The Global Macroeconomic Impacts of COVID-19: Seven Scenarios

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18 May 2020

Presentation to CEPR Network on Macroeconomic Modelling and Model Comparison (MMCN) and the Macroeconomic Model Comparison Initiative supported by the IMFS at Goethe University Frankfurt and the Hoover Institution at Stanford University.

Based on

- McKibbin W. and R. Fernando (2020) “The Global Macroeconomic Impacts of COVID-19: Seven Scenarios” COVID Economics: Vetted and Real Time papers, vol 10. Centre for Economic Policy Research, London. Pp 116-156

Overview

- Key messages
- The General Approach
- The Model Used: G-Cubed
- Results
  - 7 scenarios
- Conclusion

Key Messages

- Historical approach of costing pandemics focussing on mortality and morbidity greatly underestimates economic costs.
- Economy wide consequences through change in behaviour and policy responses are large

Key Messages

- Given the size of the true economic costs of a pandemic, there is strong case for substantial investment in prevention as well as investing in the capacity to respond in all countries.

General Approach

- Extends the approach developed by Lee and McKibbin (2004) on SARS and McKibbin and Sidorenko (2006) on Avian Influenza
- Start with epidemiological scenarios on
  - Virus infections rates
  - Case mortality rates
  - Morbidity rates
- Map these epidemiological outcomes into different countries based on a range of exposure indicators

General Approach

- Develop a set of shocks to economic variables that are created from the epidemiological assumptions but modified across economies and sectors based on a range of exposure indicators
- Implement the shocks in a global economic model

Modelling a Pandemic

- Major shocks:
  - Reduction in labour force (due to mortality and illness, includes carers)
  - Increase in business costs (differentiated by sector);
  - Disruption of production chains
  - Shift in consumers preferences
  - Re-evaluation of sector and country risks
  - Policy Responses

Epidemiological Scenarios

Scenarios

- 3 scenarios have the COVID-19 outbreak contained in China (temporary) S01, S02, S03
- 3 scenarios are global pandemics following historical epidemiological experiences (temporary) S04, S05,S06
- 1 scenario is assumed to be a permanent/recurring mild pandemic (S07)

Pandemics

- (S04) Hong Kong Flu 1968-69
- (S05) Asian Flu 1957
- (S06) Spanish Flu 1918-19

The Model

G-Cubed Model

- Developed by McKibbin and Wilcoxen since 1991
- Documented in *Handbook of CGE Modeling*, Chapter 17, North Holland
- Used for policy analysis and scenario planning by governments, international agencies, corporations, banks, and academic researchers.

G-Cubed Model

- Hybrid of a dynamic stochastic general equilibrium model (DSGE) as used by central banks and a computable general equilibrium (CGE) model.

- Inter-industry linkages, trade, capital flows, consumption, and investment.

- Annual macroeconomic and sectoral dynamics

- Captures frictions in labor market and capital accumulation
  - Full employment in the long run
  - Labor mobile across sectors but not regions

G-Cubed Model

- Firms produce output using capital, labor, energy and material inputs and maximize share market value subject to costs of adjusting physical capital.
- Households maximize expected utility subject to a wealth constraint and liquidity constraints.
- A mix of rational and non rational expectations.
- Short run unemployment possible due to nominal wage stickiness based on labor market institutions.
- Financial markets for bonds, equity, foreign exchange.
- International trade in goods, services and financial assets.

G-Cubed Model

- Each country has a fiscal rule for government spending and taxation policy

- Each country has a monetary rule which shows how interest rates are adjusted to trade off various policy target (inflation, output, exchange rates, nominal income)

Summary of Key Features

- **Intertemporal optimization** by households and firms
  - Forward-looking savings and investment
  - Financial arbitrage
  - But also rule of thumb for many households and firms

- Extensive **econometric parameterization**
  - Behavior consistent with historical demands and supplies
  - Technical change based on a catchup model of growth

- Distinguishes between **financial and physical capital**
  - Financial capital can move easily between regions and sectors
  - Physical capital does not move once installed

The G-Cubed (G20) model

Countries (20)

Argentina
Australia
Brazil
Canada
China
Euro zone
France
Germany
Indonesia
India
Italy
Japan
Korea
Mexico
Russia
Saudi Arabia
South Africa
Turkey
United Kingdom
United States

Regions (4)

Rest of the OECD
Rest of Asia
Other oil producing countries
Rest of the world

Sectors (6)

Energy
Mining
Agriculture (including fishing and hunting)
Durable manufacturing
Non-durable manufacturing
Services

Agents in Each Country

A representative household
A representative firm (in each of the 6 production sectors)
Government
Central Bank

Model version documented in McKibbin and Triggs (2019)

Baseline without a pandemic

- Solve the model from 2016 to 2100 under assumptions about
  - » population growth by country;
  - » productivity growth by sector and country;
  - » technological assumptions,
  - » policy rules etc

Baseline without a pandemic

- Using the Groningen Growth and Development 10 sector database, estimate the initial level of productivity in each sector in each economy in 2016.
- Take the ratio of this productivity to the equivalent sector in the United States, which we assume is the frontier.
- Given this initial gap in sectoral productivity, and the assumption that each sector in the US has productivity growth of 1.4% per year, use the Barro (2015) catch-up model to generate long term projections of the productivity growth rate of each sector within each country.
- This catchup rate can be varied (over time) if some regions are expected to catch up more quickly to the frontier due to economic reforms (e.g. China) or more slowly to the frontier due to institutional rigidities (e.g. Russia)
- The productivity assumptions and labor force growth assumptions are exogenous
- Capital accumulation and the sectoral and national output growth rates are endogenous

Implementation of Pandemic Shocks

- Surprise pandemic in 2020
- Agents know the future path of the shocks in 2020.
- 30% of firms and households have rational expectations
- 70% follow a rule of thumb

Creating the Epidemic Shock

- Start with China infection and case mortality rates based on the historical data and estimates based on data to February 15, 2020

Table 2 – Epidemiological Assumptions for China

	Scenario	Attack Rate for China	Case-fatality Rate for China	Mortality Rate for China
China only	S01	1%	2.0%	0.02%
	S02	10%	2.5%	0.25%
	S03	30%	3.0%	0.90%
pandemic	S04	10%	2.0%	0.20%
	S05	20%	2.5%	0.50%
	S06	30%	3.0%	0.90%
	S07	10%	2.0%	0.20%

Labor supply shocks

- Mortality is permanent
- Morbidity assume incubation period for COVID-19 is 14 days
  - » assume an average employee in a country would have to be absent from work for 14 days, if infected. Absence from work indicates a loss of productive capacity for 14 days out of working days for a year.

Labor supply shocks

- Morbidity also assumes absenteeism from work due to caregiving family members who are infected.
- Assume that 70 percent of the female workers would be care givers to family members. We adjust the effective attack rate using the proportion of labor force who have to care for school-aged children (70 percent of female labor force participation).

Transmission of the Pandemic across countries

Scenario	Countries Affected	Severity	Attack Rate for China	Case fatality rate China	Nature of Shocks	Shocks Activated	Shocks Activated
						China	Other countries
1	China	Low	1.0%	2.0%	Temporary	All	Risk
2	China	Mid	10.0%	2.5%	Temporary	All	Risk
3	China	High	30.0%	3.0%	Temporary	All	Risk
4	Global	Low	10.0%	2.0%	Temporary	All	All
5	Global	Mid	20.0%	2.5%	Temporary	All	All
6	Global	High	30.0%	3.0%	Temporary	All	All
7	Global	Low	10.0%	2.0%	Permanent	All	All

Indexes uses to scale epidemiological Shocks

Labor Supply Shock

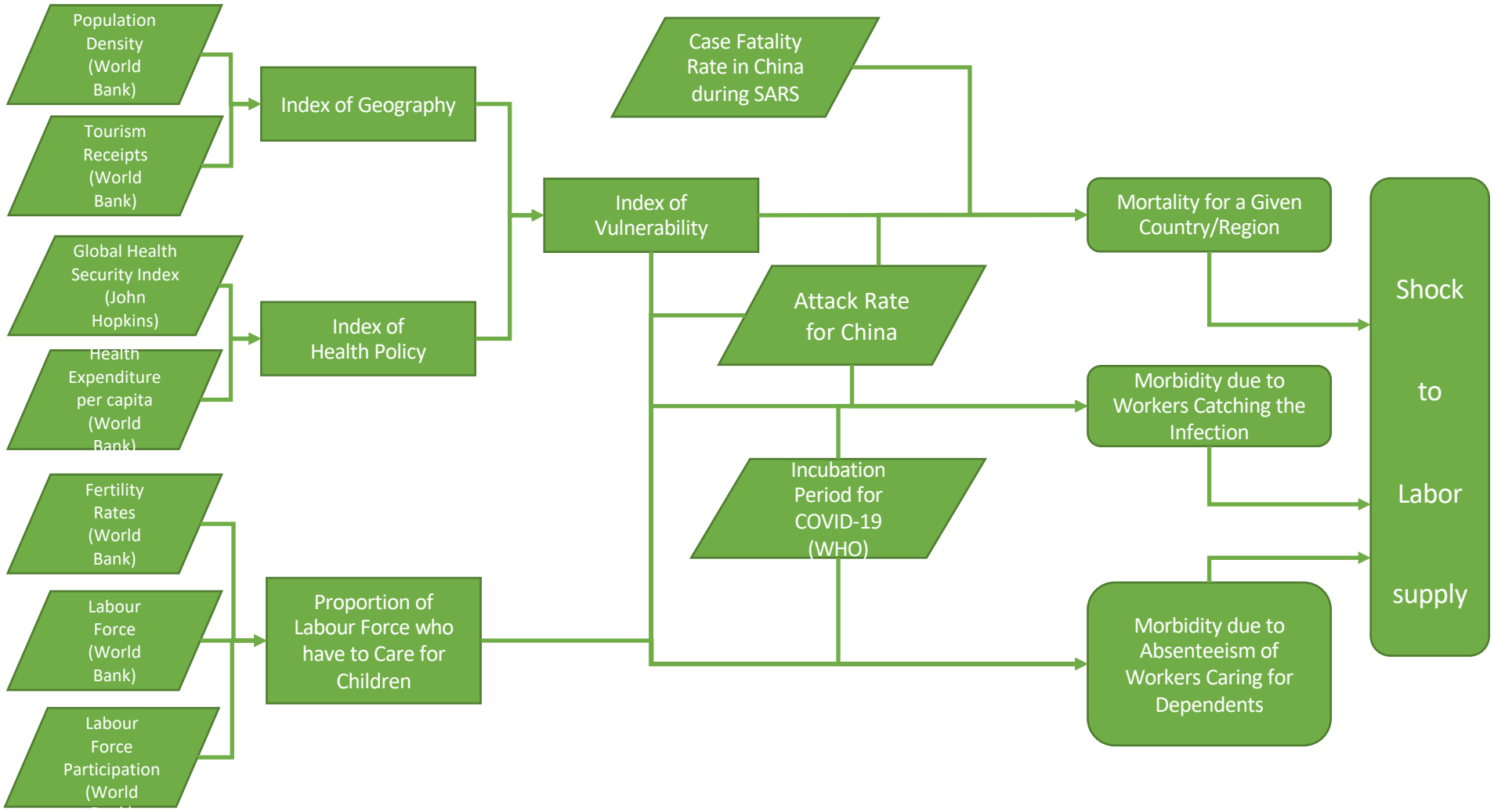


Figure 1 - Index of Geography relative to China

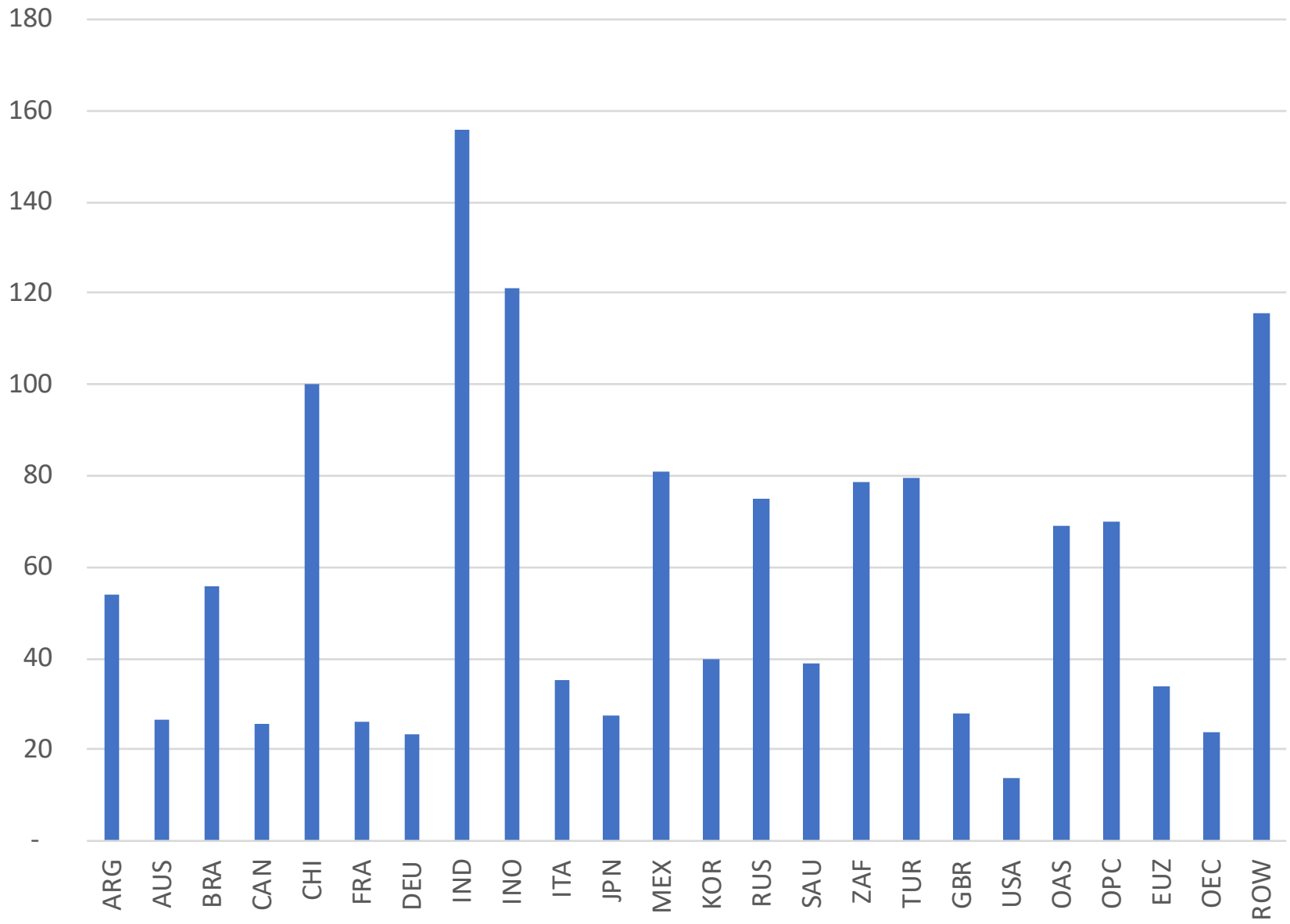
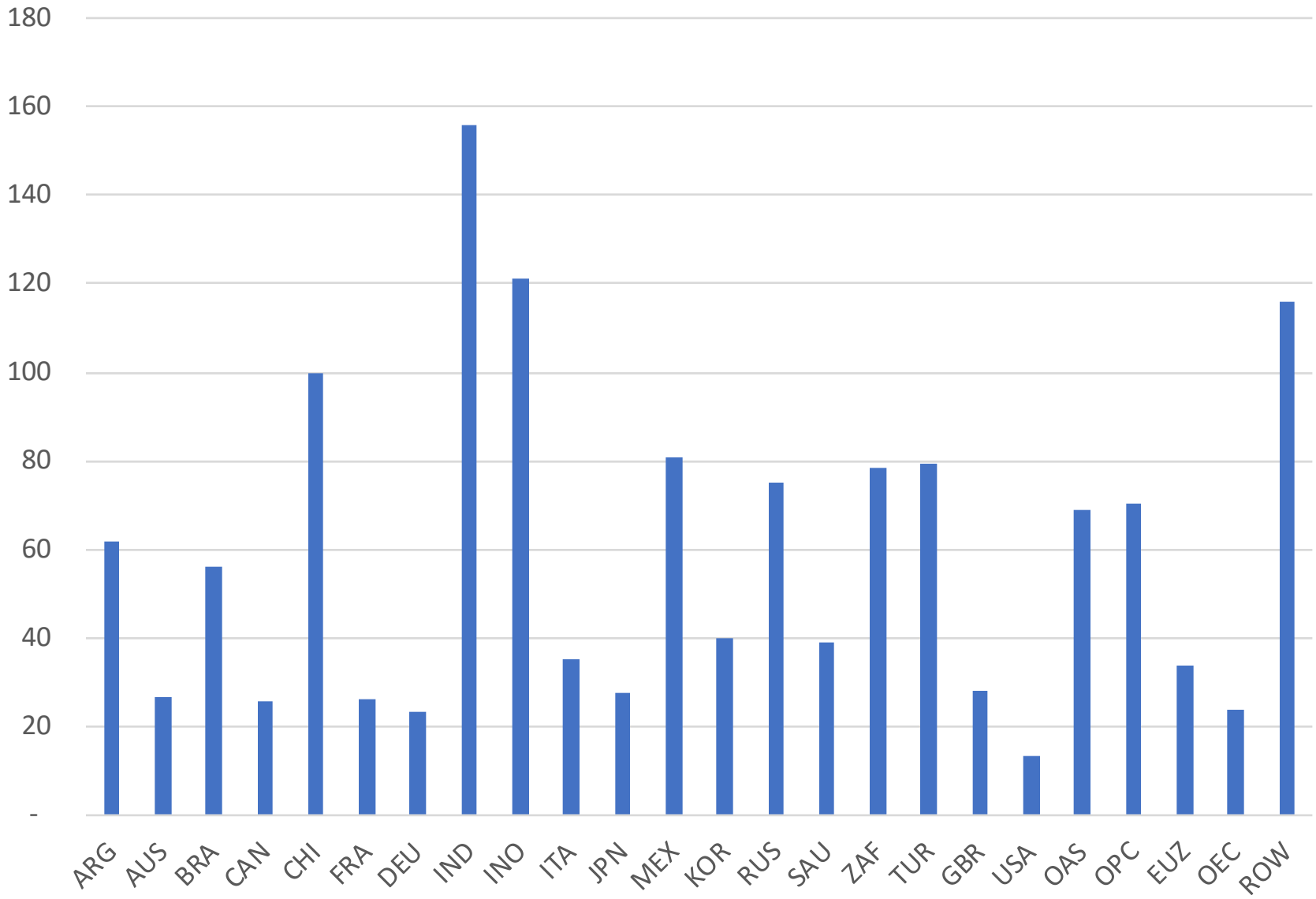


Figure 2 - Index of Health Policy relative to China

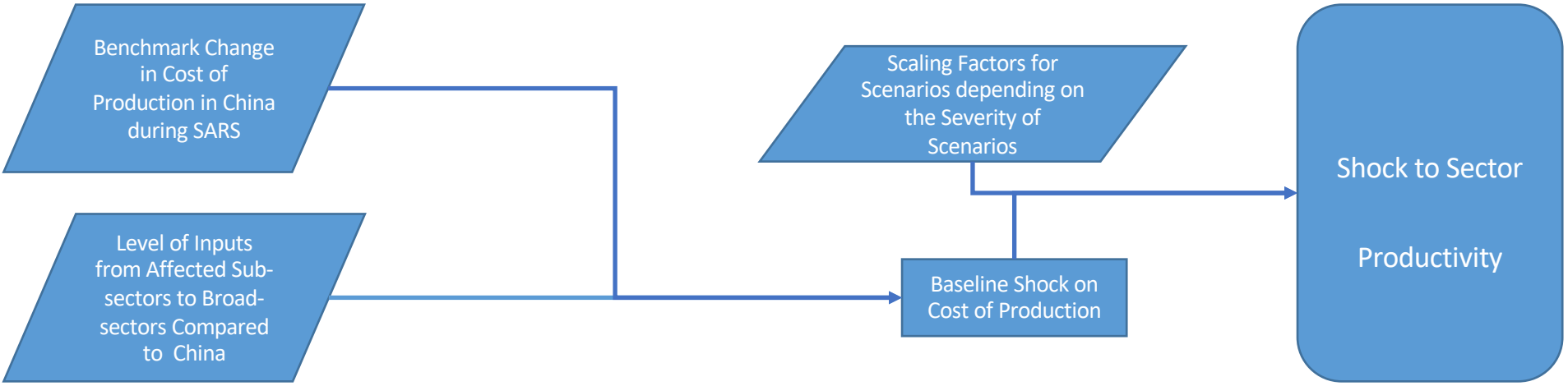


Indexes to create the additional economic shocks

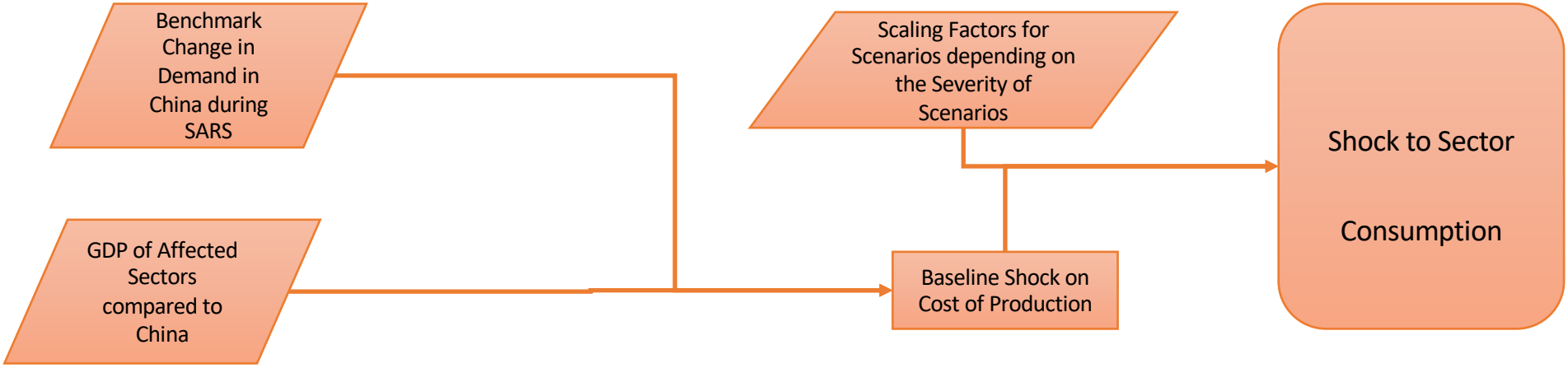
All shocks

- Reduced labor supply
- Increase costs of doing business (negative TFP)
- Increase is equity risk premium
- Change in consumption preferences

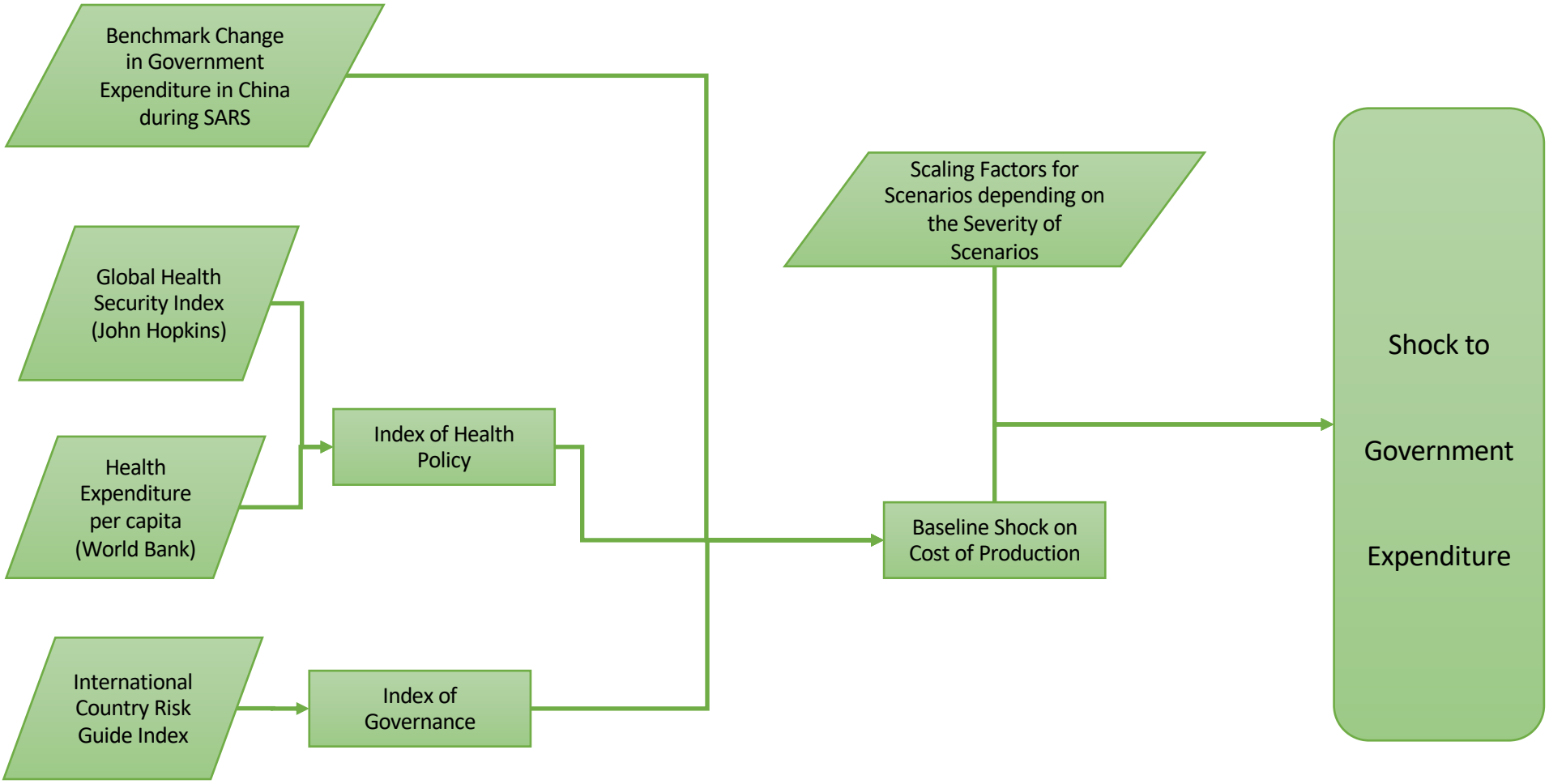
Sectoral Productivity/cost shock



Shock to consumption preferences



Shock to Government Spending



Shock to Equity Risk Premia

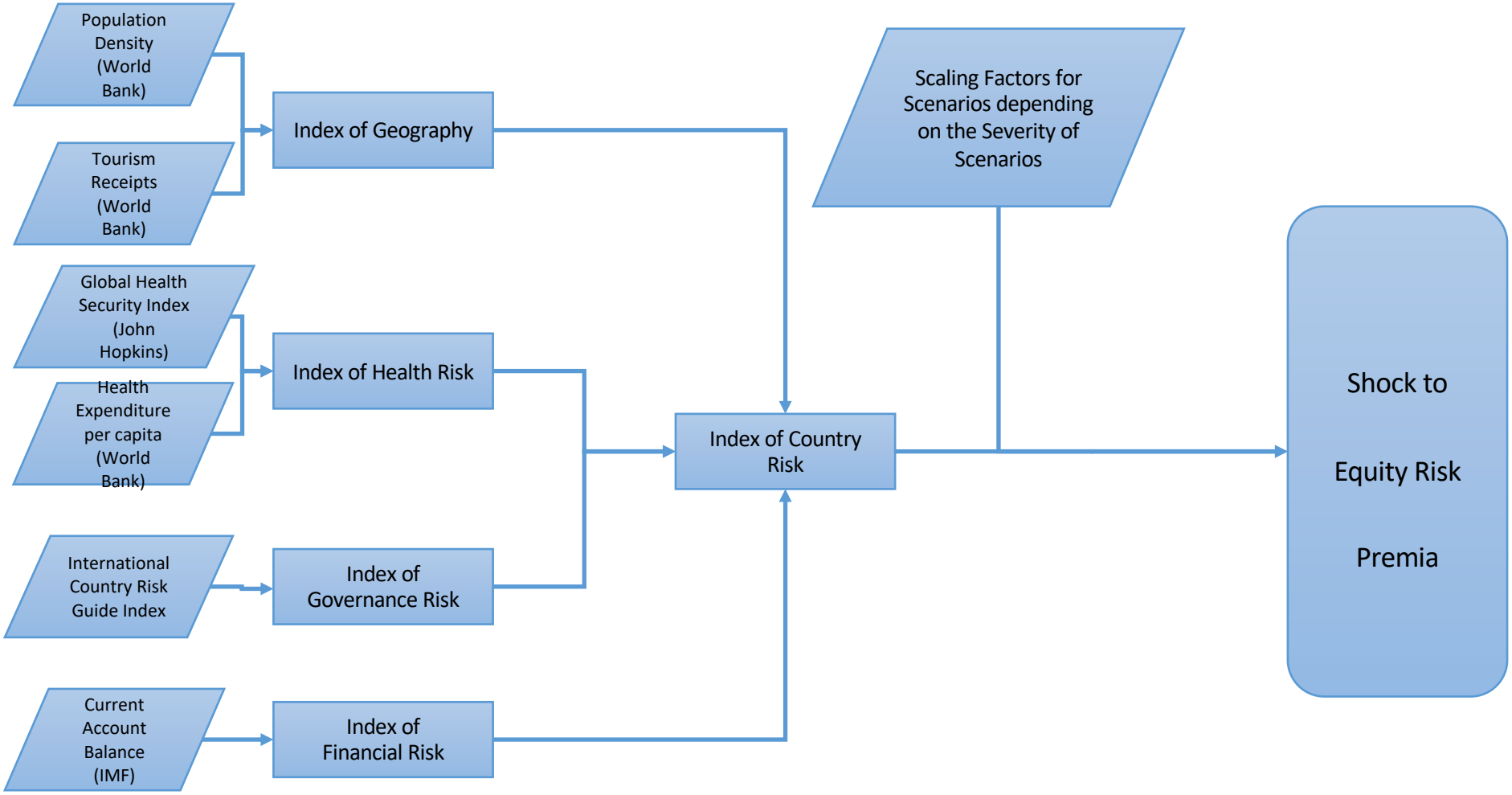


Figure 3 - Index of Governance relative to the US

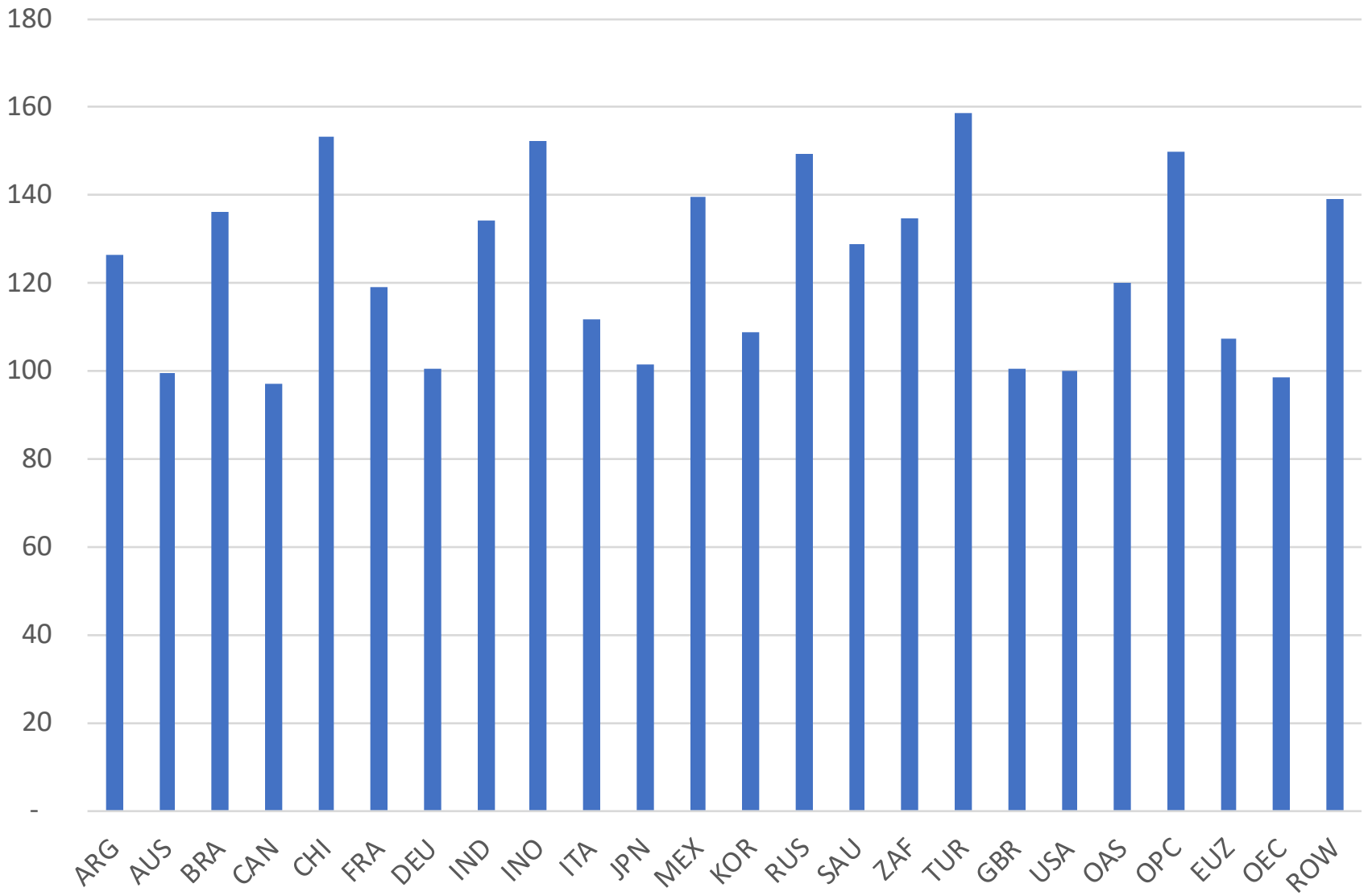


Figure 4 - Index of Financial Risk relative to the US

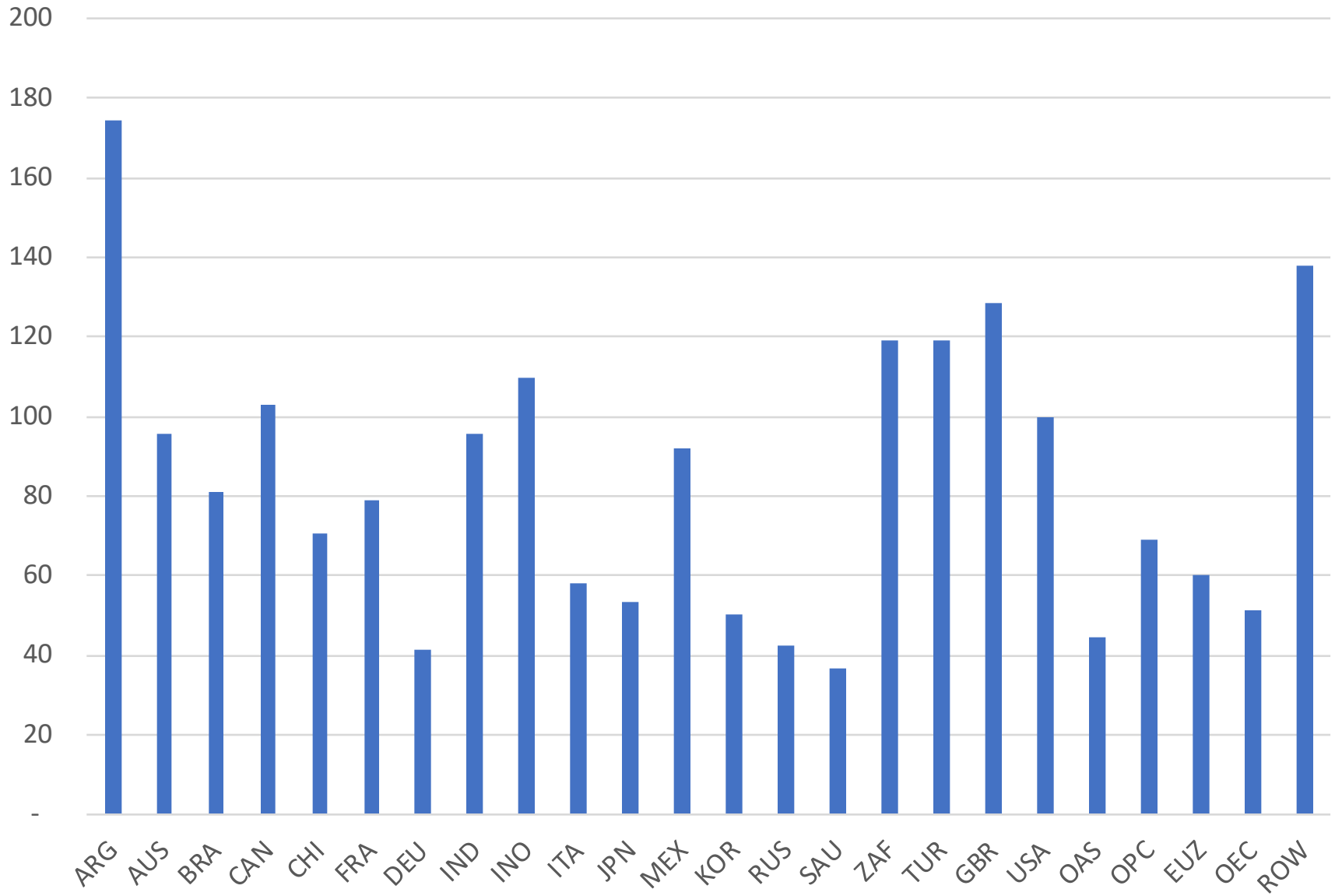


Figure 5 - Index of Health Policy relative to the US

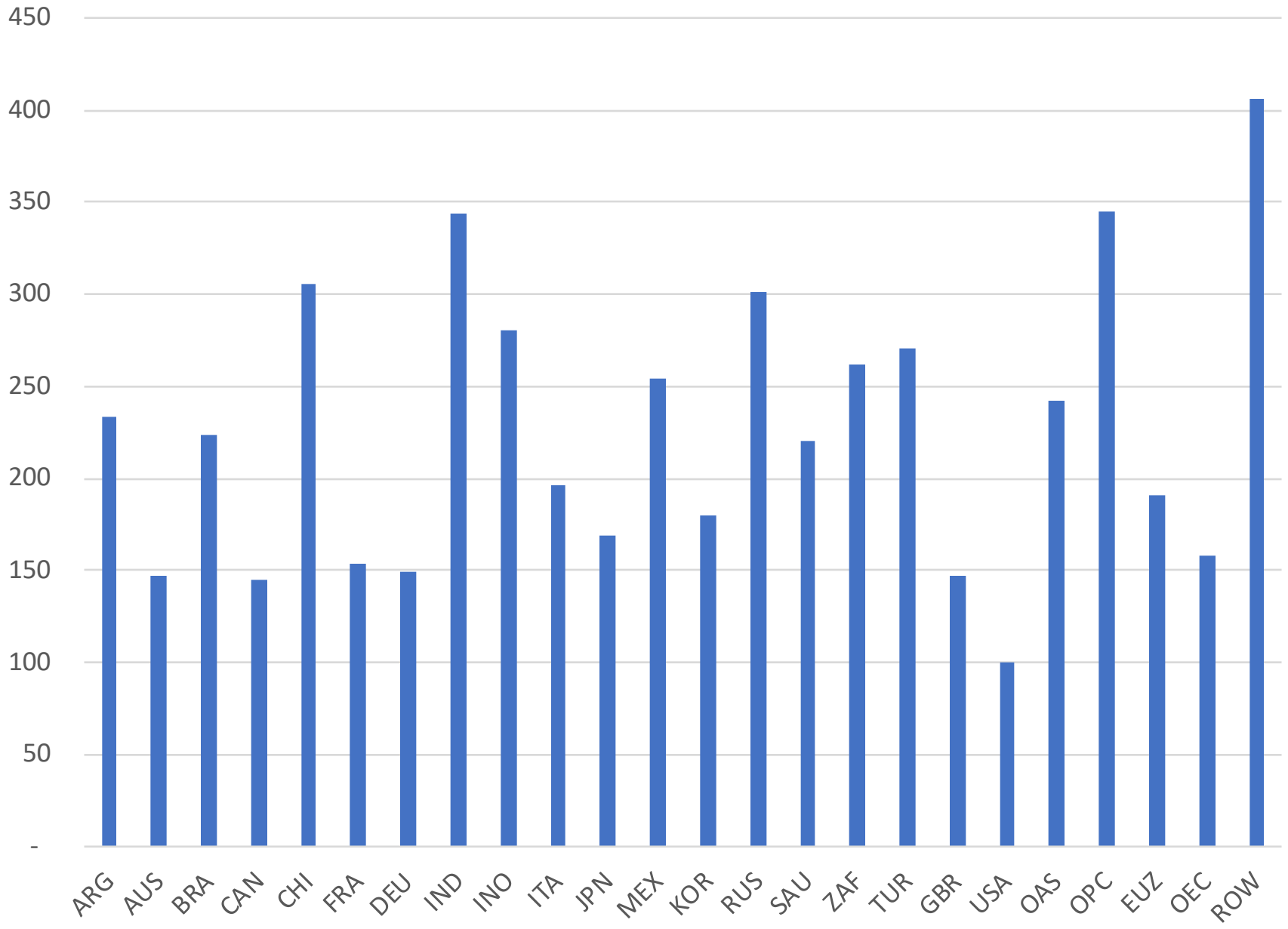


Figure 7 - Index of Sector Exposure to Exposed Activities

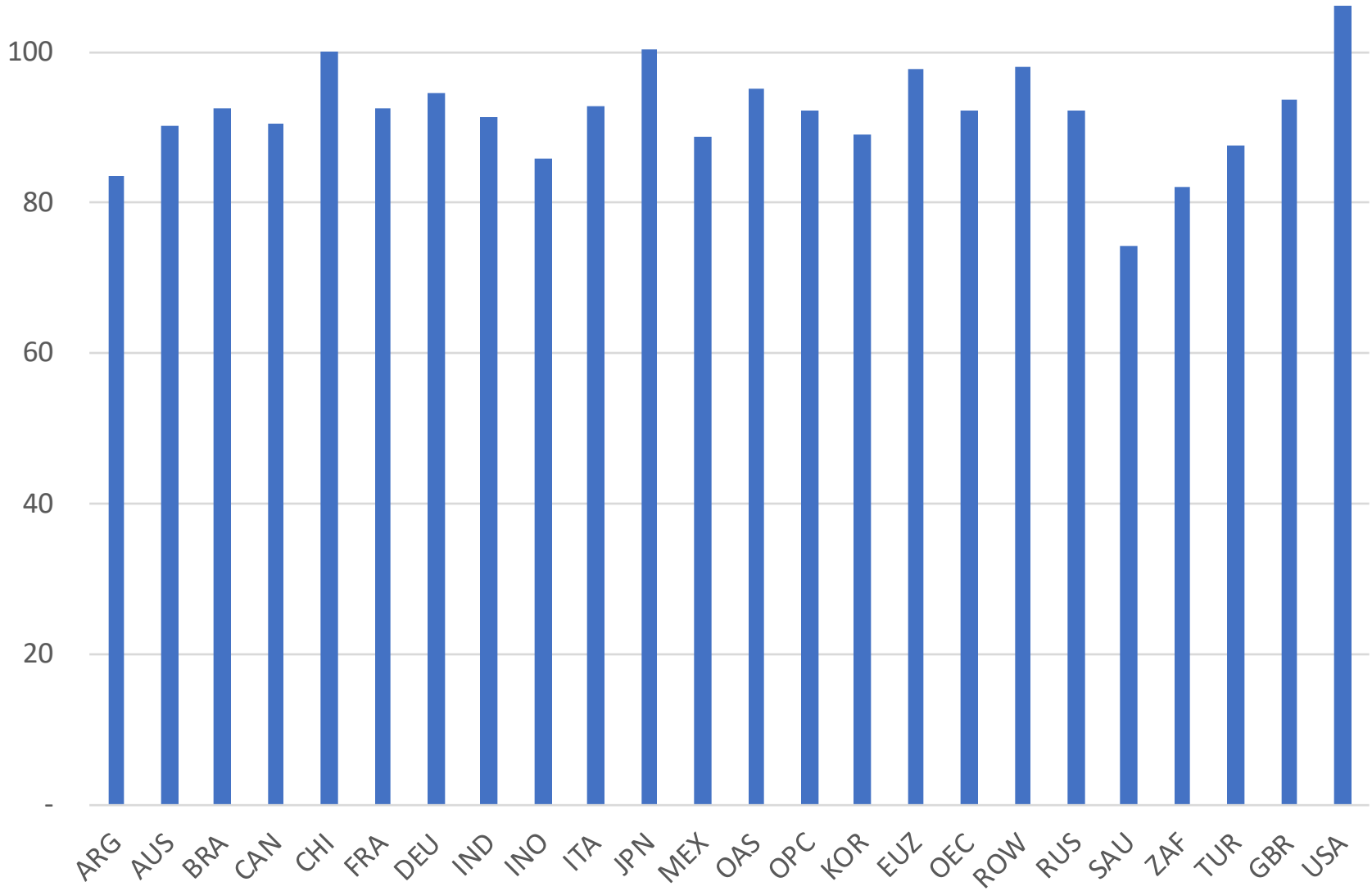


Table 4 – Shocks to labor supply

Region	S01	S02	S03	S04	S05	S06	S07
Argentina	0	0	0	- 0.65	- 1.37	- 2.14	- 0.65
Australia	0	0	0	- 0.48	- 1.01	- 1.58	- 0.48
Brazil	0	0	0	- 0.66	- 1.37	- 2.15	- 0.66
Canada	0	0	0	- 0.43	- 0.89	- 1.40	- 0.43
China	- 0.10	- 1.10	- 3.44	- 1.05	- 2.19	- 3.44	- 1.05
France	0	0	0	- 0.52	- 1.08	- 1.69	- 0.52
Germany	0	0	0	- 0.51	- 1.06	- 1.66	- 0.51
India	0	0	0	- 1.34	- 2.82	- 4.44	- 1.34
Indonesia	0	0	0	- 1.39	- 2.91	- 4.56	- 1.39
Italy	0	0	0	- 0.48	- 1.02	- 1.60	- 0.48
Japan	0	0	0	- 0.50	- 1.04	- 1.64	- 0.50
Mexico	0	0	0	- 0.78	- 1.64	- 2.57	- 0.78
Republic of Korea	0	0	0	- 0.56	- 1.17	- 1.85	- 0.56
Russia	0	0	0	- 0.71	- 1.48	- 2.31	- 0.71
Saudi Arabia	0	0	0	- 0.41	- 0.87	- 1.37	- 0.41
South Africa	0	0	0	- 0.80	- 1.67	- 2.61	- 0.80
Turkey	0	0	0	- 0.76	- 1.59	- 2.50	- 0.76
United Kingdom	0	0	0	- 0.53	- 1.12	- 1.75	- 0.53
United States of America	0	0	0	- 0.40	- 0.83	- 1.30	- 0.40
Other Asia	0	0	0	- 0.88	- 1.84	- 2.89	- 0.88
Other oil producing countries	0	0	0	- 0.97	- 2.01	- 3.13	- 0.97
Rest of Euro Zone	0	0	0	- 0.46	- 0.97	- 1.52	- 0.46
Rest of OECD	0	0	0	- 0.43	- 0.89	- 1.39	- 0.43
Rest of the World	0	0	0	- 1.29	- 2.67	- 4.16	- 1.29

Table 5 – Shock to equity risk premium for scenario 4-7

Region	S04	S05	S06	S07
Argentina	1.90	2.07	2.30	1.90
Australia	1.23	1.37	1.54	1.23
Brazil	1.59	1.78	2.03	1.59
Canada	1.23	1.36	1.52	1.23
China	1.97	2.27	2.67	1.97
France	1.27	1.40	1.59	1.27
Germany	1.07	1.21	1.41	1.07
India	2.20	2.62	3.18	2.20
Indonesia	2.06	2.43	2.93	2.06
Italy	1.32	1.47	1.66	1.32
Japan	1.18	1.33	1.53	1.18
Mexico	1.76	1.98	2.27	1.76
Republic of Korea	1.25	1.43	1.67	1.25
Russia	1.77	1.96	2.22	1.77
Saudi Arabia	1.38	1.52	1.70	1.38
South Africa	1.85	2.06	2.33	1.85
Turkey	1.98	2.20	2.50	1.98
United Kingdom	1.35	1.50	1.70	1.35
United States of America	1.07	1.18	1.33	1.07
Other Asia	1.51	1.75	2.07	1.51
Other oil-producing countries	2.03	2.25	2.55	2.03
Rest of Euro Zone	1.29	1.42	1.60	1.29
Rest of OECD	1.11	1.22	1.38	1.11
Rest of the World	2.21	2.51	2.91	2.21

Table 6 – Shocks to cost of production

Region	Energy	Mining	Agriculture	Durable Manufacturing	Non-durable Manufacturing	Services
Argentina	0.37	0.24	0.37	0.35	0.40	0.38
Australia	0.43	0.43	0.42	0.39	0.41	0.45
Brazil	0.44	0.46	0.44	0.42	0.45	0.44
Canada	0.44	0.37	0.42	0.40	0.41	0.44
China	0.50	0.50	0.50	0.50	0.50	0.50
France	0.38	0.31	0.36	0.40	0.42	0.46
Germany	0.43	0.37	0.40	0.45	0.45	0.47
India	0.47	0.33	0.47	0.42	0.45	0.43
Indonesia	0.37	0.33	0.31	0.36	0.40	0.38
Italy	0.36	0.33	0.38	0.42	0.44	0.46
Japan	0.45	0.40	0.45	0.47	0.47	0.49
Mexico	0.41	0.38	0.39	0.42	0.42	0.41
Other Asia	0.44	0.39	0.44	0.45	0.45	0.47

Table 6 (continued) – Shocks to cost of production

Region	Energy	Mining	Agriculture	Durable Manufacturing	Non-durable Manufacturing	Services
Other oil producing countries	0.49	0.41	0.47	0.40	0.43	0.45
Republic of Korea	0.39	0.30	0.37	0.43	0.42	0.43
Rest of Euro Zone	0.42	0.41	0.43	0.43	0.46	0.48
Rest of OECD	0.42	0.38	0.41	0.41	0.43	0.46
Rest of the World	0.52	0.46	0.51	0.45	0.49	0.48
Russia	0.54	0.37	0.43	0.41	0.42	0.45
Saudi Arabia	0.32	0.25	0.29	0.29	0.25	0.35
South Africa	0.40	0.35	0.39	0.41	0.43	0.38
Turkey	0.37	0.36	0.39	0.39	0.42	0.42
United Kingdom	0.39	0.37	0.39	0.39	0.42	0.46
United States of America	0.53	0.40	0.51	0.50	0.51	0.53

Table 7 – Shocks to consumption demand

Region	S04	S05	S06	S07
Argentina	- 0.83	- 2.09	- 3.76	- 0.83
Australia	- 0.90	- 2.26	- 4.07	- 0.90
Brazil	- 0.92	- 2.31	- 4.16	- 0.92
Canada	- 0.90	- 2.26	- 4.07	- 0.90
China	- 1.00	- 2.50	- 4.50	- 1.00
France	- 0.93	- 2.31	- 4.16	- 0.93
Germany	- 0.95	- 2.36	- 4.25	- 0.95
India	- 0.91	- 2.29	- 4.11	- 0.91
Indonesia	- 0.86	- 2.15	- 3.86	- 0.86
Italy	- 0.93	- 2.32	- 4.18	- 0.93
Japan	- 1.01	- 2.51	- 4.52	- 1.01
Mexico	- 0.89	- 2.22	- 4.00	- 0.89
Other Asia	- 0.95	- 2.38	- 4.28	- 0.95
Other oil producing countries	- 0.92	- 2.31	- 4.16	- 0.92
Republic of Korea	- 0.89	- 2.23	- 4.01	- 0.89
Rest of Euro Zone	- 0.98	- 2.45	- 4.40	- 0.98
Rest of OECD	- 0.92	- 2.31	- 4.16	- 0.92
Rest of the World	- 0.98	- 2.45	- 4.42	- 0.98
Russia	- 0.92	- 2.31	- 4.16	- 0.92
Saudi Arabia	- 0.74	- 1.86	- 3.35	- 0.74
South Africa	- 0.82	- 2.05	- 3.69	- 0.82
Turkey	- 0.88	- 2.19	- 3.95	- 0.88
United Kingdom	- 0.94	- 2.34	- 4.22	- 0.94
United States of America	- 1.06	- 2.66	- 4.78	- 1.06

Table 8 – Shocks to government expenditure

Region	S04	S05	S06	S07
Argentina	0.39	0.98	1.76	0.39
Australia	0.27	0.67	1.21	0.27
Brazil	0.39	0.98	1.76	0.39
Canada	0.26	0.66	1.19	0.26
China	0.50	1.25	2.25	0.50
France	0.30	0.74	1.34	0.30
Germany	0.27	0.68	1.22	0.27
India	0.52	1.30	2.34	0.52
Indonesia	0.47	1.18	2.12	0.47
Italy	0.34	0.84	1.51	0.34
Japan	0.30	0.74	1.33	0.30
Mexico	0.43	1.07	1.93	0.43
Republic of Korea	0.31	0.79	1.41	0.31
Russia	0.49	1.23	2.21	0.49
Saudi Arabia	0.38	0.95	1.71	0.38
South Africa	0.43	1.08	1.94	0.43
Turkey	0.47	1.17	2.11	0.47
United Kingdom	0.27	0.68	1.22	0.27
United States of America	0.22	0.54	0.98	0.22
Other Asia	0.39	0.99	1.77	0.39
Other oil producing countries	0.54	1.35	2.42	0.54
Rest of Euro Zone	0.33	0.81	1.46	0.33
Rest of OECD	0.28	0.70	1.26	0.28
Rest of the World	0.59	1.49	2.67	0.59

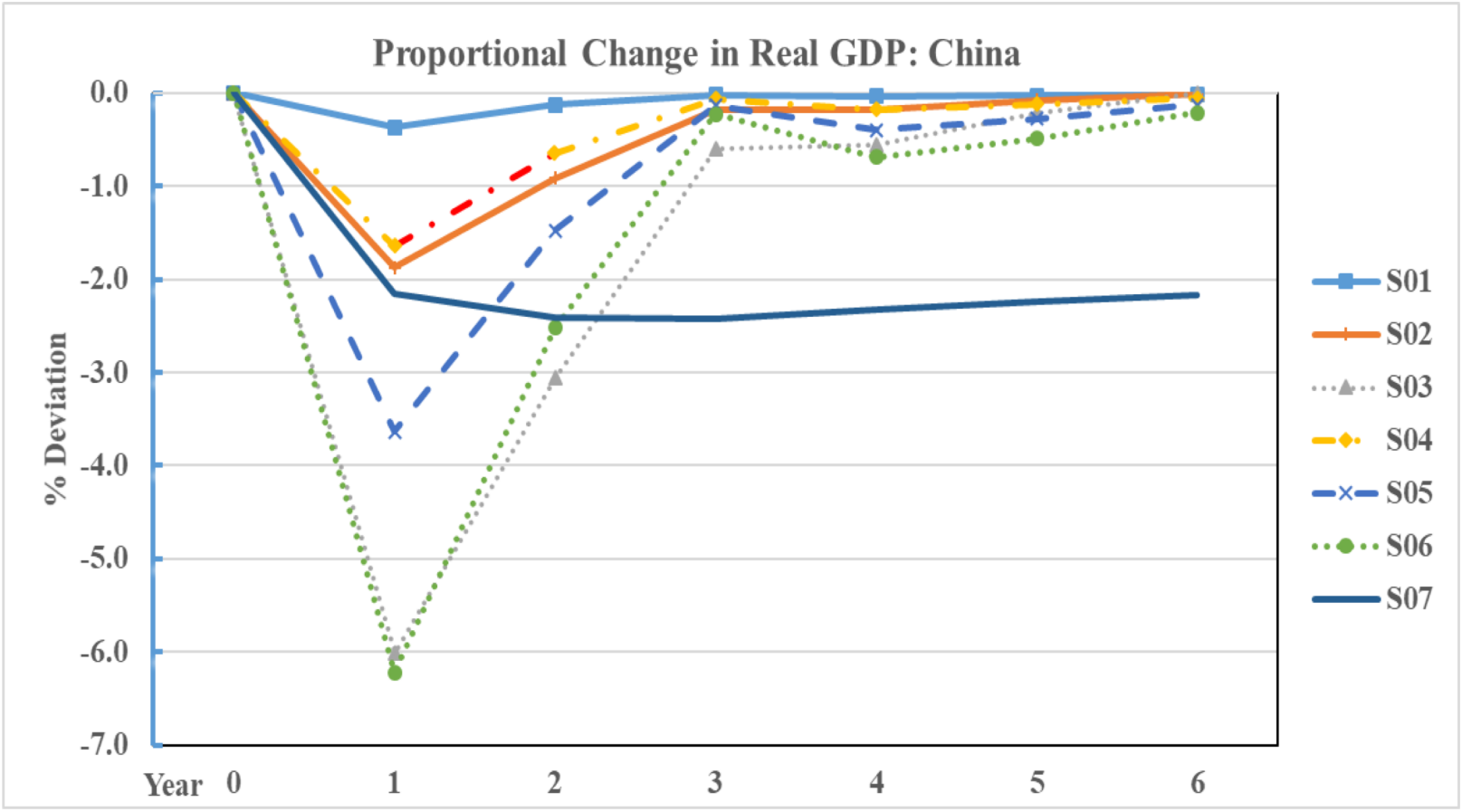
Results

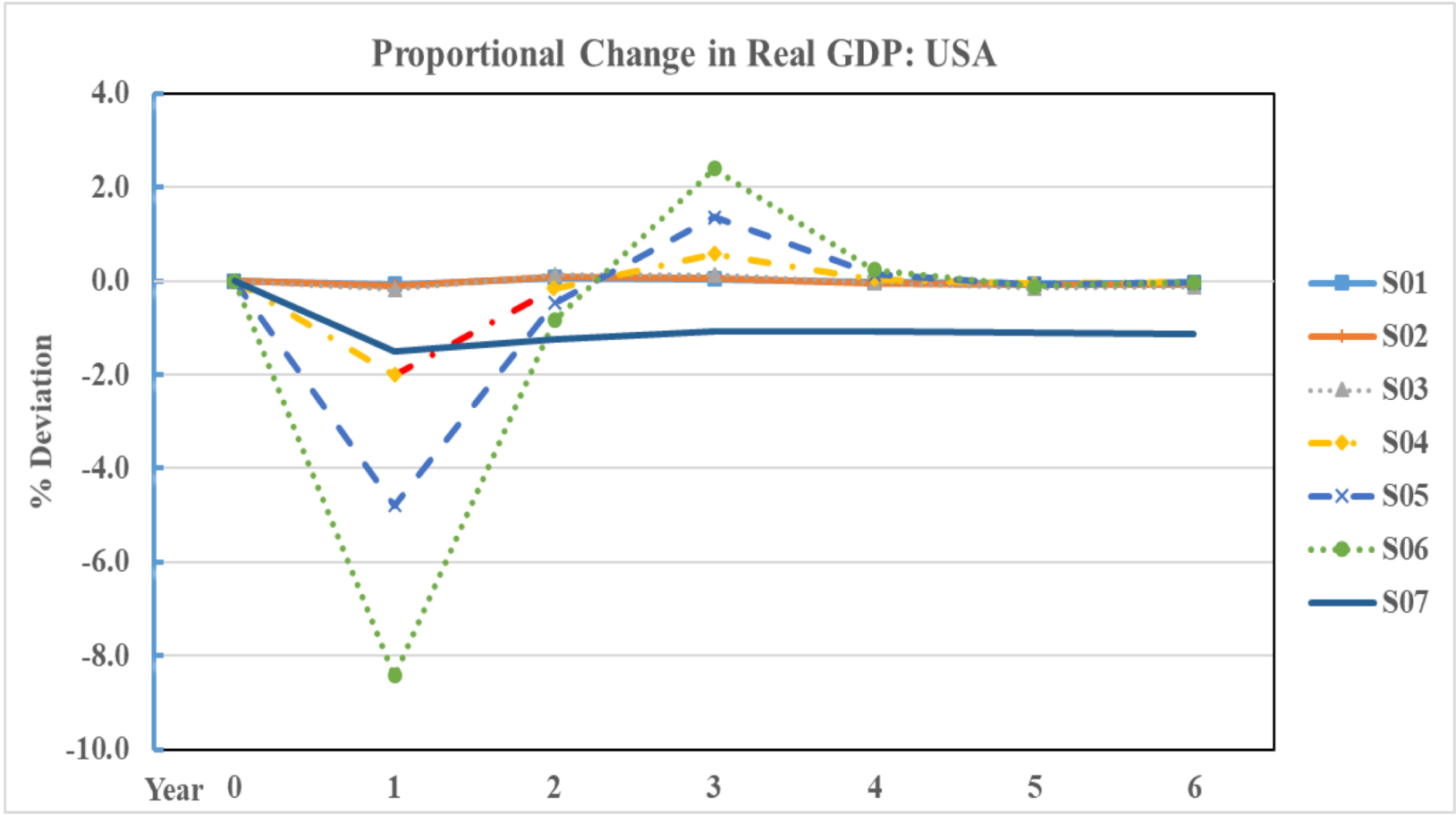
Table 9 – Impact on populations under each scenario

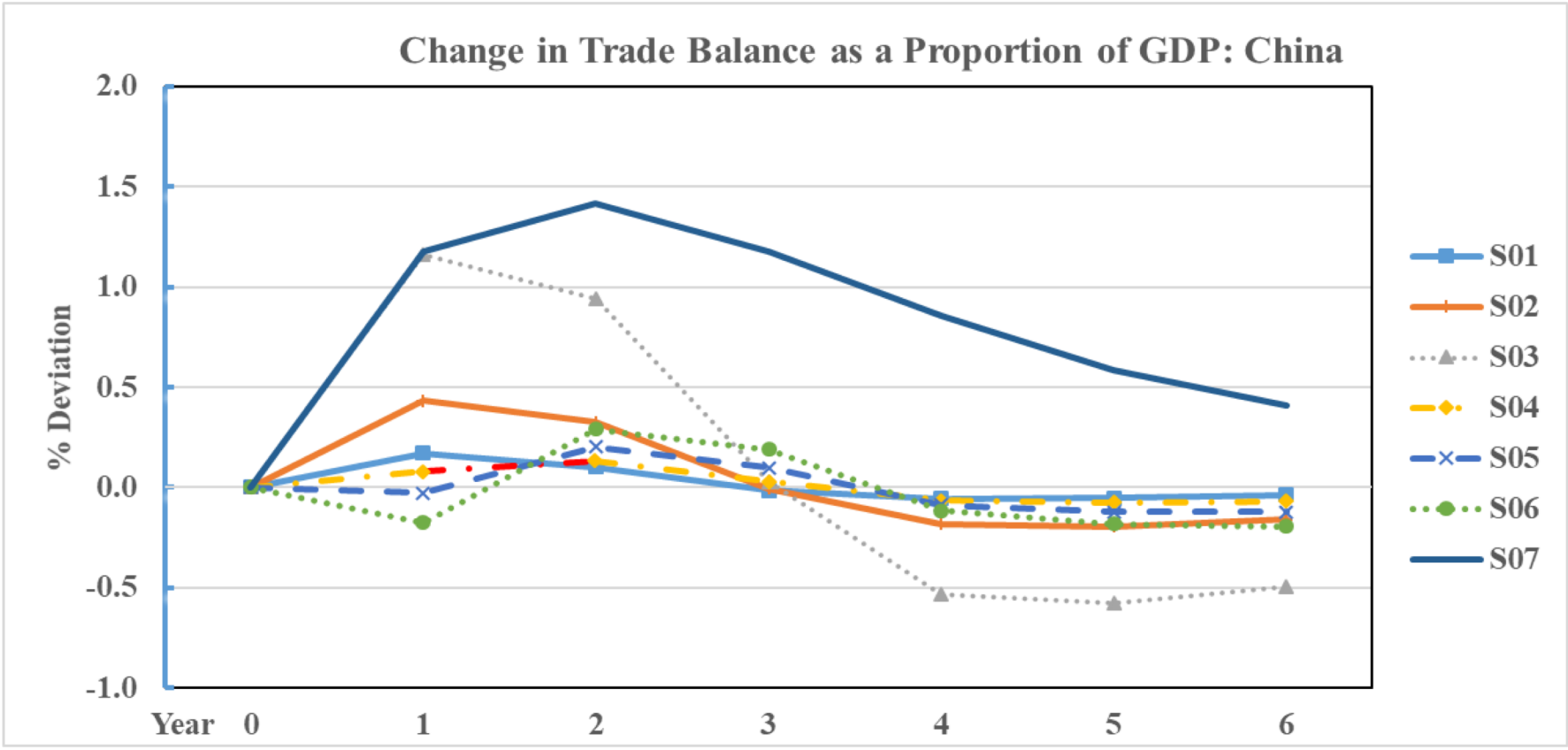
Country/Region	Population (Thousands)	Mortality in First Year (Thousands)						
		S01	S02	S03	S04	S05	S06	S07
Argentina	43,418	-	-	-	50	126	226	50
Australia	23,800	-	-	-	21	53	96	21
Brazil	205,962	-	-	-	257	641	1,154	257
Canada	35,950	-	-	-	30	74	133	30
China	1,397,029	279	3,493	12,573	2,794	6,985	12,573	2,794
France	64,457	-	-	-	60	149	268	60
Germany	81,708	-	-	-	79	198	357	79
India	1,309,054	-	-	-	3,693	9,232	16,617	3,693
Indonesia	258,162	-	-	-	647	1,616	2,909	647
Italy	59,504	-	-	-	59	147	265	59
Japan	127,975	-	-	-	127	317	570	127
Mexico	125,891	-	-	-	184	460	828	184
Republic of Korea	50,594	-	-	-	61	151	272	61
Russia	143,888	-	-	-	186	465	837	186
Saudi Arabia	31,557	-	-	-	29	71	128	29
South Africa	55,291	-	-	-	75	187	337	75
Turkey	78,271	-	-	-	116	290	522	116
United Kingdom	65,397	-	-	-	64	161	290	64
United States of America	319,929	-	-	-	236	589	1,060	236
Other Asia	330,935	-	-	-	530	1,324	2,384	530
Other oil producing countries	517,452	-	-	-	774	1,936	3,485	774
Rest of Euro Zone	117,427	-	-	-	106	265	478	106
Rest of OECD	33,954	-	-	-	27	67	121	27
Rest of the World	2,505,604	-	-	-	4,986	12,464	22,435	4,986
Total	**7,983,209**	**279**	**3,493**	**12,573**	**15,188**	**37,971**	**68,347**	**15,188**

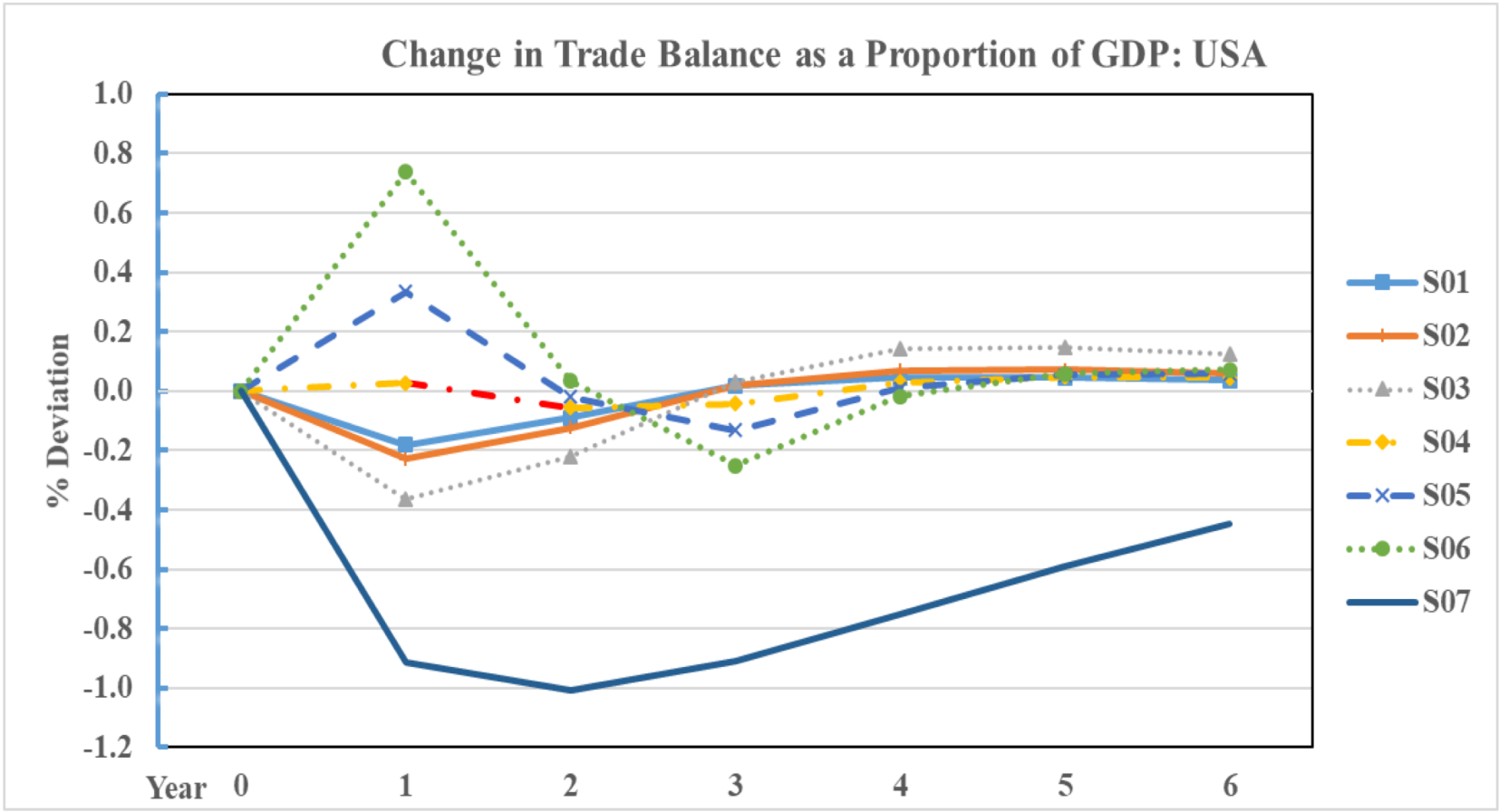
Table 10 - GDP loss in 2020 (% deviation from baseline)

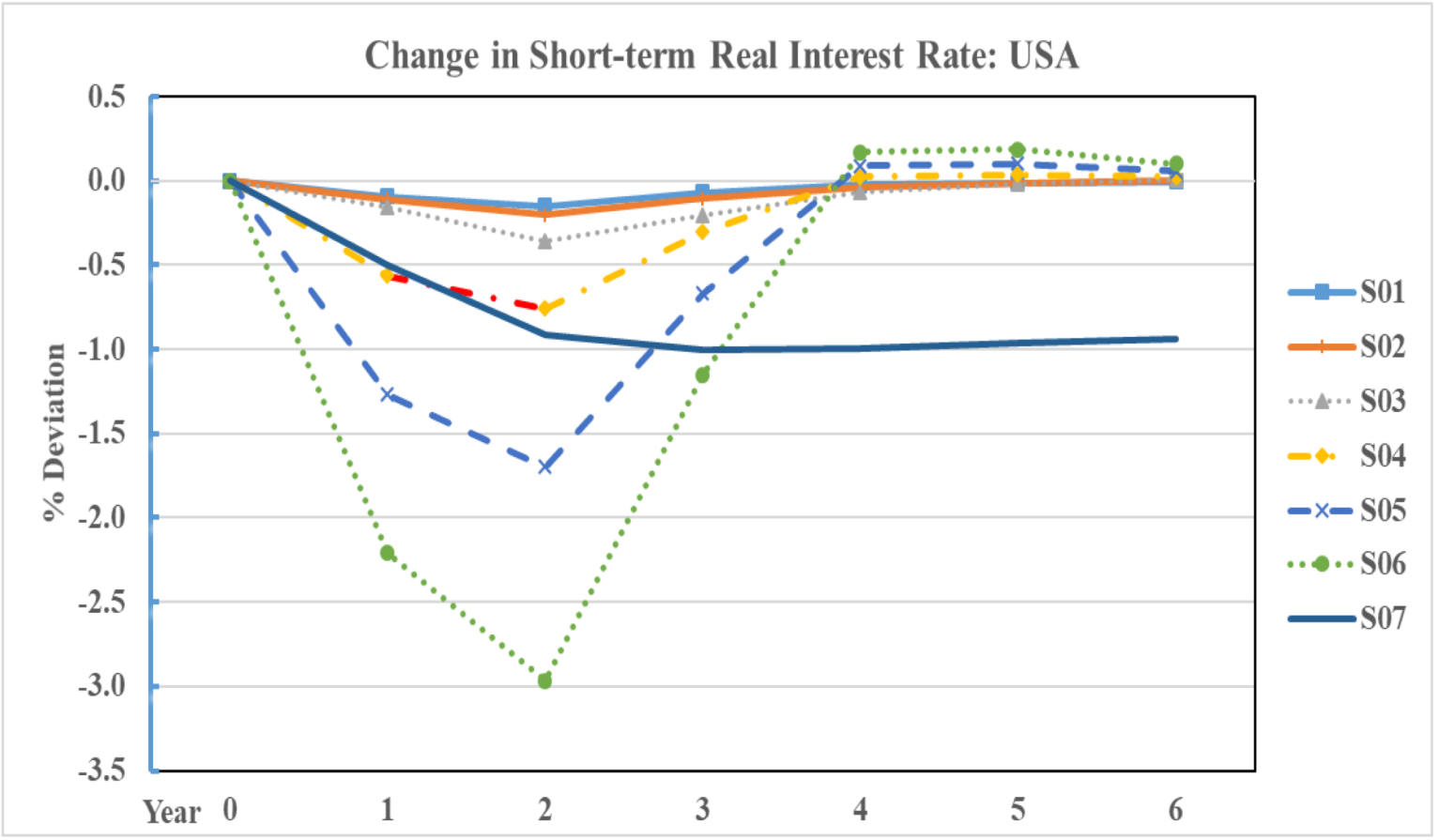
Country/Region	S01	S02	S03	S04	S05	S06	S07
AUS	-0.3	-0.4	-0.7	-2.1	-4.6	-7.9	-2.0
BRA	-0.3	-0.3	-0.5	-2.1	-4.7	-8.0	-1.9
CHI	-0.4	-1.9	-6.0	-1.6	-3.6	-6.2	-2.2
IND	-0.2	-0.2	-0.4	-1.4	-3.1	-5.3	-1.3
EUZ	-0.2	-0.2	-0.4	-2.1	-4.8	-8.4	-1.9
FRA	-0.2	-0.3	-0.3	-2.0	-4.6	-8.0	-1.5
DEU	-0.2	-0.3	-0.5	-2.2	-5.0	-8.7	-1.7
ZAF	-0.2	-0.2	-0.4	-1.8	-4.0	-7.0	-1.5
ITA	-0.2	-0.3	-0.4	-2.1	-4.8	-8.3	-2.2
JPN	-0.3	-0.4	-0.5	-2.5	-5.7	-9.9	-2.0
GBR	-0.2	-0.2	-0.3	-1.5	-3.5	-6.0	-1.2
ROW	-0.2	-0.2	-0.3	-1.5	-3.5	-5.9	-1.5
MEX	-0.1	-0.1	-0.1	-0.9	-2.2	-3.8	-0.9
CAN	-0.2	-0.2	-0.4	-1.8	-4.1	-7.1	-1.6
OEC	-0.3	-0.3	-0.5	-2.0	-4.4	-7.7	-1.8
OPC	-0.2	-0.2	-0.4	-1.4	-3.2	-5.5	-1.3
ARG	-0.2	-0.3	-0.5	-1.6	-3.5	-6.0	-1.2
RUS	-0.2	-0.3	-0.5	-2.0	-4.6	-8.0	-1.9
SAU	-0.2	-0.2	-0.3	-0.7	-1.4	-2.4	-1.3
TUR	-0.1	-0.2	-0.2	-1.4	-3.2	-5.5	-1.2
USA	-0.1	-0.1	-0.2	-2.0	-4.8	-8.4	-1.5
OAS	-0.1	-0.2	-0.4	-1.6	-3.6	-6.3	-1.5
INO	-0.2	-0.2	-0.3	-1.3	-2.8	-4.7	-1.3
KOR	-0.1	-0.2	-0.3	-1.4	-3.3	-5.8	-1.3


Proportional Change in Real GDP: China
% Deviation
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
Year
0
1
2
3
4
5
6
S01
S02
S03
S04
S05
S06
S07


Proportional Change in Real GDP: USA
% Deviation
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
Year
0
1
2
3
4
5
6
S01
S02
S03
S04
S05
S06
S07


Change in Trade Balance as a Proportion of GDP: China
% Deviation
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Year
0
1
2
3
4
5
6
S01
S02
S03
S04
S05
S06
S07


Change in Trade Balance as a Proportion of GDP: USA
% Deviation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
Year
0
1
2
3
4
5
6
S01
S02
S03
S04
S05
S06
S07


Change in Short-term Real Interest Rate: USA
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
% Deviation
Year 0 1 2 3 4 5 6
S01
S02
S03
S04
S05
S06
S07

Summary

- Failure to Act even in the case of a relatively mild pandemic can lead to very large economic costs.
- Countries have a small window to stop the pandemic from spreading
- Most of the economic loss is due to behavioral changes in response to the pandemic
- We haven’t modelled shutdowns of mandated closures.

Conclusion

- Predicting the impacts of pandemic influenza is difficult but the range of estimates found in this paper suggest that costs of any outbreak is potentially large and much larger than the resources currently being spent globally to tackle the likely sources of an outbreak
- Pre-emption in developing countries is a sound investment
  - » such as improving public health systems, changed animal husbandry techniques, increased awareness of the dangers of animal disease, and reductions in poverty

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Australian Recovery Plan

https://go8.edu.au/research/roadmap-to-recovery

Further information on G-Cubed

www.gcubed.com