Dipartimento delle Finanze

working paper

A Corporate Income Tax Microsimulation Model for Italy

DF WP n.17
February 2023

Chiara BELLUCCI, Silvia CARTA, Sara DE TOLLIS, Federica DI GIACOMO, Marco MANZO, Daniela BUCCI, Donato CURTO, Fabrizio DE GRANDIS, Francesca SICA

DF Working Papers, 2017

MEF Ministero dell'Economia e delle Finanze
Dipartimento delle Finanze
Via dei Normanni, 5
00184 Roma

Email df.wpapers@finanze.it
http://www.finanze.gov.it/

ISSN electronic edition 2610-8887

Papers can be downloaded free of charge from the MEF website:
http://www.finanze.it/opencms/it/il-dipartimento/documentazione/Collana-di-lavori-e-di-ricerca/

A Corporate Income Tax Microsimulation Model for Italy *

Chiara Bellucci, Silvia Carta, Sara De Tollis, Federica Di Giacomo, Marco Manzo†

Daniela Bucci, Donato Curto, Fabrizio De Grandis, Francesca Sica ‡

First Draft: May, 2022

This Draft: January, 2023

Abstract

The CITSIM-DF is the corporate tax microsimulation model developed by the Department of Finance in order to estimate the heterogeneous impact of changes in fiscal regulation on average effective tax rates, both in terms of financial and distributional effects. One of the main innovations of the model is the inclusion of forecasts on future economic trends into the simulations, by projecting forward the main fiscal and financial variables. Currently projections are based, at macro level, on national accounts and official projections reflected in the documents of economy and finance. In the next future, the model will be further developed in a now-casting perspective, incorporating in the projections, at micro level, the most recent administrative data available. The model proposes also a new methodology for disentangling investments and historical cost broken by type of asset (buildings, machinery and equipment). CITSIM-DF is based on a unique dataset that integrates administrative data derived from tax returns and financial statements for corporations.

JEL codes: H25, C63

Keywords: Tax treatment of losses; Allowance for corporate equity; Corporate taxation; Microsimulation

---

* The views and opinions expressed in this working paper are those of the authors and do not necessarily reflect the official position of the institution.
We are particularly grateful to Laura Benedetti and Laura Limosani from Sose for their technical support in the model's development and to Lorenzo Maggi, Gavino Mura and Giacomo Strinati for fruitful discussions and feedbacks at different stages of the project. We thank Silvia Giannini for providing us comments on the first version of this paper.

†Ministry of Economy and Finance, Department of Finance.

‡Soluzioni per il Sistema Economico S.p.A. (Sose)

1 Introduction

The CITSIM-DF is a microsimulation model developed by the Department of Finance jointly with SOSE to assess the financial and distributional impact of fiscal policies on non-financial corporations and to analyze the behavior of firms in response to policy changes, taking into account both direct effects of changes in tax regulation and indirect effects due to firms' behavioral reactions, in terms of investment choices. The CITSIM-DF is a dynamic multi-period microsimulation model consisting of two main modules:

- CITSIM-DF (I) the non-behavioral module, which assumes that investment choices are static over time;
- CITSIM-DF (II) the behavioral module that allows to analyze the optimal response in terms of investment choices to changes in marginal effective tax rates and the user cost of capital, in the context of partial economic equilibrium models, taking into account the different sources of capital financing, debt, equity, and non-redistributed profits.

This paper refers to the first module, while the second module will be finalized and validated in a subsequent work.

Compared to previous literature, the model is characterized by some methodological innovations. Firstly, it performs a robust reconstruction of depreciation and investment by type of tangible assets, machinery/equipment and buildings, and intangible assets. The investment estimation procedure is an important strength of the model, as it allows for correct estimates of the effects of measures referring to specific types of assets, to simulate changes due to general reforms of tax depreciation rules or to the introduction of harmonized corporate taxation systems (Common Consolidated Corporate Tax Base) within the European Union. Secondly, the model incorporates business cycle trends into the projections, as the main fiscal and financial variables are not held constant at the base year level, but are projected at the sector and firm level using official projections from economic and financial documents and sector coefficients obtained from the economic and financial forecasts provided by *Prometeia*. This aspect is crucial for the goodness of the estimates, as it allows us to take into account not only changes caused by legislation, but also those resulting from the business cycle. The importance of this feature of the model emerges, for example, when one considers the shock that hit the economy as a result of the restrictions caused by the COVID-19 pandemic. Indeed, the estimates obtained for the base year 2019 would be biased without projecting forward the variables, as they would not reflect either the aggregate-level shock that occurred from 2020 and its heterogeneous impact across industries. In the next future, we plan to further improve this feature of the model by projecting the variables at a granular level, by replacing the sectoral level projections with those at the individual level, in order to take into account not only aggregate shocks but also idiosyncratic ones. In particular, the model will be further developed in a now-casting perspective, incorporating in the projections, at micro level, the most recent administrative data available, such as the three-months periodic VAT returns, to account also for the within variability of each firm.

The CITSIM-DF model is based on a unique dataset that, for the period 2008-2019, integrates administrative data derived from tax returns available from the Tax Authority and financial statements for corporations submitted to the Companies' Register and available in the Unioncamere Repository. The dataset integrates also national accounts data and the Ministry of Economy and Finance forecasts included in the Official Economic and Financial Document. Data integration is timely and based on appropriately pseudonymized tax codes, allowing for an annual update of the model.

The model simulates the tax base and net tax burden of the Italian corporate taxation system in force as of 2019 and simulates the regulatory changes that have occurred in subsequent years up to the changes introduced in the 2022 Budget Law.

The paper is organized as follows. Section 2 presents a review of the main related literature; Section 3 describes the general methodological approach of the model; Section 4 illustrates the methodology for estimating asset type capital expenditure and depreciation rates; Section 5 describes the main features of the Italian corporate income tax; Section 6 compares the main results obtained with official statistics to validate the estimations provided in the model; Section 7 reports simulations aimed at estimating the revenue and redistributive effects of a reform hypothesis on the tax treatment of depreciation and Section 8 concludes.

2 Related Literature

This paper contributes to the literature on the analysis of fiscal policies addressed with micro models, however tax policy analysis can be conducted using either macro or micro models. From a macro perspective, works are typically based on dynamic Computable General Equilibrium models (CGE). In this strand of literature can be found Radulescu and Stimmelmayr (2010) that analyze the impact of the 2008 German corporate tax reform on macroeconomic variables such as investments, GDP, consumption and household's welfare and Bhattarai et al. (2017) that, focusing on the ongoing debate among policy makers in the United States, develop a DCGE model to simulate alternative policies aimed at reducing the U.S. corporate income tax.

On the other hand, thanks to the increasing availability of microdata, a stream of literature has developed microsimulation models assessing the impact of tax policies, with a focus on the distributional effects of tax reforms. Although microsimulation models are now a widespread tool for analyzing tax policies, most of the available models refer to the personal income tax and households' disposable income. Firm models are rarer, mainly because of the complexity of the corporate tax system and the need to involve the intertemporal aspect. However, several microsimulation models of corporate income tax have been developed over the past two decades (for a survey see Ahmed (2016) and Buslei et al. (2014)).

The frontier of research in this field is the integration of macro and micro models. Caiumi (2017) is the first to discuss how microsimulation and computable general equilibrium models can be effectively integrated to assess the impact of fundamental corporate tax reform proposals. In fact, microsimulation models are suitable for modeling the distributional effects of taxation on firms, but they are limited, in the case of reforms involving changes in prices, wages and macro variables, because they are unable to model adjustments in different markets. On the other hand, CGE models are powerful tools for assessing the impact of exogenous variables and policy measures on economic equilibria, but they are unable to capture distributional effects and thus the heterogeneity among firms. The combination of the two tools would lead to very powerful models.

Microsimulation models can be divided into two main types: those that incorporate the behavioural effect and hence the response mechanisms of companies with respect to new policy measures taken, and those that report first-order, non-behavioural effects (also known as static), which do not explain how companies change their investment choices as a result of a tax reform, but rather reflect the tax revenue effects and cash flow effects of companies. The model presented in this paper reports first-order effects, while a second module of the model aimed at estimating behavioral effects is currently being finalized.

One of the first non behavioural or static microsimulation models for the Italian corporate tax system is that of Bardazzi et al. (2003). This model implements the 2001 legislation on the 1998 data and applies the same mechanism to simulate the new legislation in force at the beginning of 2004, that introduced some relevant fiscal reforms with respect to the previous system (such as the switch from the dual income tax to a uniform tax rate). Moreover, this model integrates different data sources, combining survey data and published accounting data, and simulates the first-order effects of tax reforms, showing its distributional effects on a very broad set of firms (partnerships, corporations, cooperatives and others). Also, Oropallo and Parisi (2007) used a microsimulation model and similarly to the former case, by using a combination of survey and administrative data, assess the impact of the extensive corporate fiscal reform introduced in 2004, this time, taking 2000 as base year. In order to evaluate the tax reform introduced in 2001 and to contribute to the debate on the neutrality of the tax system and the efficiency of the DIT with respect to a uniform tax rate, Bontempi et al. (2001) propose a static multi-period microsimulation model to assess the distributional effects of tax incentives for investment.

Among the most recent multi-period microsimulation models, the closest to the one proposed in this paper are the "Istat-MATIS" model proposed by Caiumi and Di Biagio (2016) and currently used by Istat and "MEDITA" the one proposed by the Parliamentary Budget Office PBO (2019). Istat-MATIS is based on corporate tax returns and includes most measures of the Italian tax system. It implements a dynamic simulation that allows to consistently estimate firm-level inter-temporal developments of fiscal variables such as interests deduction, losses carry forwards and tax allowances carry forwards. Using a panel from 2005 to 2011, the Istat-MATIS model performs simulations with a backward logic. For example, the tax year 2008 is used to simulate the legislation in force in 2011, assuming it came into force in 2008 and for the other years, not taking into account differences in tax structure and economic conditions compared to the reference year. However, this model does not account for behavioral responses by taxpayers to tax changes. MEDITA integrates financial accounting data and aggregated data from tax returns. A new version of MEDITA has been introduced in 2019, in order to integrate micro administrative data from tax returns into the model. As the Istat-MATIS model, MEDITA performs dynamic simulations with a backward logic using a panel from 2011 to 2018. Compared to Istat-MATIS and MEDITA models, CITSIM-DF model overcomes the pitfalls of using a backward logic by projecting the main fiscal and financial variables forward in order to capture the economic conditions relative to the year in which the simulated legislation is in force. Whereas, with regard to the simulation of the main fiscal measures, in particular those aimed at boosting investment, the CITSIM-DF model proposes a more detailed breakdown of investment and thus a more consistent estimate of the effects of these provisions.

In the literature, two types of indicators have been proposed to measure the tax burden: backward-looking and forward-looking indicators. Backward-looking indicators show the effect of tax measures on tax burden in order to evaluate the distributional effects, while forward-looking indicators capture how the effective tax rate changes depending on the asset the company chooses to invest in and the source of financing. King and Fullerton (1984) introduced the forward-looking effective corporate tax rates. Subsequently, Devereux and Griffith (1998) extended it by introducing the distinction between the marginal effective tax rate (EMTR), which represents the effect of taxation on the minimum pre-tax rate of return required by investors to undertake an investment, and the average effective tax rate (EATR), that is particularly useful to compare different countries for the investment allocation perspective. The Devereux and Griffith (1998) approach is currently among the most widely used in the literature[1].

The CITSIM-DF model is intended to contribute to the literature of tax burden indicators, which are a very useful tool for assessing the impacts of regulatory changes. As far as backward-looking indicators are concerned, this work, as reported in the introduction, is aimed at sophisticating the method of calculating the tax base and therefore to arrive at more reliable backward indicators. As regards the forward-looking indicators, the second module of the model will provide for an improvement of the indicators through the introduction of various measures to facilitate the investments that have taken place in the observed time series.

3 Methodological approach

3.1 Data Description

The dataset used in the microsimulation model is constructed by integrating microdata from tax returns and financial statements for non-financial corporations. One of the advantages of the CITSIM-DF model is the ability to use tax returns jointly with firm's data resulting from financial statements. In fact, given the complexity of corporate tax legislation, micro data from tax return become essential for making accurate estimates of the revenues or costs that are taxable, deductible or eligible for fiscal allowances. In addition, the integration of administrative data with those reported on financial statements enables us to conduct more detailed distributional analyses and improve the assessment of the effects of fiscal reforms on public finances. Financial statements, in fact, contain a huge set of information that is complementary

[1] Caiumi et al. (2015) and Zangari (2020).

to that available in the tax returns and that may be crucial for certain types of estimates, such as the estimation of investments in plants and machinery (described in Section 4). The main fiscal and financial variables are projected to the years following 2019 using the sectoral[2] growth rates reported in the national accounts data (up to 2021) and the projections made by the Ministry of Economy and Finance (2022-2025) and reported in the Economic and Financial Document (DEF). To decompose the macro aggregates of costs and revenues are used the sector coefficients obtained by the economic-financial forecasts provided by *Prometeia*[3]. The macro-aggregates reconstructed using the variables projected with the *Prometeia* sector coefficients are reconciled with the national accounting values and the Ministry's estimates using a procedure that will be explained in the section 3.2.1.

The database includes non-financial Italian corporations[4], for a total of approximately 1,249,205 firms in 2019[5]. The CITSIM-DF model also takes into account the different tax treatment applied to fiscal group compared to single firms (98% of the sample). In particular, given the firms whose tax returns are available, in order to determine which firm belongs to a group, the consolidated profit tax return (CNM) available for each group represents the reference source. It contains the identifier of the group's consolidating firm and includes a section in which all subsidiaries of the group are listed[6].

Currently, the database covers the period between 2011 and 2019. The year 2019 represents the base year of the model and the starting point to simulate the main fiscal and financial variables of the subsequent years by applying appropriate projection coefficients and the relative fiscal system. The availability of data for several consecutive years allowed us to estimate the historical cost of assets according to the methodology described in section 4.2 and to estimate the allowance for corporate equity (ACE) as explained in section 5.5. Table 1 shows the distribution of the population in 2019 by sector, size, class, and geographical area.

[2]NACE branch of activity.

[3]The whole economy is divided into 187 sectors.

[4]The financial sector (Ateco codes 65-66-641-643-649) is not included in the model.

[5]1,249,205 companies filed tax returns in year 2020, for the 2019 fiscal year, while about 979,735 companies filed their financial statements.

[6]It should be noted that foreign companies were not taken into account for the reconstruction of the groups.

Table 1: Firms' frequencies by category

Sector*	**Frequency**	**% of total**
Agriculture-Mining	27,891	2.2
Manufacturing	155,667	12.5
Energy	20,690	1.7
Construction	185,082	14.8
Trading	249,003	19.9
Transportation	42,140	3.4
Services	527,995	42.3
Public Administration	40,296	3.2
Other	62	0.0
N.A.	379	0.0
Revenue**		
< 2mln	1,089,928	87.2
2 mln-10 mln	98,346	7.9
10 mln-50mln	25,395	2.0
>50mln	6,441	0.5
N.A.	29,095	2.3
Geographic Area		
North-East	234,940	18.8
North-West	331,964	26.6
Center	310,438	24.9
South and Islands	371,863	29.8
Ownership structure		
Single firm	1,228,463	98.3
Firm belonging to a fiscal groups	20,742	1.7
Fiscal group	6,068	
Total	1,249,205	

*Sector is the one resulting from tax returns

**Revenue is the one resulting from financial statements

3.2 Model framework

The corporate income tax (IRES) is a proportional tax, which is calculated by applying to the taxable income of corporations the legal tax rate of 24%. In order to determine the income subject to corporate tax, the Italian tax system requires the application of adjustments to the statutory profit and loss account's result. In particular, taxable income ($CIT\ base$) is calculated by adding to the income before taxes (profits or losses $P(L)$) upward fiscal adjustments (ΔUp), and by subtracting downward fiscal adjustments ($\Delta Down$), losses carryforward (LCF) and allowance for corporate equity (ACE).

$$CIT\ base = P(L) + \Delta Up - \Delta Down - LCF - ACE^{7} \tag{1}$$

[7] Losses carryforward (LCF) and ACE deduction are included in the CIT_{base} up to the profit value.

Since 2004, in Italy, a consolidated taxation option has been introduced, providing for the calculation of a single taxable income for all companies belonging to a fiscal group (FG), offsetting, for taxation purpose, income and losses of single firms within the consolidation area. Tax losses realized prior to the consolidated taxation option cannot be attributed to the parent company. This taxation system also offers other tax advantages such as the offsetting of tax credits and debits between group members. For each fiscal group, the taxable income ($CIT\ base_{FG}$) is determined as the sum of the taxable income of all the enterprises in the group and by subtracting losses carryforward and ACE not used by the single enterprises and transferred to the group:

$$CIT\ base_{FG} = \sum CIT\ base - LCF_{FG} - ACE_{FG}{}^{8} \tag{2}$$

Starting from the taxable income for both single companies and groups, we calculate the theoretical tax due by applying the legal tax rate ($r^{\ IRES}$) to the taxable income, and the effective tax due by subtracting from the theoretical tax due the tax credits. The main tax credits relating to investment activities have been simulated (Ex Super/Hyper depreciation [9], R&D and South of Italy tax credit) while the remainder are considered constant.

$$TaxDebt^{Effective} = CIT\ base*(r^{IRES}) - S\&H^{TC} - R\&D^{TC} - South^{TC} - Other^{TC} \tag{3}$$

The effective tax rate (ETR) is then calculated as the ratio between the effective tax due and the profit before taxes of the firm:

$$ETR = \frac{Tax\ Debt^{Effective}}{Profit^{PreTax}} \tag{4}$$

Table 2 shows the flow followed by the CITSIM-DF model (I), specifying the input and output data for each measure considered in the analysis and the variables used for the microsimulation.

[8]Provisions are reflected into the consolidated fiscal result in the same order they are reflected in the individual fiscal result: Losses carryforward, ACE, Tax Credits.

[9]Until 2019 Super and Hyper depreciation reduced the CIT_{Base}.

Table 2: Microsimulation model's structure

Package	**Projection of fiscal and budgetary variables**
Input data	Balance sheet
Projection variables	Coefficients relative to variables included to calculate value-added
Output data	Estimated value-added growth rate
Package	**Depreciation rates estimate**
Input data	Balance sheet
Projection variables	None
Output data	Investments, historical cost and depreciation of buildings and machinery
Package	**Super/Hyper depreciation**
Input data	*Redditi* model (RF section), output of Depreciation rates estimate package
Projection variables	Depreciation growth rate
Output data	Amount of super/hyper
Package	**Interest expense deductibility**
Input data	*Redditi* model (RF section)
Projection variables	Financial expenses, Financial income and value-added growth rate
Output data	Amount of deductible/non-deductible interest
Package	**Tax Income**
Input data	*Redditi* model (RF section), output of Super/Hyper depreciation and Interest expense deductibility packages
Projection variables	Value-added growth rate
Output data	Fiscal result
Package	**Loss Carryforward (Macro)**
Input data	*Redditi* model (RN section)
Projection variables	Value-added growth rate
Output data	Excludable losses
Package	**Loss Carryforward (Micro)**
Input data	*Redditi* model (RN section) and output of Tax Income package
Projection variables	None
Output data	Uncompensated full and limited losses
Package	**Allowance for corporate equity (ACE)**
Input data	*Redditi* model (RS section)
Projection variables	Value-added growth rate
Output data	ACE amount
Package	**Taxable Income**
Input data	*Redditi* model (RF section), Output of Tax Income, Loss Carryforward and ACE packages
Projection variables	Value-added growth rate
Output data	Taxable Income and IRES amount
Package	**Groups Taxable Income**
Input data	*Redditi* model (RF section), Output of Tax Income, Loss Carryforward and ACE package
Projection variables	Value-added growth rate
Output data	Taxable Income and IRES amount for fiscal groups
Package	**Research and Development Tax credit**
Input data	*Redditi* model (RU Section)
Projection variables	Depreciation growth rate
Output data	Amount of credit
Package	**Tax credit for South Italy**
Input data	*Redditi* model (RU Section)
Projection variables	Depreciation growth rate
Output data	Amount of credit

3.2.1 Projection of fiscal and budgetary variables

The tax year 2019 is the base year for the microsimulation. Starting from that year, the model reconstructs all the main tax returns items and determines the items to be transferred to the following year (e.g. tax credits, possible deductions, others). For each year from 2020 to 2025, the tax return of each company is reconstructed starting from the tax return of the previous year and projecting the main variables involved using the growth rates reported in the national accounts data (up to 2021) and the projections made by the Ministry of Economy and Finance (2022-2025) and reported in the Economic and Financial Document (DEF). To decompose the macro aggregates of costs and revenues we use *Prometeia* sector coefficients. This decomposition is used to calculate the projection of value added specific to each firm. In detail, the value added of the firm i at time $t+1$ is equal to:

$$\begin{aligned} ValueAdded_{i,t+1} = {} & Value\ of\ Production_{i,t} * \Delta revenues^{Prometeia}_{s,t+1} + \\ & - Cost\ of\ Sales_{i,t} * \Delta cost\ sales^{Prometeia}_{s,t+1} + \\ & - Services\ and\ other\ cost_{i,t} * \Delta service^{Prometeia}_{s,t+1} \end{aligned}$$

Where $\Delta revenues^{Prometeia}_{s,t+1}$ is the growth rate of revenues that occurred in the sector s at time $t+1$ (the same applies to cost of sales and services and other cost).

Since *Prometeia* coefficients are sectorial and are applied to the individual balance sheet values of the firm, collapsing the values at the sectorial level could lead to a different value from the one reported by the national accounts. For this reason, the growth rate of aggregate value added predicted by the model is reconciled with the growth rates in the national accounts and the forecasts reported in the Economic and Financial Document (DEF) in order to ensure consistency between model estimates and official sources. The reconciliation value is obtained by multiplying the estimated value-added for the company i in period t with a coefficient equal to the ratio between the total sectorial value-added reported in the national accounts (or in the DEF) and the total value added estimated using the *Prometeia* coefficients for the same sector of activity.

$$Reconciled\ value_{i,t} = VA_{i,t} * \frac{VA^{NA}_{s,t}}{VA^{Prometeia}_{s,t}} \tag{5}$$

This procedure allows the reconciliation of value-added while preserving the differences between firms within each sector.

4 Estimation of Investment and Depreciation Rates by Type of Assets

One of the strengths of the model is its ability to allocate investments between different types of assets. This allocation procedure is new in the literature and it is of crucial importance as it allows for the correct estimation of measures referring to specific types of assets (see for example the "Industry 4.0" plan later updated in the current "Transition 4.0" plan).

Investments (net of disinvestments) made by companies are estimated in the model through the use of balance sheet data with the purpose of quantifying the financial effects of incentives measures aimed at stimulating the purchase of capital goods by companies. In particular, it is assumed that the investment in tangible assets made by company i at time t ($I_{i,t}^{tang}$) is equal to the difference between the book value of the tangible assets recorded in the balance sheet assets at time t ($BV_{i,t}^{tang}$) and those recorded in the period $t-1$ plus the depreciation charge reported in the income statement at time t ($Depr_{i,t}^{tang}$):

$$I_{i,t}^{tang} = BV_{i,t}^{tang} - BV_{i,t-1}^{tang} + Depr_{i,t}^{tang} \quad (6)$$

A similar procedure is performed to estimate intangible investments:

$$I_{i,t}^{intang} = BV_{i,t}^{intang} - BV_{i,t-1}^{intang} + Depr_{i,t}^{intang} \quad (7)$$

Where $BV_{i,t}^{intang}$ is the book value of intangible assets recorded in the balance sheet at time t and $Depr_{i,t}^{intang}$ is the depreciation charge recorded in the income statement at time t.

Considering that a huge part of the investment incentives provided by the Italian tax system are aimed at specific types of assets and that tangible assets are subject to different depreciation rates depending on their category, it is necessary to subdivide tangible investments by category. Without making this distinction, one would risk making distorted estimates of the effects of the different measures. The available data allow for a breakdown of tangible investments into two macro groups within which the depreciation rate is approximately the same: investments in buildings and investments in machinery, equipment and other unspecified assets (they will be referred to in the rest of the text as ME investments). No breakdown is made for intangible investments. With reference to the depreciation rate, we assume that they have a useful life of three years.

4.1 Estimation of investment by category

Total tangible investment is split between investment in buildings (I^{Build}) and investment in machinery, plant and equipment (I^{ME}):

$$I_{i,t}^{ME} = BV_{i,t}^{ME} - BV_{i,t-1}^{ME} + Depr_{i,t}^{ME} \quad (8)$$

$$I_{i,t}^{Build} = BV_{i,t}^{Build} - BV_{i,t-1}^{Build} + Depr_{i,t}^{Build} \quad (9)$$

In order to estimate these variables, it is therefore necessary to allocate the book value and the depreciation charge of tangible assets between the two different groups of assets. However, as this detail is available only in analytical balance sheets (drawn up by approximately 220,000 firms out of 1,249,205 included in the model), we implement two different estimation procedures that are presented in sections 4.1.1 and 4.1.2.

It should be noted that the specification stated in equation 8, although representing a good approximation of investments, is characterized by some potential weaknesses: it does not allow identification of divestments and it does not take into account write-downs and changes in the scope of consolidation. To overcome these drawbacks and improve the robustness of the estimate, some adjustments were made by exploiting the information on the premium on depreciation allowances for assets benefiting from super and hyper depreciation reported in tax returns. This allows us to estimate the purchases of eligible goods made by companies in each year. In the case of negative or null investments in machinery and equipment estimated on the base of balance sheet data by equation 8 and positive investments eligible for Transition 4.0 resulting from tax returns for the same period, we have replaced the amounts of investments in machinery and equipment resulting from balance sheets with those estimated using the premium. In fact, total investments resulting from balance sheets can be negative or zero because asset purchases, even if positive, are more than offset by divestments and write-downs.

4.1.1 Depreciated cost allocation

Companies that draw up financial statements in analytical form are required to disclose in the balance sheet the value of tangible assets net of accumulated depreciation by type of asset. For such firms, we know the breakdown necessary for estimating equations 8 and 9. Instead, companies that draw up simplified financial statements are not subject to this requirement and only report the total value of tangible assets net of accumulated depreciation. There are approximately 220,000 companies[10] (about 28% of the total companies with tangible fixed assets greater than zero) that draw up analytical financial statements and they account for 82% in terms of total depreciated value.

[10]The value refers to companies with tangible fixed assets greater than zero in 2018.

In order to obtain the detailed balance sheet value of tangible fixed assets for firms with simplified balance sheet, we implement an imputation procedure that assigns to each of these companies the share of total fixed assets relating to buildings of the company with analytical balance sheet that is most similar according to certain characteristics. In particular, the imputation is carried out using the propensity score matching (PSM) technique, which allows to associate to each company with an analytical balance sheet (treated group), a company with a simplified balance sheet (control group) with similar characteristics.

In order to identify the most relevant characteristics for the determination of the share of buildings over total tangible fixed assets, several regressions were tested with the aim of identifying the variables that contribute the most to explaining (in terms of R2) differences in the share of land and buildings of companies. As shown in table 3, column (6) shows the model that maximizes the adjusted R2.

Table 3: Regression table

	(1)	(2)	(3)	(4)	(5)	(6)
			Building share			
Depreciation rate	-1.627***	-1.619***	-1.499***	-1.087***	-1.099***	-0.276***
	(-314.98)	(-313.09)	(-296.52)	(-233.84)	(-233.90)	(-53.16)
IMU Dummy				0.400***	0.399***	0.311***
				(260.64)	(259.63)	(226.26)
Depreciation rate's group Dummy					0.0229***	0.0159***
					(17.48)	(14.03)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Size Dummy	No	Yes	Yes	Yes	Yes	Yes
Sector Dummy	No	No	Yes	Yes	Yes	Yes
Depreciation group Dummy	No	No	No	No	No	Yes
R2 Adj.	0.330	0.332	0.394	0.547	0.548	0.663
N	201406	201406	201161	201161	201161	201161

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The variables included in the preferred specification are:

- the depreciation rate of each firm at time t defined as:

$$DeprRate_{i,t}^{tang} = depr_{i,t}^{tang} / (depr_{i,t}^{tang} + BV_{i,t}^{tang}) \tag{10}$$

- Dummy "IMU" (immovable property tax) constructed as a variable that takes value 1 if the company owns buildings on which the tax is charged and 0 otherwise;

- a dummy for the change in the depreciation rate, which is a proxy for the change in investments as a different depreciation rate from one year to the next may signal the presence of a new type of investment supported by the firm or a disinvestment;
- size dummies to capture the fixed effects of firm size;
- sector dummies to capture sector fixed effects using the 1-digit Ateco classification;
- a Depreciation group dummy to capture fixed effects of depreciation, by dividing enterprises into three classes according to average depreciation rate (less than or equal to 0.04; between 0.04 and 0.105; greater than 0.105)[11].

It should be noted that the rate of depreciation can contribute to explaining the presence or absence of buildings within investments as depreciation coefficients relating to buildings are generally lower than those relating to machinery. infact, buildings have a useful life spanning from 20 to 25 years, while machinery have to be replaced after 5 up to 10 years.

In the first step of the PSM we include the selected variables in a probit regression to obtain the estimated propensity score (p-score), which represents the probability that a firm is assigned to the treated or control group based on selected covariates. At this point, using the stratified nearest-neighbour matching technique, firms are divided into three different strata based on the depreciation rate reported in 2018 (less than or equal to 0.04; between 0.04 and 0.105; greater than 0.105). Within each stratum, matching is performed by associating each firm in the treated group with the one with the most similar p-score in the control group. Stratification allows matching within subgroups of firms that have p-scores comprised in the different ranges, thereby increasing the precision of the estimate. Robustness tests were carried out for each of the three strata to verify the goodness of matching, as shown in the table below.

[11] Groups have been defined in order to minimize the estimation error.

Table 4: Test for goodness of matching

Sample	Ps R2	LR chi2	$p > chi2$	Mean Bias	Med Bias	B	R	% concern	% bad
Unmatched	0.211	30325.14	0.000	22.5	18.8	105.2*	0.12*	47	18
Matched	0.001	337.78	0.000	1.5	1.8	7.3	1.02	0	0
Sample	**Ps R2**	**LR chi2**	$p > chi2$	**Mean Bias**	**Med Bias**	**B**	**R**	**% concern**	**% bad**
Unmatched	0.078	7673.23	0.000	12.9	9.7	58.4*	0.10*	24	18
Matched	0.000	74.51	0.000	0.7	0.5	3.8	1.07	0	0
Sample	**Ps R2**	**LR chi2**	$p > chi2$	**Mean Bias**	**Med Bias**	**B**	**R**	**% concern**	**% bad**
Unmatched	0.123	47321.90	0.000	15.3	9.5	75.0*	0.09*	47	18
Matched	0.000	308.93	0.000	0.8	0.6	4.2	0.99	0	0

if $B > 25\%$, R outside [0.5, 2]

The measures provided by the tests indicate that the matching procedure reduced the bias and made the groups of treated and control firms within each stratum more homogeneous. In fact, according to Rubin (2001), for the two groups to be considered sufficiently balanced, B must be less than 25 and R between 0.5 and 2[12].

After the matching, the building share of the company with an analytical balance sheet is finally allocated to the corresponding company with the simplified balance sheet associated through the matching. In this way, it is possible to extend the method for calculating investments to the entire population.

Next, we make an adjustment to correct the breakdown of tangible investments between machinery and buildings derived from accounting results by using the estimate of investments in assets eligible for "Transition 4.0" plan resulting from tax returns. In particular, when investments in machinery are lower than investments eligible for "Transition 4.0", the breakdown by asset type estimated is adjusted by reducing investments in buildings and increasing those in machinery and equipment up to the total tangible asset investments, so to obtain investments closer to those estimated by the fiscal premium. In the extreme case of investments in "Transition 4.0" assets greater than total tangible investments, investments in plants and machinery are set equal to total tangible investments and investments in building are set equal to zero.

4.1.2 Depreciation charges allocation

Regarding the depreciation charge, the income statement contains the split between the depreciation for tangible and intangible assets, but does not distinguish between

[12]B is the standard deviation between the means of the groups and R is the ratio of treatment variance to control variance.

the individual types of assets. In order to distinguish the depreciation charge relating to buildings from the one relating to other assets, we propose a methodology based on a comparison of the book value of buildings recorded for two subsequent years. In particular, we identify three different cases:

$$BV_{i,t}^{Build} - BV_{i,t-1}^{Build} < 0 \tag{11}$$

In the case where the book value decreases between t and $t-1$, the depreciation of the buildings is assumed to be equal to the absolute value of this difference. The basic assumption is that no new investments have been made and that the book value reduction is due to depreciation only.

$$BV_{i,t}^{Build} - BV_{i,t-1}^{Build} = 0 \tag{12}$$

If the book value is invariant between two periods, the depreciation charge for buildings is set equal to zero.

$$BV_{i,t}^{Build} - BV_{i,t-1}^{Build} > 0 \tag{13}$$

In the case of an increase in the book value, it is assumed that the positive difference is due to a new investment in buildings. As the depreciated value in the year in which the investment is made is an approximation of the historical cost, the depreciation charge is calculated from the book value assuming a depreciation rate of 4% as follows[13]:

$$Depr_{i,t}^{Build} = BV_{i,t}^{Build}/0.96 * 0.04 \tag{14}$$

The depreciation charge for other assets is calculated residually as the difference between the total tangible depreciation and the depreciation charge for buildings.

4.2 Historical cost estimation

The model includes also a package that allows for the reconstruction of the historical cost of investments. This additional feature is essential when estimating the effects of changes in the depreciation regime. The historical cost of tangible assets is defined as the sum of the value of the fixed assets in the balance sheet and the depreciation fund[14]. However, as companies are not obliged to report the value of the accumulated depreciation in the balance sheet (with reference to the 2018 tax year, only about

[13] The 1988 Ministerial Decree provides for building a depreciation coefficient in the range of 3 to 4%.

[14] The depreciation fund is an accounting item that measures the cumulative value of depreciation for the various assets in the company.

430,000 out of more than 990,000 provided this information), we develop an alternative procedure for estimating historical cost. In particular, using the breakdown of depreciation charges by type of asset, it is possible to calculate the historical cost of buildings. Buildings are in fact characterized by a rather uniform depreciation regime with depreciation rates varying between 3% and 4% depending on the type of building (in particular, buildings for industrial use are uniformly depreciated at a rate of 4%). Consequently, the total historical cost of buildings can be calculated by dividing the buildings depreciation charge of the company for a depreciation rate of 4%. Finally, as the historical series available to us (2013-2018)[15] is shorter than the useful life of buildings (25 years), we calculate a correction factor for the buildings to include in the historical cost estimation the accumulated depreciation carried out before the first year available in the series[16]. The total historical cost of tangible assets is obtained by adding this correction factor to the total investments made in the period 2014-2018 and to the depreciated value at base year. Finally, the historical cost of machinery is obtained as the difference between the total historical cost of tangible assets and the historical cost of buildings.

5 The main features of the Italian Corporate Income Tax legislation

In this section, we analyze the main measures of the Italian tax system simulated in the model.

5.1 Super and Hyper depreciation

In order to promote investments in tangible and intangible assets that foster technological and digital transformation, starting from 2015[17] the possibility of increasing the tax cost of these assets relevant for the calculation of deductible depreciation allowances was introduced. In 2020, the provision of a deduction (which is a reduction in the IRES tax base) has been replaced by the provision of a tax credit (a reduction in the IRES tax due), currently in force until December 2022[18]. Table 5 shows rates

[15] Although the years prior to 2013 are available, we decided to estimate historical cost by taking into account the estimated investments starting from 2013 as write-ups of tangible assets in the balance sheet occurred in the preceding period can distort the estimate.

[16] The correction factor is equal to the number of depreciation charges for buildings prior to the base year: $Correction\,factor^{Build} = (n.\,years - 6) * (0.04 * H.C._t^{Build})$. The number of years in which the buildings have already been depreciated is reconstructed by comparing the historical cost of the buildings and the book value recorded in 2018: $n.years = (H.C._t^{Build} - B.V._t^{Build}.{}_t)/(H.C._t^{Build}{}_t * 0.04)$.

[17] Law No. 208/2015 introduced Super depreciation and Law No. 232/2016 Hyper depreciation.

[18] Until December 2025 for Hyper depreciation.

and ceilings set by the regulation for Super and Hyper depreciation.

Table 5: Industry 4.0: Super/Hyper depreciation and Tax Credit

		Depreciation premium			**Tax credit**					
		2017	2018	2019	2020	2021	2022	2023	2024	2025
Tangible assets	Rate	40%	30%	30%	6%	10%	6%	-	-	-
not Industry 4.0	Ceiling	-	-	2.5	2	2	2	-	-	-
Intangible assets	Rate	-	-	-	-	10%	6%	-	-	-
not Industry 4.0	Ceiling	-	-	-	-	1	1	-	-	-
	Rate	150%	150%	170%	40%	50%	40%	20%	20%	20%
	Ceiling	-	-	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Tangible assets	Rate	-	-	100%	20%	30%	20%	10%	10%	10%
Industry 4.0	Ceiling	-	-	10	10	10	10	10	10	10
	Rate	-	-	50%	-	10%	10%	5%	5%	5%
	Ceiling	-	-	20	-	20	20	50	50	50
Intangible assets	Rate	40%	40%	40%	15%	20%	20%	20%	15%	10%
Industry 4.0	Ceiling	-	-	-	0.7	1	1	1	1	1

Ceilings are reported in Mln Euros

By using the amount of the depreciation premium reported in the company's tax return, it is possible to estimate the amount of investment eligible for the measure as described in the equation below:

$$EI_{i,t}^{Super/Hyper} = Depr_{i,t}^{Super/Hyper} * \frac{1/r_{i,t}^{Depr}}{r^{premium}} \tag{15}$$

Where $Depr_{i,t}^{Super/Hyper}$ is the amount of premium reported, $r^{premium}$ is the increase in the deductible fiscal value of the investment and $r_{i,t}^{Depr}$ is the depreciation rate specific for each company i. The latter is calculated for all companies that have made an investment in machinery and equipment $(I_{i,t}^{M\&E})$[19] at time t and whose depreciation charge at time t is greater than the depreciation of the previous period, since the positive difference between depreciation charges is assumed to be due to a new investment in machinery and equipment:

$$r_{i,t}^{Depr} = \frac{(Depr_{i,t} - Depr_{i,t-1})}{I_{i,t}^{ME}} \tag{16}$$

Nonetheless, as deductible depreciation is 50% of ordinary depreciation in the first year of the useful life of an asset, the information on the premium amount used to estimate investments is the one resulting from the second tax return submitted after the year in which the investment was made. In other words, we use the 2019 tax return to reconstruct the 2018 eligible investment, so to include in the estimated investments assets

[19]The procedure for estimating $I_{i,t}^{M\&E}$ is described in detail in section 4.1.

purchases started in 2018 and completed in the first half of 2019, and to neutralize the halving of the fiscal depreciation in the first year of asset's life.

In order to calculate revenue effects of this measure in the period 2022-2025 of the latest Budget Law, we estimate the eligible investments in each year and apply to them the period-specific tax regulation. In particular, the projection of eligible tangible investment is obtained as follows. First we calculate, for the most recent year available in the dataset, the share of super and hyper subsidized investments resulting from tax return data over total investment in machinery and equipment estimated on the base of accounting data. Assuming that these two shares are constant over time, we obtain the projected eligible investments for the following years by applying them to the projected investments in machinery and equipment. Instead, the projection of eligible intangible investment is obtained with a similar procedure but the share of subsidized investment is computed as the ratio between subsidized investment from tax return data and total intangible investment estimated from balance sheet data.

5.2 Interest expense deductibility

According to the Italian tax system, interest expense is fully deductible from tax base up to the amount of interest income. Thereafter, excess interest expense is deductible up to 30% of the gross operating margin (EBITDA)[20] relevant for tax purposes. Before 2019, the limit of 30% was calculated on EBITDA as reported in the financial statements. Net interest expense exceeding the yearly limitation can be carried forward and deducted in the following fiscal years. Starting from 2019, interest income exceeding interest expenses can be carried forward to offset future interest expenses in any following fiscal year. The estimate of the amount of deductible interest expenses for each company is made by projecting forward the gross operating margin, interest income and net interest expenses starting from the base year 2019.

For fiscal groups the net interest expense limitation is applied at the consolidated level. As a consequence, if a company participating in a fiscal group has an excess interest deduction capacity, this excess capacity may be used to offset the interest deduction deficit of another company belonging to the same fiscal group.

5.3 Loss Carryforward

Tax losses can be carried forward for IRES purposes and used to offset income in the following tax periods without any time limitation. Tax losses can only be partially

[20]Earnings Before Interests and Taxes, Depreciation and Amortization.

offset with taxable income for an amount not exceeding 80% of the taxable income. Nonetheless, losses arising in the first three years of activity can be used in compensation of 100% of taxable income.
In the case of group taxation, profits and losses recorded by participating companies offset each other. In the model, for firms with positive operating result, the profit is firstly offset against not partially deductible losses and then against partially deductible losses.

5.4 IMU (Real Estate Tax) deductible

The Italian tax system provides for the application of a tax for capital real estate called IMU. The tax is deductible for IRES purposes, and while the deductibility rate has changed several times over the years as shown in Table 6, it currently stands at 100%. For the purpose of determining business income within the framework of the model, the IMU relating to capital properties owned by the enterprise is deductible from the tax base.

Table 6: IMU deductibility rate

Year	Deductibility rate
2018	20%
2019	50%
2020	60%
2021	60%
2022	100%
2023	100%

5.5 Allowance for Corporate Equity (ACE)

This measure is aimed at ensuring the neutrality of the taxation of business income with respect to the choice of financing sources (equity and debt capital). As interest expenses are deductible, the measure provides for the deduction from the taxable income of “ordinary profit”, determined by applying to equity increases due to contributions and retained earnings allocated to disposable reserves net of dividends distributed to shareholders, investments in subsidiaries and certain intra-group business acquisitions and transactions a notional rate of return defined by the fiscal regulation[21]. The allowance shall not exceed the net IRES tax base; the exceeding difference can be carried forward to the next fiscal period. The equity increase is calculated assuming as a base the equity, net of current profit, disclosed in the Financial Statements for the fiscal

[21] The regulation sets the following rates: 3% for the years 2011-2013, 4% in 2014, 4,5% in 2015, 4,75% in 2016, 1,6% in 2017, 1,5% in 2018 and 1,3% from 2019.

year ending 31 December 2010.

In order to incentive capital injections, to face the firm's liquidity crisis deriving from the Covid-19 pandemic, Law No. 73/2021, the so-called "Decreto Sostegni Bis", introduced a new 15% rate to be applied to net equity increases, made from December 2020 to December 2021, up to EUR 5 million. The increase exceeding the cap was eligible for the ordinary ACE rate. The allowance could be used either as a tax credit or as an income deduction.
Since it is not possible to predict capital injections by cash contributions, only increases in the form of retained earnings are considered. For this reason, the variation in company's equity is assumed to be equal to the sum of the previous year's variation and the profit of the year multiplied by the share of retained earnings (RE) on profits experienced in the past, or alternatively minus the loss of the year in the case of a negative economic result:

$$\Delta\ Equity_{i,t} = \Delta\ Equity_{i,t-1} + (avg\ share\ of\ RE_{2011-2019} * profit_{i,t}) – loss_{i,t} \qquad (17)$$

The share of retained earnings on profits is the average value at individual firm's level of the ratio between capital changes and profits, for the period 2011-2019. We choose to use the average value instead of the previous year's value, to exclude anomalous variations from the estimate. Finally, the financial effects of the fiscal allowance are calculated as follows:

$$\Delta\ ACE_{i,t} = \Delta\ Equity_{i,t} * r_t^{ACE} \qquad if \Delta\ Equity_{i,t} > 0 \qquad (18)$$

Where $\Delta\ ACE$ is the additional ACE deriving from retained earnings in t, which is added to the ACE depending on capital increases in previous years and r_t^{ACE} is the ordinary rate of return of capital as defined by the fiscal law.

5.6 Research and Development Tax Credit

This measure, introduced in 2015[22] with the aim of promoting innovation, benefits expenditures on Research & Development[23]. Since its introduction and until 2019, this measure applied to incremental investments compared to the average spent in the 3 tax years ending 31 December 2014 ($\overline{Exp^{R\&D}}_{i,2012-2014}$)[24], while from 2020 it is

[22]Law No. 190/2014.

[23]Eligible expenses include expenditure on highly qualified employees, expenditure on the acquisition or use of laboratory instruments and equipment, expenditure on research contracts, technical skills and industrial patents.

[24]If companies do not report data on $R\&D$ average expenditure (about 16% in terms of credit amount), it is assumed that the historical average is zero. This assumption is motivated by the fact

calculated directly on the amount of the investment of the year. The 2020 Budget Law differentiates between three types of eligible investments: research and development, technological innovation and design. The 2022 Budget Law extended the benefit until 2025, as shown in Table 7 reporting rates and ceilings set by the regulation.

Table 7: Research and Development Tax Credit

		2017- 2018	2019	2020	2021	2022	2023	2024	2025
Research and	Rate	50%*	50%*	12%	20%	10%	10%	10%	10%
Development	Ceiling	20	10	3	4	4	5	5	5
Technological	Rate	-	-	10%	15%	15%	10%	5%	5%
Innovation	Ceiling	-	-	1.5	2	2	4	4	4
Design	Rate	-	-	6%	10%	10%	10%	5%	5%
	Ceiling	-	-	1.5	2	2	2	2	2
Ceilings are in Mln Euros									

*Calculated on incremental expenses

Financial effects of the measure are calculated for the period 2022 to 2025 by projecting forward investments, estimated on the basis of tax returns data, and applying the specific fiscal legislation of each year.

5.7 Tax credit for South Italy

This measure, introduced in 2016[25], states that companies investing in Basilicata, Calabria, Campania, Puglia, Sicily, Sardinia, Molise and Abruzzo can benefit of a tax credit ranging from 10% to 45%. As reported in table 8 the rates vary according to the region and the size of the enterprise (small, medium and large):

that about half of the companies reporting the information stated that they had not incurred any *R&D* expenditure in the three-year period 2012-2014.

[25] Law No. 208/2015.

Table 8: Tax Credit for South Italy

	Tax Credit Rate		
	Small	Medium	Large
Abruzzo	30%	20%	10%
Basilicata	45%	35%	25%
Calabria	45%	35%	25%
Campania	45%	35%	25%
Molise	30%	20%	10%
Apulia	45%	35%	25%
Sardinia	45%	35%	25%
Sicily	45%	35%	25%

The ceilings are 3, 5 or 10 Mln Euros for small, medium and large firms, respectively

It is currently in force and extended until December 2022. In order to estimate this measure we apply a procedure similar to the one described in paragraph 5.6 for R&D tax credit.

6 Validation of the model

6.1 Validation of IRES tax due

In this section we assess the performance of the CITSIM-DF model to consistently approximate the IRES tax due. The simulation results carried out from tax returns for the tax year 2017 are compared with official data reported in tax returns for years 2018 and 2019. This allows a comparison of the actual IRES tax due made for the years 2018 and 2019 with the estimated projections. This variable is suitable as a benchmark for model validation as it depends on all measures simulated in the model.

Table 9: IRES tax due

IRES tax due			
Year	Tax return	CITSIM estimation	% of Error
Single enterprises			
2018	20,762	20,639	-1%
2019	20,791	21,010	1%
Fiscal groups			
2018	9,152	9,084	-1%
2019	9,293	9,567	3%
Total			
2018	29,914	29,723	-1%
2019	30,084	30,577	2%
Values in Mln Euros			

Table 9 shows that the CITSIM model correctly estimates the IRES tax due. In particular, at aggregate level, the IRES tax due is underestimated by 1% in 2018, and overestimated by 2% in 2019. The estimation error is of the same sign for both fiscal groups and single companies.

6.2 Validation of Investment Estimation

As broadly described in the previous paragraphs, two different types of investments were estimated using two different procedures: investments in machinery and equipment (section 4) and investments in tangible assets eligible for super and hyper depreciation (section 5.1). The two procedures have been used jointly to improve the goodness of the investments estimation.

Table 10: Estimated investment

Size	$I^{Tr.4.0}$	I^{ME}	$I^{ME} Adj.$	% Adj.
		N. firms		
Up to 2 mln	140,451	379,749	79,517	57%
2 - 10 mln	44,065	78,858	24,728	56%
10 - 50 mln	14,262	22,123	8,602	60%
Over 50 mln	4,116	5,876	2,410	59%
N.A.	263	1,597	199	76%
Total	203,157	488,203	115,456	57%
		Investment (Mln Euros)		
Up to 2 mln	4,123	9,466	10,353	9%
2 - 10 mln	8,429	9,062	10,430	13%
10 - 50 mln	11,683	11,157	12,372	10%
Over 50 mln	34,331	41,361	43,467	5%
N.A.	9	45	49	7%
Total	58,574	71,091	76,671	7%

The table 10 shows the number of companies making investments and the relative amount. In particular, in 2018, around 488,000 companies made investments in machinery and equipment, while more than 203,000 companies made eligible investments in Industry 4.0 assets. Thanks to the integration of the two methodologies, investments of approximately 115,000 companies were adjusted. In particular, these adjustments concerned about half of the companies that made eligible investments from Industry 4.0, with an increase of investments in machinery and equipment from EUR 71 billion to EUR 77 billion. These adjustments are homogeneous between different size classes.

In order to investigate the accuracy of our estimate, we made a comparison between the investments reported in the National Accounts by ISTAT and those estimated by the CITSIM-DF model. In the National Accounts, gross fixed capital formation is defined as the acquisition (net of sales) of durable tangible assets made by an enterprise during the financial year and includes the purchase of machinery, plant, equipment, furniture, transport equipment, construction and buildings, land and the increase in fixed assets for internal work. This item includes extraordinary maintenance and repairs that extend the normal useful life and improve the productive capacity of capital goods. In order to make the comparison between the investment in machinery and equipment from National Accounts and the estimated investments, we need to homogenize the strata considered. For this purpose the investments made by financial companies and public administration has been subtracted from gross fixed capital formation reported in National Accounts as these sectors are excluded from the CITSIM-DF model. In a second step we excluded the share of investments relating to companies different from corporations, which are not included in the perimeter of application of the Corporate Income Tax. As a result of the standardization procedure, the investments in machinery and equipment from the National Accounts stand at approximately EUR 88 billion (Table 11), while those estimated by the CITSIM-DF model amount to roughly EUR 77 billion. Thus, the investments estimated by the model (about 80% of the ISTAT investments) seem to be consistent with National Accounts.

As a further robustness check, we compared the estimated investments in machinery and equipment with those facilitated with Industry 4.0. The main difference between the two investment categories concerns the range of products included and the sectors subsidized. In particular, not all categories of goods and production sectors are eligible for Industry 4.0 subsidies[26] (e.g. the vehicle macro-category and the pipeline production sector are excluded). The difference between the values estimated with the two procedures is approximately EUR 18 billion. As a consequence, excluding the macro-category of vehicles (certainly excluded from the model) and the investments made by sectors not allowed to the facility, the deviation between the two estimates is lower than 2%.

[26]Law No. 208/2015 - Appendix 3.

Table 11: Comparison between Investment estimation and national accounts

	Amount 2018 Mln Euros
Gross Fixed Capital Formation ISTAT	
GFCF Machinery and Equipment	121,249
- financial and P.A. sectors	-11,849
Gross Fixed Capital Formation non-financial firms (excluding PA)	109,400
- 10% of firms different to corporation	-10,940
Gross Fixed Capital Formation corporations	98,460
- Vehicles (all Sectors except transport and logistics)	-13,141
Eligible gross fixed capital formation	88,223
Estimated investments CITSIM-DF	
ME investments estimated from balance sheet data net of disinvestments (incl. vehicles)	76,670
ME investments estimated on tax return data*	58,574
Difference	18,096
- Investment in vehicles (non eligible)	10,237
- Investments in sectors not allowed to the facility	9,100
Difference not explained	-1,237
% of balance sheet investments	-1.6%
Percentage coverage of investments estimated over ISTAT investments	
From balance sheet (including ineligible vehicles)	77.9%
From tax return (excluding ineligible vehicles)	66.4%

* ME investments whose unit cost is lower than about 520 euros are not included because fiscal regulation states that they can be depreciated in one year.

Tax returns for the tax year 2021 show the amount of investments for which companies benefit from the Ex "Industry 4.0" tax credit. This information was used to validate the estimate of subsidised investments made in the model. In particular, tax returns show that companies made investments subsidised by the measure of approximately EUR 9 billion in the year 2021, while the simulated amount corresponds to approximately EUR 10.5 billion.

7 Simulations: "Transition 4.0 Plan"

This section illustrates an application of how the CITSIM model can be used to assess the policy implications of fiscal reforms and changes in the legislation, focusing in particular on evaluating the financial effects of the extension of the "Transition 4.0" package, included in the Budget Law 2022. In particular, with the aim of promoting the ecological and environmental transition of firms, the Budget Law 2022 extended for the period 2023-2025 the tax credit for the purchase of capital goods (ex "Industry 4.0" assets) and the tax credit for research and development activities, with different rates and ceilings. Both measures are included in the "Transition Plan 4.0", the details of the rates and ceilings applied in each year of existence of the measure are shown in Table 5 and Table 7.

7.1 Ex "Industry 4.0" Tangible assets Tax Credit

The Budget Law 2022 extended the tax credit for investments in high-tech capital goods for the three-year period 2023-2025 with revised rates: 20 per cent of investments up to EUR 2.5 million, 10 per cent of investments between EUR 2.5 and 10 million, and 5 per cent of investments between EUR 10 and 20 million. Table 12 shows the results of the simulation for the entire period, reporting the eligible investments[27], the amount of the tax credit and the annual instalments. As the tax credit can be used in three equal instalments, the latter are equal to the cumulative amount of the instalments for each eligible investment from 2023 onwards. In addition, to test the performance of the model, the estimates of the Technical Report attached to the Budget Law 2022 have been reported in the last column of the table. Note that, on the basis of administrative data, we could exclude a share equal to 10% of total value of instalments, as it refers to investments made by firms not qualified as corporations. In this way we can reliably use the Technical Report of the Budget Law 2022 as a benchmark for our estimation. No declaration data are available for the estimated period, therefore, the estimates of the technical report were identified as benchmarks[28].

Table 12: Estimated eligible investment and tax credit

Ex "Industry 4.0" Tangible assets				
		CITSIM-DF		**Technical report Budget Law 2022***
Year	Investment	Tax Credit	Installments	Installments
2023	11,953	1,484	495	480
2024	12,596	1,543	1,009	1,079
2025	12,992	1,580	1,536	1,679
Values in Mln Euros				

*From the total value 10% was excluded in order to compare it with corporations

The model estimates that the eligible investment made by Italian corporations in the period 2023-2025 will be approximately equal to EUR 38 billion, implying a reduction in revenues collected of around EUR 4.6 billion. Due to the provision of three annual installments, the financial negative effects of the measure are EUR 0,5

[27] The investments were estimated using the tax return 2020, relative to fiscal year 2019.

[28] The estimation reported in the technical report are obtained with IM4.0-SOGEI Model (Investment monitoring 4.0 Model) that is a sub-model of the IRES Microsimulation Model. The model aims to assess the ex ante effects and to monitor the Investment 4.0 regulation.

billion in 2023, EUR 1 billion in 2024 and EUR 1,5 billion in 2025.

Subsequently, Decree Law No.4 of 01/2022 extended the ceiling of the measure from EUR 20 to EUR 50 million. Table 13 shows that, given the increase in the ceiling, the amount of eligible investment increases to approximately EUR 41 billion for the three-year period. The change in the measure leads to a cumulative tax credit of EUR 4.9 billion, approximately EUR 190 million higher than the one estimated before the increase in the ceiling.

Table 13: Estimated eligible investment and tax credit after Decree Law No.4 of 01/2022

	Ex "Industry 4.0" Tangible assets CITSIM-DF		
Year	Investment	Tax Credit	Installments
2023	13,136	1,543	514
2024	13,881	1,607	1,050
2025	14,344	1,648	1,599
Values in Mln Euros			

7.1.1 Distributional Effects

In this section we show the eligible investments and the tax credit broken down by industry, size class and geographical area (Table 14). The companies with the largest share of subsidised investments are those in the manufacturing sector, which invest an average of EUR 11 billion a year over the three-year period 2023-2025 and account for more than 80% of the economy's investments. Utilisation of the measure is proportional to the size of the enterprise, measured by turnover. It turns out that around 70% of the subsidised investments will be made by companies with an annual turnover of more than EUR 10 million. Looking at the amounts of eligible investment and tax credit, even if the enterprises with a turnover greater than EUR 50 million account for more eligible investments than the previous group, the amount of tax credit is lower. This might suggest that on average firms with more than EUR 50 million in turnover make mostly large investments that fall in the last bracket of the tax credit (from EUR 10 to EUR 50 million), benefiting of the lowest tax credit rate (28% of tax credit over the total). The geographical distribution shows that the majority of subsidized investments will be made by companies in Northern Italy (almost 80% of the total) and that companies in Central and Southern Italy will account only for a residual share of investments.

Looking at the ratio between the number of enterprises benefiting from the measure and the total number of enterprises per industry, it is clear that there are minimal sectoral differences and the Manufacturing sector represents the sector in which the measure is most widely used, but with a low share (6%). Considering the enterprise size, it emerges that the measure is used by larger enterprises. Almost one fifth of firms with revenues over 50 million euro have benefited from the measure, a share that drops to 12% for enterprises with revenues between 10 and 50 million euro. Even looking at the geographical distribution, no significant differences can be appreciated. This result shows that the only variable for which differences in the spread of the incentive are appreciated is the size.

Table 14: Yearly average of estimated eligible Investment and Tax Credit 2023-2025 by category

	Ex "Industry 4.0" Tangible assets			
Sector	**Avg. yearly Investment**	**% over total**	**Avg. yearly Tax credit**	**% Beneficiaries over total**
Agriculture-Mining	134	1%	15	1%
Construction	495	4%	56	0%
Energy	369	3%	33	1%
Manufacturing	11,232	81%	1,309	6%
Public Administration	107	1%	18	1%
Services	356	3%	42	0%
Trading	821	6%	94	1%
Revenue				
Up to 2 mln	1,258	9%	157	0%
2 - 10 mln	2,637	19%	446	5%
10 - 50 mln	4,282	31%	541	12%
Over 50 mln	5,609	41%	456	19%
N.A.	0.4	0%	0.1	0%
Geographic Area				
North-West	5,638	41%	649	2%
North-East	5,307	38%	619	2%
Center	1,667	12%	203	1%
South and Islands	1,175	9%	128	0%
Values in Mln Euros				

7.2 Technological Innovation, Design and R&D activities Tax Credit

The Budget Law 2022 also extended the tax credit for investments in technological innovation, design and R&D activities. In particular, the incentive for technological innovation has been extended until 2025 with a tax credit rate of 10% in 2023 and 5% in the following two years. The maximum amount of eligible investment in the category is EUR 4 million over the entire three-year period. The same time extension and tax credit rates will be applied to design activities (but the ceiling is set to 2 million instead of EUR 4 million). The incentive for research and development activities is extended for 9 years, the relative tax credit rate remains at 10%, while the ceiling is raised from EUR 4 to EUR 5 million.

In Table 15 we report the investment estimated[29] and the total tax credit split in the three different categories of expenditure.

Table 15: Estimated eligible investment and tax credit

Year	**Investment**	**Total Tax Credit**	**R&D**	**Tech. Inn.**	**Design**
2023	10,541	1,050	787	158	105
2024	11,042	962	824	83	55
2025	11,353	989	847	85	57
Values in Mln Euros					

In Table 16 we report the installments related to the tax credit and a comparison with those included in the Technical Report attached to the 2022 Budget Law. Note that the value reported in the Technical Report is directly comparable to our estimates since we could verify from administrative data that almost 99% of firms utilizing the R&D credit are corporations.

[29]Estimated by using the tax return relative to fiscal year 2019.

Table 16: Tax Credit

Year	Installments	R&D	Tech. Inn.	Design
CITSIM-DF				
2023	350	262	53	35
2024	671	537	80	54
2025	1,000	819	109	72
Technical Report LB2022				
2023	337	250	51	36
2024	632	500	78	54
2025	927	750	105	72
Values in Mln Euros				

According to our estimates, in the three-year period 2023-2025 Italian companies will make around EUR 33 billion of eligible investments, which translates into an expenditure of around EUR 3 billion for the Government. The revenue reduction will be approximately EUR 350 million in 2023, EUR 670 million in 2024 and EUR 1 billion in 2025. These results are consistent with official figures in the technical report.

7.2.1 Distributional Effects

Focusing on the sectoral distribution (Table 17), it emerges that compared to the incentive for tangible assets included in Industry 4.0, where more than 80 per cent of the subsidised investments were made by the manufacturing sector, this measure is more uniformly distributed among different sectors. Also in this case, companies operating in the manufacturing sector are the ones that benefit the most from the tax credit (around 57%), followed by enterprises in the service sector (25%) and trade (8%). With respect to company size, there is no direct relation between company size and the amount of tax credit obtained. Companies that make the largest investments eligible for the tax credit are those with turnovers between EUR 2 and EUR 10 million (31% of the total) followed by those with turnovers greater than EUR 10 million (28% in the range between EUR 10-50 million and 21% over EUR 50 million). Looking at the geographical distribution, it emerges that companies in Northern Italy account for the largest share of the credit (62%), followed by companies in Central Italy (21%).

This measure is not very widespread among enterprises, in fact looking at the number of beneficiaries out of the total number of enterprises present per group reveals very low rates. Only 9% of manufacturing companies benefited from the tax credit, this percentage drops to 1% for all other sectors. Looking at the distribution by size class and geographical area, we find similar results with a percentage of 4% for companies with a turnover of up to EUR 10 million, a percentage that drops for larger companies. Northern Italian companies benefit from the tax credit at a rate of 3%, which drops to 2% for companies located in other geographical areas.

Table 17: Yearly average of Tax Credit 2023-2025 by category

Sector	**Avg. yearly Tax Credit**	**% over total**	**% Beneficiaries over total**
Agriculture-Mining	4	0%	1%
Construction	31	3%	1%
Energy	13	1%	1%
Manufacturing	569	57%	9%
Public Administration	24	2%	1%
Services	249	25%	1%
Trading	79	8%	1%
Transportation	31	3%	1%
Revenue			
Up to 2 mln	196	20%	4%
2 - 10 mln	307	31%	4%
10 - 50 mln	280	28%	2%
Over 50 mln	215	21%	1%
N.A.	2	0%	0%
Geographic Area			
North-West	361	36%	3%
North-East	261	26%	3%
Center	205	21%	2%
South and Islands	173	17%	2%
Values in Mln Euros			

8 Conclusions and next steps

Despite the increasing availability of microdata, corporate income tax microsimulation models are still rare compared to those on personal income tax, mainly because of the complexity in modeling firms' tax system. This paper contributes to this stream of literature by introducing the CITSIM-DF model, a dynamic multi-period model for the microsimulation of corporate income tax.

In terms of main innovations with respect to previous works, the CITSIM-DF model takes into account the forward-looking trend of the economy, by projecting forward the main fiscal and budgetary variables using official projections from economic and financial documents together with sector coefficients obtained from the economic and financial forecasts provided by Prometeia. Therefore, through this methodology, the variables in the financial and fiscal accounts are not held constant, but can vary according to the business cycle. This feature proves to be crucial when estimating counterfactual changes in fiscal regulation occurring in periods of shocks to the economic system, as the Covid-19 pandemic testifies. Secondly, the model introduces an innovative method of allocating depreciation allowances between machinery and buildings that allows for the estimation of the investment and the relative historical cost of the two categories separately. To the best of our knowledge, we are the first to propose an estimation procedure that is able to disentangle investments by asset category. This is an essential feature of our model as it allows us to correctly estimate the effect of fiscal measures designed for a specific type of assets, like the super/hyper depreciation included in the "Transition 4.0" plan or of overall reforms like the Common Consolidated Corporate Tax Base within the European Union.

We are currently working on extending the methodology presented in this document by introducing two main innovations. Firstly, we will extend the methodology to include firms' behavioral responses related to investment choices when simulating changes in tax regulation. Secondly, the current model will be integrated with an innovative projection procedure for fiscal and budgetary variables. In particular, by taking advantage of additional data sources, including periodic VAT returns (LIPE) and electronic invoicing characterized by quarterly deliveries, it will be possible to take into account in the projection process the actual variations experienced by each company. These new sources guarantee the timeliness of data availability, which will allow us to quickly include in the estimates the real growth of the economy. In this way, it will be possible to simulate different scenarios for changes in the legislation, taking into account also the short-term economic trend.

References

Ahmed, S. (2016). Corporate tax models: A review. *SBP Working Paper Series, (13).*

Bardazzi, R., M. Pazienza, and V. Parisi (2003). The effects of the Italian tax reform on corporations: a microsimulation approach.

Bhattarai, K., J. Haughton, M. Head, D. G. Tuerck, et al. (2017). Simulating corporate income tax reform proposals with a dynamic CGE model. *International Journal of Economics and Finance 9*(5), 20–35.

Bontempi, M. E., S. Giannini, M. Guerra, and A. Tiraferri (2001, 12). Incentivi agli investimenti e tassazione dei profitti: L'impatto delle recenti riforme fiscali sul cash flow delle società di capitali. *Politica Economica 17.*

Buslei, Bach, and Simmler (2014). Firm level models. *Handbook of microsimulation modelling, Contributions to Economic Analysis Vol. 293*, 479–503.

Caiumi, A. (2017). Micro-macro simulation of corporate tax reforms. *The New Generation of Computable General Equilibrium Models*, 53–64.

Caiumi, A. and L. Di Biagio (2016). The Istat-MATIS corporate tax model. *Rivista di Statistica.*

Caiumi, A., L. Di Biagio, and M. Rinaldi (2015). Computing effective tax rates in presence of non-linearity in corporate taxation. *Istat Working Papers N.9*.

Oropallo and Parisi (2007). Will Italy's tax reform reduce the corporate tax burden? a microsimulation analysis. *Rivista di statistica ufficiale, ISTAT*.

PBO (2019). Medita– A corporate tax microsimulation model at PBO.

Radulescu, D. and M. Stimmelmayr (2010). The impact of the 2008 German corporate tax reform: A dynamic CGE analysis. *Economic Modelling 27*(1), 454–467.

Rubin, D. B. (2001). Using propensity scores to help design observational studies: application to the tobacco litigation. *Health Services and Outcomes Research Methodology 2*(3), 169–188.

Zangari, E. (2020). An economic assessment of the evolution of the corporate tax system in Italy. *Banca d'Italia, Temi di discussione (Working Papers).*