SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE IN VIETNAM: A MACROECONOMIC ASSESSMENT

2021

GEMMES Vietnam project

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#WorldInCommon
AGENCE FRANÇAISE DE DÉVELOPPEMENT | FRENCH DEVELOPMENT AGENCY

Outlines

Vietnam and Climate change

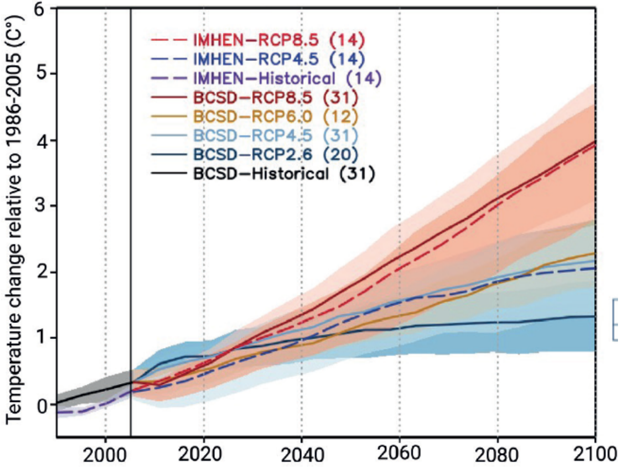


Figure: CMIP5 projected changes for Vietnam global mean temperature

Nationally Determined Contribution

THE SOCIALIST REPUBLIC OF VIET NAM

UPDATED

NATIONALLY DETERMINED CONTRIBUTION (NDC)

- By 2030: 9% compared to the BAU scenario (with domestic resources), max 27% (with international support)

Nationally Determined Contribution (con’t)

Financial resources

- **Central and local budgets** including ODA
- **Domestic and international specialised funds** related to climate change response support
- Investment capital from the **domestic private sector and FDI**
- Investment by **individuals and households**

Objectives

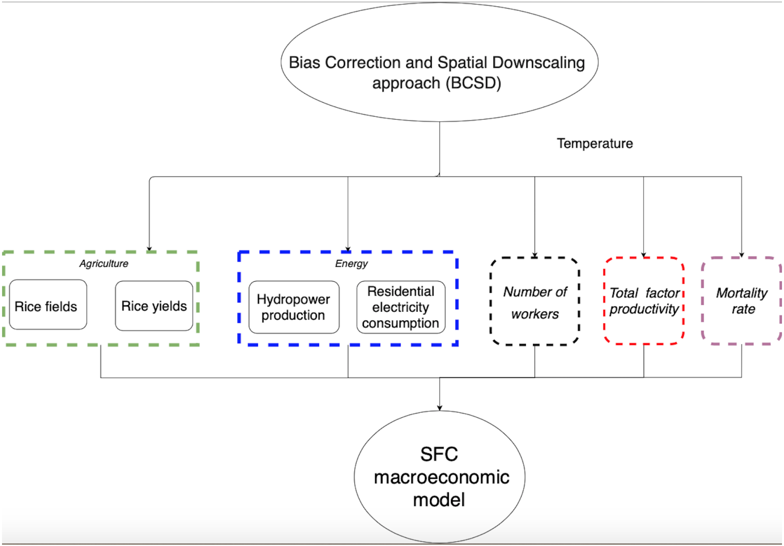
To propose an economy-wide assessment of the social and economic effects of climate impacts on the Vietnamese economy as a whole using an integrated macroeconomic framework

Outlines

Following Hsiang et al. (2017)

- Sectoral damage function calculation
- Valuation of direct damages by sector
- Aggregate national-level damage function:
  - summing sectoral damage functions to obtain the cumulative direct impacts
  - applying the direct damage impacts to the stock-flow coherent macroeconomic model

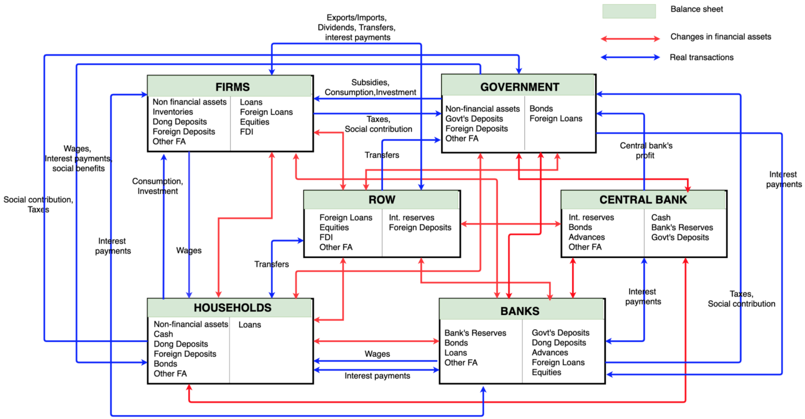
Macroeconomic impacts framework



Stock-flow consistent modelling

- Integrating the financial and the real sides of the economy in a common analysis framework
- Godley & Tobin (70s), Godley & Lavoie (2007)
- Accounting consistencies
  - Flow consistency
  - Stock consistency
  - Stock-flow links
- Dynamic behaviours
  - How economic agents determine and finance their expenditures?
  - How economic agents allocate their wealth?
  - Specify the productivity growth, wages and inflation
  - Financial flows

Circular flow of the economy and balance sheet structure



Simplified balance sheet of Vietnam

	Firms	Central Bank	Banks	Government	Households	RoW	Total
Non-financial assets	$p_K k^f$			$p_K k^g$	$p_K k^h$		$p_K k$
Inventories	$p_{K_{12}} k_{12}$						$p_{K_{12}} k_{12}$
Intl. reserves		$RES_{us} xr$				$-RES_{us} xr$	0
Cash		$-H$			H		0
Bank's Reserves		$-MB^{cb}$	MB^{cb}				0
Governments's Deposits		$-GM^{cb}$	$-GM^b$	GM			0
Dong Deposits	DM^f		$-DM$		DM^h		0
Foreign deposits	$FM^f_{us} xr$			$FM^g_{us} xr$	$FM^h_{us} xr$	$-FM_{us} xr$	0
Bonds		B^{cb}	B^b	$-B$	B^h		0
Advances		LB^{cb}	$-LB^{cb}$				0
Loans	$-L^f$		L		$-L^h$		0
Foreign loans	$-FL^f_{us} xr$		$-FL^b_{us} xr$	$-FL^g_{us} xr$		$FL_{us} xr$	0
Equity	$-p_E E^f$		$-p_E E^b$		$p_E E^h$	$p_E E^r$	0
Foreign direct investment	$-p_{FDI} FDI_{us} xr$					$p_{FDI} FDI_{us} xr$	0
Other accounts r/p	OTA^f	OTA^{cb}	OTA^b	OTA^g	OTA^h	OTA^r	0
Net Wealth	$\mathbf{NW^f}$	$\mathbf{NW^{cb}}$	$\mathbf{NW^b}$	$\mathbf{NW^g}$	$\mathbf{NW^h}$	$\mathbf{NW^r}$	$\mathbf{p_K k + p_{K_{12}} k_{12}}$

Non-financial transactions (Uses-resources tables)

	Firms	Central Bank	Banks	Government	Households	RoW	Total	
Imports						$p_{IM}im$	$p_{IM}im$	
Exports						$-p_X x$	$-p_X x$	
Trade balance (X - IM)							$-TB$	
Production	$p_Y q^f$		$p_Y q^b$	$p_Y q^g$	$p_Y q^h$		$p_Y q$	Production account
Intermediate Consumption	$-\theta^f p_Y va^f$		$-\theta^b p_Y va^b$	$-\theta^g p_Y va^g$	$-\theta^h p_Y va^h$		$-p_Y ic$	
Value added	$\mathbf{p_Y va^f}$		$\mathbf{p_Y va^b}$	$\mathbf{p_Y va^g}$	$\mathbf{p_Y va^h}$		$\mathbf{p_Y va}$	
Wages + inc from abroad	$-\lambda^f wN$		$-\lambda^b wN$	$-\lambda^g wN$	$-\lambda^h wN$	$-WB^r$	0	Operating account
					$+wN + WB^r$			
Labor/social contributions	$-\alpha^f WB^f$		$-\alpha^b WB^b$	$-\alpha^g WB^g$	$-\alpha^h WB^h$		0	
				$+SOC$				
Indirect taxes (VAT included)	$-\tau_p^f p_Y q^f - \tau^r p_{IM} im$		$-\tau_p^b p_Y q^b$	$-\tau_p^g p_Y q^g$	$-\tau_p^h p_Y q^h$		0	
				$+\tau_{VAT} p_Y va + TP$				
Subsidies	$\tau_{SUBV} p_Y q^f$			$-\tau_{SUBV} p_Y q^f$			0	
Adjustment (*)	$\chi^f Y$				$\chi^h Y$		ADJ	
Gross operating surplus	$\mathbf{F^f}$		$\mathbf{F^b}$	$\mathbf{F^g}$	$\mathbf{F^h}$		**FT**	
Interest on gov deposits		$-r_m GM_{-1}^{cb}$	$-r_m GM_{-1}^b$	$r_m GM_{-1}$			0	Allocation of primary income account
Interest on deposits	$r_m DM_{-1}^f$		$-r_m DM_{-1}$		$r_m DM_{-1}^h$		0	
Interest on bonds		$r_b B_{-1}^{cb}$	$r_b B_{-1}^b$	$-r_b B_{-1}$	$r_b B_{-1}^h$		0	
Interest on advances		$r_l^{cb} LB_{-1}^{cb}$	$-r_l^{cb} LB_{-1}^{cb}$				0	
Interest on loans	$-r_l L_{-1}^f$		$r_l L_{-1}^b$		$-r_l L_{-1}^h$		0	
Interest on foreign loans	$-r_{fl} FL_{us_{-1}}^f xr_{-1}$		$-r_{fl} FL_{us_{-1}}^b xr_{-1}$	$-r_{fl} FL_{us_{-1}}^g xr_{-1}$		$r_{fl} FL_{us_{-1}} xr_{-1}$	0	
Dividends	$-\phi F_{-1}^f$					ϕF_{-1}^f	0	
Central Bank's profits		$-F^{cb}$		F^{cb}			0	
Primary income balance	$\mathbf{YP^f}$		$\mathbf{YP^b}$	$\mathbf{YP^g}$	$\mathbf{YP^h}$		**YP**	
Income taxes	$-\tau^f YP_{-1}^f$		$-\tau^b YP_{-1}^b$	DT	$-\tau^h YP_{-1}^h$		0	Redistribution of income account
					$-\tau_w WB$			
Social benefits				$-\gamma_{SBR} YP^h$	$\gamma_{SBR} YP^h$		0	
Cur. tr. from abroad (public)				TR_g^r		$-TR_g^r$	0	
Cur. tr. to abroad (private)					$-TR_r^p$	TR_r^p	0	
Cur. tr. from abroad (private)					TR_p^r	$-TR_p^r$		
Gross disposable income	$\mathbf{YD^f}$		$\mathbf{YD^b}$	$\mathbf{YD^g}$	$\mathbf{YD^h}$		**YD**	
Consumption					$-p_C c$		$-p_C c$	Use of income account
Public current expenditure				$-p_G g$			$-p_G g$	
Gross savings	$\mathbf{S^f}$		$\mathbf{S^b}$	$\mathbf{S^g}$	$\mathbf{S^h}$		**S**	
Gross fixed capital formation	$-p_K i^f$			$-p_K i^g$	$-p_K i^h$		$-p_K i$	Capital account
Changes in inventories	$-p_{K_{12}} i_{12}$						$-p_{K_{12}} i_{12}$	
Net fin. capacity	$\mathbf{NFC^f}$	**0**	$\mathbf{NFC^b}$	$\mathbf{NFC^g}$	$\mathbf{NFC^h}$	$\mathbf{NFC^r}$	**0**	

Flow of funds

Net fin. capacity	NFC^f	0	NFC^b	NFC^g	NFC^h	NFC^r	0
Δ val. in Intl. reserves		$-\Delta RES_{us}xr$				$\Delta RES_{us}xr$	0
Δ val. in Cash		ΔH			$-\Delta H$		0
Δ val. in Bank's Reserves		ΔMB^{cb}	$-\Delta MB^{cb}$				0
Δ val. in Gov's Deposits		ΔGM^{cb}	ΔGM^{b}	$-\Delta GM$			0
Δ val. in Dong Deposits	$-\Delta DM^{f}$		ΔDM		$-\Delta DM^{h}$		0
Δ val. in Foreign deposits	$-\Delta FM^{f}_{us}xr$			$-\Delta FM^{g}_{us}xr$	$-\Delta FM^{h}_{us}xr$	$\Delta FM_{us}xr$	0
Δ val. in Bonds		$-\Delta B^{cb}$	$-\Delta B^{b}$	ΔB	$-\Delta B^{h}$		0
Δ val. in Advances		$-\Delta LB^{cb}$	ΔLB^{cb}				0
Δ val. in Loans	ΔL^{f}		$-\Delta L$		ΔL^{h}		0
Δ val. in Foreign loans	$\Delta FL^{f}_{us}xr$		$\Delta FL^{b}_{us}xr$	$\Delta FL^{g}_{us}xr$		$-\Delta FL_{us}xr$	0
Δ val. in Equity	$p_E \Delta E^{f}$		$p_E \Delta E^{b}$		$-p_E \Delta E^{h}$	$-p_E \Delta E^{r}$	0
Δ val. in FDI	$p_{FDI} \Delta FDI_{us}xr$					$-p_{FDI} \Delta FDI_{us}xr$	0
Δ val. in Other accounts r/p	$-\Delta OTA^{f}$	$-\Delta OTA^{cb}$	$-\Delta OTA^{b}$	$-\Delta OTA^{g}$	$-\Delta OTA^{h}$	$-\Delta OTA^{r}$	0
Net lending/Borrowing	NLP^f	**0**	NLP^b	NLP^g	NLP^h	NLP^r	**0**

Outlines

Supply - Production

- Economic structure with six sectors: agriculture, energy, industry, financial services, public services and services
- Adaptive expectations

$$q_t^e = \gamma_q * s_t^e + (1 - \gamma_q) * i_{12_{t-1}} \tag{1}$$

- Expected sales of firms

$$s_t^e = (1 + pop_{gr} + prod_{gr}) * s_{t-1} \tag{2}$$

- Total sales

$$s_t = c_t + i_t^f + i_t^g + i_t^h + g_t + x_t + ic_t \tag{3}$$

- Domestic production

$$q_t = q_t^e - im_t \tag{4}$$

Households

- Use their disposable income to consume, invest and accumulate financial assets (cash, deposits, equities, government bonds)
- Consumption

$$c_t = f(yd_t^h, nw_{t-1}^h) \tag{5}$$

- Household's investment

$$i_t^h = f(nw_{t-1}^h, r_{l_{t-1}} - \pi_{t-1}) \tag{6}$$

- Borrow from banks for their investment
- Impact of climate change through different channels: the number of working hours they can dedicate to the firms; their productivity declines if they are caught by an infectious disease; the aggregate mortality rate of the population.

Firm's investment and Financing

- Firm's investment

$$\frac{\Delta k^f}{k^f_{t-1}} = f(\frac{y_{t-1}}{y^*_{t-1}}, r_{l_t} - \pi_t) \tag{7}$$

- Financing of firm's investment: using retained profits, borrowing from banks or abroad, issuing equities or attracting FDI.
- Impact of climate damages: agriculture (rice yields, rice fields), energy sectors (electricity demand and the hydropower sector), total factor productivity (investment, FDI...).

Openess

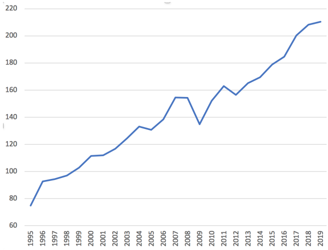


Figure: Openess, %GDP

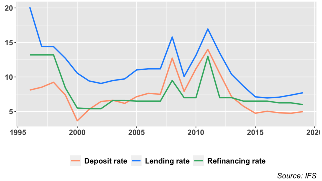
- Exports

$$x_t = f(im^{PTN}_{t-1}, q_{t-1}, xr_{t-1}) \tag{8}$$

- Imports

$$im_t = f(DMD_t, \frac{p_{IM_{t-1}}}{p_{C_{t-1}}}) \tag{9}$$

Central bank and monetary policy



- Refinancing rate: function of the level of inflation, the US interest rate and the exchange rate

$$r_{l_t}^{cb} = f(xr_t, r_{l_t}^{us} - r_{l_{t-1}}^{cb}, \pi_{t-1}) \qquad (10)$$

- Lending rate

$$r_{l_t} = f(r_{m_t}) \qquad (11)$$

- Deposit rate

$$r_{m_t} = f(r_{l_t}^{cb}) \qquad (12)$$

International reserves and exchange rate

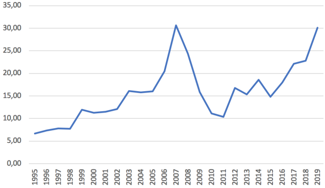


Figure: FX reserves, %GDP

- International reserves

$$\Delta RES_t = f(\Delta xr_t) \tag{13}$$

- Exchange rate

$$xr_t = f(xr_{t-1}, \frac{D^{FX}_{t-1} - S^{FX}_{t-1}}{S^{FX}_{t-1}}) \tag{14}$$

- FX demand: imports, interest payments, current transfers...
- FX supply: exports, wages from abroad, interest receives, remittances, capital inflows (FDI, portfolio investments)

Credit rationing

- Firms - Loans to Value (LTV)

$$LTV_t^f = min\left(0.7, \frac{L_t^{fD}}{NW_{t-1}^f}\right) \tag{15}$$

- Households - Debt to Income (DTI)

$$DTI_t^h = min\left(0.4, \frac{ITLH + \Delta L_t^{hD}}{YP_t^h}\right) \tag{16}$$

Public debt and the debt rule

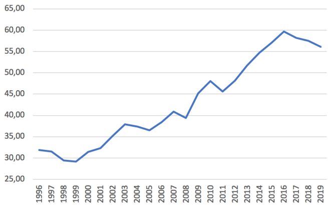


Figure: Public debt, %GDP

- Desired financing needs

$$NFC_t^{gD} = S_t^g - p_{K_t} i_t^{gD} \tag{17}$$

- Public debt rule

$$DEBT_{G_t}^R = min(0.65, \frac{DEBT_{G_t}^D}{Y_{t-1}}) \tag{18}$$

- Effective public investment

$$i_t^g = \frac{S_t^g - NFC_t^g}{p_{K_t}} \tag{19}$$

Outlines

Agriculture

Modelling implications

- We define the effective agricultural production ($Q^*_{A_t}$)

$$Q^*_{A_t} = (1 - D_{AGR_t} * \gamma_{RICE}) * Q_{A_t} \tag{20}$$

- γ_{RICE}: Part of rice in agriculture
- Q_{A_t} : Agricultural production of baseline scenario
- D_{AGR_t} : Production loss due to climate change

$$D_{AGR_t} = -6.9 * \Delta T \tag{21}$$

Agriculture - Meta-analysis

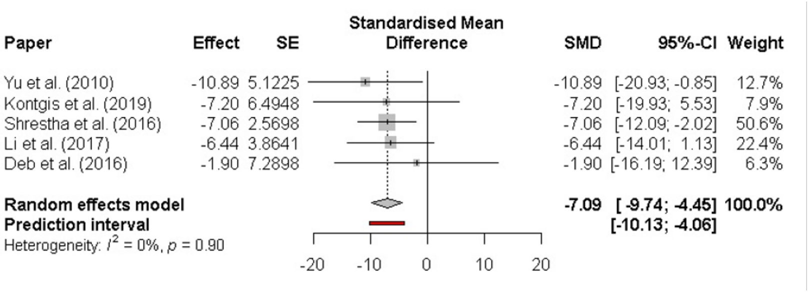


Figure: Meta analysis of the results reported in 5 selected published papers, on the impact of an increase of one degree of temperature on rice yield in percentage points. The weight given to each study result is calculated according to the 95% confident Intervals of the estimates. Effect : impact on rice yield (in %), SE : Standard Error (in %) SMD : Standard Mean Difference (in %)

Agriculture - Monte carlo simulation

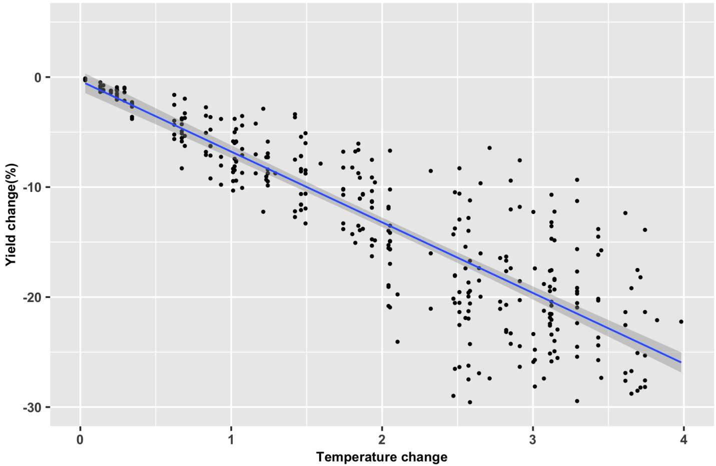


Figure: Average yield change over the period 2020-2099 as a function of VNMST change 2020-2099 relative to 1997-2019

Energy

Modelling implications on energy supply

- We define the effective energy production ($Q^*_{E_t}$)

$$Q^*_{E_t} = (1 + D_{E_t} * \gamma_{HP}) * Q_{E_t} \qquad (22)$$

- γ_{HP}: Part of hydropower on the energy sector
- Q_{E_t} : Energy production of baseline scenario
- D_{E_t} : Hydropower impact

$$D_{E_t} = 0.055 * \Delta T - 0.016 * \Delta T^2 \qquad (23)$$

Energy (con't)

Modelling implications on energy demand

- We define the effective final consumption (C_t^*)

$$C_t^* = (1 + D_{RE_t} * \gamma_{RE}) * C_t \tag{24}$$

- γ_{RE}: Part of electricity consumption
- C_t : HH's consumption
- D_{RE_t} : Residential electricity consumption impact

$$D_{RE_t} = 1.033 * \Delta T \tag{25}$$

Energy

- **Auffhammer & Mansur (2014), Yalew et al. (2020)**: climate change impacts both energy supply and demand
- **Supply side**: changes in precipitation and temperature can affect the energy production capacity, the transmission systems or the infrastructure itself (World Bank (2011), Ciscar & Dowling (2014), Perera et al.(2020)).
- **Demand side**: rising temperature and weather extremes in recent years are strongly affecting the residential electricity demand

Impact on hydropower production

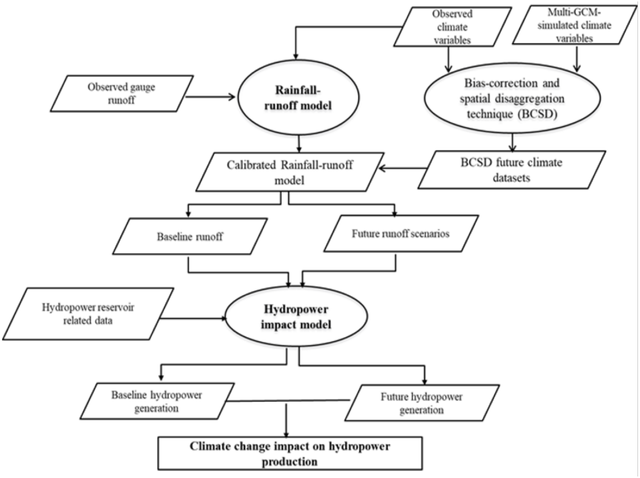
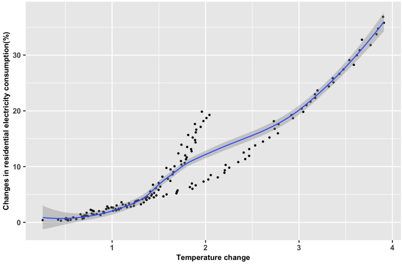


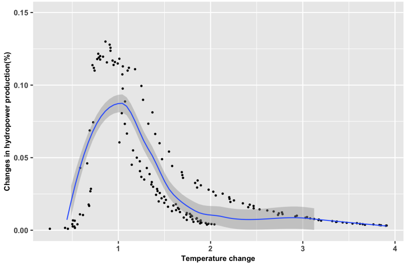
Figure: Methodology applied to model the impacts of climate change on hydropower production

Energy (con't)

Data: Viet Nam Household Living Standard Survey (VHLSS); FAO Rivers in South and East Asia and HydroBASINS, HydroSHEDS void-filled DEM, Digital Soil Map of the World version 3.6, UMD Land Cover classification collection VnGP and VnGC dataset, Institute of Energy Vietnam's Hydro-Meteorological Data Center



Average residential electricity demand changes over the period 2020-2099 as a function of VNMST change 2020-2099 relative to 1997-2019



Average change in hydropower production over the period 2020-2099, as a function of VNMST change 2020-2099 relative to 1997-2019

Labor productivity

Modelling implications

- We define the effective number of workers (NBW_t^*)

$$NBW_t^* = (1 - D_{L_t}) * NBW_t \tag{26}$$

- NBW_t : Number of workers of baseline scenario
- D_{L_t} : Labor productivity loss due to climate change

$$D_{L_t} = -2.6 * \Delta T \tag{27}$$

Labor productivity (con't)

Kjellstrom, et al. (2009a): Workplace heat stress and health

- Clinical health effects
- Work capacity affected and hourly work output reduced

Kjellstrom, et al. (2013): Mapping Occupational Heat Exposure and Effects in South-East Asia: Work loss" due to heat **Kjellstrom, et al. (2014)**: Occupational Heat Stress

- In 2030, Heat loss could represent 5.7% of Vietnam's GDP

UNDP (2016): Climate change and labour: Impacts of heat in the workplace

Labor productivity (con't)

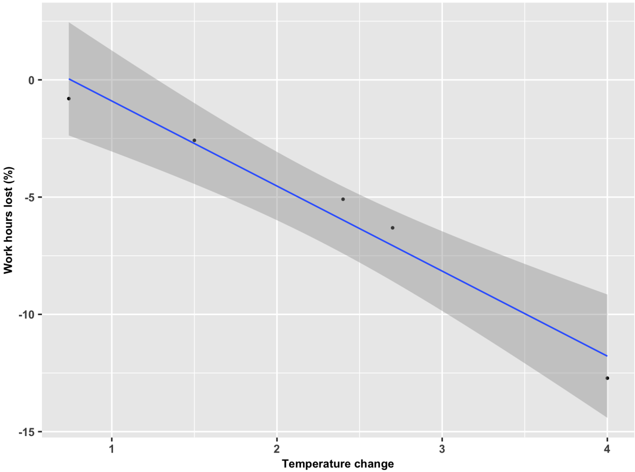


Figure: Average working hours lost over the period 2020-2099 as a function of VNMST change 2020-2099 relative to 1997-2019

Mortality

Modelling implications

- We define the effective number of workers ($MORT^{*}_{GR_t}$)

$$MORT^{*}_{GR_t} = (1 + D_{M_t}) * MORT_{GR_t} \tag{28}$$

- $MORT_{GR_t}$: Mortality rate of baseline scenario
- D_{M_t} : Mortality damage

$$D_{M_t} = 2.8 * \Delta T \tag{29}$$

Mortality (con't)

- **Gasparrini et al. (2017)**: negative impacts of climate change which potentially produce an increase in mortality
- **Guo et al. (2018)**: heatwave-related excess mortality increases the most in tropical and subtropical countries/regions
- **WHO (2014)**: relative increase in excess deaths from 2030 to 2050 including South-East Asia
- **Vicedo-Cabrera et al. (2018)**: Paris Agreement could contribute to avoid an increase of temperature-related mortality
- Valuation by using the Value Statistical Life (VSL)

Mortality (con't)

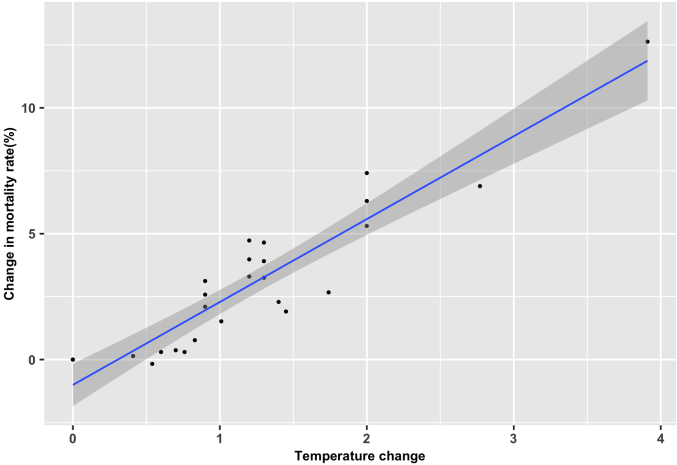


Figure: Change in mortality rate over the period 2020-2099 as a function of VNMST change 2020-2099 relative to 1997-2019

Total factor productivity

Modelling implications

- We define the effective number of workers (TFP_t^*)

$$TFP_t^* = (1 - D_{TFP_t}) * TFP_t \tag{30}$$

- TFP_t : TFP of baseline scenario
- D_{TFP_t} : Damage on TFP

$$D_{TFP_t} = -3.59 * \Delta T \tag{31}$$

Total factor productivity (con't)

- **Letta and Tol (2016)**: a negative relationship in poor countries but indistinguishable from zero in rich countries
- **Dietz and Stern (2015)**: test the macroeconomic impacts when TFP is hit.
- **Moore and Diaz (2015)**: increased impacts.
- **Moyer et al. (2014)**: future impact of global warming on TFP growth.
- Vietnam: TFP is expected to contribute 45-47 % of GDP growth

Total factor productivity (con't)

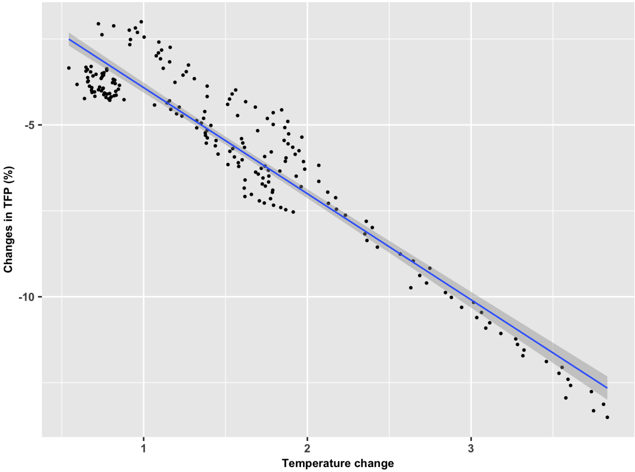


Figure: Change in TFP over the period 2020-2099 as a function of VNMST change 2020-2099 relative to 1997-2019

Infectious diseases

- **Rocque et al. (2021))**: negative impacts on health outcomes (e.g. infectious diseases, mental health..)
- Chapter 3 of the GEMMES project report: effect through the loss in labor productivity (average hourly wage)
- 1% increase of disease infections $\rightarrow$ 0.049%decrease in the average hourly wage
- Infection will increase by 29% by 2050 under both RCP4.5 and RCP8.5 and by 36% by 2100 under RCP8.5 (without adaptation).
- Valuation of infectious diseases damage by the wage lost.

Aggregate sectoral damages

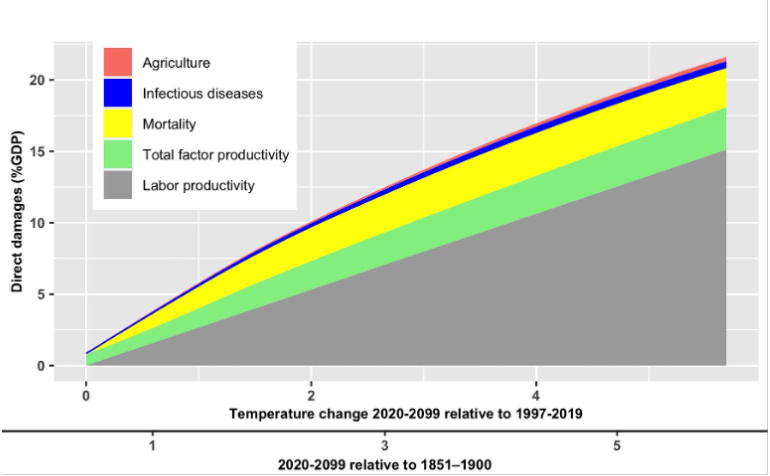


Figure: Total direct damage to the Vietnamese economy by different sectors as a function of VNMST change 2020-2099 (contemporary climate) and relative to 1851-1900 (pre-industrial climate)

Outlines

Simulation

(a) Real GDP

(b) Real consumption

(c) Real household's investment

(d) Real firm's investment

Figure: GDP components

Simulation (con't)

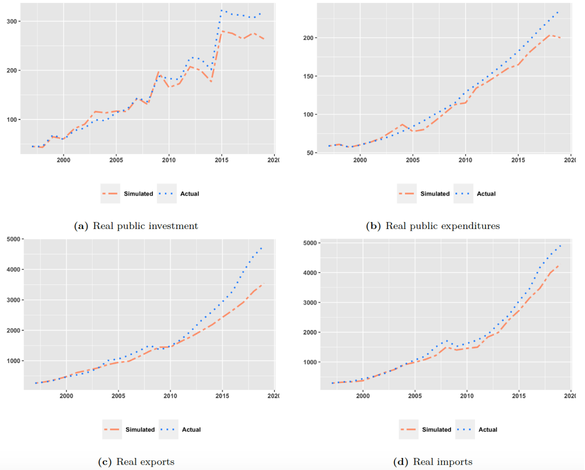


Figure: GDP components (con't)

Baseline scenario

Table: Main assumptions for exogenous variables

Population in 2040	United Nation's population projections for Vietnam (downward trend)
Unemployment rate	2% (Value in 2019)
Capital depreciation	Value in 2019
Share of public expenditures	5.9% (IMF, 2019)
Share of public investment	6.8% (IMF, 2019)
Growth rate of world GDP	Quantitative projections of the so-called Shared Socioeconomic Pathways (SSPs)
Demand for real imports of trading partners	OECD's projections
World price of imports	Grow at 1% per year
Required bank reserves ratio	Value in 2019
Price of equity for US	Average growth rate of the last 5 years
US interest rate	FED's projections

GDP loss with the macroeconomic model

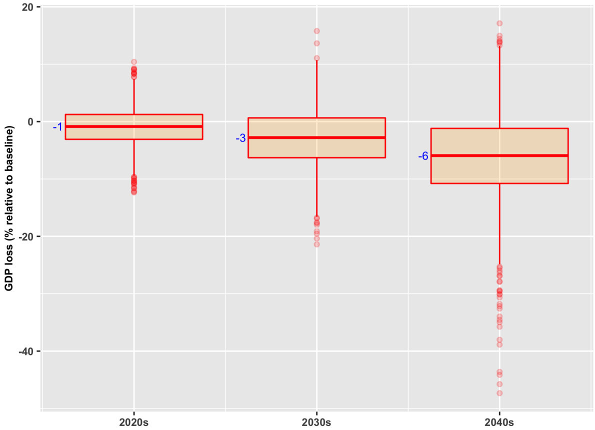


Figure: Macroeconomic damage as a percentage of GDP loss relative to baseline scenario. Damage functions (agriculture, energy, labor productivity, total factor productivity, mortality) are taken into account.

GDP loss with the macroeconomic model (con't)

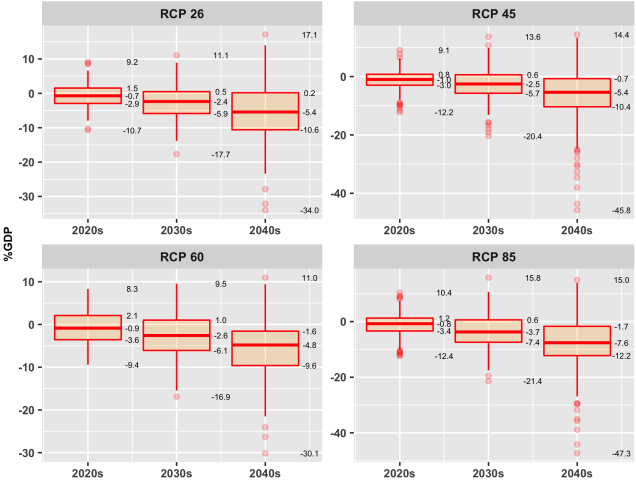


Figure: Macroeconomic damage as a percentage of GDP loss relative to baseline scenario by RCP

GDP loss with the macroeconomic model (con't)

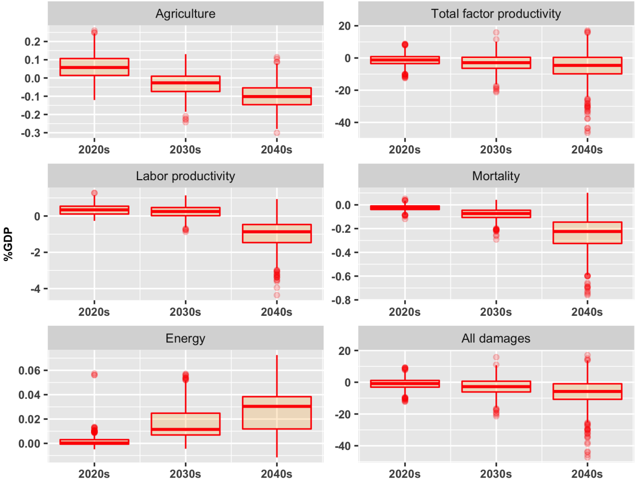


Figure: Macroeconomic damage as a percentage of GDP loss relative to baseline scenario by sector

Macro impacts vs Direct impacts

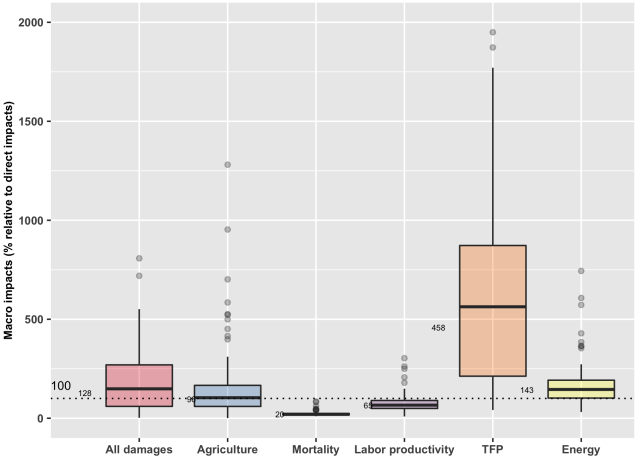


Figure: Distributions of GDP loss in the macroeconomic model compared with direct damages

Outlines

Conclusion

- Sectoral direct impacts: 6% relative to the baseline scenario at +1 ℃ of warming
- Macro impacts: by 2050, between 0.7 and 10.4% under RCP 4.5 and between 1.7 and 12.2% under RCP 8.5.
- Macroeconomic impacts losses larger than direct damages by around 30%.
- A first empirical stock-flow coherent macroeconomic model of the Vietnamese economy.
- Open to incorporate further studies on specific impacts of climate change on specific sectors

Thank you for your attention!