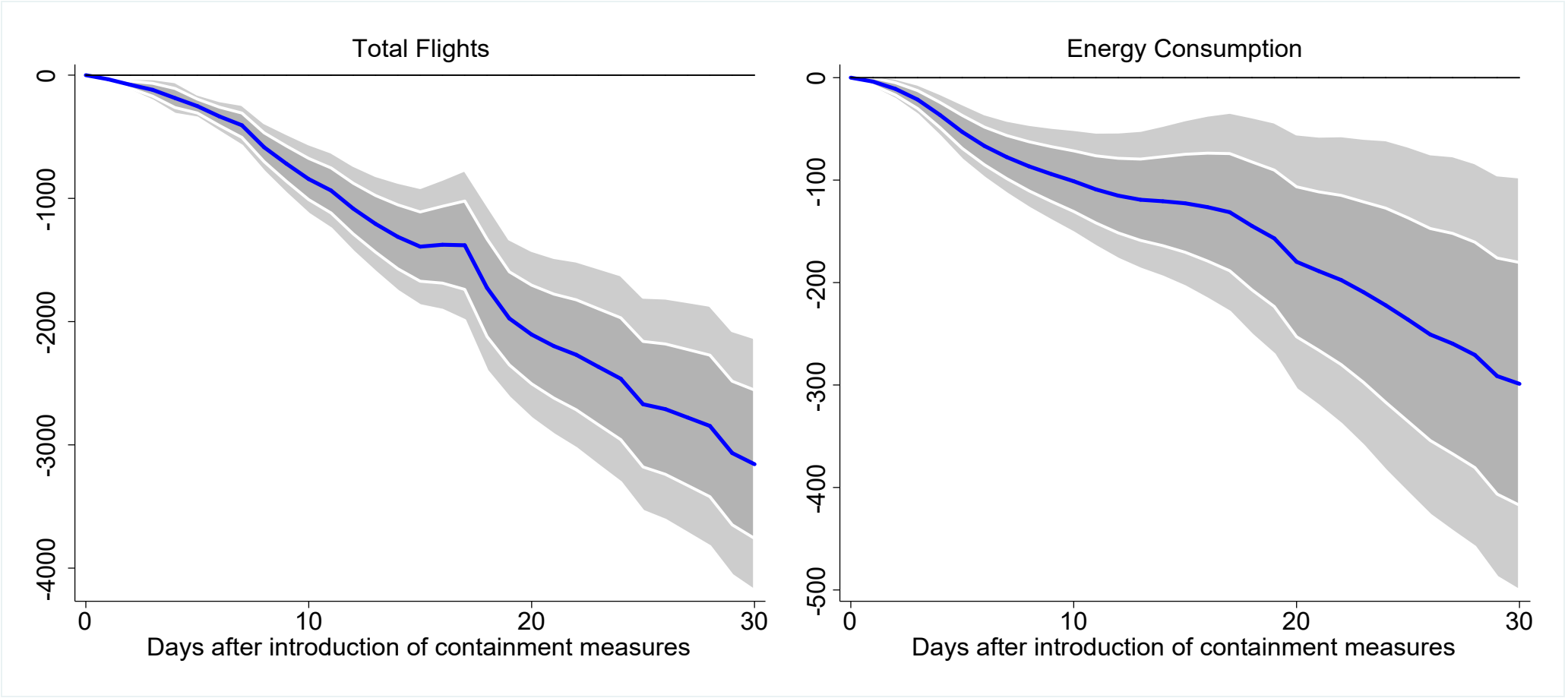
Alternative indicators



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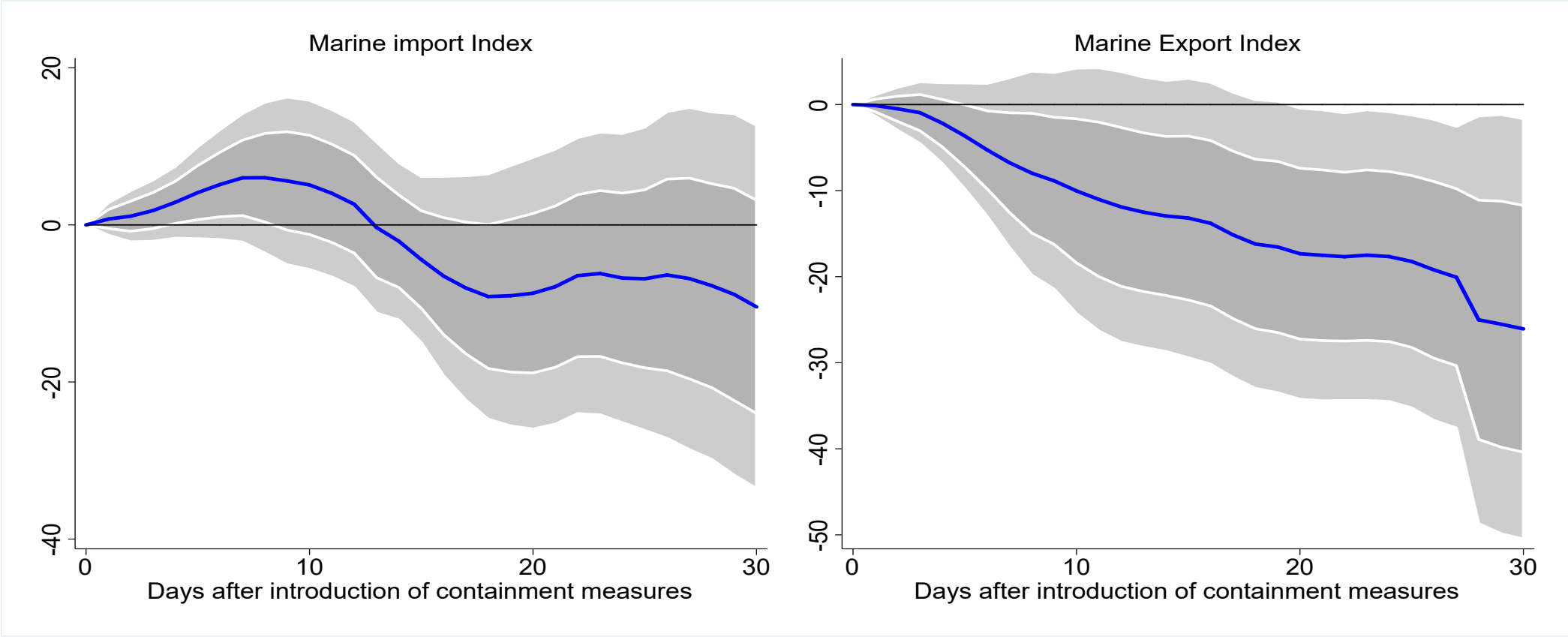

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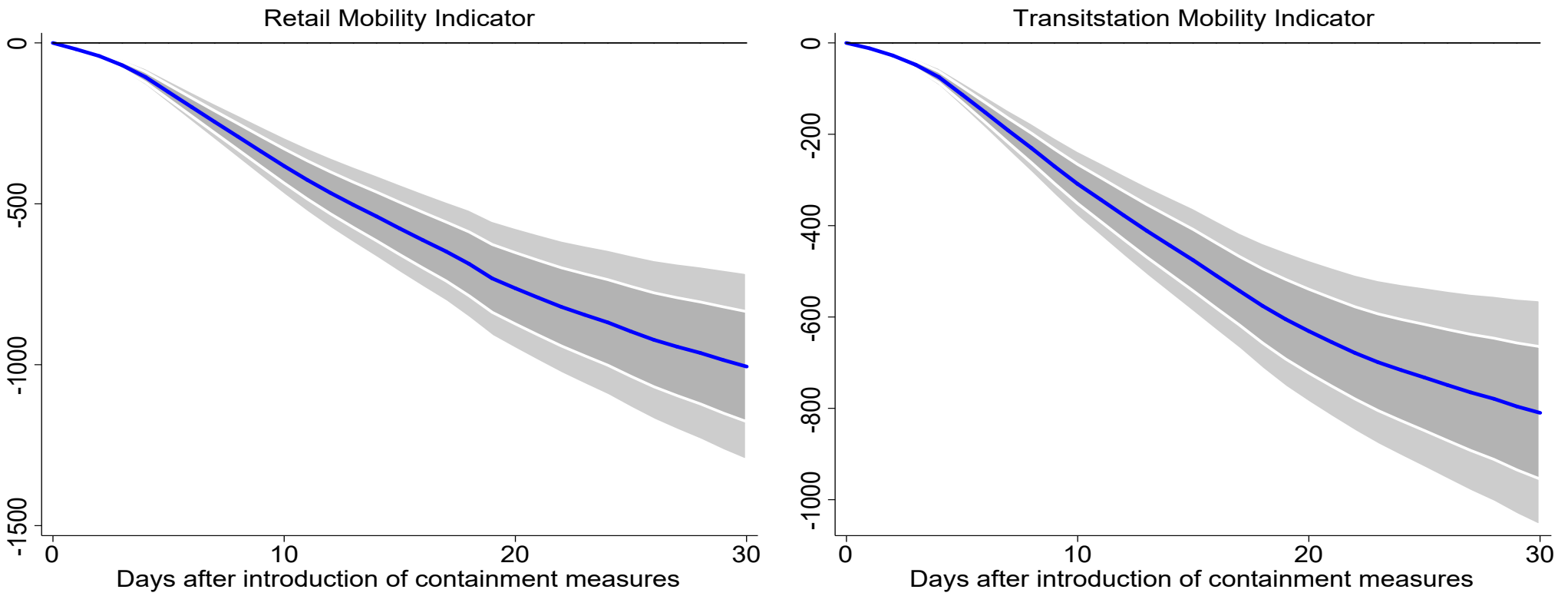
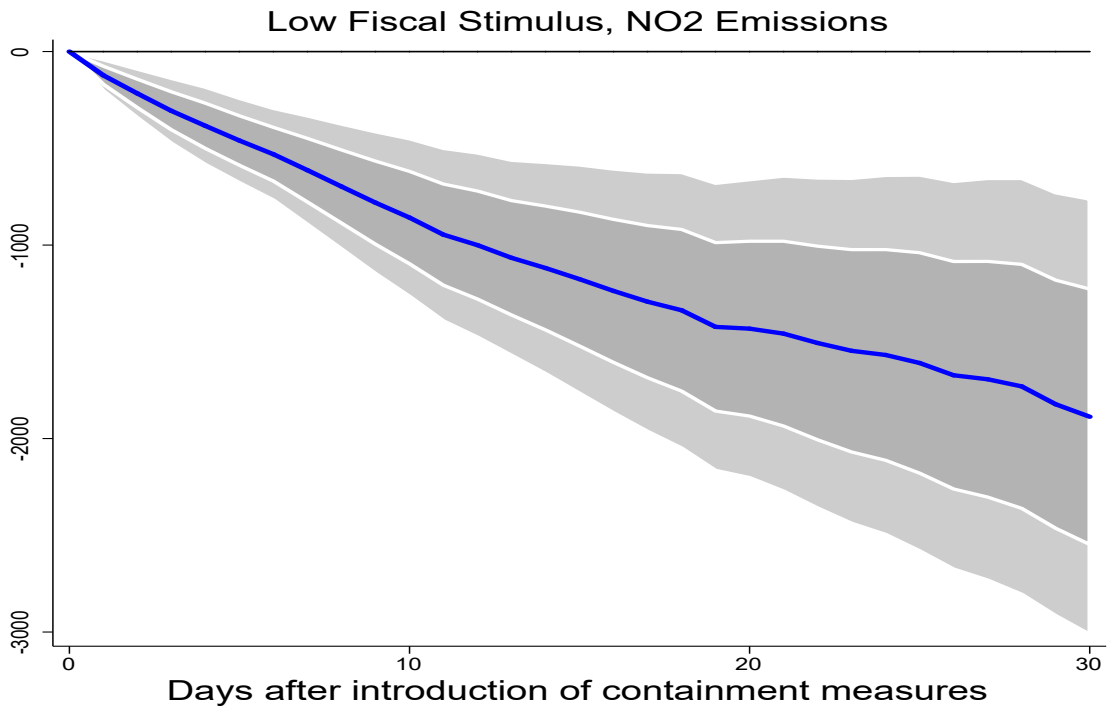


Note. Impulse response functions are estimated for a sample of 50 countries using daily data from January 1, 2020. The graph shows the response and confidence bands at 90 and 95 percent. The horizontal axis shows the response x days after the containment measures.

Fiscal policy to mitigate economic fallout

Low Fiscal Stimulus: Effect of Containment Measures on NO2 Emissions
*(deviation from the baseline, log-differences*100)*



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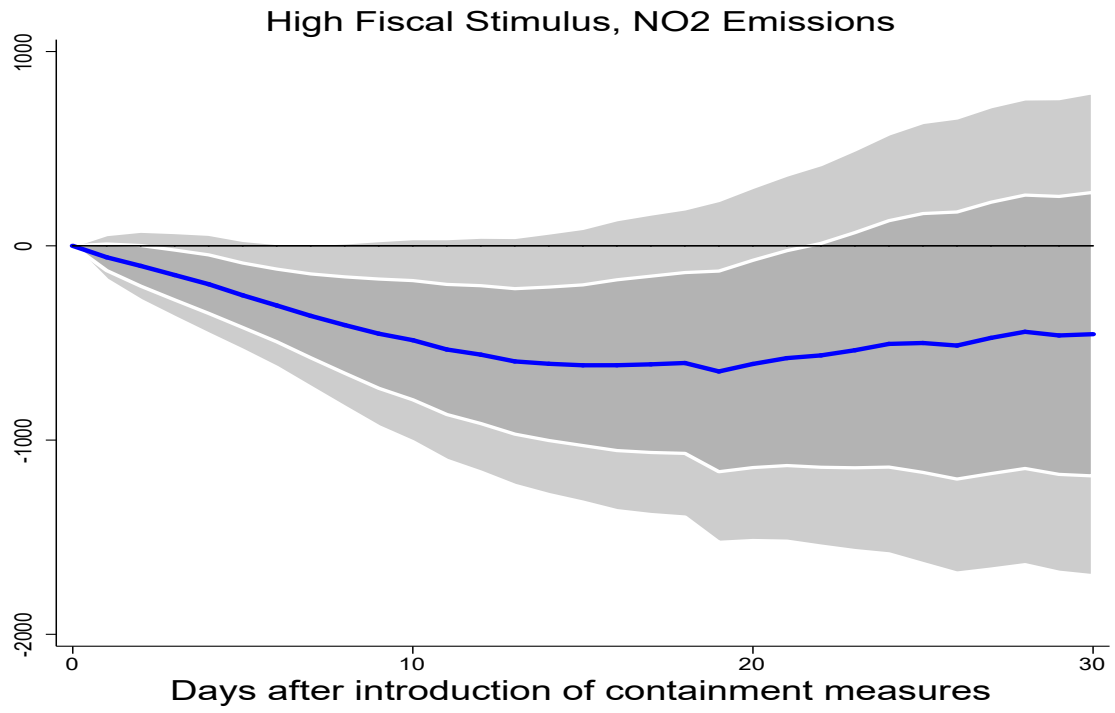


Trade-offs across measures

Cumulative effect of containment measure, 30 days after its introduction (log-percentage points)

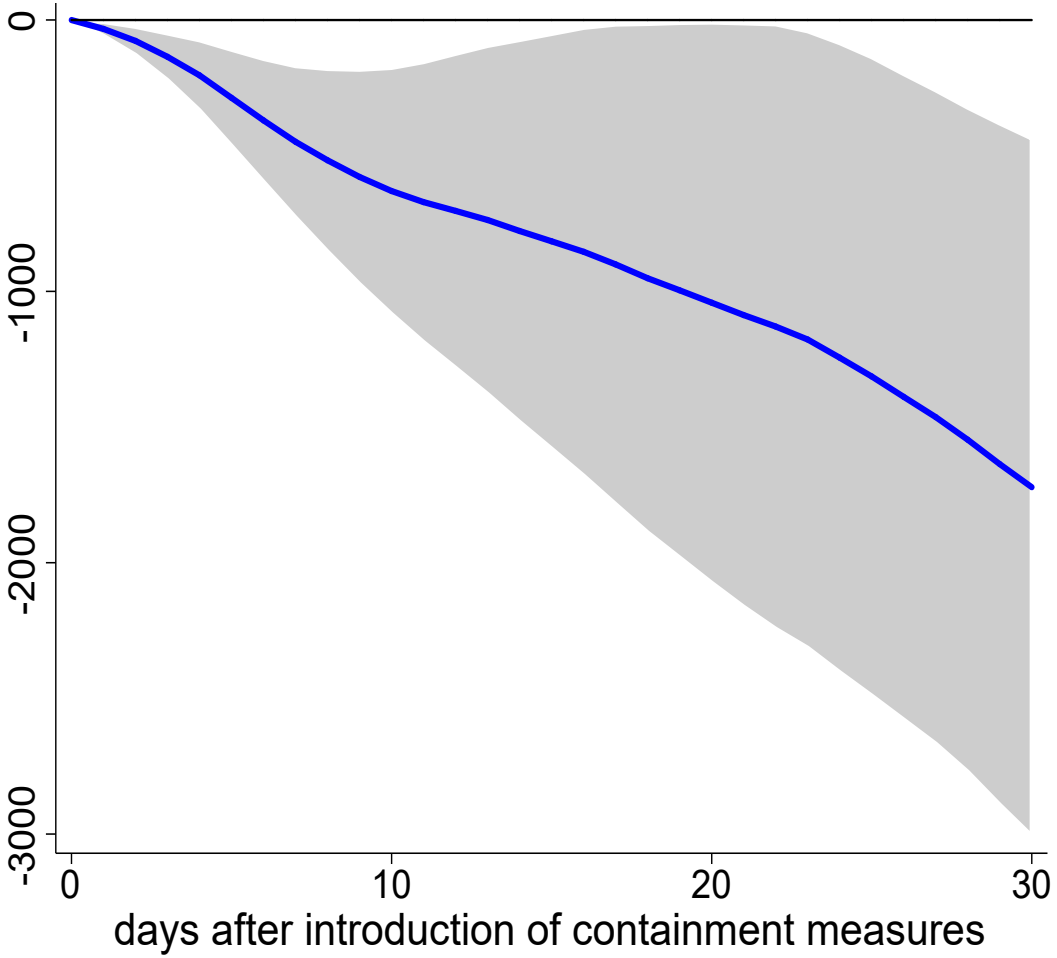
	Confirmed Cases	NO_2 emissions
School Closures	-103	-191
Workplace Closures	-81	-256
Cancellation of Events	-77	-1*
International Travel Restrictions	-77	-283
Stay-at-Home Requirements	-74	-286
Bans on Public Gatherings	-56	-128
Restrictions on Internal Movement	-50	-174
Closures of Public Transport	-49	-328

Note: The results denote the cumulative local projection response to NO_2 emissions and confirmed cases to each type of containment measure. * denotes that results are **not** significant at the 90 percent level 30 days after the introduction of containment measures

Monetary policy to mitigate economic fallout

Low Policy Rate Cuts: Effect of Containment Measures on NO2 Emissions

*(deviation from the baseline, log-differences*100)*



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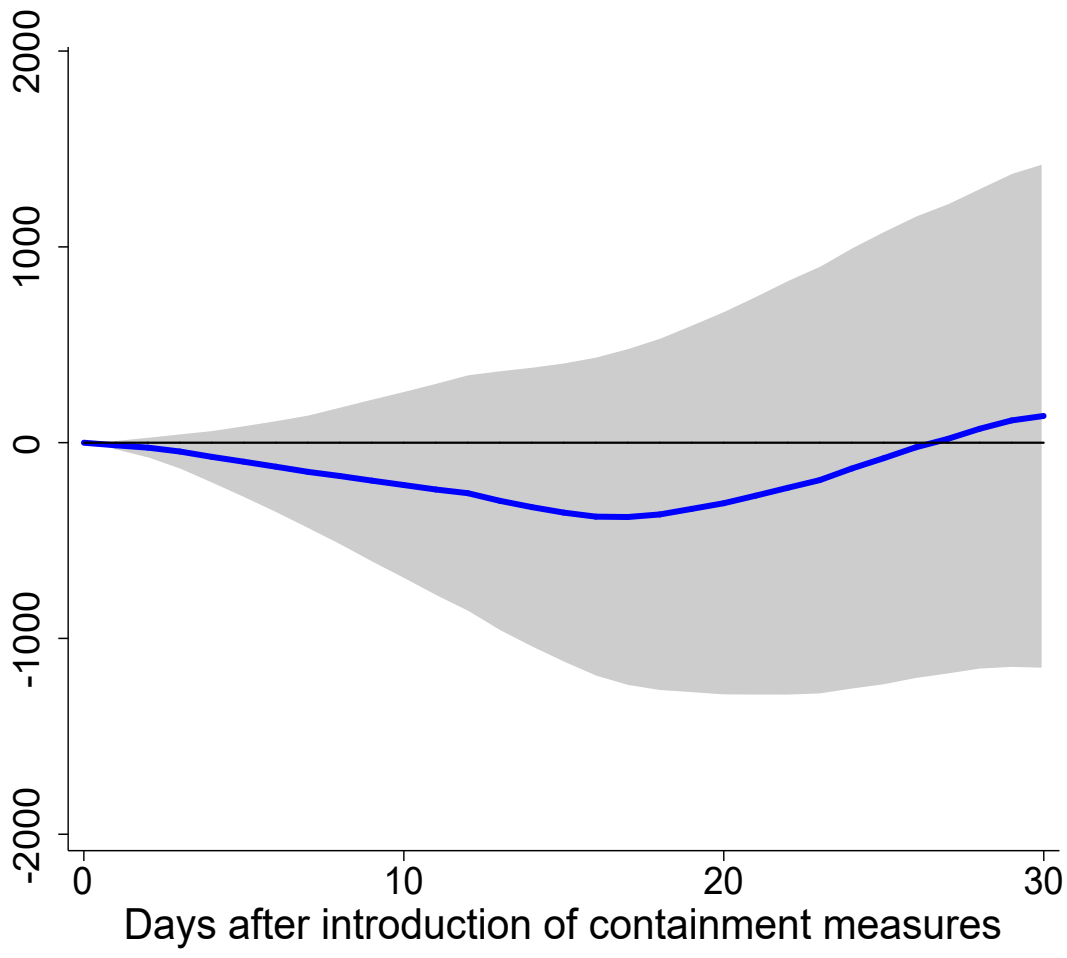
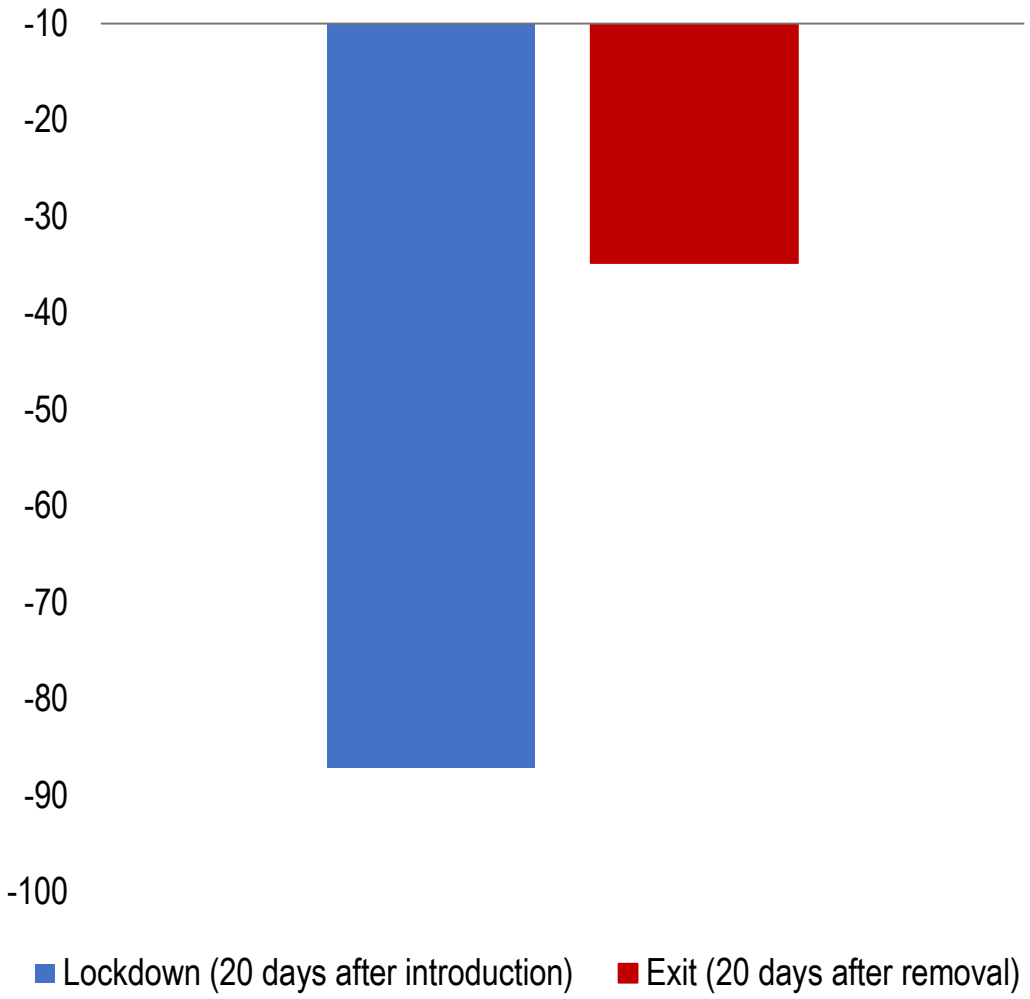
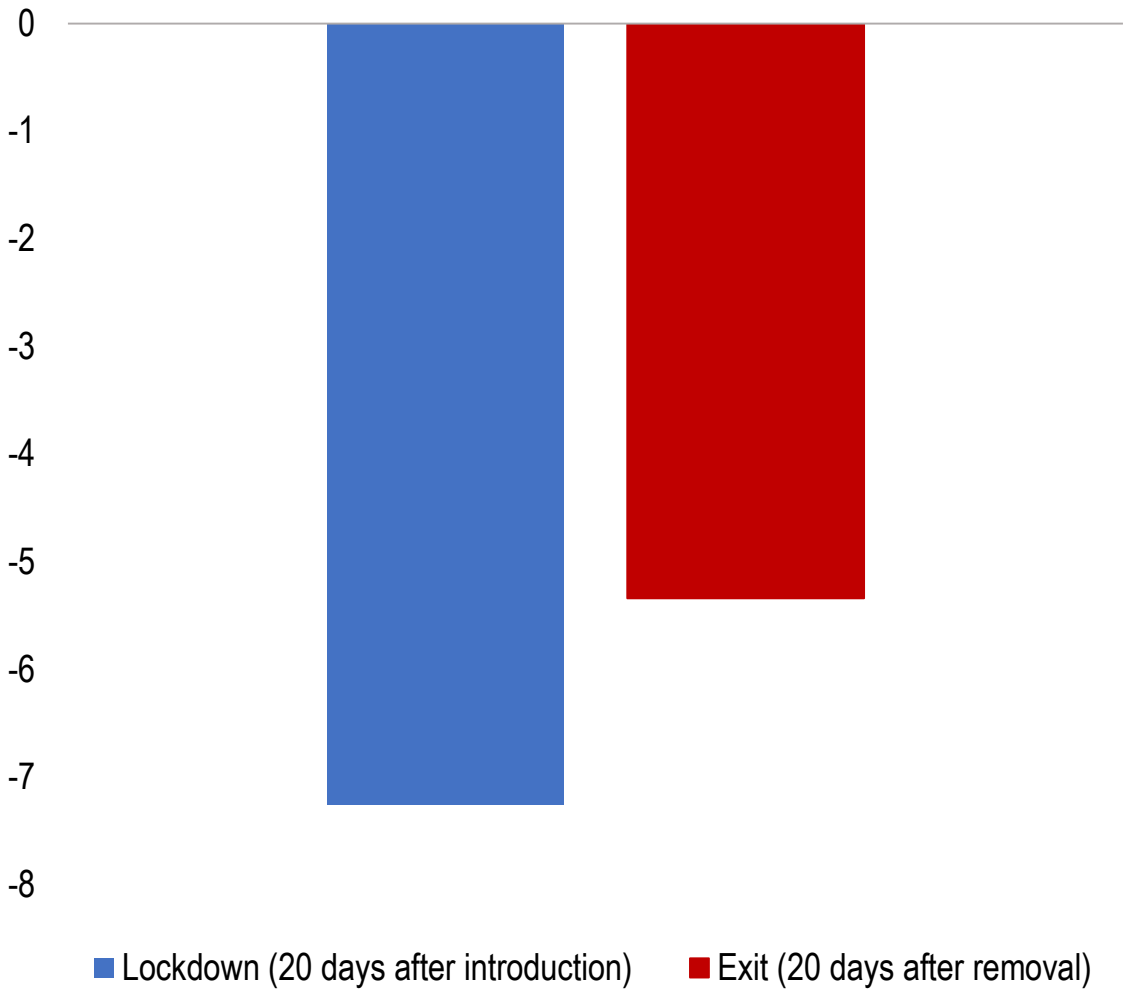


Life after the lockdown

COVID-19 Confirmed Cases
(deviation from the baseline, percent)



Implied Industrial Production Effects
(percent)



Conclusions

- Containment measures have had, on average, very large impacts on NO2 emissions, equivalent to a loss of about 10 percent in industrial production over the 30-day period following the implementation of containment measures

- Fiscal measures used during the COVID-19 crisis played an important role in mitigating the impact of containment measures on economic activity

- School closures and cancellation of public events are the most effective in curbing COVID-19 infections and are less costly in terms of their impact on economic activity. However, other highly effective containment measures, such as workplace closures and restrictions on international travel, are among the costliest measures in economic terms.