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ESSAYS ON PUBLIC INVESTMENTS IN GREEN PROJECTS AND DEVELOPMENT PARADIGM OF ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY

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ESSAYS ON INVESTMENTS IN GREEN PROJECTS AND DEVELOPMENT PARADIGM OF ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY

I, Darlington AGBONIFI, declare that this thesis is submitted in partial fulfilment of the requirements for the conferral of the degree *Doctor of Philosophy,* from the University of Verona in Italy.

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Verona, Italy
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Darlington AGBONIFI

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Abbreviations and Acronyms

€ Mln	Million euros
CBA	Cost-benefit analysis
CBAM	Carbon Border Adjustment Mechanism
CGE	Computable General Equilibrium model
CHARM	Cross-hauling adjusted regionalization method
CIS	Institutional Development Contract
CRS	Constant returns to scale production technology
DCF	Discounted cash flow analysis
DSGE	Dynamic Stochastic General Equilibrium Model.
EGD	European Green Deal
EI-MRSAM	Environmentally integrated, multi-regional social accounting matrix
EPA	US Environmental Protection Agency
ESAM	Environmentally extended social accounting matrix
EU	European Union
EU ETS	EU Emissions Trading System
EU-SILC	European Union Statistics on Income and Living Conditions
FDI	Foreign Direct Investment
GDP	Gross domestic product
GHG	Greenhouse gas emissions
GVCs	Global Value Chains
IOT	Input-Output Tables
IRR	Internal rate of return
JTF	Just Transition Fund
JTM	Just Transition Mechanism
MIBACT	Ministry of Cultural Heritage and Activities and Tourism Sector
MRIO	Multi-regional input-output
NGEU	Next Generation EU
NNP	Net National Product
NPV	Net Present Value
NRRP	National Recovery and Resilience Plan
PNRR	Piano Nazionale di Ripresa e Resilienza
PPP	Public-Private Partnership
PVAR	Panel Vector Autoregression Model
SAM	Social accounting matrix
SCC	Social cost of carbon
SDGs	Sustainable development goals
SEEA	System of Environmental Economic Accounting
SNA	United Nations' Systems of National Accounts
SVAR	Structural Vector Autoregression Model
USD	US dollars
USEPA	The US Environmental Protection Agency

ESSAYS ON INVESTMENTS IN GREEN PROJECTS AND DEVELOPMENT PARADIGM OF ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY

by

Darlington AGBONIFI

Executive Summary

This doctoral thesis is a collection of three empirical essays that develops an analytical framework to assess the impacts of demand-driven recovery investments, in local, regional, and multiregional economies in equilibrium. These recovery investments are part of a broader regional fiscal spending on many projects, including investment in urban development, environmental quality, industrial sites' rehabilitation, ports, healthcare, social inclusion and education, government systems, and various infrastructure initiatives aimed at stimulating economic growth in regions and cities affected by natural disasters and the economic slowdown caused by COVID-19 pandemic. The practical application of the developed framework is through case studies, including the Taranto Institutional Development Contract (CIS) strategic investment plan in the Apulia region of Southern Italy and the NextGenerationEU (NGEU) recovery investment projects in the Lombardy region of Northern Italy. The short-run objectives of the CIS and NGEU recovery plans for Europe in response to the Covid-pandemic crisis are consistent with the European Green Deal (EGD) long-term ambition of reducing greenhouse gas (GHG) emissions 55% by 2030 and climate neutrality by 2050 (EC, 2020; Bongardt et al. 2022). Specifically, the NGEU investment funds are dedicated to EU member states and broken down into six Missions, which represent the main thematic areas of policy interventions (Governo Italiano, 2021). These Missions include (M1) Digitalization, Competitiveness, and Culture; (M2) Green Revolution and Ecological Transitions; (M3) Infrastructure for Sustainable Mobility; (M4) Education and Research; (M5) Inclusive Cohesion; and (M6) Health.

The first chapter, titled "The dynamic approach of modelling regional recovery investment policies using environmentally-extended SAM Matrix", analyzes the socioeconomic and environmental dynamic impacts of CIS investments of around €1097 million for the 2021-2026 period on industrial outputs, household employment, and induced consumption patterns in the Italian province of Taranto.

I do this, using an environmentally extended social accounting matrix (ESAM) technique. The proposed method integrates impact evaluation, aimed at achieving climate neutrality in a local economy with a cost-benefit (CB) analysis of the project. My findings show that the dynamic impact on the local economy yields a benefit/cost ratio of 5.63. This ratio increases to 7.88 by integrating the CB analysis, and revenues generated during the operational period of the project. However, accounting for environmental externalities associated with industrial GHG emissions, reduces the benefit/cost ratio by approximately 16%, during the construction period of the project. The investments' distributional impact on households' annual income is deemed acceptably equitable.

The second chapter, titled "Impact techniques of modelling next-gen infrastructure investments projects to redress regional disparities using multi-regional input-output model", proposes an impact evaluation technique to estimates the socioeconomic impact of CIS regional investments on the labor markets (skilled and unskilled), private enterprises, and different categories of households. I do so by implementing a multi-regional input-output (MRIO) model with inter-regional trade in the Apulia region to estimate the intra-regional impact and at the national level to estimate the inter-regional spillover effects across Italy. My findings show that the intra-regional effects are almost two times the inter-regional effects. Almost 51% of the inter-regional impact on value-added accrues to Northern regions, 22% to the Central regions, while about 27% spills over to the regions in Southern Italy. This evidence clearly shows a good degree of connection between the Apulia local economy with the macro-regions of Northern Italy, while it is quite weak with the macro-regions in Southern Italy.

Finally, the third chapter, which is also my Job Market Paper (JMP) titled "Investments in green projects and value-added GDP: an environmentally integrated multiregional SAM approach", presents an integrated methodology to simultaneously estimate the socioeconomic and environmental impacts of NGEU regional investments of around €1981 million on labor markets, value-added, and household consumption. I construct a novel dataset and then implement an environmentally integrated multiregional social accounting matrix (EI-MRSAM) technique to analyze the impact of the regional investments within the Lombardy region, and across Italy. I find that Lombardy's intra-regional investment impact on value-added (GDP) share accounts for almost 78%, while 22% accrues to the rest of Italy in terms of interregional value-added spillover effects through trade channels. The total investment impact on both regional and national economies decreases by around 10% in terms of value-added after internalizing the environmental costs of climate change damages induced by industrial GHG emissions. In addition, I conduct a counterfactual macro-policy evaluation of an endogenous increase by 25% of the baseline NGEU investments to each of the thematic missions which represents the key thematic areas of the public policy interventions. I find that the return on investments in digital transformation[1] of the Italian public-administration is more efficient in terms of potential regional value-added growth compared to other counterfactual outcomes. The investment impact on household consumption expenditures and induced GHG emissions are also consistent with those of value-added.

1. The proposed interventions combine investments in new equipment and services to consolidate the existing digital infrastructure for the Italian public administration, fostering the update of cloud computing, cybersecurity and providing new digital competencies to civil servants as well as all citizens (Camera dei deputati, 2021).

1 Chapter

The Dynamic Approach of Modelling Regional Recovery Investment Policies Using Environmentally Extended SAM Matrix

Darlington AGBONIFI

Online version here

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Abstract

The aim of this paper is to analyze the socioeconomic and environmental impacts of public-financed increase in fiscal policy investments and modernization projects (CIS) of around €1097 million for the 2021-2026 period on industrial outputs, household employment, and induced consumption patterns in the Italian province of Taranto. I do so, using an environmentally extended Social Accounting Matrix (ESAM) techniques for the year 2015. The proposed method integrates impact evaluation, aimed at achieving climate neutrality in a local economy, with a cost-benefit (CB) analysis of the project. The evaluation of the dynamic impacts on the local economy yields a benefit/cost ratio of 5.63, which increase to 7.88 when considering the CB analysis of the project and the revenues generated during theoperational period. The inclusion of environmental externalities associated with industrial greenhouse gas (GHG) emissions reduces the benefit/cost ratio by about 16% in the construction period. In the operational period, assuming the adoption of green production technologies, the reduction of the ratio is more pronounced. Furthermore, the investments' distributional impact on the annual household income is deemed acceptably equitable.

Keywords: Policy impact evaluation, cost benefit analysis, fiscal multipliers, modernization projects, ESAM.
JEL classification: C67, D57, Q56, Q58, R11.

1.1 Introduction

Taranto is a provincial city with about 200,000 inhabitants, located in the Southern Apulia region (Puglia) of Italy. The city is home of the largest complete-cycle steel production facility (Gruppo ILVA) in Europe, with a capacity of about 10 million tons annually (Vagliasindi & Gerstetter, 2015; Neglia, Sangiorgi, Bordignon, & Marescotti, 2018). According to Lai et al. (2019), over the years, policy-making decisions by the Italian national authorities regarding the ILVA steel company, in the name of higher public interest, neglected not only the environmental and health risks of corporate unsustainable practices but also the relevant European Union (EU) legislation. Particularly, Taranto and the rest of the Apulia region's economic structure are mostly dependent, directly, or indirectly, on the steel supply value chain. The city has lacked a strategic sustainable development plan for more than two decades. The ILVA steel production facility, with a surface area of 15 million sq.m, still generates levels of pollution that worry not only Italian authorities, but also EU institutions (Vagliasindi et al., 2015; Neglia et al., 2018). As a result, the crisis that began in the late 1980s led to abrupt halt on the city's growth, significant job losses, and serious public health problems. Consequently, these negative trends have resulted in a gradual depopulation of residents and territorial abandonment in the region, as young people move north or abroad in pursuit of jobs.

The Taranto case study and the rest of the Apulia regional economic structural decline are reminiscent of the substantial heterogeneity and disparities in terms of production efficiency, living standards, and environmental quality across Italian regions (Istat, 2019). For example, the southern regions (Abruzzo, Basilicata, Calabria, Campania, and Apulia) are relatively poorer, and lag economically compared to the richer northern regions (Lombardy, Piemonte, and Veneto) where industrial production mainly takes place. This "North-South dualism" has persisted since the reunification of Italy in 1861, and its associated structural imbalances have been compounded by the outbreak and subsequent fallout of the COVID-19 global health pandemic (OECD, 2020; Svimez, 2020).

The main objective of this paper is to evaluate the socioeconomic and environmental dynamic impacts of public-financed increase in fiscal policy investments and modernization projects (CIS) on the Taranto local economy using an environmentally extended social accounting matrix (ESAM) approach. More specifically, how does an increase in regional fiscal spending on many projects, including investment in urban development, ports, environmental quality, healthcare, education, as well as various infrastructure initiatives affects industrial outputs, value-added (VA), equivalent to gross domestic product (GDP), employment, and induced consumption patterns of households in the

Italian province of Taranto? And what is the size the of the short-term fiscal spending multiplier? The ESAM method is highly micro-founded and contains information about households' income distribution, consumption, and savings, and three skill levels of the labor market related to each sector. At the same time, the proposed method also uses a novel technique that unifies the CB analysis of the investment project with the traditional impact evaluation technique (see, Scandizzo, 2021). This paper contributes to the literature that studies the impact of fiscal policy investments on value-added GDP growth (see, e.g., Christiano et al., 2011; Ilzetzki et al., 2013; Nakamura et al., 2014; Ghani et al., 2016; Baum-Snow et al., 2017; Aggarwal, 2018).

Italy's persistent regional disparities raise numerous questions as to the effectiveness and potential benefits of sustainable development strategies that target specific industries that do not incorporate environmental policy instruments. These strategies include tackling territorial structural imbalances not only at a national-regional levels but also at a local provincial level. Empirical studies show that well calibrated local, regional, and interregional policy-making interventions as well as exogenous investment shocks in key sectors can be a crucial engine for inclusive economic growth over the medium to long-term horizon (Mainar-Causapé et al., 2018), with both direct and indirect spillover effects on national economic agents. These agents include households, private enterprises, government as well as various industrial sectors and their interdependencies or linkages within the global value chains (GVCs).

To address the persistent structural decline that have continually undermined the economic base of Italy's southern regions, various public policies have been designed to enhance economic performance and increase regional resources. More broadly, the so-called Taranto Institutional Development Contract (Contratto Istituzionale di Sviluppo) CIS strategic investments is part of Italy's post-COVID recovery plan, including investments and reforms aimed at boosting the economy. In particular, the 2021-2026 "Taranto Coming Future" CIS investment plan of around €1,097Mln by the Apulia region represents a critical step towards achieving socioeconomic and environmentally sustainable path in Taranto.[2]

2. In effect, the European Commission (EC) identified Taranto province as facing serious short-and long-term socioeconomic challenges linked to the ambitious climate targets set by the European Green Deal (EGD) of reducing greenhouse gas (GHG) emissions 55% by 2030 and achieving climate neutral EU by 2050. In Italy, Taranto was earmarked for funding within the Just Transition Mechanism (JTM) by the EC due to its dependence on fossil fuels and greenhouse gas-intensive industrial processes. https://www.agenziacoesione.gov.it/just-transition-fund/?lang=en

The organization of the paper is as follows. Section 1.2 begins with a brief description of the CIS public investments on many projects of around €1097 million for the socioeconomic development and environmental restoration of the Taranto province. Section 1.3 presents the methodological framework for constructing local SAMs and techniques to be used to augment the SAM to host the CB analysis of the CIS Taranto strategic investment projects. Section 1.4 describes the structure and main features of the Taranto local economy in terms of consumption, income, savings, and taxes by income decile. Section 1.5 and Section 1.6 focuses on the socioeconomic and environmental impacts evaluation of the CIS investment plan on the Taranto local economy integrated with the CB analysis of the project, respectively. Finally, Section 1.7 concludes with key policy implications. The appendixes summarize other characteristics of the Taranto local economy, including the market-based GHG emission pricing measures utilized for the construction of Taranto ESAM for the reference year 2015.

1.2 The Main Objectives of the CIS Strategic Investments Plan

The CIS investment plan consist of public investments on many projects for the socioeconomic and environmental sustainability of the Taranto in the short to long-term. More broadly, the CIS short-run objectives for Taranto in response to the Covid-pandemic crisis is consistent with the EGD long-term ambition aimed at achieving climate neutrality by 2050 (EC, 2020; Bongardt et al. 2022). From a fiscal policy perspective, Taranto will experience a short-term impact from an exogenous investment shock totaling €1,700Mln. In particular, €1,100Mln will be sourced from the CIS, approximately €200Mln from industrial development contracts, and around €400Mln from the XX Mediterranean Games program. To assess the corresponding impact on the local economy, an appropriate economic modeling tool, such as a disaggregated SAM or a Computable General Equilibrium (CGE) model, will be utilized. This assessment will involve constructing specific expense vectors that simulate both the construction and operational phases, beginning with the identification of the relevant "producers" and "owners" sectors, based on the following assumptions. For the CIS, which finances a total investment amount of approximately €1,100Mln, the following documents were reviewed:

- The state of implementation by sector of intervention in 2018[3] indicates the planned expenditure amounts and the reported portions for each macro-category, totalling €1,007Mln (see, Appendix **Table A1.5.1.** Implementation Status of CIS Investment in Taranto).
- A preliminary form, which is still being completed, has been prepared by the Ministry of Cultural Heritage and Activities and Tourism (MIBACT). This form outlines the actions and investment priorities for urban regeneration interventions, in addition to the two interventions that have been concluded in the CIS. For these new interventions, an additional €90Mln will be allocated, focusing on the recovery of some historical and cultural sites as well as the neighbouring streets of the Old City (Città Vecchia) in Taranto.

Table 1 and **Table** *2* summarize the analytical presentation of the CIS investment plan into a final expense vector. This vector represents both the exogenous shocks applied to the local economy to evaluate the impact of the investment plan and the cost flow of the project, as traditionally modeled in project analysis.

[3]. The Governance of the CIS, supported by the related Mission Structure, had a setback in 2018, a critical issue that remains resolved due to the resumption of construction sites and accelerated pending. For these reasons it can probably be assumed that the actual progress is very similar to that recorded about two years ago.

Table 1. CIS Investment Plan Project List (€ Mln)

Instrument	Related sector	Projects	Project costs
CIS	Environment	Drainage Mar Piccolo	55.0
CIS	Environment	Platform riqualification	20.8
CIS	Environment	Ex Cemerad	10.0
CIS	Environment	Statte Aquifers	37.0
CIS	Environment	Environmental Centre	1.0
CIS	Environment	Waste water Ilva	14.0
CIS	Environment	Cimitery San Brunone	11.0
CIS	Environment	Restoration Statte Municipality	0.2
CIS	Environment	Water collection Crispiano	3.0
CIS	Environment	Environmental Riqualification Montemesola	3.0
CIS	Environment	Water collection Massafra	3.0
CIS	Environment	Environmental Riqualification Statte	3.0
CIS	Military Arsenal	Installations Military Arsenal	37.2
CIS	Military Arsenal	Enhancement Military Arsenal	5.7
CIS	Health	San Cataldo Hospital	207.5
CIS	Health	Medical equipments	70.0
CIS	Ports	Logistic plate Taranto	219.1
CIS	Ports	Riqualification Peer	75.0
CIS	Ports	Dredging	83.0
CIS	Ports	Taranto RFI Railroad	25.5
CIS	Ports	Foranea Dam	14.0
CIS	Education	Schools Riqualification	8.2
CIS	Education	School neighborhoods	1.2
CIS	Education	Risk Analysis of School Projects	0.1
CIS	Tourism and culture	Restoration Convento	5.1
CIS	Tourism and culture	Restoration Compendio	2.0
CIS	City Development	Soil remediation	2.0
CIS	City Development	Urban Forest	6.9
CIS	City Development	Carducci Palace	2.1
CIS	City Development	Residential construction	20.0
CIS	City Development	Restoration Via Garibaldi	2.1
CIS	City Development	Housing Sociale	15.2
CIS	City Development	Restoration Palazzo Troilo	3.6
CIS	City Development	Lungomare, Tamburi, sport facilities	40.0
CIS	MIBACT	Riqualification Città Vecchia	90.0
		Total	**1096.3**

Note: This breakdown details various CIS development initiatives aimed at upgrading local infrastructure, environmental quality, health services, education, cultural preservation, and city development within the Apulia regions, with a combined total fiscal policy investment of €1096.3 million.
Source: The Italian Development Agency (CIS Projects)

Table 2. Annual Project Costs by Sectors (€ Mln)

Industrial sectors	Construction year						Total
	1yr	2yr	3yr	4yr	5yr	6yr	
Agriculture	2	2	0	0	0	0	3
Manufacture of non-metal products	9	9	8	8	6	4	45
Manufacture of metal products	9	5	4	4	4	2	28
Computer and electronic products	14	5	5	5	5	4	38
Electrical equipment	26	6	5	5	4	2	48
Machinery & equipment	16	12	11	11	7	4	61
Other transport equipment	9	9	9	9	9	9	55
All utilities & waste	5	5	5	5	0	0	21
Construction	129	125	113	107	59	40	572
IT services	1	1	1	1	1	0	5
Business services	0	0	0	0	0	0	1
Rest of the world	73	37	34	34	26	16	220
Total	**292**	**217**	**196**	**190**	**121**	**80**	**1096**

Note: The table provided shows a breakdown of various projects under the CIS initiative, classified by related sectors and specifying their associated project costs.
Source: The Italian Development Agency (CIS Projects)

1.3 Methodological Framework

The fundamental purpose of a Social Accounting Matrix (SAM) is to document all the economic-wide series of transactions and transfers of income between different economic sectors and institutions (i.e., households, private enterprises, government, and the rest of the world) within a socio-economic system (national, regional, or sub-regional, etc.) during a specific period, usually for a year. Furthermore, SAMs represent the core economic-wide flexible and comprehensive database required for the calibration of parameters for a family of Computable General Equilibrium (CGE) models, including multiplier analysis (Scandizzo & Ferrarese, 2015).

It is important to specify that in recent decades several approaches have been used in the literature to evaluate the impact of changes in fiscal policies on value-added GDP growth and the overall economy. For example, Blanchard et al. (2002) and Ilzetzki et al. (2013) have studied the macroeconomic effects of fiscal stimuli using structural vector autoregression (SVAR) approach. More recently, Ianc et al. (2020) compared the size and effectiveness of both fiscal and tax multipliers for EU members and candidates using a panel vector autoregression (PVAR) model. On the other hand, Christiano et al. (2011) investigated the size of government spending multipliers using dynamic stochastic general equilibrium (DSGE) model. As noted by De Grauwe, (2010) and Warmedinger et al. (2015), on the one hand both VARs and DSGE-models are useful tools for policy evaluations. On the other hand, these models[4] are either prone to omitted variable bias or often require making arguable assumptions on the cognitive capabilities of individual agents with rational expectations theory.

As discussed below, the proposed ESAM analytical technique offers a level of detail able capture the existing structural interdependencies between sectors throughout the Taranto local economy compared to these other methods (Miller et al. 2009; Miernyk, 1965). Moreover, some of the limitations of Leontief input-output analytical framework include constant returns to scale (CRS) in production processes and the assumption that relative prices play no role in the allocation of resources between activities. Notably, CRS in production activities occur when an increase in inputs, like labor and capital is proportional to the increase in output (see, for example, Miller et al. 2009; Anguo et al., 2011). However, the assumption of constant technologies across all sectors is unrealistic in the context of modern economic system. In effect, the diffusion of digital technologies in production activities affects all sectors in the economy in varying degrees, with heterogeneities arising in terms of its adoption (Calvino, et al. 2018). Another drawback of the demand-driven Leontief static model is that it neglects the potential supply capacity constraints in the interaction between supply and demand across the economy (Galbusera & Giannopoulos, 2018). In particular, supply capacity constraints are important, especially in the labor and financial markets because relative market prices play a fundamental role in the allocation of scarce resources between activities. Therefore, increase production beyond potential supply can lead to displacement of production activities elsewhere, through price effects (EC, 2017).

1.3.1 The Taranto Social Accounting Matrix

The potential benefits of implementation a large-scale investment project with significant costs attract a high level of public attention due to the substantial direct and indirect impact on the local community and the environment (Donati, et al., 2020). Local SAMs are constructed using a top-down approach, starting from the national SAM, which is first consistently disaggregated at the regional level and then down to the provincial level. I now describe the design of the Taranto SAM, the data sources used, and the technique to be used to augment the SAM to host the cost-benefit analysis of the CIS Taranto

[4]. More studies on the applications of VAR estimation methods and DSGE models are Canova et al. (2013) and Warne (2023).

"large" project as well as the externalities due to the environmental impact. The names of the industrial sectors included in the provincial local SAM of Taranto for the reference year 2015 are illustrated in Appendix **A1**. The SAM includes data for 75 sectors, along with estimates of Taranto's international trade with the rest of the world. The labor employed in each sector is estimated according to its low, medium, and high skill components. Households' consumption, income and savings are disaggregated by deciles to account for the distributive impact of an exogenous shock (such as the CIS project).

1.3.2 The Basic Structure of the Local SAM for Taranto

From a double-entry accounting framework, SAM is a square matrix that extends the Leontief Input-Output (I-O) model, with an identical sequence of accounts in both horizontal rows and vertical columns. The rows represent flows of goods and factors, while the columns represent the flows of payments (Robinson, Cattaneo, & El-Said, 2001). Let T be a square matrix of SAM transactions over a given period, where each nonzero elements or cell, denoted by t_{ij} represents an expenditure or outflow in monetary terms by column account $j = 1,2, \dots . n$ and an income or inflow to row account $i = 1,2, \dots . n$. In accordance with accounting balance, the total revenues (row totals) and total expenditures (column totals) must be equal, represented as y_i for a generic account i, where $y_i = \sum_{i=1}^{n} t_{ij} = \sum_{j=1}^{n} t_{ji}$. A SAM coefficient matrix, **A**, can be derived from **T** by dividing the entries in each column of **T** by the corresponding column sums, denoted by a_{ij}, where $a_{i,j} = t_{ij}/y_j$.

A SAM constructed in this manner serves as a snapshot, illustrating the comprehensive circular flow of income distributions and consumption expenditure characteristic a market economy in equilibrium (Leontief, 1991; Stahmer, 2004; Breisinger et al., 2009). In this case, it provides a summary of the key structural features of the Taranto economy.

Figure 1 below presents the augmented macro-version of the local SAM for Taranto illustrated in Appendix **Table A1.** The Industrial-sectoral Classification of Taranto Provincial Economy**.** The SAM includes aggregated accounts for activities, factors of production, ten household groups, three skills levels for the labor market of each sector, private enterprises, government, capital formation, investment projects, environmental externalities, and Taranto's international trade flows with the rest of the World. The Taranto SAM is augmented by a column and a row devoted to the cost (or the exogenous shock) and the return stream of the project, respectively. The matrix is also augmented for the environmental accounts specific to each pollutant. The matrix augmentation technique is explained in subsection (1.3.4). The SAM accounts are generally grouped into endogenous and exogenous variables (Civardi & Lenti, 2006). Endogenous accounts (i.e., factors, institutions, activities) are determined by the economic model. On the other hand, exogenous variables (policy instrument) are determined outside the model.

Figure 1. SAM Augmented with Project and Environment Accounts

		Activity	Value added			Institutions			Direct taxation	Capital formation	Export	Investment Project	Environmental externalities	Total
		55 sectors	Labor (low, med,high skill)	Capital	Indirect taxation	Household income decile	Enterprises	Government	Taxes	Capital formation	Rest of the world			
Activity	55 sectors	Intermediate Consumption				Consumption		Consumption		Investments	Export to the rest of the world			Demand
Value added	Labor (low, med, high skill)	Wages												Gross domestic product
	Capital	Mixed income												
	Indirect taxation	Taxes												
Institutions	Household income decile		Labor income	Other income		Transfer	Capital income	Income from pensions, subsidies, contributions		Negative savings	Income from abroad			Institution incomes
	Enterprises							Contributions, subsidies		Negative savings				
	Government				Tax transfer				Tax transfer	Negative savings	Transfer form abroad			
Direct taxation	Taxes					Taxes	Taxes							Direct taxation
Capital formation	Capital formation					Savings	Savings	Savings			Capital from abroad			Saving
Import	Rest of the world	Imports from the rest of the world				Consumption								Import
Investment Project														
Environmental externalities														
Total		Supply	Factor outlays			Institution expenditures			Direct taxation	Investments	Export			

Source: Author's own elaboration.

1.3.3 Data sources for the Local Taranto SAM

The basic standards used globally for constructing SAMs adheres to reflect the United Nations guidelines called the Systems of National Accounts (SNA). In practice the classification of accounts and the degree of disaggregation can show considerable differences across countries, research, and policy applications, depending not only on the objectives and research questions under study, but also on the availability and quality of data sources (Mainar-Causapé et al., 2018). For example, macro-SAMs can be constructed, using data drawn from a country's national accounts, firms and household income surveys, government budgets and balance of payments, etc.

On the other hand, the disaggregated micro-SAMs can be obtained by using the data in the macro-SAMs accounts as control totals. The pressing challenges for constructing and updating consistent SAMs for recent years involves finding ways to incorporate fragmented or missing datasets from different sources, and fixing statistical inconsistencies related to the timing and adjustment of the I-O tables (Robinson et al., 2001). Balancing SAMs accounts to achieve broad consistency results under the equality constraints between incomes and expenditures include various mathematical and statistical techniques, which may themselves yield heterogenous or different SAMs.

1.3.4 The Augmented Local SAM for Project Analysis

The idea proposed by Scandizzo (2021) of integrating of a project accounting framework in a SAM, amounts to adding a project column of cash outflows and a project row of cash inflows. This technique is based on the intuitive interpretation of a project's cost and revenue streams as a column and row vector that can be used to augment a SAM defined in the absence of the project. By analogy, SAM production activities can be reinterpreted as sets of projects, that may consist in acquiring investment goods (in the case of the capital formation sector) or intermediate inputs, including capital user charges for the other sectors. Depending on its time profile, the project may generate net costs or net benefits in the various rounds of the calculation, but typically it is associated with net costs in the so-called construction period (T=0) and net benefits in the operational period (T=1). While the cost-benefit approach is in general a partial equilibrium analysis, impact evaluation roots on a general equilibrium set of interdependent effects.

For a project with sufficiently positive returns, the operational period is characterized by project inflows that become larger than outflows, so that returns can be assigned to capital or institutions such as governments or households. The project's contribution in both the construction and operation periods can be exhaustively described in terms of value-added formation and costs and benefits. Net returns are typically interpreted as capital costs and credited to the column thus ensuring accounting balance.

Under the assumptions of the Leontief IO model, the dynamic impact of a vector of investment expenditure shock can be consistently embedded in a specific row and column of a SAM beyond the construction period. As illustrated in **Figure 1** above, augmented SAM-based models can be applied for both impact evaluation and the cost-benefit analysis of investment projects, including their environmental footprint such as carbon emissions during the construction and operational periods

(Stone, 1952; Stahmer, 2004; Scandizzo, 2021). As illustrated by Scandizzo (2021), I can express the variation of endogenous variables, $\Delta\mathbf{X}_e = X_{ec} - X_{es}$, where the subscripts are with (ec) and, without (es) the project, by considering three different shocks in the model: (i) the SAM submatrix for the endogenous accounts with $\boldsymbol{A}_{ee,c}$ and without $\boldsymbol{A}_{ee,s}$ the project, (ii) the variation $\Delta\boldsymbol{A}_{ee}$ of the $\boldsymbol{A}_{ee}$ matrix as a consequence of the project, and (iii) the variation of exogenous SAM accounts induced by the project $\Delta\mathbf{X}_x = X_{xc} - X_{xs}$:

$$\Delta\mathbf{X}_e = (\mathbf{I} - \boldsymbol{A}_{ee,c})^{-1}[\boldsymbol{A}_{ex,c.}\Delta\mathbf{X}_x + (\Delta\boldsymbol{A}_{ee})X_{es} + (\,\Delta\boldsymbol{A}_{ex})X_{xs}\,] \tag{1.1}$$

The subscripts include (xc) and (xs), which are the exogenous vectors of activity levels with and without the project, while (ee, c) and (ee, s) are the endogenous accounts with and without the project, respectively. Equation (1.1) can be decomposed in three components: (i) the autonomous variation of the exogenous variables (capital formation, exports, or a specific vector of project expenditures); (ii) the variation of the SAM coefficient submatrix of the transactions within the endogenous accounts; and (iii) the variation of the SAM submatrix of the transactions between the endogenous and the exogenous accounts. Intuitively, the exogenous activities increase aggregate demand through the value chains quantified in the SAM, but may also introduce technological change via a change of the coefficient submatrix obtined after rebalancing the initial SAM after the shock. Therefore, the corresponding present value at rate of discount *r* of project impact can be directly derived as:

$$\sum_{t=0}^{T} \frac{\Delta\mathbf{X}_{et}}{(\mathbf{1}+\mathbf{r})^{t}} = (\mathbf{I} - \boldsymbol{A}_{ee.})^{-1} \sum_{t=0}^{T} \frac{1}{(\mathbf{1}+\mathbf{r})^{t}} [\boldsymbol{A}_{ex,t+1}\Delta\mathbf{X}_{xt} + (\Delta\boldsymbol{A}_{ee})X_{est} + (\Delta\boldsymbol{A}_{ex,t})X_{xt}\,] \tag{1.2}$$

Equation (1.2) allows the estimation of the present value of project impact using a single SAM and its variations, considering the direct and indirect effects on the present values of the project cash flows. In turn these effects are defined as the sum of two components: (i) the yearly project outlays given a specific structure of the interdependencies between the project and the rest of the economy, and (ii) the annual variations in the same outlays due to changes in the interdependencies brought about by the changes of project outlays over time (see, Scandizzo 2021).

1.3.5 The Augmented Local SAM for Environmental Analysis

As a further extension of the Leontief input-output (I/O) model, the Local SAM can be augmented with the environmental accounts (see, **Figure 1**) to take into consideration sectorial emissions within the economic system of Taranto (Tukker et al., 2006). In other words, the total direct and indirect pollutant emissions (m_i) of sector i implied in satisfying a specific amount of final demand during a specified period (i.e., a year) can be represented as:

$$\begin{aligned} \mathbf{m} &= \mathbf{e}(\mathbf{I}-\mathbf{A})^{-1}\,\mathbf{f} \\ \mathbf{m} &= \mathbf{eLf}, \end{aligned} \tag{1.3}$$

where $\mathbf{e}$ is a $q \times m$ coefficient matrix representing the quantity of pollutants (i.e., in metric tons of CO_2) emitted to produce one unit of sector i monetary output of each industry (Tukker, Huppes, van Oers, & Heijungs, 2006). **A** denotes the technological $n \times n$ square matrix, while $(\mathbf{I}-\mathbf{A})^{-1} = \mathbf{L} = [l_{ij}]$ is the Leontief inverse matrix, and **f** is the $n \times 1$ column vector of exogenous final demands. A detailed description of the method is illustrated in Appendix **A1.4.** The Construction of Taranto Environmentally Extended SAM 2015

1.4 Data: Features of the Taranto Economy and the CIS Project

This Section describes some of the most relevant characteristics and the structure of the Taranto local economy in terms of consumption, income, savings, and taxes by income decile.

1.4.1 Consumption, Income, Savings, and Taxes by Income Decile

As illustrated in **Table 3** below, SAM household accounts have been divided into income deciles to better understand the relations linking income, consumption, intra-family transfers, and direct taxation. The subdivision into deciles derives from regional elaborations performed using the dataset from the Survey on the Income and Living Conditions of Italian families (EUSILC) by ISTAT. Consumption was imputed based on expenditure deciles, again referencing the annual survey of EUSILC microdata of about 26,000 households, which was matched with the Household Budget Survey, generating an Integrated Standard of Living Survey of Italian Households. This matched information allows us to construct highly reliable data on savings and to conduct an accurate distributive analysis of the shocks of interest and the associated fiscal burdens on the income deciles. Taxation was estimated as a proportion of taxation and income for each decile of Apulian households. Income from work was divided according to the educational level of the recipient - low (up to middle school), medium (high school), and high (from graduation) - attributing the level of education by sector and by earner based on regional data from the roster of active companies (ASIA) of ISTAT.

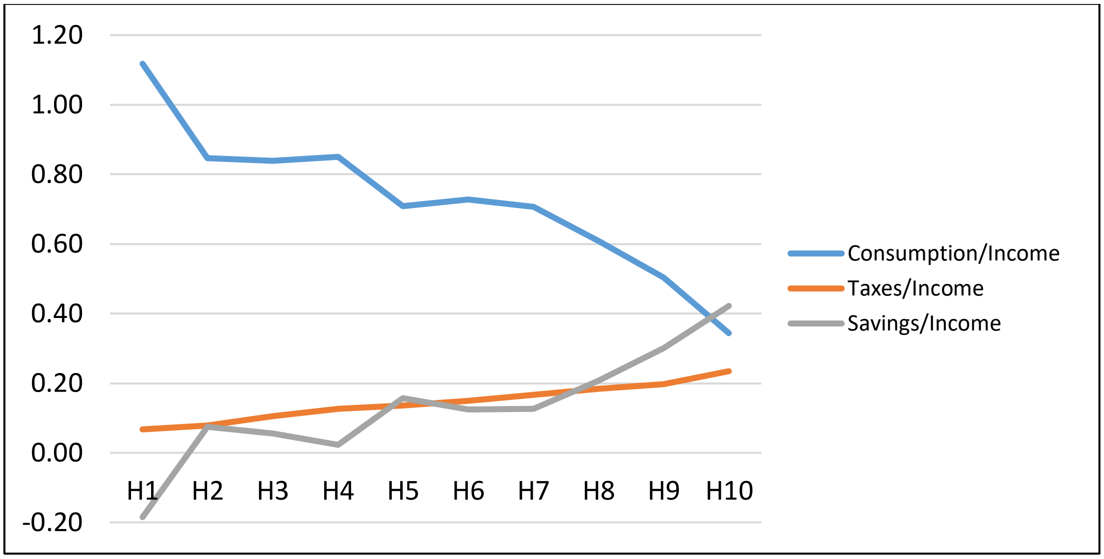
Table 3. Main Budgetary Aggregates of the Taranto Families (€ Mln)

Budgetary Aggregates	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**	**Total**
Dep. Labor Income (low skill)	35	59	78	98	117	140	171	213	282	487	1679
Dep. Labor Income (med. skill)	39	66	87	110	131	157	192	239	316	547	1884
Dep. Labor Income (high skill)	18	31	41	52	62	74	90	113	149	258	888
Other incomes	156	282	359	380	411	433	426	562	658	1155	4823
Total Incomes	248	439	565	639	719	804	880	1128	1405	2447	9273
Transfer (in and out)	1	2	3	4	4	5	5	6	8	12	50
Consumption	278	371	474	543	509	585	622	687	707	841	5617
Direct Taxes	17	35	60	81	98	119	147	208	276	574	1614
Total Expenditures	294	406	534	624	607	705	769	895	983	1414	7232
Savings	-46	33	31	15	113	99	111	233	422	1032	2042

Note: The abbreviations H1 to H10 denote household accounts grouped into income deciles, facilitating a deeper analysis of the relationships among income, consumption, intra-family transfers, and direct taxation.
Source: Author's elaborations based on data from ISTAT regarding the living conditions of Italian families (EUSILC)

About half of the income is derived from employee earnings, while the other half comes from capital income, payments from companies, and social welfare sources (such as pensions and subsidies). Income from employment is distributed as follows: 38% to recipients with a low level of education, 42% to those with a medium level, and 20% to individuals with a tertiary degree or higher. Direct taxation represents approximately 7% of the income of the poorest families and increase to 24% for families in the 10th income decile. Consumption expenditure amounts to 112% of the income for families in the first decile and 34% for those in the highest decile (see **Figures 2** and **3** below). The propensity to save is negative for the poorest families but reaches 42% of income for the wealthiest families.

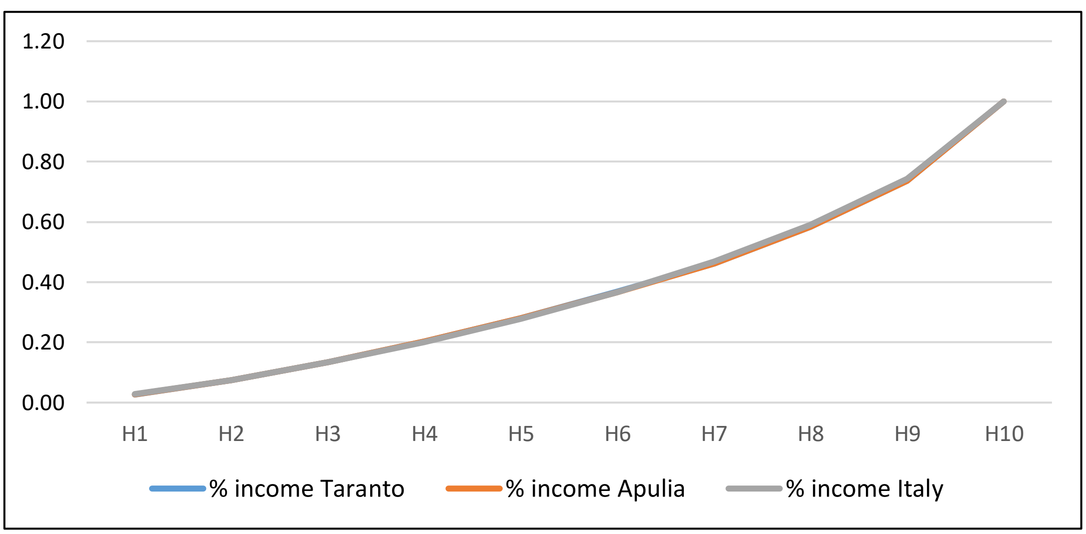
Figure 2. Household Consumption, Taxes, and Savings by Income Decile



Source: Author's elaborations based on ISTAT data regarding EUSILC

The Lorenz curves represent a comparison of income distribution in the Taranto province, Apulia region, and Italy. These curves highlight the inequality in income distribution within each of these economies as illustrated below:

Figure 3. Lorenz Curves



Source: Author's elaborations based on ISTAT data regarding EUSILC

The ex-ante investment Gini index for the province of Taranto (0.362) is lower than that of the Apulia region (0.363) but higher than the national average (0.359) in Italy. This indicates that the level of income inequality in Taranto is on average comparable to both the regional and national levels.

1.4.2 Multiplier Analysis

The industry output multiplier represents the total output produced by all industries across the local economy (under the assumptions of Leontief's model) when a unit of product in the subject industry is made available for consumption in final demand (Miller et al., 2009). The output multipliers are the column-wide sums of elements in the Leontief inverse matrix. From an intersectoral linkages perspective, I can derive the backward (BL) and forward (FL) linkages, aiming to identify the importance of individual sectors that are economically significant to the economy of Taranto (Khondker, 2018).

Table 4 below shows the multiplier effects in terms of output, value-added and household induced consumption for the local economy of Taranto. The three sectors with the highest output multiplier are Energy, associative organizations, and social assistance, over 4.5 points, followed by construction, 4.42, steel and metal, 2.84. It is important to specify that these production multipliers are very high because they record gross output effects, and thus should be interpreted as indicators of the speed of diffusion of the economic impact of CIS investments rather than the final effect, which is measured correctly only by the value-added multipliers. More specifically, the size of the short-term fiscal spending multiplier, defined here as the ratio of value-added GDP increase to the initial exogenous change in government investment spending in the construction period (Pusch & Rannenberg, 2011; Dodzin & Bai, 2016; Ianc & Turcu, 2020).

For example, in the construction period (T=0), the CIS investment of €701.08Mln generates an overall impact on output of €3946Mln, in terms of inter-sectoral purchases from intermediate suppliers (€2705Mln), of which €954Mln is derived from the direct effect, €1751Mln from the indirect effect, and €1241Mln of value-added GDP. The induced effect on potential household spending from earnings of direct and indirect expenditures is about €1078Mln (see, **Table 6**). Here, the CIS investment impact on value-added GDP (€1241Mln) is the difference between and industry's total output and the costs of its intermediate inputs. It is measured as factor incomes earned (labor and capital) and the costs of production (business taxes) estimated by industry (BEA, 2006; Arto, et al., 2020). As indicated by project performance indicators in **Table *7*** and **Table *15***, the size of the short-term fiscal spending multiplier is between 1.57 and 1.77. Notably, the size of fiscal policy response can be higher during economic crisis (COVID-19 pandemic) compared to normal times (Warmedinger, Checherita-Westphal, & Hernández de Cos, 2015). In the European context, Pusch et al. (2011) find comparably high fiscal multipliers ranging from 1.4 and 1.8 for specific spending categories for EU countries using input-output approach.

Table 4. Taranto Economic Multipliers by Selected Sectors

Sectors	Output	Direct	Indirect	Value-Added	Households
Energy	4.73	1.71	3.02	1.75	1.49
Associative organizations	4.57	1.02	3.55	2.10	1.84
Social Assistance	4.50	1.09	3.41	2.18	1.93
Water supply	4.46	1.38	3.07	1.93	1.67
Construction	4.42	1.51	2.91	2.15	1.85
Entertainment	4.40	1.25	3.15	1.99	1.68
Travel agency services	4.27	1.02	3.25	1.59	1.36
Sports and Entertainment	4.26	1.06	3.19	2.04	1.74
Security services	4.25	1.14	3.11	2.01	1.77
Accomm&Restaurants	4.25	1.12	3.13	2.02	1.72
Furniture Manufacturing	3.24	1.12	2.12	1.28	1.11
Rental and leasing activities	3.20	1.01	2.19	1.83	1.49
Textile industry	3.15	1.33	1.82	1.17	1.00
Manufacturing of petroleum products	3.12	1.24	1.88	0.87	0.72
Rubber Manufacturing	3.00	1.09	1.92	1.01	0.87
Steel and metal (Metallurgy)	2.84	1.07	1.77	1.42	1.34
Manufacturing of paper products	2.78	1.10	1.68	0.84	0.72
Chemical manufacturing	1.82	1.09	0.73	0.40	0.34
Manufacturing of electronic products	1.81	1.03	0.78	0.45	0.39
Mining	1.28	1.01	0.27	0.18	0.15

Note: The table presents production multiplier, decomposed into direct and indirect multipliers, along with value-added (GDP) and the induced effects on households' consumption for the main sectors of the economy of Taranto.
Source: Author's calculations based on the data from Taranto's SAM

1.5 Cost-Benefit and Impact Analysis of CIS Investment Projects

This Section focuses on the socio-economic and environmental impact evaluation, followed by the CB analysis of the Taranto CIS investment project. The results, obtained using the methodological framework explained in Section (**1.3**), are presented first for the impact evaluation and secondly for the cost-benefit analysis, which includes the impact evaluation.

1.5.1 The Socio-Economic Impact Evaluation

In order to obtain a feasible column vector of exogenous shock to the micro-based disaggregated local SAM, the CIS investment of €1096Mln as reported in Section (**1.2**) was reduced by €220Mln for products / services from the rest of the world outside the Apulia region, resulting in €876Mln of net investment. In general, supply is not able to respond perfectly elastically to changes in demand, as supply capacity is limited by the existing local resources. Some resources may be provided by adjacent provinces of the Apulia region. For example, increasing demand for steel exports from Taranto may not lead to increased mining production of limestone material if additional limestone deposits do not exist in Taranto or if the necessary extra investments in mining equipment have not been made. Moreover, increasing production in some sectors may lead to falling production in others if some resources are scarce. Therefore, to acknowledge such supply constraints and avoid overstating the impacts of linkage effects, I further apply a coefficient of 0.8[5] to the net investment of all sectors to isolate the impact on the province of Taranto alone, thus generating an exogenous shock of €701Mln distributed across the productive sectors, as shown in **Table 5**. The shock corresponds to the column vector of project costs in the construction period (T=0).

Table 5. Vector of CIS Investment Allocated to Key Sectors in Taranto

Ref. #	Sectors	CIS inv (€ Mln)	Share (%)
21.	Construction	457.52	65.26
14.	Manufacture of computer, electronic and optical products	69.28	9.88
15.	Manufacture of machinery and equipment	48.58	6.93
17.	Manufacture of furniture; other manufacturing	43.83	6.25
12.	Manufacture of basic metals	35.77	5.10
13.	Manufacture of metal products, except machinery and equipment	22.28	3.18
20.	Water collection, treatment, and supply	16.68	2.38
32.	Software computer consulting and related activities	4.16	0.59
1.	Agriculture, fisheries, forestry	2.47	0.35
37.	Legal and accounting activities of head office; management consulting	0.44	0.06
10.	Manufacture of rubber and plastic products	0.08	0.01
Total		**701.08**	**100**

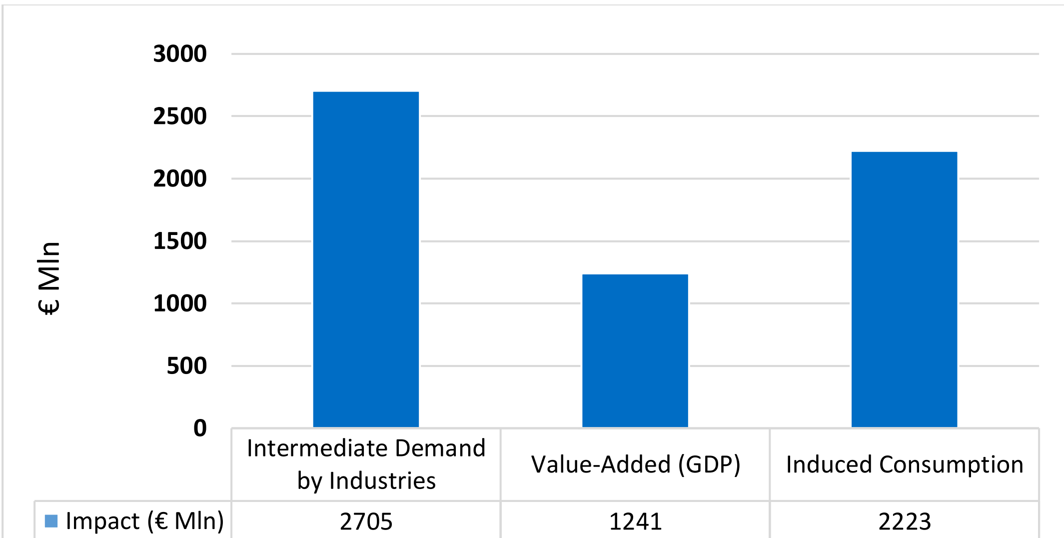
Note: The CIS investment allocation is mainly concentrated in the construction sector, which receives 65.26% to the total. The remaining sectors receive comparatively smaller shares, with a notable focus on technology and manufacturing, but much less attention given to sectors like agriculture, legal services, and rubber/plastic products.
Source: Author's elaborations based on the CIS Investment Plan Project List

As shown in **Figure 4**, the total impact on economic output generated is approximately €3946Mln, distributed as 69% in intermediate inputs (€2,705Mln), and 31% in added-value GDP (€1,241Mln). The induced impact on institutional consumption (household, government, and enterprises) is about €2,223Mln distributed as 48% on household consumption (€1078Mln), and 34% on government

[5]. The choice of the factor 0.8 to account for supply anelasticities is aimed at staying within the actual Just Transition Fund (JTF) investments earmarked for Taranto (€795.6Mln) by the European Commission (EC).

(€754Mln), and 18% on enterprises (€391Mln). The associated total impacts to cost ratio is 5.63 (€3,946Mln / €701.08Mln). This impact only accounts for the direct and indirect effects generated by the project on the local economy and does not include the revenues generated by the project during the operational period as will be shown in section (**1.5.2**).

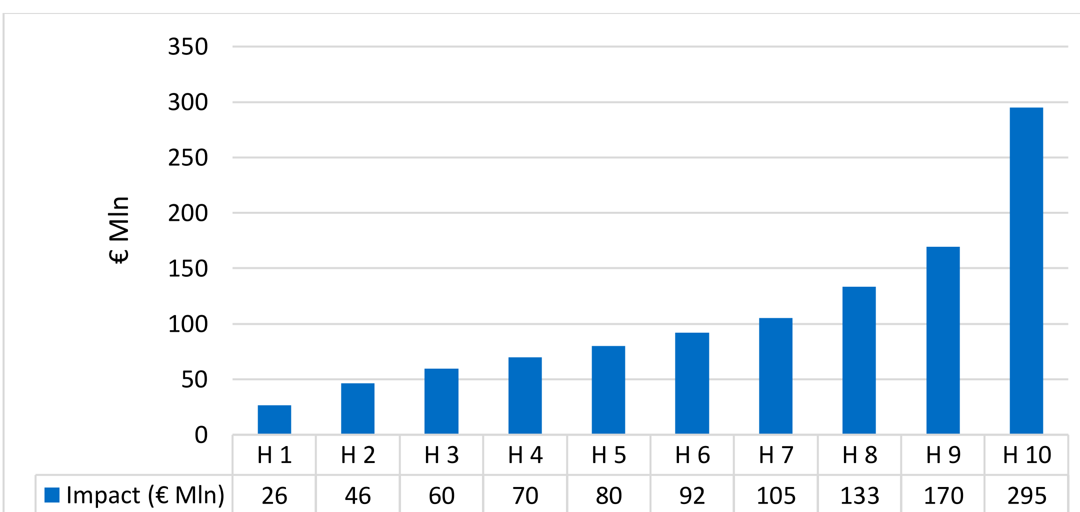
Figure 4. Impact of CIS Investment on the Economy of Taranto (€ Mln)



Source: Author's elaborations based on Taranto's SAM.

Figure 5, provides estimates on the impact of CIS investment on household induced consumption along the income distribution. The induced consumption of households in the highest decile are more than ten times compared to the poorest households in the lowest decile.

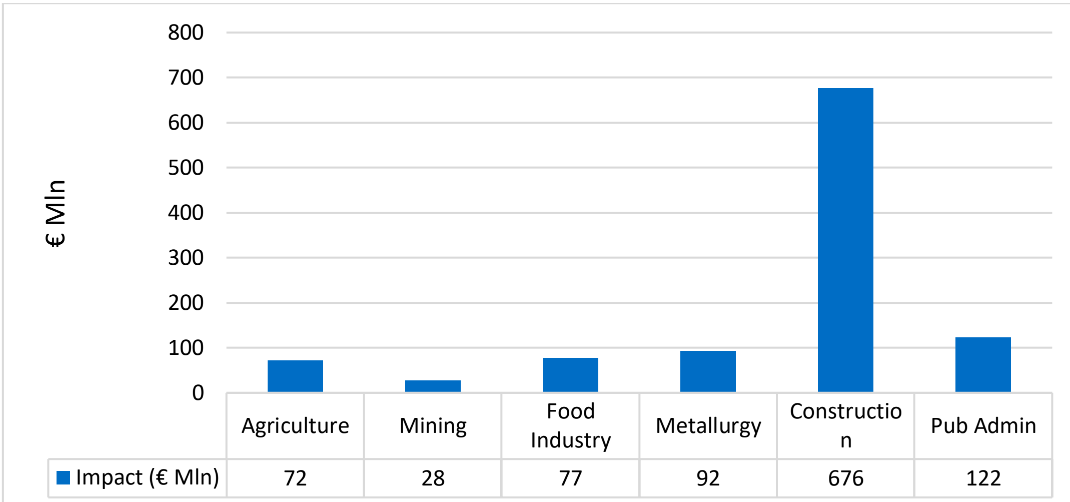
Figure 5. Impact of CIS Investment on Household Consumption by Income Decile (€ Mln)



Source: Author's elaborations based on Taranto's SAM.

The construction sector is the most responsive sector (see **Figure 6**), accounting for 25% of the total impact in terms of economic output. Public Administration generates an impact of €122Mln, while metallurgy and food industries generate an impact of about €77Mln and €90Mln, respectively. The agriculture sector follows with a contribution of €72Mln.

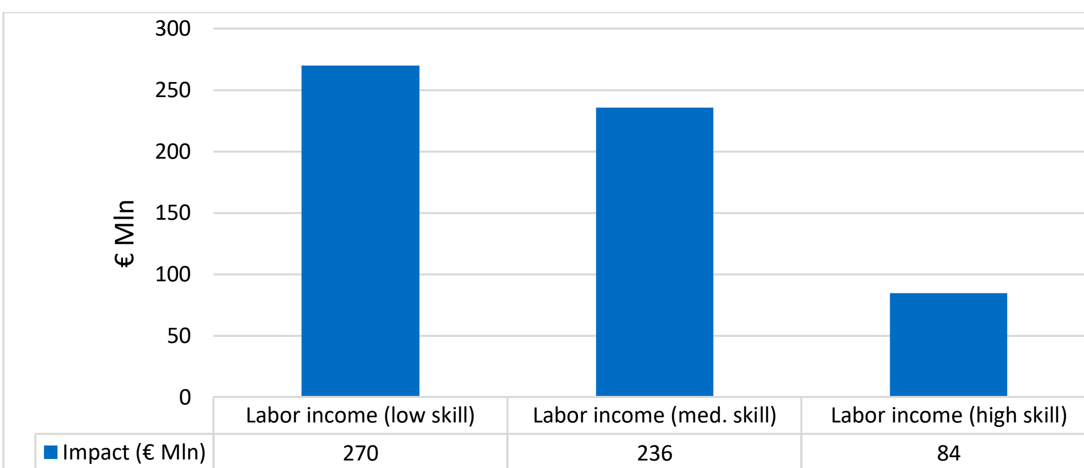
Figure 6. Impact of CIS Investment on Inter-Industry Demand in Taranto (€ Mln)



Source: Author's elaborations based on Taranto's SAM.

As shown in **Figure 7** below, the total impact on labor incomes approaches €300Mln, mainly benefiting employees with lower levels of education. This is due to the structure of the labor market within the construction sector, which employs low-skilled labor, accounting for almost 60% of its workforce. Consequently, majority of the investment is concentrated in this segment.

Figure 7. Impact of CIS Investment on Labor Incomes by Skill Levels (€ Mln)



Source: Author's elaborations based on Taranto's SAM.

1.5.2 The Socio-Economic Impact and Cost-Benefit Evaluation

Table 6 shown below, presents the values of the main SAM accounts impacted by the project, while **Table 7** compares outcome variables with project costs. Multiplier estimates for Net National Product (NNP), accounting for value-added, and depreciation charges are around 1.0 for the construction period and around 1.05 for the operational period, incorporating both costs and net revenues from the project. The total impacts-cost ratio based on the discounted values accrued to the project at the end of the operational period is 7.88. This ratio reflects both the impact evaluation and the project's cost benefits analysis, including activities, value-added, and household income. This compares consistently with similar ratio associated with only the impact on the local economy of 5.63 during the construction period.

Table 6. Total Project Impacts (€ Mln)

Sector	Construction period (T=0)	Operational period (T=1)	Present values at (4%) discount rate
Intermediate Consumption	**2704.54**	**4186.51**	**6730.03**
Direct effects	*953.75*	*278.46*	**-**
Indirect effects on other sectors	*1750.79*	*3908.05*	**-**
Value-added	**1241.16**	**3543.09**	**4647.98**
Income (Low))	*270.10*	*641.82*	-
Income (Mid)	*235.65*	*714.40*	-
Income (High)	*84.41*	*328.61*	-
Capital Income	*508.11*	*1446.05*	-
Indirect Taxes	*142.89*	*412.21*	-
Total Impact (Benefit)	**3945.69**	**7729.61**	**11378.01**
Impact on Institutions	**2223.07**	**5701.20**	**7705.00**
Households	*1077.75*	*2784.42*	-
Government	*754.24*	*1931.02*	-
Enterprises	*391.09*	*985.76*	-

Note: The Institutional account evaluate the impact of CIS Taranto' strategic investment on the income of households, government, and enterprises. For households, total income includes factor income distribution, inter-household transfers, corporate income distribution, government transfers, and transfers from the rest of the world (RoW). For enterprises, total income includes factor income distribution, government transfers, and transfers from the RoW.

Source: Author's calculations based on Taranto's SAM.

Table 7. Project Performance Indicators

Indicators	Construction period (T=0)	Operational period (T=1)	Present values at (4%) discount rate
Project Costs	**701.08**	**981.52**	**1644.85**
Project depreciation rate	1.00	1.05	**-**
Value-Added (VA) increase	1241.16	3543.09	4647.98
Net National Product (NNP) increase	1179.10	3365.94	4415.58
VA/Investment Ratio	**1.77**	**3.61**	**3.47**
NNP/Cost Ratio	1.68	3.43	3.30
Total Impact/Cost (B/C) Ratio	**5.63**	**7.88**	**7.57**

Note: this table shows the project's performance indicators of the CIS Taranto investment at the local level, over its construction (T=0) and operational (T=1) periods. The present-value at 4% benchmark discount rate shows total project's impact in terms of value-added of €4,647.98Mln. CIS project's performance ratios include the VA/Investment Ratio, NNP/Cost Ratio, and Benefit-Cost Ratio with substantial improvements from construction to operational phases, indicating its economic viability. The short-term fiscal spending multiplier in the construction period (T=1) is equal to 1.7.

Source: Author's calculations based on Taranto's SAM.

In order to validate the findings presented in **Table 6**, I employ discounted cash flow (DCF) analysis to assess both the intrinsic value-added capacity (or profitability) and the internal rate of return (IRR) of the CIS investment project. As detailed in **Table 8**, the project is anticipated to generate no revenue during its construction phase. The total investment capital outlay of €701.08Mln, spread over six years, is accounted for as an augmented column activity in the Taranto local SAM. From a SAM perspective, these expenses are fully financed through the capital formation account and contribute to increased value-added through indirect effects by mobilizing unemployed resources.

Table 8. CIS Investment Project: Discounted Cash Flow (DCF) Analysis

	CONSTRUCTION PERIOD (T=0)						**OPERATIONAL PERIOD (T=1)**													
Years	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Investment capital outflows	187	139	125	122	77	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual operating costs	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Operating revenues	0	0	0	0	0	0	203	203	203	203	203	203	203	203	203	203	203	203	203	203
Net cashflows (*)	**-187**	**-139**	**-125**	**-122**	**-77**	**-51**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**	**183**
Cumulative cashflows	**-187**	**-326**	**-451**	**-573**	**-650**	**-701**	**-519**	**-336**	**-153**	**30**	**212**	**395**	**578**	**760**	**943**	**1126**	**1309**	**1491**	**1674**	**1857**

Benchmark discount rate	**4%**
NPV (€ Mln)	**€ 1229**
Internal rate of return (IRR)	**24.89 %**

Note: The CIS Taranto project's cumulative cash flows over the 20-year period generates a positive return on investment, with a Net Project Value (NPV) of €1,229Mln, given the benchmark discount interest rate of 4%. The IRR is 24.89%, above the discount rate, this implies that the project is expected to generate returns higher than its cost of capital.

Source: Author's calculations based on Taranto's SAM.

During the operational period (T=1), the CIS project account includes the projected total operating costs of €280.42Mln, and total revenues of €2,838.79Mln. The projections assume constant monetary values within Leontief fixed-coefficient systems, with both costs and revenues distributed annually at a rate of 7% over a fourteen-year period. These revenues are normally generated from various stakeholders, including households, and government, and partly supported by the NGEU Fund. The difference between the CIS project's annual operating revenues and costs contributes to the net cash flow outlays. As illustrated in **Table 8** above, the NPV of the CIS project, at a discounted interest rate of 4%, is €1,229Mln. The IRR required to break-even is 24.89%, thereby affirming the potential economic viability of the project.

1.6 The Environmental Impact Evaluation

The environmental impact assessment focuses on the Taranto province, quantifying emissions of carbon dioxide (CO2), methane (CH4), nitric oxide (N2O), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), ammonia (NH3), and particulate matter (PM2.5 and PM10) from various sectors within Taranto. The methodology employed is elaborated in Section **1.3.5** and the Appendix. In this regard, the European Climate Law[6] sets a legally binding intermediate target of reducing economy-wide net GHG emissions by at least 55% by 2030, compared to 1990 levels in the context of the EGD.

In recent decades, the EU established the European Emission Trading System (ETS) as a market-based environmental policy instrument (EU, 2021). The EU ETS is a carbon pricing mechanism, whereby regulated sectors covered by the ETS need to purchase an emissions allowance for each ton of CO_2-equivalent they inject into the environment (Verbruggen, Laes, & Woerdman, 2019; Basaglia, Grunau, & Drupp, 2024). Moreover, a major concern of the EU-ETS is carbon leakage[7] or more broadly, the so-called "pollution heaven and race to the bottom" hypothesis, whereby companies (i.e., in the EU) can relocate their emission-intensive industries, such as steel and cement industries to poorer countries with lower environmental standards through increase in foreign direct investment (FDI) (Poelhekke &

[6] See, for example, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119

[7] In July 2021, the European Commission proposed the Carbon Border Adjustment Mechanism (CBAM) rules to address the issue of carbon leakage (Bellora & Fontagné, 2023).

Ploeg, 2015; Aichele & Felbermayr, 2015). Notably, the iron and steel plant in Taranto is one of the largest sources of CO2 emissions in Europe regulated by the EU ETS. In effect, according to a recent conservative estimate by the European Commission, the plant emits 4,700,000 tons of CO2 annually. When accounting for emissions from the two thermoelectric plants integrated into the iron and steel production cycle, this estimate increase to 10,688,650 tons per year (Vagliasindi et al., 2015).

Moreover, as noted by Basaglia et al. (2024), the EU ETS does not directly regulate local pollutants, such as PM2.5 and sulphur dioxide (SO_2). Consequently, the residents in Taranto faces higher health risks compared to residents of the average Italian city. This increased risk is attributed to the presence of polycyclic aromatic hydrocarbons, benzo(a)pyrene, dioxins, and metals, all of which have high persistence and costly abatement processes, including other harmful particulates such as PM2.5 and PM10 that exceed permissible thresholds. **Table 9** below, provides the national benchmark technological coefficients used to convert Taranto's industrial production levels, measured in €Mln per sector, into their corresponding GHG emissions, expressed in metric tons.

Table 9. National Pollution Technology by Selected Sectors

Pollution Coefficients	CO2 (tons/€Mln)	CH4 (tons/€Mln)	N2O (tons/€Mln)	CO (tons/€Mln)	NMVOC (tons/€Mln)	NH3 (tons/€Mln)	Pm5 (tons/€Mln)	Pm10 (tons/€Mln)
Energy	1003.36	1.95	0.01	0.27	0.29	0.05	0.01	0.01
Manufacture of Mineral Products	676.53	0.02	0.04	0.46	0.06	0.02	0.19	0.24
Manufacture of coke & petrol products	255.55	0.20	0.01	0.21	0.21	0.00	0.01	0.01
Transportation	244.61	0.01	0.01	0.33	0.08	0.00	0.18	0.19
Water Management	180.44	15.11	0.18	0.20	0.85	0.22	0.03	0.03
Paper Manufacture	172.03	0.02	0.00	0.00	0.05	0.00	0.01	0.02
Metallurgy	161.00	0.06	0.00	1.54	0.15	0.00	0.06	0.08
Agriculture	122.36	10.64	0.51	1.48	1.97	4.86	0.16	0.40
Mining	88.70	0.40	0.01	0.14	0.06	0.00	0.01	0.01
Press Activities	32.21	0.00	0.00	0.02	1.22	0.00	0.00	0.00
Social Assistance	31.77	0.00	0.00	0.04	0.01	0.00	0.00	0.00
Storage	31.09	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Food Industry	28.30	0.19	0.00	0.01	0.18	0.00	0.00	0.00
Construction	25.99	0.00	0.00	0.03	0.32	0.00	0.01	0.02
Computer Repair	24.07	0.00	0.00	0.04	0.51	0.00	0.00	0.01

Note: The pollution coefficients refer to carbon dioxide (CO_2), methane (CH_4), nitrous oxide N_2O), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), ammoniac (NH_3) and particulate matter PM2.5 and PM10 emissions in metric tons produced by each industrial sector per unit of output (€Mln) in Taranto using the national technical coefficients.
Source: Author's calculations based on Taranto's ESAM.

However, there is especially high production of GHGs emissions by specific industrial activities in Taranto compared to the national average. This is due to the obsolete technology of iron and steel production based on blast furnaces, which have not yet been upgraded to modern electric arc or hydrogen-based furnaces. According to Vagliasindi et al. (2015), the ILVA steel production facility emitted 7.4 million tons of C02 in 2024. Implementing technological upgrades could drastically reduce CO2 and particulate matters. Furthermore, the Taranto steel plant faces delays in adopting renewable energy sources, and in using natural gas as reductant.

For example, evidence gathered from the American Iron and Steel Institute, the World Steel Association, and published independent research by Hasanbeigi and Springer (2019), shows that the American steel industry has reduced its CO2 emissions per ton of steel shipped by 37% since 1990. In the US, electrical furnaces are adopted in about 70% of steel production plants, compared to about 30% in the rest of the world. The US Environmental Protection Agency (EPA) data indicate that the production of iron, steel and metallurgical coke in the U.S accounts for less than 1% of national CO2 emissions, compared to nearly 7% of global CO2 emissions from steel production.

To address the technological backwardness of the Taranto iron and steel plant with high production of pollutants, I adjusted the estimates reported in **Table 9**. Specifically, I increased the technical coefficients associated with pollutant production in the energy; manufacturing; non-metal minerals; petrol and coke; transportation; and metallurgy sectors; by a factor of 2.3 as illustrated in **Table 10**.

Table 10. Pollutant Technologies in Selected Sectors Specific to Taranto (T=0)

Pollutant technology for industrial sectors in Taranto at (T=0)								
Pollution Coefficients	**CO2 (tons)**	**CH4 (tons)**	**N2O (tons)**	**CO (tons)**	**NMVOC (tons)**	**NH3 (tons)**	**Pm5 (tons)**	**Pm10 (tons)**
Energy	2307.72	4.48	0.03	0.61	0.68	0.12	0.01	0.03
Manufacture of Non-Metal Minerals	1556.02	0.06	0.09	1.06	0.13	0.06	0.45	0.55
Manufacture of coke & petrol products	587.76	0.46	0.02	0.48	0.48	0.01	0.02	0.03
Transportation	562.61	0.02	0.02	0.77	0.18	0.00	0.41	0.43
Metallurgy	370.30	0.13	0.01	3.54	0.34	0.00	0.15	0.19

Pollutant technology for industrial sectors in Taranto at (T=1)								
Energy	802.69	1.56	0.01	0.21	0.24	0.04	0.00	0.01
Manufacture of Non-Metal Minerals	541.22	0.02	0.03	0.37	0.05	0.02	0.16	0.19
Manufacture of coke & petrol products	204.44	0.16	0.01	0.17	0.17	0.00	0.01	0.01
Transportation	195.69	0.01	0.01	0.27	0.06	0.00	0.14	0.15
Metallurgy	128.80	0.05	0.00	1.23	0.12	0.00	0.05	0.07

Note: The pollution coefficients refer to carbon dioxide (CO_2), methane (CH_4), nitrous oxide N_2O), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), ammoniac (NH_3) and particulate matter PM2.5 and PM10 emissions in metric tons produced by each industrial sector per unit of output (€Mln) in Taranto both at the construction and operational period.
Source: Author's calculations based on Taranto's ESAM.

At the end of the construction period (T=0), I assume that the private partner will adopt environmentally friendly blast furnaces during the operational period (T=1) due to an appropriate incentive scheme designed as part of the formal Public-Private Partnership (PPP) established for implementing the CIS investment Plan at the local level. Consequently, the private partner will be able to reduce the average level of pollutants per unit of production to 0.8 (see **Table 10**).

The results of the transformation are presented for the construction period (T=0) and the regime period (T=1) in **Table 11** for CO2 and **Table 12** for PM10. Both tables also show the relative levels computed for each sector compared to the smallest level of pollutant production. The tables also report the before and after CIS investment predicted differences, summarized in **Figure 8** for the selected CO2 and PM10 pollutants. The planned investments induce a technological change that, if the incentives are correct, should be more environmentally friendly, thus reducing emissions of pollutants. The regime levels of pollutants have been computed by reassessing the ex-post matrix of technological coefficients conditional on the implementation of the CIS project. This is obtained by balancing the project-augmented matrix of the Taranto economy.

Table 11. Comparison of CO2 Production Levels by selected Sectors Before and After the CIS Implementation, Including Predicted Differences

Main sectors	$CO2_0$	Proportion wrt smallest (T_0)	$CO2_1$	Proportion wrt smallest (T_1)	% Diff CO2
Energy	4608.59	107.51	3437.02	34.45	-25.42
Transportation	1119.11	26.11	809.47	8.11	-27.67
Metallurgy	1035.27	24.15	216.31	2.17	-79.11
Manufacture of Non-Metal Minerals	965.75	22.53	303.22	3.04	-68.60
Manufacture of coke and petrol products	908.66	21.20	705.99	7.08	-22.30
Construction	533.27	12.44	239.47	2.40	-55.09
Water Management	352.98	8.23	452.22	4.53	28.11
Agriculture	264.47	6.17	609.34	6.11	130.40
Mining	72.90	1.70	167.36	1.68	129.56
Food Industry	65.31	1.52	158.45	1.59	142.61
Wholesale	58.26	1.36	119.96	1.20	105.90
Retail	56.03	1.31	127.94	1.28	128.33
Health services	53.36	1.24	125.33	1.26	134.86
Accomm&Restaurants	45.68	1.07	99.76	1.00	118.38
Public administration	42.87	1.00	102.45	1.03	138.99

Note: This table shows the relative variations in CO2 emissions across industrial sectors before and after Local CIS investment projects. The Energy sector had the highest CO2 emissions with a corresponding reduction of 25.42%. Metallurgy and Non-Metal Minerals experienced drastic decreases of 79.11% and 68.60%, respectively.

Source: Author's calculations based on Taranto's ESAM.

Table 12. Comparison of PM10 Levels by Sectors Before ($PM10_0$) and After ($PM10_1$) CIS Implementation, Including Predicted Differences

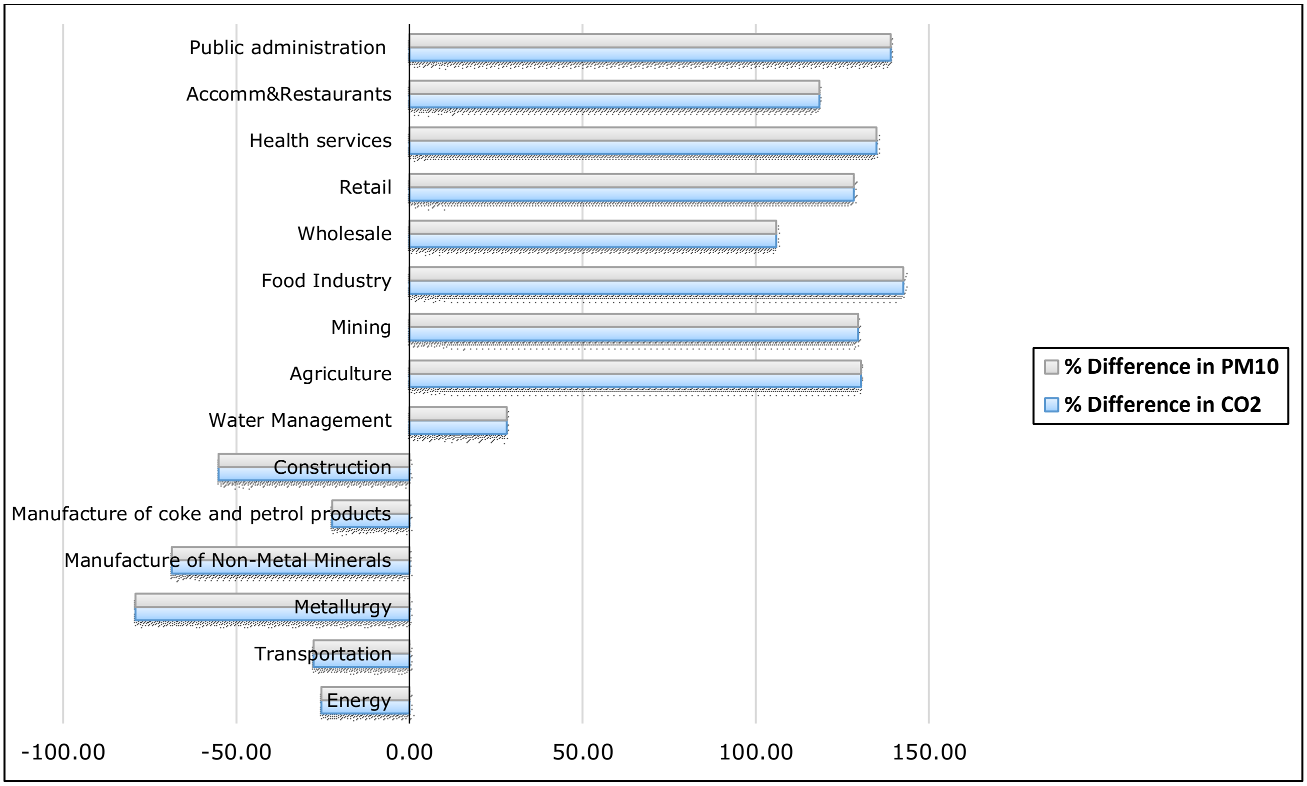
Major Sectors	$PM10_0$	Proportion wrt smallest T_0	$PM10_1$	Proportion wrt smallest T_1	% Diff PM10
Energy	0.05	37.94	0.04	12.05	-25.42
Transportation	0.85	616.99	0.61	190.02	-27.67
Metallurgy	0.54	389.99	0.11	34.69	-79.11
Manufacture of Non-Metal Minerals	0.34	249.23	0.11	33.32	-68.60
Manufacture of coke and petrol products	0.05	35.82	0.04	11.85	-22.30
Construction	0.32	233.48	0.14	44.64	-55.09
Water Management	0.06	41.81	0.07	22.80	28.11
Agriculture	0.87	633.38	2.01	621.35	130.40
Mining	0.01	5.09	0.02	4.97	129.56
Food Industry	0.00	2.82	0.01	2.91	142.61
Wholesale	0.01	8.85	0.03	7.76	105.90
Retail	0.01	8.82	0.03	8.57	128.33
Health services	0.00	1.00	0.00	1.00	134.86
Accomm&Restaurants	0.00	1.45	0.00	1.35	118.38
Public administration	0.01	8.12	0.03	8.27	138.99

Note: This table shows the relative variations in PM10 emissions across industrial sectors before and after Local CIS investment projects. There had been a decrease in PM10 levels in Taranto's traditional sectors like Metallurgy, and Non-Metallic Minerals, while Agriculture, Food Industry, and Health Services have seen dramatic increase.
Source: Author's calculations based on Taranto's ESAM.

As an example, the decline in NMVOC emissions since 1990 has primarily been due to reductions achieved in the road transport sector. This decline has been driven by the introduction of vehicle catalytic converters and carbon canisters, for evaporative emission control, tighter vehicle emission standards, combined with limits on the maximum volatility of petrol that can be sold in EU Member States, as established in fuel quality directives.

As shown in **Table 11**, the energy, transportation, metallurgy, manufacture of non-metal products, manufacture of coke and petroleum products, and construction sectors are major producers of CO2. Collectively, these sectors account for 97.8% of all CO2 production in Taranto. In relative terms, the energy sector produces 107.5 times the amount of CO2 compared to public administration, which produces the smallest quantity of CO2 per unit of product. This relative level decreases to about 34.4 after the implementation of the CIS plan, resulting in post-implementation CO2 production by the energy sector amounting to less than 25.42% of the pre-implementation level. Interestingly, thanks to the adoption of more environmentally sustainable technology, total CO2 levels show a slight reduction despite increased production levels in the main CO2-producing sectors (see **Figure 8**).

Figure 8. Comparison of industrial CO2 and PM10 pollution levels pre-and post-implementation of the CIS projects



Source: Author's elaborations based on Taranto's ESAM.

The same set of sectors (energy, transportation, metallurgy, manufacture of non-metal products, and manufacture of coke and petroleum products) accounts for 98.44% of the total PM10 production, as shown in **Table 12**. In particular, the transportation sector is among the highest producers of PM10 per unit of output in the ex-ante period, with emissions 616.99 times greater than those of the health service sector. In the ex-post scenario, the highest producers of PM10 are agriculture, construction, energy, manufacture of non-metal products, and metallurgy, all of which show a significant increase in particulate matter emissions; see **Figure 8**.

1.6.1 The Environmental Impact and Cost-Benefit Evaluation

The study conducted by Matthey et al. (2018) for the German Environmental Agency, which focuses on the methodological convention for assessing environmental costs, recommends using a cost rate of 180 euros per ton of carbon dioxide. The social cost rates for CO2 and other pollutants, shown in **Table 13**, are determined primarily using the damage costs approach, which estimates the level of damages incurred by society due to GHG emissions (see TSD, 2016).

Table 13. Social Costs per Metric Ton of Pollutant

	CO2 (tons)	CH4 (tons)	N2O (tons)	CO (tons)	NMVOC (tons)	NH3 (tons)	Pm2.5 (tons)	Pm10 (tons)
Price (€) per metric ton of pollutant	180	837	10881	180	58400	32000	58400	41200

Note: Using the damage costs approach incurred by society (see Matthey et al. 2018), this table illustrates the environmental costs per metric ton of various pollutants in Taranto. The prices for pollutants like methane (CH_4) and nitrous oxide (N_2O) are notably expensive, with cost of €837 and €10,881 per metric ton, respectively. Local pollutants like non-methane volatile organic compounds (NMVOC) and particulate matter (PM2.5), with costs of €58,400 per metric ton for each. Particulate matter (PM10) with a diameter of 10 micrometers is priced at €41,200 per metric ton. Ammoniac (NH_3) is priced at €32,000, reflecting a mid-range environmental cost, while carbon dioxide (CO_2) and carbon monoxide (CO) relatively less costly, at €180 per metric ton.

Source: Matthey et al. (2018); TSD (2016).

In is important to specify that due to the additional costs incurred by the local enterprises, the overall project impact and performance indicators, including the environmental factors are reduced. This reduction is evident from the comparison of **Table 6** and**Table** *7*, which include environmental impact, with **Table 14** and **Table** ***15***, which do not.

Table 14. Total Project Impact, Including the Environment

Sector	Construction period (T=0)	Operational period (T=1)	Present values at (4%) discount rate
Intermediate Consumption	**2681.12**	**4150.19**	**6671.99**
Direct effects	*952.56*	*277.91*	-
Indirect effects on other sectors	*1728.57*	*3872.28*	-
Value-Added	**1227.99**	**3523.12**	**4615.61**
Income (Low)	*267.50*	*637.90*	-
Income (Mid)	*233.20*	*710.84*	-
Income (High)	*83.44*	*327.23*	-
Capital Income	*502.41*	*1437.05*	-
Indirect Taxes	*141.44*	*410.10*	-
Total impacts (Benefit)	**3909.11**	**7673.32**	**11287.30**
Impact on Institutions	**2199.29**	**5,668.63**	**7649.89**
Households	*1066.39*	*2768.97*	-
Government	*746.19*	*1920.04*	-
Enterprises	*386.70*	*979.62*	-

Note: Institution measures the impact of CIS Taranto's strategic investment on the income of households, government, and enterprises. For households, total income includes factor income distribution, inter-household transfers, corporate income distribution, government transfers, and transfers from the rest of the world (RoW). For enterprises, total income includes factor income distribution, government transfers, and transfers from the RoW.
Source: Author's calculations based on Taranto's ESAM.

During the construction period (T=0), the total project impact of the CIS investment is comparatively smaller when environmental impacts are considered compared to a scenario where they are not. Furthermore, there is a slight welfare loss associated with reductions in household income, value-added, and activity levels. In the operational phase (T=1), if the private owner of the iron and steel plant invests in environmentally friendly technologies that reduce pollution coefficients from 2.3 times the national average to 0.8 times the national level (a reduction of approximately two-thirds), a modest increase in welfare of about 1% is observed, accompanied by increases in both value-added and activity levels.

Table 15. Project Performance Indicators, Including the Environment

Indicators	Construction period (T=0)	Operational period (T=1)	Present values at (4%) discount rate
Project Costs	**701.08**	**981.52**	**1644.84**
Environmental Social Costs	81.55	116.26	193.34
Project depreciation rate	1.00	1.05	-
Value-added increase	1227.99	3523.12	4615.61
Net National Product (NNP) increase	1166.59	3346.97	4384.83
Project Total Impacts	3909.11	7673.32	11287.30
VA/Investment Ratio	1.75	3.59	3.45
VA/Investment Ratio (with Environmental Costs)	**1.57**	**3.21**	**3.09**
NNP-Cost Ratio	1.66	3.41	3.28
Benefit-Cost (B/C) - with Environmental Costs)	**4.99**	**6.99**	**6.72**

Note: this table shows the project's performance indicators of the CIS Taranto investment at the local level, over its construction (T=0) and operational (T=1) periods. The present-value at 4% benchmark discount rate shows total project impact in terms of value-added of €4,615.61Mln. CIS project's performance ratios include the VA-Cost Ratio, VA/Investment Ratio (with environmental costs), NNP-Cost Ratio, and Benefit-Cost Ratio with substantial improvements from construction to operational phases, indicating its economic viability after internalizing environmental and social costs. The short-term fiscal spending multiplier adjusted by environmental costs in the construction period (T=1) is equal to 1.57.

Source: Author's calculations based on Taranto's ESAM

However, the price of CO2 quoted by the EU ETS at the beginning of September 2021 is about €62 per ton, almost twice compared to the level of the beginning of the year of about €30 per ton. I therefore ran a simulation assuming prices of €30, €80 and €180 per metric ton. The results regarding the impact on the cost/benefit analysis of CO2 emissions are illustrated below in **Table 16**.

Table 16. CIS Investment: Impact Sensitivity Analysis of CO_2 prices (€/Metric Ton)

Sector	Construction period (T=0)	Operational period (T=1)	Present values at (4%) discount rate
Project Costs (€ Mln)	**701.08**	**981.52**	**1644.85**
Environmental social costs (€30)	107.26	88.49	192.35
Project Total Impact (€ Mln)	3909.88	7,659.18	11274.47
Benefit-Cost Ratio	4.84	7.16	**6.14**
Environmental Social Costs €80	270.67	231.75	493.51
Project Total Impact (€ Mln)	3817.12	7,604.94	11129.57
Benefit-Cost Ratio	3.93	6.27	**5.20**
Environmental Social Costs (€180)	548.02	503.29	1031.96
Project Total Impact (€ Mln)	3646.83	7,500.05	10858.42
Benefit-Cost Ratio	2.92	5.05	**4.06**

Note: This table illustrates the CIS project sensitivity analysis in terms of economic viability under three different scenarios (€30, €80, and €180 environmental social costs for CO2 emissions), with 4% discount rate. The benefit-cost (B/C) ratios for the scenarios with €30, €80, and €180 in social costs per metric ton of CO2 emissions are 6.14, 5.20, and 4.06, respectively. This indicates that while the CIS project remains viable across all scenarios, higher environmental social costs reduce the overall B/C ratio.
Source: Author's calculations based on Taranto's ESAM

The estimated discounted benefits to costs ratios are 6.14, 5.20, and 4.06, respectively. These ratios, which correspond to different cost rate per metric tons of CO_2 should be compared with the scenario that excludes consideration of environmental impact, which achieves a discounted benefit cost ratio of 7.57, as illustrated in **Table 7**.

1.7 Concluding Remarks and Policy Implications

This purpose of this study was to analyze the socioeconomic and environmental dynamic impacts of CIS investment project of around €1097Mln implemented in the Taranto province during the period 2021-2026, as part of Italy's national plan for the restart and stimulate the economy. The evaluation of the short-term impact on the local economy produces a B/C ratio of 5.63, which increase to 7.88 when the CB analysis of the project, including revenues generated during the operational period (T=1). The impact of the project appears to be extensive and bolstering the local economy both through the steel value chain and the broader connections of the local economy industrial and service base. The distributive impact on households' income is moderately inequitable and highly dependent on the present structure of the local economy. The inclusion of environmental externalities in the economic evaluation reduces the B/C ratio by about 16% during the construction period.

From a policy perspective, it is fundamental to determine where to allocate scarce resources in order to maximize the socioeconomic and environmental benefits to the local economy of Taranto. In this regard, transitioning to more environmentally sustainable technologies, despite the increase in production levels of the main CO2-producing sectors, shows a slight reduction in total CO2 levels. However, the real impact depends crucially on the price of GHG emissions, public investment, and private incentives to adopt lower-emission and abatement technologies.

As discussed above, some of the limitations of input-output analytical framework include constant returns to scale in production processes and the assumption that relative prices play no role in the allocation of resources between activities. In addition, the lack of supply-side constraints assumes that supply cannot respond perfectly elastically to changes in demand as supply capacity is limited by the existing labor, capital, and other productive inputs. Furthermore, the impact of an investment project at a regional or provincial level is location-specific and cannot be fully understood unless interregional relationships are studied. Further research is needed to measure interregional relationships and determine to what extent the reduction in the incidence of pollution-related pathologies during the operation period (T=1) effectively improves the environmental quality and health status of the Taranto inhabitants.

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Appendix A1

Table A1. The Industrial-sectoral Classification of Taranto Provincial Economy

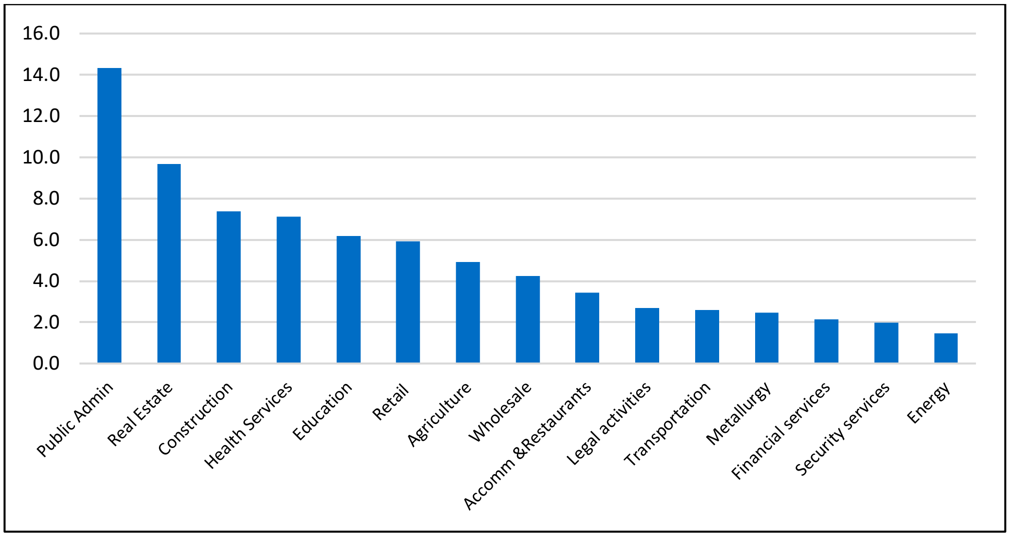
Ref.	Sectors for the Taranto Local SAM	Ref.	Sectors for the Taranto Local SAM
1.	Agriculture, fisheries, forestry	39.	Scientific research and development
2.	Mining and quarrying	40.	Advertising and market research
3.	Food, drink and tobacco industries	41.	Other professional, scientific and technical activities; veterinary services
4.	Textile industry, manufacture of wearing apparel and leather goods	42.	Rental and leasing activities
5.	Manufacture of wood and of products of wood and cork, except furniture	43.	Personnel recruitment, selection and supply activities
6.	Manufacture of paper and paper products	44.	Travel agency service activities
7.	Printing and reproduction of recorded media	45.	Investigation and security services
8.	Manufacture of coke and refined petroleum products	46.	Public administration and defence; compulsory social security
9.	Manufacture of chemicals and chemical products	47.	Education
10.	Manufacture of rubber and plastic products	48.	Human health activities
11.	Manufacture of other non-metallic mineral products	49.	Social work activities
12.	Manufacture of basic metals	50.	Creative, arts and entertainment activities
13.	Manufacture of fabricated metal products, except machinery and equipment	51.	Sporting, entertainment and recreational activities
14.	Manufacture of computer, electronic and optical products	52.	Activities of membership organizations
15	Manufacture of machinery and equipment n.e.c.	53.	Repair of computers and goods for personal and home use
16	Manufacture of motor vehicles, trailers and semi-trailers	54.	Other personal service activities
17.	Manufacture of furniture; other manufacturing	55.	Activities of households as employers of domestic staff
18.	Repair and installation of machinery and equipment	56.	Income from employee work (low)
19.	Electricity, gas, steam and air conditioning supply	57.	Income from employee work (mid)
20.	Water collection, treatment and supply	58.	Income from employee work (high)
21.	Construction	59.	Capital
22.	Wholesale and retail trade and repair of motor vehicles and motorbikes	60.	Indirect taxes
23.	Wholesale trade, except of motor vehicles and motorbikes	61.	Households_1st_decil
24.	Retail trade, except of motor vehicles and motorbikes	62.	Household_2nd_decil
25.	Land transport and transport via pipelines	63.	Household_3rd_decil
26.	Warehousing and support activities for transportation	64.	Household_4th_decil
27.	Postal and courier activities	65.	Household_5th_decil
28.	Accommodation; food service activities	66.	Household_6th_decil
29.	Publishing activities	67.	Households_7th_decil
30.	TV production, films, videos and music publishing activities	68.	Households_8th_decil
31.	Telecommunications	69.	Household_9th_decil
32.	Computer programming, consultancy and related activities; information service	70.	Households_10th_decil

	33.	Financial service activities (except insurance and pension funding)	71.	Public Admin	
	34.	Insurance, reinsurance and pension funding, except compulsory social security	72.	Direct taxes	
	35	Activities auxiliary to financial services and insurance activities	73.	Enterprises	
	36.	Real estate activities	74.	Capital formation	
	37.	Legal and accounting activities; activities of head offices; management consulting	75.	Imports rest of the world	
	38.	Architectural and engineering activities			

A1.1 Increase in Value Added at Factor Costs

As illustrated in **Figure A1.1.** Sectoral Shares of VA (%), the Taranto's economy value-added is mostly made up of service sectors compared to good-producing sectors. Public administration and defense account for about 14% of the value-added, real estate at 9.7%, health services at 7.1%; educational services and retail trade each comprising 6.2% and 5.9%, respectively.

Figure A1.1. Sectoral Shares of VA (%)

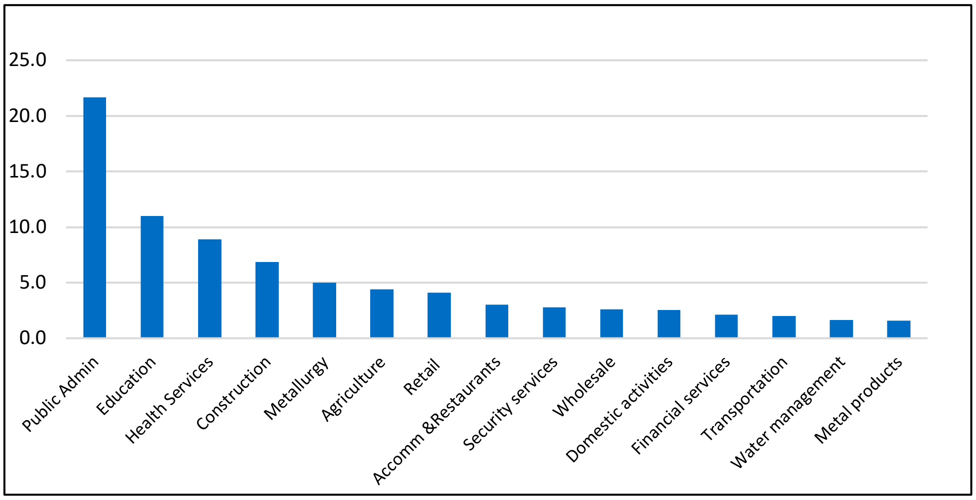


Source: Author's elaborations based on Taranto's SAM.

A1.2 Labor Market Value-Added Distribution

Labor contributes approximately 48.4% to the formation of provincial added-value. Within this, 22% represents salaries of personnel employed in public sectors such as administration and defense, with 11% in education and 9% in health care services. Among private productive sectors, construction and metallurgy contribute approximately 7% and 5%, respectively, to the value-added by labor, followed by agriculture at 4.4% (see **Figure A1.2.** Labor Value Added Shares).

Figure A1.2. Labor Value Added Shares (%)

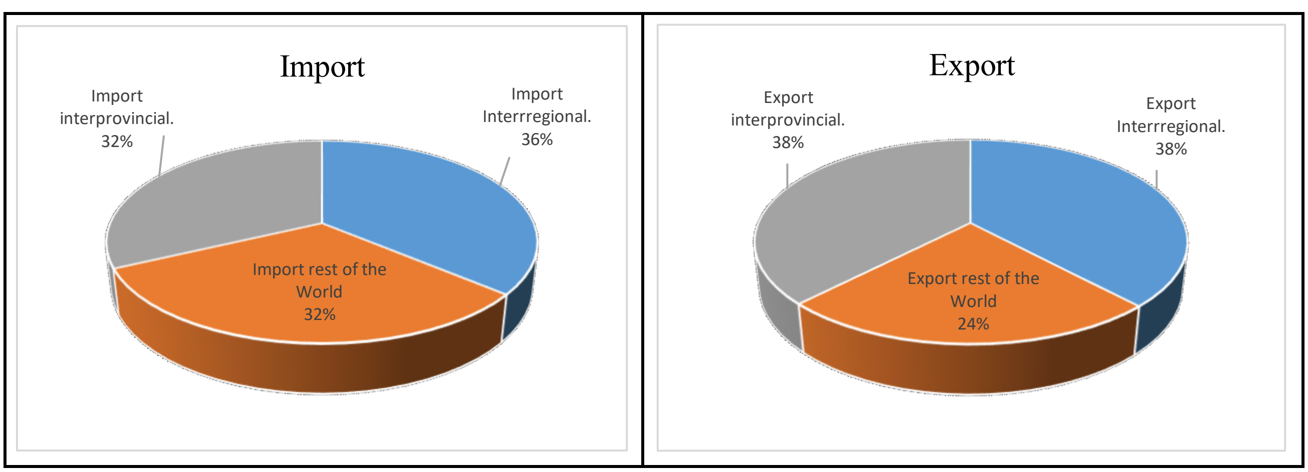


Source: Author's elaborations based on Taranto's SAM.

A1.3 Imports and Exports Shares

Imports and exports refer to goods and services exchanged among other Apulian provinces, Italian regions and with the rest of the world. As shown in **Figure A1.3.1** Imports and Exports by Interprovincial, Interregional, and International Sources the province of Taranto imports about €7,677.34Mln of products and services from outside, 36% from the rest of Italy, 32% from the other Apulian provinces, and 32% from abroad. The metallurgy and production of coke and petroleum derivatives sectors account for about 16% of total local imports. Exports amount to approximately €6443.44Mln.

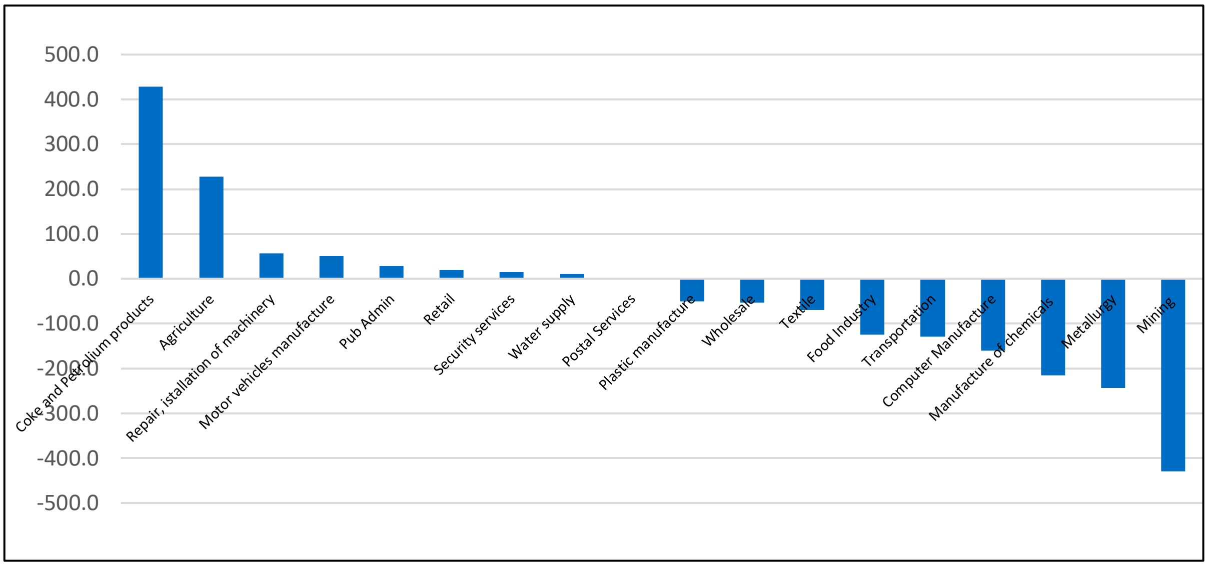
Figure A1.3.1 Imports and Exports by Interprovincial, Interregional, and International Sources



Source: Author's elaborations based on Taranto's SAM.

The trade balance is the difference in value between exports and imports for a specific period. The province of Taranto records an active trade balance in the manufacturing of coke and petroleum derivatives (+€428Mln) and agriculture (+€227Mln), but a passive balance in the mining (-€429Mln), metallurgy (-€243Mln), and chemicals (-€214Mln) sectors; see **Figure A1.3.2** Trade Balance by Sectors (€ Mln)

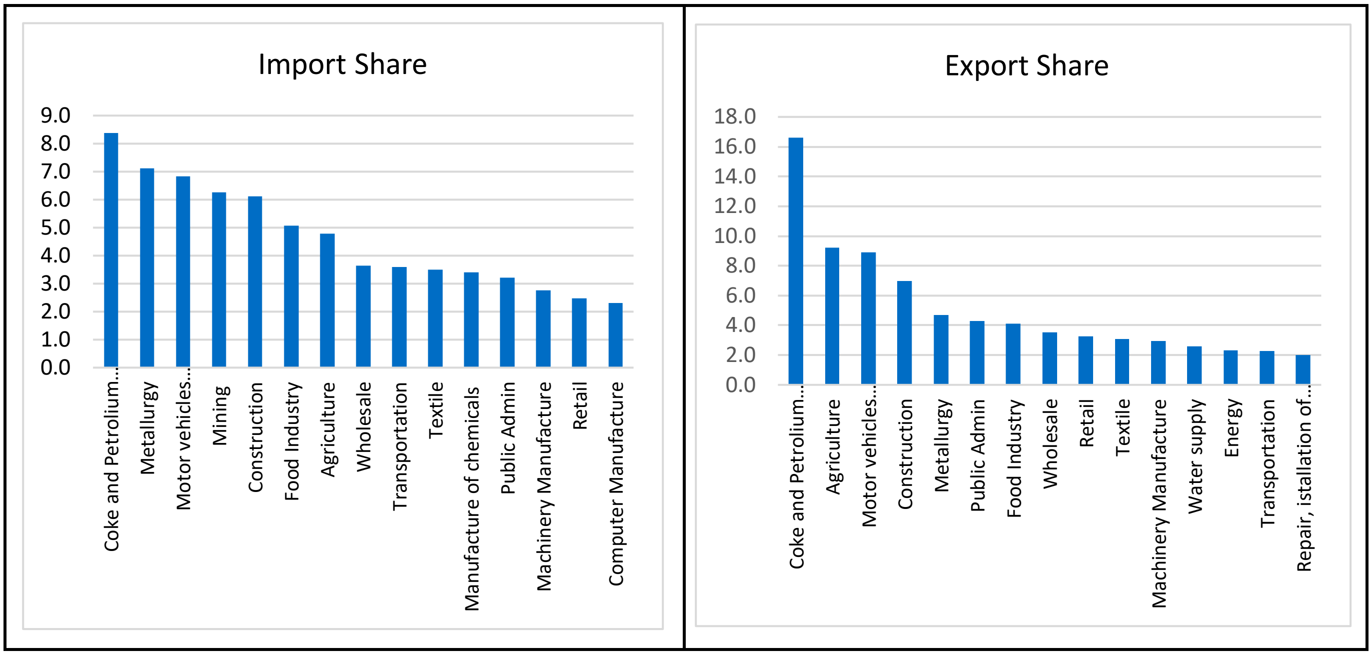
Figure A1.3.2 Trade Balance by Sectors (€ Mln)



Source: Author's elaborations based on Taranto's SAM.

The length of the value chains of the metallurgy, coke, and petroleum sectors is notably high. However, the Taranto steel production value chain is one of the shortest among the global steel production sites. This could be a crucial feature in the post-pandemic economic restart scenario. Interestingly, mining, which is mainly focused on limestone production for steel making process, shows a high import share but no export share because its production is mostly used within the Taranto province (see **Figure A1.3.3** Total Import and Export Shares by Sectors**)**. At the end of the extraction cycle, mining sites often serve as landfill owned by metallurgical companies, thus becoming potential sources of pollution, especially from micropollutants.

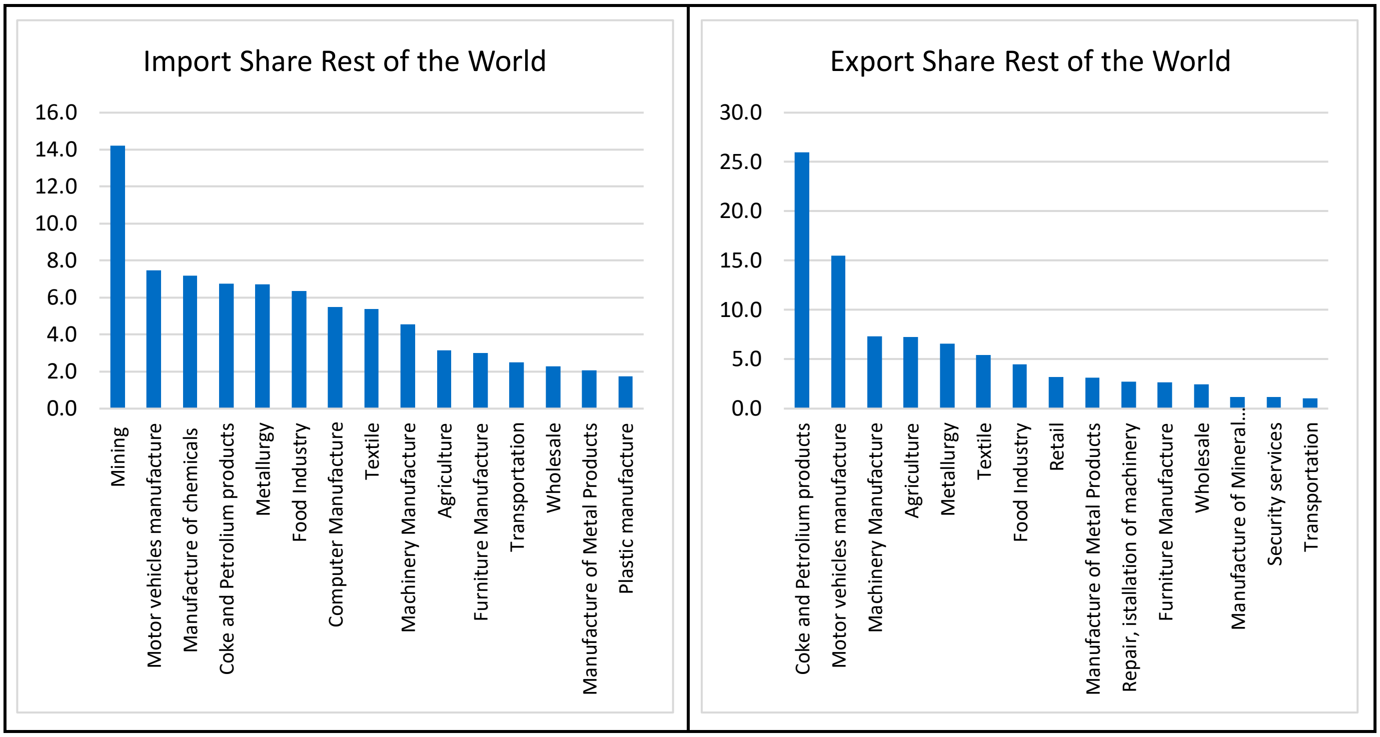
Figure A1.3.3 Total Import and Export Shares by Sectors



Source: Author's elaborations based on Taranto's SAM.

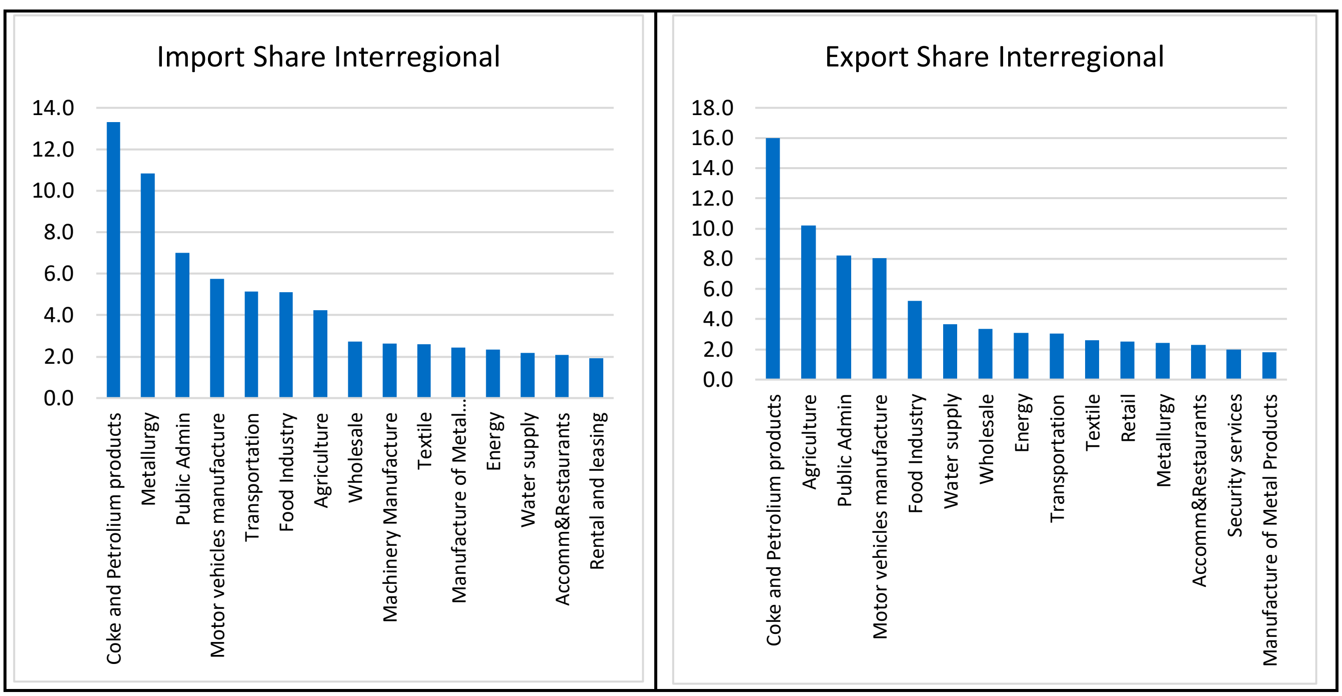
The metallurgical, coke and petroleum products, and mining integrated sectors are responsible for 28% of all imports from the rest of the world, as shown in **Figure A1.3.4** Import and Export Share by Sector from and to the Rest of the World**Figure A1.3.5** Import and Export Shares by Sector towards other Italian Regions illustrates that while the metallurgical and coke and petroleum products sectors still account for about 25% of total imports from other Italian regions, mining is only marginally related to other Italian regions because it is not among the first 15 sectors and therefore not represented in the graph. The manufacture of coke and petroleum products, machinery, vehicles, and agriculture accounts for 41% of exports to the rest of the world. Coke and petroleum products are also the two most export-oriented sectors towards both the rest of the world and other Italian regions, with agriculture being the second most important sector in terms of its relationship with Italian regions.

Figure A1.3.4 Import and Export Share by Sector from and to the Rest of the World



Source: Author's elaborations based on Taranto's SAM.

Figure A1.3.5 Import and Export Shares by Sector towards other Italian Regions



Source: Author's elaborations based on Taranto's SAM.

A1.4. The Construction of Taranto Environmentally Extended SAM 2015

The structural linkages between economic activities and the environment are very complex but can have significant and long-term impacts on trade, human health, ecosystems, and climate, including socio-welfare implications for achieving sustainable development goals (SDGs) not only at local and national levels but also on a global scale (Banerjee et al., 2019; OECD, 2021). The quantity of carbon emissions of GHG by industrial sectors can be directly or indirectly linked to production levels, consumption patterns, and specific technological characteristics (Donati et al., 2020). As noted by Duchin et al. (2007), this is because the production process in an economic system requires resource inputs from the environment and discharges waste in the form of externalities into the environment. The environmental extension accounts for the environment as a source of natural capital and ecosystem service flows and quantitatively describes its role as a sink for by-products and waste generated through productive processes following the conventions established by the System of Environmental Economic Accounting (SEEA).

The enviromental data comprises values in metric tons for the emissions sources of each specific sector at a provincial level. The pullants covered are carbon dioxide (CO_2), methane (CH_4), nitrous oxide N_2O), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), ammoniac (NH_3) and Particulate Matter PM5 and PM10 produced by each sector in Taranto. However, a critical consideration is the integration of environmental metrics, such as the social cost of carbon (SCC) and the benefits from emission reductions, into the SAM while maintaining consistent sequences of accounts in both horizontal rows and vertical columns. In a double-entry accounting framework, policies that potentially increase emissions calculate the cost by multiplying the increased tonnage by the SCC. Conversely, for policies that reduce emissions, the decrease in tonnage is multiplied by the SCC and added to the benefits side of the equation (Morilla, Díaz-Salazar, & Cardenete, 2007).

A1.4.1. The Model includes Greenhouse gas (GHGs) emissions

The major GHGs, generally expressed in unit of emission sources resulting from human activities are carbon dioxide (CO_2) from the burning of fossil fuels (oil, natural gas, and coal). Methane (CH_4) i.e., from agricultural practices. Nitrous oxide (N_2O) from the combustion of solid waste. Non-methane volatile organic compounds (NMVOC) emitted mainly from transportation, industrial processes, and the use of organic solvents. Carbon monoxide (CO), an odorless and colorless gas formed by the incomplete combustion of carbon, vehicle fumes and furnaces. Sulphur dioxide (SO_2) and ammonia (NH_3) are produced naturally by the action of bacteria on organic matter, such as in intensive livestock production and animal waste decomposition. Ammonia is also released, due to industrial activities and is used in manufacturing of plastic, fertilizers, pesticides. However, these major GHGs can be summed up and measured in unit of ton of carbon-dioxide equivalents (CO_2eq), where equivalent implies having the same warming effect as CO_2 over a period of 100 years.

A1.4.2. Carbon emission pricing and social cost-benefit estimates

The fundamental goal behind the prioritization and implementation of carbon emissions pricing measures with varying scopes, along with the social cost of carbon (SC-CO_2) estimates, is to reduce emissions of GHGs and drive investment into cleaner options. In other words, it is built on a market-based strategy of the polluter pays principle by adding the relevant price or social costs, known as negative externalities, to economic agents such as households and various industrial sectors that generate pollution. Accordingly, it serves as a benchmark for cost-benefit analyses of climate change-related regulatory actions for governments and taxpayers (IMF/OECD, 2021).

According to the IMF/OECD (2021), limiting global warming to 1.5°-2°C degrees Celsius, which is the central goal of the 2015 Paris Agreement, would require policy action equivalent to a global carbon price rising to around 25-75 in US dollars (USD) per ton of CO_2 or more by 2030. However, it is important to specify that little consensus exist among economist about the appropriate price level for damage per metric ton of carbon emissions (Kaufman et al., 2020). **Table A1.4.1.** (SC-CO_2) 2015-2050 (in 2007 US dollars per metric ton of CO_2)**A1.4.2.** Carbon emission pricing and social cost-benefit estimatesand **Table** A1.4.3. (SC-N_2O), 2015-2050 (in 2007 dollars per metric ton of N_2O) below, provided by the US Environmental Protection Agency (USEPA), illustrates the social cost of emitting CO_2, CH_4, and N_2O in USD. given different future strategies. I then convert the values to in euros at current market (Euro/Dollar) exchange rate.

Table A1.4.1. (SC-CO_2) 2015-2050 (in 2007 US dollars per metric ton of CO_2)

Discount rate in US dollars						**(EUR/USD) at 23/06/2021**			**0.837**
YEAR	5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)		5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)
2015	11	**36**	56	105		9	**30**	47	88
2020	12	42	62	123		10	35	52	103
2025	14	46	68	138		12	39	57	116
2030	16	50	73	152		13	42	61	127
2035	18	55	78	168		15	46	65	141
2040	21	60	84	183		18	50	70	153
2045	23	64	89	197		19	54	74	165
2050	26	69	95	212		22	58	80	177

Source: Adapted from the USEPA, website

According to the TSD (2016), SC-CO2 is a useful measure in dollars of the long-term damage done by emitting a metric ton of carbon dioxide into the atmosphere each year, using integrated assessment models based on different future strategies. This measure represents the average cost (derived from three climate models across five climate change scenarios) given discount rates of 5%, 3%, and 2.5%. Additionally, the table includes a high-impact case calculated from the 95th percentile of these models and scenarios, rather than the average cost, using a 3% discount rate. The discount rate is used to estimate the present value of all projected future avoided damages from emission reduction (i.e., the benefit of reducing CO2 emissions). This implies that the monetary amount can also indicate the current generation's willingness to pay to avoid projected future damages. From a societal standpoint, a higher discount rate implies placing more burden on future generations, and vice versa.

Table A1.4.2. ($SC-CH_4$), 2015-2050 (in 2007 dollars per metric ton of CH_4)

Discount rate in US dollars						(EUR/USD) at 23/06/2021			0.837
YEAR	5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)		5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)
2015	450	1000	1400	2800		377	837	1172	2344
2020	540	1200	1600	3200		452	1004	1339	2678
2025	650	1400	1800	3700		544	1172	1507	3097
2030	760	1600	2000	4200		636	1339	1674	3515
2035	900	1800	2300	4900		753	1507	1925	4101
2040	1000	2000	2600	5500		837	1674	2176	4604
2045	1200	2300	2800	6100		1004	1925	2344	5106
2050	1300	2500	3100	6700		1088	2093	2595	5608
Source: Adapted from the USEPA, website									

Table A1.4.3. ($SC-N_2O$), 2015-2050 (in 2007 dollars per metric ton of N_2O)

Discount rate in US dollars						(EUR/USD) at 23/06/2021			0.837
YEAR	5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)		5% Average	3% Average	2.5% Average	High impact (95th pct at 3%)
2015	4000	13000	20000	35000		3348	10881	16740	29295
2020	4700	15000	22000	39000		3934	12555	18414	32643
2025	5500	17000	24000	44000		4604	14229	20088	36828
2030	6300	19000	27000	49000		5273	15903	22599	41013
2035	7400	21000	29000	55000		6194	17577	24273	46035
2040	8400	23000	32000	60000		7031	19251	26784	50220
2045	9500	25000	34000	66000		7952	20925	28458	55242
2050	11000	27000	37000	72000		9207	22599	30969	60264
Source: Adapted from the USEPA, website									

It is important to specify that I decided to use the same social cost of carbon ($SC-CO_2$) of €30 per metric ton, given a 3% discount rate, for NMVOC, CO, NH_3, PM2.5 and PM10 produced by each sector in Taranto.

A1.5. Status of CIS Investments in Taranto Province

Table A1.5.1. Implementation Status of CIS Investment in Taranto

STATUS OF IMPLEMENTATION BY SECTOR OF INTERVENTION OF THE CIS OF TARANTO					
SECTOR	AMOUNT FINANCED AT 30.06.2018 (€Mln)	SECTOR IMPACT ON THE TOTAL CIS (%)	EXPENDITURE MADE AT 30.06.2018 (€Mln)	IMPACT OF SECTOR EXPENDITURE ON THE TOTAL CIS FUNDED (%)	IMPACT OF SECTOR EXPENDITURE ON THE FUNDED SECTOR (%)
Reclamation and environmental dev't	161.00	15.99	16.23	1.61	10
Port infrastructure and transport	416.64	41.37	252.74	25.09	61
Health	277.50	27.55	4.30	0.43	2
Urban regeneration	91.84	9.12	1.51	0.15	2
Redevelopment and adaptation of school buildings	8.28	0.82	7.01	0.70	85
Infrastructural recovery and tourist enhancement Arsenale Militare	42.89	4.26	1.16	0.11	3
Cultural assets and activities for tourism promotion	7.02	0.70	6.76	0.67	96
System actions to support the acceleration of interventions	2.00	0.20	0.00*	0.00*	0*
Total CIS Investment	**€ 1007.18**	**100**	**€ 289.71**	**28.76**	**--**

Table A1.5.2. Economic- Financial Framework

Economic - Financial Framework (Costs for works and Infrastructure for the Mediterranean Games – Taranto 2025)				
Financing costs and funds / *Amount in millions of euros*	*Public with State contribution*	*Region, Municipality, and other Local Authorities*	*Private*	***TOTAL***
WORKS AND INFRASTRUCTURE	***100***	***130***	***20***	***250***
Restructuring, adjustment				*75%*
Construction of new sports facilities				*15%*
Athletes' villages and media centre				*2%*
Competition set-up and equipment				*3%*

Economic - Financial Framework (Costs for organizing the Mediterranean Games - Taranto 2025)				
financial costs and funds / ***Amount in millions of euros***	*Public with State contribution*	*Region, Municipality, and other Local Authorities*	*Private*	***TOTAL***
ORGANIZATION	*20*	*12*	*8*	*40*
SPORTS, GAMES SERVICES AND OPERATIONS				*30%*
Hotel accommodation services, Food and Beverage, Medical Services (incl. Anti-Doping), Logistics Costs, Safety Costs, Sports Competition Costs, Transportation Costs, Spectator Services, Venue Operation Management, Test Events, etc.				
TECHNOLOGIES				*20%*
IT & Telecommunications				
COST OF LABOR				*20%*
Staff, volunteers, law enforcement, security				
CEREMONIES AND CULTURAL PROGRAMS				*10%*
Opening and closing ceremony, cultural and educational programs				
COMMUNICATION, PROMOTION AND MARKETING				*5%*
ADMINISTRATION AND LEGACY				*10%*
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2 Chapter

Impact Techniques of Modelling Next-Gen Infrastructure Investment Projects to Redress Regional Disparities Using Multi-Regional Input-Output Model

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Abstract

This paper estimates the socioeconomic impact of public-financed increase in fiscal policy investments and modernization projects (CIS) on the labor markets (skilled and unskilled), private enterprises, and different categories of households in the Apulia region of Italy. It does so by implementing a multi-regional input-output (MRIO) model with inter-regional trade at the level of the Apulia region to estimate the intra-regional impact, and at the national level to estimate the inter-regional supply chain linkages and spillover effects through trade. The intra-regional effects are almost twice the inter-regional effects. Nearly 51% of the inter-regional impact on value-added GDP accrues to northern regions, 22% to the center, while about 27% is captured by regions in southern Italy. This evidence clearly shows a good degree of connection between the Apulia local economy and the macro region of northern Italy, while it is quite weak with the macro south in Italy. The considerable share of inter-regional spillover effects in terms of value-added, which is transferred outside the southern macro-region, over 73%, reflects the persisting regional disparities in Italy, where the productive northern regions mostly benefit from the national development policies made in the most marginal areas in southern Italy.

Keywords: Modernization projects, multiregional input-output (MRIO), interregional trade, regional disparities, fiscal multipliers.
JEL classification: C67, D57, F14, Q58, R13.

2.1 Introduction

The degree of within-country interregional trade flows and participation in global value chains (GVCs) depends on many factors, such as trade openness, productivity gaps, and competitiveness. GVCs reflect the international division of production processes across different countries (Bentivogli et al., 2018).

In the case of Italy, because the country exhibits substantial heterogeneity and disparities in terms of trade performance, living standards, institutional capacity, and environmental quality both within and across regions, national-regional planning and development policies are especially important. For example, the southern regions (i.e., Abruzzo, Molise, Campania, Apulia, Basilicata, and Calabria) are relatively poorer and lag economically in trade performance compared to the richer northern regions (i.e., Lombardy, Piemonte, and Veneto), where industrial production and agglomeration effects are more prevalent. These longstanding structural and macroeconomic imbalances have been compounded by the outbreak and subsequent fallout of the COVID-19 pandemic, as well as the measures undertaken by Italy (see, Svimez, 2020; OECD, 2021).

This raises questions about the special relevance of implementing the so-called "Italy in the Future National Recovery and Resilience Plan" (PNRR)[8], which, developed in response to the COVID-19 pandemic under the Next Generation European Union (NGEU) stimulus package dedicated to EU member states. Specifically, it concerns the effectiveness of decentralized regional development policies versus centralized policies at the national level. To address the existing north-south disparities and the ensuing structural decline that have continually undermined the economic base and institutional capacity of Italy's southern regions, various public policies on regional development and cohesion have been designed to enhance economic growth and reduce pre-existing inequalities in Italy. Among these policies, and included in the post-COVID Italian recovery plan, is the 2021-2026 Institutional Development Contract (CIS) strategic recovery investment plan. In effect, this CIS strategic investment plan, also known as the (*CIS local-NGEU investment* plan[9]), involves approximately

[8] The PNRR is an Italian acronym for the National Recovery and Resilience Plan (NRRP), a document submitted to the EU detailing how the country intends to invest the EU's temporary funds worth about €222.1 billion under the Next Generation EU (NGEU) programme. This programme is dedicated to member states to mitigate the social and economic crisis caused by the COVID-19 pandemic. The document also presents the structural reforms supporting green and digital transitions to be implemented over the next five years (2021-2026) (see, for example, Governo Italiano, 2021).

[9] The so-called "CIS local-NGEU investment plan" is equivalent to the CIS strategic investment plan evaluated in the first chapter. However, the main objective here is to estimate the socioeconomic impact of CIS local-NGEU investment plan not only at the regional level Apulia but also the corresponding economic spillover effect across other regions in Italy.

€1,097Mln allocated by the Apulia region and the municipal administration of the province of Taranto. In this chapter both specifications will be used interchangeably.

The objective of this paper is to estimate the socio-economic impact of public-financed increase in fiscal policy investments on the Apulia regional economy local economy using a multi-regional input-output (MRIO) model. In particular, how does an increase in regional fiscal spending on many projects, including investment in urban development, ports, environmental quality, healthcare, education, as well as various infrastructure initiatives affects industrial outputs, value-added (VA), household employment, and induced consumption in Apulia region? And what is the size the of the short-term fiscal spending multiplier at the regional level? More specifically, the size of the short-term fiscal spending multiplier, defined here as the ratio of intra-regional value-added GDP increase to the initial exogenous change in government investment spending in Apulia region (see, for example, Pusch et al., 2011; Dodzin et.al., 2016; Ianc et al. 2020).

This paper contributes to the literature that studies the impact of fiscal policy investments on value-added GDP growth during times of economic crisis using quantitative spatial equilibrium models (see, e.g., Shepherd, 2016; Redding et al., 2017; Pfeiffer et al. 2021; Di Bartolomeo et al., 2021). First, the paper investigates how the impact of the local investment project is distributed within the Apulia region and across other Italian regions by exploiting the multiregional setup. The proposed MRIO framework, with its micro foundations, employs a novel technique to estimate the multilevel internal rates of return for the CIS local-NGEU investment project in the Apulia region, all regions, and at the national level, corresponding to the sum of the intraregional and interregional effects.

Within this context, the structure of the paper is organized as follows. Section 2.2 briefly reviews the methodological framework for constructing the regional social accounting matrix (SAM) for the reference year of 2015, followed by details on the CIS local-NGEU strategic investment plan of the Apulia region. Section 2.3 presents the analytical techniques of the MRIO model adopted in this study with feasible real-world empirical implementation and less restrictive data requirements. Section 2.4 focuses on the empirical simulation of the socioeconomic impacts of the CIS local-NGEU investment project and illustrate how the effects propagate among different economic agents and across Italian regions. It summarizes the main results and discusses the key policy and welfare implications in the context of sustainable development. Finally, Section 2.5 provides concluding remarks. The appendix summarizes the state of implementation and the construction of the exogenous shock of the CIS local-NGEU investment plan.

2.2 Data and Research Methodology

2.2.1 Literature Review on Social Accounting Matrix (SAM)

The conceptual origins and framework of SAM can be traced back to the late 1960s with the pioneering work of Richard Stone, who responded to the need to integrate the famous Leontief Input-Output (I-O) model[10] within the framework of the United Nations System of National Accounts (SNA). Against this backdrop, Stone and his research team in Cambridge developed the first SAM for the United Kingdom in 1960. In fact, compared to the Leontief I-O method, SAMs represent a macroeconomic equilibrium where aggregate demand equals aggregate supply.

The fundamental purpose of a SAM is to document all the economy-wide series of transactions and transfers of income between different economic sectors and institutions (i.e., households, private enterprises, government, and the rest of the world) within a socioeconomic system (national, regional, or sub-regional, etc.) during a specific period, usually for a year (Round, 2003; Scandizzo et al., 2015; Mainar-Causapé et al., 2018). Furthermore, SAMs represent the core economic-wide flexible and comprehensive database required for the calibration of parameters for a family of Computable General Equilibrium (CGE) models, including multiplier analysis (Civardi et al., 2006). This implies that an aggregate SAM describes the economy's macroeconomic behavior in an initial equilibrium (Burfisher, 2011, p. 44).

In this regard, SAM technique is the proper and viable methodological approach for ex-ante socioeconomic impact simulation of calibrated local, regional, and interregional infrastructure investment projects. It guides policy-makers in understanding the interdependences and structural adjustment mechanisms related to the efficiency of resource allocation among interrelated sectors and agents within an economic system. It also provides guidance in evaluating the likely quantitative impacts and consequences of how different domestic policy options and external exogenous shocks

[10]. The basic I-O or interindustry analysis was first developed by Professor Wassily Leontief in the late 1930s, for which he was awarded the Nobel Prize in Economics in 1973. The method is a practical means of representing the interindustry transactions and structural interdependences within a socio-economic system (see, Sraffa, 1960; Miller & Blair, 2009; Szabó, 2015).

affect society's economic welfare, in the context of sustainable development (see, Robinson & Liu, 2006; Hosoe et al., 2010). Understanding how households, private enterprises, government, as well as various industrial sectors and their interdependencies or linkages (i.e., through trade) with GVCs across the world, interact with each other is crucial for an efficient, effective, and sustainable implementation of the CIS investment plan.

2.2.2 The Data Sources for Constructing the Apulia Regional SAMs

The analytical framework for constructing SAMs for different countries and regions around the world broadly conforms to the basic internationally agreed standards of the United Nations System of National Accounts (SNA). However, the classification of accounts and the degree of disaggregation can differ across countries, depending not only on the key objectives and priorities under study, but also on the availability and quality of data (Eurostat, 2008; Mainar-Causapé et al., 2018). For example, macro-SAMs can be constructed using data drawn from a country's national accounts, firms and household income surveys, government budgets, balance of payments, etc., while the disaggregated micro-SAMs can be obtained by using the data in the macro-SAM accounts as control totals.

Figure 9 below, shows the macro structure for the Apulia regional SAM matrix and 19 other Italian regions for the reference year 2015. The SAM includes 63 sectors and distinguishes interprovincial, interregional, as well as international trade between Apulia, and other Italian regions and the rest of the world. The labor employed in each sector is categorized into low, medium, and high skill components. Households' consumption, income and savings are disaggregated by deciles to account for the distributive impact of the CIS investment projects. The names of the industrial sectors included in the Apulia SAM are illustrated in Appendix **A2.1** Apulia Regional SAM Sectoral Classification. The dataset consists of 85 rows by 85 columns, including totals, and provides a detailed summary of the Apulia economy.

Figure 9. The Structure of the Puglia and Italian Regional SAM

		Activity	Value added			Institutions			Direct taxation	Capital formation	Export		Total
		63 sectors	Labor (low, med,high skill)	Capital	Indirect taxation	Household income decile	Enterprises	Government	Taxes	Capital formation	Other Regions	Rest of the world	
Activity	63 sectors	Intermediate Consumption				Consumption		Consumption		Investments	Export to other regions	Export to ROW	Demand
Value added	Labor (low, med, high skill)	Wages											Gross domestic product
	Capital	Mixed income											
	Indirect taxation	Taxes											
Institutions	Household income decile		Labor income	Other income		Transfer	Capital income	Income from pensions, subsidies, contributions		Negative savings		Income from abroad	Institution incomes
	Enterprises							Contributions, subsidies		Negative savings			
	Government				Tax transfer				Tax transfer	Negative savings		Transfer from abroad	
Direct taxation	Taxes					Taxes	Taxes						Direct taxation
Capital formation	Capital formation					Savings	Savings	Savings				Capital from abroad	Saving
Import	Other Regions	Imports from other regions				Consumption							Import
	Rest of the world	Imports from ROW				Consumption							
Total		Supply	Factor outlays			Institution expenditures			Direct taxation	Investments	Export		

Source: Author's own elaboration.

The pressing challenges in constructing and updating consistent SAMs for recent years involve not only finding ways to incorporate fragmented or missing datasets from different sources but also fixing statistical inconsistencies related to the timing and adjustment of the I-O tables (Robinson et al., 2001). In this regard, some of the commonly used statistical techniques for balancing SAMs accounts with equality between incomes and expenditures include, for example, the RAS method, cross-entropy minimization, and least squares methods. It is worth mentioning that different balancing techniques tend to yield heterogeneous or slightly different SAMs.

2.2.3 Construction of the Exogenous Shock of the CIS Local-NGEU Investment Plan

The provincial territory of Taranto will be impacted in the short-term by an exogenous investment shock totaling €1,700Mln. These includes €1,100Mln from the CIS, about €200Mln from industrial development contracts, and €400Mln from the XX Mediterranean Games program. To evaluate this impact, I will utilize an economic modelling tool, such as a disaggregated SAM or a CGE model. This process will involve constructing expense vectors for both the construction and operational phases, starting with identifying the relevant producers, and owners' sectors, based on the following assumptions

For the CIS, which finances a total investment amount of approximately €1,100Mln, the following documents were reviewed:

- The 2018 implementation status by sector, detailing planned versus reported expenditures for each macro-category, totals €1,007Mln (see Appendix **A2.3** Implementation status CIS Taranto).
- A preliminary document by MIBACT outlines actions and investment priorities for urban regeneration, adding to the two completed CIS interventions. An additional €90Mln will focus on restoring historical-cultural sites and nearby streets in Taranto's Old City (Città Vecchia).

Table 17 and **Table *18*** present an analysis of the CIS investment project, detailing the exogenous shocks to the local economy and the project's cost flow as traditionally modeled.

Table 17. CIS Local-NGEU Investment Plan List (€ Mln)

Instrument	Related sectors	Project	Project costs
CIS	Environment	Drainage Mar Piccolo	55.0
CIS	Environment	Platform riqualification	20.8
CIS	Environment	Ex Cemerad	10.0
CIS	Environment	Statte Aquifers	37.0
CIS	Environment	Environmental Centre	1.0
CIS	Environment	Waste water Ilva	14.0
CIS	Environment	Cimitery San Brunone	11.0
CIS	Environment	Restoration Statte Municipality	0.2
CIS	Environment	Water collection Crispiano	3.0
CIS	Environment	Environmental Riqualification Montemesola	3.0
CIS	Environment	Water collection Massafra	3.0
CIS	Environment	Environmental Riqualification Statte	3.0
CIS	Military Arsenal	Installations Military Arsenal	37.2
CIS	Military Arsenal	Enhancement Military Arsenal	5.7
CIS	Health	San Cataldo Hospital	207.5
CIS	Health	Medical equipments	70.0
CIS	Ports	Logistic plate Taranto	219.1
CIS	Ports	Riqualification Peer	75.0
CIS	Ports	Dredging	83.0
CIS	Ports	Taranto RFI Railroad	25.5
CIS	Ports	Foranea Dam	14.0
CIS	Education	Schools Riqualification	8.2
CIS	Education	School neighborhoods	1.2
CIS	Education	Risk Analysis of School Projects	0.1
CIS	Tourism and culture	Restoration Convento	5.1
CIS	Tourism and culture	Restoration Compendio	2.0
CIS	City Development	Soil remediation	2.0
CIS	City Development	Urban Forest	6.9
CIS	City Development	Carducci Palace	2.1
CIS	City Development	Residential construction	20.0
CIS	City Development	Restoration Via Garibaldi	2.1
CIS	City Development	Housing Sociale	15.2
CIS	City Development	Restoration Palazzo Troilo	3.6
CIS	City Development	Lungomare, Tamburi, sport facilities	40.0
CIS	MIBACT	Riqualification Città Vecchia	90.0
		Total	**1096.3**

Note: This breakdown details various local-NGEU development initiatives aimed at upgrading local infrastructure, environmental quality, health services, education, cultural preservation, and city development within the Apulia regions, with a combined total investment of €1096.3 million.

Source: The Italian Development Agency (CIS Project)

Table 18. Local-NGEU Project Costs by Sectors (€ Mln)

Industrial sectors	Construction year						
	1yr	2yr	3yr	4yr	5yr	6yr	Total
Agriculture	2	2	0	0	0	0	3
Manufacture of non-metal products	9	9	8	8	6	4	45
Manufacture of metal products	9	5	4	4	4	2	28
Computer and electronic products	14	5	5	5	5	4	38
Electrical equipment	26	6	5	5	4	2	48
Machinery & equipment	16	12	11	11	7	4	61
Other transport equipment	9	9	9	9	9	9	55
All utilities & waste	5	5	5	5	0	0	21
Construction	129	125	113	107	59	40	572
IT services	1	1	1	1	1	0	5
Business services	0	0	0	0	0	0	1
Rest of the world	73	37	34	34	26	16	220
Total	**292**	**217**	**196**	**190**	**121**	**80**	**1096**

Note: The table provided shows a breakdown of various projects under the CIS initiative, segmented by related sectors and specifying their associated project costs.
Source: The Italian Development Agency (CIS Project)

2.3 Multi-regional Input-Output (MRIO) Models

MRIO models are modified extensions of Isard's interregional input-output (IRIO) model with feasible real-world empirical implementation and less restrictive data requirements (Bon, 1975, p. 5; Hyland et al., 2012, p. 153; Többen et al., 2015). Unlike the IRIO model, trade flows among regions are captured differently in MRIO models. Particularly, interindustry transaction flows denoted by $t_{ij}^{\bullet s}$ are estimated by sector in multiregional models lacking inputs' regional origins, where the dot superscript indicates all possible geographical locations of sector i. Put differently, similar commodities are no longer distinguished by their regional origins (Toyomane, 1988, p. 17; Miller et al., 2009, p. 90; Polenske et al., 2004). Similarly, the corresponding technical coefficients for each receiving region in the MRIO model indicated by $a_{ij}^{\bullet s}$ are ratios measuring the quantity of commodity i required to produce one unit of sector $j's$ total output located in region s.

$$a_{ij}^{\bullet s} = \frac{t_{ij}^{\bullet s}}{x_j^s} \qquad where, \quad \mathbf{A}^s = [a_{ij}^{\bullet s}]_{s=1,\cdots m} \tag{2.1}$$

By re-expressing equation (2.1), I obtain the structural equation $t_{ij}^{\bullet s} = (a_{ij}^{\bullet s} x_j^s)_{s=1,\cdots m}$, which relates the interindustry multiregional intermediate transactions to total output. In general, depending on the specifications of the missing regional origins and accounting scheme for spatially differentiated interregional trade, MRIO models can be classified into three major groups: column coefficient (Chenery-Moses) models, row coefficient models, and gravity coefficient models (see, e.g., Polenske, 1970; Bon, 1975, 1984; Toyomane, 1988, p. 17).

2.3.1 The Chenery-Moses' Column Coefficient MRIO Model

The Chenery-Moses MRIO model assumes that the purchasing sectors decide the compositions of each inputs' regional origins. In other words, every purchasing industrial sector, including the final demand sector for commodity i, in region s, would purchase commodity i, from both domestic and imported sources in the same proportions among the selling regions (Moses, 1955; Ungsoo, 1974, p. 9; Toyomane, 1988, p. 17). The overall commodities traded between selling and purchasing regions can be illustrated in **Table 19**. Let $t_{ij}^{rs} = t_i^{rs}$ for all j, represent a flow or purchase of commodity i from region r to the producing and final demand sectors in any other region s, regardless of the destination sector in the purchasing regions.

Table 19. Interregional Trade of Commodity i

	Importing Region					
Exporting Region	*1*	*2*	...	*s*	...	*m*
1	t_i^{11}	t_i^{12}	...	t_i^{1s}	...	t_i^{1m}
2	t_i^{21}	t_i^{22}	...	t_i^{2s}	...	t_i^{2m}
⋮	⋮	⋮	...	⋮	...	⋮
r	t_i^{r1}	t_i^{r2}	...	t_i^{rs}	...	t_i^{rm}
⋮	⋮	⋮	...		...	⋮
m	t_i^{m1}	t_i^{m2}	...	t_i^{ms}	...	t_i^{mm}
Total	T_i^1	T_i^2	...	T_i^s	...	T_i^m

Each column sums in **Table 19** represents the total shipments (supplies) of commodity i into region s from all other regions, including the amount supplied from within the region itself, (i.e., t_i^{ss}). In other words, T_i^s is the total amount of commodity i consumed in region s. Furthermore, since the total supplies for each commodity i, regardless of regional origins, must be equivalent to the intermediate and final demands for each commodity i in region s, I have (see, Miller et al., 2009, p. 107).

$$T_i^s = t_i^{1s} + t_i^{2s} + \cdots + t_i^{rs} + \cdots + t_i^{ms}$$
$$= \sum_{r=1}^{m} t_i^{rs} = \overbrace{\sum_{j=1}^{n} a_{ij}^{\bullet s} x_j^s + f_i^s}^{T_i^s} \qquad \begin{matrix}(r = 1, 2 \ldots, m)\\ (i = 1, 2 \ldots, n)\end{matrix} \tag{2.2}$$

By dividing each element in the column (see **Table 19**) of a particular region s by the column total T_i^s, of the receiving region, I obtain the fraction of the total supply of commodity i used in region s that came from within region s and other regions r (where $r = 1, \ldots, m$). These trade or supply coefficients in any column denoted by c_i^{rs}, must sum to unity when aggregated over the selling regions, as stated below:

$$c_i^{rs} = \frac{t_i^{rs}}{T_i^s} \quad where, \quad \sum_{r=1}^{m} c_i^{rs} = 1 \quad (all\ i) \tag{2.3}$$

The structural equation obtained from equation (2.3), $t_i^{rs} = (c_i^{rs} T_i^s)$ states that the shipments of a given commodity i from regions r into region s are directly proportional to the total consumption of commodity i in region s (see, Bon, 1984, p. 795; Polenske et al., 2004, p. 271). Note that the trade coefficients assume identical or fixed regional supply patterns for any given inputs among all purchasers, including the final users of each commodity i in a specific region (Ungsoo, 1974, p. 9). By substituting the structural equation into the right-hand side of Equation (2.2), the Chenery-Moses MRIO model for m-regions and n-sectors of industries can be represented by the set of linear equations (see, Moses, 1955; Toyomane, 1988, p. 17).

$$x_i^r = \sum_{s=1}^{m} \overbrace{c_i^{rs} T_i^s}^{t_i^{rs}} = \sum_{s=1}^{m} c_i^{rs} \overbrace{\left(\sum_{j=1}^{n} a_{ij}^{\bullet s} x_j^s + f_i^s \right)}^{T_i^s} \qquad \begin{matrix}(r = 1, 2 \ldots, m)\\ (i = 1, 2 \ldots, n)\end{matrix} \tag{2.4}$$

$$= \sum_{s=1}^{m} \sum_{j=1}^{n} c_i^{rs} a_{ij}^{\bullet s} x_j^s + \sum_{s=1}^{m} c_i^{rs} f_i^s$$

where x_i^r is the total production (supply) of commodity i in region r, while f_i^s denotes the total exogenous final demand for commodity i in region s. Based on Equation (2.4)[11], I can derive a set m matrix equations for the entire multi-regional economy (see, Miller et al. 2009, p. 108), with one equation for each region r, where $r = 1, \ldots, m$.

$$\mathbf{x}^r = \sum_{s=1}^{m} \mathbf{C}^{rs}(\mathbf{A}^s \mathbf{x}^s + \mathbf{f}^s) = \sum_{s=1}^{m} \mathbf{C}^{rs} \mathbf{A}^s \mathbf{x}^s + \sum_{s=1}^{m} \mathbf{C}^{rs} \mathbf{f}^s \qquad (r = 1, 2 \ldots, m) \tag{2.5}$$

the matrix form becomes

$$\mathbf{x} = \begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \vdots \\ \mathbf{x}^m \end{bmatrix}; \ \mathbf{f} = \begin{bmatrix} \mathbf{f}^1 \\ \mathbf{f}^2 \\ \vdots \\ \mathbf{f}^m \end{bmatrix}; \ \mathbf{A}^\star = \begin{bmatrix} \mathbf{A}^1 & 0 & \cdots & 0 \\ 0 & \mathbf{A}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{A}^m \end{bmatrix} \textit{where, } \mathbf{A}^r = [a_{ij}^{\bullet r}]_{r=1,\cdots m} \tag{2.6}$$

and

$$\mathbf{C}^\star = \begin{bmatrix} \mathbf{C}^{11} & \mathbf{C}^{12} & \cdots & \mathbf{C}^{1m} \\ \mathbf{C}^{21} & \mathbf{C}^{22} & \cdots & \mathbf{C}^{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{C}^{m1} & \mathbf{C}^{m2} & \cdots & \mathbf{C}^{mm} \end{bmatrix}, \text{ where, } \mathbf{C}^{rs} = \begin{bmatrix} c_1^{rs} & 0 & \cdots & 0 \\ 0 & c_2^{rs} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_n^{rs} \end{bmatrix}$$

$$\text{and} \qquad \mathbf{C}^{ss} = \begin{bmatrix} c_1^{ss} & 0 & \cdots & 0 \\ 0 & c_2^{ss} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_n^{ss} \end{bmatrix} \tag{2.7}$$

From equation (2.5), (2.6) and (2.7), the solution equation yields

$$\begin{aligned} \mathbf{x} &= \mathbf{C}^\star \mathbf{A}^\star \mathbf{x} + \mathbf{C}^\star \mathbf{f} \\ (\mathbf{I} - \mathbf{C}^\star \mathbf{A}^\star)\mathbf{x} &= \mathbf{C}^\star \mathbf{f} \end{aligned} \tag{2.8}$$

[11] The Chenery-Moses MRIO column coefficient model's balance equation shows that the total production of commodity i, in region r equals the sum of shipments of that commodity to all other regions s, including within-region supply (t_i^{rr}). Moreover, the product of interregional trade and technical coefficients in the Chenery-Moses model equates to the Isard IRIO model's technical coefficients, $a_{ij}^{rs} = c_i^{rs} a_{ij}^{\bullet s}$ (Isard, 1951; Miller et al. 2009, p. 107). Moses (1955) demostrated that this decomposition allows for the independent estimation and periodic updating of both interregional trade and technical coefficients.

$$\mathbf{x} = (\mathbf{I} - \mathbf{C}^{\star}\mathbf{A}^{\star})^{-1}\mathbf{C}^{\star}\mathbf{f}$$

Here, $\mathbf{x}$ and $\mathbf{f}$ represent the vectors of regional total outputs and final demands, respectively. Furthermore, $\mathbf{C}^{\star}$ is a block of interregional trade coefficients, with each of the submatrices (i.e., $\boldsymbol{C}^{r\mathcal{s}}$ and $\boldsymbol{C}^{\mathcal{s}\mathcal{s}}$**)** containing the trade coefficients for n-traded commodities, while the off-diagonal elements equal to zero. The matrix, $\mathbf{A}^{\star}$ is a block of diagonal matrix of regional IO technical coefficients for all regions, with each of the submatrices $\mathbf{A}^{r} = [a_{ij}^{\bullet r}]_{\mathcal{s}=1,\cdots m}$ along the principal diagonal, and the elements in the off-diagonal positions are equal to zero.

2.4 Empirical Findings

2.4.1 Estimation of Interregional Trade Flows

The starting point for the construction of the MRIO model for the 20 Italian regions is the regional SAMs, which estimates interregional trade flows using a non-survey methodology. This approach was dictated by cost-related issues and the absence of information on interregional trade flows for different sectors either at national or regional level. (Huang & Koutroumpis, 2023). Cross-hauling in interregional trade is the process in which each region simultaneously exports and imports the output of a generic sector *i* (Fujimoto, 2019). Here, interregional trade was estimated using the cross-hauling adjusted regionalization method (CHARM) model proposed by Kronenberg (2009) and subsequently refined by Többen et al. (2015) with some adaptations. The model assumes that cross-hauling in interregional trade is proportion to the cross-hauling potential determined by the amount of output or demand. Particularly, interregional import-export is zero-sum at the national level, the sum of regional exports by branch corresponds to the sum of regional import.

Figure 10 below presents the interregional exports and imports of agri-food products between the Apulia region and 19 other Italian regions, as estimated using the CHARM model. As shown in **Figure 11**, the Apulia region exhibits a positive interregional trade balance in agri-food products with the regions of Lazio (€110.30Mln), Sicily (€40.70Mln), and Calabria (€29.29Mln), while it faces a negative interregional trade balance with Emilia-Romagna (-€113.55Mln), Lombardy (-€74.58Mln), Piedmont (-€70.34Mln), and Veneto (-€61.19Mln). An overview of the total interregional trade between Apulia and the rest of Italy is provided in Appendix **A2.2** Apulia: Total Interregional Trade with the Rest of Italy

Furthermore, a gravity econometric model was used to determine how the outflows from each region are divided among the remaining regions. The gravity model holds that the volume of bilateral trade flows between regions is directly proportional to their economic sizes and inversely proportional to the distances between them, reflecting transportation costs (Leontief & Strout, 1963; Polenske, 1969). The interregional flows were subsequently calibrated with a spatial interaction procedure (Wilson, 1971; Fotheringham, 1983a, 1983b; Dennet, 2012), which made it possible to account for the total outgoing and incoming flows for each region. The fixed supply form of the static MRIO model is based on the following four assumptions:

1. Constant technology coefficients. No substitution among inputs is allowed to occur maintaining fixed technological relationships.

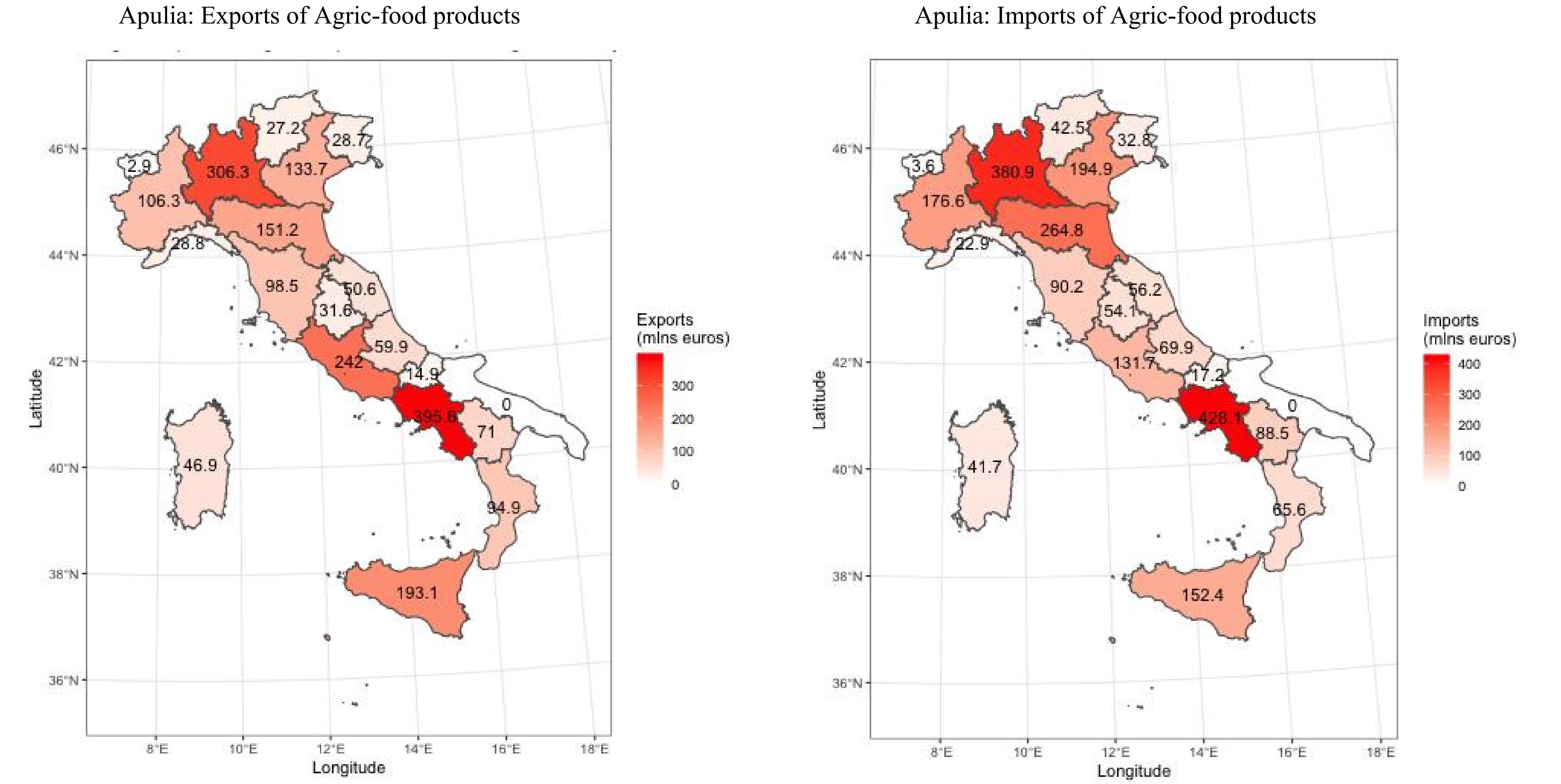
2. Constant trade coefficients. No substitution among supplying regions is allowed to occur. Thus, a region is assumed to continue supplying a given fraction of the consumption of another region over time. Interregional trade flows data are not readily available at the national level, hence it needed to be estimated using gravity-based models.

3. Constant industrial shares. Each industry within a given region is assumed to purchase a fixed share of the total supply of a given good within that region. Again, lack of data has prevented the empirical testing of this assumption. However, incorporating these assumptions, reduces the data requirements for implementing the model.

4. Excess capacity. All producers and transportation facilities are assumed to be operating at less than full capacity.

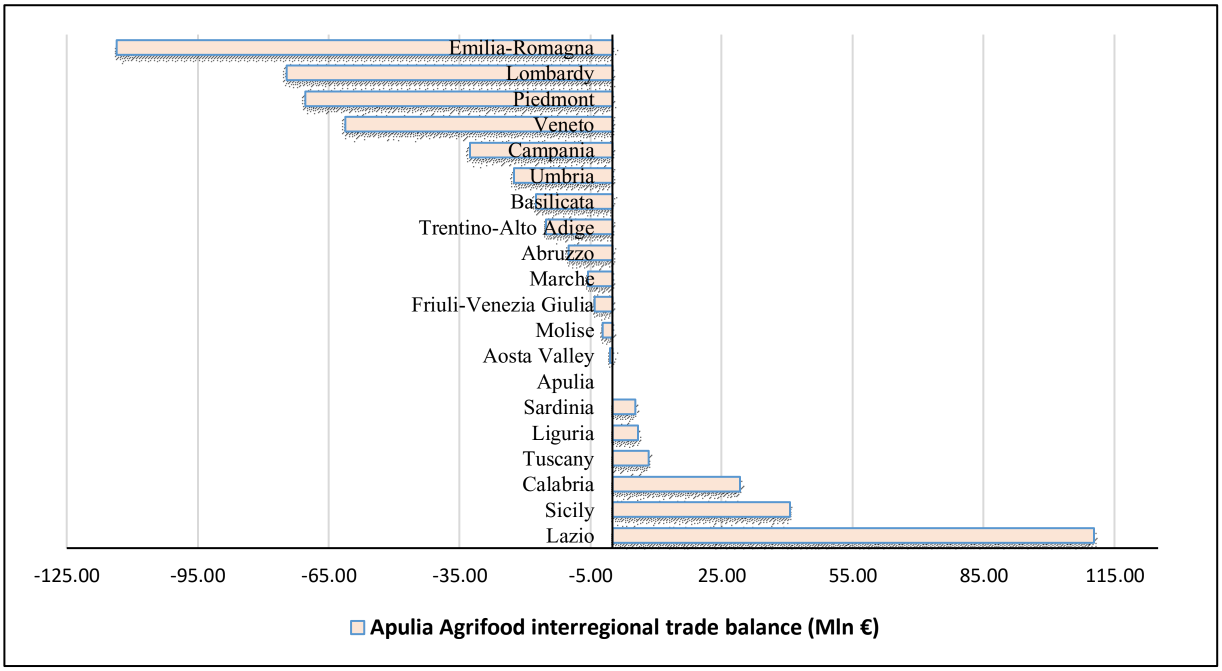
Some of the limitations of these assumptions have been extensively elaborated in the first chapter of this dissertation.

Figure 10. Apulia Agri-food Trade with other Regions in Italy (€ Mln)



Note: Figure 10 shows the total values in terms of interregional trade (exports and imports) of approximately (€ 2084.28 Mln) and (-€2314.69 Mln) respectively in agri-food products between Apulia and 19 other Italian regions, corresponding to a trade balance of (-€230.41Mln). Here, the Apulia intra-regional exports and imports are set to zero by construction to better reflect the trade flows in the diagram.
Source: Author's elaborations based on Italy's SAM.

Figure 11. Apulia's Inter-regional Trade Balance for Agri-Food Products (€ Mln)



Source: Author's elaborations based on Italy's SAM.

2.4.2 Empirical results: Intra and Interregional Impacts

The impact on the local economy is evaluated by applying the exogenous shock vector from **Table 20** to the regional SAM illustrated below. Approximately 65% of the total investment shock is directed towards the construction sector.

Table 20. CIS Local-NGEU Investment Allocated to Key Sectors in Apulia Region (€ Mln)

Ref. #	Sector Description	CIS Investments (€ Mln)	Share (%)
-	Construction	571.90	65.26
-	Manufacture of machinery and equipment	60.72	6.93
-	Manufacture of motor vehicles, trailers, and semi-trailers	54.79	6.25
-	Manufacture of basic metals	44.71	5.10
-	Manufacture of computer, electronic and optical products	43.30	4.94
-	Manufacture of electrical equipment	43.30	4.94
-	Manufacture of fabricated metal products, except machinery and equipment	27.85	3.18
-	Water collection, treatment, and supply	10.43	1.19
-	Management of sewer networks; waste collection, treatment, and disposal	10.43	1.19
-	Software, computer consulting and related activities; information service activities	5.20	0.59
-	Agriculture and hunting	3.08	0.35
-	Other technical, scientific professions; Veterinary services	0.55	0.06
-	Manufacture of chemicals and chemical products	0.10	0.01
Total Investments		**876.35**	**100**

Source: Author's elaborations based on the CIS Investment Plan

2.4.3 Intra-regional impact of CIS Local-NGEU investments on the Apulia region

As illustrated in **Table 21**, the intraregional impact calculated with the MRIO model have been grouped into Total impact: Intermediate consumption, and Value-added (Low income, Mid income, High income, Capital income and Indirect taxes), and Impact on Institutions (Households, Government and Enterprises). The CIS Local-NGEU investments of €876.35Mln in the construction period generates an overall intra-regional impact on the Apulia economic output of €3353.73Mln. This impact is broken down into inter-sectorial purchases from intermediate input suppliers in the production process (€2242.44Mln), which includes €1079.55Mln from direct effects in intermediate input expenditures, €1162.89Mln from indirect intermediate input increase, and €1111.29Mln of value-added GDP, constituting 33.14% of the total intra-regional impact.

The intra-regional value-added GDP (€1111.29Mln) as shown in **Table 21**, divided by the total CIS local-NGEU investment costs (€876.35Mln) is equal to the size of the short-term fiscal spending multiplier of 1.27. Notably, the size of the short-term fiscal spending multiplier in Taranto was between 1.57 and 1.77. The size of fiscal policy response in Apulia is lower compared to Taranto due to the interregional value-added spillover effects across other regions in Italy. Moreover, the size of the short-term fiscal spending multiplier within the Apulia region, increases from 1.27 to 2.14, after accounting for the interregional value-added spillover effects through interregional trade at the national level. In general, the size of fiscal policy response can be higher during economic crisis compared to normal times (Warmedinger et al., 2015). Furthermore, Pusch et al. (2011) find comparably high fiscal multipliers ranging from 1.4 and 1.8 for specific spending categories for EU countries using input-output approach. Economic output multiplier indicates the intensity with which a sectoral investment spreads over the entire domestic economy. The induced consumption effects from potential household spending on goods and services, derived from employees' earnings of direct and indirect business expenditures is about €974.27Mln, as shown in **Table 21**.

Table 21. Intra-regional Impact of CIS-local NGEU in Apulia region (€ Mln)

Sectors	Impact (€ Mln)	Impact/Total (%)
Intermediate Consumption	**2242.44**	**66.86**
Direct effects	*1079.55*	*32.19*
Indirect effects	*1162.89*	*34.67*
Value-Added GDP	**1111.29**	**33.14**
Income (Low)	*210.29*	*6.27*
Income (Mid)	*189.00*	*5.64*
Income (High)	*69.40*	*2.07*
Capital Income	*505.88*	*15.08*
Indirect Taxes	*139.72*	*4.08*
Impact on Institutions (Induced Effects)	**1987.16**	**100%**
Households	*974.27*	*49.03*
Government	*653.85*	*32.90*
Enterprises	*359.03*	*18.07*
Total Impact (TI)	**3353.73**	**100%**

Note: Induced effects is the link between regional wages and labor and household spending. This link reflects endogenous consumption, where income earned within the region is also spent within the region. A sector's export's demand typically creates the combined effects of induced effects along with the direct and indirect effects. Interestingly, a source of pure induced effects occurs when payments, e.g., social security payments from the federal government, are made to households. Regional household spending from outside sources of income can have a strong induced effect, but it does not contribute to any direct or indirect effects.
Source: Author's calculations based on Italy's SAM.

2.4.4 Interregional Impact of CIS Local-NGEU Investments on the other Italian Regions

As illustrated in **Table 22**, the total inter-regional impact on the rest of Italy is estimated with the MRIO model to be €2,498.19Mln, while the impact on intermediate consumption in the production process is €1,733.98Mln, equal to 69.41% of the total. The impact on inter-regional value-added GDP is €764.21Mln, or 30.59% of total economic output. As shown in **Figure 12**, a considerable share of the inter-regional spillover effects in terms of value-added GDP, which is transferred outside the southern macro-region, is over 73%. This reflects the regional disparities in Italy, where the more productive northern regions mostly benefit from the national development policies, which are implemented in the more marginal areas of southern Italy. The total impact and the induced interregional consumption effects on potential institutional spending on goods and services are graphically represented on the regional map shown in **Figure 13**.

Table 22. Interregional Impact of CIS local-NGEU on the other 19 Italian Regions (€Mln)

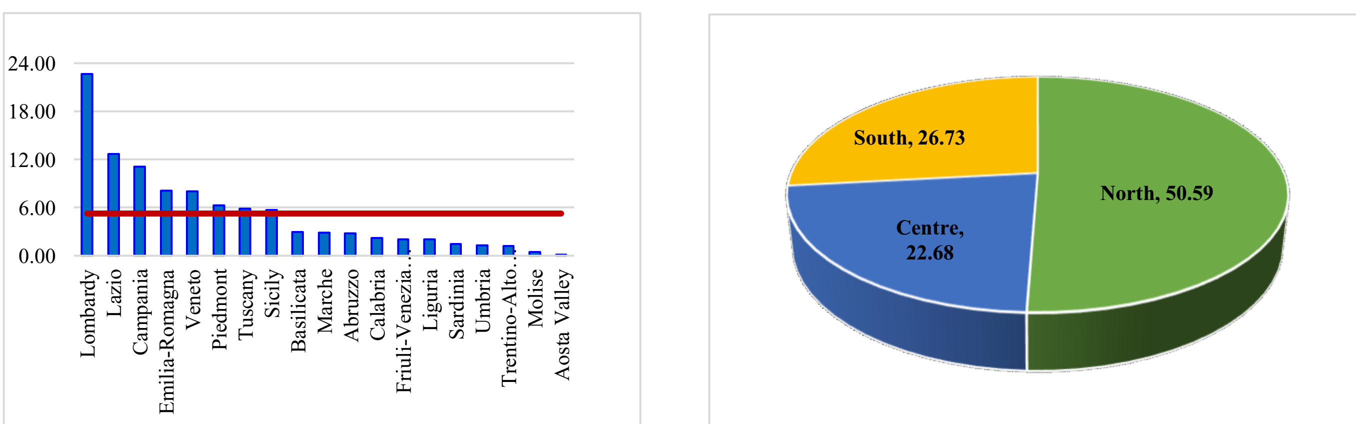
Sectors	Impact (€ Mln)	Impact/Total (%)
Intermediate Consumption	**1733.98**	**69.41**
Direct effects	*528.96*	*21.17*
Indirect effects	*1205.01*	*48.24*
Value-Added GDP	**764.21**	**30.59**
Income (Low)	*95.58*	*3.83*
Income (Mid)	*141.28*	*5.66*
Income (High)	*62.14*	*2.49*
Capital Income	*366.68*	*14.68*
Indirect Taxes	*98.52*	*3.94*
Impact on Institutions (Induced Effects)	**1380.92**	**100%**
Households	*652.16*	*47.23*
Government	*461.93*	*33.95*
Enterprises	*266.83*	*19.32*
Total Impact (TI)	**2498.19**	**100%**

Note: Total impact (TI) is the sum total of Intermediate consumption and Value-added. The impact of CIS investments on institutions (induced effects) measures the link between regional wages, labor and household spending. This link reflects endogenous consumption, where income earned within the region is also spent within region. For households, total income includes factor income distribution, inter-household transfers, corporate income distribution, government transfers, and transfers from the rest of the world (RoW). For enterprises, total income includes factor income distribution, government transfers, and transfers from the RoW.

Source: Author's calculations based on Italy's SAM.

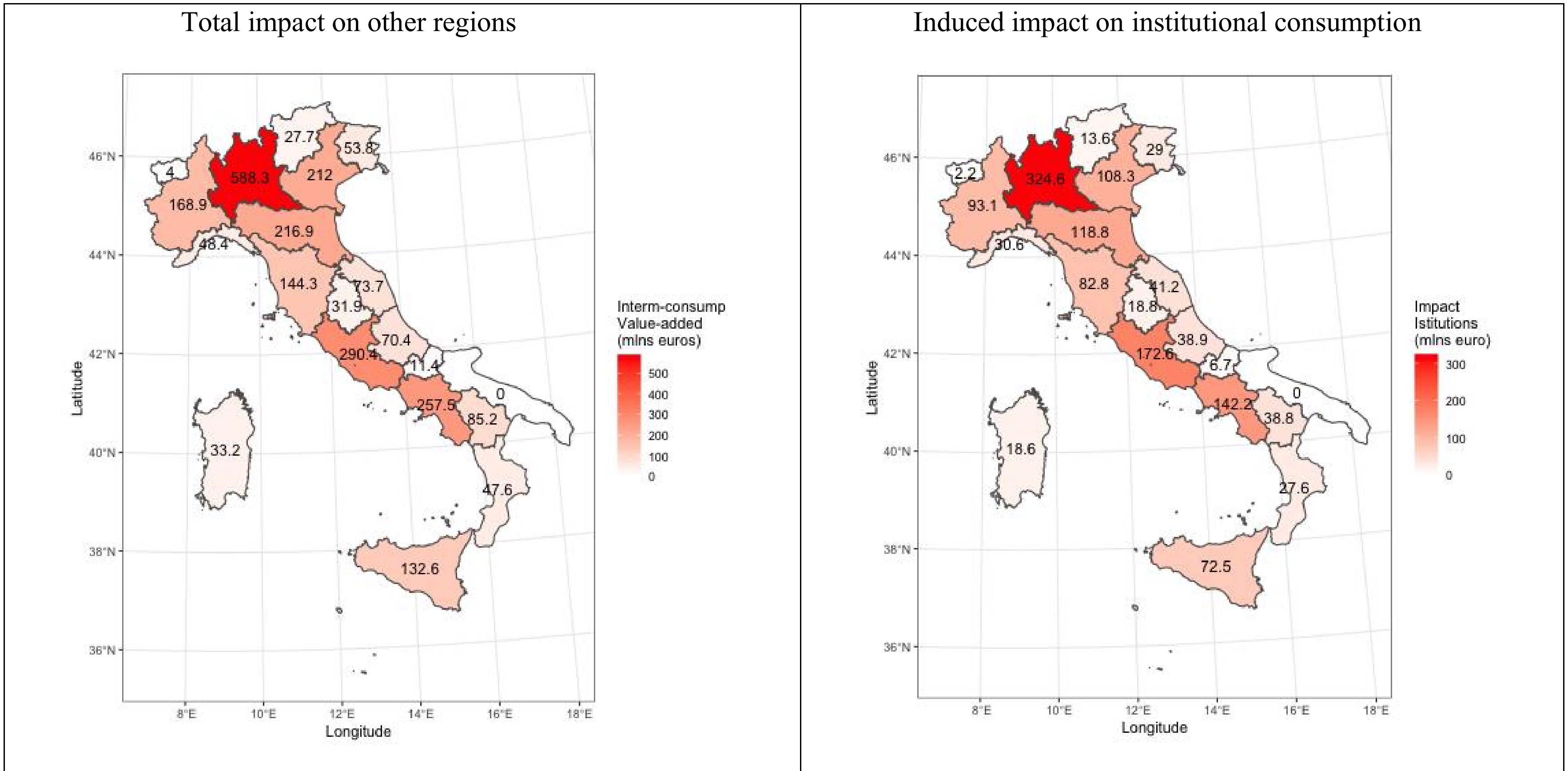
Figure 12. Inter-regional Value-Added Share by Italy's Regions and Macro-Regions

Italy's other Regions (%) | Italy's Macro-Regions (%)



Note: Italy's northern regions include Piemonte, Aosta Valley, Liguria, Lombardy, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, and Emilia-Romagna. The central regions include Tuscany, Umbria, Marche, and Lazio. The southern regions include Abruzzo, Molise, Campania, Basilicata, Calabria, Sicily, and Sardinia.
Source: Author's elaborations based on Italy's SAM.

Figure 13. Interregional Effects: Total Impact and Induced Effects on Institutional Consumption (€ Mln)



Note: Figure 13 illustrates the interregional total impact of recovery investments in the Apulia region on the other 19 Italian regions, as well as the induced effects on institutional consumption. For clarity in the distributional analysis, the intra-regional impact of Apulia has been set to zero.
Source: Author's elaborations based on Italy's SAM.

2.4.5 National impact of the CIS local-NGEU investment in Italy

Lastly, the spillover effect produced at the national level was estimated, which corresponds to the sum of the intra-regional and inter-regional effects, as shown in **Table 23**. The national impact of the CIS local-NGEU investments estimated with the MRIO model is worth €5851.92Mln. The impact on intermediate input consumption is €3976.42Mln, which is 67.95% of the total impact. The impact on national value-added GDP is equal to €1875.50Mln, accounting for 32.05% of the total national impact. The total value-added GDP at the national level (€1875.50Mln) as shown in **Table 23**, divided by the total CIS local-NGEU investment costs (€876.35Mln) is equal to 2.14, after accounting for inter-sectoral supply chain linkages and spillover effects through trade at the national level.

Table 23. National Impact of CIS Local-NGEU in Italy (€ Mln)

Sectors	Impact (€ Mln)	Impact/Total (%)
Intermediate Consumption	**3976.42**	**67.95**
Direct effects	*1608.51*	*27.49*
Indirect effects	*2367.90*	*40.46*
Value-Added GDP	**1875.50**	**32.05**
Income (Low)	*305.87*	*5.23*
Income (Mid)	*330.29*	*5.64*
Income (High)	*131.54*	*2.25*
Capital Income	*872.56*	*14.91*
Indirect Taxes	*235.24*	*4.02*
Impact on Institutions (Induced Effects)	**3368.08**	**100%**
Households	*1626.43*	*48.29*
Government	*1115.79*	*33.13*
Enterprises	*625.87*	*18.58*
Total Impact (TI)	**5851.92**	**100%**

Note: Total impact (TI) is the sum total of Intermediate consumption and Value-added. The impact of CIS local-NGEU investments on institutions (induced effects) measures the link between regional wages, labor and household spending.
Source: Author's calculations based on Italy's SAM.

The impact on national value-added of €1,875.50Mln within the Italian economy, divided by the total investment costs of €876.35Mln (as shown in **Table 20**), produces a value-added benefit/cost ratio of 2.14. This ratio accounts for interregional and inter-sectoral supply chain linkages, as well as spillover effects through trade at the national level.

2.5 Conclusions and Policy Implications for Italy and Europe

The purpose of this paper was to estimate the socio-economic impact of CIS local-NGEU recovery investments and resilience plans for the Apulia region on different categories of households, labor markets (both skilled and unskilled), and private enterprises across Italy by implementing an MRIO model with inter-regional trade. The intraregional effects are nearly twice as large as the interregional effects. Almost 51% of the inter-regional impact on value-added accrues to northern regions, 22% to the center, while about 27% is captured by regions in southern Italy. This empirical evidence clearly shows a good degree of connection between the Apulia local economy and the macro region of northern Italy, while it is relatively weak compared to the macro southern Italy. However, Apulia is particularly connected to the regions of Lombardy, Lazio, and Campania. Compared to chapter one, the intra-regional fiscal spending multiplier within Apulia region is lower compared to Taranto due to the interregional value-added spillover effects across other regions in Italy. In fact, the size of fiscal policy response within Apulia increases from of 1.27 to 2.14, after accounting for the interregional and inter-sectoral supply chain linkages and spillover effects through trade at the national level.

From a policy perspective, these empirical results show how an ex-ante impact evaluation of investments provides useful indications for orienting recovery investments to maximize their benefits for local economic development and address regional disparities in Italy. In this regard, the considerable share of inter-regional spillover effects, in terms of value-added over 73% which is transferred outside the southern macro-region, reflects the persistent regional disparities in Italy. Generally speaking, the productive northern regions primarily benefit from national development policies directed at the more marginal areas in southern Italy, as widely discussed in the context of EU Cohesion Policy. More specifically, Lombardy has a higher capacity of attracting inter-regional value-added from every unit of fiscal investment spending in Apulia relative to other regions in Italy (see **Figure 12**). However, to trigger a catching-up process, structural reforms are necessary to enhance institutional capacity in the southern regions for the efficient implementation of national development policies associated with the recovery investments.

The application of a static MRIO analysis has some limitations, including the assumptions of constant returns to scale in production technology and no substitution among inputs. This implies that relative prices play no role in the allocation of resources between activities. In addition, the assumption of constant trade coefficients implies that regions continue to demand and supply a given fraction of the consumption of other regions. A further concern is the lack of supply-side constraints in the model implies that supply cannot respond perfectly elastically to changes in demand, as supply capacity is limited by the existing labor, capital, and other productive inputs. Further research is needed to measure spatial multi-regional relationships within the dynamic general equilibrium model for the national economy.

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Appendix A2

A2.1 Apulia Regional SAM Sectoral Classification

#	SECTORS	#	SECTORS
1	Agriculture	43	Activities auxiliary to financial services and insurance activities
2	Fisheries	44	Real estate activities
3	Forestry	45	Legal and accounting activities; activities of head offices; management consulting
4	Mining and quarrying	46	Architectural and engineering activities
5	Food, drink and tobacco industries	47	Scientific research and development
6	Textile industry, manufacture of wearing apparel and leather goods.	48	Advertising and market research
7	Manufacture of wood and of products of wood and cork, except furniture	49	Other professional, scientific and technical activities; veterinary services
8	Manufacture of paper and paper products	50	Rental and leasing activities
9	Printing and reproduction of recorded media	51	Personnel recruitment, selection and supply activities
10	Manufacture of coke and refined petroleum products	52	Travel agency service activities
11	Manufacture of chemicals and chemical products	53	Investigation and security services
12	Manufacture of pharmaceutical products	54	Public administration and defence; compulsory social security
13	Manufacture of rubber and plastic products	55	Education
14	Manufacture of other non-metallic mineral products	56	Human health activities
15	Manufacture of basic metals	57	Social work activities
16	Manufacture of fabricated metal products, except machinery and equipment	58	Creative, arts and entertainment activities
17	Manufacture of computer, electronic and optical products	59	Sporting, entertainment and recreational activities
18	Manufacture of electrical equipment	60	Activities of membership organisations
19	Manufacture of machinery and equipment n.e.c.	61	Repair of computers and goods for personal and home use
20	Manufacture of motor vehicles, trailers and semi-trailers	62	Other personal service activities
21	Manufacture of other means of transport	63	Activities of households as employers of domestic staff
22	Manufacture of furniture; other manufacturing	64	Income from employee work (low)
23	Repair and installation of machinery and equipment	65	Income from employee work (mid)
24	Electricity, gas, steam and air conditioning supply	66	Income from employee work (high)
25	Water collection, treatment and supply	67	Capital
26	Management of sewer networks; waste collection, treatment and disposal	68	Indirect taxes
27	Construction	69	Households_1st_decil
28	Wholesale and retail trade and repair of motor vehicles and motorbikes	70	Household_2nd_decil
29	Wholesale trade, except of motor vehicles and motorbikes	71	Household_3rd_decil
30	Retail trade, except of motor vehicles and motorbikes	72	Household_4th_decil
31	Land transport and transport via pipelines	73	Household_5th_decil
32	Sea and water transport	74	Household_6th_decil
33	Airplane transport	75	Households_7th_decil
34	Warehousing and support activities for transportation	76	Households_8th_decil
35	Postal and courier activities	77	Household_9th_decil
36	Accommodation; food service activities	78	Households_10th_decil
37	Publishing activities	79	PA
38	Motion picture, video and television programme production, sound recording and music publishing activities	80	Direct taxes
39	Telecommunications	81	Enterprises
40	Computer programming, consultancy and related activities; information service activities	82	Capital formation
41	Financial service activities (except insurance and pension funding)	83	Imports Interr.
42	Insurance, reinsurance and pension funding, except compulsory social security	84	Imports rest of the world

A2.2 Apulia: Total Interregional Trade with the Rest of Italy

Regions of Italy	*Interr_exports* (€ Mln)	Share (%)	*Interr_imports* (€ Mln)	Share (%)	Trade balance (€ Mln)
Piedmont	1286.40	5.47	1578.65	5.61	-292.24
Aosta Valley	28.08	0.12	24.81	0.09	3.27
Liguria	337.22	1.43	396.14	1.41	-58.93
Lombardy	4236.25	18.03	6206.73	22.04	-1970.48
Trentino-Alto Adige	261.33	1.11	306.10	1.09	-44.78
Veneto	1524.65	6.49	2089.78	7.42	-565.13
Friuli-Venezia Giulia	366.17	1.56	474.29	1.68	-108.13
Emilia-Romagna	1521.11	6.47	2013.89	7.15	-492.77
Tuscany	1239.80	5.28	1647.75	5.85	-407.95
Umbria	269.50	1.15	320.20	1.14	-50.71
Marche	615.99	2.62	895.42	3.18	-279.44
Lazio	2937.01	12.50	3204.57	11.38	-267.56
Abruzzo	656.45	2.79	800.95	2.84	-144.50
Molise	139.05	0.59	146.46	0.52	-7.41
Campania	3894.80	16.57	3959.30	14.06	-64.50
Apulia	0.00	0.00	0.00	0.00	0.00
Basilicata	1071.10	4.56	1303.87	4.63	-232.77
Calabria	857.37	3.65	657.65	2.34	199.72
Sicily	1859.89	7.91	1775.57	6.31	84.32
Sardinia	398.49	1.70	354.28	1.26	44.21
Total	**23500.66**	**100**	**28156.43**	**100**	**-4655.77**

Note: This table presents the total interregional trade between the Apulia and 19 other Italian regions. The Apulia has a trade deficit of (-€1970.48Mln) with Lombardy region, with 18.03% of total exports and 22.04% of imports. The region also has a. notable trade deficits with Veneto (-€565.13Mln) and Emilia-Romagna (-€492.77Mln). However, Apulia exhibits a positive interregional trade balance with the southern regions of Calabria and Sicily of €199.72Mln and €84.32Mln, respectively. Apulia's total interregional trade balance across all regions is a deficit of (-€4,655.77Mln), while it's intra-regional exports and imports is intentionally set to zero by construction.

Source: Author's calculations based on Italy's SAM.

A2.3 Implementation status CIS Taranto

STATUS OF IMPLEMENTATION BY SECTOR OF INTERVENTION OF THE CIS OF TARANTO					
SECTOR	AMOUNT FINANCED AT 30.06.2018 (€ Mln)	SECTOR IMPACT ON THE TOTAL CIS (%)	EXPENDITURE MADE AT 30.06.2018 (€ Mln)	IMPACT OF SECTOR EXPENDITURE ON THE TOTAL CIS FUNDED (%)	IMPACT OF SECTOR EXPENDITURE ON THE FUNDED SECTOR (%)
Reclamation and environmental dev't	161.00	15.99	16.23	1.61	10
Port infrastructure and transport	416.64	41.37	252.74	25.09	61
Health	277.50	27.55	4.30	0.43	2
Urban regeneration	91.84	9.12	1.51	0.15	2
Redevelopment and adaptation of school buildings	8.28	0.82	7.01	0.70	85
Infrastructural recovery and tourist enhancement Arsenale Militare	42.89	4.26	1.16	0.11	3
Cultural assets and activities for tourism promotion	7.02	0.70	6.76	0.67	96
System actions to support the acceleration of interventions	2.00	0.20	0.00*	0.00*	0*
Total CIS	**€ 1007.18**	**100**	**€ 289.71**	**28.76**	**--**

A2.4 Economic- Financial Framework

Economic - Financial Framework (Costs for works and Infrastructure for the Mediterranean Games – Taranto 2025)				
Financing costs and funds / *Amount in millions of euros*	*Public with State contribution*	*Region, Municipality, and other Local Authorities*	*Private*	***TOTAL***
WORKS AND INFRASTRUCTURE	***100***	***130***	***20***	***250***
Restructuring, adjustment				*75%*
Construction of new sports facilities				*15%*
Athletes' villages and media centre				*2%*
Competition set-up and equipment				*3%*

Economic - Financial Framework (Costs for organizing the Mediterranean Games - Taranto 2025)				
financial costs and funds / ***Amount in millions of euros***	*Public with State contribution*	*Region, Municipality, and other Local Authorities*	*Private*	***TOTAL***
ORGANIZATION	*20*	*12*	*8*	*40*
SPORTS, GAMES SERVICES AND OPERATIONS				*30%*
Hotel accommodation services, Food and Beverage, Medical Services (incl. Anti-Doping), Logistics Costs, Safety Costs, Sports Competition Costs, Transportation Costs, Spectator Services, Venue Operation Management, Test Events, etc.				
TECHNOLOGIES				*20%*
IT & Telecommunications				
COST OF LABOR				*20%*
Staff, volunteers, law enforcement, security				
CEREMONIES AND CULTURAL PROGRAMS				*10%*
Opening and closing ceremony, cultural and educational programs				
COMMUNICATION, PROMOTION AND MARKETING				*5%*
ADMINISTRATION AND LEGACY				*10%*
OTHER COSTS (RIGHRS, Trademarks, etc.)				*5%*

Source: http://asset.regione.Puglia.it/?Ambiente-dossier

3 Chapter

Investments in Green Projects and Value-added GDP: An Environmentally Integrated Multiregional SAM Approach

(Job Market Paper)

Online version here

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January 2025

Abstract

This paper presents an integrated methodology to simultaneously estimate the socioeconomic and environmental impacts of Next Generation EU (NGEU) public investments of around €1981 million on labor markets, value-added, and household consumption expenditures within a multiregional economy in equilibrium. I construct a novel dataset and then implement an environmentally integrated multiregional social accounting matrix (EI-MRSAM) modeling technique for regional macroeconomic investment analyses in Italy. The results show that Lombardy's intra-regional investment impact on the value-added (GDP) share accounts for almost 78%, while 22% accrues to the rest of Italy through interregional value-added spillover effects via trade channels. The impact of public investments on the regional and national economy decreases by around 10% of value-added after accounting for the environmental costs of climate change damages induced by industrial greenhouse gas (GHG) emissions. I then conduct a counterfactual ex-ante macro-policy evaluation of a 25% increase in the baseline investments for each of the thematic missions, which represent key areas of public policy intervention. I find that the return-on-investments in digital transformation of the public administration is more efficient in terms of potential regional value-added growth compared to other counterfactual outcomes. The distributional impact on household consumption expenditures and induced GHG emissions is also consistent with those of value-added.

Keywords: EI-MRSAM model, NGEU investments, interregional spillovers, value-added GDP, GHG emissions, environmental valuation, digital transformation.
JEL classification: C67, D57, F18, H54, Q56, R12.

3.1 Introduction

The trade-offs between economic development strategies and the ambitious goal of achieving a societal transition to net-zero emissions present numerous welfare policy challenges. These challenges vary across and within countries, regions, households, industrial sectors, and private enterprises. Concurrently, the concept of green economy initiatives and clean energy technologies highlights a new paradigm for economic growth that emphasizes sustainable development and intergenerational equity (see Agbonifi, 2023a; Kruse et al., 2022; Clootens, 2021; Nordhaus, 2019; UN, 2011). In Italy, like other industrialized countries in Europe, the drive towards implementing a circular economy through multi-billion investments aimed at a climate-neutral future comes at a critical time. This is set against the backdrop of the European Union (EU) COVID-19 pandemic relief National Recovery and Resilience Plan ((NRRP)[12], worth about €222.1 billion for the 2021-26 period. More broadly, the NRRP, through the NGEU investment funds dedicated to EU member states, is broken down into six key Missions, which represent the main thematic areas of policy intervention (Governo Italiano, 2021). The Missions include: (M1) Digitalization, Innovation, Competitiveness, and Culture; (M2) Green Revolution and Ecological Transition; (M3) Infrastructure for Sustainable Mobility; (M4) Education and Research; (M5) Inclusive Cohesion; and (M6) Health. The short-run NGEU recovery plan for Europe in response to the COVID-pandemic crisis is consistent with the European Green Deal (EGD) long-term ambition of reducing greenhouse gas (GHG) emissions 55% by 2030 and climate neutrality by 2050 (EC, 2020; Bongardt et al. 2022).

Lombardy is the most industrialized and populated regions in Italy that suffered severe economic losses during the Covid-pandemic crisis (ESPON, 2022). Meanwhile, the region was not only severely hit by the health pandemic but also ranked among the top air polluted regions in Europe (see De Angelis et al., 2021 for details). This raises fundamental, policy-relevant research questions about the integrated environment-economy welfare implications and the effectiveness of regional implementations of public-financed NGEU investments in the Lombardy region. Specifically, how does an increase in

[12] The National Recovery and Resilience Plan (NRRP) is the Italian acronym for "Piano Nazionale di Ripresa e Resilienza" (PNRR). It is a document submitted to the EU detailing how Italy intends to invest the temporary financial support measures (grants and low-interest, long-term loans) from the NextGenerationEU (NGEU) recovery investments package, which is dedicated to member states to mitigate the adverse effects of global pandemic shocks. The document also outlines the structural reform milestones in public administration, justice, and competition to be implemented over the next five years (2021–2026) (Governo Italiano, 2021). Details on the allocation of NGEU investments to various missions at the regional level are illustrated in the Appendix **Table A3.1.** NGEU Investments Projects in the Lombardy Region (Italy)

NGEU investment spending in the Lombardy region impacts the labor markets (both skilled and unskilled), household employment, value-added or gross domestic product (GDP),[13] and consumption, in the face of Italy's transition towards a carbon-neutral economy? What is the size the of the short-term fiscal spending multiplier at the regional level? How does an endogenous increase in the reallocation of NGEU investments to each mission's thematic areas in the Lombardy region impact the value creation of private enterprises and the well-being of households across Italy? The main purpose of the counterfactual macro-policy impact evaluation is to identify the most efficient reallocations in terms of value-added (GDP) returns on NGEU investment benefits for the regional and national economy. This would lead to insights for making informed investment decisions and evaluating environmental policies in terms of the accountability of public expenditures on green projects. Measures of societal well-being, including household income and wealth, consumption possibilities, and quality of life, are affected by factors such as levels of health care, environmental quality, and resource management (OECD, 2013). This paper contributes to the literature that studies the integrated environment-economy impact and the effectiveness of fiscal policy investments on value-added GDP growth during times of economic crisis using quantitative spatial equilibrium models (see, e.g., Redding et al., 2017; Pfeiffer et al. 2021; Di Bartolomeo et al., 2021, 2022; Monteduro et al. 2023).

Empirical studies show the links between air pollution levels and health outcomes (Henschel et al., 2012; Chanel et al., 2014). In particular, the excess mortality rates during the health pandemic outbreak in the region were further exacerbated by environmental factors such as greenhouse gas (GHG) emissions linked to climate change (González Ortiz et al., 2020; De Angelis et al., 2021). Although public interventions and the aggressive pandemic measures undertaken by national and local authorities in most countries led to reductions in GHG and local pollutants (Chanel, 2022; Cottafava et al., 2022), disruptions in global value chains (GVCs) induced by the pandemic further intensified pre-existing regional socioeconomic disparities across Italy (Svimez, 2020; OECD, 2021). GVCs reflect the international division of production processes across different countries (Bentivogli et al., 2018).

13. Value-added or gross domestic product (GDP), measured as factor incomes earned (labor and capital) and the costs of production (business taxes) estimated by industry. See: https://www.govinfo.gov/app/details/GOVPUB-C59-PURL-LPS77574

The remainder of the paper is organized as follows: Section 3.2 briefly presents the methodological approach for constructing the multi-regional environmental social accounting matrix (MR-ESAM) database, starting from the Leontief national Input-Output (I/O) model. Section 3.3 presents the methodological framework for developing the operational, environmentally integrated multi-regional social accounting matrix (EI-MRSAM) model for the Italian economy using linear algebra. Section 3.4 focuses on the simulation of the integrated socio-environmental-economic impacts and benefits of the NGEU-investments on societal wellbeing. Finally, Section 3.5 concludes the paper and discusses the key policy implications at the regional and national levels, as well as potential directions for future research. Further details on the Lombardy regional NGEU investments policy plan is illustrated in the Appendix **A3.**

3.2 Dataset and Research Methodology

3.2.1 Data: Social Accounting Matrix (SAM)

The Social Accounting Matrix (SAM) records all the economy-wide series of transactions and transfers of income between various economic sectors and institutions (i.e., households, private enterprises, government, and the rest of the world) during a specific period, usually a year (Stahmer, 2004; Breisinger et al., 2009; Scandizzo et al., 2015). This implies that an aggregate SAM describes the economy's macroeconomic behavior in an initial equilibrium (Burfisher, 2011). As such, it guides policymakers in understanding the interdependencies and structural adjustment mechanisms related to the efficiency of resource allocation among interrelated sectors and agents within an economic system. As a further extension, SAM can be augmented with environmental accounts to take into consideration sectoral emissions within the economic system (Tukker et al., 2006). **Figure 14** shows a detailed description and structure of the regional SAM augmented with environmental accounts. The data sources for constructing the SAM, starting from the national (I/O) data, are mainly from the Italian National Institute of Statistics (ISTAT), the Central Bank of Italy, and Eurostat. This includes aggregated accounts for activities, factors of production, income deciles of different household groups, three skill levels for the labor market of each sector, private enterprises, government, capital formation, imports, exports, regional, and international trade flows within Italy and the rest of the world. The environmental account is composed of values in metric ton for GHG and local pollutants sources of each individual sector at a regional and national levels.

Figure 14. Structure of the Regional SAM Augmented with Environmental Accounts

		Activity	Value-added			Institutions			Direct taxation	Savings-Investments	Export		Environmental externalities	Total
		63 sectors	Labor (low, mid, high skill)	Capital	Indirect taxation	Household (10th income decile)	Enterprises	Government	Taxes	Capital formation	Other Regions	Rest of the world		
Activity	63 sectors	*Intermediate Consumption*				*Consumption*		*Consumption*		*Investments*	*Export to other regions*	*Export to ROW*		Demand
Value added	Labor (low, mid, high skill)	*Wages*												Gross domestic product
	Capital	*Mixed income*												
	Indirect taxation	*Taxes*												
Institutions	Household (10th income decile)		*Labor income*	*Other income*		*Intra-houlehold transfers*	*Distributed profits*	*Govt trasfers to households*				*Income from abroad*		Institution incomes
	Enterprises			*Earnings b. taxes*				*Govt trasfers to enterprises*				*Transfer from ROW*		
	Government				*Tax transfer*	*Taxes/social security*	*Taxes*		*Tax transfer*	*Budget deficits*		*Transfer from ROW*		
Direct taxation	Taxes					*Taxes*	*Taxes*							Direct taxation
Savings-Investments	Capital formation					*Household savings*	*Enterprises savings*	*Budget surplus*				*Capital from abroad*		Saving
Import	Other Regions	*Imports from other Regions*				*Consumption*								Interregional trade
	Rest of the world	*Imports from ROW*				*Trasfers to ROW*		*Trasfers to ROW*						International trade
Environmental externalities														Payments to ROW
Total		Supply	Factor outlays			Institution expenditures			Direct taxation	Investments	Interregional trade	Income from ROW		

Source: Author's own elaboration.

3.3 Research Methodology

3.3.1 Integrated Environment-Economic Models

In this subsection, I illustrate the methodological foundation and the mathematical framework for developing the operational, environmentally integrated multi-regional social accounting matrix (EI-MRSAM) model for the Italian economy using linear algebra. Starting from a standard Leontief national input-output (I-O) open model,[14] I then accommodate spatial distribution of output and environmental GHG emissions with regional input-output dimensions (Polenske, 1970; Bon., 1984; Szabó, 2015).

3.3.2 The Multiregional SAM (MRSAM) Model for Italy

At a country level, a national open market economy can be split into integrated *m-regions* and consisting of *n-sectors* producing *n* different products. Let $\tau_{ij}^{rs} = \tau_i^{rs}$ for all sectors j, representing the flow of purchases in goods and services of a generic sector i from region r to the producing and final demand sectors in any other region s, regardless of the destination sector in the purchasing regions during a specific time period (i.e., a year). The superscripts $(r, s = 1, \dots, m)$ denote origin and destination regions, while the subscripts refer to sectors of industries. The Chenery-Moses multiregional input-output (MRIO) column coefficient model of the overall commodities traded between exporting and importing regions can be illustrated in **Table 24**. The diagonal entries contain the intra-regional trade flows within the individual regions, (i.e., τ_i^{ss}).

[14] The Leontief IO analytical technique distinguishes between closed and open production models. In a closed endogenous model, all outputs are also consumed internally as inputs within the industries without exogenous external demand; therefore, the focus is to find the relative price of each product. On the other hand, in an open model, the entire production is consumed both internally by industries and by other exogenous demand (i.e., consumers, government, etc.). Hence, the focus is to find the production level needed to satisfy a given or desired increase in demand (Moses, 1955; Miller et al., 2009).

Table 24. Intraregional and Interregional Trade Flows in Goods and Services

	Importing Region															
Exporting Region	***R1***	***R2***	***R3***	***R4***	***R5***	***R6***	***R7***	***R8***	***R9***	***R10***	***R11***	***R12***	…	***Rs***	…	***Rm***
R1	$\tau_i^{1,1}$	$\tau_i^{1,2}$	$\tau_i^{1,3}$	$\tau_i^{1,4}$	$\tau_i^{1,5}$	$\tau_i^{1,6}$	$\tau_i^{1,7}$	$\tau_i^{1,8}$	$\tau_i^{1,9}$	$\tau_i^{1,10}$	$\tau_i^{1,11}$	$\tau_i^{1,12}$	…	$\tau_i^{1,s}$	…	$\tau_i^{1,m}$
R2	$\tau_i^{2,1}$	$\tau_i^{2,2}$	$\tau_i^{2,3}$	$\tau_i^{2,4}$	$\tau_i^{2,5}$	$\tau_i^{2,6}$	$\tau_i^{2,7}$	$\tau_i^{2,8}$	$\tau_i^{2,9}$	$\tau_i^{2,10}$	$\tau_i^{2,11}$	$\tau_i^{2,12}$	…	$\tau_i^{2,s}$	…	$\tau_i^{2,m}$
R3	$\tau_i^{3,1}$	$\tau_i^{3,2}$	$\tau_i^{3,3}$	$\tau_i^{3,4}$	$\tau_i^{3,5}$	$\tau_i^{3,6}$	$\tau_i^{3,7}$	$\tau_i^{3,8}$	$\tau_i^{3,9}$	$\tau_i^{3,10}$	$\tau_i^{3,11}$	$\tau_i^{3,12}$	…	$\tau_i^{3,s}$	…	$\tau_i^{3,m}$
R4	$\tau_i^{4,1}$	$\tau_i^{4,2}$	$\tau_i^{4,3}$	$\tau_i^{4,4}$	$\tau_i^{4,5}$	$\tau_i^{4,6}$	$\tau_i^{4,7}$	$\tau_i^{4,8}$	$\tau_i^{4,9}$	$\tau_i^{4,10}$	$\tau_i^{4,11}$	$\tau_i^{4,12}$	…	$\tau_i^{4,s}$	…	$\tau_i^{4,m}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	…	⋮	…	⋮
Rr	$\tau_i^{r,1}$	$\tau_i^{r,2}$	$\tau_i^{r,3}$	$\tau_i^{r,3}$	$\tau_i^{r,3}$	$\tau_i^{r,3}$	$\tau_i^{r,7}$	$\tau_i^{r,8}$	$\tau_i^{r,9}$	$\tau_i^{r,10}$	$\tau_i^{r,11}$	$\tau_i^{r,12}$	…	$\tau_i^{r,s}$	…	$\tau_i^{r,m}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	…	⋮	…	⋮
Rm	$\tau_i^{m,1}$	$\tau_i^{m,2}$	$\tau_i^{m,3}$	$\tau_i^{m,4}$	$\tau_i^{m,5}$	τ_i^{m6}	$\tau_i^{m,7}$	$\tau_i^{m,8}$	$\tau_i^{m,9}$	$\tau_i^{m,10}$	$\tau_i^{m,11}$	$\tau_i^{m,12}$	…	$\tau_i^{m,s}$	…	$\tau_i^{m,m}$
Total trade flows	T_i^1	T_i^2	T_i^3	T_i^4	T_i^5	T_i^6	T_i^7	T_i^8	T_i^9	T_i^{10}	T_i^{11}	T_i^{12}	…	T_i^s	…	T_i^m

Source: Author's own elaboration.

Each column sum T_i^s in **Table 24** represents the total supplies of commodity i into region s from all other regions, including intraregional trade flows within the individual regions (i.e., τ_i^{ss}). Note that, since the total supplies in goods and services, regardless of regional origins, must be equivalent to both intermediate demands, denoted by $t_{ij}^{\bullet s}$ (where the dot superscript indicates all possible geographical locations of sector i), and exogenous final demands $f_i{}^s$, for each commodity i in region s, I have:

$$T_i^s = \sum_{s=1}^{m} \tau_i^{r,s} = \overbrace{\left(\sum_{j=1}^{n} \overbrace{(a_{ij}^{\bullet s} x_j^s)}^{t_{ij}^{\bullet s}} + f_i{}^s \right)}^{T_i^s} \qquad \begin{matrix} (r = 1, 2 \ldots, m) \\ (i = 1, 2 \ \ldots, n) \end{matrix} \qquad (3.1)$$

In Equation (3.1), the technology or technical coefficients for each receiving region in the model indicated by $a_{ij}^{\bullet s} = (t_{ij}^{\bullet s}/x_j^s)$, can be expressed as a non-negative ratio measuring the quantity of sector i inputs required to produce one unit of sector $j's$ total output located in region s. In addition, from **Table 24**, I can estimate the interregional trade coefficient denoted by $d_i^{rs} = (\tau_i^{rs}/\ T_i^s)$, expressed as a ratio measuring the fraction of total supplies, $T_i{}^s$, of commodity i in region r that is shipped to region s. The trade coefficients assume fixed regional supply patterns of any given inputs among all purchasers, including the final users of each commodity in a specific region (see, Isard, 1951; Miller et. al., 2009; Boero et. al., 2018, Agbonifi, 2023b). Note that these column trade coefficients must add up to unity when summed column-wise over the purchasing regions, where $\sum_{r=1}^{m} d_i^{rs} = 1\ (for\ all\ i)$.

In addition, by substituting the structural equation $\tau_i^{rs} = (d_i^{rs}/T_i^{s})$ into the right-hand side of Equation (3.1) I obtain:

$$x_i^r = \overbrace{\sum_{s=1}^{m} \overbrace{d_i^{rs} T_i^{s}}^{\tau_i^{rs}}}^{T_i^s} = \sum_{s=1}^{m} d_i^{rs} \overbrace{\left(\sum_{j=1}^{n} \overbrace{(a_{ij}^{\bullet s} x_j^s)}^{t_{ij}^{\bullet s}} + f_i^{s} \right)}^{T_i^s} = \sum_{s=1}^{m} \sum_{j=1}^{n} d_i^{rs} (a_{ij}^{\bullet s} x_j^s) + \sum_{s=1}^{m} d_i^{rs} f_i^s \qquad \begin{matrix} (r = 1, 2 \dots, m) \\ (i = 1, 2 \dots, n) \end{matrix} \qquad (3.2)$$

where x_i^r is the total production output (supply) of commodity i in region r for $(r = 1, \dots, m)$. From Equation (3.2), I can express the Chenery-Moses multiregional economic model for m-regions and n-sectors of industries as stated below:

$$\mathbf{x}^{r\star} = \sum_{s=1}^{m} \boldsymbol{D}^{rs} (\boldsymbol{A}^{s} \mathbf{x}^{s} + \mathbf{f}^{s}) = \sum_{s=1}^{m} \boldsymbol{D}^{rs} \boldsymbol{A}^{s}\, \mathbf{x}^{s} + \sum_{s=1}^{m} \boldsymbol{D}^{rs} \mathbf{f}^{s} \qquad (r = 1, 2 \dots, m) \qquad (3.3)$$

In matrix notation I have:

$$\mathbf{x}^{\star\star} = \begin{bmatrix} \mathrm{x}^1 \\ \mathrm{x}^2 \\ \vdots \\ \mathrm{x}^{\mathrm{m}} \end{bmatrix}, \text{ where, } \mathbf{A}^{\star\star} = \begin{bmatrix} \mathbf{A}^{\mathrm{r},1} & 0 & \cdots & 0 \\ 0 & \mathbf{A}^{\mathrm{r},2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \mathbf{A}^{\mathrm{r,m}} \end{bmatrix} \text{ and, } \Delta\mathbf{f} = \begin{bmatrix} \mathrm{f}^{\mathrm{r}1} \\ \mathrm{f}^{\mathrm{r}2} \\ \vdots \\ \mathrm{f}^{\mathrm{rm}} \end{bmatrix}$$

$$\mathbf{I} = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1 \end{bmatrix} \qquad (3.4)$$

$$\mathbf{D}^{\star\star} = \begin{bmatrix} \mathbf{D}^{1,1} & \mathbf{D}^{2,1} & \cdots & \mathbf{D}^{\mathrm{m},1} \\ \mathbf{D}^{1,2} & \mathbf{D}^{2,2} & \cdots & \mathbf{D}^{\mathrm{m},2} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{D}^{1,\mathrm{m}} & \mathbf{D}^{2,\mathrm{m}} & \cdots & \mathbf{D}^{\mathrm{m,m}} \end{bmatrix}, \text{ where, } \mathbf{D}^{r,s} = \begin{bmatrix} d_1^{r,s} & 0 & \cdots & 0 \\ 0 & d_2^{r,s} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & d_n^{r,s} \end{bmatrix} \qquad (3.5)$$

Note that throughout the text, matrices are denoted by bold capital letters, vectors by bold small letters unless indicated otherwise. Here, matrices $\mathbf{x}$ and $\mathbf{f}$ denotes the vectors of total outputs and final demands of sectors located in region r, respectively, for $(r = 1, \dots, m)$. Matrix $\boldsymbol{A}^{\star\star}$ is a block of diagonal-matrix of regional IO technical coefficients in all regions, with each of the submatrices along the principal diagonal and the elements on the off-diagonal equal to zero. **I** denote an $n \times n$ identity matrix. Furthermore, $\boldsymbol{D}^{\star\star}$ is a block of interregional trade coefficients matrix, with each of the submatrices (i.e., $\boldsymbol{D}^{r\delta}$ and $\boldsymbol{D}^{\delta\delta}$) containing the trade coefficients for n-*traded* commodities, while the off-diagonal elements equal to zero.

3.3.3 The Environmentally Integrated Multiregional SAM (EI-MRSAM) model for Italy

Similarly, environmental externalities induced by human activities can be incorporated in a measurable way (i.e., in metric ton of CO2) into the standard IO analysis and, by extension, the MRSAM model (Tukker et al., 2006; Agbonifi, 2023a). The environmental account is composed of values in metric ton for the emission sources of each individual sector at regional and national levels. The pollutant sources and their corresponding average nominal monetary cost rates per metric ton are illustrated in **Table 25** below:

Table 25. Environmental Prices per Metric tons of Pollutants

Pollutants	Formula	Measurement unit	Prices (€/unit)
Carbon dioxide	CO_2	tonnes of CO_2-eq	€ 180
Methane	CH_4	tonnes of CO_2-eq	€ 180
Nitrous Oxide	N_2O	tonnes of CO_2-eq	€ 180
Hydrofluorocarbons	HFCs	tonnes of CO_2-eq	€ 180
Perfluorocarbons	PFCs	tonnes of CO_2-eq	€ 180
Sulphur hexafluoride	SF_6	tonnes of CO_2-eq	€ 180
Nitrogen trifluoride	NF_3	tonnes of CO_2-eq	€ 180
Greenhouse gas emissions	GHG	tonnes of CO_2-eq	€ 180
Ammoniac	NH_3	tonnes	€ 32000
Particulate matter	PM10	tonnes	€ 41200

Note: The GHG emissions refers to the so-called "Kyoto basket" group of seven gases which includes carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases F-gases (HFC, PFCs, SF_6 and NF_3) are expressed in a common unit, tonnes of CO2-equivalents produced by each industrial sector in Italy and the regional levels.

Source: Matthey & Bünger (2018).

Environmental prices at pollutant level indicate the loss of economic welfare to society when additional unit of the pollutant finds its way into the environment (the Bruyn, et al., 2018). The study conducted by Matthey et al. (2018) of the German Environmental Agency on the methodological convention for assessing environmental costs recommend using a cost rate of 180 euros per ton of CO_2-eq. The cost rates for CO_2 and other local pollutants shown in **Table 25** are determined mainly using the damage cost approach caused by climate change, which estimates the average GHG emissions in specific countries (see, for example, Matthey et. al., 2018; TSD, 2016). Given the emissions of substances m_i , the corresponding pollutant coefficients for each receiving region in the model, indicated by $e_{ij}^{\bullet s} = (m_{ij}^{\bullet s}/x_j^s)$, can be expressed as a ratio measuring the quantity of pollutants (i.e., in metric tons of CO2) emitted to produce one unit of sector $j's$ total output of each industry located in region s (Tukker et. al., 2006; Hyland et. al., 2012). The corresponding EI-MRSAM model can be illustrated below:

$$\mathbf{x}^{r\star\star} = \sum_{s=1}^{m} \mathbf{E}^{rs}(\mathbf{I} - \mathbf{D}^{rs}\mathbf{A}^{s})^{-1}\mathbf{D}^{rs}\,\mathbf{f}^{s} \qquad (r = 1, 2 \ldots, m) \qquad (3.6)$$

The matrix form becomes

$$\mathbf{E}^{\star\star} = \begin{bmatrix} \mathbf{E}^{1,1} & \mathbf{E}^{1,2} & \cdots & \mathbf{E}^{1,m} \\ \mathbf{E}^{2,1} & \mathbf{E}^{2,2} & \cdots & \mathbf{E}^{2,m} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{E}^{m,1} & \mathbf{E}^{m,2} & \cdots & \mathbf{E}^{m,m} \end{bmatrix}, \text{ where, } \mathbf{E}^{r,s} = \begin{bmatrix} e_1^{r,s} & 0 & \cdots & 0 \\ 0 & e_2^{r,s} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & e_n^{r,s} \end{bmatrix} \qquad (3.7)$$

From Equations (3.3), (3.6) and (3.7), the solution equation for the vector of endogenous outputs $\Delta\mathbf{x}$ is obtained as follows:

$$\begin{aligned} \Delta\mathbf{x} &= \mathbf{D}^{\star\star}\mathbf{A}^{\star\star}\Delta\mathbf{x} + \mathbf{E}^{\star\star}\mathbf{D}^{\star\star}\mathbf{f} \\ (\mathbf{I} - \mathbf{D}^{\star\star}\mathbf{A}^{\star\star})\Delta\mathbf{x} &= \mathbf{E}^{\star\star}\mathbf{D}^{\star\star}\Delta\mathbf{f} \\ \Delta\mathbf{x} &= (\mathbf{I} - \mathbf{D}^{\star\star}\mathbf{A}^{\star\star})^{-1}\mathbf{E}^{\star\star}\mathbf{D}^{\star\star}\mathbf{f} \end{aligned} \qquad (3.8)$$

Here, $\boldsymbol{E}^{\star\star}$ is a block of interregional pollutant coefficients matrix, with each of the submatric*es (i.e.,* $\boldsymbol{E}^{rs}$ and $\boldsymbol{E}^{ss}$*)* containing the pollutant coefficients for *n-traded* commodities, while the off-diagonal elements are equal to zero. Equation (3.8) relates $E^{\star\star}$ to both production and final demand **(**Agbonifi, 2023a, Hyland et. al*.,* 2012). Finally, from Equation (3.8), I can calculate the changes in the equilibrium regional outputs $\Delta\mathbf{x}$, given the matrices $\mathbf{A}^{\star\star}$, $\mathbf{D}^{\star\star}$, and $\mathbf{E}^{\star\star}$, as well as the vector of regional exogenous final demand shock, $\mathbf{f}$. As illustrated by Miller et. al. (2009), to assess the impacts of new regional-specific demand shock, it is necessarily to replace $\mathbf{D}^{\star\star}\mathbf{f}$ with, $\mathbf{f}$.

3.4 Empirical Results

3.4.1 The Estimation of Interregional Trade Flows

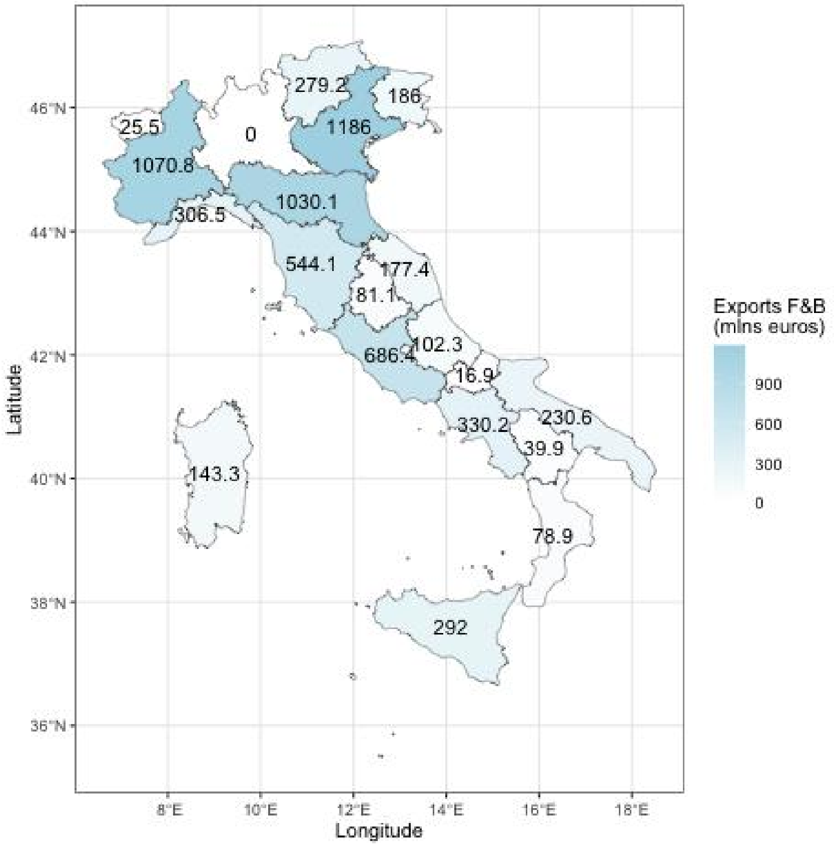
The construction of the multiregional model for the 20 Italian regions is based on regional SAMs with interregional trade flow estimates, adopting a non-survey methodology. This approach was dictated by cost-related issues and the fact that there is no information on interregional trade flows for different sectors either at national or regional level (Huang & Koutroumpis, 2023). Here, interregional trade was estimated using the cross-hauling adjusted regionalization method (CHARM) model proposed by Kronenberg (2009) and subsequently refined by Többen et al. (2015) with some adaptations. Cross-hauling in interregional trade is the process in which each region simultaneously exports and imports the output of a generic sector *i* (Fujimoto, 2019). The model assumes that cross-hauling in interregional trade is proportional to the cross-hauling potential determined by the amount of output or demand. Particularly, interregional import-export is zero-sum at the national level, where the sum of regional exports by branch corresponds to the sum of regional imports. **Figure 15** below illustrates the values of interregional trade exports and imports of food and beverages (F&B) between the Lombardy region and the other 19 Italian regions estimated with the CHARM model. As shown in the Appendix in **Figure A3.1.** Lombardy Interregional Trade Balance in Food and Beverages with the Rest of ItalyLombardy records an active interregional trade balance in terms of F&B products with respect to the regions of Lazio (€188.39Mln), Sicily (€72.87Mln), Liguria (€50.24Mln). However, it has a negative interregional trade balance relative to Veneto (-€299.24Mln), Emilia-Romagna (-€271.67Mln), Piedmont (-€199.06Mln), and Friuli-Venezia Giulia region (-€40.58Mln). The total interregional trade relative to all sectors between Lombardy and the rest of Italy is illustrated in the Appendix **Table A3.2.** Estimates of Lombardy Interregional Trade Flows with the Rest of Italy

Furthermore, to determine the allocation of outflows from each region to the remaining regions, a gravitational model was employed. This model is based on the inverse distance between regions, measured by the centroid of each region, and is weighted by an indicator as follows: (Purchasing power region *i* / national purchasing power) x population region *i*. This approach yields a value representing the regional population weighted by the purchasing power index, defining the potential for "comparative purchasing" of each region. Subsequently, the interregional flows were calibrated using a spatial interaction procedure (see, Wilson, 1971; Fotheringham, 1983a, 1983b; Dennet, 2012), ensuring the consistency of outgoing and incoming flows for each region.

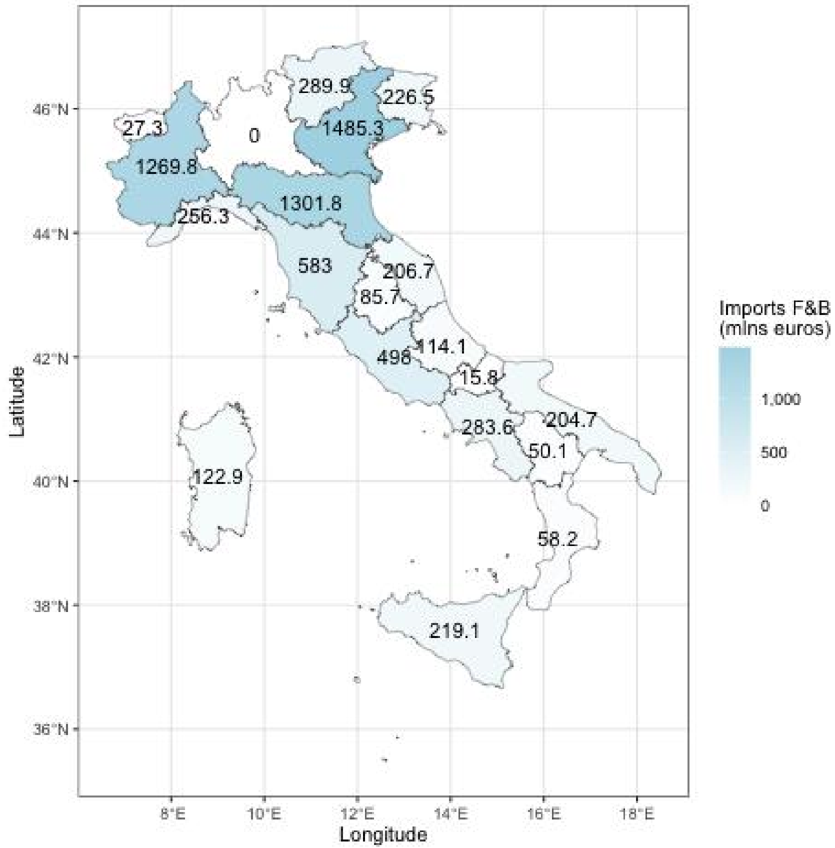
The EI-MRSAM model is formulated using the following four assumptions. (1) No substitution among inputs is allowed to occur. (2) Constant trade coefficients. Thus, no substitution among supplying regions is allowed to occur. A region is expected to continue supplying a given fraction of the consumption of another region over time. No empirical verification of this assumption has been possible because of the lack of data. (3) Constant industrial shares. Thus, each industry in a given region is assumed to continue purchasing a fixed share of the total amount of a given good supplied to the region. Again, because of the lack of data, no empirical testing of this assumption has been made. By incorporating this assumption, however, the amount of data required to implement the model is drastically reduced. (4) Excess capacity. All producers and transportation facilities are assumed to be operating at less than full capacity.

Figure 15. Lombardy Interregional Trade Flows and the Rest of Italy

Exports: Food and Beverages (F&B)



Imports: Food and Beverages (F&B)



Note: Figure 15 shows the total values of interregional trade (exports and imports) of approximately (+€6807.32Mln) and (-€7298.86Mln), respectively, in food and beverages products between Lombardy and 19 other Italian regions. This corresponds to a trade balance of (-€491.54Mln). In this diagram, Lombardy's intra-regional exports and imports are set to zero by design to better reflect the trade flows.
Source: Author's elaborations based on Italy's MRSAM.

3.4.2 Intra-regional and Inter-regional Impacts of Investments in Green Projects

The socioeconomic impact of the (€1981.18Mln) investments in green projects on the economy is obtained by applying the demand-driven shock vector illustrated in **Table 26**. About 60.5% of the baseline investments funds are allocated to the health sector, while about 24% is allocated to green revolution and ecological transition. The baseline allocation illustrates the approved implementations of the regional investment funds by decision-makers. In contrast, the reallocation illustrates the counterfactual ex-ante macro-policy evaluation of a 25% endogenous increase in the baseline NGEU investments corresponding to (€495.30Mln) reallocated to each of the observed missions illustrated in **Table 26**. The main purpose of the counterfactual evaluation exercise is to identify the most efficient reallocations in terms of value-added return on the NGEU investment benefits for the regional and national economy. This would lead to insights for making informed investment and environmental policy decision analysis in terms of the accountability of public expenditures in green projects.

Table 26. NGEU-investments in the Lombardy Region, Italy

(0)			(1)	(2)	(3)	(5)	(6)
Actual policy			Counterfactual policy evaluation				
NGEU Missions	Baseline (€Mln)	Share (%)	M1 (€ Mln)	M2 (€ Mln)	M3 (€ Mln)	M5 (€ Mln)	M6 (€ Mln)
Mission 1.	87.89	4.44	583.18	87.89	87.89	87.89	87.89
Mission 2.	467.88	23.62	467.88	963.17	467.88	467.88	467.88
Mission 3.	59.40	3.00	59.40	59.40	554.70	59.40	59.40
Mission 5.	168.12	8.49	168.12	168.12	168.12	663.42	168.12
Mission 6.	1197.90	60.46	1197.90	1197.90	1197.90	1197.90	1693.19
Total	**1981.18**	**100%**	**2476.48**	**2476.48**	**2476.48**	**2476.48**	**2476.48**
NGEU-investments							
Difference (€Mln)			495.30	495.30	495.30	495.30	495.30
Changes (%)			25.00%	25.00%	25.00%	25.00%	25.00%

Note: M1: Digitalization, Innovation, Competitiveness and Culture. M2: Green Revolution and Ecological Transition. M3: Infrastructures for Sustainable Mobility. M5: Inclusive Cohesion. M6: Health. Details on the investments allocation to the various missions are illustrated in Appendix A3

Source: Adapted from Corte dei Conti (2021) - Regione Lombardia

3.4.3 Intra-regional on Value-Added in Lombardy

Table 27 illustrates the intraregional impact on value-added (GDP) in the Lombardy region calculated using the MRSAM model both for both the baseline and the reallocation scenarios. In the baseline scenario, regional investments of €1981.18Mln generate an impact of €3602.29Mln on intraregional value-added. Furthermore, the intra-regional value-added GDP impact of €3602.29Mln, divided by the investment costs of €1981.18Mln is equal to the size of the short-term fiscal spending multiplier of 1.82. The size of fiscal policy response in Lombardy is higher compared to Apulia region due to its capacity retain value-added for every unit of fiscal spending allocated to the region. Almost 46.5% of the intraregional value-added impact accrues to capital income, while 19.5% and 11.8% are attributed to wages of high-skilled and low-skilled labor, respectively. In contrast, as illustrated in **Table 27**, an endogenous increase in the NGEU investment of €495.30Mln in digital transformation of public-administration (M1) generates the most impact on intraregional value-added of €1052.05Mln compared to other counterfactual outcomes. This corresponds to a 29.21% regional value-added increase relative to the baseline scenario. In effects, the proposed M1 interventions combine investments in new equipment and services to consolidate the existing digital infrastructure for the Italian public administration and providing new digital competencies to civil servants (Camera dei deputati, 2021).

Table 27. Intra-regional Impact on Value-Added (€ Mln)

	(0)		(1)	(2)	(3)	(5)	(6)
	Actual policy		Counterfactual policy evaluation				
Sectors	Baseline (€Mln)	Share (%)	M1 (€ Mln)	M2 (€ Mln)	M3 (€ Mln)	M5 (€ Mln)	M6 (€ Mln)
Income (low skilled)	426.92	11.85	548.75	533.13	543.77	544.98	530.66
Income (middle skilled)	703.04	19.52	909.22	866.10	872.85	904.63	878.20
Income (high skilled)	294.32	8.17	382.29	359.08	358.59	380.83	368.94
Capital income	1673.10	46.45	2161.73	2065.49	2085.36	2150.19	2088.37
Indirect taxes	504.90	14.02	652.35	623.31	629.30	648.87	630.21
Value-added (GDP)	**3602.29**	**100%**	**4654.34**	**4447.12**	**4489.87**	**4629.49**	**4496.39**
Household consumption	3118.48	100%	4029.23	3849.83	3886.85	4007.72	3892.50
Counterfactual impact							
Value-added							
Difference (€ Mln)			1052.05	844.83	887.58	1027.20	894.10
Changes (%)			29.21%	23.45%	24.64%	28.52%	24.82%
Household consumption							
Difference (€ Mln)			910.76	731.36	768.37	889.24	774.02
Changes (%)			29.21	23.45	24.64	28.52	24.82

Note: Total may not sum due to rounding. The source of induced effects on household consumption is the link from regional wages to labor and household spending. M1: Digitalization, Innovation, Competitiveness and Culture. M2: Green Revolution and Ecological Transition. M3: Infrastructures for Sustainable Mobility. M5: Inclusive Cohesion. M6: Health.
Source: Author's calculations based on Italy's MRSAM.

3.4.4 Interregional Impact on Value-Added on the Rest of Italy

As shown in **Table 28**, the NGEU investments of €1981.18Mln in the Lombardy region impact on interregional value-added in the rest of Italy, estimated using the MRSAM model is €1029.45Mln in the baseline scenario. Almost 54% of the interregional value-added accrues to the Northern regions, 26% to the Central regions, while about 20% spills over to the regions in Southern Italy. **Table 28** also illustrates the investments impact on interregional value-added with respect to the counterfactual simulations. The counterfactual results show the difference and percentage change in value-added impact between a 25% endogenous increase in the NGEU investments reallocated to each of the observed missions compared with the value-added impact of the actual policy. An endogenous increase in investment of €495.30Mln in Health (M6) and Infrastructures for Sustainable Mobility (M3) generates an increase of 26.3% and 26.1% in expected interregional value-added, respectively, relative to the baseline scenario. The distributional impact on households' consumption expenditure is also consistent with those of value-added, as illustrated in the Appendix **Table A3.3.** NGEU Investments Induced Impact on Household Interregional Consumption Expenditures

Table 28. NGEU Investments Impact on Inter-regional Value-Added (GDP)

	(0)		(1)		(2)		(3)		(5)		(6)	
	Actual policy		Counterfactual investment impacts on value-added (GDP)									
Regions in Italy	Baseline (€ Mln)	Share (%)	Diff M1 (€ Mln)	Change (%)	Diff M2 (€ Mln)	Change (%)	Diff M3 (€ Mln)	Change (%)	Diff M5 (€ Mln)	Change (%)	Diff M6 (€ Mln)	Change (%)
Piedmont	135.37	*13.15*	32.09	*23.70*	31.25	*23.08*	37.55	*27.74*	32.32	*23.87*	35.02	*25.87*
Aosta Valley	4.10	*0.40*	0.96	*23.49*	0.91	*22.29*	1.03	*25.10*	0.99	*24.15*	1.08	*26.27*
Liguria	52.51	*5.10*	10.40	*19.81*	10.73	*20.43*	13.21	*25.16*	11.92	*22.69*	14.43	*27.48*
Trentino-Alto Adige	43.73	*4.25*	8.63	*19.74*	9.22	*21.09*	12.61	*28.84*	9.77	*22.35*	11.85	*27.09*
Veneto	148.55	*14.43*	35.21	*23.70*	34.53	*23.24*	42.10	*28.34*	35.26	*23.73*	38.32	*25.79*
Friuli-Venezia Giulia	29.69	*2.88*	6.99	*23.55*	6.76	*22.77*	8.01	*26.99*	7.05	*23.75*	7.73	*26.05*
Emilia-Romagna	141.23	*13.72*	33.56	*23.76*	32.87	*23.27*	39.97	*28.30*	33.47	*23.70*	36.41	*25.78*
Tuscany	84.36	*8.19*	19.82	*23.50*	19.11	*22.65*	22.14	*26.24*	20.23	*23.98*	22.03	*26.11*
Umbria	12.46	*1.21*	2.97	*23.80*	2.84	*22.76*	3.26	*26.15*	2.98	*23.90*	3.25	*26.07*
Marche	24.93	*2.42*	5.93	*23.79*	5.77	*23.15*	6.88	*27.62*	5.90	*23.66*	6.45	*25.86*
Lazio	143.00	*13.89*	27.03	*18.90*	27.81	*19.45*	32.86	*22.98*	31.76	*22.21*	40.19	*28.11*
Abruzzo	14.97	*1.45*	3.59	*23.99*	3.45	*23.02*	4.00	*26.70*	3.58	*23.88*	3.88	*25.93*
Molise	2.73	*0.26*	0.70	*25.64*	0.62	*22.82*	0.66	*24.32*	0.67	*24.69*	0.71	*25.94*
Campania	57.23	*5.56*	14.10	*24.64*	12.72	*22.22*	13.58	*23.73*	14.03	*24.51*	15.02	*26.24*
Apulia	37.37	*3.63*	9.76	*26.13*	8.50	*22.74*	8.89	*23.80*	9.33	*24.96*	9.67	*25.87*
Basilicata	4.82	*0.47*	1.21	*25.04*	1.14	*23.73*	1.34	*27.73*	1.15	*23.83*	1.23	*25.49*
Calabria	16.39	*1.59*	4.58	*27.93*	3.71	*22.61*	3.67	*22.37*	4.20	*25.62*	4.22	*25.76*
Sicily	54.13	*5.26*	14.38	*26.57*	12.07	*22.30*	12.16	*22.47*	13.73	*25.36*	14.08	*26.01*
Sardinia	21.88	*2.13*	5.82	*26.59*	4.96	*22.67*	5.13	*23.45*	5.52	*25.21*	5.66	*25.84*
Macro Regions												
North-West	191.98	*18.65*	43.45	*22.63*	42.89	*22.34*	51.78	*26.97*	45.22	*23.56*	50.52	*26.32*
North-East	363.20	*35.28*	84.39	*23.24*	83.37	*22.96*	102.69	*28.27*	85.55	*23.55*	94.31	*25.97*
Centre	264.75	*25.72*	55.75	*21.06*	55.52	*20.97*	65.14	*24.61*	60.86	*22.99*	71.92	*27.16*
South and Islands	209.52	*20.35*	54.15	*25.84*	47.17	*22.51*	49.43	*23.59*	52.20	*24.91*	54.46	*25.99*
Italy's other regions	**1029.45**	***100.00***	**237.74**	***23.09***	**228.95**	***22.24***	**269.05**	***26.14***	**243.84**	***23.69***	**271.21**	***26.35***

Note: Totals may not sum due to rounding. The counterfactual results show the difference and percentage change in value-added impact between a 25% endogenous increase in the NGEU-investments corresponding to and additional (€495.30Mln) reallocated to each of the observed missions compared with the baseline value-added impact of the actual policy.

Source: Author's calculations based on Italy's MRSAM.

3.4.5 The NGEU Impact on National Value-Added in Italy

The total investment impact at a national level national corresponds to the sum of intra-regional and interregional impacts, as illustrated in **Table 29**. The regional investments of €1981.18Mln generate €4631.74Mln in national value-added in the baseline scenario. Meanwhile, in the baseline scenario, almost 89% of the total value-added impact accrues to the Northern regions, 6% to the Central regions, while the residual 5% is accredited to Southern Italy. In contrast, as illustrated, the counterfactual endogenous increase in investment of €495.30Mln in digital transformation of the public-administration (M1) and Inclusive Cohesion (M5) generates an increase of 27.8% and 27.4% in expected national value-added, respectively, relative to the baseline scenario. In **Table 29**, the distributional impact on household consumption is also consistent with that of value-added.

Table 29. NGEU Investment Impact on National Value-Added and Household Consumption

	(0)		(1)	(2)	(3)	(5)	(6)
	Actual policy		Counterfactual policy evaluation				
Sectors	Baseline (€Mln)	Share (%)	M1 (€ Mln)	M2 (€ Mln)	M3 (€ Mln)	M5 (€ Mln)	M6 (€ Mln)
Income (low skilled)	**553.61**	*11.95%*	704.91	688.40	704.51	701.59	690.51
Income (middle skilled)	**900.62**	*19.44%*	1152.35	1107.48	1121.75	1149.02	1127.92
Income (high skilled)	**375.72**	*8.11%*	482.38	458.31	460.55	481.59	471.92
Capital income	**2161.07**	*46.66%*	2762.47	2662.04	2700.91	2753.76	2704.86
Indirect taxes	**640.72**	*13.83%*	819.43	789.30	800.66	816.82	801.84
Value-added (GDP)	**4631.74**	***100%***	**5921.53**	**5705.52**	**5788.37**	**5902.77**	**5797.05**
Counterfactual impact							
Difference (€ Mln)			1289.79	1073.78	1156.63	1271.04	1165.32
Changes (%)			*27.85%*	*23.18%*	*24.97%*	*27.44%*	*25.16%*
Italy's macro regions							
Value-added							
North-West	3794.27	*81.92%*	4889.77	4681.99	4733.63	4866.69	4738.89
North-East	363.20	*7.84%*	447.60	446.58	465.89	448.75	457.51
Centre	264.75	*5.72%*	320.49	320.27	329.89	325.61	336.66
South and Islands	209.52	*4.52%*	263.67	256.69	258.96	261.72	263.98
Household consumption							
North-West	3293.31	*81.10%*	4243.68	4063.75	4108.87	4223.75	4113.33
North-East	317.10	*7.81%*	390.91	389.95	406.72	391.84	399.40
Centre	239.96	*5.91%*	290.57	290.34	299.06	295.15	305.10
South and Islands	210.20	*5.18%*	264.56	257.51	259.73	262.59	264.83
Total	**4060.56**	**100%**	**5189.72**	**5001.55**	**5074.38**	**5173.32**	**5082.66**

Note: Total may not sum due to rounding. The source of induced effects on household consumption is the link from regional wages to labor and household spending. M1: Digitalization, Innovation, Competitiveness and Culture. M2: Green Revolution and Ecological Transition. M3: Infrastructures for Sustainable Mobility. M5: Inclusive Cohesion. M6: Health.
Source: Author's calculations based on Italy's MRSAM.

3.4.6 The NGEU Investment Economy-Environmental Impacts

Finally, **Table *30*** estimate the investment's total impact on value-added and household consumption-induced GHG emissions using the EI-MRSAM model. Lombardy's intra-regional investment impact on value-added (GDP) accounts for almost 78%, while 22% accrues to the rest of Italy in terms of interregional value-added spillover effects through trade channels. On the other hand, **Figure 16** illustrates the investment's interregional impact on adjusted value-added and household consumption after internalizing the social costs of GHG emissions. The social costs of GHG emissions are assumed to be €180 per metric ton of CO_2-equivalent as illustrated in **Table 25**. The total investment impact on the regional and national economy decreases by around 10% of value-added net effects after internalizing the social environmental costs of climate change damages induced by industrial GHG emissions. Further details on the total value-added and household consumption-induced pollutants or emissions sources in metric tons are illustrated in the Appendix **Table A3.4.** NGEU Investments Impact on Value-Added (GDP) - Induced emission Sources in Metric tons across Italyand **Table** A3.5 NGEU Investments Impact on Household Consumption Expenditures - Induced emissions Sources in Metric tons across Italy

Table 30. NGEU Investment Impact on National Value-Added and Household Consumption Induced GHG Emissions

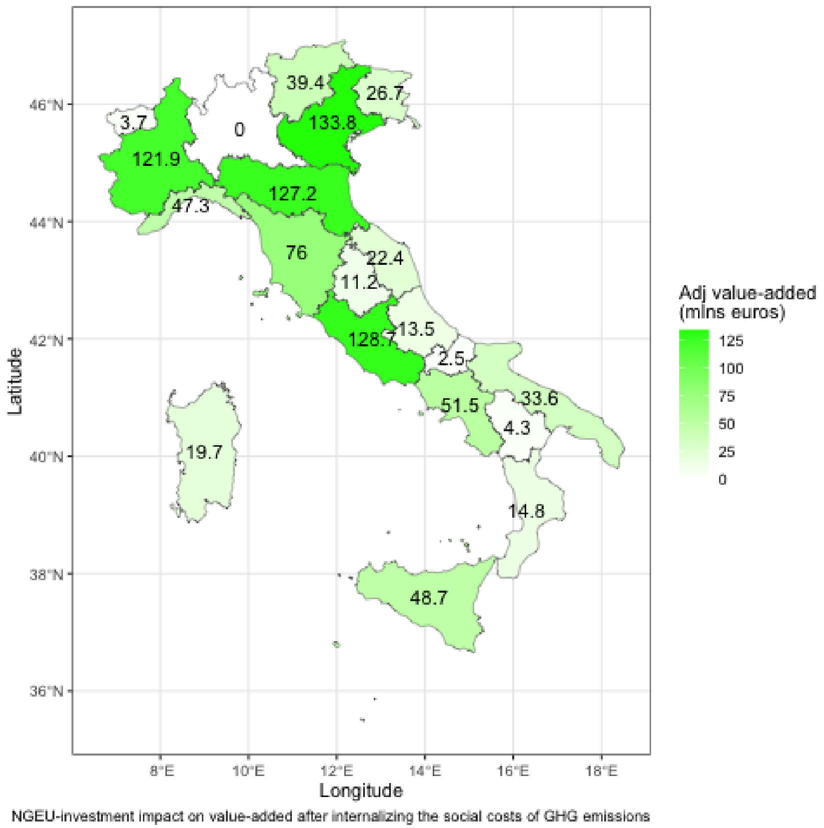
	NGEU- Investment impacts on value-added induced GHG emissions					NGEU-investment impact on Household consumption induced GHG emissions				
Regions in Italy	Value-added (€ Mln)	Share (%)	GHG costs (€ Mln)	GHG_CO2E (metric tons)	Adj_value-added (€ Mln)	Consumption (€ Mln)	Share (%)	GHG costs (€ Mln)	GHG_CO2E (metric tons)	Adj_consumption (€ Mln)
Piedmont	135.37	*2.92*	13.49	74942.28	121.88	124.36	*3.06*	12.39	68845.50	111.97
Aosta Valley	4.10	*0.09*	0.41	2269.75	3.69	3.46	*0.09*	0.35	1917.11	3.12
Liguria	52.51	*1.13*	5.23	29068.35	47.28	47.02	*1.16*	4.68	26027.43	42.33
Lombardy	*3602.29*	*77.77*	*358.96*	*1994219.90*	*3243.33*	*3118.48*	*76.80*	*310.75*	*1726383.44*	*2807.73*
Trentino-Alto Adige	43.73	*0.94*	4.36	24209.97	39.37	34.98	*0.86*	3.49	19362.11	31.49
Veneto	148.55	*3.21*	14.80	82238.71	133.75	130.27	*3.21*	12.98	72114.50	117.28
Friuli-Venezia Giulia	29.69	*0.64*	2.96	16436.34	26.73	27.47	*0.68*	2.74	15206.80	24.73
Emilia-Romagna	141.23	*3.05*	14.07	78183.05	127.15	124.39	*3.06*	12.39	68859.90	111.99
Tuscany	84.36	*1.82*	8.41	46701.01	75.95	76.68	*1.89*	7.64	42449.37	69.04
Umbria	12.46	*0.27*	1.24	6898.94	11.22	12.15	*0.30*	1.21	6728.44	10.94
Marche	24.93	*0.54*	2.48	13799.55	22.44	23.24	*0.57*	2.32	12867.29	20.93
Lazio	143.00	*3.09*	14.25	79163.47	128.75	127.88	*3.15*	12.74	70793.61	115.14
Abruzzo	14.97	*0.32*	1.49	8287.37	13.48	13.90	*0.34*	1.39	7695.57	12.52
Molise	2.73	*0.06*	0.27	1509.11	2.45	2.76	*0.07*	0.27	1525.72	2.48
Campania	57.23	*1.24*	5.70	31682.99	51.53	56.44	*1.39*	5.62	31243.43	50.81
Apulia	37.37	*0.81*	3.72	20686.87	33.64	38.91	*0.96*	3.88	21539.96	35.03
Basilicata	4.82	*0.10*	0.48	2668.90	4.34	4.57	*0.11*	0.46	2529.94	4.11
Calabria	16.39	*0.35*	1.63	9075.69	14.76	16.61	*0.41*	1.65	9193.61	14.95
Sicily	54.13	*1.17*	5.39	29965.73	48.74	54.88	*1.35*	5.47	30383.70	49.41
Sardinia	21.88	*0.47*	2.18	12114.95	19.70	22.13	*0.55*	2.21	12252.24	19.93
Macro Regions										
North-West	3794.27	*81.92*	378.09	2100500.28	3416.18	3293.31	*81.10*	328.17	1823173.48	2965.14
North-East	363.20	*7.84*	36.19	201068.06	327.01	317.10	*7.81*	31.60	175543.30	285.50
Centre	264.75	*5.72*	26.38	146562.97	238.36	239.96	*5.91*	23.91	132838.71	216.04
South and Islands	209.52	*4.52*	20.88	115991.61	188.64	210.20	*5.18*	20.95	116364.18	189.25
Italy	**4631.74**	***100%***	**461.54**	**2564122.92**	**4170.20**	**4060.56**	***100%***	**404.63**	**2247919.67**	**2965.14**

Note: Totals may not sum due to rounding. Induced effect measures the impact on household consumption. The source of induced effects is the link from regional wages to labor and household spending.

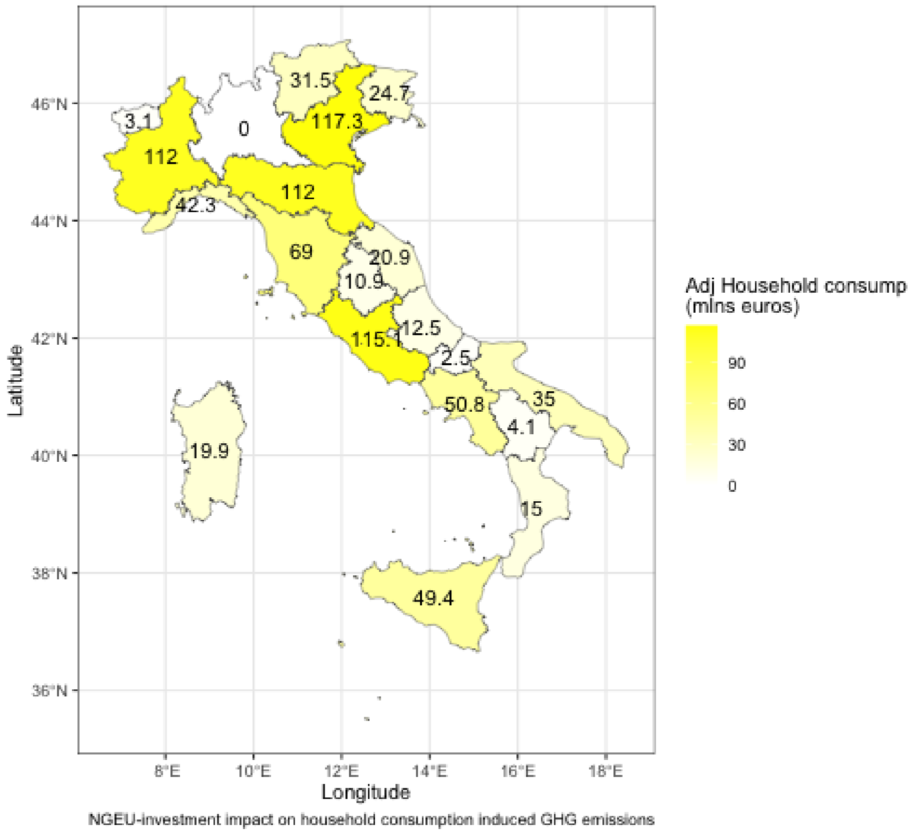
Source: Author's calculations based on Italy's MRSAM.

Figure 16. NGEU Investment Impact on Interregional Value-Added (GDP) and Household Induced GHG Emissions

Value-Added - Induced GHG Emissions



Household Consumption - Induced GHG Emissions



Note: Figure 16 shows the impact of the NGEU investments made in the Lombardy region on the other 19 Italian regions in terms of interregional spillover effects on value-added and households' consumption-induced GHG emissions in CO2 equivalent. The social costs of GHG emissions are assumed to be (€180) per metric ton of CO_2-eq. Here the Lombardy intra-regional investment impact on value-added and household consumption-induced GHG emissions is set to zero by construction to better reflect the interregional spillover effects.

Source: Author's elaborations based on Italy's MRSAM.

3.5 Conclusion

The aim of this paper was to propose an integrated methodology to simultaneously estimate the economy-environmental impacts of publicly financed investments in green projects on labor markets, value-added, and household consumption in a multiregional economy in equilibrium. It does so by implementing EI-MRSAM modeling techniques with interregional and international trade flows in goods and services in the macroeconomic investment analysis for Italy.

The results show that the societal value-added GDP benefits in the Lombardy region accounts for 78%, while 22% accrues to the rest of Italy in terms of interregional value-added spillover effects through trade channels. The intra and interregional value-added benefits impact decreases by almost 10% net effects after controlling for environmental impact, specifically the social costs of GHG emissions induced by industrial and human-related sources. However, the net impact on society depends on the pricing mechanisms and social cost of GHG emissions. Under a counterfactual macro-policy evaluation, the return-on-investments in digital transformation of the public-administration is more efficient in terms of potential regional value-added growth compared to other counterfactual outcomes. The distributional impact on household's consumption expenditures and induced GHG emissions are also consistent with those of value-added.

From a policymaking perspective, the research findings show how an ex-ante impact evaluation of public-financed investments provides useful insights for orienting NGEU investments to maximize regional economic development in Italy. Although it is not a policy failure if the value-added benefits induced by the NGEU fiscal stimulus in Lombardy spillover across other regions in Italy. In fact, the NGEU funds have been disbursed simultaneously across various regions in Italy, thus affecting regions at the same time rather than only Lombardy. However, the ability of Lombardy to retain value-added for every unit of fiscal spending investment is higher compared to the regions in Southern Italy. This implies that the region may predominantly benefits from the overall NGEU recovery funds allocated at the national level, due to its ability to attract value-added GDP, especially from the poorer regions in Southern Italy.

The findings also demonstrate how to connect the digital transformation of the public-administration to real value-added outcomes and environmental policy in the transition to climate neutrality. This is due to the complexities inherent in public administration and their implications, which creates uncertainty that influences long-term investment decisions by economic agents, thereby hindering sustained economic growth prospects. In this regard, the unique role of the Lombardy region is strategically important for Italy, especially concerning regional industrial agglomeration, innovation diffusion, and green technological spillover effects. This result is also consistent with the EU policy objectives, namely, managing the green transition and the digital transformation, promoting sustainable and inclusive growth, ensuring social and territorial cohesion, and fostering economic, social, and institutional resilience.

The application of MRSAM and EI-MRSAM models is in a static setting with some limitations, including the assumption of constant returns to scale in production technology and no substitution among inputs. This implies that relative prices play no role in the allocation of resources between activities. In addition, the constant trade and pollutant coefficients assumption implies that region continue to trade a given fraction of their consumption with other regions. A further concern is that the lack of supply-side constraints in the model implies that supply cannot respond perfectly elastically to changes in demand, as supply capacity is limited to the existing labor, capital, and other productive inputs. Further research is needed to measure spatial multiregional relationships and environmental policy in a dynamic setting using general equilibrium models.

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Appendix A3

Table A3.1. NGEU Investments Projects in the Lombardy Region (Italy)

Missions	Projects	Project costs (€ Mln)	(%) Share
M1.	**DIGITALIZATION, INNOVATION, COMPETITIVENESS AND CULTURE**	**87.89**	**4.44%**
M1.C1.I 2.2.1	Technical assistance at central and local level	*38.63*	-
M1.C3.I 2.2	Protection and enhancement of architecture and the rural landscape	*49.25*	-
M2.	**GREEN REVOLUTION AND ECOLOGICAL TRANSITION**	**467.88**	**23.62%**
M2.C2.I 4.1	Cycling mobility enhancement (Vento)	*16.88*	-
M2.C2.I 4.1	Strengthening of cycling mobility (Garda)	*7.84*	-
M2.C2.I 4.4.1	Renewal of bus and green train fleets (buses)	*60.88*	-
M2.C2.I 4.4.2	Renewal of bus and green train fleets (trains)	*64.60*	-
M2.C3	Energy efficiency and building renovations	*252.94*	-
M2.C4.I. 2.1b	Measures for the management of flood risk and for the resolution of hydrogeological risk	*64.74*	-
M3.	**INFRASTRUCTURES FOR SUSTAINABLE MOBILITY**	**59.40**	**3.00%**
M3.C1.I 1.6	Upgrading of regional lines (FNM – Safety measures – replacement of ACEI equipment with ACC-M Milan branch)	*59.40*	-
M4.	**EDUCATION AND RESEARCH**	**-**	**-**
M5.	**INCLUSIVE COHESION**	**168.12**	**8.49%**
M5.C1.R 1.1	Active Labour and Training Policies (GOL)	*101.29*	-

M5.C2.I 2.3	Innovative programme for the quality of living (PINQUA)	*66.83*	-
M6.	**HEALTH**	**1197.90**	**60.46%**
M6.C1.I 1.	Community houses and taking care of people	*277.20*	-
M6.C1.I 2 – 1.2.2	Home as a first place of care, home care and telemedicine (Business Interconnection)	*7.18*	-
M6.C1.I 2. – 1.2.2	Home as a first place of care, home care and telemedicine (Device)	*9.77*	-
M6.C1.I 2 – 1.2.2	Home as a first place of care, home care and telemedicine (C.O.T)	*17.48*	-
M6.C1.I 3	Development of intermediate care	*151.20*	-
M6.C2.I 1.1	Modernization of the hospital technology and digital park (DEA digitization)	*219.26*	-
M6.C2.I 1.1	Modernization of hospital technology and digital park (Large equipment)	*179.80*	-
M6.C2.I 1.2.	Towards a new safe and sustainable hospital (New Projects)	*96.60*	-
M6.C2.I 1.2.	Towards a new safe and sustainable hospital	*219.24*	-
M6.C2.I 1.3.2	Strengthening of the technological infrastructure and tools for the collection, processing, data analysis and simulation (New information flows)	*4.58*	-
M6.C2.I 2.2.	Development of technical professional, digital and managerial skills of health system personnel (a - additional scholarships in general medicine training)	*5.14*	-
M6.C2.I 2.2.	Development of technical, professional, digital, and managerial skills of health system personnel (b - hospital infection training course)	*10.45*	-
TOTAL NGEU FUNDS		**1981.18**	**100%**

Note: According to Corte dei conti (2021), the interventions of the PNRR of the Lombardy region represent a total amount of resources equal to 1 billion 981 million euros with confirmation in the 2021 and forecast budget for 2022-2024.
Source: Adapted from the Court of Auditors elaboration - Regional Control Section for the Lombardy region

Table A3.2. Estimates of Lombardy Interregional Trade Flows with the Rest of Italy

Regions of Italy	Inter-regional Exports (€ Mln)	Share (%)	Inter-regional Imports (€ Mln)	Share (%)	Trade balance (€ Mln)
Piedmont	11695.69	*15.22*	12360.56	*15.95*	-664.87
Aosta Valley	304.47	*0.40*	293.51	*0.38*	10.96
Liguria	3466.02	*4.51*	3311.43	*4.27*	154.59
Lombardy	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Trentino-Alto Adige	3321.88	*4.32*	3417.95	*4.41*	-96.07
Veneto	13088.15	*17.03*	14247.90	*18.39*	-1159.75
Friuli-Venezia Giulia	2094.40	*2.73*	2271.05	*2.93*	-176.65
Emilia-Romagna	11140.04	*14.50*	12448.29	*16.07*	-1308.25
Tuscany	5927.66	*7.71*	6041.49	*7.80*	-113.83
Umbria	919.25	*1.20*	886.72	*1.14*	32.53
Marche	1950.22	*2.54*	2000.74	*2.58*	-50.52
Lazio	8450.71	*11.00*	7499.30	*9.68*	951.41
Abruzzo	1160.56	*1.51*	1118.35	*1.44*	42.21
Molise	205.43	*0.27*	180.58	*0.23*	24.85
Campania	3883.87	*5.05*	3355.77	*4.33*	528.10
Apulia	2687.49	*3.50*	2361.34	*3.05*	326.16
Basilicata	493.22	*0.64*	464.23	*0.60*	29.00
Calabria	981.05	*1.28*	813.09	*1.05*	167.96
Sicily	3410.18	*4.44*	2928.34	*3.78*	481.84
Sardinia	1662.73	*2.16*	1483.96	*1.92*	178.76
Total	**76843.05**	***100.00***	**77484.59**	***100.00***	**-641.55**
Macro Regions					
North-West	15466.18	*20.13*	15965.50	*20.60*	-499.31
North-East	29644.48	*38.58*	32385.20	*41.80*	-2740.71
Centre	17247.85	*22.45*	16428.25	*21.20*	819.59
South and Islands	14484.53	*18.85*	12705.64	*16.40*	1778.89
Italy's other regions	**76843.05**	***100.00***	**77484.59**	***100.00***	**-641.55**

Note: This table presents the total interregional trade between Lombardy and 19 other Italian regions. The Lombardy intra-regional exports and imports is intentionally set to zero by construction.
Source: Author's calculations based on Italy's MRSAM.

Table A3.3. NGEU Investments Induced Impact on Household Interregional Consumption Expenditures

	(0)		(1)		(2)		(3)		(5)		(6)	
	Actual policy		Counterfactual induced effects on household consumption									
Regions in Italy	**Baseline (€ Mln)**	**Share (%)**	**Diff M1 (€ Mln)**	**Change (%)**	**Diff M2 (€ Mln)**	**Change (%)**	**Diff M3 (€ Mln)**	**Change (%)**	**Diff M5 (€ Mln)**	**Change (%)**	**Diff M6 (€ Mln)**	**Change (%)**
Piedmont	124.36	*13.20*	29.48	*23.71*	28.70	*23.08*	34.49	*27.74*	29.69	*23.87*	32.17	*25.87*
Aosta Valley	3.46	*0.37*	0.82	*23.53*	0.77	*22.26*	0.87	*25.12*	0.84	*24.11*	0.91	*26.28*
Liguria	47.02	*4.99*	9.31	*19.81*	9.61	*20.43*	11.83	*25.15*	10.67	*22.69*	12.92	*27.47*
Trentino-Alto Adige	34.98	*3.71*	6.91	*19.75*	7.38	*21.09*	10.09	*28.85*	7.82	*22.35*	9.48	*27.10*
Veneto	130.27	*13.83*	30.88	*23.70*	30.28	*23.24*	36.92	*28.34*	30.92	*23.73*	33.60	*25.79*
Friuli-Venezia Giulia	27.47	*2.92*	6.47	*23.55*	6.26	*22.77*	7.41	*26.99*	6.52	*23.75*	7.15	*26.05*
Emilia-Romagna	124.39	*13.20*	29.56	*23.76*	28.95	*23.28*	35.21	*28.31*	29.48	*23.70*	32.07	*25.78*
Tuscany	76.68	*8.14*	18.02	*23.50*	17.37	*22.65*	20.12	*26.24*	18.39	*23.98*	20.02	*26.11*
Umbria	12.15	*1.29*	2.89	*23.80*	2.77	*22.77*	3.18	*26.16*	2.90	*23.89*	3.17	*26.07*
Marche	23.24	*2.47*	5.53	*23.81*	5.38	*23.16*	6.42	*27.63*	5.50	*23.67*	6.01	*25.87*
Lazio	127.88	*13.57*	24.17	*18.90*	24.87	*19.45*	29.39	*22.98*	28.40	*22.21*	35.94	*28.11*
Abruzzo	13.90	*1.48*	3.33	*23.98*	3.20	*23.01*	3.71	*26.67*	3.32	*23.88*	3.60	*25.92*
Molise	2.76	*0.29*	0.71	*25.62*	0.63	*22.79*	0.67	*24.27*	0.68	*24.64*	0.71	*25.83*
Campania	56.44	*5.99*	13.91	*24.64*	12.54	*22.22*	13.39	*23.73*	13.83	*24.51*	14.81	*26.25*
Apulia	38.91	*4.13*	10.17	*26.13*	8.85	*22.74*	9.26	*23.79*	9.71	*24.96*	10.06	*25.86*
Basilicata	4.57	*0.49*	1.14	*25.03*	1.09	*23.74*	1.27	*27.72*	1.09	*23.83*	1.17	*25.49*
Calabria	16.61	*1.76*	4.64	*27.93*	3.76	*22.61*	3.72	*22.38*	4.26	*25.62*	4.28	*25.76*
Sicily	54.88	*5.83*	14.58	*26.57*	12.24	*22.29*	12.33	*22.47*	13.92	*25.36*	14.28	*26.01*
Sardinia	22.13	*2.35*	5.89	*26.60*	5.02	*22.67*	5.19	*23.45*	5.58	*25.22*	5.72	*25.84*
Macro Regions												
North-West	174.84	*18.56*	39.61	*22.65*	39.08	*22.35*	47.19	*26.99*	41.19	*23.56*	46.00	*26.31*
North-East	317.10	*33.66*	73.81	*23.28*	72.86	*22.98*	89.63	*28.26*	74.74	*23.57*	82.31	*25.96*
Centre	239.96	*25.47*	50.62	*21.09*	50.39	*21.00*	59.11	*24.63*	55.20	*23.00*	65.15	*27.15*
South and Islands	210.20	*22.31*	54.37	*25.86*	47.31	*22.51*	49.53	*23.56*	52.39	*24.92*	54.63	*25.99*
Italy's other regions	**942.08**	***100%***	**218.40**	***23.18%***	**209.64**	***22.25%***	**245.45**	***26.05%***	**223.52**	***23.73%***	**248.08**	***26.33%***

Note: Totals may not sum due to rounding. Induced effect measures the impact on household consumption expenditure in goods and services. The source of induced effects is the link from regional wages to labor and household spending.
Source: Author's calculations based on Italy's MRSAM.

Table A3.4. NGEU Investments Impact on Value-Added (GDP) - Induced emission Sources in Metric tons across Italy

	Global pollutants							Local pollutants	
Regions in Italy	**CO2**	**CH4 CO2E**	**N2O CO2E**	**HFC CO2E**	**NF3_SF6 CO2E**	**PFC CO2E**	**GHG CO2E**	**NH3** (metric tons)	PM10 (metric tons)
Piedmont	16146.99	37132.39	21497.40	165.50	0.00	0.00	74942.28	670.15	198.17
Aosta Valley	489.04	1124.62	651.09	5.01	0.00	0.00	2269.75	20.30	6.00
Liguria	6263.04	14402.78	8338.34	64.19	0.00	0.00	29068.35	259.93	76.87
Lombardy	*429672.69*	*988095.84*	*572047.45*	*4403.92*	*0.00*	*0.00*	*1994219.90*	*17832.63*	*5273.35*
Trentino-Alto Adige	5216.26	11995.55	6944.70	53.46	0.00	0.00	24209.97	216.49	64.02
Veneto	17719.07	40747.63	23590.40	181.61	0.00	0.00	82238.71	735.39	217.47
Friuli-Venezia Giulia	3541.36	8143.87	4714.81	36.30	0.00	0.00	16436.34	146.98	43.46
Emilia-Romagna	16845.24	38738.13	22427.02	172.66	0.00	0.00	78183.05	699.13	206.74
Tuscany	10062.15	23139.41	13396.31	103.13	0.00	0.00	46701.01	417.61	123.49
Umbria	1486.44	3418.29	1978.98	15.24	0.00	0.00	6898.94	61.69	18.24
Marche	2973.24	6837.40	3958.44	30.47	0.00	0.00	13799.55	123.40	36.49
Lazio	17056.48	39223.91	22708.26	174.82	0.00	0.00	79163.47	707.89	209.33
Abruzzo	1785.59	4106.22	2377.25	18.30	0.00	0.00	8287.37	74.11	21.91
Molise	325.15	747.73	432.89	3.33	0.00	0.00	1509.11	13.49	3.99
Campania	6826.39	15698.29	9088.35	69.97	0.00	0.00	31682.99	283.31	83.78
Apulia	4457.17	10249.93	5934.08	45.68	0.00	0.00	20686.87	184.99	54.70
Basilicata	575.04	1322.39	765.58	5.89	0.00	0.00	2668.90	23.87	7.06
Calabria	1955.44	4496.82	2603.39	20.04	0.00	0.00	9075.69	81.16	24.00
Sicily	6456.39	14847.42	8595.75	66.17	0.00	0.00	29965.73	267.96	79.24
Sardinia	2610.27	6002.71	3475.21	26.75	0.00	0.00	12114.95	108.33	32.04
Macro Regions									
North-West	452571.75	1040755.63	602534.27	4638.63	0.00	0.00	2100500.28	18783.01	5554.39
North-East	43321.93	99625.18	57676.92	444.03	0.00	0.00	201068.06	1797.98	531.69
Centre	31578.32	72619.00	42041.99	323.66	0.00	0.00	146562.97	1310.59	387.56
South and Islands	24991.44	57471.51	33272.51	256.15	0.00	0.00	115991.61	1037.22	306.72
Italy	**552463.44**	**1270471.32**	**735525.70**	**5662.46**	**0.00**	**0.00**	**2564122.92**	**22928.80**	**6780.35**

Note: The GHG emissions refers to the so-called "Kyoto basket" group of seven gases which includes carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases F-gases (HFC, PFCs, SF_6 and NF_3) are expressed in a common unit, tons of CO2-equivalents produced by each industrial sectors in Italy and the regional levels. The local pollutants including Ammoniac (NH3) and Particulate matter (PM10) are expressed in metric tons.
Source: Author's calculations based on Italy's EI-MRSAM.

Table A3.5 NGEU Investments Impact on Household Consumption Expenditures - Induced emissions Sources in Metric tons across Italy

	Global pollutants in CO2 equivalent							Local pollutants	
Regions in Italy	**CO2**	**CH4 CO2E**	**N2O CO2E**	**HFC CO2E**	**NF3_SF6 CO2E**	**PFC CO2E**	**GHG CO2E**	**NH3** (metric tons)	**PM10** (metric tons)
Piedmont	14833.39	34111.56	19748.52	152.03	0.00	0.00	68845.50	615.63	182.05
Aosta Valley	413.06	949.89	549.93	4.23	0.00	0.00	1917.11	17.14	5.07
Liguria	5607.84	12896.07	7466.04	57.48	0.00	0.00	26027.43	232.74	68.82
Lombardy	*371964.90*	*855388.26*	*495217.83*	*3812.45*	*0.00*	*0.00*	*1726383.44*	*15437.60*	*4565.10*
Trentino-Alto Adige	4171.74	9593.53	5554.07	42.76	0.00	0.00	19362.11	173.14	51.20
Veneto	15537.72	35731.28	20686.24	159.25	0.00	0.00	72114.50	644.86	190.69
Friuli-Venezia Giulia	3276.44	7534.66	4362.11	33.58	0.00	0.00	15206.80	135.98	40.21
Emilia-Romagna	14836.49	34118.69	19752.65	152.07	0.00	0.00	68859.90	615.76	182.09
Tuscany	9146.10	21032.81	12176.72	93.74	0.00	0.00	42449.37	379.59	112.25
Umbria	1449.70	3333.80	1930.07	14.86	0.00	0.00	6728.44	60.17	17.79
Marche	2772.37	6375.48	3691.02	28.42	0.00	0.00	12867.29	115.06	34.03
Lazio	15253.12	35076.81	20307.34	156.34	0.00	0.00	70793.61	633.05	187.20
Abruzzo	1658.08	3813.00	2207.50	16.99	0.00	0.00	7695.57	68.82	20.35
Molise	328.73	755.96	437.66	3.37	0.00	0.00	1525.72	13.64	4.03
Campania	6731.68	15480.49	8962.27	69.00	0.00	0.00	31243.43	279.38	82.62
Apulia	4640.98	10672.62	6178.80	47.57	0.00	0.00	21539.96	192.61	56.96
Basilicata	545.10	1253.54	725.72	5.59	0.00	0.00	2529.94	22.62	6.69
Calabria	1980.85	4555.25	2637.21	20.30	0.00	0.00	9193.61	82.21	24.31
Sicily	6546.44	15054.51	8715.65	67.10	0.00	0.00	30383.70	271.70	80.34
Sardinia	2639.86	6070.74	3514.59	27.06	0.00	0.00	12252.24	109.56	32.40
Macro Regions									
North-West	392819.19	903345.78	522982.32	4026.19	0.00	0.00	1823173.48	16303.11	4821.05
North-East	37822.39	86978.17	50355.08	387.66	0.00	0.00	175543.30	1569.74	464.19
Centre	28621.30	65818.91	38105.15	293.35	0.00	0.00	132838.71	1187.86	351.27
South and Islands	25071.71	57656.11	33379.38	256.97	0.00	0.00	116364.18	1040.55	307.70
Italy	**484334.59**	**1113798.97**	**644821.93**	**4964.18**	**0.00**	**0.00**	**2247919.67**	**20101.26**	**5944.21**

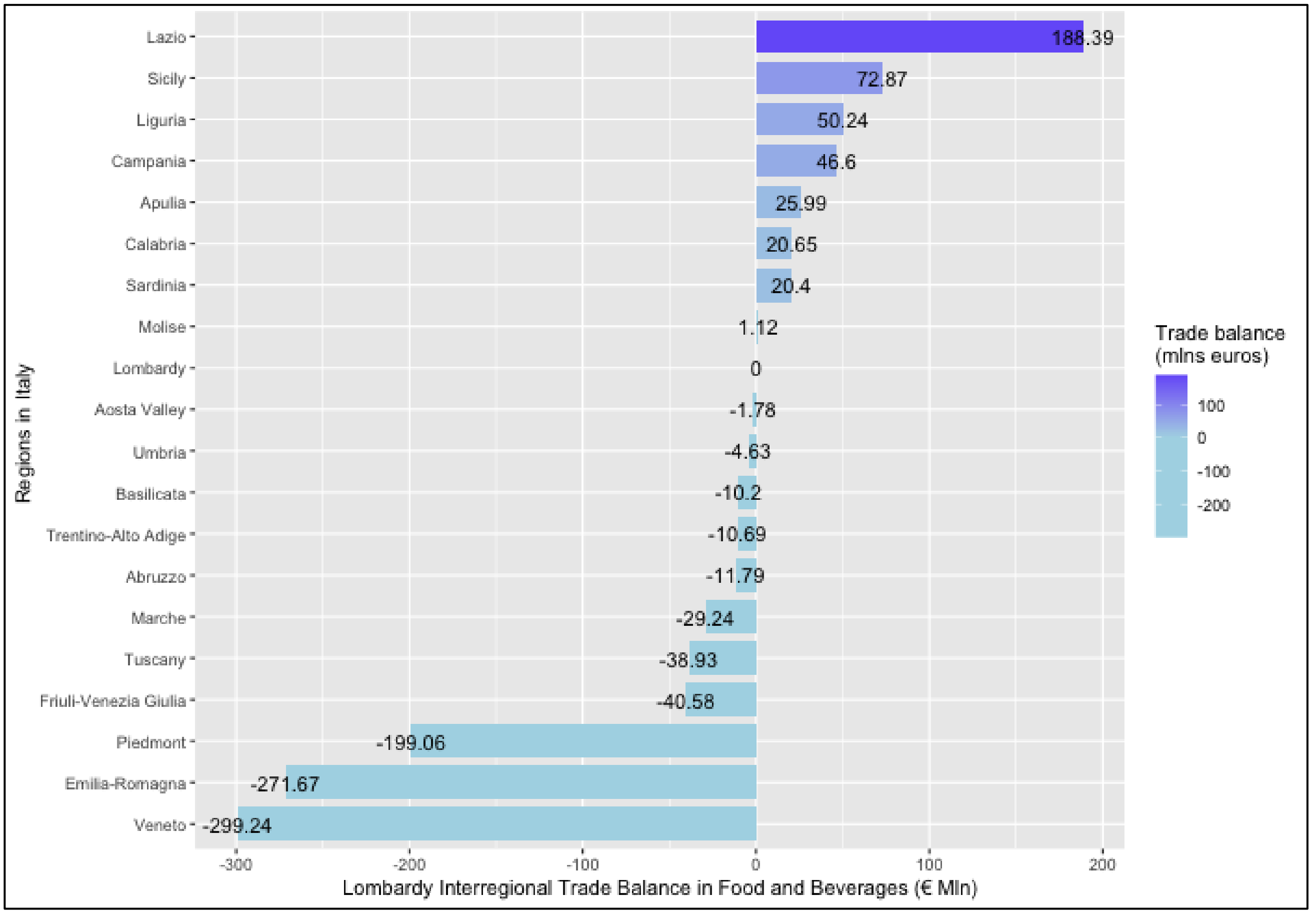
Note: The GHG emissions refers to the so-called "Kyoto basket" group of seven gases which includes carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases F-gases (HFC, PFCs, SF_6 and NF_3) are expressed in a common unit, tons of CO2-equivalents produced by each industrial sectors in Italy and the regional levels. The local pollutants including Ammoniac (NH3) and Particulate matter (PM10) are expressed in metric tons.
Source: Author's calculations based on Italy's EI-MRSAM.

Table A3.6. Micro-SAM Sectoral Classifications

Ref.	Description	Ref.	Description
1.	Agriculture and hunting	43.	Other financial services
2.	Forestry	44.	Real estate activities
3.	Fishings	45.	Legal activities and accounting
4.	Mining and quarrying	46.	Architecture and engineering
5.	Food, beverages and Tobacco	47.	Scientific research and development
6.	Textiles, leather and footwear	48.	Marketing and market research
7.	Wood and Products of Wood and Cork	49.	Other technical, scientific professions; Veterinary
8.	Paper and paper products	50.	Leasing and rent activities
9.	Printing and publishing	51.	Research, selection of human resources
10.	Coke, Refined Petroleum and Nuclear Fuel	52.	Travel agencies
11.	Manufacture of men-made fibres	53.	Investigation and surveillance services
12.	Pharmaceuticals	54.	Public Admin and Defence; Compulsory Social Security
13.	Rubber and Plastics	55.	Education
14.	Non-metallic minerals	56.	Health
15	Basic metals	57.	Social work
16	Fabricated metals	58.	Entertainment, arts and creative activities; libraries, archives and museums
17.	Computers and optical equipment	59.	Sports
18.	Electrical equipment	60.	Associations
19.	Machinery	61.	Repair of computers and other objects of personal use
20.	Production of Motor Vehicles	62.	Other personal services
21.	Production of other vehicles	63.	Private Households with Employed Persons
22.	Production of furniture; Other manufactoring industries	64.	Reddito da lavoro dipendente (low)
23.	Repair and installation of machinery	65.	Reddito da lavoro dipendente (mid)
24.	Electricity, gas supply	66.	Reddito da lavoro dipendente (high)
25.	Water supply	67.	Capital
26.	Drainage system management	68.	Indirect taxes
27.	Construction	69.	Households1
28.	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles	70.	Households2
29.	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	71.	Households3
30.	Retail Trade, Except of Motor Vehicles and Motorcycles	72.	Households4
31.	Inland transport	73.	Households5
32.	Water transport	74.	Households6
33.	Air transport	75.	Households7
34.	Other Supporting and Auxiliary Transport Activities	76.	Households8
35	Post services	77.	Households9
36.	Hotels and Restaurants	78.	Households10

	37.	Publishing	79.	Public Admin	
	38.	Film, video, tv programme production	80.	Direct taxes	
	39.	Telecommunications	81.	Enterprises	
	40.	Software, computer consulting	82.	Capital Formation	
	41.	Financial services	83.	Interregional imports	
	42.	Insurance, reinsurance and pension funds	84.	Import from ROW	

Figure A3.1. Lombardy Interregional Trade Balance in Food and Beverages with the Rest of Italy



Source: Author’s elaborations based on Italy’s MRSAM.