Private Sector Alignment with the European Green Deal in the Western Balkans

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Contents

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Acronyms

CCAP- Climate Change Action Plan
CEE- Central and Eastern Europe
DTIDZ- Directorate for Technological and Industrial Zones
EGD- European Green Deal
ERR- economic rate of return
EU- European Union
FITD- Fund of Innovation and Technical Development
GDP- Gross domestic product
GHG- greenhouse gas
GSIF – Green Strategy Investment Fund
GTAP CGE – Global Trade Analysis Project Computable General Equilibrium
ICT- Information and Communications Technology
IFC- International Finance Corporation
IMF- International Monetary Fund
IRR- internal rate of return
MFMod- Macro-Fiscal Model
MSME – Micro Small and Medium Enterprise
PPP- Public Private Partnership
UNIDO- United Nations Industrial Development Organisation
VC- Joint venture
WDI- World Development Indicators

Executive Summary

The aim of this paper is to estimate how the role of the private sector in the Western Balkans aligns with the European Green Deal. For this purpose, we developed an economy-wide Computable General Equilibrium (CGE) model based on the net economic and environmental benefits obtained from climate finance projects in North Macedonia. We focus on two types of investments: those that target green/digital startups and innovative SMEs (MSME Fund), and others that support large enterprises and infrastructure PPP SPVs (Special Purpose Vehicle) in European Green Deal (EGD) sectors (GSIF).

Our analysis focuses on the time frame 2023-2050; the rate of return of those two investments at the end of 5 cycles of investment is around 1.15 to 1.16 for the MSME and GSIF. Both Funds contribute towards decoupling in the approach to 2050. GDP increases by around 1.22 and 2.67 percentage points above the baseline in 2050 while CO2 emissions decrease by about 5.28 and 6.6 (under MSME and GSIF respectively). Overall effects on GDP components (consumption, exports, imports) are positive and higher for GSIF which is a larger fund than MSME. During the implementation of the MSME Fund and GSIF, GDP increases lead to higher household consumption (by 1.18% and 2.67% respectively above the baseline in 2050) considering the likely price changes. Their positive impacts are more pronounced towards the end of the investment period. Real imports and exports increase under both Funds (by 2.35% in MSME and 6.05% in GSIF), while export increase is higher for GSIF since the Fund invests in large enterprises with high export potential. Import dependence of the economy explains the rise in imports under both Funds (by 0.43% in MSME and 1.79% in GSIF); imported intermediate goods support production in export sectors. Changes in imports are fewer compared to the boost in exports.

The model estimates a cross-economic increase by 0.69% (or 9,468 jobs) for the MSME Fund and a 1.36% increase (or 18,648 jobs) for the GSIF when above the baseline in 2050. This estimate includes a 0.38% increase in employment in the "sectors within the MSME portfolio", hence an additional 867 jobs above the baseline in 2050. Regarding the "sectors within the GSIF portfolio", the model estimates a 1.35% increase in employment, equivalent of 17,867 new jobs in 2050 compared to the baseline.

The limitations of this approach allude to the purely "economic" nature of the CGE model. Emission reduction potential would have been better assessed in an "integrated modeling framework" wherein engineering processes could be captured. For instance, there is no distinction between fossil fuel electricity generation and renewable electricity generation in the CGE model. Greening scenarios refer to the substitution of highly polluting energy types with natural gas and LPG. The CGE model cannot distinguish between existing steel technologies and clean steel technology (based on green hydrogen).

An expansion of the current model would involve the incorporation of bilateral trade relations with the EU as separate from other trading blocks. Incorporating more country-specific details with a focus on government and financial accounts would allow for an analysis of various funding options for the Government's contributions to the Funds. It would also be appropriate to incorporate multiple-household consumption data to provide a detailed analysis of poverty alleviation outcomes.

Introduction

The study developed an economy wide CGE model to estimate the net economic and environmental benefits of climate finance in North Macedonia through "Green Strategic Investment Fund (GSIF)", and the "Green/Digital Economy MSME Fund (MSME)". The Global Analysis Program (GTAP) is used to stimulate growth, sectoral production, and emission trajectory to 2050. This complex analytical tool allowed the project team to gauge the potential macro-economic, environmental, and distributional impacts of the proposed interventions.

The model is unique in several aspects: (i) the first time GHG emission coefficients were linked to the North Macedonia Input-Output (IO) table; (ii) the IO was expanded to capture highly polluting sectors - such as steel- individually; and (iii) North Macedonia economy was incorporated a global dataset (GTAP) for the first time. The model framework is dynamic and keeps track of the two Funds' annual investments target sectors.

Green/Digital MSME Fund invests in green/digital startups and innovative SMEs while GSIF invests in large enterprises and infrastructure PPP SPVs (Special Purpose Vehicle) in European Green Deal (EGD) sectors. The GTAP CGE model's resolution accounts for forward and backward linkages from these investments, and assesses their potential impact on GDP, employment, other macro-economic variables such as trade, and GHG emissions.

This report first briefly describes the investment structures, and the hypotheses used in the development of the CGE framework, followed by a brief description of the CGE model structure. This is followed by expansions of the standard GTAP model, baseline development, and lastly, model simulations on the funds' economic, environmental, and distributional benefits.

Green/Digital MSME Fund

The Green/Digital MSME Fund aims to contribute towards the EGD through the SME Strategy for a Sustainable and Digital Europe (EU Commission 2020).

The Strategy aims to advance the objectives of the EGD, Digital Decade, and other EU actions launched in the context of the digital and green transition towards a climate-neutral, resource-efficient, and agile digital economy, via the mobilization of small and medium-sized enterprises (SMEs) across industrial sectors in Europe.

The proposed Fund seeks to close the financing gap for startups and SMEs by leveraging private investment, given their alignment with the EGD.

Furthermore, the Fund aims to provide timely intervention in supporting start-ups by easing issues around access to finance, considering that the start-up environment in North Macedonia has matured in recent years.

Based on recent surveys, start-ups seek external financing, as their funding needs grow beyond what the government provides. Banks are reluctant to support high-performing SMEs without "hard collateral" and credit history, and existing regional joint-venture (VC) funds do not fill the identified financing gap for Macedonian start-ups. This creates a finance gap that may prevent new initiatives from acquiring their full potential.

This paper develops an economy-wide analysis of the potential impact of the MSME Fund, including the effects of capital injection into the economy which boosts GDP and increases export and employment opportunities. These potential effects are assessed by the CGE model developed for the purpose of this project.

Green Strategic Investment Fund (GSIF)

GSIF's overall development objective includes several factors: the facilitation of private sector financing for a smooth transition to a modern, resource-efficient economy that is independent of resource use; improved compliance with the Sofia Declaration on the green agenda, and an improvement in private financing environments that can alleviate the government's burden. Furthermore, GSIF intends to facilitate and attract "clean" industries that will help create jobs and boost the economy.

Through this plan, the private sector emerges as a key driver of climate action, since private companies are at the forefront of consistent innovations, while also maintaining their role as important economic players. Privately-owned financial institutions oversee trillions of dollars' worth of investible capital that will boost the new climate economy. However, to mobilize this capital in line with green investments and necessary innovative improvements, the right regulatory government support is essential. Such a partnership is necessary to create enabling environments for green, inclusive businesses through public funding.

GSIF is designed to promote North Macedonia's alignment with the EU Green Deal (EGD). As a candidate for EU membership, and as a Western Balkan Contracting Parity of Energy Community, North Macedonia is committed to achieving the 2050 climate neutrality target central to the European Green Deal.

The Strategy outlines ambitions and goals across different sectors. To ensure a smooth implementation, existing regulations and standards must be revised while new laws and directives are implemented over the next few years. There are eight key areas that constitute the Green Deal and also apply to North Macedonia:

- Increasing the EU's climate ambition for 2030 and 2050 (reducing GHG emissions by at least 55% from 1990 levels by 2030).
- Supplying clean, affordable, secure energy.
- Mobilizing industry for a clean and circular economy.
- Building and renovating in energy and resource-efficient way.
- A zero-pollution ambition for a toxic-free environment.
- Preserving and restoring ecosystems and biodiversity.
- Farm to Fork: a fair, healthy, and environmentally friendly food system.
- Accelerating the shift to sustainable and smart mobility[2].

These goals require improvements in energy efficiency and switching to renewable sources as outlined in the National Energy Development Strategy till 2040. Main recommendations include:

[2] European Commission, 2020. Communication From the Commission to the European Parliament, The Council, The European Economic, and Social Committee and The Committee of The Regions - The European Green Deal.

- maximizing energy savings,
- limiting the increase of GHG emissions, (green scenario aims at 53.2% CO2 emissions reduction by 2030 compared to 1990 level, broadly aligned with the EGD target of 55% GHG emissions reduction over the same period.)
- decline in coal utilization and mining
- decarbonization of the economy, and
- greater reliance on renewable energy resources.

The proposed interventions follow the World Bank's vision on Climate Policy. The Bank, in conjunction with its development bank counterparts, produced an extensive report in 2015 *(Joint Report on MDB Climate Finance)* [3] on the guidelines for climate change mitigation and adaptation benefits that can assist North Macedonia in its path towards climate resilience.

Based on these principles, green Private sector activities eligible to climate funds analyzed by the North Macedonia CGE model are listed in Table 12.

North Macedonia Economy-wide Analysis

The analytical framework encompasses a multi-sectoral CGE model[4] which allows for an account of forward and backward linkages from greening activities proposed by the MSME and GSIF in terms of emission mitigation, sectoral value creation, employment, and incomes. As such, the CGE model developed for North Macedonia allows the assessment of potential socio-economic and environmental benefits in the medium to long term.

The utility of the CGE models is its ability to simulate several macro-economic dimensions including (i) structural changes in the medium and long-term, (ii) the effect of changes in one part of the economy upon the rest of the sectors, and international trade, as well as (iii) ripple effects from digitalization and greening measures and investments at the project, sectoral, national, and international levels.

In terms of distributional impact analysis using the CGE models, the representative single household is often expanded to multiple household types differentiated by their income levels and expenditure structure (WiseEurope, 2019). For example, Rausch et al. (2011) use survey data to incorporate household heterogeneity into analysis of the distributional impact of carbon pricing in the US. Their results indicate significant variations across and within broad socio-economic groups, and show that variation on an individual level regarding vulnerability to climate policies outweighs differences between groups. Van der Mensbrugghe et al. (2018) link a global recursive dynamic computable general equilibrium model ENVISAGE with the GIDD microsimulation model and explore three levels of mitigation effort and five carbon pricing options (trade coalitions). Results suggest that while there is a higher incidence of poverty in all scenarios, mainly driven by lower economic growth, Nationally Determined Contribution (NDC) policies result in progressive income distribution at the global level. Such progressivity is caused not only

[3] World Bank. 2015. Joint Report on MDB Climate Finance.

[4] A detailed list of model equations can be found in the Annex.

by lower relative prices of food versus non-food commodities but also by a general decline in skill wage premia.

This current study largely benefited from the analysis of the environmental tax assessment for North Macedonia based on the World Bank's Macro-Fiscal Model (MFMod) (Burns et al., 2019). The CGE model developed for this study complements the short-term macro-economic analysis of environmental taxation (by Burns et al. 2021) by developing a baseline to 2050 that accounts for structural changes, more specifically in production, investment, and international trade.

This analysis focuses on investments and technological change in emission abatement based on the output multipliers estimated in IMF (2021). Thus, our CGE analysis estimates the value created from start-up activities is to be funded by the projects, alongside their contribution to economic activity and jobs. There are several reasons why a green stimulus will improve GDP and job creation. First, the IMF (2021) estimates that green multipliers are higher than traditional ones. For example, renewable energy investment multipliers are about 1.1-1.5 compared with 0.5-0.6 for fossil fuel investment. Abstracting from the co-benefits of a greener environment (such as, improved health and biodiversity), green investment spending often overlaps with infrastructure spending (such as public transportation), which tends to have attractive effects on private-sector investment and boosts productivity in the long run. Even spending on increasing energy efficiency, via actions such as building renovation, can improve resource allocation, as energy cost savings can be used for other avenues over the longer term such as greening activities and green jobs.

In this study, the activities eligible for climate funds analyzed by the North Macedonia CGE model are listed in Table 12, according to the World Bank report. However, it is part of the overall energy used by the transport sector. Water is not a production factor in the standard GTAP CGE framework; hence water treatment and sewage activities are not part of the CGE analysis. Although environmental education and monitoring of emissions are important components of the EU Green Deal, it is not possible to assess their impact using the CGE model, therefore they are not part of the simulations.

Development of an economic baseline (no Project) to 2050

The North Macedonia GTAP CGE model was used to develop an economic baseline for 2021-2050 as a reference scenario. This *Business-as-usual scenario* (Baseline) refers to potential economic performance in 2021-2050 under various assumptions regarding dynamics in and outside of the country. Model *simulation* results that lead to an alternative development growth path for North Macedonia if about mentioned projects are implemented are expressed in percentage (%) change from the baseline.

Table 1. Economic Baseline to 2050 (no project) – Main assumptions

	2021	2025	2030	2035	2040	2045	2050
Population (millions)	2.08	2.07	2.05	2.01	1.97	1.91	1.86
GDP (USD-millions)	12,792	14,721	17,156	21,232	24,998	29,262	34,254
GDP per capita (USD)	6,142	7,099	8,366	10,541	12,709	15,294	18,448

Source: UN-Data (2021) and UNDP (2020).

Analytically and within a long-term horizon (till 2050):

- The GDP is expected to be grown by around 2.7 times
- Per capita income's likely to be multiplied by 3.

The standard GTAP model was tailored to the policy question that analyzes the greening potential of the North Macedonia economy and resulting employment impact. In this objective standard model was modified as follows:

(i) Substitution between intermediate inputs (energy v non-energy) made possible
(ii) Highly polluting sectors such as steel and energy producers were disaggregated than the original IO using information from similar European Countries
(iii) Regarding GSIF; sectors were grouped into two as "clean v polluting"; likewise, jobs as "traditional v green"
(iv) Emission coefficients for GHG were incorporated to the GTAP model using ECLIPSE's model's specific values for North Macedonia
(v) Labor supply function was built-in using an elasticity wage to labor (1.02).

Macro-economic results (Table 5) from the model simulation regarding implementation of the proposed Funds used on the assessment of the distributional aspects.

Model Assessment about Project Implementation

Assumptions

Expected GDP gain from the project is aligned with the green multiplier analysis by the IMF. GSIF totals $883 million, MSME Fund adds up to $335 million till 2045 (equivalent of 380 million Euros and 1 billion Euros). MSME Investments are funded 25% by the project (15% government budget v 85% private sector) and 75% by the beneficiary. GSIF Investments are sourced 20% by the project (47% government budget v 53% private sector) and 80% by the beneficiary.

Portfolio allocation for the MSME includes agriculture and food, textile, leather, apparel, paper, electronic and electric equipment, manufacture, as well as service sectors such as support to businesses, accommodation, and restaurants, etc.

GSIF investment sectors are manufacture of motor vehicles, trailers, and semi-trailers; agriculture; manufacture of electrical equipment; printing and reproduction of recorded media; electricity, gas, steam, and air conditioning supply; repair and installation of machinery and equipment.
Funds aim to reduce CO2 emissions per unit of production. Emissions from energy use across production activities are estimated using the emission coefficients by IIASA (Table 2).

Table 2: Emission Coefficients Index for Select Model Sectors

IEF	1 Coal	2 Diesel	3 Fuelwoo	4 Gas	5 HevyFuel	6 JetFuel	7 LPG	8 Gasoline	Total
1 Agriculture	97.5	75.2	5.62	56.4	77.3	0	68.7	0	381
2 Aviation	0	0	0	0	0	0.051	0	0	0.051
3 construction	0	74.8	0	0	0	0	0	0	74.8
4 manufact	97.2	73.6	0.565	56	77.2	0	68.7	0	373
5 otherInd	99.5	73.6	0.553	56	77.4	0	68.7	0	376
6 powerGen	99.8	0	0.14	56	76.9	0	0	0	233
7 rail	0	75.1	0	0	0	0	0	0	75.1
8 residential	107	73.6	5.98	56.4	0	0	68.7	0	312
9 services	101	73.6	0.653	56.4	77.3	0	68.7	0	378
10 RoadTransp	0	71.8	0	0	0	0	69.5	58.5	200
Total	602	591	13.5	337	386	0.051	413	58.5	2402

Source : GAINS 4 Europe www.iiasa.ac.at

Tables 3 and 4 show Funds' investment allocations and emission reduction targets by sector based on the annual investment allocation across sectors.

Table 3. GSIF Investment Sectors and Emission Reduction Targets

GSIF Investment Sectors	Investments made per sector	Average emission reduction per sector	GTAP sector
Manufacture of motor vehicles, trailers, and semi-trailers	2	50	22
Agriculture	1	25	1
Manufacture of electrical equipment	5	80	20
Printing and reproduction of recorded media	1	50	34
Electricity, gas, steam, and air conditioning supply	2	100	25
Repair and installation of machinery and equipment	2	37.5	21
Total	13		

Table 4. MSME Investment Sectors and Emission Reduction Targets

MSME Investment Sectors	Investments made per sector	Average emission reduction per sector	GTAP sector
Manufacture of chemicals and chemical products	5	28	11 and 12
Manufacture of rubber and plastic products	5	28	14
Manufacture of electrical equipment	5	28	20
Manufacture of machinery and equipment, etc.	6	31.7	21
Electricity, gas, steam, and air conditioning supply	1	100	25
Total	22		

Main model outputs:

Two separate simulations are developed using the CGE model regarding injection of capital from the MSME Fund and GSIF. Sectoral allocation of investments follows the portfolio distribution. This is simulated as subsidies to capital if used in targeted activities[5].

Both funds lead to decoupling; GDP increases by around 1.22 and 2.67 percentage points above the baseline in 2050 while CO2 emissions decrease by about 5.28 and 6.6 (for MSME and GSIF respectively). Overall effects on GDP components (consumption, exports, imports) are positive and higher for GSIF which is a larger fund than MSME. Exports growth relative to GDP is also higher in GSIF, since this fund targets larger, export-oriented enterprises. Table 5 summarizes the main outputs from the model assessment of the two funds as percentage deviations from the baseline in 2050.

[5] Subsidy rate is small in the order of (0.115 to 0.18) and constant over time.

Table 5. CGE simulation effects on key macro-economic variables

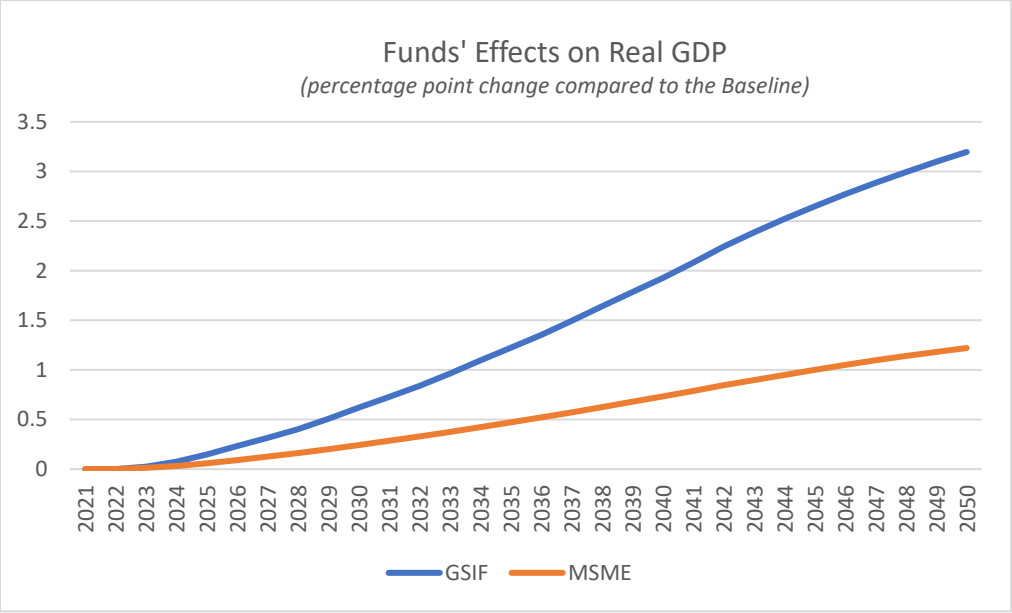
	MSME	GSIF
I. Incremental Capital – Output ratio, (Cumulative effect in 2050)	1.16	1.15
II. Effects for MSME portfolio sectors, % deviations from baseline in 2050	**MSME**	
a. CO2 emissions	-12.20	
b. Labor employment	0.38	
c. Capital employment	3.57	
III. Effects for GSIF portfolio sectors, % deviations from baseline in 2050		**GSIF**
a. CO2 emissions		-14.80
b. Labor employment		1.35
c. Capital employment		4.40
IV. Economy-wide effects, % deviations from baseline in 2050	**MSME**	**GSIF**
a. CO2 emissions	-5.28	-6.60
b. Labor employment	0.69	1.36
c. Capital employment	1.58	4.18
d. Real GDP	1.22	2.67
e. Real Imports	0.43	1.79
f. Real Exports	2.35	6.03
g. Real Private Consumption	0.37	2.51

Impact on GDP:

Both Funds lead to an increase in the real GDP; around 1.22pp for MSME and 2.67pp for GSIF above the baseline in 2050 (see Row IV d). GSIF's boost on the GDP is more than twice that of MSME Fund, this is due to the larger size of the Fund amounting to $335 million MSME compared to $883million GSIF (respectively 380 million Euros v 1 billion Euros).

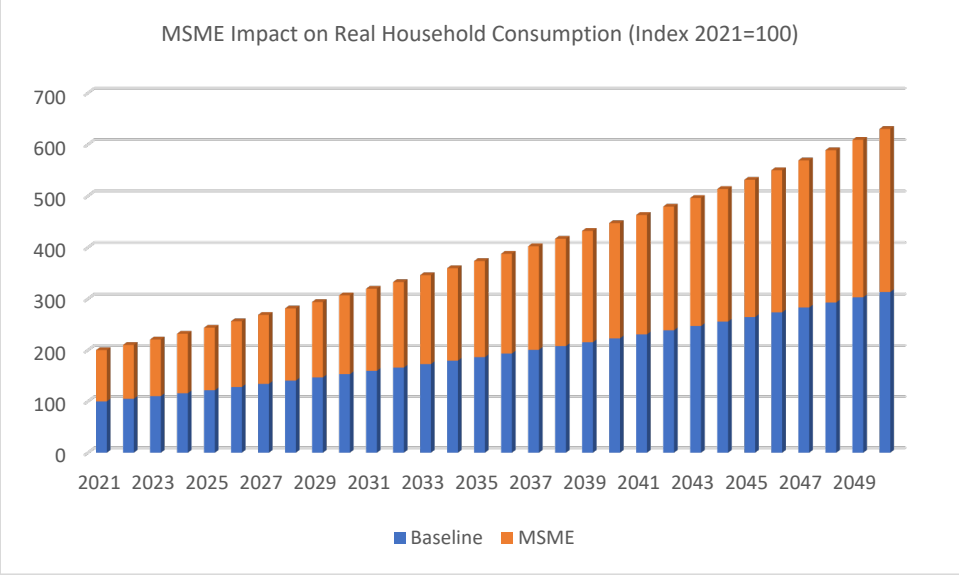
Strong GDP effect in GSIF is in line with the IMF (2021) analysis on green investment multipliers; they crowd in the private sector while investment in traditional activities (e.g., fossil fuel-intensive sectors such as steel) would have crowded out private investments (Figure 1).

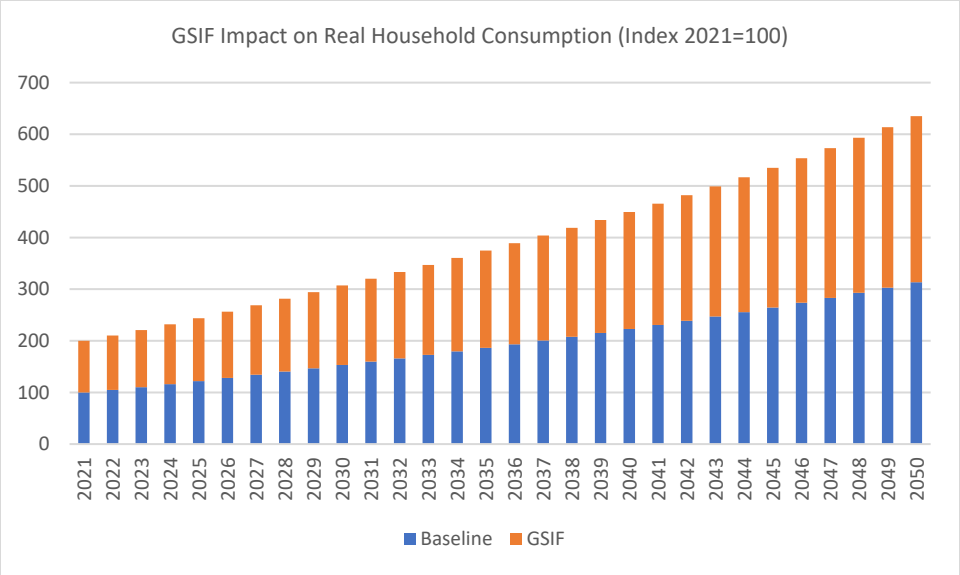
Figure 1. Impact on Real GDP



During the implementation of the MSME Fund and GSIF, GDP increases lead to higher household consumption (respectively by 1.18% and 2.67% above the baseline in 2050) considering for the likely price changes. Their positive effects are more pronounced towards the end of the investment period (Figure 2).

Figure 2. Funds' Impact on Real Household Consumption





Real imports and exports increase under both Funds (by 2.35% in MSME and 6.05% in GSIF), while exports' increase is higher for the GSIF since the Fund targets large enterprise with high export potential (see Row IV e and f). Import dependance of the economy explains the rise in imports under both Funds (by 0.43% in MSME and 1.79% in GSIF) needed to support exporting sectors. These changes are less compared to the boots in exports (see Row IV e).

Impact on CO2 emissions:

Both investments lead to "decoupling"[6] through promotion of service sectors and greening activities by the Funds.

In 2050, the model forecasts a 5.28% decrease in Co2 emissions in North Macedonia from the Baseline. Regarding MSME Fund investment sectors, their carbon footprint decreases by 12.2% compared to the baseline in 2050.

CO2 emissions caused by the "GSIF portfolio sectors" are estimated to decrease by around 14.8% along with an overall emission decrease by (6.6%) in 2050 with respect to the Baseline.

Impact on jobs:

- Indirect effects:

[6] Emissions decrease in parallel to GDP increase during the project implementation compared to the Baseline.

The model estimates across sectors a 0.69% increase (or 9,468 jobs)[7] for the MSME Fund and a 1.36% increase (or 18,648 jobs) for the GSIF when compared to the baseline[8] in 2050.

- Direct effects:

The CGE model predicts a 0.38% increase in employment (Row IIb) in the "sectors within the MSME portfolio"; hence additional 867 jobs compared to the baseline in 2050.

Regarding the "sectors within the GSIF portfolio" the model estimates a 1.35% increase in employment (Row III b) that translates to 17,867 new jobs in 2050 compared to the baseline.

Distributional effects:

Positive ripple effects from the two funds lead to higher demand for capital and labor lead to more jobs and higher value addition across sectors which improves employment in green activities (GSIF) and decoupling (MSME) in 2050. GSIF leads to better employment numbers by adding green jobs across all sectors and increases in current activities given the bigger size of the investment portfolio.

Benefit-Cost Analysis

CGE model shows that North Macedonia's capital income share is around 62%; assuming a 3% annual capital depreciation rate, in the time frame 2023-2050, the rate of return at the end of 5 cycles of investment is around 1.15 to 1.16 for the MSME and GSIF.

Strengths and Limitations of the Approach

A multi-sector, multi-region CGE model was developed for North Macedonia using assumptions from the portfolio allocation among activities and time horizons, potential activities to be funded as well as impact on GHG. The CGE model allows assessments to be made while keeping informed of the linkages between the GSIF and MSME investment sectors and the rest of the economy. The model also informs us about the labor and capital shifts among the sectors, and potential impacts of the two funds on exports and exports. Model results show higher job creation potential from the GSIF through promotion of traditional and green activities across the board. Both Funds lead to better macro-economic performance and a less significant GHG footprint.

Limitations of the CGE model mostly allude to its purely "economic" nature. Emission reduction potential would have been better assessed in an "integrated modelling framework" where engineering processes would have been captured as well as renewable energy investment for targeted GHG reductions. For instance, the current version of the model offers no distinction between fossil fuel electricity generation

[7] Our simulations result is in line with the MASIT report (2020) that highlights higher job creation by the ICT sector compared to traditional sectors: "If additional 1-million-euro revenue is generated in the "Software and IT Services" subsegment it will allow potential employment of 31 new employees with the current average".

[8] Reference year value: 892,399 jobs in 2020 (WDI, 2021).

and renewable electricity generation. Greening scenarios refer to the substitution of highly polluting energy types (coal, diesel, fuelwood, heavy fuel oil, and jet fuel) with natural gas and LPG. However, the CGE model cannot distinguish between existing steel technologies and clean steel technology- based on green hydrogen.

Courtesy of the CGE model, the North Macedonian economy has been presented as part of a multi-country framework for the first time. However, the model feature could be improved if it were to incorporate bilateral trade relations with the EU as being separate from the rest of the world.

This analysis could also be complemented by incorporating more country-specific details into the existing GTAP-CGE model or developing a new CGE model with a focus on government and financial accounts. Such a modeling framework would allow analyzing various funding options for the Government's contributions to the Funds. It would be suitable for incorporating multiple-household consumption data hence a detailed analysis of poverty alleviation outcomes.

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ANNEXES

ANNEX I - Mapping between North Macedonia Input-Output Table and standard GTAP sectors

Table 6- North Macedonia I-O sectors		
ID	Title in English	Mapping to GTAP sectors
01	Products of agriculture, hunting and related services	1-12
02	Products of forestry, logging, and related services	13
03	Fish and other fishing products; aquaculture products; support services to fishing	14
Б/ В	Mining and quarrying	15-18
10-12	Food products, beverages, and tobacco products	19-26
13-15	Textiles, wearing apparel and leather products	27-29
16	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials	30
17	Paper and paper products	31a
18	Printing and recording services	31b
19	Coke and refined petroleum products	32
20	Chemicals and chemical products	33
21	Basic pharmaceutical products and pharmaceutical preparations	34
22	Rubber and plastic products	35
23	Other non-metallic mineral products	36
24	Basic metals	37-38
25	Fabricated metal products, except machinery and equipment	39
26	Computer, electronic and optical products	40
27	Electrical equipment	41
28	Machinery and equipment n.e.c	42
29	Motor vehicles, trailers, and semi-trailers	43
30	Other transport equipment	44
31-32	Furniture; other manufactured goods	45
33	Repair and installation services of machinery and equipment	45

35	Electricity, gas, steam, and air-conditioning	46-47
36	Natural water; water treatment and supply services	48a
37-39	Sewerage; waste collection, treatment, and disposal activities; materials recovery; remediation activities and other waste management services	48b
Ґ / F	Constructions and construction work	49
45	Wholesale and retail trade and repair services of motor vehicles and motorcycles	50a
46	Wholesale trade services, except of motor vehicles and motorcycles	50b
47	Retail trade services, except of motor vehicles and motorcycles	50c
49	Land transport services and transport services via pipelines	52
50	Water transport services	53
51	Air transport services	54
52	Warehousing and support services for transportation	55
53	Postal and courier services	56
3 / I	Accommodation and food services	51
58	Publishing services	56
59-60	Motion picture, video and television program production services, sound recording and music publishing; programming and broadcasting services	56
61	Telecommunications services	56
62-63	Computer programming, consultancy, and related services; information services	56
64	Financial services, except insurance and pension funding	57
65	Insurance, reinsurance, and pension funding services, except compulsory social security	58
66	Services auxiliary to financial services and insurance services	57
68Б/ 68В	Real estate services (excluding imputed rent)	59
68А/ 68А	Imputed rents of owner-occupied dwellings	65
69-70	Legal and accounting services; services of head offices; management consulting services (M)	60
71	Architectural and engineering services; technical testing and analysis services M)	60
72	Scientific research and development services (M)	60
73	Advertising and market research services (M)	60
74-75	Other professional, scientific, and technical services; veterinary services (M)	60
77	Rental and leasing services (N)	60

78	Employment services (N)	60
79	Travel agency, tour operator and other reservation services and related services (N)	60
80-82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services (N)	60
84	Public administration and defense services; compulsory social security services	62
85	Education services	63
86	Human health services	64a
87-88	Social work services	64b
90-92	Creative, arts and entertainment services; library, archive, museum, and other cultural services; gambling and betting services R	61
93	Sporting services and amusement and recreation services R	61
94	Services furnished by membership organizations	61
95	Repair services of computers and personal and household goods S	61
96	Other personal services S	61
П / Т	Services of households as employers; undifferentiated goods and services produced by households for own use T	61

ANNEX II – Description of sectors in the standard GTAP model (65 sectors)

Table 7- GTAP Sectors			
Number	**Code**	_	**Description**
1	pdr	Paddy rice	Rice: seed, paddy (not husked)
2	wht	Wheat	Wheat: seed, other
3	gro	Cereal grains nec	Other Grains: maize (corn), sorghum, barley, rye, oats, millets, other cereals
4	v_f	Vegetables, fruit, nuts	Veg & Fruit: vegetables, fruit and nuts, edible roots and tubers, pulses
5	osd	Oil seeds	Oil Seeds: oil seeds and oleaginous fruit
6	c_b	Sugar cane, sugar beet	Cane & Beet: sugar crops
7	pfb	Plant-based fibers	Fibres crops
8	ocr	Crops nec	Other Crops: stimulant; spice and aromatic crops; forage products; plants and parts of plants used primarily in perfumery, pharmacy, or for insecticidal, fungicidal, or similar purposes; beet seeds (excluding sugar beet seeds) and seeds of forage plants; natural rubber in primary forms or in plates, sheets or strip, living plants; cut flowers and flower buds; flower seeds, unmanufactured tobacco; other raw vegetable materials nec
9	ctl	Bovine cattle, sheep and goats, horses	Cattle: bovine animals, live, other ruminants, horses and other equines, bovine semen

10	oap	Animal products nec	Other Animal Products: swine; poultry; other live animals; eggs of hens or other birds in shell, fresh; reproductive materials of animals; natural honey; snails, fresh, chilled, frozen, dried, salted or in brine, except sea snails; edible products of animal origin n.e.c.; hides, skins and fur skins, raw; insect waxes and spermaceti, whether or not refined or colored
11	rmk	Raw milk	Raw milk
12	wol	Wool, silk-worm cocoons	Wool: wool, silk, and other raw animal materials used in textile
13	frs	Forestry	Forestry: forestry, logging and related service activities
14	fsh	Fishing	Fishing: hunting, trapping and game propagation including related service activities, fishing, fish farms; service activities incidental to fishing
15	coa	Coal	Coal: mining and agglomeration of hard coal, lignite and peat
16	oil	Oil	Oil: extraction of crude petroleum, service activities incidental to oil and gas extraction excluding surveying (part)
17	gas	Gas	Gas: extraction of natural gas, service activities incidental to oil and gas extraction excluding surveying (part)
18	oxt	Other Extraction (formerly omn Minerals nec)	Other Mining Extraction (formerly omn): mining of metal ores; other mining and quarrying
19	cmt	Bovine meat products	Cattle Meat: fresh or chilled; meat of buffalo, fresh or chilled; meat of sheep, fresh or chilled; meat of goat, fresh or chilled; meat of camels and camelids, fresh or chilled; meat of horses and other equines, fresh or chilled; other meat of mammals, fresh or chilled; meat of mammals, frozen; edible offal of mammals, fresh, chilled or frozen
20	omt	Meat products nec	Other Meat: meat of pigs, fresh or chilled; meat of rabbits and hares, fresh or chilled; meat of poultry, fresh or chilled; meat of poultry, frozen; edible offal of poultry, fresh, chilled or frozen; other meat and edible offal, fresh, chilled or frozen; preserves and preparations of meat, meat offal or blood; flours, meals and pellets of meat or meat offal, inedible; greaves
21	vol	Vegetable oils and fats	Vegetable Oils: margarine and similar preparations; cotton linters; oil-cake and other residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes; animal fats
22	mil	Dairy products	Milk: dairy products
23	pcr	Processed rice	Processed Rice: semi- or wholly milled, or husked
24	sgr	Sugar	Sugar and molasses
25	ofd	Food products nec	Other Food: prepared and preserved fish, crustaceans, mollusks and other aquatic invertebrates; prepared and preserved vegetables, pulses and potatoes; prepared and preserved fruits and nuts; wheat and meslin flour; other cereal flours; groats, meal and pellets of wheat and other cereals; other cereal grain products (including corn flakes); other vegetable flours and meals; mixes and doughs for the preparation of bakers' wares; starches and starch products; sugars and sugar syrups n.e.c.; preparations used in animal feeding; lucerne (alfalfa) meal and pellets; bakery products; cocoa, chocolate and sugar confectionery; macaroni, noodles, couscous and similar farinaceous products; food products n.e.c.
26	b_t	Beverages and tobacco products	Beverages and Tobacco products
27	tex	Textiles	Manufacture of textiles
28	wap	Wearing apparel	Manufacture of wearing apparel
29	lea	Leather products	Manufacture of leather and related products
30	lum	Wood products	Lumber: manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
31	ppp	Paper products, publishing	Paper & Paper Products: includes printing and reproduction of recorded media
32	p_c	Petroleum, coal products	Petroleum & Coke: manufacture of coke and refined petroleum products
33	chm	Chemical products	Manufacture of chemicals and chemical products

34	bph	Basic pharmaceutical products	Manufacture of pharmaceuticals, medicinal chemical and botanical products
35	rpp	Rubber and plastic products	Manufacture of rubber and plastics products
36	nmm	Mineral products nec	Manufacture of other non-metallic mineral products
37	i_s	Ferrous metals	Iron & Steel: basic production and casting
38	nfm	Metals nec	Non-Ferrous Metals: production and casting of copper, aluminum, zinc, lead, gold, and silver
39	fmp	Metal products	Manufacture of fabricated metal products, except machinery and equipment
40	ele	Computer, electronic and optical products	Manufacture of computer, electronic and optical products
41	eeq	Electrical equipment	Manufacture of electrical equipment
42	ome	Machinery and equipment nec	Manufacture of machinery and equipment n.e.c.
43	mvh	Motor vehicles and parts	Manufacture of motor vehicles, trailers and semi-trailers
44	otn	Transport equipment nec	Manufacture of other transport equipment
45	omf	Manufactures nec	Other Manufacturing: includes furniture
46	ely	Electricity	Electricity; steam and air conditioning supply
47	gdt	Gas manufacture, distribution	Gas manufacture, distribution
48	wtr	Water	Water supply; sewerage, waste management and remediation activities
49	cns	Construction	Construction: building houses factories offices and roads
50	trd	Trade	Wholesale and retail trade; repair of motor vehicles and motorcycles
51	afs	Accommodation, Food and service activities	Accommodation, Food, and service activities
52	otp	Transport nec	Land transport and transport via pipelines
53	wtp	Water transport	Water transport
54	atp	Air transport	Air transport
55	whs	Warehousing and support activities	Warehousing and support activities
56	cmn	Communication	Information and communication
57	ofi	Financial services nec	Other Financial Intermediation: includes auxiliary activities but not insurance and pension funding
58	ins	Insurance (formerly isr)	Insurance (formerly isr): includes pension funding, except compulsory social security
59	rsa	Real estate activities	Real estate activities
60	obs	Business services nec	Other Business Services nec
61	ros	Recreational and other services	Recreation & Other Services: recreational, cultural and sporting activities, other service activities; private households with employed persons (servants)
62	osg	Public Administration and defense	Other Services (Government): public administration and defense; compulsory social security, activities of membership organizations n.e.c., extra-territorial organizations and bodies
63	edu	Education	Education

64	hht	Human health and social work activities	Human health and social work
65	dwe	Dwellings	Dwellings: ownership of dwellings (imputed rents of houses occupied by owners)

ANNEX III – Description of sectors (43) in the North Macedonia GTAP CGE Model with updated sectors from the IO

Table 8

#	NM GTAP CGE sector	Description
1	Agriculture	Products of agriculture, hunting and related services
2	Forestry	Products of forestry, logging, and related services
3	Fish	Fish and other fishing products; aquaculture products; support services to fishing
4	Mining, oil, gas	Mining and quarrying
5	Cement	Cement
6	Food	Food products, beverages, and tobacco products
7	Textile	Textiles, wearing apparel and leather products
8	Wood	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
9	Paper	Paper and paper products. Printing and recording services
10	Petroleum	Coke and refined petroleum products
11	Chemicals	Chemicals and chemical products
12	Chemical Products	Chemical Products
13	Pharmaceuticals	Basic pharmaceutical products and pharmaceutical preparations
14	Plastic	Rubber and plastic products
15	Non-metallic minerals	Other non-metallic mineral products
16	Basic metals	Basic metals
17	Metal products	Fabricated metal products, except machinery and equipment
18	Electronics	Computer, electronic and optical products
19	Steel	Steel
20	Electrical	Electrical equipment
21	Machinery	Machinery and equipment n.e.c
22	MotorVehicles	Motor vehicles, trailers, and semi-trailers
23	OtherEquipment	Other transport equipment
24	Manufacture	Furniture; other manufactured goods. Repair and installation services of machinery and equipment
25	Utilities	Electricity, gas, steam, and air-conditioning
26	Water	Natural water; water treatment and supply services. Sewerage; waste collection, treatment, and disposal activities; materials recovery, remediation activities and other waste management services
27	Construction	Constructions and construction work
28	RetailTrade	Wholesale and retail trade and repair services of motor vehicles and motorcycles. Wholesale trade services, except for motor vehicles and motorcycles. Retail trade services except for motor vehicles and motorcycles
29	Accomodation	Accommodation and food services
30	LandTransport	Land transport services and transport services via pipelines
31	WaterTransport	Water transport services
32	AirTransport	Air transport services

33	Warehouses	Warehousing and support services for transportation
34	Communication	Postal and courier services. Publishing services. Motion picture, video and television program production services, sound recording and music publishing; programming and broadcasting services, sound recording and music publishing, programming, and broadcasting services
35	Financial	Financial services, except insurance and pension funding. Services auxiliary to financial services and insurance services
36	Insurance	Insurance, reinsurance, and pension funding services, except compulsory social security
37	RealEstate	Real estate services (excluding imputed rent)
38	OtherServices	Legal and accounting services; services of head offices; management consulting. Architectural and engineering services; technical testing and analysis services. Advertising and market research services Advertising and market. Travel agency. Security. research services. Scientific research and development services.
39	Recreation	Creative arts. Sporting services. Recreational activities. Repair services of computers and personal household goods. Other personal services.
40	PublicAdmin	Public administration and defense services; compulsory social security services
41	Education	Education services
42	Health	Human health services. Social work services
43	Dwelling	Imputed rents of owner-occupied dwellings

ANNEX IV – Growth Projections to 2050 (Economic Baseline)

YEAR	REAL GDP GROWTH (%)
2017	1.1
2018	2.9
2019	3.2
2020	-4.5
2021	4.1
2022	3.5
2023	3.4
2024	3.6
2025	3.8
2026	4
2027	3.9
2028	3.9
2029	3.8
2030	3.8
2031	3.7
2032	3.6
2033	3.6
2034	3.5
2035	3.5
2036	3.4
2037	3.4
2038	3.3
2039	3.3
2040	3.2

Source: UNDP (2020)

ANNEX V – Literature on CO2 emissions by key fuel/activity/sectors in North Macedonia

Mt CO2[9]

Table 9

2015	Coal	Liquid fuels	Gaseous fuels	Process	Sum
Power and heating plants	3.67	0.16	0.19		4.01
Fuel conversion		0.01	0		0.01
Residential combustion	0.01	0.2	0.01		0.21
Industrial combustion	0.67	0.26	0.06		1
Industrial processes				0.53	0.53

[9] ECLIPSE_V6b_CLE_base: This is a baseline scenario for the EU BC Action project that will be used in the several model simulations (climate mostly) within work for the AMAP Assessment Report 2021. The scenario is drawing on the work for the WEO2018 and then ECLIPSE_V6a_base scenario. The energy data for historical years (the last one 2015) originates from IEA statistics and projections from the WEO2018 (IEA). For agriculture, data relies on the FAO, IFA, Eurostat statistics, and FAO livestock projection. GAINS 4 Europe online: Key fuels/activities and key sectors (iiasa.ac.at)

Light duty vehicles		0.87			0.87
Heavy duty vehicles-diesel		0.95			0.95
Non-road machinery		0.06			0.06
Nonenergy use of fuels		0.05			0.05
Sum	4.34	2.56	0.26	0.53	7.7

2020	Coal	Liquid fuels	Gaseous fuels	Process	Sum
Power and heating plants	4.14	0.51	0.43		5.09
Fuel conversion		1.16	0		1.16
Residential combustion	0	0.11	0.4		0.52
Industrial combustion	0.5	0.34	0.59		1.43
Industrial processes				0.58	0.58
Light duty vehicles		1.21			1.21
Heavy duty vehicles-diesel		1.4			1.4
Non-road machinery		0.03			0.03
Nonenergy use of fuels		0.03			0.03
Sum	4.65	4.78	1.42	0.58	11.43

2025	Coal	Liquid fuels	Gaseous fuels	Process	Sum
Power and heating plants	3.75	0.06	0.54		4.35
Fuel conversion		0.93	0		0.93
Residential combustion	0	0.1	0.44		0.55
Industrial combustion	0.47	0.35	0.23		1.05
Industrial processes				0.65	0.65
Light duty vehicles		1.5			1.5
Heavy duty vehicles-diesel		1.79			1.79
Non-road machinery		0.04			0.04
Nonenergy use of fuels		0.04			0.04
Sum	4.22	4.81	1.21	0.65	10.88

2030	Coal	Liquid fuels	Gaseous fuels	Process	Sum
Power and heating plants	2.83	0.03	0.5		3.36
Fuel conversion		0.49	0		0.5
Residential combustion	0	0.08	0.27		0.35
Industrial combustion	0.43	0.36	0.17		0.96
Industrial processes				0.7	0.7
Light duty vehicles		1.88			1.88
Heavy duty vehicles-diesel		2.28			2.28
Non-road machinery		0.04			0.04
Nonenergy use of fuels		0.04			0.04
Sum	3.26	5.2	0.94	0.7	10.11

ANNEX VI – GTAP methodology

Model overview

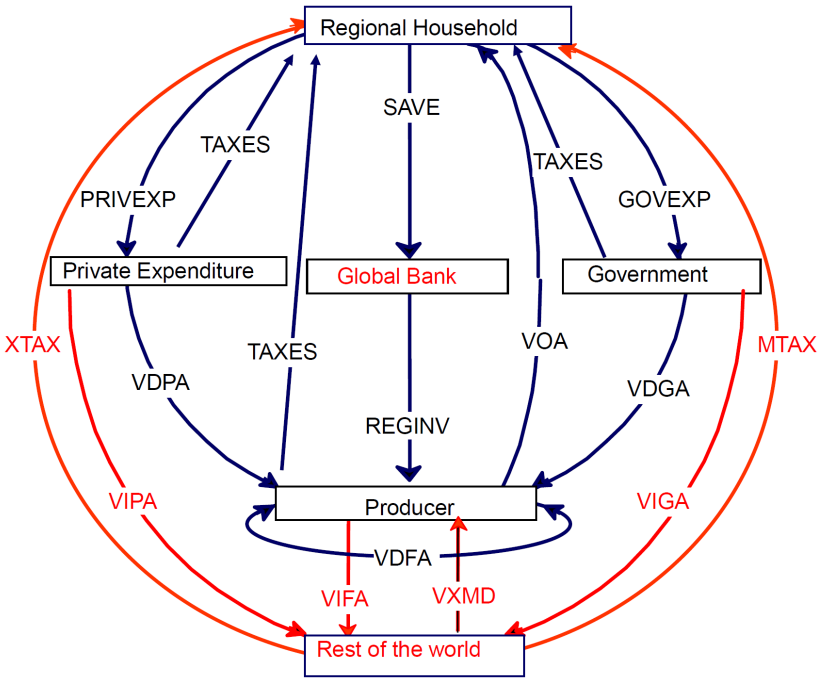
Incorporating North Macedonia into the Global Trade Analysis Project (GTAP) dataset and model:

In its standard version, the GTAP model uses data drawn from a common global database that is regularly updated. In its latest form, it distinguishes between eight production factors (cropland; pasture/forest; capital; and 5 occupational categories), 65 sectors (industries), and 140 countries. North Macedonia had not been part of the standard GTAP dataset until our team incorporated it into the global database (GTAP version10). North Macedonia dataset was developed using the latest Input-Output Table (2015); global trade statistics and other data provided by the National Statistics Institute.

The GTAP CGE framework used in this study specifies 43 production sectors, production factors (cropland; pasture/forest; capital; and labor) for North Macedonia, a small economy trading with the rest of the world (ANNEX III).

The GTAP starts by mapping the interdependent components of the economy that include industries, households, investors, governments, importers, and exporters as well as the inter-industry links with countries/regions that trade with a specific economy. It then imposes several behavioral assumptions on the economic agents and policy decisions makers. For example, households/consumers are motivated by utility maximization subject to the size of their budget, producers/suppliers to be driven by the objective of profit maximization subject to their limited resources and those available in the economy, governments to strive to maintain a balanced budget, markets to be perfectly competitive and traded goods to be imperfect substitutes. Specifically for North Macedonia, the GTAP model represents a small open economy.

Figure 3. The overall structure of the GTAP-CGE model for North Macedonia



Source: Hertel, T. W. (Ed.). (1997).

The North Macedonia GTAP model traces the flows of goods and services within the domestic economy and between the economy and its trading partners. The model allows production, consumption, prices, and other economic factors to interact with each other and thus determine the final outputs and eventually the size of the country's GDP. It also allows for regional variation in prices and demand for goods and services depending on demand and supply conditions at the domestic and global markets.

Each region is balanced in private, public, and foreign sectors:

S - I = X – M

The world is balanced in Savings and investments, and global exports equal global imports:

Global Saving = Global Investment

Total Exports = Total Imports

The GTAP model is an open economy model with perfect competition, and it contains two regions, North Macedonia, and all the other countries in the world that are grouped in one region named Rest of the World. Agents in the model take the form of a household, firm, government, global bank, or a global transport sector. Households supply land, labor and capital and use the proceeds to finance their expenditure and saving. Households demand both domestic goods and imports. The government uses taxation revenue to finance its expenditure on domestic goods and imports. Firms use primary factors of

production (land, labor, capital), domestic intermediate and imported intermediate inputs to produce total output. The output of firms is divided between domestic sales and exports to the rest of the world. The global bank provides an investment portfolio and offers it to households for their savings. The model is set up in comparative static, thus there is no endogenous capital accumulation.

General notation: commodity i, sector j, region r, s

Firm behavior

All firms in the model use constant returns to scale technologies. They use primary factors of production and intermediate inputs, domestically produced, or imported. The primary factors of production are land, labor, and capital. Firms choose the optimal mix of primary factors independently of the prices of intermediate inputs with the elasticity of substitution between primary factors and intermediate inputs being equal. Firms first decide on their imports and then based on the composite imports price, decide on the domestically produced intermediate goods (Armington approach). The production structure in the model is divided in three stages related to the 1) production of intermediaries; 2) production of value added and 3) production of total output. Each stage of the production process can be defined by a price equation and a conditional demand equation.

Intermediaries:

Equation (1) shows the demand price for composite tradeable pf as a weighted share of the price for the imported pfm and for the domestically produced tradeable good pfd. Equation (2) and (3) show the demanded quantity of the imported and domestically produced tradeable good, qfm and qfd, respectively, relating the quantity of composite tradeable good, qf, to the difference in prices between the imported and domestically produced tradeable good with the demand price for the composite tradeable good, pf.

(1) $pf(i,j,r) = FMSHR(i,j,r) * pfm(i,j,r) + [1 - FMSHR(i,j,r)] * pfd(i,j,r)$

(2) $qfm(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfm(i,j,s) - pf(i,j,s)]$

(3) $qfd(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfd(i,j,s) - pf(i,j,s)]$

$$\forall i \varepsilon TRAD, \forall j \varepsilon PROD, \forall r \varepsilon REG$$

Value-added:

Equation (4) shows the composite price of value added as a function of the share of the endowment commodity in the total cost of value added SVA, the demand price for the endowment commodity pfe and the primary factor augmenting technological change afe. Equation (5) shows the demanded quantity for the endowment commodity qfe as a function of the quantity of value added qva, the demand price for the endowment commodity pfe and the composite price of value added pva:

(4) $pva(j,r) = \sum_{k \varepsilon ENDW} SVA(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]$

(5) $qfe(i,j,r) + afe(i,j,r) = qva(j,r) - \sigma_{VA}(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)]$

$$\forall j \varepsilon PROD, \forall r \varepsilon REG, \forall i \varepsilon ENDW$$

Total output:

Equations (6) and (7) show the total output production with the use of the quantity of value added qva, the quantity of non-saving commodity qo and the quantity of composite tradeable commodity qf, through the value added, primary factor and Hicks-neutral technological change (ava, af, ao):

(6) $qva(j,r) + ava(i,r) = qo(j,r) - ao(j,r)$

(7) $qf(i,j,r) + af(i,j,r) = qo(j,r) - ao(j,r)$

$$\forall j \varepsilon PROD, \forall r \varepsilon REG, \forall i \varepsilon TRAD$$

Zero-profits condition:

The revised ZPC serves to determine the total output price:

(8) $VOA(j,r) * [ps(j,r) + ao(j,r)] = \sum_{i \varepsilon ENDW\_COMM} VFA(i,j,r) * [pfe(i,j,r) - afe(i,j,r) - ava(j,r)] + \sum_{i \varepsilon TRAD\_COMM} VFA(i,j,r) * [pf(i,j,r) - af(i,j,r)] + VOA(j,r) * profitslack(j,r)$

$$\forall j \varepsilon PROD, \forall r \varepsilon REG$$

Household behavior

Regional Household collects all income and allocates across private consumption, government and saving. Private demand for commodities and services derived from a demand function with income and price elasticities. The household behavior in the model is represented by an aggregate utility function that is a special case of the Stone – Geary utility function, with income being divided into private expenditure, government expenditure and savings:

(9) $INCOME\ (r) * u(r) = PRIVEXP(r) * up(r) + GOVEXP(r) * [ug(r) - pop(r)] + SAVE(r) * [qsave - pop(r)]$

In the standard model closure, each expenditure type has constant share of total income.

Savings expenditure is further described by:

(10) $qsave(r) = y(r) - psave(r) + saveslack(r)$

Government expenditure is further defined by:

(11) $ug(r) = y(r) - pgov(r) + govslack(r)$

Note that the slack variables can be swapped with quantities of savings and government purchases for an exogenous specification of either or both.

After the amount of government expenditure is determined, the demand and price for a composite government good allocate the expenditure between imports and domestically produced goods:

(12) $$pgov(r) = \sum_{i\varepsilon TRAD\_COMM} \left(\frac{VGA(i,r)}{GOVEXP(r)}\right) * pg(i,r)$$

(13) $$qg(i,r) = ug(r) - [pg(i,r) - pgov(r)]$$

(14) $$pg(i,s) = GMSHR(i,s) * pgm(i,s) + [1 - GMSHR(i,s)] * pgd(i,s)$$

(15) $$qgm(i,s) = qg(i,s) + \sigma_D(i) * [pg(i,s) - pgm(i,s)]$$

(16) $$qgd(i,s) = qg(i,s) + \sigma_D(i) * [pg(i,s) - pgd(i,s)]$$

When it comes to private expenditure, the exposition needs to consider population growth, such that the percentage change in private utility is on a per capita basis. Private household preferences are defined by a CDE functional form which through its total differentiation leads to the equation below, that defines the relationship between minimum expenditure, prices, and utility:

(17) $$yp(r) = \sum_{i\varepsilon TRAD}[CONSHR(i,r) * pp\ (i,r)] + \sum_{i\varepsilon TRAD}[CONSHR(i,r) * INCPAR(i,r)] * up(r) + pop(r)$$

The composite household demand, as well as its corresponding household demand for domestic and imported goods and their price are shown in (..):

(18) $$qp(i,r) = \sum_{k\varepsilon TRAD} EP(i,k,r) * pp\ (k,r) + EY(i,r) * [yp(r) - pop(r)] + pop(r)$$

(19) $$pp(i,s) = PMSH(i,s) * ppm(i,s) + [1 - PMSHR(i,s)] * ppd(i,s)$$

(20) $$qpd(i,s) = qp(i,s) + \sigma_D(i) * [pp(i,s) - ppd(i,s)]$$

(21) $$qpm(i,s) = qp\ (i,s) + \sigma_D(i) * [pp(i,s) - ppm(i,s)]$$

$$\forall i\varepsilon TRAD, \forall s\varepsilon REG, \forall r\varepsilon REG$$

Note that the parameters of the CDE function are not constant – they vary with expenditure shares/relative prices. They are initially calibrated to replicate a previously specified vector of price and income elasticities of demand that are updated per iteration of a non-linear solution procedure (for more details, see GTAP reference manual chapter 2).

Capital stocks

Finally, the value of the initial capital stock VKB along with regional investment added $REGINV$ and depreciation expenses deducted $VDEP$ returns the value of ending capital stock VKE.

(22) $$VKB(r) + REGINV(r) - VDEP(r) = VKE(r)$$

Note that the accounting equations shown above are linearized and the solution of this nonlinear model is obtained via their linearized representation. For details on the linearized equations, please see the GTAP model documentation.

Additional information

Imperfect factor mobility (linearized)

The responsiveness of sluggish factors of production to changes in the rental rates is described with the use of a CES revenue function. The elasticity of transformation σ_T is nonpositive, thus for larger values of it in absolute terms, the degree of sluggishness is reduced and rental rates for different uses move together.

$$(1)\ pm(i,r) = \sum_{k\varepsilon PROD\_COMM} REVSHR(i,k,r) * pmes(i,k,r)$$

$$(2)\ qoes(i,j,r) = qo\ (i,r) - endwslack(i,r) + \ \sigma_T(i) * \ [pm(i,r) - pmes(i,j,r)]$$

$$\forall i\varepsilon ENDWS, \forall j\varepsilon PROD, \forall r\varepsilon REG$$

Macroeconomic closure

The theoretical framework is based on the Walras Law that implies that a market for a commodity is in equilibrium if at the current price of the commodity, the quantity of the commodity demanded equals the quantity supplied, in other words. The sum of excess demands across all markets must equal zero for all prices; there is no excess demand. An economy is in general equilibrium if every market in the economy is in equilibrium. This implies that if all markets, but one is in equilibrium, then that last market must also be in equilibrium.

Based on the Walras' Law in a model with two markets economy; if first market is in equilibrium, then the second market is in equilibrium too. Excess expenditures in two markets are zero. There is no need for inclusion of the equilibrium condition in the second market in the model. Last market must be in equilibrium.

The closure needs the classification of variables as either "Endogenous" (values determined by the model based on each solution of the simulation) or "Exogenous" (values predetermined outside the model). By Walras' rule, the number of endogenous variables must be equal to the number of equations. The equations must be independent. These are necessary but not sufficient conditions. Closure must also represent a valid assessment of the characteristics of the economies.

The GTAP does not incorporate macroeconomic policies and is not an intertemporal model, thus giving rise to the fallacy of indeterminacy of investment and the issue of macroeconomic closure. To overcome this challenge, a global closure approach is adopted, whereby the global bank uses the receipts obtained from the sale of savings commodities to individual regional households to buy shares in a portfolio of regional investment goods. This enables some adjustment to investment on a regional level.

A neoclassical closure General Equilibrium (GE) closure is satisfied through equilibrium in all accounting relationships. Labor market is at full employment. Investment adjusts to regional changes in savings. It is worth noting that neoclassical restrictions (such as full employment) are not necessary to obtain a GE closure. If need necessary, it is possible to swap real wage rate with labor demand to introduce unemployment into the CGE framework.

Model solution

As stipulated before, model equations are linearized and are used in *percentage change* form in the model software, GEMPACK, to obtain the model solution. Solving the model entails perturbing a representation of one state to obtain another state (in equilibrium). For each simulation of the model, the user species the set of endogenous/exogenous components. The model is solved with the use of a multi-step solution method.

Endogenous variables meaning prices and quantities of non-endowment commodities, and regional incomes that are determined by the model solutions. Policy variables, technical change variables, endowments and population are exogenous and can be shocked as part of the model simulations. The impact on welfare and macro-economics are displayed in model solution files as percentage changes from the reference year.

Model solution is based on the following conditions: (i) markets' equilibrium (supply=demand) for factors of production, as well as for goods; and services; (ii) firms earn zero pure profits; (iii) regional household spends within its budget constraint; (iv) Fixed employment of primary factors; and (v) mobility of labor and capital across sectors.

If equilibrium conditions hold, then corresponding slack variables are equal to zero except *walraslack*. If any slack variable is non-zero, then the corresponding equilibrium condition does not hold. Slack variables can be used to deactivate equilibrium conditions, therefore move from long-run general equilibrium to a medium and short-run partial equilibrium, or short-run general equilibrium.

If markets are in equilibrium, slack variables (Table 10) are zero.

Table 10.

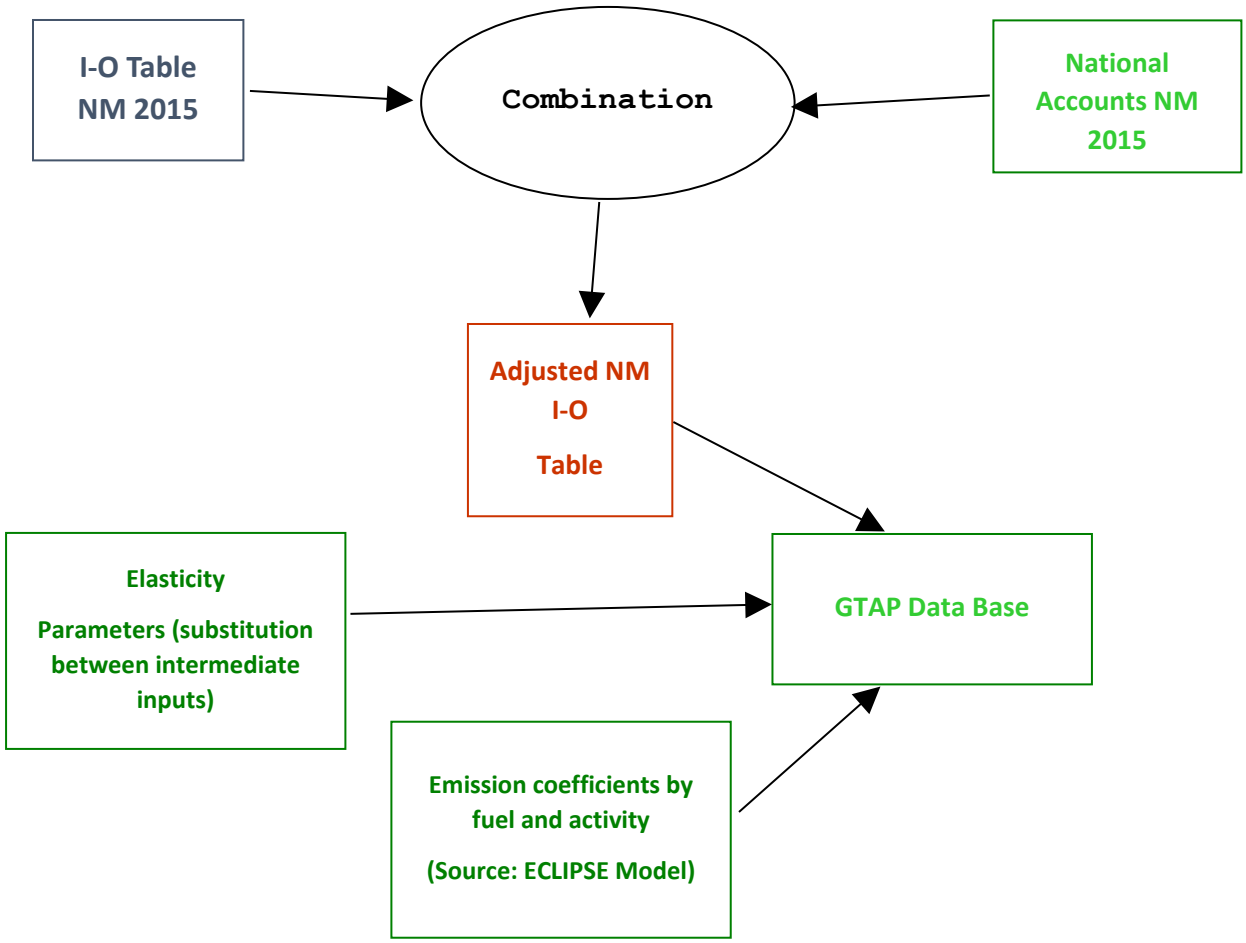
Market clearing conditions	Slack variable
Tradable commodities	*tradslack(i,r)*
Mobile endowment commodities	*endwslack(i,r)*
Sluggish endowment commodities	*endwslack(i,r)*
Rate of return condition	*cgdslack(i,r)*
Zero pure profit conditions	*profitslack(i,r)*
Income-expenditure balance	*incomeslack(i,r)*
Saving-investment balance	*walraslack(i,r)*

The exchange rate used for conversion from national accounts to USD was 1 Euros = 1.13 USD (as of 21 November 2021).

Parameters

Standard GTAP elasticities were used in this analysis, except for one change that relates to the substitution between intermediate inputs. This elasticity was modified to allow substitution between highly polluting and less polluting fuels.

Figure 4. CGE Model Structure with polluting fuels and emissions



ANNEX VII – Emission data (IISA) mapped to North Macedonia GTAP CGE sectors

Table 11

	CGE model sectors	Correspondence to Sector group in IEF data		
1	Agricult	Agriculture		
2	frs	otherInd		
3	fsh	otherInd		
4	Cement	otherInd		
5	OthMinerals	otherInd		
6	FoodProc	manufact		
7	TWL	manufact		
8	lum	manufact		
9	ppp	manufact		
10	p_c	manufact		
11	Chemicals	manufact		
12	ChemicalProd	manufact		
13	bph	manufact		
14	rpp	manufact		
15	nmm	manufact		
16	Steel	manufact		
17	OthMetals	manufact		
18	fmp	manufact		
19	ele	manufact		
20	eeq	manufact		
21	ome	manufact		
22	mvh	manufact		
23	otn	manufact		
24	omf	manufact		
25	ELY_GDT	powerGen		
26	wtr	services		
27	cns	construction		
28	trd	services		
29	otp	RoadTransp	and	rail
30	Wtp	RoadTransp	and	rail
31	Atp	Aviation		
32	Whs	services		
33	Cmn	services		
34	afs	services		
35	Ofi	services		
36	Ins	services		
37	Rsa	services		
38	Obs	services		

39	Osg	services		
40	Edu	services		
41	Hht	services		
42	Ros	services		
43	Dwe	residential		

ANNEX VIII – Emission and Energy Variables in the NM CGE model

No.	Energy variable
1	Coal
2	Diesel
3	Fuelwood
4	Gas
5	HevyFuelOil
6	JetFuel
7	LPG
8	Gasoline

No.	Emission variable
1	CH4
2	CO
3	CO2
4	NOX
5	PM_2_5
6	PM_BC
7	PM_OC
8	SO2
9	VOC

ANNEX X - Climate Mitigation Activities (World Bank, 2015)

Table 12

#1 Category	#2 Sub-Category	#3 Eligible Activities	#4 Modeled (Y/N)	#5 Method in CGE/Emissions Satellite Module
1. Renewable Energy	1.1 Electricity generation	Wind power	Y	Reductions in net emissions /fossil fuel use
		Geothermal power (only if net emission reductions can be demonstrated)	Y	Reductions in net emissions /fossil fuel use
		Solar power (concentrated solar power, photovoltaic power)	Y	Reductions in net emissions /fossil fuel use Production / imports of solar panels
		Biomass or biogas power (only if net emission reductions, including carbon pool balance, can be demonstrated)	Y	Reductions in net emissions /fossil fuel use
		Ocean power (wave, tidal, ocean currents, salt gradient, etc.)	Y	Reductions in net emissions /fossil fuel use
		Hydropower plants (only if net emission reductions can be demonstrated)	Y	Reductions in net emissions /fossil fuel use Improved electricity supply
		Renewable energy power plant retrofits	Y	Reductions in net emissions /fossil fuel use Improved electricity supply
	1.2 Heat production or other renewable energy application	Solar water heating and other thermal applications of solar power in all sectors	Y	Reductions in net emissions /fossil fuel use
		Thermal applications of geothermal power in all sectors	Y	Reductions in net emissions /fossil fuel use
		Wind-driven pumping systems or similar applications	Y	Reductions in net emissions /fossil fuel use
		Thermal applications of sustainably/produced bioenergy in all sectors, including efficient, improved biomass stoves	Y	Reductions in net emissions /fossil fuel use
	1.3 Measures to facilitate integration of renewable energy into grids	New, expanded and improved transmission systems (lines, substations)	Y	Reductions in net emissions /fossil fuel use
		Storage systems (battery, mechanical, pumped storage)	Y	Reductions in net emissions /fossil fuel use
		New information and communication technology, smart-grid and mini-grid	Y	Reductions in net emissions /fossil fuel use
2. Lower-Carbon and Efficient Energy Generation	2.1 Transmission and distribution systems	Retrofit of transmission lines or substations and/or distribution systems to reduce energy use and/or technical losses including improving grid stability/reliability, (only if net emission reductions can be demonstrated)[a]	Y	Reductions in net emissions /fossil fuel use
	2.2 Power plants	Thermal power plant retrofit to fuel switch from a more GHG-intensive fuel to a different and less GHG-intensive fuel type[b]	Y	Reductions in net emissions /fossil fuel use

#1 Category	#2 Sub-Category	#3 Eligible Activities	#4 Modeled (Y/N)	#5 Method in CGE/Emissions Satellite Module
		Conversion of existing fossil-fuel based power plant to co-generation[c] technologies that generate electricity in addition to providing heating/ cooling	Y	Reductions in net emissions /fossil fuel use
		Energy-efficiency improvement in existing thermal power plant	Y	Reductions in net emissions /fossil fuel use
3. Energy Efficiency	3.1 Energy efficiency in industry in existing facilities	Industrial energy efficiency improvements though the installation of more efficient equipment, changes in processes, reduction of heat losses and/or increased waste heat recovery	Y	Reductions in net emissions /fossil fuel use
		Installation of co-generation plants that generate electricity in addition to providing heating/cooling	Y	Reductions in net emissions /fossil fuel use
		More efficient facility replacement of an older facility (old facility retired)	Y	Reductions in net emissions /fossil fuel use
	3.2 Energy efficiency improvements in existing commercial, public and residential buildings	Energy efficiency improvement in lighting, appliances and equipment	Y	Reductions in net emissions /fossil fuel use
		Substitution of existing heating/cooling systems for buildings by co-generation plants that generate electricity in addition to providing heating/cooling[d]	Y	Reductions in net emissions /fossil fuel use in electricity generation
		Retrofit of existing buildings: architectural or building changes that enable reduction of energy consumption	Y	Reductions in net emissions /reduction in electricity use in public, residential and commercial buildings
	3.3 Energy efficiency improvements in the utility sector and public services	Energy efficiency improvement in utilities and public services through the installation of more efficient lighting or equipment	Y	Reductions in net emissions /reduction in electricity use in public, residential and commercial buildings
		Rehabilitation of district heating and cooling systems	Y	Reductions in net emissions /reduction in electricity use
		Utility heat loss reduction and/or increased waste heat recovery	Y	Reductions in net emissions /reduction in electricity use for heating
		Improvement in utility scale energy efficiency through efficient energy use, and loss reduction	Y	Reductions in net emissions /reduction in wastage in energy use
	3.4 Vehicle energy efficiency fleet retrofit	Existing vehicles, rail or boat fleet retrofit or replacement (including the use of lower-carbon fuels, electric or hydrogen technologies, etc.)	Y	Reductions in net emissions /reduction in fuel use
	3.5 Energy efficiency in new commercial, public and residential buildings	Use of highly efficient architectural designs, energy efficient appliances and equipment, and building techniques that reduce building energy consumption, exceeding available standards and complying with high energy efficiency certification or rating schemes	Y	Reductions in net emissions /reduction in energy use in public, residential and commercial buildings
	3.6 Energy audits	Energy audits to energy end-users, including industries, buildings, and transport systems	Y	Reductions in net emissions /reduction in energy use in industries, buildings, and transport systems

#1 Category	#2 Sub-Category	#3 Eligible Activities	#4 Modeled (Y/N)	#5 Method in CGE/Emissions Satellite Module
4. Agriculture, Forestry and Land-Use	4.1 Agriculture	Reduction in energy use in traction (e.g. efficient tillage), irrigation, and other agricultural processes	Y	
		Agricultural projects that improve existing carbon pools (e.g. Rangeland management, collection and use of bagasse, rice husks, or other agricultural waste, reduced tillage techniques that increase carbon contents of soil, rehabilitation of degraded lands, peatland restoration, etc.)	Y	Reductions in net GHG emissions, improvements in agricultural productivity and arable land
		Reduction of non-CO_2 GHG emissions from agricultural practices (e.g. paddy rice production, reduction in fertilizer use)	Y	Reductions in net non-CO2 GHG emissions, reduction in fertilizer use
	4.2 Afforestation and reforestation, and biosphere conservation	Afforestation (plantations) on non-forested land	Y	Land use change, increased forest cover, Carbon sink
		Reforestation on previously forested land	Y	Land use change, increased forest cover, Carbon sink
		Sustainable forest management activities that increase carbon stocks or reduce the impact of forestry activities	Y	Land use change, increased forest cover, Carbon sink
		Biosphere conservation projects (including payments for ecosystem services) targeting reducing emissions from the deforestation or degradation of ecosystems	Y	Land use change, increased forest cover, Carbon sink
	4.3 Livestock	Livestock projects that reduce methane or other GHG emissions (manure management with biodigesters, etc.)	Y	Reduced GHG emissions
	4.4 Biofuels	Production of biofuels, including biodiesel and bioethanol (only if net emission reductions can be demonstrated)	Y	Reduced GHG emissions; change in energy mix used in agriculture
5. Non-Energy GHG Reductions	5.1 Fugitive emissions	Reduction of gas flaring or methane fugitive emissions in the oil and gas industry	Y	Reduced GHG emissions
		Coal mine methane capture	Y	Reduced GHG emissions
	5.2 Carbon capture and storage	Projects for carbon capture and storage technology that prevent release of large quantities of CO2 into the atmosphere from fossil fuel use in power generation, and process emissions in other industries	Y	Reduced GHG emissions
	5.3 Air conditioning and refrigeration	Retrofit of existing industrial, commercial and residential infrastructure to switch to cooling agent with lower global warming potential	Y	Reduced GHG emissions
	5.4 Industrial processes	Reduction in GHG emissions resulting from industrial process improvements and cleaner production (e.g. cement, chemical), excluding carbon capture and storage	Y	Reduced GHG emissions from industrial activities
6. Waste and Wastewater	6.1 Waste and wastewater	Treatment of wastewater if not a compliance requirement (e.g. performance standard or safeguard) as part of a larger project that reduces methane emissions (only if net GHG emission reductions can be demonstrated)	N Y	Would need to add water as a factor of production to the model. Reduces methane emissions.
		Waste management projects that capture or combust methane emissions	N	Would need to add a waste management / recycling sector to the model

#1 Category	#2 Sub-Category	#3 Eligible Activities	#4 Modeled (Y/N)	#5 Method in CGE/Emissions Satellite Module
		Waste to energy projects	N	Would need to add a waste management / recycling sector to the model
		Waste collection, recycling and management projects that recover or reuse materials and waste as inputs into new products or as a resource (only if net emission reductions can be demonstrated)	N	Would need to add a waste management / recycling sector to the model
7. Transport	7.1 Urban transport modal change	Urban mass transit	N	Would need to add people's transportation to the model. Currently it is about freight transports
		Non-motorized transport (bicycles and pedestrian mobility)	N	Ibid
	7.2 Transport oriented urban development	Integration of transport and urban development planning (dense development, multiple land-use, walking communities, transit connectivity, etc.), leading to a reduction in the use of passenger cars[e]	N	Ibid
		Transport demand management measures dedicated to reduce GHG emissions (e.g. speed limits, high-occupancy vehicle lanes, congestion charging/road pricing, parking management, restriction or auctioning of license plates, car-free city areas, low-emission zones)	N	Ibid
	7.3 Inter-urban transport	Railway transport ensuring a modal shift of freight and/or passenger transport from road to rail (improvement of existing lines or construction of new lines)	Y/N	Modal shift for freight transport only from road to rail is possible; reduced fossil fuel use; reduction in emissions in freight
		Waterways transport ensuring a modal shift of freight and/or passenger transport from road to waterways (improvement of existing infrastructure or construction of new infrastructure)	Y/N	Modal shift for freight transport only from road to rail is possible; reduced fossil fuel use; reduction in emissions
8. Low-Carbon Technologies	8.1 Products or equipment	Projects producing components, equipment or infrastructure dedicated for the renewable and energy efficiency sectors	Y	Reduced GHG emissions in intermediate inputs use; improved energy efficiency
	8.2 Research and development	Research and development of renewable energy or energy efficiency technologies	Y	Would need estimates of R&D impact on energy efficiency
9. Cross-Cutting Issues	9.1 Support to national, regional or local policy, through technical assistance or policy lending	National, sectoral or territorial mitigation policies/planning/action plan/planning/institutions	Y	Reduced GHG emissions at the national level
		Energy sector policies and regulations leading to climate change mitigation or mainstreaming of climate action (energy efficiency standards or certification schemes; energy efficiency procurement schemes; renewable energy policies)	Y	Reduced GHG emissions at the national level
		Systems for monitoring the emissions of greenhouse gases	N	
		Efficient pricing of fuels and electricity (subsidy rationalization, efficient end-user tariffs, and efficient regulations on electricity generation, transmission, or distribution)	Y	Reduced GHG emissions at the national level

#1 Category	#2 Sub-Category	#3 Eligible Activities	#4 Modeled (Y/N)	#5 Method in CGE/Emissions Satellite Module
		Education, training, capacity building and awareness raising on climate change mitigation/sustainable energy/sustainable transport; mitigation research	N	
		Other policy and regulatory activities, including those in non-energy sectors, leading to climate change mitigation or mainstreaming of climate action	Y	Such as removal of energy subsidies
	9.2 Financing instruments	Carbon markets and finance (purchase, sale, trading, financing and other technical assistance). Includes all activities related to compliance-grade carbon assets and mechanisms, such as Clean Development Mechanism, Joint Implementation, Assigned Amount Units, as well as well-established voluntary carbon standards like the Verified Carbon Standard or the Gold Standard.	Y/N	Through development of a model with multi-stakeholders
10. Miscellaneous	10.1 Other activities with net greenhouse gas reduction	Any other activity if agreed by MDBs may be added to the Joint Typology of Mitigation Activities when the results of ex ante GHG accounting (undertaken according to commonly agreed methodologies) show emission reductions that are higher than a commonly agreed threshold, and is consistent with a pathway towards low greenhouse gas emissions development.	Y	Net reduction in GHG at the global level