

## Vietnam's Long-run Growth: Connecting the Dots through Climate Damage Spillovers

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**Abstract** We propose to examine how climate damage may transform Vietnam's long-run growth rate. Because of cross-country linkages forged by bilateral trade, there are two channels through which international damage spillovers may occur. First, the dynamics of partners' growth determine future trends in Vietnam's volume of exports. Second, since the domestic impact of climate change may be heterogeneous across countries, there will be a differentiated impact on export and import market shares. Both terms play a critical role in changing trade patterns that are likely to shift Vietnam's external constraint. This demand-side view of growth based on the balance-of-payments constraint is a powerful predictor of inter-country growth differences. Our study shows that the consequences of climate change could equate to a 2.5% reduction in Vietnam's growth rate over the period 2020-2060. Our decomposition exercise by effect and by partner area shows that international damage spillovers result from very different individual behaviours.

**Keywords:** balance-of-payments-constrained growth model, climate change adaptation, international damage spillovers, macroeconomic resilience, Vietnam

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## I. Introduction

There is powerful evidence that climate change will disproportionately impact the developing

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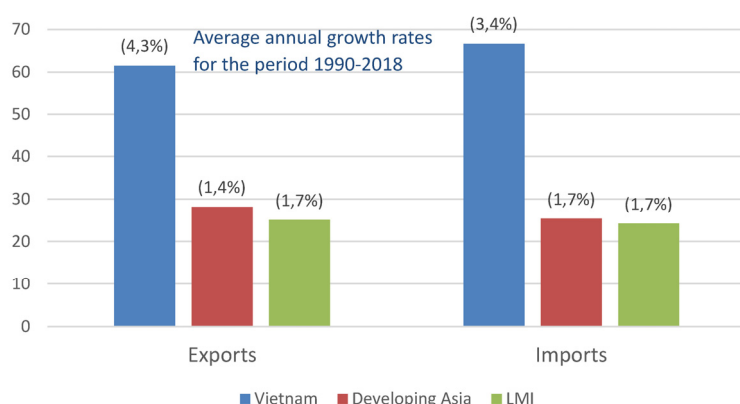
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world (Mendelsohn et al., 2006; World Bank, 2013). The IMF (2020) reports that emerging and developing economies suffered almost twice as much damage as average relative to the size of their economies during the period 1980-2018. At the same time, they are among the countries with the largest and fastest growth projections as their involvement in global trade increases. With non-OECD countries' share of global GDP set to rise well beyond that of the current OECD area by 2060, Africa is forecast to have the world's highest economic growth rate, while the coming 50 years will see a major shift in economic balance towards the emerging economies of Asia (Braconier et al., 2014). The OECD (2015) reports that Africa and Asia will be the regions hardest hit in the next 50 years by the economic effects of climate change.

The consequences of climate change (*i.e.* climate damage) on international trade have attracted increasing interest in the recent economic literature. Two important strands have emerged: the first focuses on the direct effects on trade-relevant supply, transport infrastructure and distribution chains, and the second on the indirect effects on production and trade. Due to a lack of data however, the direct effects are difficult to quantify and are subject to debate although there is a consensus that climate change will imply higher trading costs (OECD, 2017).

**Figure 1.** Vietnam's trade openness in % of GDP (1990-2018)



(Source) World Bank's World Development Indicators (WDI).

Notes. 'Developing Asia' defines East Asia & Pacific (excluding high income) and 'LMI' Low & Middle Income. Trade openness is measured here by exports/GDP and imports/GDP and expressed in %.

The *nexus* between climate change and trade is particularly relevant for Vietnam, which is among the countries most vulnerable to the damaging effects of climate change while simultaneously being one of the most open to global trade (Brenton and Chemutai, 2021). Figure 1 shows the average level of exports and imports in per cent of GDP, as well as their average annual growth rates over the period 1990-2018. Vietnam's economy is clearly one of the most open in the world, with an average ratio of 61.5% and 66.6% for exports and imports respectively. Meanwhile, both flows grew at an average rate of 4.3% and 3.4% respectively per year. Because export-oriented

activity clearly supports the country's growth, further opportunities are expected from the recent adoption of three major Free Trade Agreements (FTAs), namely: the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) with 10 of the fastest-growing economies of the Pacific Rim in December 2018; the European Union-Vietnam Free Trade Agreement (EVFTA) in June 2020; and the Regional Comprehensive Economic Partnership (RCEP) with 14 Asian neighbours in November 2020. Together, these three agreements covered approximately 81% of Vietnam's trade flows in 2019 (World Bank, 2020b).

However, there are several aspects of climate-induced economic factors, especially in combination with international trade, that are not fully understood. The changing geography of global trade can shape the evolution of a country's future path through international spillovers, that is: transmission of any shock or disturbance from one country to the others in a highly interconnected global trading system. In the long term, there will be a differentiated impact on countries' export and import growth rates, and that impact will vary over time and across different groups of exporting and importing countries.

Accordingly, the present contribution aims to examine how climate damage may transform Vietnam's relative competitiveness and redefine its long-run growth rate through trade-related cross-country linkages. In that respect, Balance-of-Payments-Constrained Growth (BPCG) theory is particularly well suited to our purpose. Drawing on a multi-country setting, our decomposition of the country's long-run predicted growth into different factors from different sources is undertaken to assess the demand-side constraints of climate change. In the empirical implementation of our BPCG model, we refer to the OECD's ENV-Linkages model simulations that highlight geographic disparities in the projected impacts of climate change on the trading partners and on the patterns of international trade. We test the model predictions for Vietnam by constructing the BPCG rate corresponding to two alternative scenarios, namely: a no-damage baseline and the scenario with climate damage. Firstly, we compare both predicted rates over the period 2020-2060 in order to assess if climate damage will tighten Vietnam's Balance-of-Payments (BP) constraint (reflecting a deteriorating trade position relative to its partners). Secondly, we examine how, and through which transmission channels, the changing trade patterns resulting from climate damage will impact the evolution of Vietnam's competitive position in the long run. Overall, our study shows that the consequences of climate change could equate to a 2.5% reduction in Vietnam's average growth rate over the period 2020-2060. Moreover, a linear decomposition by effect and by partner area shows that international damage spillovers result from very different individual behaviours, reflecting causes abroad that spillover to home.

The remainder of this article is organized as follows. Section 2 presents the background and motivation for this study. Section 3 describes the theoretical framework while in Section 4 we present our database and the general options of our econometric approach. Section 5 begins by analysing how climate change affects partners' growth and the subsequent market shares in

exports and imports. We go on in Section 6 to assess the impact of climate change on Vietnam's long-run growth rate and trade position relative to its partners. Section 7 summarizes our main results and their limitations.

## II. Background and Motivation

### A. Country background

In the vulnerability index compiled as part of the Notre Dame University Global Adaptation Index (ND-GAIN) for 2018, Vietnam is ranked 58<sup>th</sup> out of 181 countries, while it is 85<sup>th</sup> in terms of readiness to respond effectively to climate change<sup>1)</sup>. According to the Global Climate Risk Index (CRI) published by Germanwatch (2019), Vietnam is ranked 6<sup>th</sup> among the countries most directly affected by extreme weather events. Firstly, geographical location explains the country's high susceptibility to the damaging effects. Vietnam is located at the end of several transboundary river basins and its low-lying coastline of 3,444 kilometres exposes the country to rising sea levels. Secondly, a large part of domestic economic activities is clustered in the Mekong and Red River deltas. The Mekong River basin, for example, which produces 50% of the country's rice and contributes significantly to Vietnam's rice exports, is especially vulnerable to rising sea levels (World Bank, 2013). Moreover, while the country has the highest population density in Southeast Asia, 70% of the population lives in coastal areas and low-lying deltas, where fast population growth, urbanization and high density increase the risks of socioeconomic losses attributable to climate hazards.

From the business standpoint, the geographic distribution of the main clusters indicates that production sites, supply chains or trading businesses are located in areas of high exposure and vulnerability to climate hazards. Table 1 depicts the Provincial Competitiveness Index (PCI) according to the surveys of firms on the business environment in Vietnam. We can see that most of the top-ranked provinces (highlighted in bold) are in coastal cities or river basin provinces, with large populations and assets. Moreover, those in italics are also heavily outward-oriented since they host free zones. For example, 18 economic zones are coastal; out of 326 industrial parks, 76 are located in the Red River Delta and 45 in the Mekong Delta while 38 are in coastal areas. This could explain why a wide-ranging enterprise survey on the topic was published recently. Attracting respondents from 10,356 enterprises across all 63 provinces and cities, this remains Vietnam's most comprehensive survey on the topic.<sup>2)</sup>

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- 1) A country's ND-GAIN index is composed of climate vulnerability and adaptation readiness scores based on compiled indicators. An explanation of each indicator and their data sources can be viewed on the Indicators page
  - 2) Vietnam Chamber of Commerce and Industry (VCCI): *Adapting to succeed. Assessing the Impact of Climate Change on Vietnamese Businesses*, Hanoi, September 16, 2020. This publication can be downloaded at: <https://pcivietnam.vn/en>

**Table 1.** Top Ranking Provinces in Vietnam's Provincial Competitiveness Index (PCI) 2019

Province	Location	Rank	The Weighted PCI Score
<b>Quang Ninh</b>	<b>N</b>	1	73.40
Dong Thap	S	2	72.10
Vinh Long	S	3	71.30
<i>Bac Ninh</i>	<i>N</i>	4	70.79
<b>Da Nang</b>	<b>C</b>	5	70.15
<b>Quang Nam</b>	<b>C</b>	6	69.42
<b>Ben Tre</b>	<b>S</b>	7	69.34
<i>Long An</i>	<i>S</i>	8	68.82
<i>Ha Noi</i>	<i>N</i>	9	68.80
<b>Hai Phong</b>	<b>N</b>	10	68.73
<i>Can Tho</i>	<i>S</i>	11	68.38
Thai Nguyen	N	12	67.71
<i>Binh Duong</i>	<i>S</i>	13	67.38
<b>Ho Chi minh City</b>	<b>S</b>	14	67.16
Tay Ninh	S	15	67.05
<b>Ba Ria-Vung Tau</b>	<b>S</b>	16	66.96
Vinh Phuc	N	17	66.75
<b>Nghe An</b>	<b>C</b>	18	66.64
<b>Binh Dinh</b>	<b>C</b>	19	66.56
<b>TT-Hue</b>	<b>C</b>	20	66.50
<b>Memo</b>	Among 63 provinces		
Median	65.13		
Max	73.40		

(Source) The Provincial Competitiveness Index (PCI), <https://pcivietnam.vn/en>

Notes. (N) Northern region; (S) Southern region; (C) Central region.

In our view however, there are two main drawbacks to the climate economics literature as applied to Vietnam. Firstly, the existing studies mainly adopt a supply-side approach to various aspects of the economic system, with a focus on sectoral studies (agriculture and aquaculture, energy, tourism), food security, land use, water supply management or irrigation shortfalls. Otherwise, they mainly focus on the production function aspects such as the supply of production factors (with physical destruction of productive capital and land, infrastructure), a decline in factor productivity growth, technology change or technical efficiency.

Secondly, since the promulgation and implementation of the National Target Program to Respond to Climate Change (NTP-RCC) in 2008, the government has recognized the importance of responding to climate change. On the policy side, various programs, policies and legislation have been put in place to address climate-related challenges, with a cross-cutting approach dominated by adaptation to the impacts. However, even in the National Action Plan on Climate

Change (NAP-CC), which has been updated until 2025, nothing is stated about the indirect consequences of climate change coming from the rest of the world.

Overall, most studies applied to Vietnam omit demand shocks arising from global trade. At the macroeconomic level, partial or general equilibrium model analyses have been conducted in order to simulate the potential implications of climate damage at national, regional or local level. For example, UNU-WIDER and CIEM (2012) use a Dynamic Computable General Equilibrium (DCGE) model to evaluate the climate impacts on growth and welfare. By adopting a multi-sector approach and comparing a baseline scenario with the full range of climate projections over the period 2007-2050, the report predicts a reduction in average annual GDP growth rates of between 0.02 and 0.10 percentage points. The losses caused by climate change will be large in absolute terms, providing incentives for adaptation policies.

Ultimately, however, climate change is a global externality, meaning that Vietnam could be further affected by climate damage incurred by the country's trading partners. By ignoring 'international damage spillovers', the Vietnamese government may be misjudging the climate shock on the domestic economy. As Batten (2018: 2) notes: *'A meaningful quantification of the macro-economic impacts of climate change, however, faces a number of severe challenges, some of which have been extensively addressed by the economic literature, while others are only just emerging. These challenges are directly related to the features that distinguish the climate change externality from other externalities: (1) it is global in its causes and consequences; (2) the impacts of climate change are long-term and persistent; (3) the uncertainties about the economic impacts are pervasive and (4) there is a serious risk of major, irreversible change.'*

## B. Research question

These would be widely accepted that climate change may indirectly impact Vietnam's economy through changing trade patterns. Firstly, the country is heavily involved in global trade networks, meaning that the composition of its individual trade basket could be exposed to localized supply shocks from the import of specific goods (Korniyenko et al., 2017). Secondly, the country may both export to and import from climate-sensitive countries. In 2017, 47% of the country's exports went to East Asia and Pacific (with over 20% going to North America and to Europe), while 73% of imports were purchased from the same area. But the fact that Asia will be one of the regions in the world most affected by climate change, combined with the country's high trade openness, may increase Vietnam's vulnerability to damage spillovers.

A key concern, then, is whether Vietnam's trade-led growth strategy is sustainable in the long run and whether it is resilient to adverse and persistent consequences of climate change. Furthermore, the impact of climate change is likely to vary considerably across countries at different levels of economic development and trade openness, depending on the physical

conditions and their adaptive capacities. If climate change had the same impacts on trading partners as it is likely to have on Vietnam, there would be no change in the country's relative competitiveness. On the other hand, however, if Vietnam was negatively affected by climate damage while the trading partners were more severely impacted, then the country's relative competitiveness would improve. Consequently, we need to understand not only the potentially disruptive impact of climate change on Vietnam's domestic activity, but also the projected impacts on the country's trading partners and their positions relative to Vietnam in global markets. Otherwise, any exercise will underestimate the consequences of spillovers from damage incurred in each specific economy.

In this article, we propose to examine how climate damage may transform the country's relative competitiveness and redefine its long-run growth rate. Our contribution here is to draw on a demand-side approach to trade and growth in order to assess climate impacts. It appears that export-oriented industrialization provides active transmission channels to any potential shock in overseas demand. International spillovers reflect the fact that the responsiveness of trade flows to change in demand has been rising over time (Freund, 2009). With projections on the implications of climate change for Vietnam and its trading partners, these inter-linked impacts known as 'international damage spillovers' will allow us to measure the related effect on Vietnam's international trade position. To the best of our knowledge, Gassebner et al. (2010) and Oh and Reuveny (2010) were the first to highlight the significant effects of negative supply shocks such as natural climate disasters on bilateral trade by using pairs of countries in a trade gravity analysis. Although research on the trade effect is in its infancy, a multi-country setting is still lacking from any assessment of the indirect effects of climate change on international trade. The OECD (2015) and Dellink et al. (2017) embraced the climate-related issues linked to the global geography of trade by developing a DCGE modelling approach to climate damage. The OECD (2015) examined how climate change affects different drivers of economic growth with global coverage and sector-specific international trade flows. It was then used by Dellink et al. (2017) to explore the long-term climate impacts on international trade, delving much deeper into the consequences for competitiveness, specialization and changes in trade patterns.

This contribution builds on the OECD's ENV-Linkages model simulations to highlight geographic disparities in the indirect consequences of climate change. While an aggregated model of the domestic economy is assumed to focus on the macroeconomic channels, a multi-country setting is required to simulate the effects of climate damage on the geography of trade. Since Vietnam is an export-dependent country, we need to examine how trade interrelations are channels through which climate impacts are transmitted into the Vietnamese economy. Moreover, climate change can cause long-lasting damage and is therefore likely to impact on GDP growth rather than its level. As a result, the *relative* impact in a country compared to its trading partners matters more for growth predictions than the *absolute* size of the damage a country sustains.

Dellink et al. (2017: 47) note: '*There are two key international spillovers in determining the domestic economic consequences of climate change: (i) damages from climate impacts in other countries; and (ii) changes in international trade patterns due to shifts in competitive positions.*' Because of trade-related cross-country linkages, we apply BPCG theory to address our research question. More precisely, as the trading partners are also commonly affected by climate-induced damage, we posit that output growth differentials and the subsequent change in relative competitiveness could magnify the vulnerability of Vietnam's economy to climate change.

### III. The Theoretical Framework

In the recent literature, models of export-led growth have emphasized demand-side factors by relying on BPCG theory. Also known as Thirlwall's law, this theory postulates that the growth rate of an open economy that is consistent with its BP equilibrium defines the maximum rate that it can reach in the long run (Thirlwall, 1979). In its original version, this growth rate of domestic income is determined by the ratio of the growth rate of aggregate exports (which is, in turn, determined by the exogenously given growth of world income) to the income elasticity of import demand. In practice, however, a country trades with numerous partner countries and each bilateral trade relationship may have different outcomes. Since a country's economic growth depends on the growth rate of other countries through the BP constraint, this mutual interdependence should be captured in a model with multilateral trade relations. In view of this, our analytical framework draws on Mania et al. (2022), who apply an alternative BPCG model developed by Bagnai et al. (2016). To save space, the BPCG model is provided in Appendix A.

If we express the BP-equilibrium condition in terms of growth rates, we obtain a multi-country specification of Thirlwall's law as follows:

$$\dot{Y}_{i,BP} = \frac{\sum_j \dot{R}_{ij} [\mu_{ij}(1 - \psi_{ij}) - \nu_{ij}\eta_{ij}] + \sum_j \nu_{ij}\epsilon_{ij} \dot{Y}_j}{\sum_j \mu_{ij}\pi_{ij}} \quad (1)$$

where dots denote the growth rates.

$\dot{Y}_{i,BP}$  is the growth rate of an open economy  $i$  that is consistent with its BP equilibrium;  $\dot{Y}_j$  is the income growth in partner  $j$ ;  $\dot{R}_{ij}$  is the rate of change in the bilateral real exchange rate (namely the ratio of domestic to foreign prices expressed in domestic currency). The price and income elasticities are denoted by  $\psi_{ij}$  and  $\pi_{ij}$  respectively for country  $i$  imports from partner  $j$ ;  $\eta_{ij}$  and  $\epsilon_{ij}$  for country  $i$  exports to  $j$ . Lastly,  $\nu_{ij}$  and  $\mu_{ij}$  are, respectively, the market shares of partner  $j$  in country  $i$ 's exports (in volume) and in country  $i$ 's imports (in value)<sup>3</sup>.



Equation (1) defines the maximum growth rate (also the BPCG rate) that an economy  $i$  can reach in the long run. It is a binding constraint in the sense that it cannot exceed this upper limit for prolonged periods because, if it does, it will quickly incur BP difficulties. A central feature of the BPCG framework is the role of externally originated demand in driving expansions of aggregate demand, and consequently the rate of growth defined by BP conditions. In our disaggregated law, the numerator features both a relative price effect (whose sign depends on the market shares weighted by bilateral price elasticities) and a volume effect (a weighted sum of real export growth where the export market shares intertwine with the income elasticities to magnify partners' income growth). The denominator features an 'appetite for imports' (a sum of bilateral income elasticities of imports weighted by the corresponding market shares).

Under the assumption that relative prices are not trending, Equation (1) becomes:

$$\dot{Y}_{i,BP} = \frac{\sum_{j=1}^n \nu_{ij} \epsilon_{ij} \dot{Y}_j}{\sum_{j=1}^n \mu_{ij} \pi_{ij}} \quad (2)$$

which can be seen as a generalization of Perraton's (2003) 'strong' version of Thirlwall's law, where the term 'strong' alludes to the strong hypothesis of constant relative prices.

At the core of BPCG models are the income elasticities of demand for exports and imports, which give demand a prominent role in growth theory. But the contribution of our multi-country setting is to add market shares on exports and imports, which lie at the heart of the country's competitiveness: any change in the geographic distribution of import and export market shares adds to the structural parameters in determining the BPCG rate. Another important feature of the multi-country specification is that it cannot be decomposed in bilateral terms. However, it allows the contribution of each country or group of countries (partner  $j$ 's variables either in country  $i$ 's export market or import demand) to *changes* in the aggregate BP constraint to be assessed separately.

Altogether, the changing geography of international trade can shape the evolution of the BP constraint, as the elasticity ratio is rooted in different patterns of production and trade. Taking into account the BPCG model, a country's long-run predicted growth is based on trading partners' growth, on the one hand and, on the other, on the country's relative competitiveness. Yet both factors are identified as the two key international spillovers through which country  $i$  may be affected by the long-run effect of climate change through changes in trade patterns, namely the changing volume of exports and market shares in country  $i$ 's total exports (in volume) and total imports (in value).

3) This asymmetric treatment of the market shares is a mathematical consequence of the fact that, in the equilibrium condition, the summation in bilateral exports involves terms in volume while the summation in imports involves terms in value (see Equation A3, Appendix A).

Our approach involves evaluating the impact of climate change on Vietnam's BPCG rate. But to do this, it is assumed that no mitigation actions or new involvement in FTAs are taken to tackle climate change during the period considered. Moreover, because our model spells out cross-country interdependencies, we need to refer to a database that assesses the consequences of climate change for partner  $j$ 's growth rates and the geography of international trade.

## IV. Data and Methodology

### A. The OECD's ENV-Linkages model

To assess the impact of climate change on the structure of global trade, we use data from Dellink et al. (2017)<sup>4</sup>. Although projections made by the OECD's ENV-Linkages model are subject to a high degree of uncertainty, the impacts of climate change are analysed from a multi-sectoral, multi-regional perspective, in which one scenario is simulated in order to focus specifically on international trade. Our quantitative approach would improve in robustness if we could compare different scenarios and simulations from different models; but to the best of our knowledge, this is the only model that studies the impact of climate change on the geographic structure of international trade.

The OECD's ENV-Linkages model links economic activities in 35 sectors and 25 regions across the world in an attempt to assess the costs of 'policy inaction' in addressing climate change. Accordingly, two scenarios are projected to 2060: a no-damage baseline which simulates overall change in the world economy without taking into account any damage caused by climate, and a second scenario in which climate impacts are integrated into the model. Climate damage is defined as the fractional loss in annual economic output at a given level of global warming compared to output in the same economy with no warming. One special feature of this model is that it takes into account not only the climate impacts on national economies (both supply-side and demand-side effects), but also the differentiated impacts across trading partners that modify the structure of international trade.

Looked at from a regional perspective, the consequences of climate change are especially marked in Sub-Saharan Africa and South-East Asia, with damage estimated at around 4% of GDP in 2060. In terms of sectoral production, the report shows that it is trade in agricultural goods that is most affected by climate change, which is a matter of concern as most Developing Countries (DCs) depend more directly on climate-sensitive natural resources for domestic income. However, the OECD's simulations generally point out that the most diversified economies in

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4) We are grateful to Jean Chateau (OECD) for providing us with raw data derived from the ENV-linkages model simulations.

terms of trading partners are better able to absorb the shocks.

Although there are significant differences between the modelling approaches, the macroeconomic projections of the OECD's ENV-Linkages model are well aligned with the literature on quantified economic damage (see Nordhaus, 2011; Eboli et al., 2010; Bosello et al., 2012; Roson and Van der Mensbrugghe, 2012; Bosello and Parrado, 2014; Ciscar Martinez, 2014). An average projection of a 2% impact on global GDP is assumed in the simulation exercises, the same as is found in many studies that quantify the impact of climate change on the global economy<sup>5</sup>).

## B. Construction of the database and methodology

In the empirical implementation of the BPCG model, the Dellink et al. (2017) database is used to capture the structural composition of Vietnam's exports and imports in a bilateral trade relationship. We refer here to Mania et al. (2022) in the consolidation of country groupings: the 25 regions considered in the OECD's ENV-Linkages model are aggregated by selecting ten key individual countries or blocks of countries that are Vietnam's major trading partners. Appendix B presents the list of countries in each partner area; the 11<sup>th</sup> group covers the rest of the world. In our trade statistics, these ten partner areas accounted in 2017 for 90% and 91% respectively of Vietnam's exports in volume and imports in value.

However, one difficulty to overcome is that Vietnam does not appear separately in the geographic classification adopted in the OECD reports but is included in ASEAN9 (ASEAN *minus* Indonesia). Therefore, we need to make some assumptions about the evolution of Vietnam's relative position in the total trade of ASEAN9 over the period 2020-2060. First, we define a methodology to isolate Vietnam's import and export market shares from ASEAN9 trade with the other 24 regions. To extrapolate Vietnam's export and import series over the period 2020-2060 from the ones that Dellink et al. (2017) proposed, we assume that the trend that is observed in the country's exports (imports) in total ASEAN9 exports to (imports from) partner  $j$  over the period 2010-2017 continues until 2020 and stabilizes thereafter<sup>6</sup>). Second, we assume that Vietnam proportionally replicates its relative position within ASEAN9 bilateral trade with each partner over the entire period 2020-2060. We check Vietnam's relative position within ASEAN9 by comparing Dellink et al.'s (2017) estimates for ASEAN9 trade over the period 2010-2017

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5) This central projection is notably based on an increase in temperature compared to the pre-industrial level of 3°C by 2100. In an uncertainty interval of a temperature rise between 1°C and 4.5°C, the ENV-Linkages model simulations show that the loss in world GDP would be between 1% and 3.3% in 2060; for a temperature increase of 6°C, the loss would amount to 4.4% of world GDP. The degree of uncertainty of the proposed projections is therefore very important. See Note 17 in Dellink et al. (2017).

6) This extrapolation method was not applied in a few cases where Vietnam's import and export market shares were relatively stable at the end of the period 2010-2017, in which case it was considered stable before 2020. This applies to Latin America for exports and imports (with and without climate damage) and RoW for exports (with and without climate damage).

with the Comtrade dataset over the same period.

As a starting point, we rely on Mania et al. (2022), who constructed the average growth rates predicted by the BPCG model for Vietnam over the period from 1990 to 2017. The long-run elasticities of bilateral exports and imports featuring Vietnam's BP constraint are estimated and reported in Table A1, Appendix A. The authors show that the bilateral Marshall-Lerner condition is not satisfied by demonstrating that the demand for exports and imports is inelastic to prices in most cases. As the information loss is relatively low, projections will then be performed with Equation (2).

By relating a country's long-run growth rate to its external constraint, the BPCG model is well suited to assessing our international damage spillovers. Therefore, we test the model predictions for Vietnam by using the OECD's ENV-Linkages model simulations and construct the BPCG rate corresponding to two alternative scenarios, namely: a no-damage baseline (with  $\dot{Y}_{VN,BP}^{(Baseline)}$ ) and the scenario with climate damage (denoted  $\dot{Y}_{VN,BP}^{(CC)}$ ). Firstly, we compare both predicted rates over the period 2020-2060. If  $\dot{Y}_{VN,BP}^{(Baseline)} > \dot{Y}_{VN,BP}^{(CC)}$ , this indicates that climate damage will tighten Vietnam's BP constraint and reflect a deteriorating trade position relative to partners (and *vice-versa*). Secondly, we examine how, and through which transmission channels, the changing trade patterns resulting from climate damage would impact the evolution of Vietnam's competitive position in the long run.

Looking at Equation (2), comparison of both predicted rates reveals three explanatory elements. On the one hand, climate change will hurt partners' income growth and subsequently modify Vietnam's volume of exports ( $\dot{Y}_j$ ); on the other hand, the domestic impact of climate change in each country over time will have a differentiated impact on Vietnam's export ( $\nu_{ij}\epsilon_{ij}$ ) and import ( $\mu_{ij}\pi_{ij}$ ) competitiveness relative to partner  $j$ . In the following analysis, we consider that the latter arises exclusively from variations in the export and import market shares ( $\Delta \nu_{ij}$ ,  $\Delta \mu_{ij}$ ) given that the long-run income elasticities ( $\epsilon_{ij}$ ,  $\pi_{ij}$ ) are structural parameters that remain unchanged when no mitigation actions are taken.

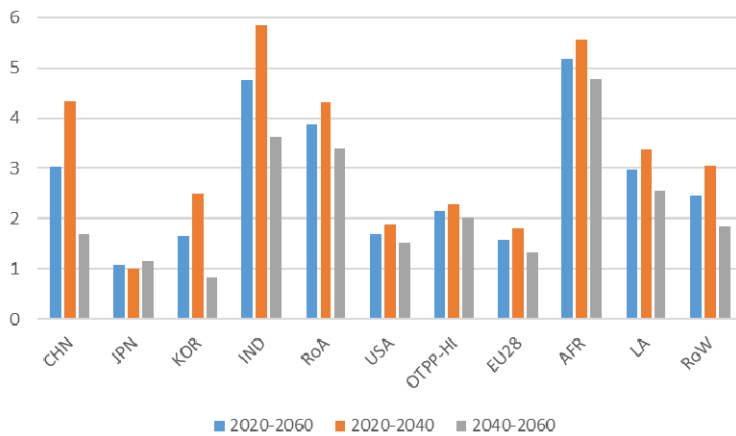
## V. Prospective Background Information

### A. Impact of climate change on partners' income growth

On the theoretical ground, an improvement in country  $i$ 's bilateral exports growth has a positive effect on long-run growth; conversely, a heavier reliance on bilateral imports is detrimental to long-run growth. Therefore, we need to trace the behavioural parameters that are highlighted in our BPCG model: they appear to be worrisome for growth predictions when climate damage

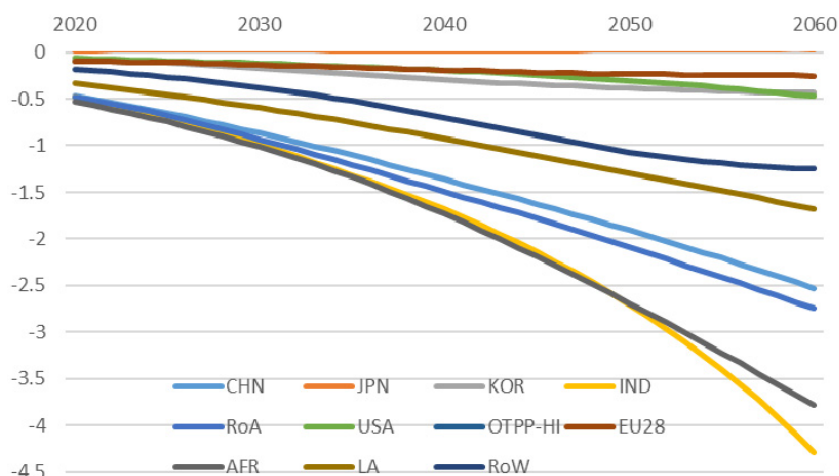
is taken into account. We first trace the consequences of climate damage for partners' growth by drawing on the OECD's ENV-Linkages model estimates. By way of illustration, the case with climate damage will provide a scenario for measuring the costs of 'policy inaction'. Our analysis of the projected costs of climate change is measured in comparison with a baseline scenario absent climate considerations. This baseline scenario is not a prediction for future actual developments but rather a hypothetical trajectory of the main macroeconomic variables using a planetary 'business-as-usual' scenario as a benchmark.

**Figure 2.** Average annual GDP growth rates for Vietnam's trading partners, without climate damage (in %)



(Source) Dellink et al. (2017), authors' calculations.

Figure 2 shows partners' GDP growth in the baseline scenario. For each partner, the average growth rates are constructed for the whole period 2020-2060 and separately for the two sub-periods 2020-2040 and 2040-2060. Our figure shows that the most advanced countries (JPN, KOR, USA, OTPPHI, EU28) lag behind over the period 2020-2060 compared to non-OECD countries. The growth performance is particularly striking in Africa and Developing Asia (CHN, IND, RoA). With the exception of Japan however, all countries show a decline in their growth rates in the second sub-period. This decline is substantial in China, where the catch-up process runs out of steam: the annual growth rate averages 4.3% over the sub-period 2020-2040 and then drops to 1.7% during the sub-period 2040-2060. The same trend applies to India and South Korea, whose average annual growth rates fall by 38% and 67% respectively between the two sub-periods.

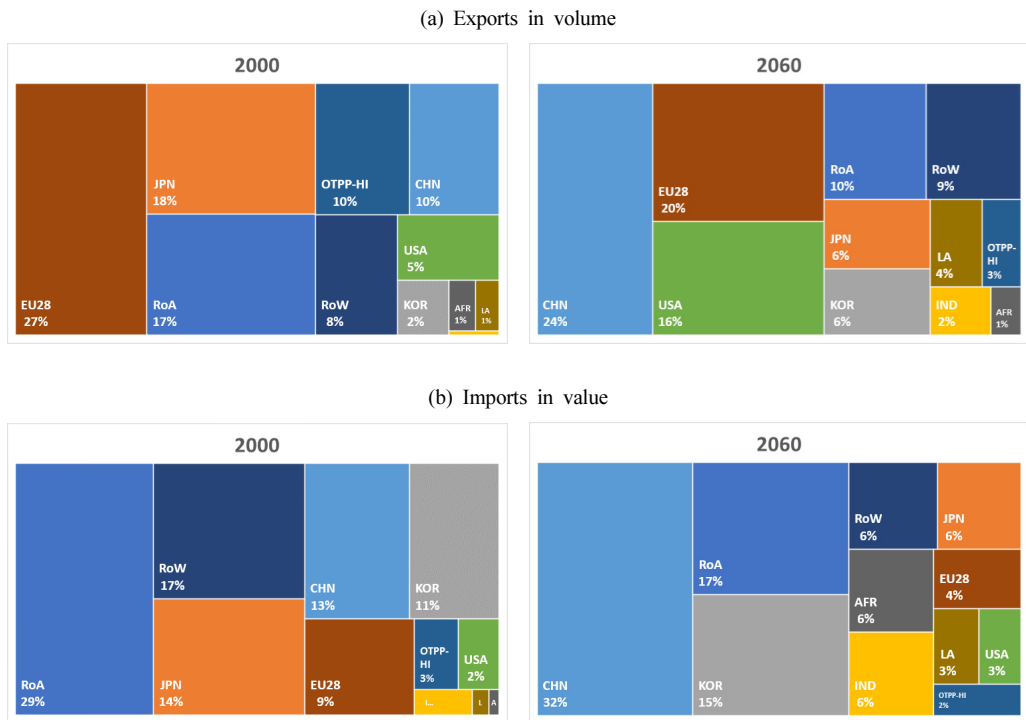
**Figure 3.** Climate damage in % of GDP (difference in % between the level of GDP with and without climate change)

(Source) Dellink et al. (2017), authors' calculations.

Figure 3 projects the evolving costs caused by climate change as a % of GDP over the period 2020-2060 for Vietnam's trading partners. Firstly, we observe that climate-induced damage is non-linear over time, with the strongest effects expected from 2040. Although the central projection of the temperature rise is assumed to be linear, the magnitude of climate damage increases over the years. This result reflects threshold effects and some cumulative processes in climate change (OECD, 2015). Secondly, the fractional losses are greatest in the countries or regions with the highest average growth rates over the period considered, that is: Africa and Developing Asia. Thus, in descending order, India will suffer a decline in GDP of 4.3%, Africa of 3.8%, RoA of 2.7% and China of 2.5% in 2060. Overall, the climate impacts increase over time, with the strongest effects expected from 2040 in the main developing economies of Africa and Asia.

## B. Impact of climate change on export and import market shares

Impacts on import and export shares are modelled in line with the OECD ENV-Linkages model. Variations in the export and import market shares in relation to partner  $j$  due to shifts in international trade patterns are depicted in Figures 4a and 4b, where the graphics are based on Comtrade statistics for 2000 and on the climate damage-free scenario of the OECD's ENV-Linkages model for 2060. This enables us to analyse first the changing geography of Vietnam's trade regardless of climate considerations.

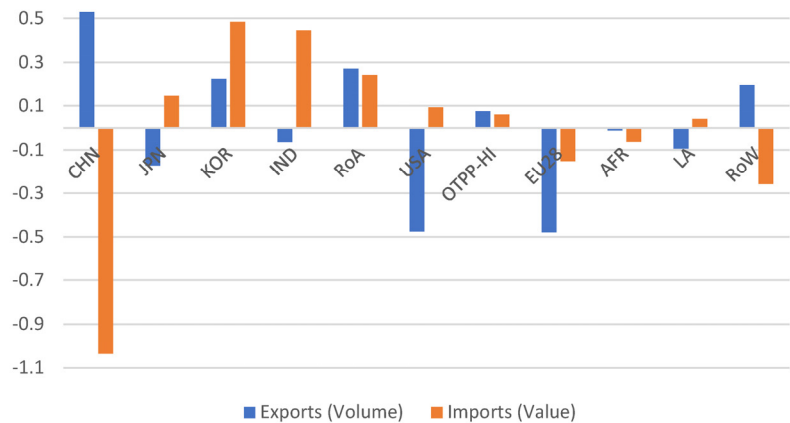
**Figure 4.** Trade market shares, without climate damage (in %)

(Source) Comtrade for 2000; Dellink et al. (2017) for 2060, authors' calculations.

Vietnam dramatically increases its export shares in China and the US, showing that the country will gain competitiveness *vis-à-vis* its competitors (Figure 4a). These two partners replace Japan, the other Asian partners (RoA) and the EU to become the country's leading export markets. Conversely, the bulk of the country's imports come from regional partners, namely: RoA, JPN, CHN and KOR (Figure 4b). In 2000, these partners accounted for 67% of Vietnam's total imports in value and explained 70.5% of its appetite for imports. However, the share of imports from China and South Korea will increase in 2060 (by 32% and 15% respectively) at the expense of the other Asian partners. Trade with these two countries is the most tangible aspect of Vietnam's integration into regional value chains and explains the counterintuitive sign for the corresponding price elasticities (see Table A1, Appendix A).

Figure 5 shows the impact of climate damage on Vietnam's trade market shares in relation to partner  $j$ . We measure here the difference in absolute terms between the shares in per cent with and without climate damage. For example, a positive sign on the export side means that climate change leads to an increase in Vietnam's export share in market  $j$  (an improvement in export competitiveness). Symmetrically, a positive sign on the import side means that partner  $j$  increases its share in Vietnam's total imports as a result of climate damage.

**Figure 5.** Impact of climate change on trade market shares (in percentage points, 2020-2060 average)



(Source) Dellink et al. (2017), authors' calculations.

Looking at the exports first, it can be seen that Vietnam's competitiveness improves in relation to CHN, RoA and KOR, whereas it deteriorates with USA, EU28 and JPN. On the import side, China's share in Vietnamese imports decreases, which confirms the trend observed in exports. By contrast, we observe that all Asian partners increase their share in Vietnam's total imports, namely (in descending order): South Korea, India, RoA and Japan. All in all, Vietnam will improve its competitive position *vis-à-vis* China; conversely, change in the opposite direction in the export and import market shares reflects deteriorating competitiveness relative to the US, Japan and India.

## VI. Assessing the Impact of Climate Change on Vietnam's International Trade Position

### A. A global assessment

We now turn to the main purpose of our empirical investigation, which is to verify whether climate change affects Vietnam's long-run growth when no mitigation actions are taken during the period considered. If this impact is negative, it will reflect the fact that climate damage has tightened the external constraint and therefore, has led to a deterioration in the country's competitive position. Table 2 compares the BPCG rates predicted with and without climate damage over the period 2020-2060 and separately for the two sub-periods 2020-2040 and 2040-2060. We observe that  $\dot{Y}_{VN,BP}(Baseline) > \dot{Y}_{VN,BP}(CC)$  whatever the time span considered. Thus climate change leads to a tightening of Vietnam's BP constraint. This overall impact is



reflected in a 0.13 point (a 2.5%) reduction in the average growth rate over the period 2020-2060<sup>7)</sup>. Note that, as for its partners (see Figure 2), the climate-induced impact on Vietnam's BPCG rate is non-linear as the decline is deeper in the second sub-period (-3.2% vs -2.1%). The gap is not excessively large because, as growth is a cumulative process, the reductions in GDP levels as a result of climate change translate into small reductions in average annual GDP growth rates over the simulation period.

**Table 2.** *Vietnam's BPCG Rates by Sub-periods, with and without Climate Damage*

	$\dot{Y}_{VN,BP}(Baseline)$	$\dot{Y}_{VN,BP}(CC)$	Difference in percentage*
2020-2060	5.13%	5.00%	-2.5%
2020-2040	6.17%	6.04%	-2.1%
2040-2060	4.11%	3.98%	-3.2%

\* Defined as follows:  $-\left(1 - \left(\dot{Y}_{VN,BP}(CC) / \dot{Y}_{VN,BP}(Baseline)\right)\right) \cdot 100$

The UNU-WIDER and CIEM report (2012) includes some simulation exercises aimed at forecasting the impact of climate damage on the Vietnamese economy. The average GDP growth rate was estimated to decrease by between 0.02 and 0.10 percentage points over the period 2007-2050. By taking into account international damage spillovers, our estimates lead to a more pessimistic result for the period 2020-2060 with a reduction of 0.13 percentage points. In order to capture the scale and implications of this gap, it can be stated that if Vietnam's actual future growth rates matched the BPCG ones predicted, the fractional loss would be 4.84% of GDP in 2060<sup>8)</sup>. Compared to its trading partners, Vietnam would incur the largest loss, far larger than the two most heavily impacted partners according to the ENV-Linkages model simulations. In India and Africa precisely, the evolving costs caused by climate change represent respectively 4.29% and 3.78% of GDP in 2060 (see Figure 3).

## B. Vietnam's competitiveness vis-à-vis its trading partners

At this juncture, it would be interesting to examine the channels through which this overall impact is transmitted into Vietnam's evolving position with respect to its partners. As pointed out already, the multi-country law cannot be additively disaggregated by individual partner area; however, it still makes sense to analyse the contribution of each explanatory variable and partner area to the tightening of the BP constraint between the two scenarios. Although

7) Recall that these results are based on the assumption that Vietnam's relative position within ASEAN9 bilateral trade with each partner is stabilized in 2020. Assuming that this happens in 2030, the reduction is 0.12 percentage points.

8) In 2060, the loss attributed to climate change would be equal to  $\left(1 - \frac{(1.05)^{40}}{(1.0513)^{40}}\right) \cdot 100$  in per cent of GDP.

the effects cannot be predicted with certainty, the goal of the simulations presented here is to illustrate the mechanisms at work.

Owing to its structure, equation (2) can be decomposed linearly through a Taylor series expansion as follows:

$$\Delta \dot{Y}_{VN,BP} = \sum_j \left( \underbrace{\Delta \dot{Y}_j \frac{\partial \dot{Y}_{VN,BP}}{\partial \dot{Y}_j}}_{\text{partner growth}} + \underbrace{\Delta v_{ij} \frac{\partial \dot{Y}_{VN,BP}}{\partial v_{ij}}}_{\text{export market share}} + \underbrace{\Delta \mu_{i,j} \frac{\partial \dot{Y}_{VN,BP}}{\partial \mu_{i,j}}}_{\text{import market share}} \right) + R$$

where  $D$  represents the change in the variables relative to the climate damage scenario ( $\Delta \dot{Y}_{VN,BP} = \dot{Y}_{VN,BP}(\text{Baseline}) - \dot{Y}_{VN,BP}(CC)$ ;  $\Delta \dot{Y}_j = \dot{Y}_j(\text{Baseline}) - \dot{Y}_j(CC)$ ; ... ) and the last term  $R$  is the remainder of the approximation.

The following partial derivatives with respect to partner  $j$ 's variables are evaluated to  $\dot{Y}_{VN,BP}(CC)$ :

$$\begin{aligned} \frac{\partial \dot{Y}_{VN,BP}}{\partial \dot{Y}_j} &= \frac{\nu_{ij} \epsilon_{ij}}{\sum_{j=1}^{11} \mu_{ij} \pi_{ij}} \\ \frac{\partial \dot{Y}_{VN,BP}}{\partial v_{ij}} &= \frac{\epsilon_{ij} \dot{Y}_j}{\sum_{j=1}^{11} \mu_{ij} \pi_{ij}} = \frac{\dot{X}_{ij}}{\sum_{j=1}^{11} \mu_{ij} \pi_{ij}} \\ \frac{\partial \dot{Y}_{VN,BP}}{\partial \mu_{ij}} &= -\frac{\pi_{ij} \sum_{j=1}^{11} \nu_{ij} \epsilon_{ij} \dot{Y}_j}{\left( \sum_{j=1}^{11} \mu_{ij} \pi_{ij} \right)^2} = -\frac{\pi_{ij} \dot{Y}_{VN,BP}}{\sum_{j=1}^{11} \mu_{ij} \pi_{ij}} \end{aligned}$$

The BP constraint development can then be disaggregated into three components:

- i) *A partner growth effect.* Climate change will hurt partners' income growth and, by modifying Vietnam's volume of exports, it will subsequently affect the external constraint. A positive sign associated with this component explains the tightening of the BP constraint.
- ii) *An export market share effect.* When climate change increases the relative size of Vietnam's volume of exports in partner  $j$ 's market, it will soften the constraint tightening. This favourable effect is then associated with a negative sign.
- iii) *An import market share effect.* Symmetrically, when partner  $j$  increases its share in Vietnam's imports (in value), the unfavourable effect explains the tightening of the BP constraint and is therefore associated with a positive sign.

Overall, the empirical disentanglement shows that changes in the export volume term (*i.e.* the two first effects) prevail in the result.

**Table 3.** *A Full Breakdown of the Overall Decrease in Vietnam's BPCG Rate with and without Climate Damage, by Effect and by Partner Area (in %)*

	Partner growth	Export market share	Import market share	Total by area
CHN	12.7	-13.3	-30.6	-31.3
JPN	-0.1	6.6	6.6	13.1
KOR	0.8	-4.8	22.4	18.4
IND	3.2	4.6	25.5	33.2
RoA	3.7	-7.0	9.7	6.4
USA	6.1	30.7	4.1	40.9
OTTP-HI	0.0	-2.2	2.4	0.2
EUR28	2.1	21.6	-4.8	18.8
AFR	1.1	0.8	-3.8	-1.9
LA	2.5	6.4	2.6	11.5
RoW	2.7	-6.2	-5.9	-9.3
<b>Total by effect</b>	<b>34.8</b>	<b>37.0</b>	<b>28.1</b>	<b>100.0</b>

Table 3 presents the result of the linear decomposition of  $\Delta \dot{Y}_{VN,BP}$  (a 0.13 point reduction in the average growth rate) by effect and by partner area. To get a better understanding of their relative weights, the contributions of each effect and partner are expressed as a percentage of the overall decrease in the predicted growth rate  $\dot{Y}_{VN,BP}(CC)$ . For example, the contribution of China's income growth to the tightening of Vietnam's BP constraint is equal to 12.7% of the overall decrease (first line), while a negative sign associated with the export market share effect (-13.3%) means that this partner has helped to mitigate the overall decrease.

By aggregating over partner areas, we get the decomposition by effect of the overall constraint tightening (shown in the last line of Table 3), which enables us to gauge the relative importance of the different mechanisms at work. We observe that 34.8% of the deterioration in the BP constraint is explained by the negative impact of climate damage on partners' growth (mainly China and the US), 37% by a reduction in export market shares (particularly *vis-à-vis* the US and EU28) and 28.1% by deteriorating import market shares (with India's and South Korea's growing shares in Vietnam's imports).

If instead we aggregate over the three effects, we get the decomposition by partner area reported in the last column of Table 3. A contrasting picture is revealed between China (which is Vietnam's main trading partner), on the one hand, and India and the US, on the other. This line of interpretation sheds some light on appropriate diversification or, conversely, on increased dependence on specific partners as explanations for Vietnam's resilience following a shock.

If the partner/effect levels are combined, we observe that the largest positive effects (the main explanations for the overall tightening of Vietnam's BP constraint) are the export market share effect relative to the US (30.7%) and EU28 (21.6%) and the import market share effect

relative to India (25.5%) and South Korea (22.4%). Symmetrically, a sizeable negative effect (the main explanation for the mitigation of the overall tightening) is the import (-30.6%) and export (-13.3%) market share effect relative to China. In other words, China would help to alleviate the impact of climate damage on Vietnam's long-run growth (-31.3% as shown in the first line, last column) because of a joint increase in the export market share and decrease in the import market share (an improvement in Vietnam's competitiveness *vis-à-vis* this partner). By contrast, because the US is the second largest individual market for Vietnam's exports, the negative evolution of the bilateral export market share interacts with sluggish growth to deeply affect the BPCG rate in the climate damage scenario. This shows that the US undermines Vietnam's resilience to the climate shock.

## VII. Conclusion

In an attempt to contribute to the literature, our article has aimed to identify the impact of climate change on Vietnam's economy through the BP aspects of trade. As the trading partners are also commonly affected by climate-induced damage, we posit that output growth differentials and the subsequent change in relative competitiveness could magnify the burden of climate impacts. These two transmission channels (which we call international damage spillovers) are also the key determinants of long-run growth predicted in the multi-country Thirlwall's law. This theory based on demand-side constraints is a particularly appropriate approach and constitutes our contribution to climate economics as applied to Vietnam.

Overall, the significant economic damage could equate to a 2.5% reduction in the average growth rate over the period 2020-2060. By ignoring these international damage spillovers, the Vietnamese government may be underestimating the climate shock. Moreover, our linear decomposition of the external constraint development shows that China helps to alleviate the impact of climate damage because of an improvement in Vietnam's trade competitiveness with respect to this partner. By contrast, our findings reveal that the US weakens Vietnam's macro resilience to the climate shock. All in all, these outcomes clearly show that international damage spillovers may indirectly impact Vietnam's economy through changing trade patterns.

The results of our research must be viewed against the background of data availability concerning the damaging effects of climate change in a multi-country setting. The OECD's ENV-Linkages model only provides detailed results for the central projection based on an increase in temperature of 3°C by 2100. In addition, the magnitudes are unavoidably subject to substantial uncertainty and should be taken with caution. As discussed in the study, climate change can cause long-lasting damage but with pervasive uncertainties (Batten, 2018). Notwithstanding some caveats due to uncertainty in the full range of climate projections, some aspects remain

unclear while the type of scientific evidence required to link climate change impacts is debated. This limits the scope of our quantitative approach.

Nevertheless, the implementation of measures for adapting to climate change can no longer be ignored; a policy window has been opened in all countries worldwide as the simulation exercise assumed that no domestic actions are taken during the period considered. However, one main implication of our results is to highlight potential asymmetries in adaptation policies: even though climate change is a global externality, capacity across countries in building adaptation to emerging constraints still varies significantly. This lends support to the argument embodied in the principle of 'common but differentiated responsibilities' in the United Nations Framework Convention on Climate Change (UNFCCC).

To some extent, our article illustrates how critical the choice of partners is in adaptation. By looking simply at predicted changes in a country's BP constraint, we demonstrate how, in adapting to inevitable climate change, account has also to be taken of the projected impacts on trading partners and their relative trade positions. Because our study makes a case for the importance of cross-country linkages in explaining resilience, we argue that re-orientating patterns of trade could help to shift economies onto climate-resilient growth paths.

From the perspective of adaptation, one direction for future research is to evaluate the effect of asymmetrical capacity for adaptation across partner areas. Adaptations to a changing climate in many fields are arising out of a growing awareness but do not result in equal action. The incentives for meeting global commitments, as well as technical and financial abilities, are domestic. Against this background, our perspective is to consider how asymmetrical efforts in adaptation impact the evolution of Vietnam's external constraint and growth rates.

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## Appendix

### Appendix A. The balance-of-payments-constrained growth model (Mania et al., 2022)

Our analytical extension assumes that a given country  $i$  has  $n$  trading partners. As a consequence, equations (A1) and (A2) feature the conventional demand functions for imports and exports respectively, and equation (A3) sets an equilibrium condition for the current account as follows:

$$M_{ij} = \left( \frac{P_i}{E_{ij}P_j} \right)^{\psi_{ij}} Y_i^{\pi_{ij}} \quad (\text{A1})$$

$$X_{ij} = \left( \frac{E_{ij}P_j}{P_i} \right)^{\eta_{ij}} Y_j^{\epsilon_{ij}} \quad (\text{A2})$$

$$P_i \sum_j X_{ij} = \sum_j E_{ij} P_j M_{ij} \quad (\text{A3})$$

where  $P_i$  is country  $i$  export prices,  $X_{ij}$  is the real demand of partner  $j$  for country  $i$  exports,  $E_{ij}$  is the bilateral nominal exchange rate,  $P_j$  is export prices in  $j$ , and  $M_{ij}$  is country  $i$ 's imports from partner  $j$ ,  $\psi_{ij} > 0$  and  $\pi_{ij} > 0$  are, respectively, the price and income elasticities for country  $i$  imports from partner  $j$ ;  $\eta_{ij} > 0$  and  $\epsilon_{ij} > 0$  the price and income elasticities for country  $i$  exports to partner  $j$ .

Taking the growth rates in (A3) we obtain:

$$\dot{P}_i + \sum_j \nu_{ij} \dot{X}_{ij} = \sum_j \mu_{ij} (\dot{E}_{ij} + \dot{P}_j + \dot{M}_{ij}) \quad (\text{A4})$$

$$\text{Where: } \nu_{ij} = \frac{X_{ij}}{\sum_j X_{ij}} \quad \mu_{ij} = \frac{E_{ij} P_j M_{ij}}{\sum_j E_{ij} P_j M_{ij}}$$

$\nu_{ij}$  and  $\mu_{ij}$  are, respectively, the market shares of partner  $j$  in country  $i$ 's total exports (in volume) and in country  $i$ 's total imports (in value).

Solving for the growth rate of country  $i$  and denoting  $R_{ij} = P_i/(E_{ij}P_j)$  the bilateral relative price or real exchange rate (namely the ratio of domestic to foreign prices expressed in domestic currency), we obtain a multi-country version of Thirlwall's law:



$$\dot{Y}_{i,BP} = \frac{\sum_j \dot{R}_{ij} [\mu_{ij}(1 - \psi_{ij}) - \nu_{ij}\eta_{ij}] + \sum_j \nu_{ij}\epsilon_{ij} \dot{Y}_j}{\sum_j \mu_{ij}\pi_{ij}} \quad (\text{A5})$$

Mania et al. (2022) use this equation to compare Vietnam's BP-equilibrium growth rates with actual annual data from 1990 to 2017 and to measure the respective contribution of each trading partner to growth predictions. Applying cointegration techniques, the long-run elasticities featuring the BP constraint are estimated and reported here.

**Table A1.** *A Summary of Vietnam's Estimated Elasticities for the Period 1990-2017*

	Bilateral Imports		Bilateral Exports	
	Income	Prices	Income	Prices
CHN	1.758***	-3.148**	2.521***	1.158*
JPN	2.703***	-0.629***	10.567***	0.860***
KOR	2.756***	ns	3.813***	-0.734***
IND	3.402***	ns	4.566***	ns
RoA	2.370***	ns	2.026***	0.915***
USA	2.647***	ns	11.298***	0.721*
OTPP-HI	2.364***	0.778*	4.054***	1.947**
EU-28	1.891***	ns	8.556***	ns
AFR	3.539***	ns	3.743***	ns
LA	3.839***	ns	6.869***	ns
RoW	1.357***	ns	3.840***	ns

(Source) Mania et al. (2022)

Notes. ns stands for not significant. \*\*\*, \*\* and \* indicate that coefficients are significant respectively at 1%, 5% and 10%

## Appendix B. Countries in each Vietnam's partner group

**CHN:** China (including Hong-Kong, SAR)

**JPN:** Japan

**KOR:** Republic of Korea

**IND:** India

**USA:** United States of America

**RoA (Rest of Asia):** Bangladesh, Bhutan, Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Macao SAR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand.

**OTPP-HI (Other Trans-Pacific Partnership-High Income):** Australia, Canada, New Zealand.

**EU-28 (European Union):** Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia,

Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom.

**AFR** (Africa): Algeria, Angola, Burkina Faso, Cameroon, Dem. Rep. of Congo, Rep. of Congo, Cote d'Ivoire, Arab Rep. of Egypt, Ethiopia, Ghana, Guinea, Kenya, Libya, Madagascar, Mali, Morocco, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, Zimbabwe

**LA** (Latin America): Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Venezuela RB

**RoW**: Rest of the World