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Environment, equality, and resilience: fiscal policy assessed through General Equilibrium Models

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A renewed debate on fiscal policy effectiveness

With the financial crisis of 2007 and the COVID-19 epidemic crisis today, the debate on the effectiveness of fiscal policy has been renewed, for which there remains a wide range of views on the strength of macroeconomic effects, the channels through which these effects operate and the different effectiveness on the basis of a country's starting economic conditions.

Some economists believe that it would be better to let fiscal policy have a countercyclical impact only through automatic stabilisers and that discretionary fiscal policies are left to long-term action, leading to less frequent changes. This is because discretionary fiscal policies are considered not to have contributed to economic stability but rather to have destabilising effects (Taylor, 2000, 2009; Feldstein, 2002). However, the previous crises, in the 80s and 90s, were mainly supply-side crises as a result of oil shocks, while the most recent crises have led to significant demand-side effects, with increased restrictions on the availability of credit to households and firms, in an environment of very low interest rates in which the effects of conventional monetary policy are limited. It is clear that different conditions can lead to a different view on the effectiveness of fiscal policies and the different role they can play in normal or crisis times. In particular, the role of automatic stabilisers is considered to play an essential role in 'normal' economic situations, while their usefulness has been judged to be low during severe recessions (Banca d'Italia, 2011).

By reviewing the literature, Hamming R., Kell M., Mahfouz S. (2002) highlight that the appropriate fiscal policy response to an economic downturn depends on a number of factors, and only a country-by-country approach by type of problem can find the best instrument. In particular, several elements need to be considered: fiscal policy is more effective if the shock originates on the demand side; the response of prices, interest rates and exchange rates may make it necessary to assess whether fiscal policy should be accompanied by monetary policy; the influence on risk premia of the duration of fiscal expansion and the sustainability of public debt should also be assessed. The increase in government expenditure, provided it is productive, is generally

associated with larger fiscal multipliers than tax cuts. Moreover, expenditure and fiscal measures that have supply-side effects may have short-term impacts affecting expectations. Finally, the behaviour of firms and households in saving and investment decisions is influenced by factors such as liquidity constraints, expectations formation and confidence which are likely to be affected by tax policy. The choice and timing of a tax policy is also influenced by the structure and the tax burden, which have a different impact and different effects on economic activity according to the country in which they are applied and the starting circumstances (Roeger W., In 't Veld J., 2009).

Recent findings of the European Commission (2020) show that the success of a policy lies in a number of factors. The reforms that form part of an integrated package of measures seem to be more effective, both because an appropriate sequencing of reforms and their coordination in time is crucial, and because short-term forms of compensation included in the 'package' of measures can make some reforms more acceptable. Not least, an evidence-based policy design, leading to a coherent and comprehensive strategy, can facilitate the acceptance of a reform and, therefore, the implementation of the reform itself.

Being taxation one of the most important tools of fiscal policies, the relationship between taxation and economic growth represents a strongly debated question for researchers and policy makers (Baxter M., King R. G. 1993).

Economic theory argues that taxes create distortions that negatively affect growth and economic operators. According to the OECD[1], corporate and personal income taxes have the greatest negative impact on growth, while types of taxation on consumption, environment and property are less harmful.

In a situation such as the present one, characterized by credit constraints, low interest rates and deflationary shocks, Roeger W. and In't Veld J. (2009) using a DSGE model have shown that

[1] OECD, Going for Growth 2009
https://www.oecd.org/economy/growth/economicpolicyreformsgoingforgrowth2009.htm

temporary fiscal policy 'shocks' can be more effective than in the past, but have significant effects in the case of expenditure interventions rather than on the tax reduction side.

These evidences, derived from the extensive literature on tax policy, do not take into account the fact that tax policies now have to pursue a number of policy objectives, focusing not only on economic growth but also on redistribution of income, resource allocation and environmental objectives. It was only since 2017 that, in its publication 'Going for Growth', the OECD has included the reduction of inequality as one of the political priorities that Governments must also pursue. While the environment has long been one of the most controversial topics of political debates, it has emerged as a global priority, especially with the latest crises, following which the European Union has launched the Green New Deal and each Member State has adopted its own Climate Plan[2]. It seems that there is also a stronger focus on environmental issues in the USA and, although not at federal level, individual States have implemented a number of targets ranging from energy efficiency to specific greenhouse gas reduction targets.

Tax policy instruments should also aim to improve the allocation of capital and labour between firms and encourage firms to invest and innovate. Reforms in this field also include reforms to facilitate firms' access to markets, including capital markets. A better allocation of resources increases the resilience of an industry, understood as the ability to cope with traumatic events by adapting and overcoming them, such as a bamboo barrel, which falls under strong winds without breaking.

Taking into account the previous issues, the present work deals with these three main goals: equity, environment and resilience, analysing the instruments that have frequently emerged in the recent policy debate to provide a different view on the effects of the instruments themselves. The analysis is carried out though General Equilibrium Models.

[2] In Italy, the drafting of the Integrated National Energy and Climate Plan (PNIEC) was completed in December 2019.

The 2007 financial crisis and the actual pandemic crisis originated from different sources: a lack of regulation that caused the liquidity shortages, in one case, and a lockdown that curbed production and consumption, on the other. Nevertheless, what the 2007 crises have taught is that to ensure the success of the reform effort it is necessary that policy instruments be constantly updated to meet the new challenges, and that greater policy analysis be promoted to ensure that the instruments implemented by Governments takes account of the specific circumstances faced by a Country. This require an approach that is general and disaggregated. General Equilibrium models in this context are widely applied because they are able to analyse economic effects from different angles (Carrasco et al., 2013).

The first chapter deals with the introduction of flat tax in Italy. The political debate within several developed and developing countries questioned over the profitability of introducing a "flat-tax" on households' income to reduce the tax burden, simplify the tax system and boost the economic growth. The main concern is related to the direct, indirect and induced income redistribution effect that could be generated by the reform of the tax system and thus generate a final impact on income below the forecasts. In this perspective, this study provides a quantification of how the introduction of the flat rate tax on income in Italy could affect the Italian economic system. From the analysis of the theoretical and applied contributions that the literature provides, it is not easy to draw a clear conclusion on the overall effect of a flat-tax system. Above all, it is not so straightforward to determine whether the benefits offset any unwanted effects. In this perspective, this study aims to analyse the economic impact of the tax rates' reform in Italy, assuming the introduction of a unique tax rate on household income, replacing the present progressive taxation on personal income. The main purpose of the analysis is evaluating the impact of a tax reform considering all the effects that could be generated within the income circular flow moving to a flat tax system. The aim is to contribute to the debate on the flat tax profitability by using household-level data, whose use in the literature seems to be limited on the issue. The

analysis is carried out through the Italian Social Accounting Matrix for 2016 built for the purpose, where the Households Institutional Sector is broken down by income deciles. The MAC18 Computable General Equilibrium (CGE) model developed by the Department of Economics and Law of the University of Macerata is then calibrated according to the new SAM. The CGE model allows providing a realistic and coherent picture of the income circular flow in Italy and allows assessing the direct, indirect, and induced effects of the reform on both macroeconomic variables and income distribution. By this way, the opposite results emerging from the literature can be addressed, as well as the main features and effects of a flat tax in Italy can be highlighted. Countries experiences, indeed, are very different not only for the different choices in terms of flat tax adopted, but also in terms of starting point conditions, which are essential in determining the effects on growth, State revenue and inequality. Three policy scenarios are analysed assuming different tax rates and different hypothesis on the policy funding by the Government. No simulation shows a trade-off between growth and inequality, while a negative effect on real GDP occurs, coupled with an uneven effect on Households disposable income.

In the second chapter, to take into account the increasing concern for climate change, the introduction of a carbon tax on productive activities in the USA at the Federal level is envisaged. The study demonstrates that fiscal reforms can be combined with environmental measures, to achieve the complex target represented by economic growth and environmental protection. In this vein, this study evaluates the economic and environmental impact of the reorganisation of federal taxation on corporate and personal income occurred in USA, coupled with the introduction of a carbon tax on economic activities. The analysis is carried out through a dynamic CGE model calibrated on a U.S. Social Accounting Matrix (SAM) with environmental accounts. The U.S. SAM for 2017 has been built for the purpose, by also integrated it with environmental data, by using the Environmental Protection Agency data on greenhouse gas emissions allocated to economic sectors. The SAM has also been integrated with the full-time equivalent data for each

activity, so to look also at the effects on employment of the fiscal policy proposed in the paper. A dynamic Computable General Equilibrium (CGE) model has been constructed, calibrated on the U.S. (SAM) for 2017, in order to analyse the effects during time. The work demonstrate that the carbon tax can have a twofold objective. On the one side, the carbon tax can relieve the loss of federal revenue following the personal income tax reduction. On the other side, the greenhouse gas tax is not detrimental for growth, on the contrary it may constitute a tax dividend useful to pursue other objectives not only for the environment, but also for health, work and fair taxation. Results indicate that the reduction of personal income tax is more geared to economic growth compared to the reduction of corporate income tax. Moreover, if the personal income tax reduction is financed with the introduction of a carbon tax on economic activities, there is no harm to the economic growth and a benefit for the environment arises.

Finally, the third chapter aims at assessing the impact of the policies put in place by the Government to support businesses during crises times so to reduce liquidity constraints and increasing resilience. The approach is twofold: in a first phase, through a general economic equilibrium model the economic impacts of a shock can be assessed, without excluding the effects on other sectors of the economy (Verikios, 2016 e 2020). Unlike previous works, the effectiveness of the policies implemented by the government and which are likely to improve the liquidity of businesses is assessed through a financial dynamic CGE model, able to capture also the changes in financial assets and liabilities of the Institutional Sectors. Two policies are considered: firstly, the reduction in employers' social security contributions, aimed at reducing the tax wedge, which has an impact on the economic account component of liquidity. Secondly, the increase in State guarantees granted through the Guarantee Fund for SMEs, which are intended to make it easier to obtain credit and, therefore, to affect the liquidity component linked to bank credit.

The second phase of the work involves the integration of CGE model with the main business data, taken from the ORBIS database, so to have the possibility to assess how the sectoral results stemming from the CGE model affect liquidity margins at industry level. The more margins

are larger, the more industries are resilient to exogenous shocks that, translating into lower revenues, put pressure on liquidity and solvency. Considering the results from the point of view of the opportunity of implementing a policy, it emerges that some sectors would benefit more from the tax wedge reduction, while others from the increase in State guarantees, depending on the structure of the sector itself. Thus, it would be appropriate to implement policies at sectoral level, to have higher benefit for the whole economic system.

References

Banca d'Italia (2011), Fiscal Policy – lessons from the crisis. Papers presented at the Banca d'Italia workshop held in Perugia, 25-27 March, 2010 in: Seminari e Convegni No.6 Febbraio 2011.

European Commission (2020), Understanding the political economy of reforms: evidence from the EU – Technical Note for the Eurogroup https://www.consilium.europa.eu/media/45511/ares-2020-4586969_eurogroup-note-on-political-economy-of-reforms.pdf

Feldstein, M. (2002), The Role for Discretionary Fiscal Policy in a Low Interest Rate Environment, NBER Working Paper No. W9203.

IMF (2016), World Economic Outlook – Chap.3 Time for A Supply-Side Boost? Macroeconomic Effects of Labour and Product Market Reforms in Advanced Economies.

Hamming R., Kell M., Mahfouz S. (2002), The effectiveness of fiscal policy in stimulating economic activity – a review of the literature, IMF Working Paper WP/02/208. https://www.imf.org/external/pubs/ft/wp/2002/wp02208.pdf

Metelli L. and Pallara K. (2020), Fiscal space and the size of fiscal multiplier, Banca d'Italia – Temi di Discussione No.1293.

OECD (2008). Taxing Wages. 2006-2007.

OECD – Going for Growth, 2009 – 2017.

Roeger W., in 't Veld J. (2009), Fiscal Policy with Credit Constrained Households - European Commission, DG ECFIN - Economic and Financial Affairs Brussels.

Taylor, John B. (2000), Reassessing Discretionary Fiscal Policy, The Journal of Economic Perspectives, 14 (3): 21-36.

Taylor, John B. (2009), The Lack of an Empirical Rationale for a Revival of Discretionary Fiscal Policy", Annual Meeting of the American Economic Association Session "The Revival of Fiscal Policy", January 2009. http://www.aeaweb.org/annual_mtg_papers/2009/author_papers.php?author_ID=6624

CHAPTER 1 - INEQUALITY AND FLAT INCOME TAX IN ITALY

1.1. Can flat tax stimulate growth and reduce inequality?

The variety of experiences around the world preclude generalisations, nevertheless the effects of a flat tax can be disentangled from three main point of view: simplification, growth and equality. The first flat income tax was adopted by the British empire in 1842 (Keen M., Kim Y., Varsano R., 2006), but the issue came to the fore when Milton Friedman proposed for the first time the flat tax for the USA, in a conference at Claremont College in California in 1956. His idea was retrieved by Robert E. Hall e Alvin Rabushka at the beginning of the 1990s (Hall R. E., Rabushka A., 1995). They proposed a 19 per cent flat tax, with the elimination of all kind of deductions (exception made for a deduction related to the numerousness of the family) claiming that the tax would have enhanced the efficiency of the US economy. The flat tax stems from the "supply-side" economics, according to which a high level of taxation would negatively affect individual economic choices, while a lighter tax burden would rise labour supply as well as private investment, with the subsequent rise of tax revenues, albeit the reduction in tax rate. Following this idea, the tax reform would boost national wealth and produce efficiency gains.

This proposal spread all over the East-Europe after the end of the USSR. The main scope of the new unique tax rate was to attract foreign investment to make the economies rebound after the fall of the Berlin Wall. The flat taxes adopted in those Countries differ significantly. Some Countries set the single rate equal at the highest rate of the pre-reform marginal tax rates; others set it at the lowest, accompanying it by a substantial increase in indirect taxation (especially the excises). Moreover, some States applied the same rate to corporate earnings, while others did not. Notwithstanding the idea of Hall and Rabushka to apply the same tax rate for all income sources (labour, profit and financial revenues) to grant simplicity and tax compliance, a 'pure' flat tax is

not common. In Lithuania and Estonia the fiscal deductions are applied to all incomes, in Romania the deductions are linked to labour income, in Bulgaria and Hungary deductions depends upon the number of children. In Latvia deductions are differentiated according to income level. Georgia eliminated all deductions. Tax credits also apply, in Baltic Countries as well as in Romania, Bulgaria and Hungary, with a different degree of universality.

After the experience of the flat tax, some Countries (Czech and Slovak Republics, Albania, Serbia and Island) returned to a progressive system of taxation. According to Remeta et al. (2015), the 2004 flat tax reform of Slovak Republic contributed to make the Country one of the fastest growing OECD economies. Nevertheless, after 10 years the flat tax system appeared inadequate to face multiple challenges such ageing population, high and persistent unemployment rate, significant regional disparities, skills gaps and risks related to the increasing international competition for capital. The Slovak Ministry of Finance worked jointly with OECD to find a solution. As for Czech Republic, the share of tax revenues on GDP declined in each year since the establishment of the Republic. Most of the fall reflected reductions in corporate income tax receipts, following the lowering of rates from 42 to 35 per cent between 1994 and 1998, and a narrowing of the tax base (Bronchi C., Burns A., 2002). Since it entered the European Union, Czech taxation system was completely revised to tackle the deficit of public spending. In 2008, the introduction of flat rate on income tax was compensated by a rise in VAT rates (from 5 per cent to 9 per cent). Some studies reported a reduction in tax evasion, nevertheless it was estimated that the minimum monthly personal income threshold to gain from flat tax was earned only by residents in the centre of Prague, while below that threshold, only drawbacks applied. Thus, the unique rate of taxation was abandoned.

According to the flat tax promoters in Italy, the most relevant advantage of the flat tax is the simplification (Gatteschi S., 2018). Making the tax system simpler and more transparent would reduce administration costs and the costs of compliance if the reform is coupled with a reorganisation of the deduction and transfer systems (Keen M., Kim Y., Varsano R., 2006).

Moreover, the rate could be fixed at a level that lowers fiscal pressure, thus raising the efficiency of the economic system, boosting the economic growth and curbing the tax evasion. Simplification would indeed be a very important advantage for Italy, having a very complex tax system. Nevertheless, this complexity is mostly attributable to the tax base, which is calculated considering a lot of tax expenditures, "most of which stratified during the years without an overall design" (Gatteschi S., 2018). This means that in Italy the simplification could be achieved by redesigning the current tax rates system that includes deductions and transfers.

Beyond the potential benefits related to the simplification, the economic literature mostly debates on the economic advantages of the flat-tax system as described by Hall and Rabushka (1995). Indeed, there is no evidence that the flat tax would increase the incentives to work, contrary to the progressive tax system[3]. For the highest income groups, reducing the marginal tax rate would increase the incentive to work but this effect emerges also by reducing the average tax rate. Similar ambiguities, also accompanied by disincentive to work, appear in other income groups. Studies conducted for Russian economy, which looks at actual household responses to the introduction of a flat tax, do not detect any significant impact on work incentive (Ivanova A., Keen M., Klemm A., 2005). These researches demonstrated that after the introduction of the flat tax in Russia in 2001, GDP evidenced a strong dynamic, but the impact on growth is most probably to be attributed to a strong rise in the oil prices, which doubled between 1998 and 2002 (Gatteschi S., 2018; Keen M., Kim Y., Varsano R., 2006).

Other studies, mainly focused on advanced economies, found only small negative effects of tax progressivity on economic growth. Padovano and Galli (2002) found a negative relationship between progressivity and growth by using a panel data of 25 advanced economies in the three decades (1970-79, 1980-89 and 1990-98). According to their findings, marginal effective tax rates

[3] With some exceptions since "in-work benefits" can increase work incentives for low-income workers (OECD, Tax and Economic Growth 2008).

and tax progressivity have a negative influence on economic growth (also after controlling for State and policy fixed effects), while average tax rates seem not to affect the dynamic of the output.

However, according to the IMF (IMF, Fiscal Monitor, October 2017, p. 13), "there is no strong empirical evidence showing that progressivity has been harmful to growth…empirical evidence on the direct link between tax progressivity and growth is mixed"[4]. The possibility of a negative impact on economic growth of an extremely progressive tax systems (like the tax rates of nearly 100 percent in Sweden or the United Kingdom in the 1970s) is not ruled out, but there is no clear evidence that progressivity levels in OECD countries have been demonstrably harmful to growth.

As far as Government revenues are concerned, by the existing literature it is not possible to conclude that positive effects on tax revenues were brought only by introducing the flat tax. The tax reform occurred in Georgia seems to be successful from the point of view of State revenue. In 2004, the flat tax was introduced to replace both personal and corporate income taxes in order to fight against growing corruption and tax evasion after the Soviet Union failure. By 2008, Georgia's ratio between tax revenue and GDP doubled to 25 per cent. Nevertheless, the tax system reform was accompanied by an improved efficiency of the public administration, which made it easier to pay taxes through an electronic filing system and reduced opportunities for corruption (IMF, 2018). Studies conducted on some other Eastern Countries (Estonia, Lithuania, Latvia, Russia, Ukraine, Slovak, Romania) evidenced a reduction of Government revenues as a ratio to GDP, notwithstanding the enlargement of the tax base, apart from Russia, Lithuania and Latvia. There is evidence that compliance improved after the Russian reform, but it was probably due to changes in enforcement occurring around the same time rather than to the tax reform (Keen M., Kim Y., Varsano R., 2006). In general and with few exceptions, the low-rate flat tax reforms have been associated with a reduction in revenue from the personal income tax, but in no case it has generated

[4] IMF based the analysis on progressivity and economic growth on a panel of OECD Countries, during the period 1981–2016; results suggest that there is not a strong relationship between progressivity and growth.

Laffer effects (Keen M., Kim Y., Varsano R., 2006). In Lithuania, revenue raised because of the chosen flat tax rate: 33 per cent, the highest of the marginal tax rates before the reform. The same for Latvia, where before the reform the system was regressive: the rate was of 25 per cent for the first income bracket and 10 per cent for the highest. By raising the tax rate of the highest income bracket to 25 per cent the revenue raised. Ji and Ligthart (2012) employed a panel dataset of 75 countries for the period 1990-2011 (they also included Countries that left the flat system afterwards)[5]. They found some evidence that the flat income tax is an effective instrument in raising tax revenue, particularly when countries have a small agricultural sector, do not have a high level of income per capita and have a federal structure.

The choice of the tax schedule in a Country, however, also depends on how the trade-off between equity and tax distortions is valued. Even if growth effects of a tax reform may be small, welfare effects are not (Stokey, N. L., & Rebello, S. 1995). A flat tax system with few allowances and tax credits is simpler to administer and probably produces less tax-induced distortions compared to other systems, but it put less emphasis on redistribution (OECD, 2008).

Fuest C., Peichl A., Schaefer T. (2008) used a microsimulation model to analyse the effects on equity and efficiency of a revenue neutral flat tax rate reform in Germany. They found that the increase in income inequality can be avoided by combining a higher tax rate with a higher basic allowance. But in this case the efficiency gains are not large enough to justify the increase in inequality implied by this type of tax reform. Nevertheless, their analysis does not take into account the flat tax effects on investment and capital accumulation.

Aaberge R., Colombino U., Strøm S. (2000), used a micro-econometric framework to examine the labour supply responses and the welfare effects of replacing the current tax systems with a flat tax on total income in Italy, Norway and Sweden. The flat tax rates are determined so

[5] The revenue equation is estimated by the generalized method of moments (GMM) approach, by including a one-period time lag of the dependent variable to address the potential endogeneity of flat-tax adoption, coming from the fact that the revenue needs of a country may induce it to adopt a flat tax.

that the tax revenues are equal to the revenues as of 1992 and correspond to 23 per cent in Italy, 25 per cent in Norway, 29 per cent in Sweden. The results show the existence of efficiency costs of the current tax systems compared to a flat tax system and, in all three countries "rich" households – defined by their pre-tax-reform income – tend to benefit more than "poor" households in terms of welfare.

As for Central and Eastern European Countries, since income inequality is high in these Countries, the question of introducing some progressivity in the tax system has become crucial. Barrios S. et al. (2020), analysed the fiscal, redistributive and macroeconomic impact of re-introducing progressivity in a number of those Countries with flat tax systems. Results of combining microsimulation and macro model[6] show a significant reduction in income inequality by moving from a flat to a progressive tax system with positive, albeit small, macroeconomic and employment impact. The magnitude of these effects depends on country-specificities and tax system characteristics, in terms of tax allowances and tax credits.

On the contrary, Magnani R., Piccolo L. (2020) used a micro–macro simulation model for the French economy and found that a revenue-neutral tax reform introducing a universal basic income scheme coupled with a flat income tax, induces not only a significant reduction in income inequalities and poverty, but also a slightly positive effect at the macroeconomic level.

Nevertheless, assessing the distributional effects of flat tax is complex: reforms accompanied by an increase in the basic tax-free amount are beneficial to both the lowest and the highest earners, and compliance effects may lead to an increase in effective progressivity. Some countries constructed a reform package that included significant base broadening through the elimination of various exemptions and preferences. In Ukraine, for example, the base broadening measures seems to have increased the revenue by around one point of GDP. This is likely to have been a source of improved horizontal equity, efficiency gains, as well as of greater simplicity.

[6] The European Commission's QUEST III, that include different skilled workers.

1.2. How the application of flat tax is modelled

1.2.1. The Households breakdown into income deciles

The Social Accounting Matrix (SAM) is an accounting scheme which makes it possible to represent with a multisectoral, multi-input and multi-output structure, productive interrelations as well as their links with final demand. To the Input-Output scheme the relationships between the institutional sectors, with income accounting, for both primary and secondary distribution, are added. Having both production and income accounting, this makes it possible to represent the various stages of the circular flow of income and, in addition, to record social characteristics (Socci, 2004), which is the purpose of this work. The SAM used to calibrate the CGE model is for the year 2016 and has a disaggregation of Households groups according to income deciles. The SAM for 2016 is used to update and modify the MAC18 Computable General Equilibrium (CGE) model developed by the Department of Economics and Law of the University of Macerata.

Using a different methodology compared to the one used in Ahmed I., Socci C., Severini F., Pretaroli R. (2018), the breakdown of the Households' Institutional Sector is obtained by matching the information from the Bank of Italy's Survey on Household Income and Wealth (SHIW, on 7,420 households) on the one side and, on the other, the consumption database from the 'Survey on Household Budget' (HBS) conducted by the ISTAT (containing information on about 15,237 households).

The net income per households and the data on wealth are gathered from the Bank of Italy's questionnaire, while micro-data on consumption derive from the ISTAT questionnaire.

Consumption data are indeed observed also in the SHIW database, though in a less disaggregated way: it is possible to retrieve information on total consumption, durable and non-durable consumption. HBS, on the contrary, provides a high disaggregated classification of

consumption (485 expenditure items in 2016), and undoubtedly gives a more accurate representation of the true distribution of some consumption aggregates.

The databases of the Bank of Italy and the ISTAT - very different both in terms of sample size and type of information - are combined with the *Propensity Score Matching* technique. This technique allows selecting the family in the ISTAT questionnaire that better approach the family in the Bank of Italy's questionnaire for its characteristics. The consumption data gathered by the ISTAT become the consumption made on the basis of the net income recorded in the Bank of Italy's questionnaire. In this way, the SHIW is the recipient sample, while HBS is the donor of some missing information. The technique of *Propensity Score Matching* represents the probability of a subject of undergoing a treatment as a function of some individual's observed characteristics (John L., Wright R., Duku E. K., and Willms J. D. 2007); formally it is represented in the following way:

$$P(Y = 1|X) = \pi(X) = \frac{e^{\alpha+\beta X}}{1+e^{\alpha+\beta X}} \quad [1]$$

where $\pi(X)$ is a one-dimensional continuous variable which, before the matching, assumes value 0 if the subject belongs to ISTAT database and value 1 if the subject belongs to the SHIW database. To estimate the propensity score a Logistic Regression was used (the probit one doesn't change the results significantly):

$$\text{logit p(x)} = \ln\left(\frac{\pi(X)}{1-\pi(X)}\right) = \alpha + \beta X \quad [2]$$

The logistic expression is constructed as the odd's ratio, i.e. the probability of success compared to the probability of failure.

According to the theory of Rosenbaum and Rubin (1993), units with the same propensity score value (pscore) can be assumed to have the same values of the X characteristics. These latter 'secondary' information (so-called confounders), namely households' members, age, qualification, occupation and sex of the head of household, region of residence and marital status are extracted from both questionnaires.

This approach is not immune from drawbacks since it presumes the conditional-independence assumption, which requires that the outcomes are independent of the treatment, conditional on X. Thus, the assumption is that the choice whether an individual gets treated or not, is not correlated to possible outcomes. The problem is that the possible selection into treatment should be random. This assumption is only partly verified, because some households are part of the Surveys for more than one year. Nevertheless, such a non-random assignment to treatment depends only on X, so conditional on X the assignment to treatment is random, and it cannot correlate with possible outcomes.

The concept of common support is used to combine similar units. This is done by removing from comparison those units whose *pscore* value is less than the minimum or over the maximum *pscore* of the 'treated' units (i.e. households from the SHIW database). The treated unit is matched with control unit with the closest *pscore* by using the *caliper* matching, a definition of distance as a fixed radius: it is based on the *pscore* distance minimization between all units into an interval, set at the 25 per cent of *pscore* standard deviation (Rubin and Thomas, 1996).

By applying this technique, a sample of 7,415 households, 99 per cent of the sample of households in the Bank of Italy, has been extracted, for which both the income data and the micro-data on consumption are thus available. The households' matching leads to an average error of 2.7 per cent, well below the 10 per cent usually accepted in literature (see Table 1 and Figure 1):

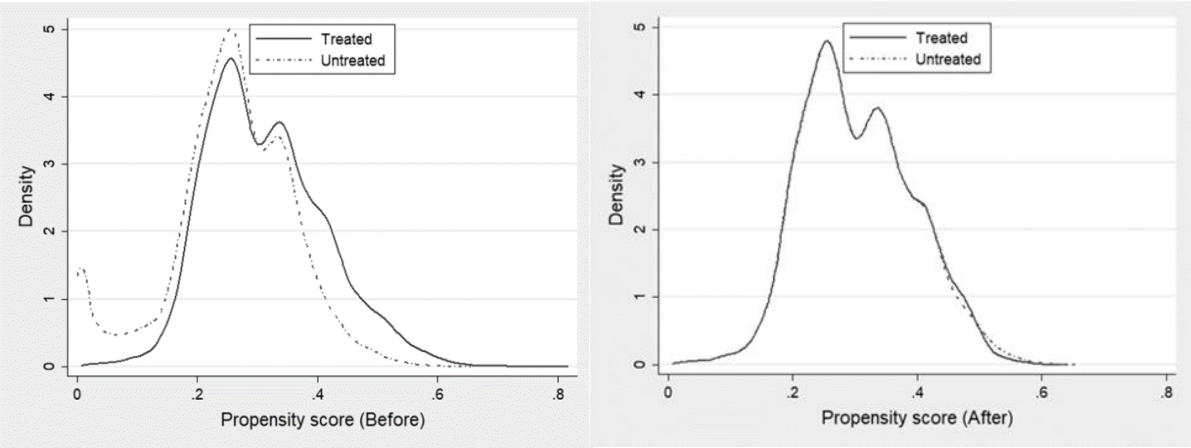
Table 1 - Propensity Score Matching results and statistics

psmatch2: Treatment assignment	psmatch2: Common support		
	Off suppo	On suppor	Total
Untreated	0	15,237	15,237
Treated	5	7,415	7,420
Total	5	22,652	22,657

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.005	150.71	0.000	8.9	9.2	17.4	1.07	43
Matched	0.003	66.67	0.000	2.7	2.6	13.4	1.15	14

Source: Author's elaboration on ISTAT and Bank of Italy data.

Figure 1 - Density function for treated and not treated before and after matching



Source: Author's elaboration on ISTAT and Bank of Italy data.

Some descriptive statistics in the following tables highlights the composition of the database, before and after matching. After matching, the percentage of Households belonging to each decile of income seems to be higher for the first two and the last three deciles, while it is lower for the middle of the distribution (see Table 2). Differences are mainly attributable to the different weights used: before matching, the deciles are constructed by the Bank of Italy (Table 2, by column) using the weights to return each family to the universe. After matching, the information of the selected households is traced back to the universe according to the weights of the ISTAT database. The 5 unmatched households belong to the upper part of the income classes (Table 3).

Table 2 – Number of Households' per income decile before and after matching

	quantiles of y	Before matching										
		1	2	3	4	5	6	7	8	9	10	Total
After matching	1	675	65	0	0	0	0	0	0	0	0	740.0
	2	0	701	81	0	0	0	0	0	0	0	782.0
	3	0	0	660	61	0	0	0	0	0	0	721.0
	4	0	0	0	697	54	0	0	0	0	0	751.0
	5	0	0	0	0	684	0	0	0	0	0	684.0
	6	0	0	0	0	1	726	0	0	0	0	727.0
	7	0	0	0	0	0	35	716	0	0	0	751.0
	8	0	0	0	0	0	0	98	651	0	0	749.0
	9	0	0	0	0	0	0	0	81	677	0	758.0
	10	0	0	0	0	0	0	0	0	37	715	752.0
	Total	675	766	741	758	739	761	814	732	714	715	7415.0

Source: Author's elaboration on ISTAT and Bank of Italy data.

Table 3 – Percentage of Households' per income decile before and after matching

Quantiles of Y	BdI database		BdI Unmatched		Quantiles Before matching		Quantiles After matching	
1	675	9.1%	0	0.0%	675	9.1%	740	10.0%
2	766	10.3%	0	0.0%	766	10.3%	782	10.5%
3	741	10.0%	0	0.0%	741	10.0%	721	9.7%
4	758	10.2%	0	0.0%	758	10.2%	751	10.1%
5	739	10.0%	0	0.0%	739	10.0%	684	9.2%
6	762	10.3%	1	20.0%	761	10.3%	727	9.8%
7	817	11.0%	3	60.0%	814	11.0%	751	10.1%
8	733	9.9%	1	20.0%	732	9.9%	749	10.1%
9	714	9.6%	0	0.0%	714	9.6%	758	10.2%
10	715	9.6%	0	0.0%	715	9.6%	752	10.1%
Total	**7,420**	**100%**	**5**	**100%**	**7415**	**100%**	**7415**	**100.0%**

Source: Author's elaboration on ISTAT and Bank of Italy data.

After the matching, a matrix of information related to income, wealth and consumption for each decile was obtained. In particular, a matrix of 485 consumption headings was therefore obtained for ten income categories. In order to link the 485 COICOP items to the 63 NACE activities, the correspondence matrix published by Eurostat between COICOP 1999 and CPA 2009 was used, whereby item by item the expenditure has been charged to the relevant activity. A particular characteristic of the ISTAT questionnaire is also the possibility to retrieve information on where goods are purchased by households, so to have the possibility to charge goods to the relevant activities, if more than one is suitable. For some items, an imputation criterion was also used based on information from other sources.

The methodology has therefore led to the expansion of the household consumption column in 10 columns, resulting in the consumption per product per each decile of income.

On the value added side, the values were expanded into 10 categories, using the data on households' wealth extracted from the SHIW which, combined with the data from the Ministry of Economy and Finance on the taxes paid, allowed also the taxes paid by consumer and producer households to be attributed to the different income earners.

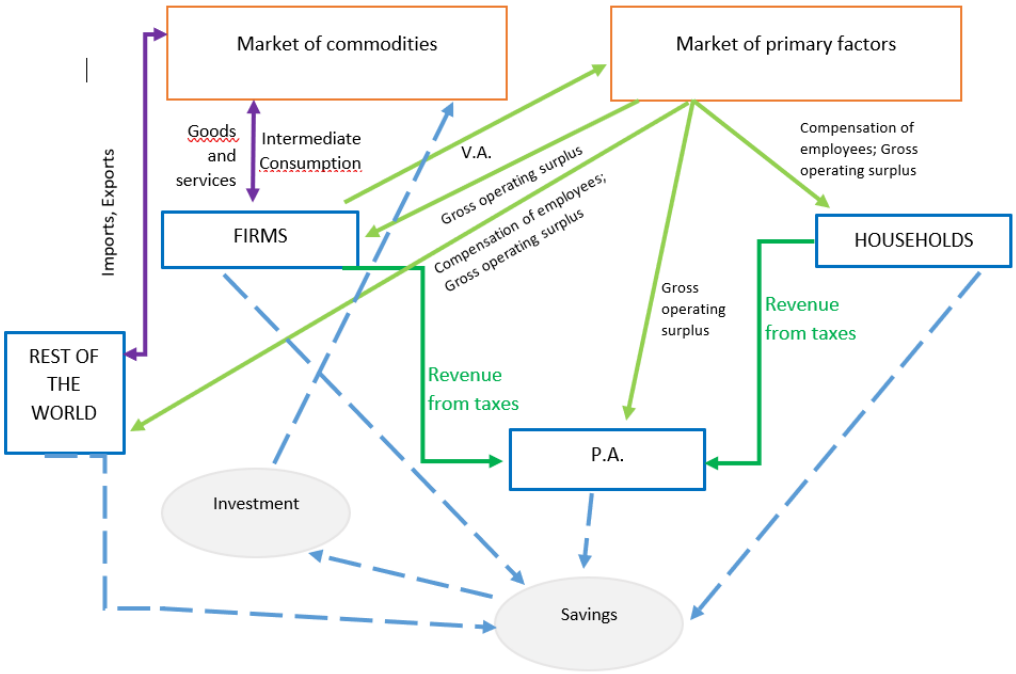
In the SAM thus constructed, the first two deciles have a disposable income level below their consumption levels, with negative savings, while the third decile has a very low savings, equivalent to 0.7 per cent of its disposable income. This figure rises to 41 percent for the last decile, which saves just under half of its income. The propensity to consume is 3.5 and 2.5 for the first two deciles, respectively. The third decile has a propensity to consume 0.99, while this propensity lowers to 0.58 for the last decile. The average propensions for the whole distribution are 0,88 for consumption and 0,12 for savings.

In order to have a synthetic measure of inequality in income distribution, it is possible to compare the first and last fifth of the distribution. In the hypothetical situation of perfect equality, every fifth of the distribution would have an income share of 20 percent of the total. In the SAM built for this work, this ratio between the incomes of the last 2 deciles and those of the first two deciles is 6.6 (including imputed rents).

1.2.2. A static CGE model to evaluate the economic impact

The CGE model is widely used as an instrument to evaluate the impact of policy measures within the economic system (Scrieciu, 2007). It is built as a system of simultaneous non-linear equations that allow assessing the effects that exogenous shocks may have on resource allocation, efficiency and welfare. Through the changes in prices and quantities of goods, as well as income formation and redistribution among institutional sectors, the income circular flow is completely disentangled in all its phases, highlighting the different effects of an exogenous shock in the economy (see Figure 2).

Figure 2 – Income Circular Flow



Source: Author's elaboration.

The construction and solution of a CGE requires several steps (Shoven and Whalley, 1984) assuming a priori that the system is in balance and that this balance is the solution of the model. As a result, the model allows comparing an initial equilibrium situation (benchmark equilibrium) to a counterfactual equilibrium resulting from the application of new economic policy measures. The Social Accounting Matrix (SAM) represents the proper accounting scheme able to represent the initial equilibrium of the economic system. It depicts the income circular flows in all its phases and it presents a disaggregation of Households group into income deciles, providing for each decile a representation of income structure, its distribution and redistribution, as well as consumption. The parameters and exogenous variables of the CGE model are calibrated on the SAM flows to measure the direct and indirect effects of a policy aimed at replacing the actual system of progressive taxation on personal income with a flat tax. The inclusion of household's income characteristics into the SAM and the CGE model allows formalising the behaviour of the agents

according to their income, track policy transmission mechanisms in the income circular flow and highlight potential change in social equality.

Table 4 – The structure of interactions among agents [(a)]

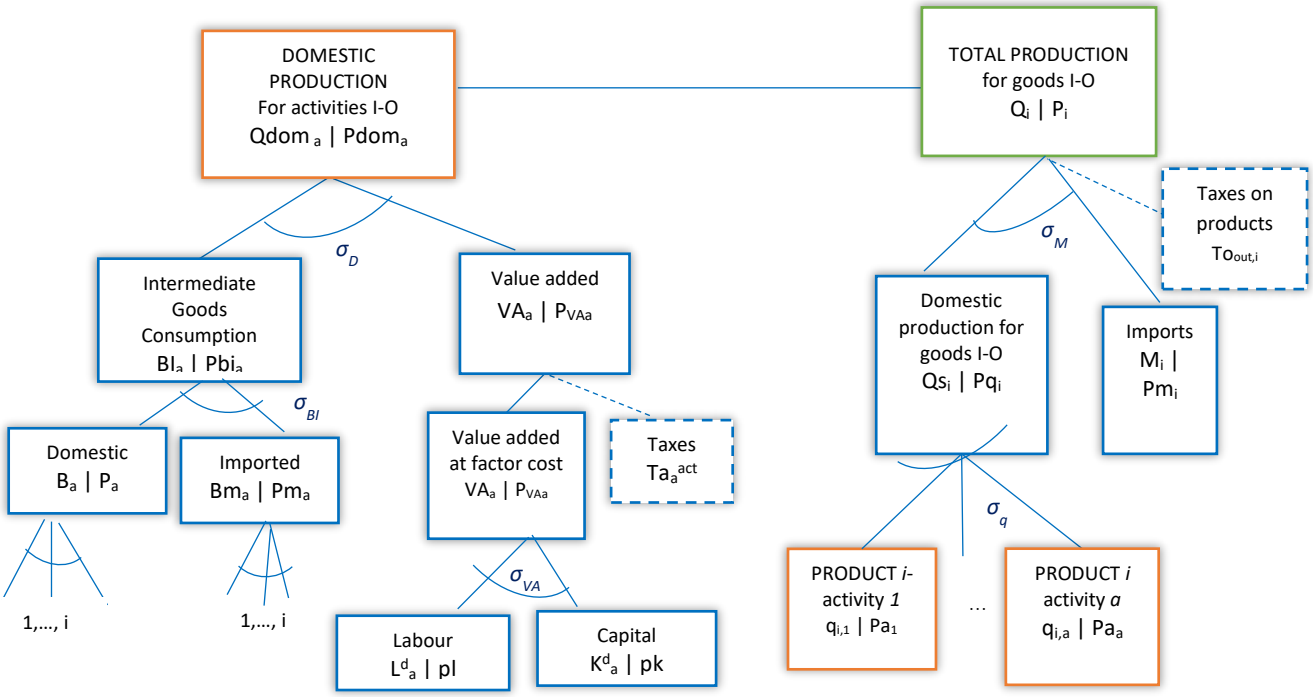
	Commodities (1, …, i)	Industries (1, …, a)	Primary Factors (1,.,f)	Taxes on Commodities (1,.., out)	Taxes on VA (1, …, a)	Private Institutional Sectors (1,…,h)	Government (1,…,g)	Taxes on Income (1, …, e)	Investment	Rest of world
Commodities (1, …, i)		$Q_{a,i}$				$C_{i,h}(Y_h, PC)$	$G_{i,g}$		I_i (S,P_i)	E_i (P_i, P_{row})
Industries (1, …, a)	$Q_{a,i}$									
Primary Factors (1, …, f)		$VA_{f,j}$: $L_j(Q_j\ pL)$, $K_j(Q_j\ pK)$								
Taxes on commodities (1, …, out)	$Tout_{out,i}$ $(Q_i, to_{out,i})$									
Taxes on VA (1, …, va)		$Tva_{va,a}$ $(Q_j, tva_{va,a})$								
Private Institutional Sectors (1,…,h)			Yf_h $(VA_{h,f})$			$Tr_{h,h}$ $Yf_h, tr_{h,h}^{tras}$)	$Tr_{h,g}$ $(Yf_g, tr_{h,g}^{tras})$			$Tr_{h,row}$
Government (1,…, g)			$Yf_g(VA_{g,f})$	$Tout_{out,i}$ $(Q_i, to_{out,i})$	$Tva_{va,a}$ $(Q_j, tva_{va,a})$	$Tr_{g,h}$ $(Yf_h, tr_{g,h}^{tras})$	$Tr_{g,g}$ $(Yf_g, tr_{g,g}^{tras})$	$Ty_{g,e}$ (Yf_h, ty_h^{inc})		$Tr_{g,row}$
Taxes on Income (1, …, e)						$Ty(Yf_h, ty^{inc})$				
Savings						$S(Yf_h,r)$	S_g (Yf_g,r)			$(+/-)$ S_{row}
Rest of the world	$M_{row,i}(Q_i\ Pm_i)$		Yf_{row} $(VA_{row,f})$			$Tr(Yf_h, tr^{tras})$	$Tr_{g,row}^{tras}$			

(a) Source: Author's elaboration on Taylor (1990), Ciaschini et al. (2012).

Table 4 depicts the structure of the SAM and the interactions among economic agents. Since the model is based on the SAM, the indices from {1 to *i*} indicate 63 commodities, and {1 to *a*} indicate 63 activities (see Appendix 1); {1 to *f*} denote primary factors; {1 to *h*} are 14 private institutional sectors (Non-financial corporations, Financial Corporations, Households divided into deciles, Non-profit Institution serving Households, Rest of the World). Indices from {1 to *g*} represent the 6 public institutional sectors (Central Government, Social Security Funds, Regions, Provinces, Municipalities, Other Central Administrations). The SAM also include the flows of 20 different taxes on income {1, …, *e*} as well as 27 taxes on output with indices {1, …, *o*}.

As the model formalizes the main phases of income generation, distribution and utilisation, it is useful to start from the description of the production process (Figure 3), considering production by activity and by product to take account of the Make-Use structure.

Figure 3. Production function by industry and by commodity.



Source: Author's elaboration.

As for the production by activity, the functional form is a CES in different steps, in which production inputs are combined as indicated in the left part of Figure 3. Starting from the top nest, domestic output by activity $Qdom_a$ is obtained combining intermediate goods BI_a and value added VA_a as follow:

$$Qdom_a = \left[d_a^D BI_a^{\rho_D} + (1 - d_a^D) VA_a^{\rho_D}\right]^{\frac{1}{\rho_D}} \quad [3]$$

where d_a^D is the share of intermediate goods on total production by activity, and ρ_D is the exponent of the CES function linked to σ_D. In this stage a Leontief function is assumed, thus $\sigma_D \cong 0$. The correspondent average cost function, the dual of the production function, can be written as follows:

$$Pdom_a(1 - \sum_{act} ta_a^{act}) = \left[\delta_a^D Pbi_a^{(1-\sigma_D)} + (1 - \delta_a^D) Pva_a^{(1-\sigma_D)}\right]^{\frac{1}{(1-\sigma_D)}} \quad [4]$$

Where $Pdom_a$ is the output price for each industry, ta_a^{act} represents tax rates on activity, δ_a^D is the share of intermediate goods on total production, Pbi_a is the price of intermediate goods used

by industry for production, and Pva_a is the price of value added absorbed by each industry. In each activity, the demand for intermediate goods BI_a and value added VA_a is determined as follows:

$$BI_a = \delta_a^D \, Qdom_a \left(\frac{Pdom_a}{Pbi_a}\right)^{\sigma_D} \quad [5]$$

$$VA_a = (1 - \delta_a^D) \, Qdom_a \left(\frac{Pdom_a}{Pva_a}\right)^{\sigma_D} \quad [6]$$

In the second nest of the production function, these two aggregates are formed, assuming a combination with fixed coefficients, calibrated on the SAM. Considering only the duale, the function cost for intermediate goods can be expressed as follows:

$$Pbi_a = \left[\sum_i \delta_{i,a}^{BI} P_i^{(1-\sigma_{BI})}\right]^{\frac{1}{(1-\sigma_{BI})}} \quad [7]$$

Where σ_{BI} is the elasticity of substitution between intermediate goods, which is equal to zero; $\delta_{i,a}^{BI}$ is the cost share of intermediate goods on the total cost for intermediate goods per each activity; P_i is the good price deriving from market clearing condition on goods market.

Value added is obtained as a combination of the primary factors (labour and capital) and indirect net taxes. Prices of primary factors are obtained in their respective markets from the combination of supply and demand. The market of capital is competitive (Ciaschini et al. 2012).

The duale can be expressed as follows:

$$Pva_a \left(1 - \sum_{va} tva_{va,a}\right) = \left[\delta_a^L pl^{(1-\sigma_{va})} + (1 - \delta_a^L) pk^{(1-\sigma_{va})}\right]^{\frac{1}{(1-\sigma_{va})}} \quad [8]$$

Where σ_{va} is the elasticity of substitution between labour and capital, set at 0.5218 according to Van Der Werf (2008); δ_a^L is the share of labour on value added; pl an pk are, the prices for labour and capital, respectively.

Considering the right side of Figure 3, the production by goods can be derived considering the main and secondary productions of each industry. Starting from the top nest, the total output by product is obtained combining domestic production Qs_i and imports M_i using Armington's

imperfect substitutability between domestic and imported goods (Armington, 1969). The dual cost function is:

$$P_i\left(1-\sum_{out} to_{out,i}\right) = \left[\delta_i^O Pq_i^{(1-\sigma_M)} + \left(1-\delta_i^O\right)Pm_i^{(1-\sigma_M)}\right]^{\frac{1}{(1-\sigma_M)}} \quad [9]$$

Where σ_M is the elasticity of substitution between domestic and imported goods, differentiated by goods; δ_i^O is the share of domestic output on total output by commodity; $to_{out,i}$ is the tax rate on output by commodity; Pq_i and Pm_i are the prices of domestic goods and imported goods. Price of imported goods depends on exogenous variables, pwm_i, which is the world price of goods, tm_i represents the taxes on imports, and EXR, which is the exchange rate.

$$Pm_i = pwm_i(1+tm_i)/EXR \quad [10]$$

The demand for imports depends on the total demand and on relative prices:

$$M_i = \left(1-\delta_i^O\right) Q_i \left(\frac{P_i}{Pm_i}\right)^{\sigma_M} \quad [11]$$

Moving from the production to the Income distribution part of the model, a detailed description of the flows determining the disposable income by Institutional Sector is provided. To consider only the main equations of the model (See Appendix 2 for a complete list of variables and equations), starting from Households and NPISHs (their behaviour can be considered similar), they maximise their utility function U_h by deciding whether they consume (C_h) or save (S_h):

$$U_h = \left(C_h^{\frac{\sigma_U-1}{\sigma_U}} + S_h^{\frac{\sigma_U-1}{\sigma_U}}\right)^{\frac{\sigma_U}{\sigma_U-1}} \quad [12]$$

subject to the constraint of disposable income Y_h:

$$Y_h = YF_h\left(1-\sum_{inc} ty_h^{inc} - \sum_{tras} tr_h^{tras}\right) + \sum_{hh}\sum_{tras} tr_{hh}^{tras} YF_{hh} + \sum_g Tr_g + Tr_{row} \quad [13]$$

Where Households' and NPISHs disposable income is derived from compensation of primary factors: $YF_h = L_h pl + K_h pk$ [14]

net of income taxes (ty_{cons}^{inc}) and transfers to (tr_{cons}^{tras}) and from other institutional sectors ($tr_{hh}^{tras} YF_{hh}$), plus Tr_g and Tr_{row} representing transfers from Government and Rest of World.

The disposable income of Financial and non-financial corporations follows the same rules, with the difference in primary factors because they receive only the rent of capital:

$$YF_h = K_h^s pk \quad [15]$$

Public Institutional Sector behaviour is modelled according to the different structure of Central and Local Government in terms of different disposable income and deficit.

$$YF_g = K_g^s pk + \lambda_g^{act} \sum_{act} \sum_a (ta_a^{act} \cdot Pa_a \cdot X_a) + \lambda_g^{va} \sum_{VA} \sum_a (tva_a^{VA} \cdot Pva_a \cdot VA_a) + \lambda_g^{out} \sum_{out} \sum_i (tq_i^{out} \cdot P_i \cdot Q_i) + \sum_h \sum_{inc} ty_h^{inc} YF_h \quad [16]$$

where: YF_g is the primary income earned by each level of Government g; λ_g^{act} is the share of tax revenues on activities for each level of Government; λ_g^{va} is the share of tax revenues on value added for each level of Government; λ_g^{out} is the share of tax revenues on commodities for each level of Government. The disposable income by Government, Y_g is obtained adding/subtracting the transfers from/to other Institutional Sectors (including Rest of World and other levels of Government).

$$Y_g = YF_g + \sum_h Tr_h + Tr_{row} - \sum_g Tr_g \quad [17]$$

Reverting to the utility function, it can also be considered in its dual form, where the price of utility Pu_h is given by:

$$Pu_h = \left[\beta_h^U \, Pc_h^{(1-\sigma_U)} + (1-\beta_h^U)\, r^{(1-\sigma_U)}\right]^{\frac{1}{(1-\sigma_U)}} \quad [18]$$

Where $\beta_h^U = \left(\frac{C_h}{Y_h}\right)^{\sigma_U}$ is the share of consumption on disposable income for each institutional sector h; Pc_h is the index price of the consumption bundle purchased by each Institutional sector h; σ_U is the elasticity of substitution between consumption and savings, and r is the price of gross savings. The demand of consumption C_h and savings S_h by institutional sector corresponds to:

$$C_h = \beta_h^U \, U_h \left(\frac{Pu_h}{Pc_h}\right)^{\sigma_U} \quad [19]$$

$$S_h = (1-\beta_h^U)\, U_h \left(\frac{Pu_h}{r}\right)^{\sigma_U} \quad [20]$$

The closure of the model consists into a set of equations related to: *i)* the conditions on commodity markets, ii) the Saving-Investment balance, iii) the Rest of the World balance, iv) the conditions on primary factors markets, v)the Government balance.

The market of each commodity is perfectly competitive, and the commodity price is flexible to balance demand and supply:

$$Q_i = \sum_a bi_{i,a} + \sum_h c_{i,h} + \sum_g g_{i,g} + I_i + e_i \quad [21]$$

Where the total supply by commodity is allocated between intermediate and final consumption, investment and exports, following a Constant Elasticity of Transformation (CET) function. Investment is supposed to be saving-driven:

$$\sum_i I_i = \sum_h S_h + \sum_g S_g + S_{row} \quad [22]$$

Government and Rest of world savings are fixed, thus changes in the level of investment depend on the savings of Households, NPISHs, financial and non-financial Corporations. The condition for the balance of Rest of World imposes that gross saving is fixed in nominal terms.

As for primary factors, market of capital is competitive, so the rent of capital allows the balance between demand (endogenous) and supply (exogenous). The market of labour is assumed to be not competitive.

Full details of the model can be found in Appendix 2.

1.3. Income tax reform: implementation and results

The Italian PIT (IRPEF) was established in 1973 as a personal and progressive tax, the precondition for which is income, in cash or in kind, falling within the categories set out by law. Taxable persons are both resident (for income owned in Italy and abroad) and not resident in Italy (limited to income produced in the territory of the State). The taxable amount on which the tax rate applies is, for the residents, all income, net of deductible expenses, whereas for non-residents

only income produced in the territory of the State is taxable. The tax period for PIT purposes is the calendar year.

Table 5 – Structure of the actual income tax in Italy [(a)]

Income in euro	Tax rate	Income tax
Up to 7,500 (8,000 for pensioners)	-	No-tax area
Until 15,000	23%	23% of the income
Between 15,001 and 28,000	27%	3,450 + 27% on the part over EUR 15,000
Between 28,001 and 55,000	38%	6,960 + 38% on the part over EUR 28,000
Between 55,001 and 75,000	41%	17,220 + 41% on the part over EUR 55,000
Over 75,000	43%	25,420 + 43% on the part over EUR 75,000

(a) Source: Ministry of Economy and Finance.

The present work simulates the introduction of a flat rate tax applied to household's income. The idea follows a long-standing debate on the restructuring of the Italian personal income tax (PIT), moving from a progressive system (as reported in Table 5) to a flat system, with a single rate that would apply to family income, rather than on individual income.

In this perspective, three possible scenarios are assumed.

- Scenario 1 – the tax rate is 23 per cent. According to the data published by the Ministry of Economy and Finance, the value of 23 per cent represents the middle of the distribution of average deciles' tax rate, weighted with the number of taxpayers for each decile. Even though the new income tax revenue is below the benchmark value, we assume that the Government operates in deficit.
- Scenario 2 – the tax rate is 23 per cent and the Government provide a provision to compensate for the loss of revenue.
- Scenario 3 – the tax rate corresponds to the actual average income tax rate of 26.5 per cent, which guarantees ex ante the same income tax revenue as in the benchmark.

In each scenario it is possible to obtain the impact of the shift in taxation on the main macroeconomic variables, on tax burden as well as the impact on equity, measured as the ratio between the disposable incomes of the two extreme classes of the deciles distribution. Results are expressed as percentage change from the benchmark represented by the SAM. The benchmark is the counterfactual, and each scenario differs from the benchmark only for the introduction of the flat tax, while the no-tax area and transfers from the government to households are left unchanged.

All the simulations imply that income taxation is shifted from the upper to the lower part of the deciles' distribution and this generates various effects on the economic system. The impact stems from the changes in the disposable income of institutional sectors, because of different level of income taxation compared to the benchmark. The change in the disposable income affects consumption, savings and investments, under the assumption that all these channels operate simultaneously.

Results for Scenario 1 are shown in second column of Table 6. The introduction of a unique tax rate of 23 per cent determines a reduction of real GDP of 0.1 per cent. This reduction derives from the contraction of final consumption, notwithstanding the rise in real investment. The contraction of the final consumption stems from a reduction of disposable income of the first 8 Households' income deciles while, as expected, income of wealthier Households (9th and 10th deciles) shows an opposite result and, albeit the latter deciles have a lower propensity to consume compared to the first ones, the increase of their income indirectly feeds the raise in investment through an increase of savings. The increase in investments is strictly linked to how investments and savings decisions are modelled: the closure rule of the model follow the neoclassical approach, where investment is savings-driven, thus gross fixed investment depends on gross savings. Moreover, a slight contraction in employment is registered (-0.1 percent), while the slowdown in economic activity and the loose rise in deflators lead to an improvement in the current balance. Deflators are affected by rising demand for investment goods.

The Government has a larger deficit of EUR 22 billion, compared to an ex ante deficit resulting from lower taxes of EUR 21.6 billion, as a consequence of the indirect effects of the reform that generates a reduction of final demand, a contraction of production and thus, a reduction in value added in most sectors.

Since Italy is a member of the EU, the tax reform needs to be verified also in terms of the respect of the Fiscal Compact rules[7]. At present, the introduction of a 23 per cent flat tax rate brings an ex ante requirement of 13 per cent of total income tax to compensate for the loss of revenue.

The Scenario 2 considers the introduction of the flat tax rate of 23 per cent as in simulation 1, coupled with a cut in public consumption by the same amount of the loss of revenue. The cut of public final consumption is weighted according to the basket of products consumed by the Government in the Input-Output table. Specific cuts could have important consequences in the simulation results, according to the multipliers associated to each product, thus the weighted approach is neutral on the reform effect.

As showed in Table 6 column 3, in this scenario a higher negative aggregated effect is shown, with GDP contracting by -1.2 percent. The final consumption registers drop, and the absolute value of the percentage change is higher if compared to the first scenario. Indeed, the cut in Government spending adds a stronger effect on final demand that decreases and generates a more incisive effect on production and income generation. The total income tax revenue, after the simulation, reduces more compared to both the benchmark and the results in scenario 1, due to more significant direct and indirect effects. Albeit the reform has a hedging instrument in the reduction of public expenditure, Government accumulates an ex post deficit of 13 billion.

[7] The new "Treaty on Stability, Coordination and Governance in the Economic and Monetary Union" was agreed at the EU summit of 30 January 2012, to strengthen the fiscal governance framework in the euro area, by imposing a mandatory balanced budget rule for the signatory Member Countries. Provided that a rapid convergence towards the medium-term objective is required, deviation from this rule must be temporary. For major details see https://ec.europa.eu/info/publications/fiscal-compact-taking-stock_en

Table 6 - Flat Tax simulations main effects (percent change from benchmark)

Macroeconomic aggregates	*Simulation 1* 23%	*Simulation 2* 23% - no deficit	*Simulation 3* 26.5%
Real Variables			
Real GDP	-0.09	-1.23	-0.83
Investment	1.59	0.43	-0.34
Household consumption	-0.56	-0.77	-2.18
Households group 1° decile	*-9.87*	*-9.93*	*-11.10*
Households group 2° decile	*-8.57*	*-8.47*	*-9.55*
Households group 3° decile	*-10.13*	*-10.27*	*-11.54*
Households group 4° decile	*-7.27*	*-7.35*	*-8.67*
Households group 5° decile	*-4.32*	*-4.48*	*-5.84*
Households group 6° decile	*-1.16*	*-1.35*	*-2.69*
Households group 7° decile	*-0.54*	*-0.74*	*-2.22*
Households group 8° decile	*-0.63*	*-0.80*	*-2.26*
Households group 9° decile	*0.16*	*-0.14*	*-1.80*
Households group 10° decile	*15.97*	*15.49*	*13.84*
General government consumption	0.00	-6.69	0.00
Export	-0.16	0.81	0.80
Import	-0.21	-0.79	-1.14
Disposable income			
Non-financial corporations	*0.19*	*-1.11*	*-1.02*
Financial corporations	*-0.18*	*0.08*	*0.48*
Households group 1° decile	*-9.87*	*-9.93*	*-11.10*
Households group 2° decile	*-8.57*	*-8.47*	*-9.55*
Households group 3° decile	*-10.13*	*-10.27*	*-11.54*
Households group 4° decile	*-7.27*	*-7.35*	*-8.67*
Households group 5° decile	*-4.32*	*-4.48*	*-5.84*
Households group 6° decile	*-1.16*	*-1.35*	*-2.69*
Households group 7° decile	*-0.54*	*-0.74*	*-2.22*
Households group 8° decile	*-0.63*	*-0.80*	*-2.26*
Households group 9° decile	*0.16*	*-0.14*	*-1.80*
Households group 10° decile	*15.97*	*15.49*	*13.84*
NPISHs	*-0.11*	*-1.03*	*-0.24*
Savings			
Non-financial corporations	*0.19*	*-1.11*	*-1.02*
Financial corporations	*-0.18*	*0.08*	*0.49*
Households group 1° decile	*-9.87*	*-9.98*	*-11.15*
Households group 2° decile	*-8.56*	*-8.52*	*-9.60*
Households group 3° decile	*-10.12*	*-10.31*	*-11.58*
Households group 4° decile	*-7.26*	*-7.38*	*-8.70*
Households group 5° decile	*-4.31*	*-4.50*	*-5.86*
Households group 6° decile	*-1.15*	*-1.36*	*-2.70*
Households group 7° decile	*-0.53*	*-0.77*	*-2.25*
Households group 8° decile	*-0.60*	*-0.97*	*-2.43*
Households group 9° decile	*0.19*	*-0.29*	*-1.94*
Households group 10° decile	*15.99*	*15.38*	*13.74*
NPISHs	*-0.12*	*-0.98*	*-0.19*
Nominal Variables			
Government revenue from income taxes			
Central Government	*-9.32*	*-11.51*	*-1.59*
Local: Regional	*-4.78*	*-7.04*	*-1.48*
Local: Provincial	*0.43*	*-2.16*	*-2.11*
Local: Municipal	*0.20*	*-2.21*	*-1.56*
Other PA revenue	*0.32*	*-2.27*	*-2.10*
Unemployment	*0.09*	*0.78*	*0.40*
GDP deflator	0.25	-1.25	-1.22
Consumption deflator	0.23	-1.11	-1.10
Export deflator	0.16	-0.80	-0.79
Import deflator	0.00	0.00	0.00

Source: Author's elaboration on MAC-18 CGE static model results.

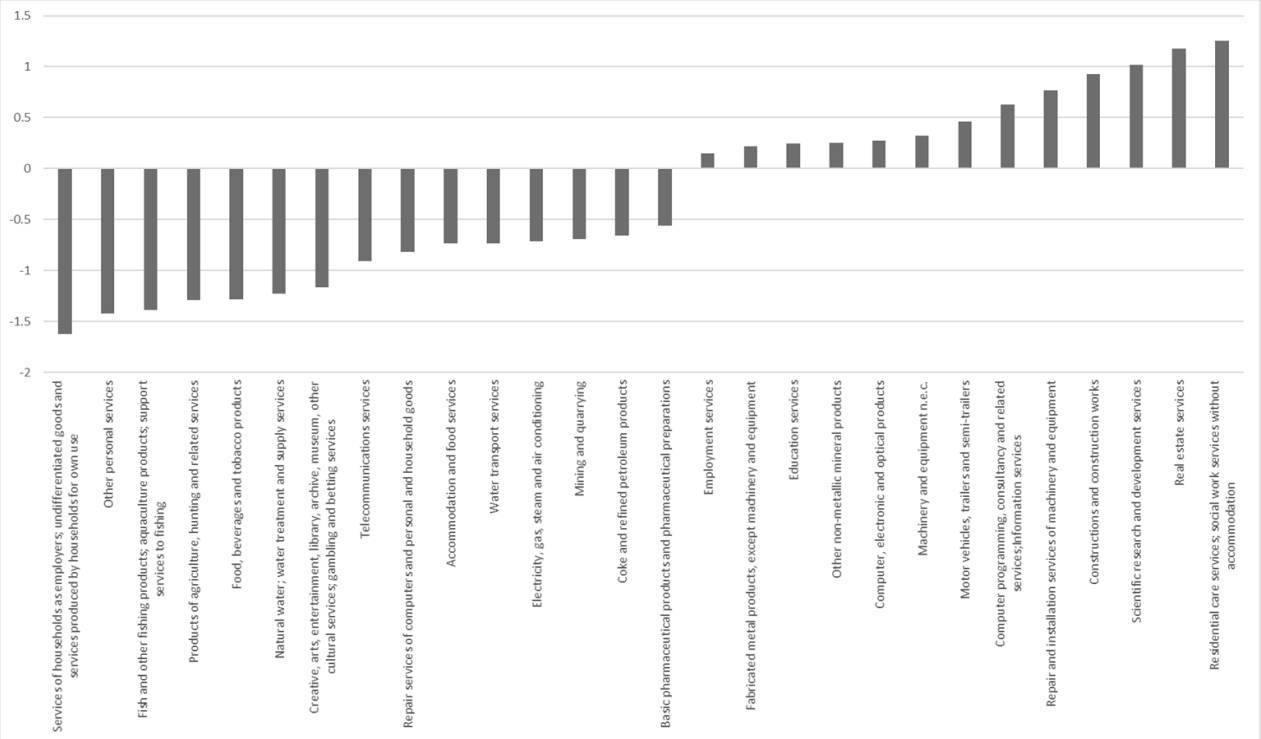
The slowing economic activity also determines the deflator reduction and, consequently, an improvement of current account.

The Scenario 3 is based on the introduction of a unique flat tax rate on income of 26.5 per cent, which is the threshold value granting ex ante the same revenue from the income tax. The results, displayed in the 4th column of Table 6, show that the impact on GDP is intermediate between the first two simulations, while the effects in the composition of final demand highlights a weightier effect for consumption, because of higher taxes on income. Moreover, investment shows a reduction, because the Household's 10th decile benefit less from the reduction in income tax paid. Government revenue from income taxes, albeit to a lesser extent compared to the other scenarios, shows a contraction notwithstanding the neutral effect ex ante accruing a deficit of 10.4 billion. Effect on GDP is smoothed by the improvement of current account.

On the production side, the introduction of a flat tax on households' income results in an output slight rise (0.2 per cent) in the first simulation and in the last simulation depending on the increase in final demand for investment. On the contrary, when a deficit provision applies, results worsen, and a reduction of 1.1 per cent for output applies after the introduction of the flat tax.

Going more in deep in the disaggregated effects of the tax reform, Figures 4, 5 and 6 show the products whose total output is mostly affected by the policy. In the first scenario (Figure 4), products that record a deeper reduction in total output are the services of households as employers, other personal services, food products (including agriculture and fishing products), network utilities, creative arts and entertainment, accommodation and food services, coke and refined petroleum products. On the contrary, residential care services, real estate services, R&D, construction, repair and installation of machinery, are some of the products benefiting most from the flat tax introduction, also influenced by investment final demand pattern.

Figure 4 – Scenario 1 – 23% in deficit - Products most affected after flat tax introduction (output % change)

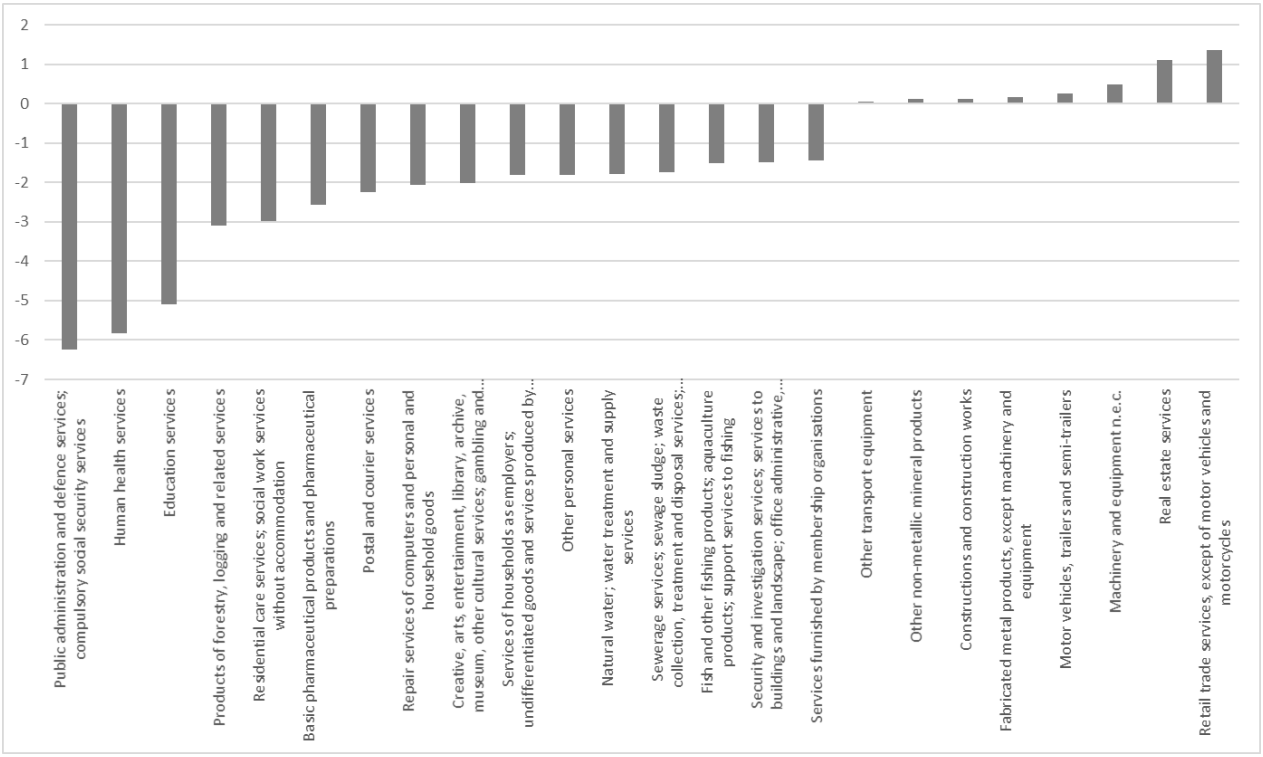


Source: Author's elaboration on MAC-18 CGE static model results.

In the second simulation (Figure 5), products that register a more incisive reduction in total output are the services provided by the Public Administration as expected, because of the spending cut, while the only products showing an increase are those indicated and, compared to the first simulation, there is an increase in retail trade services.

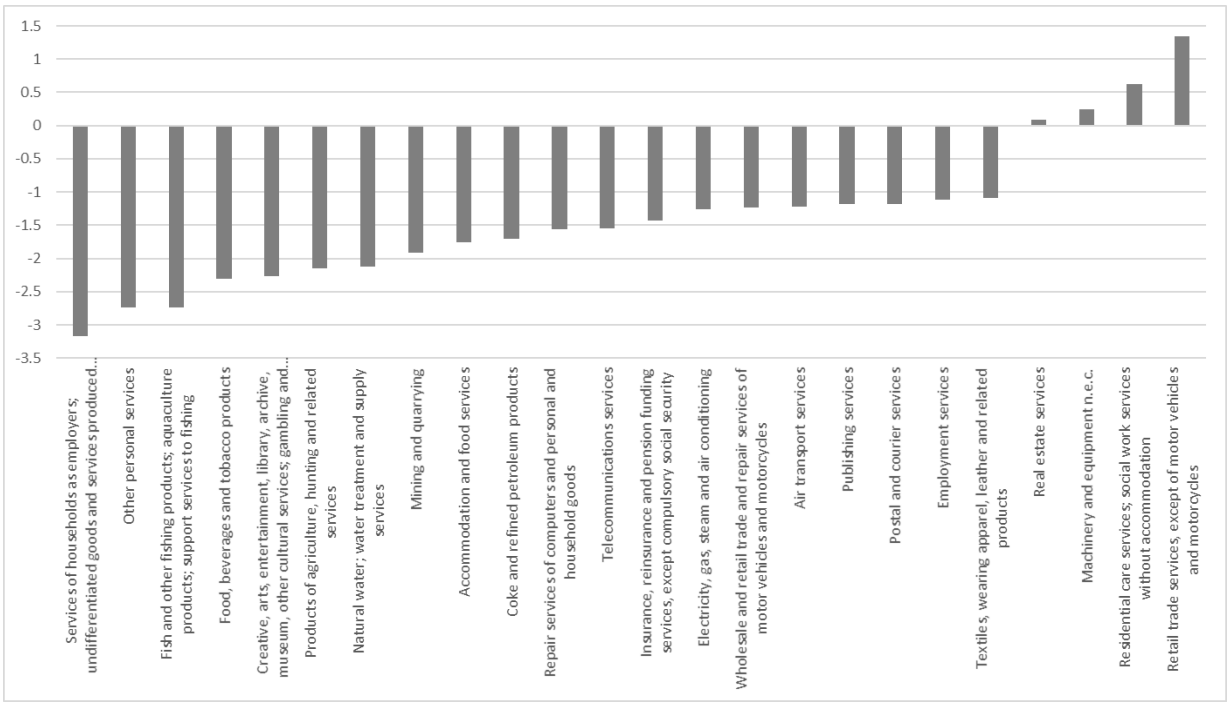
Finally, Figure 6 illustrates the disaggregate effects on output when a flat income tax rate of 26.5 per cent is applied. In this case, a deeper output contraction compared to the other scenarios is registered by insurance services, wholesale and retail trade and air transport, while fishery, food products, agriculture and water services are still among the sectors most affected (lower deciles consumption demand is traditionally more dedicated to these products). In this simulation, the 10th Household decile is benefiting less than in the two previous scenario, thus products whose total output expand are very few (only 4), and real estate services, the consumption of which was driven by wealthier consumers in the two previous hypotheses, show only a slight increase in this scenario.

Figure 5 – Scenario 2 – 23% with provision - Products most affected after flat tax introduction (output % change)



Source: Author's elaboration on MAC-18 CGE static model results.

Figure 6 – Scenario 2 – 26.5% - Products most affected after flat tax introduction (output % change)



Source: Author's elaboration on MAC-18 CGE static model results.

To test for the robustness of the results, a sensitivity analysis has been carried out for all the simulations on exogenously determined variables, namely the elasticity of substitution in the utility functions (see Appendix 3).

Compared to the disadvantages in terms of macroeconomic performance, whose effect on GDP is nevertheless small, the introduction of the flat tax remains negative for income distribution, carrying a strong uneven effect. In terms of income tax distribution, the cumulative percentage as the ratio between the income tax paid by each decile and the total income tax paid by all the Households (Table 7). The portion of income tax paid tends to be larger in all deciles compared to the benchmark (cumulative percentages are the same in all the simulations, being the tax reduction calculated as a share of income).

Table 7 - Income tax distribution (cumulative percentages)

Decile	Benchmark	Simulations	Difference
I	0.26%	1.62%	1.36%
II	0.78%	4.81%	4.03%
III	1.61%	10.13%	8.52%
IV	3.92%	15.79%	11.87%
V	8.28%	22.80%	14.51%
VI	14.92%	30.69%	15.78%
VII	23.56%	40.65%	17.08%
VIII	35.13%	54.17%	19.05%
IX	51.74%	72.98%	21.24%
X	100.00%	100.00%	0.00%

Source: Author's elaboration.

Taking into account the evolution of the income ratio of the last 10 percent of the distribution compared to the first 10 percent, there is an increase of 3.6 percentage points in the inequality measure for the first scenario, and 3.5 percentage points in the second and third scenarios. When considering the ratio of the first 20 per cent of the distribution to the last one, there is an increase in the inequality of 1.4-1.3 percentage points (see Table 8).

Table 8 - Income inequality

Income inequality	*Simulation 1* 23%	*Simulation 2* 23% with no deficit	*Simulation 3* 26.5%
Ex ante:			
9th+10th deciles / 1st + 2nd deciles	6.64	6.64	6.64
10th decile / 1st decile	12.50	12.50	12.50
Ex post:			
9th+10th deciles / 1st + 2nd deciles	7.99	7.95	7.93
10th decile / 1st decile	16.09	16.03	16.01

Source: Author's elaboration on MAC-18 CGE static model results.

1.4. Concluding: no trade-off between growth and equality

Developing a SAM based GCE model offers the possibility of identifying income circular flow by institutional sectors, here including the distinction of households according to income deciles, and thus quantifying the overall impact of fiscal reforms within the economic system. The model formalises the behaviour of the agents according to their income and then tracks the policy transmission mechanisms in the income circular flow.

The scope of the work is to demonstrate that introducing a flat tax rate in the economic system generates effects that depend mostly on the characteristics of the Country and in particular on the income distribution and consumption propensities. Going more in deep in the impact of a flat-tax-reform in Italy, three potential scenarios are simulated. Two different tax rates are considered, 23% and 26.5%, corresponding to the average rate of the fifth decile and the average rate of the entire distribution, respectively. For the 23% a hedging instrument for the deficit is also tested, to take account of the need for Italy to respect Constitution and Fiscal Compact rules, while the 26.5% rate guarantees, ex ante, the same income tax revenue as in the benchmark.

Even if the impact of a flat tax on economic growth in the literature are diverging, in this paper a negative effect on real GDP occurs in all the simulations (ranging from -0.09 to -1.23 per cent), with the worst result for the simulation with provision, because of a significant reduction in

public consumption. As expected, income reduction for lower deciles, determined by a higher tax burden compared to the benchmark, weighs on final consumption. On the contrary, the increase of disposable income benefiting the richest deciles stimulates investment, since the highest deciles have a lower propensity to consume.

The contraction of institutional sectors' final consumption derives from a significant reduction in the first 8 households' deciles: consumption increase are evidenced for the ninth and tenth deciles for the first simulation, while in the other two scenarios only the 10^{th} decile benefits from the reform. These negative results more than offset the increase in investment in the first and the second scenarios, determined by the savings increase in the last deciles, for which the income tax applied in the simulations is well below the benchmark level. In the third scenario, on the contrary, savings increase of the 10^{th} decile is not enough to determine a rise in investment. Consumption decrease carries on a price level reduction, more significant when the flat tax introduction is accompanied by the deficit coverage, exception made for the first scenario in which the demand for investment goods determines a loose deflator increase.

Results in terms of State budget seem to confirm what has been found in literature. A loss of tax revenue occurs, due to the direct and indirect effects (a lower final demand carries a contraction of production and thus, reduction in output and value added). In particular, Government revenue is negatively affected not only in the first two scenarios, but also in the third one, where an ex ante budget balance is considered, because the drop in the production reduces the income generated and distributed to the Institutional Sectors.

The potential benefit for Government revenue of introducing a flat tax is highly linked to the threshold value of the adopted unique tax rate. A theoretical value of optimal imposition is difficult to be identified from the empirical point of view since it is linked to the ex post response of the economic system to the tax reform, both in aggregate and in disaggregated terms.

The results of the simulations confirms what found by Fuest C., Peichl A., Schaefer T. (2008), Aaberge R., Colombino U., Strøm S. (2000), Alari P., Peichl A. (2009), as well as by

Barrios S. et al. (2020): introducing a flat income tax results in an increase in the inequality of the system. The ratio between the income of the last decile and the income in the first decile raises in all scenarios, determining an uneven effect on Households disposable income, with a strong advantage for the richest ones.

The results presented in this work depend on the choices and assumptions in the model.

Possible future developments include testing a different system of taxation, with the flat tax being accompanied by a complete revision of deduction and tax allowances system, in order to reduce inequalities. Moreover, the reduction of public spending is the hedging instrument tested in this paper, but it is not possible to rule out that a different system of provision give different results.

References for Chapter 1

Aaberge R., Colombino U., Strøm S. (2000) Labour Supply Responses and Welfare Effects from Replacing Current Tax Rules by a Flat Tax: Empirical Evidence from Italy, Norway and Sweden. *Journal of Population Economics,* 13, 595-621.

Ahmed I., Socci C., Severini F., Pretaroli R. (2018) "Fiscal policy for households and public budget constraint in Italy". *Economia Politica*, 1-17. 10.1007/s40888-018-0114-6.

Alari P., Peichl A. (2009), Effects of flat tax reforms in Western Europe. *Journal of Policy Modeling*, Volume 31, Issue 5, September–October 2009, Pages 620-636 https://doi.org/10.1016/j.jpolmod.2009.06.001.

Armington P.S. (1969). A theory of demand for products distinguished by place of production (Une théorie de demande de produits differenciés d'après leur origine). *Staff Papers – IMF*, 16, 159-178.

Baxter M., King R. G. (1993). Fiscal Policy in General Equilibrium. *American Economic Review*, 82(3), 315–334.

Barrios S., Ivaškaitė-Tamošiūnė V., Maftei A., Narazani E., Varga J. (2020). Progressive tax reforms in flat tax countries. *Eastern European Economics*, 58(2), 83-107.

Bronchi C., Burns A. (2002). The Tax system in the Czech Republic. *Czech Journal of Economics and Finance (Finance a uver)*, 51, 618-638.

Ciaschini M., Pretaroli R., Severini F., Socci C. (2012). Regional double dividend from environmental tax reform: An application for the Italian economy. *Research in Economics*, 66, 273-283.

Conti P.L., Marella D. and Neri A. (2015) Statistical matching and uncertainty analysis in combining household income and expenditure data, Temi di Discussione Banca d'Italia, number 1018, July 2015.

Fuest C., Peichl A., Schaefer T. (2008). Is a Flat Tax Feasible in a Grown-up Welfare State? A simulation study for Germany. *International Tax and Public Finance*, 15, 620–636.

Gatteschi S. (2018). *Flat tax*, teoria e pratica. Osservatorio Conti Pubblici Italiani – Università Cattolica del Sacro Cuore.

Hermeling C., Mennel T. (2008). Sensitivity analysis in economic simulations - a systematic approach. ZEW Discussion Papers 08-068, ZEW - Leibniz Centre for European Economic Research.

Ivanova A., Keen M., Klemm A. (2005). The Russian Flat Tax Reform. *Economic Policy*, Volume 20, Issue 43, 1 July 2005, Pages 398–444, https://doi.org/10.1111/j.1468-0327.2005.00143.x.

John L., Wright R., Duku E. K., and Willms J. D. (2007). The Use of Propensity Scores as a Matching Strategy, Research on Social Work Practice, Vol 18, Issue 1, June 2007 https://doi.org/10.1177/1049731507303958.

Keen M., Kim Y., Varsano R. (2007). The flat tax(es): Principles and Evidence. *International Tax and Public Finance*, 15, 712–751 (2008).

Magnani R., Piccolo L. (2020). Universal basic income with flat tax reform in France. *Journal of Policy Modeling*, Volume 42, Issue 2, March–April 2020, Pages 235-249. https://doi.org/10.1016/j.jpolmod.2019.07.005.

Padovano F., Galli E. (2002). Comparing the Growth Effects of Marginal vs. Average Tax Rates and Progressivity. *European Journal of Political Economy* 18 (3), 529–44.

Reis Gomes F.A., Fernandes Ribeiro P. (2015). Estimating the elasticity of intertemporal substitution taking into account the precautionary savings motive, *Journal of Macroeconomics*, Elsevier, 45(C), 108-123.

Remeta J., Perret S., Jareš M. and Brys B. (2015). Moving beyond the flat tax – tax policy reform in the Slovak Republic. Issue 22 of OECD Taxation Working Papers, ISSN 2223-5558 https://doi.org/10.1787/22235558.

Rosenbaum P.R., Rubin D.B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*, 70(1), 41-55.

Rubin D.B., Thomas N. (1996). Matching using estimated propensity scores: relating theory to practice. *Biometrics*, 52(1), 249-64.

Scrieciu, S. (2007). How Useful are Computable General Equilibrium Models for Sustainability Impact Assessment. In: C. George and C. Kirkpatrick (eds.) *Impact Assessment and Sustainable Development: European Practice and Experience*. Cheltenham, Edward Elgar.

Socci C. (2004), Distribuzione del reddito e analisi delle politiche economiche per la Regione Marche, A. Giuffré.

Stokey, N. L., & Rebello, S. (1995). Growth effects of flat-rate taxes. *Journal of Political Economy*, 103, 519–550.

Taylor L. (1990). Structuralist CGE models. Taylor L. (ed): *Socially relevant Policy Analysis: Structural computable general equilibrium models for developing world*. Cambridge (MA): MIT press, 1-70.

Tedeschi S., Pisano E. (2013) Data Fusion Between Bank of Italy-SHIW and ISTAT-HBS, MPRA Paper 51253, University Library of Munich, Germany.

Van der Werf, E. (2008). Production Functions for Climate Policy Modelling: An Empirical Analysis. *Energy Economics*, 30, 2964–2979.

Appendix 1. ISTAT National Accounts – Classification of activities and products

ISTAT National Accounts - 63 activities

a1	Crop and animal production, hunting and related service activities	a37	Publishing activities
a2	Forestry and logging	a38	Motion picture, video, television programme production; programming and broadcasting activities
a3	Fishing and aquaculture	a39	Telecommunications
a4	Mining and quarrying	a40	Computer programming, consultancy, and information service activities
a5	Manufacture of food products; beverages and tobacco products	a41	Financial service activities, except insurance and pension funding
a6	Manufacture of textiles, wearing apparel, leather and related products	a42	Insurance, reinsurance and pension funding, except compulsory social security
a7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	a43	Activities auxiliary to financial services and insurance activities
a8	Manufacture of paper and paper products	a44	Real estate activities
a9	Printing and reproduction of recorded media	a45	Legal and accounting activities; activities of head offices; management consultancy activities
a10	Manufacture of coke and refined petroleum products	a46	Architectural and engineering activities; technical testing and analysis
a11	Manufacture of chemicals and chemical products	a47	Scientific research and development
a12	Manufacture of basic pharmaceutical products and pharmaceutical preparations	a48	Advertising and market research
a13	Manufacture of rubber and plastic products	a49	Other professional, scientific and technical activities; veterinary activities
a14	Manufacture of other non-metallic mineral products	a50	Rental and leasing activities
a15	Manufacture of basic metals	a51	Employment activities
a16	Manufacture of fabricated metal products, except machinery and equipment	a52	Travel agency, tour operator reservation service and related activities
a17	Manufacture of computer, electronic and optical products	a53	Security and investigation, service and landscape, office administrative and support activities
a18	Manufacture of electrical equipment	a54	Public administration and defence; compulsory social security
a19	Manufacture of machinery and equipment n.e.c.	a55	Education
a20	Manufacture of motor vehicles, trailers and semi-trailers	a56	Human health activities
a21	Manufacture of other transport equipment	a57	Residential care activities and social work activities without accommodation
a22	Manufacture of furniture; other manufacturing	a58	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
a23	Repair and installation of machinery and equipment	a59	Sports activities and amusement and recreation activities
a24	Electricity, gas, steam and air conditioning supply	a60	Activities of membership organisations
a25	Water collection, treatment and supply	a61	Repair of computers and personal and household goods
a26	Sewerage, waste management, remediation activities	a62	Other personal service activities
a27	Construction	a63	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
a28	Wholesale and retail trade and repair of motor vehicles and motorcycles		
a29	Wholesale trade, except of motor vehicles and motorcycles		
a30	Retail trade, except of motor vehicles and motorcycles		
a31	Land transport and transport via pipelines		
a32	Water transport		
a33	Air transport		
a34	Warehousing and support activities for transportation		
a35	Postal and courier activities		
a36	Accommodation and food service activities		

ISTAT National Accounts - 63 products

g1	Products of agriculture, hunting and related services	g37	Publishing services
g2	Products of forestry, logging and related services	g38	Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services
g3	Fish and other fishing products; aquaculture products; support services to fishing	g39	Telecommunications services
g4	Mining and quarrying	g40	Computer programming, consultancy and related services;Information services
g5	Food, beverages and tobacco products	g41	Financial services, except insurance and pension funding
g6	Textiles, wearing apparel, leather and related products	g42	Insurance, reinsurance and pension funding services, except compulsory social security
g7	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	g43	Services auxiliary to financial services and insurance services
g8	Paper and paper products	g44	Real estate services
g9	Printing and recording services		Imputed rents of owner-occupied dwellings
g10	Coke and refined petroleum products	g45	Legal and accounting services; services of head offices; management consultancy services
g11	Chemicals and chemical products	g46	Architectural and engineering services; technical testing and analysis services
g12	Basic pharmaceutical products and pharmaceutical preparations	g47	Scientific research and development services
g13	Rubber and plastic products	g48	Advertising and market research services
g14	Other non-metallic mineral products	g49	Other professional, scientific and technical services and veterinary services
g15	Basic metals	g50	Rental and leasing services
g16	Fabricated metal products, except machinery and equipment	g51	Employment services
g17	Computer, electronic and optical products	g52	Travel agency, tour operator and other reservation services and related services
g18	Electrical equipment	g53	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services
g19	Machinery and equipment n.e.c.	g54	Public administration and defence services; compulsory social security services
g20	Motor vehicles, trailers and semi-trailers	g55	Education services
g21	Other transport equipment	g56	Human health services
g22	Furniture and other manufactured goods	g57	Residential care services; social work services without accommodation
g23	Repair and installation services of machinery and equipment	g58	Creative, arts, entertainment, library, archive, museum, other cultural services; gambling and betting services
g24	Electricity, gas, steam and air conditioning	g59	Sporting services and amusement and recreation services
g25	Natural water; water treatment and supply services	g60	Services furnished by membership organisations
g26	Sewerage services; sewage sludge; waste collection, treatment and disposal services; materials recovery services; remediation services and other waste management services	g61	Repair services of computers and personal and household goods
g27	Constructions and construction works	g62	Other personal services
g28	Wholesale and retail trade and repair services of motor vehicles and motorcycles	g63	Services of households as employers; undifferentiated goods and services produced by households for own use
g29	Wholesale trade services, except of motor vehicles and motorcycles		
g30	Retail trade services, except of motor vehicles and motorcycles		
g31	Land transport services and transport services via pipelines		
g32	Water transport services		
g33	Air transport services		
g34	Warehousing and support services for transportation		
g35	Postal and courier services		
g36	Accommodation and food services		

Appendix 2. Parameters, variables and equations of the static model

PARAMETERS AND EXOGENOUS VARIABLES

ρ_D	Exponent of the CES production function
d_a^D	Share of intermediate goods on total production by activity
σ_D	Elasticity of substitution between intermediate goods and value added derived from ρ_D
δ_a^D	Share of intermediate goods on total production in cost function
σ_{BI}	Elasticity of substitution between intermediate goods
δ_i^{BI}	Share of intermediate commodity cost on total cost
σ_{va}	Elasticity of substitution between labour L_a^d and capital K_a^d demand
δ_a^L	Labour cost share on value added
ta_a^{act}	Tax rates on activities
tva_a^{VA}	Tax rates on value added
$d_{a,i}^q$	ith product share produced by activity *a* on total production o *a*
σ_q	Elasticity of substitution between main and secondary production
σ_M	Elasticity of substitution between domestic and imported goods
δ_i^O	Share of national commodity on total production by product
tq_i^{out}	Tax rates on output
tm_i	Tax rates on imports
σ_q	Elasticity of substitution between goods offered by activity
$\delta_{i,a}^q$	Share of good offered by activity on total domestic offer
ty_h^{inc}	Implicit tax rates on Institutional Sector *h* income
tr_h^{tras}	Implicit tax rates of transfers paid by Institutional Sector *h* to the other Public and private Institutional Sectors
λ_g^{act}	share of revenue from tax on activities collected by the *gth* Public Administration
λ_g^{va}	share of revenue from tax on value added collected by the *gth* Public Administration
λ_g^{out}	share of revenue from tax on output collected by the *gth* Public Administration
$\beta_h^U = \left(\frac{C_h}{Y_h}\right)^{\sigma_U}$	Share of consumption on available income of Institutional Sector *h*
σ_U	Elasticity of substitution between consumption and gross savings
$\delta_{i,h}^C = \left(\frac{c_{i,h}}{C_h}\right)^{\sigma_C}$	share of consumption of ith product on total consumption of Institutional Sector *h*
σ_C	Elasticity of substitution between consumption goods in the consumption basket
$\delta_{i,h}^I = \left(\frac{I_i}{I}\right)^{\sigma_I}$	Share of investment on ith product on total gross investment
σ_I	Elasticity of substitution between investment goods in the investment basket
$\delta_i^E = \left(\frac{e_i}{E}\right)^{\sigma_e}$	Share of export of ith product on total exports
σ_e	Elasticity of substitution between consumption goods in the Rest of the World consumption basket
e_i	Export demand for the ith product
Pm_i	Price of imported goods
pwm_i	World Price
EXR	Nominal exchange rate
L_h^s	Labour endowment of Institutional Sector *h*
L_{row}^s	Labour endowment of the Rest of the World
K_h^s	Capital endowment of Institutional Sector *h*
K_g^s	Capital endowment of *gth* Public Administration
K_{row}^s	Capital endowment of the Rest of the World
Tr_g	Transfers paid by *gth* Public Administration
Tr_{row}	Transfers paid by the Rest of the World
$G_g = \sum_i g_{i,g}$	Consumption basket of *gth* Public Administration
S_g	Savings / gross borrowing of *gth* Public Administration in the base year

Y_{row}	Gross available income of the Rest of the World
S_{row}	Savings / gross borrowing of the Rest of the World
γ	Trade Union's quota of risk aversion
a	Fixed component of tax on labour
tv	Variable component of tax on labour
σ_s	Elasticity of substitution between the aggregate containing labour and the aggregate not containing it in stage *s* of the production function
Φ	Share of cost to be imputed to aggregate not containing labour in stage s of the production function
b	Unemployment benefit

ENDOGENOUS VARIABLES

X_a	Output per activity
BI_a	Total of intermediate commodities
Pbi_a	Price of intermediate commodities aggregate
$bi_{i,a}$	Demand of intermediate commodity for each activity
VA_a	Value added aggregate
Pva_a	Price Value added aggregate
P_i	Goods' prices
L_a^d	Labour demand for activity
K_a^d	Capital demand for activity
pl	Wage
pk	Price of Capital
Pq_i	Domestic price per product
M_i	Import demand per product
Pa_a	Price per activity
YF_h	Private Institutional Sectors' Primary income
u	Unemployment rate
Y_h	Available income of Institutional Sector *h*
YF_g	Primary income of g^{th} Public Administration
Y_g	Available income of g^{th} Public Administration
C_h	Aggregate Consumption of Institutional Sector *h*
S_h	Gross Savings of Institutional Sector *h*
S_g	Gross Savings of Institutional Sector *g*
S_{row}	Gross Savings of the Resto of the World
U_h	Utility of Institutional Sector *h*
Pu_h	Utility price of Institutional Sector *h*
Pc_h	Index price of consumption basket of Institutional Sector *h*
p_I	Price of Gross Savings, coincident with price of fictitious gross investment
def_g	Change in Savings / Gross borrowing of g^{th} Public Administration
I_i	Demand for i^{th} product as an investment good
ε_{npl}	Elasticity of labour demand to wage

EQUATIONS

$$X_a = (d_a^D {BI_a}^{\rho_D} + (1 - d_a^D){VA_a}^{\rho_D})^{\frac{1}{\rho_D}}$$

$$Pa_a(1 - \sum_{act} ta_a^{act}) = \left(\delta_a^D {Pbi_a}^{(1-\sigma_D)} + (1 - \delta_a^D){Pva_a}^{(1-\sigma_D)}\right)^{\frac{1}{(1-\sigma_D)}}$$

$$BI_a = \delta_a^D \cdot X_a \cdot \left(\frac{Pa_a}{Pbi_a}\right)^{\sigma_D}$$

$$VA_a = (1 - \delta_a^D) \cdot X_a \cdot \left(\frac{Pa_a}{Pva_a}\right)^{\sigma_D}$$

$$Pbi_a = \left(\sum_i \delta_{i,a}^{BI} {P_i}^{(1-\sigma_{BI})}\right)^{\frac{1}{(1-\sigma_{BI})}}$$

$$bi_{i,a} = \delta_{i,a}^{BI} \cdot X_a \cdot \left(\frac{Pbi_a}{P_i}\right)^{\sigma_{BI}}$$

$$Pva_a(1 - \sum_{VA} tva_a^{VA}) = \left(\delta_a^L pl^{(1-\sigma_{va})} + (1 - \delta_a^L) pk^{(1-\sigma_{va})}\right)^{\frac{1}{(1-\sigma_{va})}}$$

$$L_a^d = \delta_a^L \cdot VA_a \cdot \left(\frac{Pva_a(1 - \sum_{VA} tva_a^{VA})}{pl}\right)^{\sigma_{va}}$$

$$K_a^d = (1 - \delta_a^L) \cdot VA_a \cdot \left(\frac{Pva_a(1 - \sum_{VA} tva_a^{VA})}{pk}\right)^{\sigma_{va}}$$

$$X_a = \left(\sum_i d_{a,i}^q q_{i,a}\right)^{\frac{1}{(1-\sigma_q)}}$$

$$P_i(1 - \sum_{out} tq_i^{out}) = \left(\delta_i^O {Pq_i}^{(1-\sigma_M)} + (1 - \delta_i^O) {Pm_i}^{(1-\sigma_M)}\right)^{\frac{1}{(1-\sigma_M)}}$$

$$Pm_i = pwm_i(1 + tm_i) \cdot EXR$$

$$M_i = (1 - \delta_i^O) \cdot Q_i \cdot \left(\frac{P_i}{Pm_i}\right)^{\sigma_M}$$

$$Pq_i = \left(\sum_a \delta_{i,a}^q {Pa_a}^{(1-\sigma_q)}\right)^{\frac{1}{(1-\sigma_q)}}$$

$$YF_h = \left((1 - u) L_h^s pl + K_h^s pk\right)$$

$$Y_h = YF_h\left(1 - \sum_{inc} ty_h^{inc} - \sum_{tras} tr_h^{tras}\right) + \sum_{hh} \sum_{tras} tr_{hh}^{tras} YF_{hh} + \sum_g Tr_g + Tr_{row}$$

$$YF_h = K_h^s pk$$

$$YF_g = K_g^s pk + \lambda_g^{act} \sum_{act} \sum_a (ta_a^{act} \cdot Pa_a \cdot X_a) + \lambda_g^{va} \sum_{VA} \sum_a (tva_a^{VA} \cdot Pva_a \cdot VA_a) + \lambda_g^{out} \sum_{out} \sum_i (tq_i^{out} \cdot P_i \cdot Q_i) + \sum_h \sum_{inc} ty_h^{inc} YF_h$$

$$Y_g = YF_g - \sum_g Tr_g - Tr_{row}$$

$$U_h = \left(C_h^{\frac{\sigma_U - 1}{\sigma_U}} + S_h^{\frac{\sigma_U - 1}{\sigma_U}}\right)^{\frac{\sigma_U}{\sigma_U - 1}}$$

$$Pu_h = \left(\chi_h^U \cdot Pc_h^{(1-\sigma_U)} + (1 - \chi_h^U) \cdot p_I^{(1-\sigma_U)}\right)^{\frac{1}{(1-\sigma_U)}}$$

$$C_h = \chi_h^U \cdot U_h \cdot \left(\frac{Pu_h}{Pc_h}\right)^{\sigma_U}$$

$$S_h = (1 - \chi_h^U) \cdot U_h \cdot \left(\frac{Pu_h}{p_I}\right)^{\sigma_U}$$

$$Pc_h = \left(\sum_i \delta_{i,h}^C \cdot P_i^{(1-\sigma_C)}\right)^{\frac{1}{(1-\sigma_C)}}$$

$$c_{i,h} = \delta_{i,h}^C \cdot U_h \cdot \left(\frac{Pc_h}{P_i}\right)^{\sigma_C}$$

$$U_g = G_g + S_g + def_g$$

$$r = \left(\sum_i \delta_i^I \cdot P_i^{(1-\sigma_I)}\right)^{\frac{1}{(1-\sigma_I)}}$$

$$I_i = \delta_i^I \cdot I \cdot \left(\frac{p_I}{P_i}\right)^{\sigma_I}$$

$$e_i = \delta_i^E \cdot Y_{row} \cdot \left(\frac{pwm_i \cdot EXR}{P_i}\right)^{\sigma_e}$$

$$Q_i = \sum_a bi_{i,a} + \sum_h c_{i,h} + \sum_g g_{i,g} + I_i + e_i$$

$$\sum_i I_i = \sum_h S_h + \sum_g S_g + S_{row}$$

$$\sum_i M_i + \sum_h tr_h^{tras} \cdot YF_h + \sum_g Tr_g^{row} + L_{row}^s pl + K_{row}^s pk = \sum_i e_i + \sum_h YF_h \cdot tr_h^{row} + \sum_g Tr_{row} + S_{row}$$

$$\sum_a K_a^d = \sum_h K_h^s + \sum_g K_g^s + K_{row}^s$$

$$U(1-u)\frac{pl^{1-\gamma}}{1-\gamma}\left(\frac{b^{1-\gamma}}{1-\gamma}\right)_{sin}$$

$$pl = \left(-\varepsilon_{npl} \cdot u \cdot b - \frac{a}{1+tv}\right) \cdot \frac{1}{1+\varepsilon_{npl} \cdot u}$$

$$\varepsilon_{npl} = \sum_{s=1}^{n} -\sigma_s \Phi_s \cdot \prod_{v=1}^{s-1}(1 - \Phi_v)$$

$$\sum_a L_a^d = (1-u)\sum_h L_h^s + L_{row}^s$$

Appendix 3 - Sensitivity analysis – Chapter 1

The elasticities of substitution in the production functions, denoted by "σ", are exogenously determined, depending on the nature and characteristics of the aggregates to be combined at each stage of the model. In particular, the elasticity of substitution between value added and intermediate consumption is set equal to zero, meaning that there is no possibility of changes in technology (Hermeling C., Mennel T., 2008).

The possibility of substitution between the components of value added (capital and labour, σ_v) is set to 0.5218, according to the literature on the issue (Van der Werf, E., 2008). As it can be seen from Table 9, within the σ_v fluctuation band, response of the variables changes, but they are consistent with the elasticity changes and maintain the same sign.

Table 9: Sensitivity analysis on σ_v - Effects on macroeconomic aggregates

Simulation 1	$\sigma_v - \sigma_v/2$	σ_v	$\sigma_v + \sigma_v/2$
Real Variables			
Real GDP	-0.114	-0.088	-0.069
Investment	1.834	1.593	1.833
Household consumption	-0.596	-0.560	-0.533
General government consumption	0.000	0.000	0.000
Export	-0.191	-0.163	-0.142
Import	-0.227	-0.211	-0.199
GDP deflator	0.297	0.252	0.219

Simulation 2	$\sigma_v - \sigma_v/2$	σ_v	$\sigma_v + \sigma_v/2$
Real Variables			
Real GDP	-1.100	-1.228	-1.323
Investment	0.489	0.428	0.495
Household consumption	-0.594	-0.773	-0.905
General government consumption	-6.690	-6.690	-6.690
Export	0.952	0.811	0.707
Import	-0.712	-0.791	-0.850
GDP deflator	-1.461	-1.246	-1.087

Simulation 3	$\sigma_v - \sigma_v/2$	σ_v	$\sigma_v + \sigma_v/2$
Real Variables			
Real GDP	-0.707	-0.832	-0.924
Investment	-0.343	-0.337	-0.332
Household consumption	-2.007	-2.182	-2.310
General government consumption	0.000	0.000	0.000
Export	0.941	0.799	0.695
Import	-1.059	-1.136	-1.192
GDP deflator	-1.438	-1.223	-1.065

Source: Author's elaboration on MAC-18 CGE static model results.

As for the elasticity of substitution between consumption and savings, the value is set equal to 1. This imply that the utility function is represented by a Cobb-Douglas function. However, the value may vary depending on the decision

of the consumer to retain a saving share for precautionary purposes, thus responding to the risk assumptions (Reis Gomes at al., 2015). It is therefore necessary to assess whether changes in taxation policy in the different simulations are sensitive to changes in elasticity between consumption and savings, in order to verify the consistency of simulations results. As can be seen in Table 9, modifying the elasticity of the utility function within a range from 0.5 to 1.5, the model does not show any significant variations in relation to the value of the elasticity used in the simulations. The greater or lower rigidity of the substitution elasticity is not amplifying the policy's effects.

Table 10: Sensitivity analysis on Sigma utility - Effects on macroeconomic aggregates

Simulation 1	$\sigma_u - \sigma_u/2$	σ_u	$\sigma_u + \sigma_u/2$
Real Variables			
Real GDP	-0.089	-0.088	-0.087
Investment	1.824	1.593	1.843
Household consumption	-0.560	-0.560	-0.560
General government consumption	0.000	0.000	0.000
Export	-0.162	-0.163	-0.164
Import	-0.212	-0.211	-0.210
GDP deflator	0.251	0.252	0.254
Simulation 2	$\sigma_u - \sigma_u/2$	σ_u	$\sigma_u + \sigma_u/2$
Real Variables			
Real GDP	-1.225	-1.228	-1.232
Investment	0.539	0.428	0.445
Household consumption	-0.773	-0.773	-0.772
General government consumption	-6.690	-6.690	-6.690
Export	0.807	0.811	0.815
Import	-0.786	-0.791	-0.796
GDP deflator	-1.240	-1.246	-1.253
Simulation 3	$\sigma_u - \sigma_u/2$	σ_u	$\sigma_u + \sigma_u/2$
Real Variables			
Real GDP	-0.829	-0.832	-0.836
Investment	-0.297	-0.337	-0.376
Household consumption	-2.182	-2.182	-2.181
General government consumption	0.000	0.000	0.000
Export	0.795	0.799	0.803
Import	-1.131	-1.136	-1.140
GDP deflator	-1.217	-1.223	-1.229

Source: Author's elaboration on MAC-18 CGE static model results.

CHAPTER 2 – ECONOMIC GROWTH AND A U.S. FEDERAL CARBON TAX

2.1. Environment should be at the core of public policy

The investment change that a modern society pursues today cannot be seen exclusively from a strictly economic point of view. Tax reforms geared towards economic development must promote equitable and sustainable growth, making it therefore necessary to evaluate the effects of a policy also from an environmental and sustainability point of view.

According to the analysis made in the OECD "Revenue Statistics 2019 -the United States"[8], the tax structure of the United States, if compared to the OECD average, is characterised by relative higher revenues from taxes on personal income, profits and gains, as well as from property taxes. On the reverse, a lower proportion of state revenues stems from taxes on corporate income and gains and social security contributions. Nevertheless, the USA had the highest statutory corporate tax rates, representing an inefficient source of revenue: the average tax rate was below the OECD average, while marginal tax rate is high, creating distortions.

With the aim of stimulating investment growth and economic growth, the U.S. government enacted the Tax Cuts and Jobs Act (TCJA) in the end of 2017, carrying a reorganisation of federal corporate and personal income taxation. The TCJA intervened also on the deduction system at Federal level to allow tax relief to middle-income households, to lower the tax rate on labour.

According to the law, the reduction of Federal corporate income tax is permanent, while the cut of personal income tax is set to expire in 2025. Debate is lively on the possibility to render the cut permanent.

If they were made permanent, a study of Kaeding, Pomerleau, Muresianu (2018) reveals that they would increase long-run GDP by 2.2 percent, long-run wages by 0.9 percent, and add 1.5 million full-time equivalent jobs. Nevertheless, on the other side, the federal revenue would be reduced yearly by $165.8 billion in a static perspective, while the reduction would be $112.8

[8] The Report can be downloaded at the following link: https://www.oecd.org/tax/revenue-statistics-2522770x.htm

billion annually on a dynamic basis, i.e. taking into account the economic growth (brought by the income tax reduction) that would re-enter as revenue.

Indeed, these estimates indicate that making the personal income tax changes of the TCJA permanent would mean a significant cost for Federal budget. Both IMF and OECD pointed to the unsustainable path of the U.S. public debt and recommended to raise indirect taxes and institute a federal carbon tax to also boost investments and allow the maintenance of infrastructure (IMF and OECD economic analysis of the U.S., Art.IV and Economic Survey, respectively).

Nevertheless, letting the personal income tax changes expire would have negative effects in terms of economic growth as well as in terms of tax distortions from corporate to personal income taxes.

In the present study, a different approach for the reorganisation of the U.S. Federal taxation on income is proposed, compared to what has been enacted with the Tax Cuts and Jobs Act (TCJA) in the end of 2017. In particular, an alternative proposal is provided, consisting in the introduction at federal level of a carbon tax on productive activities, with a level of 20$/Ton of greenhouse gases emitted. The aim is to demonstrate that the carbon tax can have a twofold objective. On the one side, the carbon tax can relieve the loss of federal revenue following the personal income tax reduction. On the other side, the greenhouse gas tax is not detrimental for growth, on the contrary it may constitute a tax dividend useful to pursue other objectives not only for the environment, but also for health, work and fair taxation. According to the report drawn up by the World Bank (2019), the Countries which introduced *carbon pricing* measures are 56 in 2019, compared with 19 in 2010, with a more pronounced spread in Europe. The US has taken no action to introduce a carbon tax, nor to implement the Clean Power Plan. Moreover, they formally left the Paris agreements in 2019. According to the 2020 OECD Economic Survey[9], no action has been taken to introduce a price on carbon. Nevertheless, some indicators of environment pressures have been improving:

[9] https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-united-states-2020_12323be9-en

CO_2 emissions in 2018 were 12% lower compared to 2007, thanks to innovation, regulatory reforms and changes in relative prices between oil and natural gas. These changes lead to lower emissions in electricity and transportation sectors. The federal government has not adopted a greenhouse gas emissions target for the United States, but the Department of Energy supports projects for carbon capture, utilisation and storage. State and local governments have imposed various targets, including energy efficiency and greenhouse gases emission reduction, the attainment of carbon neutrality by the mid-century, as well as the cap-and-trade system adopted in California. However, in 2018 (latest data available) greenhouse gas emissions were still 1% above their 1990 levels. The US has a national system that supports innovation and has a well-functioning labour market, which can facilitate the transition from a carbon-intensive to a low-emission economic system, as this latter changes according to the carbon-based pricing policy. According to Herrnstadt E., Dinan T. (2020), with invariant policy scenario climate change would reduce U.S. GDP growth yearly by an average of 0.03 percentage points from 2030 to 2050. In addition, the introduction of a carbon tax coupled with the tax provisions of the TCJA can be regarded as a policy framework aimed, on the one side, at counterbalancing the potential risks of a negative impact on competitiveness, with the reduction of corporate tax on income. On the other side, tax interventions aimed at increasing household income can also be considered as a method of avoiding the disadvantages which carbon pricing can have on households, especially lower income households, by 'protecting' them without undermining the effectiveness of the incentive to reduce high emission activities.

To assess the effectiveness of a carbon tax introduction, a dynamic Computable General Equilibrium (CGE) model is constructed, calibrated on the U.S. Social Accounting Matrix (SAM) for 2017. Four simulations are carried out: in the first one, the effects of the reduction of the corporate income tax implemented with the TCJA are quantified. The second simulation shows the effects on the economic system of a permanent reduction of personal income tax by the same amount of the corporate income tax reduction.

The last two simulations are aimed at verifying the effectiveness in terms of economic effects of the carbon tax as a possible means of covering the loss of revenue resulting from the reduction of personal income tax. In particular, in the third simulation the reduction in federal revenue is assumed to be financed by a reduction in Federal Government expenditure (excluding defence expenditure). The fourth simulation identifies the introduction of a carbon tax at the federal level on productive activities as the hedging instrument for the loss of revenue resulting from the reduction of personal income tax.

The paper is structured as follows. Section 2 is devoted to methodology, by firstly illustrating the construction of the Social Accounting Matrix (SAM), together with an environmental framework for greenhouse gas emissions from production activities. This environmental framework is added to the SAM to assess the effects on the emissions of the carbon tax introduction. The illustration of the dynamic Computable General Equilibrium (CGE) model calibrated on the U.S. Social Accounting Matrix (SAM) for 2017 follows. Section 3 describes the simulations scenario and their results. Section 4 is devoted to conclusions and policy recommendations.

2.2. Construction of the Framework

2.2.1. National Accounts and environmental data

The SAM is the most suitable accounting scheme to represent the complex framework of links characterising economic systems that are comprehensive, relevant and internally consistent. A SAM is a representation of the macroeconomic accounts of a socio-economic system, and it captures the transactions between all economic agents (Pyatt and Round, 1985; Reinert and Roland-Holst, 1997). It is generally recognised that the construction and study of SAMs began with Sir Richard Stone's pioneering work in the 1960s, based in the UK and some other industrialised countries, and subsequently extended to the analysis of the poverty problems and

income distribution in developing countries, through Pyatt, Thorbecke (1976) . Its use has largely spread because it presents specific characteristics in a framework of general economic equilibrium, which are necessary in order to capture the transmission and feedback mechanisms the impulses at the various stages of production, distribution, use of income and real and financial accumulation. It is therefore a key tool for simulations and impact analyses. For this reason, the SAM represents an analytical structure that is useful for modelling purposes, used in particular as a basis for both fixed-price multiplier models, and calibration of computable general equilibrium models (CGE) (Pyatt, 1988). The US SAM is structured as follows (table 1).

More precisely, as depicted in Table 9 the SAM records the flows among the different operators/accounts at the various stages of the circular flow of income. The index {1 to *i*} indicates the 73 products; {1 to *j*} means 71 industries (the complete list of products and industries can be found in Appendix 4); for the Value Added generation, the 2 primary factors are labour and capital; {1 to h} are the 4 private institutional sectors (non-financial corporations, financial corporations, Households, Rest of the World), whereas {1 to g} represents the 2 public institutional sectors: Federal Government and State and Local Governments. The primary income allocation is function of income from labour and capital. The secondary distribution of income is related to transfers among institutional sectors, function of their income for private sectors while exogenous for public sectors. The use of income is related to consumption, investment, and capital accumulation, highlighting circularity. The vectors of investment and savings have indices {1 to z} that represents public and private sectors.

Table 11. The Social Accounting Matrix and the structure of interactions among agents (a)

	Commodities (1, …, i)	Activities (1, …, j)	Primary Factors (L, K)	Taxes on output	Taxes on activities and VA	Private Institutional Sectors (1,…,h)	Government (1,…,g)	Taxes on Income (1, …, e)	Investments (1, …, z)	Rest of the world
Commodities (1, …, i)		*Intermediate consumption*				*Private consumption*	*Public consumption*		*Private, Public Investment*	*Exports*
Activities (1, …, j)	*Make*									
Primary Factors (L, K)		*Value added*								*Value added*
Taxes on output	*Taxes on goods*									
Taxes on activites and VA		*Taxes on activities and V.A.*								
Private Institutional Sectors (1,…,h)			*Value added to institutional sectors*			*Transfers*	*Transfers*			*Transfers*
Government (1,…, g)			*Value added to Government*	*Revenue taxes on output*	*Revenue taxes on activities*	*Transfers*	*Transfers*	*Revenue Taxes on income*		*Transfers*
Taxes on Income (1, …, e)						*Taxes on income paid*				
Savings (1, …, z)						*Private saving*	*Public saving*			*Current account*
Rest of the world	*Imports*		*Value added*			*Transfers*	*Transfers*			
Greenhouse gas emissions		*GHG emissions*								
Employment		*Employment by activity*								

(a) Source: Authors elaboration on Taylor (1990), Ciaschini et al. (2012).

As regards taxes, SAM includes taxes on activities, on products and income taxes. They are divided according to the institutional sector that collects them (federal government and State and local governments), to be able to pursue policy simulations on federal taxes only.

The transactions recorded in the matrix cells represent an entry (inflow of resources) for the operator/account to which the line is headed and an exit (loss of resources) for the operator/account to which the column is headed. This makes it possible to assess the effects of economic phenomena on particular segments of institutions, such as households, businesses (both financial and non-financial) or public administrations, according to their relevance for the examined policy objectives, analysing the phases of construction, distribution and redistribution of income.

The SAM for 2017 has been constructed by using the Bureau of Economic Analysis (BEA) National Accounts data on Supply and Use Tables with 71 activities and 73 commodities as well as Institutional Sectors accounts.

The construction of the SAM requested the reconciliation of some items between the national accounts system used by BEA - the National Income and Product Accounts (NIPAs) - and the System of National Accounts (SNA). Differences in the definitions affect the comparability of estimates throughout the accounts: in the SNA, institutional sectors are equally defined across all measures; on the contrary, in the NIPAs, some entities are part of one institutional sector for production-related data, while form part of another institutional sector for income-related data (McCulla et al., 2015). The production account has been made consistent with the income formation account by cross-referencing the data with the income-based estimates that the BEA regular submits to the OECD. These estimates made it possible to allocate the statistical discrepancy to the rest of the world gross operating surplus.

The integration of the SAM with environmental data is obtained using the data for 2017 of the Environmental Protection Agency (EPA – 2019 Report) on greenhouse gas emissions allocated to economic sectors (with emissions related to electric power re-distributed into end-use categories, i.e. emissions from electric power are allocated to the economic sectors in which the electricity is used). The EPA report carries out a direct attribution to the industries only for the transport sector. For the manufacturing and agricultural sectors, the allocation to each industry according to the NACE codes was carried out considering their use of energy products and fossil fuels. Gross greenhouse gas emissions were considered, i.e. excluding the so-called LULUCF - land use, land use change and forestry. This work focuses attention on GHG emissions of industrial and services sectors, while residential sector GHG emissions are not considered.

The SAM has also been integrated with the full-time equivalent data for each activity, so to look also at the effects on employment of the fiscal policy proposed in the paper.

2.2.2. A dynamic CGE model for the U.S. economic system

In the economic literature, CGE models are considered as analysis instruments able to assess the impacts of an exogenous shock on macro-economic variables along the circular flow of income (Radulescu, Stimelmayr 2010). Several studies use CGE models to address different domains such as trade liberalisation, environment-economy interactions and climate-change challenges, labour market deregulation, fiscal reform, monetary policies, public infrastructure, gender policies, mega events and specific industry sector's studies (Gunning and Keyzer 1995; Dixon and Parmenter 1996; Devarajan and Robinson, 2002; Dixon and Jorgenson, 2013; Socci et al. 2018; Felici et al. 2018; Severini et al. 2018). As regard to the analysis of environmental problems, CGE are widely used since they are able to formalise the relationship between the environmental and economic variables, thus allowing the assessment of fiscal and industrial policies aimed to achieve economic and ecological targets. In this perspective it is worth to mention the extended use of this methodology to verify and quantify the impact of carbon taxes also from the point of view of the double/triple dividend hypothesis (Goulder, 1995; Bovenberg and Goulder, 1997; Böhringer et al., 1997; Bovenberg and De Mooij, 1998; Manresa and Sancho, 2005; Takeda, 2007; Glomm et al., 2008; Bor and Huang, 2010; Severini et al., 2018).

The dynamic general equilibrium model built in this paper is a system of simultaneous non-linear equation following the Ramsey analysis of optimal economic growth under certainty (Lau, Pahlke, Rutherford, 2000). The model is characterised by a representative household, which is infinitely lived, forward-looking, rational and it maximises the present value of its utility (as will be explained from equation [27]). Following the methodology in Paltsev (2004), the complementarity approach is used to approximate the infinite horizon choices in a finite horizon model, as explained in equation [34]). Five years characterise the finite horizon of this dynamic model. The dynamic CGE model is not divided into defined time periods, but simply links two steady state solutions according to an adjustment path that has no precise reference to a time

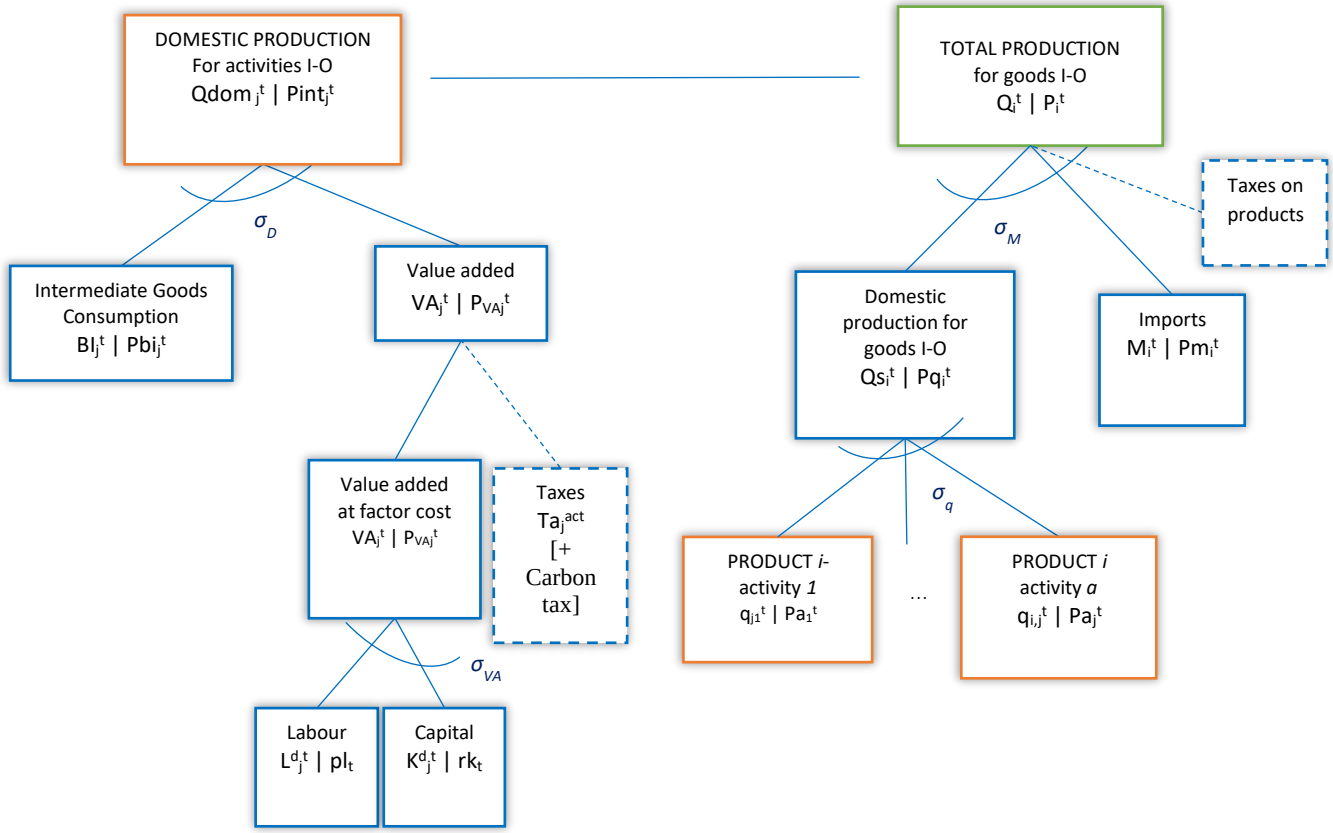
schedule (Grassini, 2009). Therefore, on a conservative basis, the distance between two steady states (Keuschnigg, Kohler 1999) can be defined as 'period'. However, as the basic data on which the model is calibrated are referred to a period of one year, it is assumed that the reference period is the year, considered as the period in which the overall economic equilibrium effects are complete.

The model represents an economy with perfect competition in all markets, and a steady-state growth, where capital, output, consumption etc. grow at constant rates. In particular, the growth rate is fixed at 1%, and the interest rate is fixed at 2.5%. These figures are consistent with the OECD Economic Outlook forecasts of November 2019, coupled with the OECD Interim Economic Outlook Forecasts of March 2020[10].

The production function of the model is structured according to Figure 7 and is modelled in GAMS using a vectoral notation for institutional sectors and markets.

[10] OECD Economic Outlook, different volumes, can be downloaded at the following link: https://www.oecd-ilibrary.org/economics/oecd-economic-outlook-volume-2019-issue-2_9b89401b-en

Figure 7. Production function by industry and by commodity.



Starting from the first nest, total production by goods is obtained through the combination of domestic and imported goods, using the imperfect substitutability assumption (Armington, 1969). Domestic production ($Qdom_{j,t}$) per activity j and time t, is obtained through the combination of intermediate goods ($BI_{j,t}$) and value added ($VA_{j,t}$) according to the following function:

$$Qdom_{j,t} = \left(d_j^D BI_{j,t}^{\rho_D} + \left(1 - d_j^D\right) VA_{j,t}^{\rho_D}\right)^{\frac{1}{\rho_D}} \qquad [23]$$

where d_j^D represents the share of intermediate goods ($BI_{j,t}$) on output, $Va_{j,t}$ is the value added. The dual cost function can then be written in the form

$$Pdom_{j,t}\left(1 - Tax_{j,t}^{act}\right) = \left(\sum_i {\delta_{i,j}}^D {Pbi_{j,t}}^{(1-\sigma_j)} + \sum_i (1 - {\delta_{i,j}}^D) {Pva_{j,t}}^{(1-\sigma_j)}\right)^{\frac{1}{(1-\sigma_j)}} \qquad [24]$$

Where $Pdom_{j,t}$ is the price net of taxes on activities ($Tax_{j,t}^{act}$); σ_j represents the elasticity of substitution between the intermediate goods and the Value Added and it depends from ρ, the exponent of the function [23]: $\sigma_j = \frac{1}{1-\rho} \Leftrightarrow \rho = \frac{\sigma_j - 1}{\sigma_j}$

The value of σ_j is set to zero, indicating that the aggregating function follows a Leontief production function. Pbi_j and Pva_j represent the respective prices.

In the second stage, formation of intermediate goods prices is described; looking only at the dual of the function:

$$Pbi_{j,t} = \sum_i \left(\delta_{i,j} P_{j,t}{}^{(1-\sigma_{BI})}\right)^{1/(1-\sigma_{BI})} \quad [25]$$

where the average price is obtained by combining the price of the product ($P_{j,t}$) with the fixed coefficients $\delta_{i,j}$ calibrated on the SAM. The elasticity of substitution among intermediate goods (σ_{BI}) is zero (Leontief production function).

The Value Added is obtained from the combination of productive factors of capital and labour, and the corresponding prices are obtained by matching demand and offer. Regarding gross operating surplus, the market is assumed to be in perfect competition (Ciaschini et al. 2012):

$$Pva_j^t = \left[\delta_j^v \cdot pl_t{}^{(1-\sigma_v)} + \left(1-\delta_j^v\right) \cdot rk_t{}^{(1-\sigma_v)}\right]^{\frac{1}{1-\sigma_v}} \quad [26]$$

where δ_j^v represents the labour share on total factor input; σ_v represents the substitution elasticity between capital and labour, which is equal to 0.3194 for the USA (according to Van der Werf, 2008); pl_t and rk_t finally represent prices of labour and capital.

As for the demand formation, private institutional sectors maximise the types of intertemporal choices in terms of consumption, under the constraint of their global income. It is assumed that the decision-making choices for the institutional sectors are different.

Households make the present and future choices between consumption and savings through the maximisation of the intertemporal utility function under the budget constraint based on

actualized disposable income for the entire period. The process can be summarised as follows (the subscript *hh* indicates the households):

$$maxU_{hh} = \sum_{t=0}^{T} \left[\left(\frac{1}{1+\rho} \right)^{t} \sum_{i} C_{i,hh,t} \right] \quad [27]$$

subject to the following constraints:

$$\sum_{i} C_{i,hh,t} = \sum_{i} Q_{i,t} - \left[\sum_{i} \sum_{j} b_{i,j,t} + \sum_{i} \sum_{g} G_{i,g,t} + \sum_{i} \sum_{z} I_{i,s,t} + \sum_{i} e_{i,t} \right] \quad [28]$$

in which total consumption $\sum_i \mathrm{C}_{\mathrm{i,hh}}^{\mathrm{t}}$ equals total production $\sum_i \mathrm{Q}_{\mathrm{i}}^{\mathrm{t}}$ less the intermediate consumption $\sum_i \sum_j \mathrm{b}_{\mathrm{i,j}}^{\mathrm{t}}$, public expenditure $\sum_i \sum_j \mathrm{G}_{\mathrm{i,g}}^{\mathrm{t}}$, investment $\sum_i \sum_s \mathrm{I}_{\mathrm{i,s}}^{\mathrm{t}}$ and exports

$$\sum_{i} C_{i,hh,t} = Y_{hh,t} - S_{hh,t} \quad [29]$$

where total consumption $\sum_{\mathrm{i}} \mathrm{C}_{\mathrm{i,hh,t}}$ must equal the difference between disposable income $\mathrm{Y}_{\mathrm{is,t}}$ (see equation 11) and savings $\mathrm{S}_{\mathrm{hh,t}}$. Financial and non-financial corporations shift income variations to savings, being consumption equal to zero:

$$S_{Firms,t} = Y_{firms,t} \quad [30]$$

The amount of demand by both Federal Government and State and local Governments is fixed in real terms and the variations in public disposable income over each period are set aside; in addition, governments' expenditure may exceed disposable income by generating deficits, which means that the utility function of the governments U^{gov} is the sum of public expenditure $\sum_{\mathrm{t}} G_t^{gov}$ and deficit $\mathrm{Def}_{\mathrm{g}}^{\mathrm{t}}$:

$$U^{gov} = \sum_{t} \left(G_t^{gov} + def_t^{gov} \right) \quad [31]$$

The disposable income for private institutional sectors in each period is calculated as follows:

$$Y_t^{priv} = YF_t^{priv}(1 - \sum_{inc} ty_{inc}^{priv} - \sum_{tras} tr_{tras}^{priv}) + \sum_{priv} \sum_{tras} tr_{tras}^{priv} YF_t^{priv} + \sum_{g} Tr_t^{g} + Tr_t^{row} \quad [32]$$

Where:

- income from primary factors YF_t^{priv} in each period is given by the sum of labour income $L_t^{priv} pl_t$ and capital income $K_t^{priv} rk_t$: $YF_t^{priv} = L_t^{priv} pl_t + K_t^{priv} rk_t$ [33]
- income from primary factors is net of income taxes $\sum_{inc} ty_{inc}^{priv}$ and transfers $\sum_{tras} tr_{tras}^{priv}$ to other institutional sectors,
- and adds to transfers from other institutional sectors ($tr_{tras}^{priv} YF_t^{priv}$) as well as transfers from government ($\sum_g Tr_t^g$) and from the rest of the world (Tr_t^{row}).

Private Institutional Sectors' gross disposable income at present value derives from the actualisation of disposable income in each period, plus the stock of capital accumulated during the time horizon of the model:

$$Y^{priv} = \sum_t Y_t^{priv} \left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{priv} pk_{tfirst} - KS_T^{priv} pk_T \left(\frac{1}{1+r}\right)^T \quad [34]$$

Finally, the demand for export goods is linked to the following exogenous variables: rest of the world income, exchange rate, foreign prices, and the price of domestic goods.

$$e_{it} = \delta_i^E Y_{tfirst}^{row} (1 + g^{row})^t \left(\frac{pmw_i(1+\pi_t)/exr_t}{P_{it}}\right)^{\sigma_E} \quad [35]$$

Where e_{it} represents the demand for exports for each commodity at the time t, Y_{tfirst}^{row} the initial income of the rest of the world, g^{row} is the growth rate of the world demand (exogenous); δ_i^E is the export share of each good on total exports; σ_E is the substitution elasticity between goods in the Rest of the World basket, which is put equal to zero; pmw_i is the world price of commodities, set as invariant and equal to 1, thus no assumption on inflation in the rest of the world is made; exr_t is also set equal to 1.

The demand for investment goods (I) over time t is obtained by combining, in accordance with the following function, the demand for investment goods. Through the dual function of investment, price or return of the investment P_t^I can be determined as follows:

$$P_t^I = \left(\sum_i \delta_i^I \, P_{it}^{(1-\sigma_I)}\right)^{\frac{1}{1-\sigma_I}} \quad [36]$$

where δ_i is the share of the investment good on total investment, and σ_I is the substitution elasticity between the investment goods, set equal to zero.

Capital stock is formed in the following equation:

$$KS_{t+1} = KS_t(1-\tau) + \sum_i \sum_{is} I_{i,is,t} \quad [37]$$

Where KS is capital stock at one period that depends on capital stock of previous period net of τ, the capital depreciation, plus I_t the total investment of the previous period, summed by goods *i* and Institutional Sectors *is*. Equation (9) represents the evolution of capital; in a steady state growth (where g is the exogenous rate of growth), capital growth is given by

$$K^{t+1} = (1+g)\, K^t \quad [38]$$

In the SAM, the total value of capital endowment VK^t equals capital earnings: $VK_t = K_t * rk_t$. Two prices for capital are defined: the price to purchase capital pk^t and the price to rent it rk^t.

The empirical connection between investment flows and capital can be derived from equations (8) and (9):

$$I^t = (\partial + g)\, K^t \quad [39]$$

A 'special treatment' of capital in the last period of the model is needed, to approximate infinite horizon with model's finite periods, following Rutherford (1997). Capital level of terminal period *T* is a variable, with endogenous capital accumulation. This allows to avoid that in the last period all capital would be consumed, and nothing would be invested. In this model, investment in the terminal period is constrained to grow at the same rate as saving.

$$\frac{I_T}{I_{T-1}} = \frac{S_T}{S_{T-1}} \quad [40]$$

This has the advantage of imposing a balanced growth in the terminal period, without requiring that the model achieve the steady-state growth.

The complete list of equations and parameters can be found in Appendix 5.

2.3. Income taxes reform coupled with the carbon tax introduction

With the aim of stimulating investment and economic growth, after the enactment of the TCJA, the federal corporate income tax rate was curbed from 35 per cent to 21 per cent as at January 2018[11].

U.S. Federal government estimated that the reduction of the federal corporate income tax, coupled with the possibility for firms to fully deduct expenses for investments, would have raised output by 2 to 4 per cent over the long run, and boost average household wages by about $4,000.

The TCJA intervened also on U.S. personal income taxes, whose structure is mixed, compared to a flat corporate tax on income. To recap some of the main characteristics of the U.S. personal income tax, Federal personal taxes on income are progressive; pension and social security income, as well as income from U.S. Treasury securities and savings bonds, are taxable under the federal rules. At State level, 7 States (Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming) have no income tax at all. 43 States apply personal income tax; among them, 41 tax wage and salary income in very different ways: nine have flat-rate tax structures[12], while 32 states levy progressive-rate income taxes (with different numbers of brackets and rates). The remaining two States, New Hampshire and Tennessee, tax only interest income and dividends and Tennessee is going to repeal even this taxation by 2021. The federal government and some States adjust annually to inflation their brackets thresholds, deduction amounts, and credit values. The TCJA intervened also by reorganising the deduction system at Federal level.

The most prominent changes in personal income federal taxation were: *i)* the reduction of the top personal income tax bracket rate from 39.6 percent to 37 percent, *ii)* and the doubling of

[11] With this reduction, the U.S. combined rate (federal plus the average of State corporate income tax rates) dropped from 38.9 per cent to 25.7 per cent.

[12] As at 2020, nine states use a flat rate tax on income: Colorado (4.63%), Illinois (4.95%), Indiana (3.23%), Kentucky (5%), Massachusetts (5.05%), Michigan (4.25%), North Carolina (5.25%), Pennsylvania (3.07%), and Utah (4.95%).

standard deductions. As at 2020, there are seven marginal tax brackets at the federal level: 10%, 12%, 22%, 24%, 32%, 35%, and 37%. For the 2020 tax year, the lowest rate applies up to $9,875. The top rate of 37% applies to income over $518,401 for singles and $622,050 for married couples filing jointly[13].

According to the law, the reduction of Federal corporate income tax is permanent, while the cut of personal income tax is set to expire in 2025. Debate is lively on the possibility to render the cut permanent. As simulations results will highlight, letting the personal income tax changes expire would have negative effects not only in terms of economic growth, but also in terms of tax distortions from corporate to personal income taxes.

According to Congressional Budget Office data, the U.S. total deficit in 2017 amounted to -665.4 billion dollars ($-984 billion in 2019). In this framework, the annual cost of $112.8 billion in a dynamic perspective to make the reduction of personal income tax permanent, as estimated by Kaeding, Pomerleau, Muresianu (2018) would have a significant impact on Federal Budget.

Against this background, in this paper the introduction of a carbon tax on productive activities is proposed with a level of 20$/Ton of greenhouse gases emitted.

To demonstrate that, besides relieving the federal revenue loss related to the reduction of personal taxation, it is not detrimental for economic growth, four different simulations are proposed.

In the first simulation, the effects of the corporate income tax reduction enacted with the TCJA, with a cut in the federal corporate income tax rate of 14 percentage points, are quantified.

The second simulation shows the effects on the economic system of a reduction in personal income tax. Albeit personal income tax is progressive, and the marginal tax rate is different for different households, only one household is modelled according to the database available, and an average income tax rate is used, highlighting the effects on total households income. Analysing

[13] After the TCJA also standard deductions increased considerably and for the 2020 tax year, the standard deduction is $12,400 for single taxpayers, $18,650 for head of household filers, and $24,800 for married couples filing jointly.

distribution of income and equality issues is beyond the scope of the paper and could be the object of further studies. The simulation does not replicate exactly the modification enacted with the TCJA. On the contrary, it is supposed that the reduction in personal income taxation can be made permanent implementing a tax cut that ex ante has the same reduction in federal revenue generated by the cut of corporate tax rate.

The changes of corporate and personal federal taxation are considered separately, to highlight their different impact on the economic system.

Covering expenditure in the current state of US legislation is not compulsory. However, the third simulation assumes that the reduction in revenue resulting from the reduction of personal income taxation is financed by a reduction in federal government expenditure (excluding defence expenditure).

Finally, the last simulation identifies as a hedging instrument for the deficit resulting from the reduction of personal income tax, the introduction of a carbon tax at the federal level on productive activities.

For all the simulations impact effects on macro variables in real terms are presented, together with some results in nominal terms related to effect on taxation, to highlight eventual tax distortions. For each scenario effects on GHG emissions will also be presented, for the results to be compared with the introduction of the carbon tax hypothesis.

Sensitivity analysis is carried out in Appendix 7.

2.3.1. - Simulation 1: Corporate income tax reduction

As mentioned above, this simulation assumes a reduction in federal corporate income tax rate of 14 percentage points, replicating the tax rate cut implemented with the TCJA. Effects on the main macroeconomic aggregates are shown in Table 12.

Simulation results show that the reduction of the tax rate has a positive effect on private investment: the tax cut for businesses leads to an increase in their disposable income and, thus, savings (firms do not consume and all their income is saved). Employment levels are also slightly rising[14].

Nevertheless, private consumption reduction and the worsening of current account balance more than offset investment growth, resulting in a slight GDP contraction.

Fiscal policy changes that can increase growth depend on the starting point of each State, in terms of the tax system. The results shown in Table 12 seem to confirm that cutting the corporate tax rate can stimulate economic growth, but only if the current tax rate is very high (Rebelo S., Jaimovich N., 2018). As business taxation in the US was already flat, change has probably affected small businesses that are not key to driving economic growth.

Table 12. Impact of the reduction of the corporate tax on income (percentage change from benchmark, in real terms)

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	-0.108	-0.091	-0.075	-0.060	-0.044
Households consumption	-0.521	-0.507	-0.495	-0.483	-0.471
Private investment	2.428	2.462	2.500	2.544	2.594
Exports	-0.989	-0.939	-0.892	-0.847	-0.805
Imports	0.454	0.465	0.477	0.490	0.504
GDP deflator	1.193	1.133	1.076	1.022	0.970
Nominal Variables					
Households income taxes	1.099	1.069	1.041	1.015	0.992
Financial corporations' income taxes	-31.486	-31.546	-31.603	-31.657	-31.707
Non-Financial corporations' income taxes	-32.198	-32.257	-32.313	-32.367	-32.417
Unemployment	-0.061	-0.072	-0.084	-0.095	-0.107
GHG	-0.274	-0.251	-0.228	-0.206	-0.184

Source: Author's elaboration on dynamic model's results.

A crucial issue emerging from the taxation is the change in relative prices induced by taxation, to which economic operators respond by leading to a reallocation of resources in the economy. There is, therefore, a tax distortion, as the change in relative prices leads to a change in household consumption, reducing welfare. Household consumption is reduced, driven by higher

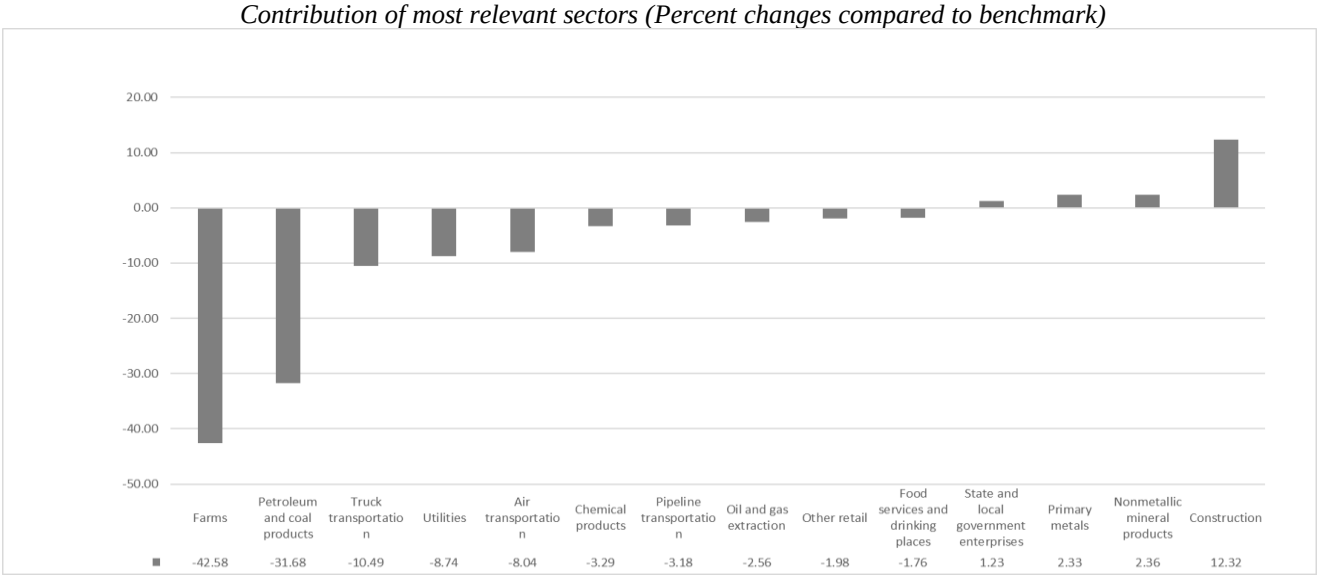
[14] Employment levels vary according to the value added component changes determined by prices and quantities movements.

price levels, which also leads to a reduction in real disposable income. On the contrary, nominal income increases, causing another form of tax distortion highlighted by this simulation, that is a shift from corporate to personal income taxes (Nicodème G., 2009).

Public expenditure choices are set as exogenous: as the State can operate in deficit, they do not depend on State income. Following this assumption, public expenditure real changes equals to zero, thus they are not listed in Table 12.

Greenhouse gas emissions are linked to production levels; changes in economic activities point to a reduction of total emissions. As highlighted in Figure 8, the total reduction of GHG emissions is linked to the trend in most polluting sectors, as farms, petroleum products, air and truck transport, utilities, and chemical products. The reduction in these sectors is not compensated by the increase in GHG emissions for some sectors, mainly construction and production of non-metallic mineral product and primary metals.

Figure 8. Greenhouse gas emissions - Impact of the reduction of the corporate tax on income
Contribution of most relevant sectors (Percent changes compared to benchmark)



Source: Author's elaboration on dynamic model's results.

2.3.2. - Simulation 2: Household income tax reduction

In this simulation, a permanent reduction of personal income tax is proposed, which ex ante determines the same annual reduction in Federal revenue (-5.6%), compared to that resulting from the curbing of federal corporate taxes.

The effect on the aggregated macroeconomic variables differs significantly from the first simulation, as shown in Table 13.

The increase in real household disposable income (+1% in the first year) resulting from the tax cut, generates, via the marginal propensity to consume and save, both an increase in consumption and an increase in savings, resulting in increased investment. The growth of the latter is also driven by the increase in real disposable income of corporations (+0.08% in the first year), which can be linked to indirect effects. The current account balance deteriorates, as the increase in prices results in a fall in exports and greater price competitiveness for imported goods. However, all these changes are conducive to an increase in real GDP, indicating that a reduction in household income taxes leads to higher both economic growth and employment.

Table 13. Impact of the reduction of the households' income tax (percentage change from benchmark, in real terms)

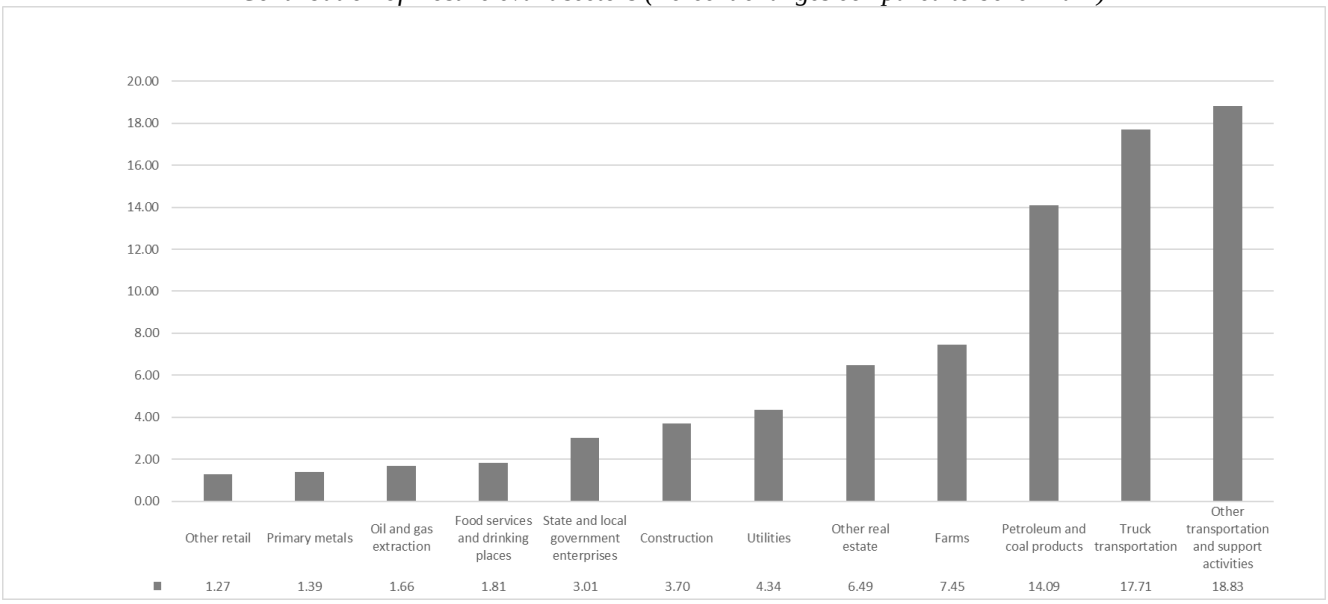
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	0.734	0.750	0.766	0.782	0.797
Households consumption	0.948	0.957	0.966	0.974	0.982
Private investment	1.677	1.702	1.730	1.763	1.799
Exports	-0.677	-0.643	-0.611	-0.580	-0.551
Imports	0.844	0.855	0.866	0.878	0.891
GDP deflator	0.815	0.773	0.734	0.696	0.661
Nominal Variables					
Households income taxes	-4.692	-4.708	-4.723	-4.736	-4.748
Financial corporations' income taxes	1.980	1.920	1.863	1.809	1.757
Non-Financial corporations' income taxes	1.980	1.920	1.863	1.809	1.757
Unemployment	-0.778	-0.788	-0.799	-0.810	-0.821
GHG	0.615	0.633	0.650	0.668	0.686

Source: Author's elaboration on dynamic model's results.

As in the previous simulation, also in this scenario a tax distortion emerges, pointing to the need of enacting the two modification of taxation at the same time, as implemented in the TCJA,

to limit the tax distortion. This means that not only one, but both changes in taxation should be permanent. The increase in private consumption and investment could determine the rise of GHG emissions, as evidenced in Figure 9.

Figure 9. Greenhouse gas emissions - Impact of the reduction of the household tax on income Contribution of most relevant sectors (Percent changes compared to benchmark)



Source: Author's elaboration on dynamic model's results.

The most relevant rise in GHG emissions can be explained by considering the relationship between goods consumed and invested, on the one side, and the intermediate sectors, on the other. The highest rise in Households' consumption is registered by the housing sector, weighing for the 16% on the total increase of private consumption; the housing sector uses as intermediate goods, among others, some of the most polluting sectors listed in Figure 3, namely construction, food services and drinking places, other real estate. Almost 8% of the Households' consumption increase is attributable to Food, beverages, and tobacco products; this sector is responsible for the increase in output and GHG emissions of the Farms sector, among the most polluting ones. Food services sector, accounting for 6% of total rise in consumption determine, among others, the rise in output of utilities sector. Petroleum products rise in GHG emissions can be partly explained by the rise in consumption of chemical products (5% of the total increase in consumption). As for

investment, the increase is most concentrated in the construction sector (with a weight of 6% on total investment rise).

2.3.3. - Simulation 3: Household income tax reduction and public expenditure reduction

In this simulation the hypothesis of exogenous public expenditure is relaxed: the reduction of personal income tax, which is identical to simulation 2, is financed by a reduction in federal government expenditure on non-defence related products so as to guarantee the balance ex ante. Main results are highlighted in Table 14.

Table 14. Impact of the reduction of the households' income tax with provision through public expenditure reduction (percentage change from benchmark, in real terms)

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	-0.058	-0.055	-0.053	-0.050	-0.048
Households consumption	0.845	0.844	0.844	0.844	0.843
Federal expenditure	-12.070	-12.070	-12.070	-12.070	-12.070
Private investment	0.070	0.069	0.067	0.065	0.062
Exports	0.033	0.032	0.030	0.029	0.027
Imports	0.227	0.228	0.229	0.230	0.231
GDP deflator	-0.040	-0.038	-0.037	-0.035	-0.034
Nominal Variables					
Households income taxes	-6.005	-6.001	-5.998	-5.995	-5.991
Financial corporations' income taxes	-0.081	-0.075	-0.070	-0.065	-0.059
Non-Financial corporations' income taxes	-0.081	-0.075	-0.070	-0.065	-0.059
Unemployment	0.034	0.032	0.029	0.027	0.024
GHG	0.446	0.447	0.447	0.448	0.449

Source: Author's elaboration on dynamic model's results.

The increase in household consumption and private investment, resulting from the increase in households' disposable income, is more than compensated by the reduction in public expenditure, ensuing in a slight contraction of GDP compared to the previous simulation.

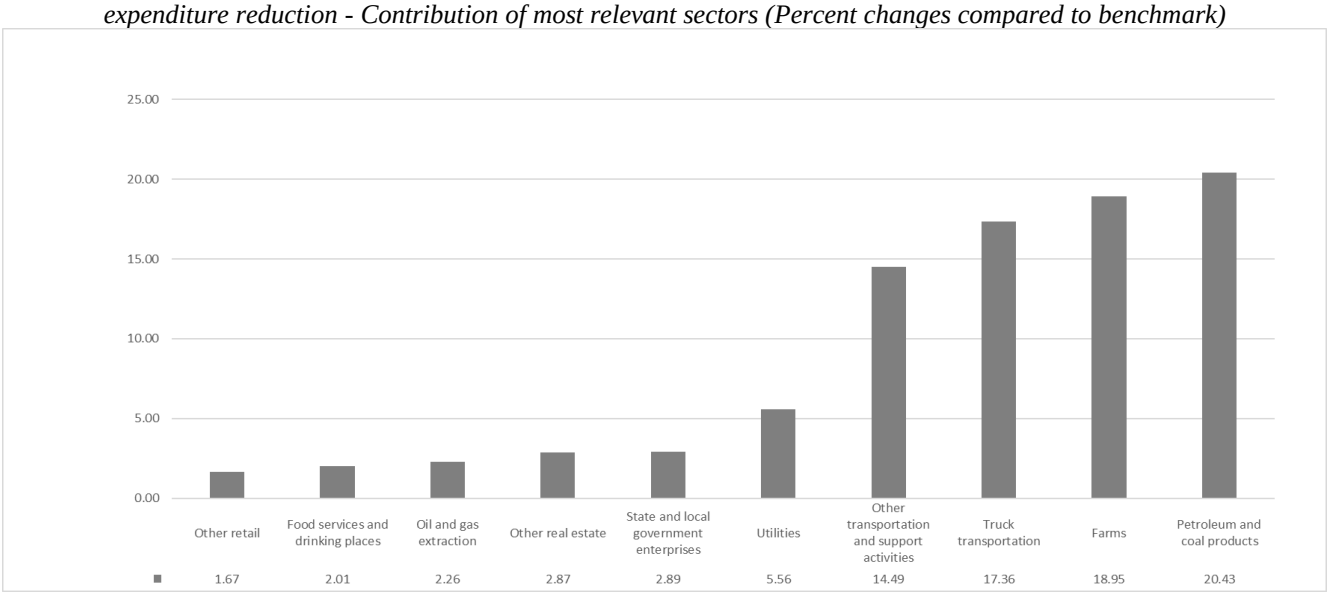
Negative effects of reducing public expenditure are highlighted by the fact that households are benefiting less from the reduction of taxes on income, if results are compared with simulation 2, in which no hedging instrument was considered for the federal revenue reduction: a smaller

increase of disposable income occurs (+0.7% in real terms in the first year, compared to +1%), carrying a lower increase in both household consumption and investment.

Employment trend is slightly contracting. A deterioration of the current balance occurs, even if in this scenario exports register a small increase due to a slight rise in competitiveness.

The increase in private consumption and investment, which is not necessarily oriented towards less polluting goods, leads to an increase in greenhouse gas emissions, albeit lower compared to the previous simulation, because of a minor increase both of consumption and investment, as above mentioned. As shown in Figure 10, sectors most affected by the GHG rise are essentially the same compared to simulation 2.

Figure 10. Greenhouse gas emissions: Impact of the reduction of the household tax on income, financed by public expenditure reduction - Contribution of most relevant sectors (Percent changes compared to benchmark)



Source: Author's elaboration on dynamic model's results.

2.3.4. - Simulation 4: Household income tax reduction and the introduction of a carbon tax

In this scenario, it is assumed that the Federal Government finances the reduction of the households' tax cut with the introduction of a federal carbon tax on productive activities of approximately $20 per tonne of greenhouse gas emitted. The total revenue from the tax is calculated on the percentage of emissions per unit of production, considering the GHG emissions

in 2017 and is such to ensure ex ante the coverage of the loss of federal revenue resulting from the reduction of personal income tax. GHG emissions are taken from the 2019 Environmental Protection Agency Report and are expressed in millions of Ton of CO_2 equivalent allocated to economic sectors (for major details see section 2.2). Main results are presented in Table 14.

Table 15. Impact of the reduction of the households' income tax with provision through a Federal carbon tax (percentage change from benchmark, in real terms)

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	0.147	0.145	0.141	0.137	0.133
Households consumption	0.209	0.209	0.209	0.209	0.209
Private investment	0.862	0.862	0.860	0.859	0.858
Exports	-0.878	-0.799	-0.721	-0.643	-0.566
Imports	0.295	0.394	0.492	0.591	0.689
GDP deflator	0.665	0.664	0.664	0.665	0.666
Nominal Variables					
Households income taxes	-5.619	-5.615	-5.611	-5.607	-5.602
Financial corporations' income taxes	0.075	0.066	0.059	0.053	0.048
Non-Financial corporations' income taxes	0.075	0.066	0.059	0.053	0.048
Unemployment	-0.142	-0.150	-0.157	-0.165	-0.172
GHG	-2.268	-2.253	-2.239	-2.226	-2.212

Source: Author's elaboration on dynamic model's results.

In this hypothesis, the remarkable result is the increase of GDP, albeit the introduction of a tax on productive activities. Indeed, the effects of the introduction of the carbon tax may consist either of a reduction in the other costs of the firms affected (in particular, the costs of primary inputs), and/or the increase in the prices of goods sold by the taxable firms. In any case, a carbon tax reduces real incomes earned by taxpayers. This effect is partially offset by the reduction in personal income taxes. The increase in household disposable income spur the increase of both private consumption and investment which, albeit lower compared to simulations 2 and 3, determines the growth of real GDP, notwithstanding the introduction of the carbon tax. Financing the personal income tax reduction with the carbon tax revenues results in the reduction of tax distortions stemming from the enactment of income tax changes. By this way, the 'second dividend' can be achieved (Ciaschini et al., 2012).

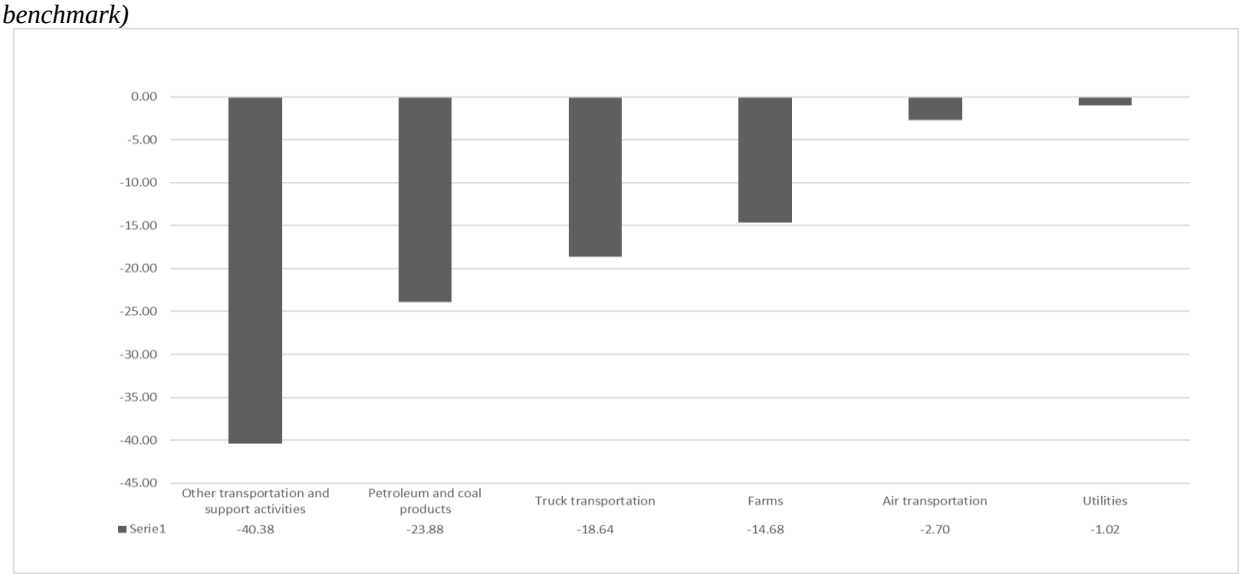
The slight rise in employment, carried on by the stimulus on economic activity, constitute the 'triple dividend' of the carbon tax introduction. As expected, employment is boosted in the less

polluting industries (for details of change in employment for each economic activity, see Appendix 6). The loss in price competitiveness carries a reduction in exports while a rise in imports occurs, resulting in a deterioration of current account balance.

The level of 20 $/ton assumed in this scenario, as already mentioned, does not claim to be an appropriate level for achieving the environmental objectives, but only a first step of what can be a gradual introduction of a tax that leads to the conversion of the production system.

Compared to simulation 3, the introduction of a tax on activities proportional to their polluting power, determines a price increase of products sold by the concerned activities and, consequently, a reduction in the quantity consumed and produced. This implies a reduction of emissions, attributed to the more polluting sectors (see Figure 11), while consumption and investment shift to cleaner production, giving the possibility to activate a long-term conversion of more polluting production processes.

Figure 11. Greenhouse gases emissions - Contribution of most relevant sectors (Percent changes compared to benchmark)



Source: Author's elaboration on dynamic model's results.

2.4. Concluding: Carbon tax does not appear harmful

In this paper the introduction of a federal carbon tax on productive activities, with a level of 20$/Ton of greenhouse gases emitted, is proposed to finance a permanent personal income tax change. Besides being a relief for the loss of federal revenue, the analysis demonstrates that the

introduction of a carbon tax, i.e. a tax proportional to the quantity of greenhouse gases emitted by each industry, is not harmful to the economic system, if accompanied by policy measures aimed at counterbalance the potential negative impacts on competitiveness. Tax interventions aimed at increasing household income can also be considered as a method of avoiding the disadvantages that carbon pricing can have on Households.

To assess the effectiveness of a carbon tax introduction, a dynamic Computable General Equilibrium (CGE) model has been constructed, calibrated on the U.S. Social Accounting Matrix (SAM) for 2017. Four simulations are carried out, to replicate the TCJA reduction on corporate income tax and to propose a permanent reduction of personal income tax, without provision and with two different kind of hedging instruments: a federal expenditure cut on the one side, and the introduction of a carbon tax on the other. First of all, the changes of corporate and personal federal taxation are considered separately, to highlight their different impact on the economic system. A reduction in household income taxes leads to higher both economic growth and employment. Nevertheless, in both cases when reducing a tax some tax distortions emerge, induced by both changes in relative prices and shifts from corporate to personal taxation and viceversa. This point to the need of enacting the two modification of taxation at the same time, as implemented in the TCJA, to limit the tax distortion. This means that not only one, but both changes in taxation should be permanent.

The last two simulations are aimed at verifying the effectiveness in terms of economic effects of the carbon tax as a possible way of covering the loss of federal revenue resulting from the reduction of personal income tax. In particular, the reduction in federal revenue from the reduction of personal income tax is assumed to be financed either by a reduction in Federal Government expenditure (for non-defence goods and services), or by the introduction of a carbon tax at the federal level on productive activities, as alternative hedging instruments.

Differences between the two kind of provision are significant in terms of multipliers. Indeed, the coverage of the deficit with a reduction in expenditure results in a counter-shock to

aggregate demand that more than offsets the beneficial effects on the economic system carried by the Household income tax reduction, determining a GDP contraction.

By contrast, the introduction of the carbon tax to cover the federal deficit stemming from the reduction of Household income tax seems to have a higher multiplier compared to the use of spending cut as hedging instrument. Albeit lower compared to the scenario in which no coverage is assumed, the remarkable result is the increase of GDP, coupled with the reduction of GHG emissions. This means that not only the first dividend is achieved, which is the improvement of environmental quality, but also the efficiency of tax system is enhanced, achieving the so called second dividend (Ciaschini et al., 2012). If, on the one hand, the carbon tax depresses the economic activity by affecting production activities, on the other hand the rise in consumption and investment resulting from the tax reduction allows the GDP rise. Considering the critics to double dividend hypothesis (Bovenberg and De Mooij, 1994), in this paper carbon tax revenues are used to counterbalance the distortions that arise from other tax changes, following the 'weak' double dividend hypothesis (Goulder, 1995).

Employment growth is the 'triple' dividend that may allow the economic system in the longer run to move towards productions with a lower environmental impact.

Moreover, as above mentioned, in this paper residential sector GHG emissions are not considered, being the focus on manufacturing and services sectors. This means that other potential benefits for the whole economy could come from households with the lowest emissions that might also be paying less taxes in their energy bill of for fuels, freeing resources for consumption or savings.

Indeed, the level of the carbon tax as well as the level of accompanying measures can change the results. Firstly, the evolution of carbon revenues depends on the initial level of the tax, on its design (static or increasing over time), on emitters covered, and on their responsiveness (Marron D. et al, 2015, Marten M. et al, 2019). Moreover, a carbon tax of 20 $/ton applied in our hypothetic scenario is likely to be low for the USA to reflect the social and environmental damage

caused using polluting products. According to Payr (2019), carbon price levels depend on Countries level of pollution as well as on the use of polluting products: it seems that emissions from activities using coal are most responsive to carbon pricing, implying a problem of technology know-how. Looking at the problem from the households energy consumption perspective, Duarte R., Sánchez-Chóliz J., Sarasa C. (2018), using a dynamic Computable General Equilibrium (CGE) model for Spain, show that reductions in emissions are consistent with economic growth, and confirm the role of technology improvements in delivering positive results for the environment. However, it is thought that the introduction of this kind of a tax can be a first step towards the gradual introduction of a 'Pigouvian' tax that can transform the economic system by creating soft incentives for moving towards cleaner technologies and activities, as a result of the price increase and the related decline in the consumption of polluting goods/services.

References for Chapter 2

Bhattarai K., Haughton J., Head M. & Tuerck D.G. (2017), Simulating Corporate Income Tax Proposals with a Dynamic GE Model, International Journal of Economics and Finance, Canadian Center of Science and Education, vol. 9 (5), pages 20-35, May.

BEA — Bureau of Economic Analysis U.S. Department of Commerce, Concepts and Methods of the U.S. National Income and Product Accounts. May 2019.

Bonini B., Carbon tax: The price to be paid to save the planet, Analysis, Osservatorio dei Conti Pubblici Italiani, November 2019.

Böhringer C., Pahlke, A., Rutherford, T. (1997), Environmental tax reforms and the prospect for a double dividend. http://debrue.colorado.edu/.

Bor, Y. J., & Huang, Y. (2010). Energy taxation and the double dividend effect in Taiwan's energy conservation policy. An empirical study using a computable general equilibrium model. Energy Policy, 38, 2086–2100.

Bovenberg, A., and De Mooij, R. (1994), Environmental levies and distortionary taxation, American Economic Review, 94, 1085-1089.

Bovenberg, A., & De Mooij, R. (1998), Environmental taxes, international capital mobility and inefficient tax systems: Tax burden versus tax shifting. International tax and Public Finance, 5, 7–39.

Bovenberg, A., Goulder, L. (1997), Costs of environmentally motivated taxes in the presence of other taxes: general equilibrium analysis. Nat. Tax J. 70, 59-87.

Bovenberg, A., Goulder, L. (2002), Environmental taxation and regulation. In: Auerbach, A., Feldstein, M. (Eds.), Handbook of Public Economics. Elsevier, Amsterdam, North Holland, Ch. 23, pp. 1471-1545.

Ciaschini, M., Pretaroli, R., Severini, F., & Socci, C. (2012), Environmental tax reform and double dividend evidence. Research in Economics, 66, 273-283.

De Pauw D. J.W., Vanrolleghem P. A. (2006), Practical Aspects Of Sensitivity Analysis For Dynamic Models, Journal of Mathematical and Computer Modelling of Dynamical Systems, Volume 12, 2006.

Duarte R., Sánchez-Chóliz J., Sarasa C. (2018), Consumer-side actions in a low-carbon economy: A dynamic CGE analysis for Spain, Energy Policy, Elsevier, vol. 118(C), pages 199-210.

European Commission (2017), Tax policies in the European Union: 2017 Survey.

Goulder, L. (1995), Environmental taxation and the double dividend: a reader's guide, International tax and public Finance, 2, 157-183.

Herrnstadt E., Dinan T. (2020), CBO's Projection of the Effect of Climate Change on U.S. Economic Output, Working paper series 56505.

Kaeding N., Pomerleau K., Muresianu A. (2018), Making the Tax Cuts and Jobs Act Individual Income Tax Provisions Permanent, Tax Foundation, FISCAL FACT No. 597, July 2018.

Kopp E., Leigh D., Mursula S., Tamunlertchi S., U.S. Investment Since the Tax Cuts and Jobs Act of 2017. IMF Working Paper, May 2019.

Lau M. I., Pahlke A., Rutherford T. (2000), Approximating infinite-horizon Models in a Complementarity Format: a primer in Dynamic General Equilibrium Analysis, Journal of Economic Dynamics and Control, Vol.26, pp. 577-609.

Marron D., Toder E., and Austin L. (2015), Taxing Carbon: What, Why, And How, Tax Policy Center Urban Institute & Brookings Institution, June 2015.

Marten M., van Dender K. (2019), The use of revenues from carbon pricing, OECD Taxation Working Papers no.43.

McCulla S. H., Moses K. E., Moulon B. R. (2015), The National Income and Product Accounts and the System of National Accounts 2008 — Comparison and Research Plans. BEA.

De Mooij, R.A. de and Ederveen, S. (2003), Taxation and Foreign Direct Investment: A Synthesis of Empirical Research, International Tax and Public Finance, 10: 673-693.

De Mooij, R.A. (2005), Will Corporate Income Taxation Survive? De Economist 153, 277–301. https://doi.org/10.1007/s10645-005-1989-5

De Mooij, R.A. de and Ederveen, S. (2006), What a Difference does it Make? Understanding the Empirical Literature on Taxation and International Capital Flows, Economic Paper, 261, European Commission.

De Mooij, R.A. and Nicodème, G. (2008), Corporate Tax Policy and corporation in the EU, International Tax and Public Finance, 15: 478-498.

Devarajan S., Robinson S. (2002), The Influence of Computable General Equilibrium Models on Policy. Frontiers in applied General Equilibrium Modeling: in Honor of Herbert Scarf.

Dixon P. B., Jorgenson D. W. (2013), Handbook of Computable General Equilibrium Modeling. www.sciencedirect.com. Available at: http://www.sciencedirect.com/science/handbooks/22116885.

Dixon, Peter B., Parmenter, B.R. (1996) Computable general equilibrium modelling for policy analysis and forecasting in: H. M. Amman & D. A. Kendrick & J. Rust (ed.), Handbook of Computational Economics, edition 1, volume 1, chapter 1, pages 3-85, Elsevier.

Felici F, Pretaroli R, Severini F, Socci C (2018), Milan expo 2015: the best is yet to come. Event Management, 22. pp.1–13

Glomm G., Kawaguchi D., Sepulveda, F. (2008), Green taxes and double dividends in a dynamic economy. Journal of Policy Modeling, 30, 19–32.

Goulder, L. (1995), Environmental taxation and the double dividend: a reader's guide. International tax and public finance 2, 157-183.

Gunning J. W., Keyzer M. A. (1995), Applied general equilibrium models for policy analysis. Handbook of development economics, 3, 2025-2107.
Manresa, A., & Sancho, F. (2005), Implementing a double dividend: Recycling eco taxes towards 604 lower labour taxes. Energy Policy, 33, 1577–1585.

Nicodème G. (2009), Corporate Income Tax and Economic Distortions, European Commission, Centre Emile Bernheim (Solvay Business School), Ecares (ULB) and CES Ifo.

Parry I. (2019), Putting a price on pollution, Finance and Development, Dec. 2019.

Paltsev S. (2004), Moving from static to Dynamic General Equilibrium Economic Models. MIT Joint Program on the Science and Policy of Global Change, Technical Note No. 4.

Pyatt G., and J. I. Round (eds) (1985), Social Accounting Matrices: A Basis for Planning. The World Bank, Washington D C.

Pyatt, G., and Thorbecke, E. (1976), Planning Techniques for a Better Future: A Summary of a Research Project on Planning for Growth, Redistribution and Employment (Geneva: International Labour Office): 51–84.

Pyatt, G, (1988), A SAM Approach to Modelling, Journal of Policy Modelling, 10(3):327-352.

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

Rebelo S., Jaimovich N. (2018), Does Lowering the Corporate Tax Rate Spur Economic Growth? Kellog School of Management at Northwestern University, Mar. 5th, 2018.

Reinert, K. A. and D. W. Roland-Holst (1997), Social Accounting Matrices, in J. F. Francois and K. A. Reinert (eds), Applied Methods for Trade Policy Analysis: A Handbook, Cambridge University Press, Cambridge: pp 94-121.

Rutherford T. F. (2001), Review of models with multi-year Period, Department of Economics, University of Colorado, 2001.

Severini, F., Pretaroli R., Socci C. (2018), The effects of environmental taxation through a dynamic CGE model, in Perali F., Scandizzo P.L. (Eds.) (2018), The New Generation of General Equilibrium Models — Modeling the Economy, Springer.

Socci C., Severini F., Pretaroli R., Ahmed I., Ciaschini C. (2018), Unconventional monetary policy expansion: the economic impact through a dynamic CGE model. In International Journal of Monetary Economics and Finance, Vol. 11(2), pp. 140-162

Stone J. R. N. (1985), The Disaggregation of the Household Sector in the National Accounts, in G. Pyatt and J. I. Round (eds), Social Accounting Matrices: A Basis for Planning. The World Bank, Washington D.C.; pp 145-185.

Takeda S. (2007), The double dividend from carbon regulations in Japan. The Japanese and International Economies, 21, 336–364.

Taylor L. (1990), in Taylor L. (ed): “Socially relevant Policy Analysis: Structural calculation for development for developing world.” Cambridge (MA): MIT press pp 1-70.

Ten Kate F., Milionis P. (2019), Is capital taxation always harmful for economic growth? International Tax and Public Finance. https: //doi.org/10.1007/s10797-019-09530-3.

Van der Werf, E. (2008), Production functions for climate policy modeling: an empirical analysis, Energy Economics, Vol. 30, No. 6.

World Bank (2019), State and Trends of Carbon Pricing, 2019.

Appendix 4. BEA - Products and Industries Classifications

NIPAs -National Accounts 71 activities

1	Farms	38	Other transportation and support activities
2	Forestry, fishing, and related activities	39	Warehousing and storage
3	Oil and gas extraction	40	Publishing industries, except internet (includes software)
4	Mining, except oil and gas	41	Motion picture and sound recording industries
5	Support activities for mining	42	Broadcasting and telecommunications
6	Utilities	43	Data processing, internet publishing, and other information services
7	Construction	44	Federal Reserve banks, credit intermediation, and related activities
8	Wood products	45	Securities, commodity contracts, and investments
9	Non-metallic mineral products	46	Insurance carriers and related activities
10	Primary metals	47	Funds, trusts, and other financial vehicles
11	Fabricated metal products	48	Housing
12	Machinery	49	Other real estate
13	Computer and electronic products	50	Rental and leasing services and lessors of intangible assets
14	Electrical equipment, appliances, and components	51	Legal services
15	Motor vehicles, bodies and trailers, and parts	52	Computer systems design and related services
16	Other transportation equipment	53	Miscellaneous professional, scientific, and technical services
17	Furniture and related products	54	Management of companies and enterprises
18	Miscellaneous manufacturing	55	Administrative and support services
19	Food and beverage and tobacco products	56	Waste management and remediation services
20	Textile mills and textile product mills	57	Educational services
21	Apparel and leather and allied products	58	Ambulatory health care services
22	Paper products	59	Hospitals
23	Printing and related support activities	60	Nursing and residential care facilities
24	Petroleum and coal products	61	Social assistance
25	Chemical products	62	Performing arts, spectator sports, museums, and related activities
26	Plastics and rubber products	63	Amusements, gambling, and recreation industries
27	Wholesale trade	64	Accommodation
28	Motor vehicle and parts dealers	65	Food services and drinking places
29	Food and beverage stores	66	Other services, except government
30	General merchandise stores	67	Federal general government (defense)
31	Other retail	68	Federal general government (nondefense)
32	Air transportation	69	Federal government enterprises
33	Rail transportation	70	State and local general government
34	Water transportation	71	State and local government enterprises
35	Truck transportation		
36	Transit and ground passenger transportation		
37	Pipeline transportation		

NIPAs — National Accounts 73 products

1	Farms	38	Other transportation and support activities
2	Forestry, fishing, and related activities	39	Warehousing and storage
3	Oil and gas extraction	40	Publishing industries, except internet (includes software)
4	Mining, except oil and gas	41	Motion picture and sound recording industries
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7	Construction	44	Federal Reserve banks, credit intermediation, and related activities
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9	Non-metallic mineral products	46	Insurance carriers and related activities
10	Primary metals	47	Funds, trusts, and other financial vehicles
11	Fabricated metal products	48	Housing
12	Machinery	49	Other real estate
13	Computer and electronic products	50	Rental and leasing services and lessors of intangible assets
14	Electrical equipment, appliances, and components	51	Legal services
15	Motor vehicles, bodies and trailers, and parts	52	Computer systems design and related services
16	Other transportation equipment	53	Miscellaneous professional, scientific, and technical services
17	Furniture and related products	54	Management of companies and enterprises
18	Miscellaneous manufacturing	55	Administrative and support services
19	Food and beverage and tobacco products	56	Waste management and remediation services
20	Textile mills and textile product mills	57	Educational services
21	Apparel and leather and allied products	58	Ambulatory health care services
22	Paper products	59	Hospitals
23	Printing and related support activities	60	Nursing and residential care facilities
24	Petroleum and coal products	61	Social assistance
25	Chemical products	62	Performing arts, spectator sports, museums, and related activities
26	Plastics and rubber products	63	Amusements, gambling, and recreation industries
27	Wholesale trade	64	Accommodation
28	Motor vehicle and parts dealers	65	Food services and drinking places
29	Food and beverage stores	66	Other services, except government
30	General merchandise stores	67	Federal general government (defense)
31	Other retail	68	Federal general government (nondefense)
32	Air transportation	69	Federal government enterprises
33	Rail transportation	70	State and local general government
34	Water transportation	71	State and local government enterprises
35	Truck transportation	72	Noncomparable imports and rest-of-the-world adjustment
36	Transit and ground passenger transportation	73	Scrap, used and second-hand goods
37	Pipeline transportation		

Appendix 5: Parameters, variables and equations of the dynamic model

Parameters and variables

t	Time index
T	Last time period
i	Commodities
j	Industries
is	Institutional sectors
priv	Households, Firms
gov	Public Administration
row	Rest of the world
$Q_{i,t}$	Output by commodity
$P_{i,t}$	Price of goods
$Q_{j,t}$	Output by industry
δ_i^{dom}	Cost function - share of domestic goods on total production
d_i^{dom}	Share of domestic goods on total production
$Pdom_{j,t}$	Prices of domestic activities
$Qdom_{j,t}$	Quantity of domestic activities
$Tax_{i,t}^{out}$	Taxes on output by commodity
$Pm_{i,t}$	Prices of imports from the rest of the world
$M_{i,t}$	Quantity of imports from the rest of the world
$\sigma_{Q_{dom}}$	Elasticity of substitution between domestic and imported goods
$\rho_{Q_{dom}}$	Exponent of the CES production function linked to $\sigma_{Q_{dom}}$
$Pbi_{j,t}$	Prices of intermediate goods
$BI_{j,t}$	Quantities of intermediate goods
$Tax_{j,t}^{act}$	Taxes on activities
$Pva_{j,t}$	Prices of value added
$VA_{j,t}$	Quantities of value added
δ_j^D	Share of intermediate goods in total domestic production
σ_D	Elasticity of substitution between intermediate goods and value added
ρ_D	Exponent of the CES production function linked to σ_D
$P_{i,t}$	Average price on goods market from the market clearing condition
$\delta_{i,j}^{BI}$	Share of intermediate goods cost on their total cost
σ_{BI}	Elasticity of substitution between intermediate goods
PL_t	Price of labor
PK_t	Price of capital
δ_j^v	Share of labour in the total of primary factors
σ_v	Elasticity of substitution between labour and capital
δ_j^L	Share of labour costs on added value
$L_{j,t}^d$	Labor endowment
$K_{j,t}^d$	Capital endowment
d_{ji}^q	Share of i^{th} product realized by industry j on total production of j
$d_{i,j}^q$	Share of goods supply by each activity on total domestic supply
$q_{i,j,t}$	Quantity of goods i produced by industry j
σ_q	Elasticity of substitution between primary and secondary production

δ_i^M	Share of domestic production on total production
$pmw_{i,t}$	Price of foreign goods
exr_t	Nominal exchange rate
Y^{is}	Primary income by Institutional sectors
ty_{inc}	Implicit rates of income tax
tr	Implicit rates of transfers between institutional sectors
tq_i^{out}	Implicit tax rates on output
tq_i^{act}	Implicit tax rates on activities
γ_{out}^{gov}	Share of taxes on output
γ_{act}^{pub}	Share of taxes on activity
U^{is}	Utility of Institutional sectors
C_t^{is}	Consumption of Institutional sectors
S_t^{is}	Saving of Institutional sectors
Y_t^{is}	Disposable income
YF_t^{is}	Primary income
Pu^{is}	Utility price
Pc_t^{is}	Price of consumption by institutional sector
P_t^I	Price of investment
δ_i^C	Share of consumption of the ith good in total consumption for each Institutional sector
σ_C	Elasticity of substitution among goods in the consumption basket
$c_{i,t}^{is}$	Quantity of consumption of each good by Institutional sector
δ_i^I	Investment share of the ith goods in total investments
σ_I	Elasticity of substitution among goods in the investment basket
$I_{i,t}$	Quantity of investment by goods
e_{it}	Export demand by goods from Rest of the World
δ_i^E	Export share of ith goods in total exports to the rest of the World
σ_E	Elasticity of substitution among goods in the export to the rest of the World basket
π_t	Foreign inflation rate
r	Interest rate
τ	Capital depreciation rate
g	Growth rate of production in the steady state
Ks_t^{priv}	Capital endowment by institutional sector
rk_t	Return on capital
ρ	Parameter of intertemporal preference
$alpha(t)$	Coefficient of intertemporal preference in consumption

Equations

$$Q_{i,t} = \left(d_i^{dom} Qdom_{i,t}^{\rho_{Q_{dom}}} + \left(1 - d_i^{dom}\right) M_{i,t}^{\rho_{Q_{dom}}}\right)^{\frac{1}{\rho_{Q_{dom}}}}$$

$$P_{i,t}\left(1 - Tax_{i,t}^{out}\right) = \left(\delta_i^{dom} Pdom_{i,t}^{\left(1-\sigma_{Q_{dom}}\right)} + \left(1 - \delta_i^{dom}\right) Pm_{i,t}^{\left(1-\sigma_{Q_{dom}}\right)}\right)^{\frac{1}{1-\sigma_{Q_{dom}}}}$$

$$Qdom_{j,t} = \left(d_j^D BI_{j,t}^{\rho_D} + \left(1 - d_j^D\right) VA_{j,t}^{\rho_D}\right)^{\frac{1}{\rho_D}}$$

$$\mathrm{Pdom_{j,t}}\left(1 - \mathrm{Tax_{j,t}^{act}}\right) = \left[\sum_{\mathrm{i}} \delta_{\mathrm{i,j}}{}^{\mathrm{D}} \mathrm{Pbi_{j,t}}^{\left(1-\sigma_{\mathrm{j}}\right)} + \sum_{\mathrm{i}} \left(1 - \delta_{\mathrm{i,j}}{}^{\mathrm{D}}\right) \mathrm{Pva_{j,t}}^{\left(1-\sigma_{\mathrm{j}}\right)}\right]^{\frac{1}{\left(1-\sigma_{\mathrm{j}}\right)}}$$

$$BI_{j,t} = \delta_j^D Qdom_{j,t} \left(\frac{Pdom_{j,t}}{Pbi_{j,t}}\right)^{\sigma_D}$$

$$VA_{j,t} = \left(1 - \delta_j^D\right) Qdom_{j,t} \left(\frac{Pdom_{j,t}}{Pva_{j,t}}\right)^{\sigma_D}$$

$$Pbi_{j,t} = \sum_i \left(\delta_{i,j} P_{j,t}^{\left(1-\sigma_{BI}\right)}\right)^{\frac{1}{1-\sigma_{BI}}}$$

$$bi_{i,j,t} = \delta_{i,j}^{BI} Qdom_{j,t} \left(\frac{Pbi_{j,t}}{P_i}\right)^{\sigma_{BI}}$$

$$Pva_{j,t} = \left(\delta_j^v \cdot {PL_t}^{1-\sigma_v} + \left(1 - \delta_j^v\right) \cdot {PK_t}^{1-\sigma_v}\right)^{\frac{1}{1-\sigma_v}}$$

$$L_{j,t}^d = \delta_j^L VA_{j,t} \left(\frac{Pva_{j,t}}{PL_t}\right)^{\sigma_v}$$

$$K_{j,t}^d = \left(1 - \delta_j^L\right) VA_{j,t} \left(\frac{Pva_{j,t}}{PK_t}\right)^{\sigma_v}$$

$$Q_{j,t} = \left(\sum_i d_{j,i}^q q_{i,j,t}\right)^{\frac{1}{1-\sigma_q}}$$

$$Pq_{dom,i,t} = \left(\sum_j d_{i,j}^q {P_{dom,j,t}}^{\left(1-\sigma_q\right)}\right)^{\frac{1}{1-\sigma_q}}$$

$$M_{i,t} = \left(1 - \delta_i^M\right) Q_{i,t} \left(\frac{P_{i,t}}{Pm_{i,t}}\right)^{\sigma_{Qdom}}$$

$$Pm_{i,t} = pmw_{i,t}(1 + \pi_t)/exr_t$$

$$YF_t^{households} = L_t^{households} pl_t + K_t^{households} rk_t$$

$$YF_t^{firms} = Ks_t^{firms} rk_t$$

$$Y_t^{priv} = YF_t^{priv}(1 - \sum_{inc} ty_{inc}^{priv} - \sum_{tras} tr_{tras}^{priv}) + \sum_{priv}\sum_{tras} tr_{tras}^{priv} YF_t^{priv} + \sum_{g} Tr_t^{g} + Tr_{row}^{t}$$

$$Y^{priv} = \sum_t Y_t^{priv} \left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{priv} PK_{tfirst} - KS_T^{priv} PK_T \left(\frac{1}{1+r}\right)^T$$

$$PK_t = (1-\tau)PK_{t+1} + rk_t$$

$$I_{tfirst} = \frac{(\tau + g)\sum_{priv} Ks_{tfirst}^{priv} rk_{tfirst}}{\tau + r}$$

$$\tau = \frac{g\sum_{priv} Ks_{tfirst}^{priv} rk_{tfirst} - r\, I_{tfirst}}{I_{tfirst} - Ks_{tfirst}^{priv}\, rk_{tfirst}}$$

$$YF_t^{gov} = Ks_t^{gov} rk_t + \lambda_{act}^{gov} \sum_{act}\sum_{j}\left(ta_j^{act} P_{dom,j,t} Q_{j,t}\right) + \lambda_{out}^{gov} \sum_{out}\sum_{i}\left(tq_i^{out} P_{i,t} Q_{i,t}\right) + \sum_{priv}\sum_{inc} ty_{inc}^{priv} YF_t^{priv}$$

$$Y_t^{gov} = YF_t^{gov} - \sum_{gov} Tr^{gov} - Tr^{row}$$

$$Y^{gov} = \sum_t Y_t^{gov} \left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{gov} PK_{tfirst} - KS_T^{gov} PK_T \left(\frac{1}{1+r}\right)^T$$

$$maxU^{priv} = \sum_{t=0}^{T}\left[\left(\frac{1}{1+\rho}\right)^t C_t^{priv}\right]$$

$$C_t^{priv} = \sum_i c_{i,t}^{priv}$$

s.t.

$$\sum_{priv} C_t^{priv} = \sum_i Q_{i,t} - \sum_i\sum_j bi_{i,j,t} - \sum_{gov} G_g - \sum_i I_{i,t} - \sum_i e_{i,t}$$

$$KS_{t+1} = KS_t(1-\tau) + I_t$$

$$\sum_t \left(\frac{1}{1+\rho}\right)^t C_t^{priv} Pc_t^{priv} = Y^{priv}$$

$$Pu^{priv} = \prod_t \left(\frac{Pc_t^{priv}}{1+r}\right)^{alpha(t)}$$

$$alpha(t) = \frac{\left(\frac{1+g}{1+r}\right)^{t-1}}{\sum_t \left(\frac{1+g}{1+r}\right)^{t-1}}$$

$$C_t^{priv} = \frac{U^{priv}}{1+r}\left(\frac{Pu_{priv}}{Pc_t^{priv}(1+r)}\right)^{alpha(t)}$$

$$Pc_t = \left(\sum_i \delta_i^C \, P_{i,t}^{(1-\sigma_C)}\right)^{\frac{1}{1-\sigma_C}}$$

$$c_{i,t}^{priv} = \delta_i^C U^{priv}\left(\frac{Pc_t}{P_{i,t}}\right)^{\sigma_C}$$

$$U^{gov} = \sum_t \left(G_t^{gov} + def_t^{gov}\right)$$

$$P_t^I = \left(\sum_i \delta_i^I \, P_{i,t}^{(1-\sigma_I)}\right)^{\frac{1}{1-\sigma_I}}$$

$$I_{i,t} = \delta_i^I \, I_t \left(\frac{P_t^I}{P_{i,t}}\right)^{\sigma_I}$$

$$e_{i,t} = \delta_i^E Y_{tfirst}^{row}(1+g^{row})^t \left(\frac{pmw_i(1+\pi_t)/exr_t}{P_{i,t}}\right)^{\sigma_E}$$

$$Q_{i,t} = \sum_j bi_{i,j,t} + \sum_{hh} C_{i,t}^{hh} + \sum_{pub} G_{i,t}^{pub} + I_{i,t} + E_{i,t}^{row}$$

$$\sum_i I_{i,t} = \sum_{is} S_t^{is}$$

$$\sum_i M_{i,t} + \sum_{priv} tr^{priv,row} YF_t^{priv} + \sum_{gov} Tr_t^{gov,row} + L^{row} PL_t + K^{row} PK_t = \sum_i e_{i,t} + \sum_{row} Tr^{priv,row} + \sum_{row} Tr_t^{gov,row} + S_t^{row}$$

$$L_t^d = L_t^s$$

$$K_t^d = K_t^s$$

$$KS_{t+1} = (1-\tau)KS_t + I_t$$

$$\frac{I_T}{I_{T-1}} = \frac{S_T}{S_{T-1}}$$

Appendix 6. Employment percent change – simulation 4

Simulation 4 - Employment percentage change from benchmark

Name	t1	t2	t3	t4	t5
Farms	-0.027	-0.027	-0.027	-0.027	-0.026
Forestry, fishing, and related activities	0.004	0.005	0.005	0.005	0.005
Oil and gas extraction	0.005	0.005	0.005	0.005	0.006
Mining, except oil and gas	-0.004	-0.003	-0.003	-0.003	-0.003
Support activities for mining	0.011	0.011	0.011	0.011	0.011
Utilities	-0.005	-0.005	-0.005	-0.005	-0.005
Construction	0.006	0.006	0.006	0.006	0.006
Wood products	0.004	0.004	0.004	0.004	0.004
Nonmetallic mineral products	-0.003	-0.002	-0.002	-0.002	-0.002
Primary metals	-0.004	-0.003	-0.003	-0.003	-0.003
Fabricated metal products	0.004	0.004	0.004	0.005	0.005
Machinery	0.006	0.006	0.006	0.007	0.007
Computer and electronic products	0.006	0.006	0.006	0.007	0.007
Electrical equipment, appliances, and components	0.004	0.004	0.005	0.005	0.005
Motor vehicles, bodies and trailers, and parts	0.004	0.004	0.004	0.004	0.005
Other transportation equipment	0.003	0.003	0.004	0.004	0.004
Furniture and related products	0.003	0.003	0.004	0.004	0.004
Miscellaneous manufacturing	0.003	0.003	0.003	0.004	0.004
Food and beverage and tobacco products	-0.003	-0.003	-0.003	-0.003	-0.003
Textile mills and textile product mills	0.000	0.000	0.000	0.001	0.001
Apparel and leather and allied products	0.001	0.001	0.002	0.002	0.002
Paper products	0.001	0.001	0.002	0.002	0.002
Printing and related support activities	0.002	0.002	0.002	0.002	0.003
Petroleum and coal products	-0.028	-0.028	-0.028	-0.028	-0.027
Chemical products	0.001	0.001	0.001	0.002	0.002
Plastics and rubber products	0.003	0.003	0.003	0.003	0.003
Wholesale trade	0.003	0.004	0.004	0.004	0.004
Motor vehicle and parts dealers	0.002	0.002	0.002	0.002	0.002
Food and beverage stores	0.004	0.004	0.004	0.004	0.005
General merchandise stores	0.004	0.004	0.004	0.004	0.004
Other retail	0.001	0.001	0.001	0.002	0.002
Air transportation	-0.019	-0.019	-0.018	-0.018	-0.017
Rail transportation	0.001	0.001	0.001	0.001	0.002
Water transportation	-0.001	-0.001	-0.001	-0.001	-0.001
Truck transportation	-0.031	-0.030	-0.030	-0.030	-0.030
Transit and ground passenger transportation	0.000	0.000	0.000	0.000	0.000
Pipeline transportation	-0.009	-0.009	-0.008	-0.008	-0.007
Other transportation and support activities	-0.065	-0.065	-0.064	-0.064	-0.064
Warehousing and storage	-0.001	0.000	0.000	0.000	0.000
Publishing industries, except internet (includes software)	0.006	0.006	0.006	0.006	0.006
Motion picture and sound recording industries	0.004	0.005	0.005	0.005	0.005
Broadcasting and telecommunications	0.004	0.004	0.004	0.004	0.005
Data processing, internet publishing, and other information services	0.005	0.005	0.005	0.006	0.006
Federal Reserve banks, credit intermediation, and related activities	0.002	0.003	0.003	0.003	0.003
Securities, commodity contracts, and investments	0.003	0.003	0.003	0.003	0.003
Insurance carriers and related activities	0.004	0.004	0.004	0.004	0.004
Funds, trusts, and other financial vehicles	0.002	0.002	0.002	0.002	0.002
Housing	-0.011	-0.011	-0.011	-0.011	-0.011
Other real estate	0.000	0.000	0.000	0.000	0.000
Rental and leasing services and lessors of intangible assets	0.004	0.005	0.005	0.005	0.006
Legal services	0.005	0.005	0.005	0.005	0.005
Computer systems design and related services	0.007	0.007	0.007	0.007	0.008
Miscellaneous professional, scientific, and technical services	0.005	0.005	0.005	0.006	0.006
Management of companies and enterprises	0.007	0.007	0.007	0.007	0.007
Administrative and support services	0.006	0.006	0.006	0.006	0.006
Waste management and remediation services	0.004	0.004	0.004	0.004	0.004
Educational services	0.002	0.002	0.002	0.002	0.002
Ambulatory health care services	0.002	0.002	0.002	0.002	0.002
Hospitals	0.002	0.002	0.002	0.002	0.002
Nursing and residential care facilities	0.002	0.002	0.002	0.002	0.002
Social assistance	0.002	0.002	0.002	0.002	0.002
Performing arts, spectator sports, museums, and related activities	0.004	0.004	0.004	0.004	0.004
Amusements, gambling, and recreation industries	0.003	0.003	0.003	0.003	0.003
Accommodation	0.002	0.002	0.002	0.002	0.002
Food services and drinking places	0.001	0.001	0.001	0.001	0.001
Other services, except government	0.004	0.004	0.004	0.004	0.004
Federal general government (defense)	0.000	0.000	0.000	0.000	0.000
Federal general government (nondefense)	0.000	0.000	0.000	0.000	0.000
Federal government enterprises	0.005	0.005	0.005	0.005	0.005
State and local general government	0.000	0.000	0.000	0.000	0.000
State and local government enterprises	-0.003	-0.003	-0.003	-0.003	-0.002

Appendix 7. Sensitivity analysis – Chapter 2

Sensitivity analysis can be used to quantify the magnitude of the model's reliance on the parameters initially assumed, i.e. how much the model is sensitive to the change of these parameters.

Sensitivity analysis is performed on the exogenous parameter of substitution elasticity between capital and labour, which in this paper is set to 0.3194, according to literature findings (Van Der Werf, 2008). The choice to test the response of the model to changes in this parameter is linked to the purpose of the paper to highlight changes in economic growth, employment and GHG emissions, which are linked to value added formation.

In order to carry out the sensitivity analysis, the methodology of De Pauw and Vanrolleghem (2006) was followed, as regards the local sensitivity analysis tested in accordance with the final difference method, which can be explained as follows:

$$\frac{\partial y_i}{\partial \sigma_v} = \lim_{\Delta\sigma_v \to 0} \frac{y_i(t, \sigma_v + \Delta\sigma_v) - y_i(t, \sigma_v)}{\Delta\sigma_v}$$

where y_i represents the vector of the interest variables of which we want to test the sensitivity, whereas σ_v represents the elasticity of capital and labour.

The analysis is conducted for simulation 4, the simulation of interest for the conclusions of the paper. The results are shown in Table 16. As it can be seen, within the σ_v fluctuation band variations in the response of the variables occur, but they are consistent with the elasticity changes and maintain the same sign.

Table 16. Simulation 4 - sensitivity analysis (percentage change from benchmark, in real terms)

$\sigma_v - (\sigma_v/2)$					
	t_1	t_2	t_3	t_4	t_5
Real GDP	0.111	0.107	0.103	0.098	0.092
Employment	0.101	0.108	0.115	0.121	0.128
GHG	-2.277	-2.265	-2.254	-2.242	-2.231
σ_v					
	t_1	t_2	t_3	t_4	t_5
Real GDP	0.147	0.145	0.141	0.137	0.133
Employment	0.142	0.150	0.157	0.165	0.172
GHG	-2.268	-2.253	-2.239	-2.226	-2.212
$\sigma_v + (\sigma_v/2)$					
	t_1	t_2	t_3	t_4	t_5
Real GDP	0.204	0.201	0.198	0.194	0.189
Employment	0.202	0.209	0.216	0.223	0.229
GHG	-2.228	-2.213	-2.198	-2.184	-2.170

Source: Author's elaboration on dynamic model's results.

CHAPTER 3 - SUPPORTS TO FIRMS' LIQUIDITY

3.1. The need for Government intervention

What the 2007 financial crisis and the actual pandemic COVID-19 crisis have in common is, among the main aspects, the emergence of a serious liquidity problem for households and businesses.

The 2007 financial crisis was set at a double level: on the one hand, macroeconomic policies with an effect on liquidity, on the other hand, a regulatory framework which, rather than contributing to a 'defensive' line, was at the root of the crisis (Blundell-Wignall, Atkinson, Hoon Lee, 2008). At that time, the OECD recommended that policy action should focus on addressing immediate problems of stability, but without forgetting the need for a thorough strategy to mitigate the impact of the recession and enable the global economy to return to a sustained growth trajectory. This strategy should have included productivity-enhancing reforms in order to support growth in the medium to long term. Given the importance and scale of the policy interventions implemented by Governments, the OECD called for them to be well designed and implemented by governments.

Today, after the outbreak of the COVID-19 crisis, international bodies (OECD, IMF) as well as the G20 and the European Commission have started to reflect on the possible recovery strategy to bring the world economy out of the post-epidemic crisis, caused by the need for most Countries around the world to impose health restrictions that have cut production and trade in goods and services. These supply-side problems have been compounded by the collapse in household and corporate spending and investment capacities caused by lockdown, concerns about prospective labour and income, worsening financial conditions, and uncertainty about the future course of the crisis that has pervasive effects on economic and social spheres.

Marco Buti, Head of Cabinet of Commissioner Gentiloni, stressed[15] that the response to the crisis should reflect its very characteristics: 1) the shock, as well as the subsequent recovery, is likely to be differentiated by Country; 2) the crisis will have a lasting impact on economic growth; 3) the risk is that this situation will exacerbate the long-standing decline in potential growth, combined with the new challenges Europe is facing (climate and technological change, digitalisation, inequalities, increased market concentration).

Europe has immediately deployed a number of instruments in response to the emergency - including the activation of General Escape Clause and the SURE - alongside the Next Generation EU strategy. At the level of individual States, Governments have sought to address the economic effects of the spread of COVID-19 in 2020 through support packages. As of 1 May 2020, these packages amounted to EUR 1,900 billion in the EU Member States and the United Kingdom[16]. Of this amount, EUR 996 billion were allocated in Germany (29% of GDP), 324 billion in France (13.4% of GDP), 302 billion in Italy (17% of GDP), 54 in Belgium (11% of GDP) and 27 billion in Spain (2.2% of GDP). Disparity in support volumes across Member States indeed reflect national policy preferences but is mainly affected by the available fiscal headroom. The total financial commitment of these Countries amounts to 89.6% of the overall package.

The measures contained in these packages concerned non-repayable aid, the granting of loans or guarantees for loans granted by financial intermediaries, in order to cover liquidity losses. In addition, with specific reference to employment, governments have sought to limit dismissals by taking on the cost of hours not worked and by making transfers - partially compensating - to the workers concerned as well as to firms, through the reduction of the tax wedge.

[15]Conference '*Policy Toolkit For A Better Europe*', 9 October 2020.

[16]This figure has been calculated by the European Commission and only includes COVID-19 aid measures approved by the Commission, based on the State aid Temporary Framework and Articles 107(2)(b) and (3)(b) TFEU. 1)). This does not include support that Countries may have implemented without needing Commission approval. See: Commission Staff Working Document — COM (2020) 456 FINAL.

After the 2007 financial crisis the major problem was to address a lack of regulation that caused the liquidity shortages. In the recent crisis, on the other side, problems originate from lockdown that curbed production and consumption. Nevertheless, what the 2007 crises have taught is that to ensure the success of the reform effort it is necessary that policy instruments are constantly updated to meet the new challenges, and that greater policy analysis is promoted to ensure that the instruments implemented by Governments takes account of the specific circumstances faced by a Country. This require an approach that is general and disaggregated. General Equilibrium models in this context are widely applied, and different models have been proposed in the literature to analyse economic effects from different angles (Carrasco et al., 2013).

Against this background, the aim of this work is to assess the impact of the policies put in place by the Government to support businesses following an exogenous shock. The approach of a general economic equilibrium model makes it possible to assess the economic impacts of a shock, without excluding the effects on other sectors of the economy (Verikios, 2016 e 2020).

The main business data, taken from the ORBIS database, gives us the possibility to estimate the initial situation at industry level in terms of liquidity margins. The more margins are larger, the more industries are resilient to exogenous shocks that, translating into lower revenues, put pressure on liquidity and solvency.

The second phase of the work involves assessing the effectiveness of the policies implemented by the government and which are likely to improve the liquidity of businesses: reduction in employers' social security contributions, aimed at reducing the tax wedge, which has an impact on labour costs, as well as the increase in guarantees granted through the Guarantee Fund for SMEs, which are intended to make it easier to obtain credit and, therefore, to affect the liquidity component linked to bank credit (see paragraph 3.5). In the final phase of the work, the results of the financial dynamic CGE model resulting from the application of the policies implemented by the Government are compared with the initial liquidity conditions, in order to assess the scale of the intervention implemented (paragraph 3.6).

The effect on liquidity relates to the ability of the firm to withstand a reduction in turnover through the buffer of cash and cash reserves or, alternatively, its current assets net of current liabilities. The pressure on solvency relates to the company's ability to cope with the reduction in turnover through its own resources buffer (net worth). Firms reaching negative liquidity are defined as illiquid. Some of the illiquid companies may also become insolvent, when the economic loss cancels net worth and consequently requires compensatory capital injections by shareholders, assuming that the fixed assets cannot be easily disposed of.

The effects of insolvency may be listed as follows: *i)* redundancies in insolvent firms lead to an increase in unemployment with deterioration in human capital; *ii)* there may be a loss of tangible and intangible capital (partial and total, respectively) in the case of alternative use after insolvency; *iii)* there may be the bankruptcy of creditor companies whose capital has been eroded by the initial insolvency. These factors lead to second-round effects on investment, employment, and GDP. Rising unemployment worsens the levels of domestic demand, in particular for services in direct contact with customers, manufacturing and agriculture. These sectors have a high share of low-skilled and temporary workers employed in tasks which are unlikely to be carried out remotely. Moreover, there is also a reduction in labour supply among the youngest, the oldest and the most vulnerable. Reductions in labour demand and supply have a stronger impact on lower-income households, where low-skilled and temporary workers are concentrated.

A recent study by Schivardi and Romano (2000), basing the analysis on Italian business balance sheets and sales forecasts, estimated companies that would become illiquid as the COVID-19 crisis materialises, making a monthly estimate from March 2020 until the end of the year. The analysis is applied to around 650,000 firms, which account for three quarters of private sector output. In the baseline scenario, the lockdown is active from mid-March to early May for all non-essential sectors. It is then assumed that economic activity will gradually recover at different speeds depending on sectoral characteristics. Moreover, all cash outflows and tax payments are set to zero, considering the debt moratorium and the deferral of tax payments set by the

Government. The results of this paper show that at the height of the crisis, around 200,000 companies, employing around 3.3 million workers, are experiencing liquidity problems. At the same time, however, the liquidity shortage is not huge, amounting to less than 4% of GDP, as the contraction in sales is accompanied by a reduction in costs, limiting the negative effects on cash flow. Thanks to the measures put in place by the Government to increase guarantees for the granting of loans and, assuming that all companies have access to all the instruments put in place, the authors conclude that almost all companies are able to recover their liquidity problems.

The method used by Schivardi and Romano (2000) was taken up by the Bank of Italy in the 1st Financial Stability Report 2020, the OECD (OECD2020) and the European Commission (EU Commission Staff Working Document, 2020), to mention the most relevant, with comparable results.

In particular, in the Commission study, the effects of the COVID-19 shock on companies' balance sheets were assessed for the European Union on the basis of company level balance sheet data (profit and loss account and balance sheet). The Commission document identified two scenarios: i) a 'base' one, which takes into account Spring Forecasts; ii) a 'risky' one, which adds possible penalties due to regulatory restrictions on economic activity. The shock leads to a deterioration in firms' leverage, as losses reduce liquidity on the asset side and equity on the liability side. Increased leverage also leads to a lower ability to borrow, but, on the other hand, firms need to recover the lower liquidity due to losses and reduce leverage with higher indebtedness. The simulations were based on the ORBIS Database Bureau van Dijk (BvD), from which companies with already negative net current assets and up to 19 employees were removed. The simulations carried out by the European Commission aim to assess the extent to which the policies of reducing labour costs and deferring cash outflows affect the additional liquidity needs of fourth quarter 2020 as a result of the losses accumulated in the period March-December. The net worth losses of the 'Base' scenario amount to EUR 720 billion, which becomes EUR 1,200 billion in the 'risky' scenario. The loss of liquidity in the absence of policies amounts to EUR 825

billion. After allowing absorption through the cash buffer and working capital buffer, the remaining losses would amount to EUR 450 billion and EUR 350 billion, respectively. The redundancy fund (CIG) would reduce the liquidity needs to EUR 725 billion, which would become around EUR 600 billion in the event of deferral of tax and interest payments. Simulations show that around 25-35 percent of firms would experience, in the 'Base' scenario, insufficient working capital and liquidity buffers, respectively. In the 'risky' scenario, the above percentages become respectively 35 (+10 p.p.) and 50 (+15 p.p.) per cent. In absolute terms, this implies that between 180,000/260,000 firms (with 25/35 million employees) could be involved in the 'Base' and 'Risky' scenarios with additional liquidity needs of between EUR 350-500 billion and EUR 650/900 billion, respectively.

Unlike previous works, in the present work a dynamic financial CGE model will be used to assess policies aimed at affecting the liquidity of companies, focusing on decontribution and public guarantees for granting loans. This will also make it possible to assess changes in the financial assets and liabilities of the Institutional Sectors.

The main characteristics of the Financial Social Accounting Matrix (FSAM) and of the dynamic financial CGE model calibrated on the FSAM will be set out in section 3.2; section 3.3 deals with the liquidity position by industry; sections 3.4 and 3.5 assess the effects of government policies to support business liquidity; sections 3.6 deals with comparing results of the CGE model with the initial liquidity position as detected in section 3.3 from Orbis database. Finally, section 3.7 draws some conclusions.

3.2. A dynamic CGE Model integrated with financial instruments

The Dynamic Financial Computable General Equilibrium (FDCGE) model calibrated on the Italian Financial Social Accounting Matrix (FSAM) is the set of analysis instrument functional

to providing a detailed description of the real economy integrated with the financial flows for a given Country.

The Italian FSAM has been built with the aim of providing a complete and detailed database both considering the economic flows related to the circular flow of income of the institutional sectors involved in the economy, and considering the financial flows related to the financial instruments of the same sectors. During a crisis such as that of 2007 or the current crisis, the government injects into the economic system resources from the sale of public debt securities and/or from European funds, in order to stabilise the confidence of economic operators whose expectations, when economic or financial difficulties emerge, become uncertain thus reducing their propensity to buy in the goods market and to invest in the financial markets (Ahmed I., Socci C., Severini F., Yasser Q. R., Pretaroli R.,2018).

The FSAM built for this work includes 63 products and 63 activities and was transformed into symmetrical, product by product. The components of value added are 4: Compensation of employees, mixed income, gross operating surplus and net indirect taxes. There are 4 institutional sectors: Firms, Households, Government and the Rest of the World. To each institutional sector, flows from the capital account and financial assets and liabilities are added, so net saving is a balance of flows of assets and liabilities and, together with capital transfers, returns to the real sector to feed non-financial flows (United Nations, 2008). Institutional sectors show net lending or net borrowing, depending on whether they are in surplus or deficit, with which they enter the financial market. Thus, the financial accounts record changes in lending or borrowing, changing financial assets and liabilities. The FSAM considers the flows of 33 financial instruments (see Appendix 8) based on financial accounts data published by the Bank of Italy. The structure of the FSAM is synthetised in Table 17.

Table 17 - The structure of interactions among agents (a)

<table>
<tr><td></td><td></td><td>Products (1, …, i)</td><td>Primary Factors (1, …., f)</td><td>Taxes on Commodities and VA</td><td>Taxes on Income</td><td colspan="4">Institutional Sectors Current Account</td><td>Institutional Sectors Capital Formation (FF, HH, Gov, Row)</td><td>Financial Accounts (i+1, …., z)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>FF</td><td>HH</td><td>GOV</td><td>RoW</td><td></td><td></td></tr>
<tr><td>Products (1, …, i)</td><td></td><td>Intermediate consumption</td><td></td><td></td><td></td><td></td><td colspan="2">Private and Public Consumption</td><td>Exports</td><td>Investments</td><td></td></tr>
<tr><td>Primary Factors (1, …, f)</td><td></td><td>Value added by commodity</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Taxes on products and VA (1, …, o)</td><td></td><td>Taxes on products less subsidies</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Institutional Sectors Current Account</td><td>FF</td><td></td><td rowspan="4">Value added To Institutional Sectors</td><td></td><td></td><td colspan="4" rowspan="3">Current Transfers</td><td></td><td></td></tr>
<tr><td>HH</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>GOV</td><td></td><td>Revenue from taxes on products less subsidies</td><td>Revenue from Taxes on income</td><td></td><td></td><td></td></tr>
<tr><td>RoW</td><td>Imports</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Taxes on Income</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Income taxes paid</td><td></td><td></td></tr>
<tr><td>Institutional Sectors Capital Formation (FF, HH, Gov, Row)</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Savings by institutional sector</td><td>Capital Transfers by institutional sector</td><td>Financial liabilities by institutional sector</td></tr>
<tr><td>Financial Accounts (FF, HH, Gov, Row)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Financial assets by institutional sector</td><td></td></tr>
</table>

(a) Source: Author's elaboration.

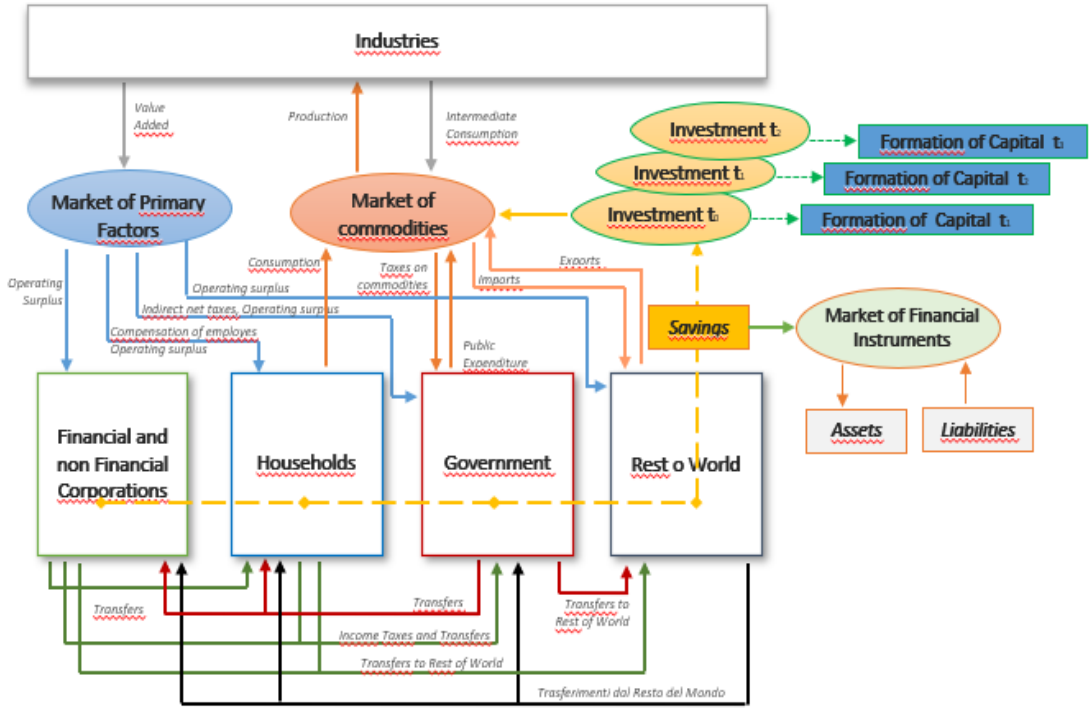
The FDCGE built for this work analysis is a system of simultaneous non-linear equation following the Ramsey analysis of optimal economic growth under certainty (Lau, Pahlke, Rutheford, 2000), and solves a recursive optimization problem, where the complete specification of quantities and prices is determined by the equilibrium between demand and supply in goods, factor and financial markets as well as by the zero-profit condition in all the markets.

According to structuralist models, FDCGE considers that the structural characteristics of the economy are fundamental to its behaviour; structural factors include the distribution of income and wealth, the type and degree of specialisation in foreign trade, the density of production chains, the functioning of financial intermediaries. Indeed, basing the analysis on institutions and economic policy is the main feature of the structuralist approach (Taylor, 1990).

The multisectoral aspect allows to emphasise the behaviour of agents operating in the economic system involved in production processes, income generation, income distribution and the formation of final demand (Prasad et al., 2004; Goodhart et al., 2004, 2005). Rigidity and imperfections in the behaviour of certain operators and markets, such as the Government and primary factor markets are also included.

The financial DCGE also incorporates the behaviour of institutional sectors as regards the choice between consumption and savings, and in the allocation of savings among financial instruments in response to their price fluctuations, therefore considering a breakdown of savings. Moreover, the Financial DCGE incorporates the dynamic aspect as a sequence of single period of static equilibria linked each other by the capital accumulation condition (Lau et al. 2002) (see Figure 12).

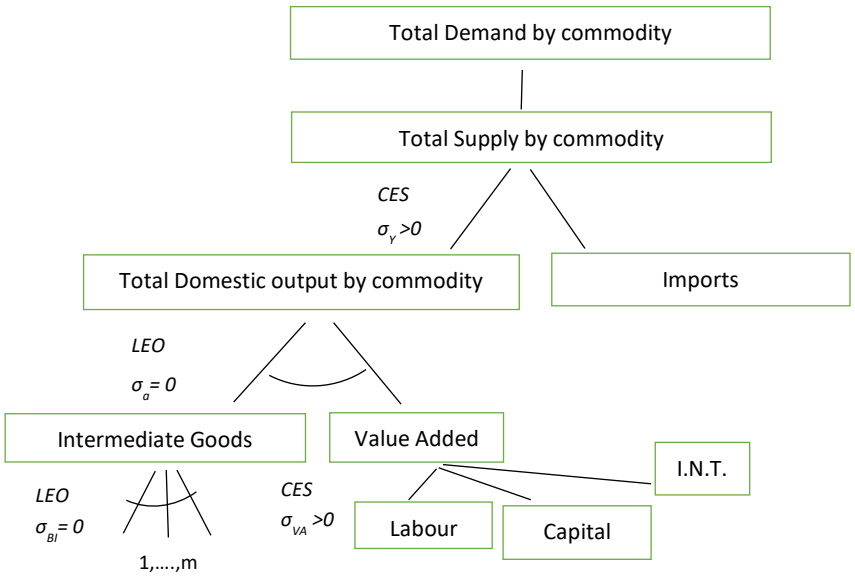
Figure 12 – Scheme of the Dynamic Computable General Equilibrium Model with Financial Flows



Source: Author's elaboration.

On the supply side, production is carried out by the industries, which maximize their profit function under the constraint represented by price and production technology; it is modelled through a nested production function, where the value of output by commodity at time *t* results from the combination through a nested production function of intermediate goods, primary factors, taxes and imports (Armington, 1969), according to Figure 13:

Figure 13 - Production function by commodity



Source: Author's elaboration.

Then, it is possible to capture the substitutability and complementarity between primary factors, between intermediate goods within each production process, and the CES function allows to easily switch to other functional forms (Leontief, Cobb-Douglas). Total production, i.e. total supply of the economic system, is used by the different demand components: intermediate consumption, final consumption, public expenditure, gross investment and exports to the rest of the world.

Starting from the top nest, the total output by commodity (in this chapter a symmetric product by product SAM is used) is obtained combining domestic production and imports using Armington's imperfect substitutability between domestic and imported goods (Armington, 1969).

Domestic production (Qdom) is achieved using the combination of intermediate inputs (BI) and value added (VA), assuming a Leontief production function:

Domestic production ($Qdom_{j,t}$) per product j[17] and time t, is obtained through the combination of intermediate goods ($BI_{j,t}$) and value added ($VA_{j,t}$) according to the following function:

$$Qdom_{j,t} = \left(d_j^D BI_{j,t}^{\rho_D} + \left(1 - d_j^D\right) VA_{j,t}^{\rho_D}\right)^{\frac{1}{\rho_D}} \quad [41]$$

where d_j^D represents the share of intermediate goods ($BI_{j,t}$) on output, $Va_{j,t}$ is the value added. The dual cost function can then be written in the form

$$Pdom_{j,t}\left(1 - Tax_{j,t}^{act}\right) = \left(\sum_i {\delta_{i,j}}^D Pbi_{j,t}^{\left(1-\sigma_j\right)} + \sum_i (1 - {\delta_{i,j}}^D) Pva_{j,t}^{\left(1-\sigma_j\right)}\right)^{\frac{1}{\left(1-\sigma_j\right)}} \quad [42]$$

Where $Pdom_{j,t}$ is the price net of taxes on activities ($Tax_{j,t}^{act}$); σ_j represents the elasticity of substitution between the intermediate goods and the Value Added and it depends from ρ, the exponent of the function (1): $\sigma_j = \frac{1}{1-\rho} \Leftrightarrow \rho = \frac{\sigma_j - 1}{\sigma_j}$

The value of σ_j is set to zero, indicating that the aggregating function follows a Leontief production function. Pbi_j and Pva_j represent the respective prices.

In the second stage, formation of intermediate goods prices is described:

$$Pbi_{j,t} = \sum_i \left(\delta_{i,j} P_{j,t}^{\left(1-\sigma_{BI}\right)}\right)^{1/(1-\sigma_{BI})} \quad [43]$$

where the average price is obtained by combining the price of the j products ($P_{j,t}$) with the fixed coefficients $\delta_{i,j}$ calibrated on the SAM. The elasticity of substitution among intermediate goods (σ_{BI}) is zero (Leontief production function).

[17] For notation clarity, subscripts i and j are used to distinguish rows and columns, although the intersectoral table is symmetric, product by product.

The Value Added is obtained from the combination of productive factors of capital and labour, and the corresponding prices are obtained by matching demand and offer.

$$Pva_j^t = \left[\delta_j^v \cdot {pl_t}^{(1-\sigma_v)} + \left(1-\delta_j^v\right) \cdot {rk_t}^{(1-\sigma_v)}\right]^{\frac{1}{1-\sigma_v}} \quad [44]$$

where δ_j^v represents the labour share on total factor input; σ_v represents the substitution elasticity between capital and labour, which is equal to 0.5218 for Italy, following Van der Werf (2008); pl_t and rk_t are prices of labour and capital, respectively.

As for the demand formation, private institutional sectors maximise their intertemporal choices in terms of consumption, under the constraint of their global income. It is assumed that the decision-making choices for the institutional sectors are different. In the model, the behaviour of agents is based on adaptive expectations (Thurlow J., 2008), the prices and quantities that maximise the producer's profits and the utility of the consumer in each period are determined by the consumer's intertemporal optimisation. Households (firms do not consume and their income is totally saved) make the present and future choices between consumption and savings through the maximisation of the intertemporal utility function under the budget constraint based on actualized disposable income for the entire period. The process can be summarised as follows (the superscript *hh* indicates households):

$$maxU^{hh} = \sum_{t=0}^{T}\left[\left(\frac{1}{1+\rho}\right)^t \sum_i C_{i,t}^{hh}\right] \quad [45]$$

subject to the following constraints:

- $$\sum_i C_{i,t}^{hh} = \sum_i Q_{i,t} - \left[\sum_i \sum_j b_{i,j,t} + \sum_i \sum_g G_{i,t}^{gov} + \sum_i \sum_{is} I_{i,t}^{is} + \sum_i e_{i,t}\right] \quad [46]$$

  in which total consumption $\sum_i C_{i,t}^{hh}$ equals total production $\sum_i Q_i^t$ less the intermediate consumption $\sum_i \sum_j b_{i,j}^t$, public expenditure $\sum_i \sum_g G_{i,t}^{gov}$, investment $\sum_i \sum_{is} I_{i,t}^{is}$ and exports.

- $$\sum_i C_{i,hh,t} = Y_{hh,t} - S_{hh,t} \quad [47]$$

where total consumption $\sum_i C_{i,hh,t}$ must equal the difference between disposable income $Y_{is,t}$ (see equation 54) and savings $S_{hh,t}$.

While considering the process of demand formation, it is essential to keep in mind the closure of the model, consisting into a set of equations related to: *i)* the Government balance, with endogenous savings, obtained as the difference between disposable income and consumption; *ii)*the Rest of the world balance; *iii)* Savings-Investments balance, where the gross fixed capital formation is the result of the sum of savings from the institutional sectors.

As regards equality between savings and investment, in the financial model the balance of each operator considers both the real and financial markets, following Maldonado W.L., Tourinho O.A.F., Valli M. (2008), and is characterised by the fact that each operator's savings can be used to purchase both real and financial assets (in this case it is transferred to other operators). Therefore, at the aggregate level, changes in assets ($\Delta Afin_t$) and financial liabilities ($\Delta Lfin_t$) in period *t* must be consistent with the availability of savings and investment decisions:

$$\sum_{is} S_t^{is} + \sum_{is} \Delta Lfin_t^{is} = \sum_i I_{i,t} + \sum_{is} \Delta Afin_t^{is} \quad [48]$$

Quantities and prices of financial assets and liabilities are determined by the demand-offer balance, as in the goods markets:

$$PLfin_{i,t} = \sum_j \left(\delta_{i,j}^{fin} P_{j,t}^{(1-\sigma_{fin})}\right)^{\frac{1}{1-\sigma_{fin}}} \quad [49]$$

$$PAfin_{j,t} = \sum_i \left(\delta_{i,j}^{fin} P_{j,t}^{(1-\sigma_{fin})}\right)^{\frac{1}{1-\sigma_{fin}}} \quad [50]$$

$$Lfin_{i,t} = \delta_i^{fin} Qfin_{i,t} \left(\frac{Pfin_{i,t}}{P_{i,t}}\right)^{\sigma_{fin}} \quad [51]$$

$$Afin_{j,t} = \delta_j^{fin} Qfin_{j,t} \left(\frac{Pfin_{j,t}}{P_{i,t}}\right)^{\sigma_{fin}} \quad [52]$$

The amount of demand by both Federal Government and State and local Governments is fixed in real terms and the variations in public disposable income over each period are set aside; in addition, governments' expenditure may exceed disposable income by generating deficits, which means that the utility function of the governments U^{gov} is the sum of public expenditure

$\sum_t G_t^{gov}$ and deficit def_g^t, and the deficit can be financed on the financial market by issuing public bonds:

$$U^{gov} = \sum_t \left(G_t^{gov} + def_t^{gov}\right) \quad [53]$$

The disposable income for private institutional sectors in each period is calculated as follows:

$$Y_t^{priv} = YF_t^{priv}(1 - \sum_{inc} ty_{inc}^{priv} - \sum_{tras} tr_{tras}^{priv}) + \sum_{priv} \sum_{tras} tr_{tras}^{priv} YF_t^{priv} + \sum_g Tr_t^g + Tr_t^{row} \quad [54]$$

Where:

- income from primary factors YF_t^{priv} in each period is given by the sum of labour income $L_t^{priv} pl_t$, capital income $K_t^{priv} rk_t$ as well as financial income $\sum_j Lfin_{j,t}^{priv} PLfin_{j,t}$:

$$YF_t^{priv} = L_t^{priv} pl_t + K_t^{priv} rk_t + \sum_j Lfin_{j,t}^{priv} PLfin_{j,t} \quad [55]$$

- income from primary factors is net of income taxes $\sum_{inc} ty_{inc}^{priv}$ and transfers $\sum_{tras} tr_{tras}^{priv}$ to other institutional sectors,
- to which are added transfers from other institutional sectors ($tr_{tras}^{priv} YF_t^{priv}$) as well as transfers from government ($\sum_g Tr_t^g$) and from the rest of the world (Tr_t^{row}).

Private Institutional Sectors' gross disposable income at present value derives from the actualisation of disposable income in each period, plus the stock of capital accumulated during the time horizon of the model:

$$Y^{priv} = \sum_t Y_t^{priv} \left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{priv} pk_{tfirst} - KS_T^{priv} pk_T \left(\frac{1}{1+r}\right)^T \quad [56]$$

The demand for export goods is linked to the following exogenous variables: rest of the world income, exchange rate, foreign prices, and the price of domestic goods.

$$e_{it} = \delta_i^E Y_{tfirst}^{row} (1 + g^{row})^t \left(\frac{pmw_i(1+\pi_t)/exr_t}{P_{it}}\right)^{\sigma_E} \quad [57]$$

Where e_{it} represents the demand for exports for each commodity at the time t, Y_{tfirst}^{row} the initial income of the rest of the world, g^{row} is the growth rate of the world demand (exogenous); δ_i^E is the export share of each good on total exports; σ_E is the substitution elasticity between goods in the Rest of the World basket, which is put equal to zero; pmw_i is the world price of commodities, set as invariant and equal to 1, thus no assumption on inflation in the rest of the world is made; exr_t is also set equal to 1.

The demand for investment goods (I) over time t is obtained by combining, in accordance with the following function, the demand for investment goods. Through the dual function of investment, price or return of the investment P_t^I can be determined as follows:

$$P_t^I = \left(\sum_i \delta_i^I \, P_{it}^{(1-\sigma_I)}\right)^{\frac{1}{1-\sigma_I}} \quad [58]$$

where δ_i is the share of the investment good on total investment, and σ_I is the substitution elasticity between the investment goods, set equal to zero.

As evidenced by Figure 12, dynamism is governed through the condition of capital accumulation, that is the total value of the capital stock (KS) in each period is obtained from the sum of the capital stock and investments at previous time.

$$KS_{t+1} = KS_t(1-\tau) + \sum_i \sum_{is} I_{i,is,t} \quad [59]$$

Where capital stock at one period depends on capital stock of previous period net of τ, the capital depreciation, plus I_t the total investment of the previous period, summed by goods *i* and Institutional Sectors *is*. Equation [60] represents the evolution of capital; in a steady state growth (where g is the exogenous rate of growth), capital growth is given by

$$K^{t+1} = (1+g)\, K^t \quad [60]$$

In the SAM, the total value of capital endowment VK^t equals capital earnings: $VK_t = K_t * rk_t$. Two prices for capital are defined: the price to purchase capital pk^t and the price to rent it rk^t.

The empirical connection between investment flows and capital can be derived from Equations [59] and [60]:

$$I^t = (\partial + g)\, K^t \qquad [61]$$

A 'special treatment' of capital in the last period of the model is needed, to approximate infinite horizon with model's finite periods, following Rutherford (1997). Capital level of terminal period *T* is a variable, with endogenous capital accumulation. This allows to avoid that in the last period all capital would be consumed, and nothing would be invested. In this model, investment in the terminal period is constrained to grow at the same rate of output Lau M. I., Pahlke A., Rutheford T. (2000).

$$\frac{I_T}{I_{T-1}} = \frac{Q_T}{Q_{T-1}} \qquad [62]$$

This has the advantage of imposing a balanced growth in the terminal period, without requiring that the model achieve the steady-state growth.

The complete list of equations and parameters can be found in Appendix 9.

3.3. Estimation of the liquidity position of firms

The approach is based on company balance sheet data extracted from the ORBIS-Bureau Van Djik (BvD) database. These are *panel* data per company and year. Each firm is classified according to NACE 4-digit and for each enterprise information is available on the number of employees, expenses and revenues, assets and liabilities on the balance sheet, as well as cash flows. The NACE 4-digit classification of enterprises is revised to make it consistent with that of industries used in the CGE model.

This database is not exhaustive of the sample of firms in Italy (and in other Countries), since, although it collects information from listed and non-listed companies, it cannot have complete data on micro-enterprises which are not obliged to file their financial statements (to the Chambers of Commerce). Therefore, the ORBIS database is characterised by having, on average,

information on larger, older and more productive companies than the entire population of companies in a country. This means that the results that the following analysis returns could represent a lower threshold on the amount of non-financial firms that could encounter a lack of liquidity problem, following a downturn in the economic cycle or an exogenous shock.

The analysis is based on the latest data available in the ORBIS database for 2014 (last year for which the sample shows more adequate coverage) and it is assumed that they represent the financial situation of a firm in normal times, with regard to average turnover, operating costs, payment of debts and taxes. Data on enterprises both without or with one employee (0-1) and with 500 employees and more have been cut, due to distortions caused by the following reasons: *i)* the former are under-represented in the sample; *ii)* the latter put in place very different financial management strategies from other firms. Companies with no or negative net current assets were also excluded. The total sample relates to 2014, the last year available with an adequate number of companies, around 485,000. The use of microdata from the ORBIS database rather than the ISTAT data makes it possible to obtain more detail in relation to the profit and loss account of firms - for which ISTAT does not provide sufficient detail in relation to the current assets - and thus to estimate the liquidity held by them.

Cash can be defined as net current assets, i.e. the difference between current assets and current liabilities. According to this indicator, an enterprise is considered to be liquid when it has current assets (i.e. cash and cash equivalents, short-term receivables, including with customers, short-term securities and inventories) in excess of current liabilities (Pbt, i.e. short-term liabilities, including those with suppliers).Thus, *working capital* ($WC_{j,t-1}$) or initial liquidity is understood as short-term assets net of short-term liabilities.

The change in liquidity resulting from the change in turnover in generic enterprise *j* at time *t* can be obtained as the algebraic sum of the change in turnover and of two different channels:

$$\mathrm{VarWC}_{j,t} = \mathrm{VarTurnover}_{j,t} - \mathrm{VarWC1}_{j,t} + \mathrm{VarWC2}_{j,t} \qquad [63]$$

Where $\mathrm{VarWC}_{j,t}$ is the change in total liquidity, expressed in million euro, $\mathrm{VarTurnover}_{j,t}$ is the change in turnover, $\mathrm{VarWC1}_{j,t}$ and $\mathrm{VarWC2}_{j,t}$ are the two components of the profit and loss account and credit by financial institutions, respectively. This formula takes account of the fact that, if a firm is experiencing a contraction in turnover, it also has a reduction in costs linked to economic component ($\mathrm{VarWC1}_{j,t}$) as a result of lower production, which acts in the opposite way on the change in liquidity. On the contrary, the component linked to credit ($\mathrm{VarWC2}_{j,t}$) in case of a turnover reduction would act as a further negative element, because firms would experience more difficulties in accessing credit market.

The income statement component $\mathrm{VarWC1}_{j,t}$ may be expressed with the following formula:

$$\mathrm{VarWC1}_{j,t} = \left[\left(\varepsilon_{j,t}^{\frac{\mathrm{Turnover}}{\mathrm{LabCost}}} - 1\right) * \mathrm{LabCost}_{j,t} + \left(\varepsilon_{j,t}^{\frac{\mathrm{Turnover}}{\mathrm{MatCost}}} - 1\right) * \mathrm{MatCost}_{j,t}\right] * \mathrm{Var\%Turnover}_{j,t} \quad [64]$$

where:

- $\mathrm{LabCost}_{j,t}$ and $\mathrm{MatCost}_{j,t}$ are labour costs and intermediate purchase costs, respectively.
- $\mathrm{Var\%Turnover}_{j,t}$ is the intensity of the shock on turnover expressed in terms of annual percentage change.
- $\varepsilon_{j,t}^{\mathrm{Turnover/LabCost}}$ and $\varepsilon_{j,t}^{\mathrm{Turnover/MatCost}}$ are the elasticities with which, respectively, labour costs and intermediate purchase costs respond to contemporaneous changes in operating revenue.

The elasticity of expenditure on intermediate goods and services to turnover $\varepsilon_{j,t}^{\mathrm{Turnover/MatCost}}$ is 0.50, while the elasticity of labour to turnover $\varepsilon_{j,t}^{\mathrm{Turnover/LabCost}}$ is 0.75 and are assumed to be constant throughout the year. These elasticities are common to all industries and have been estimated by Schivardi and Romano (2000) on the basis of the CERVED database on financial statements of Italian non-financial firms for the period 2005-2015, with 2.9 million observations per firm. The first-difference of the logarithm of expenditure in intermediate inputs and wages was regressed on the percentage change in revenue by controlling for year-on-year and firm-specific fixed effects. The resulting elasticity of intermediate goods is 0.7 with a higher

elasticity for goods than for services. To capture non-linearity related to the size of the revenue shock, Schivardi and Romano (2000) excluded from the sample observations with variations of less than -10%, resulting in an estimated coefficient of 0.62; given that it is easier to adjust to small shocks than to large ones, it follows the conservative estimate of 0,50. As regards labour costs, the estimate for the whole sample is 0,46, which falls to 0,40 on the narrow sample. The presence of the CIG with 900 million hours paid in April 2020 (the same amount paid throughout 2009) increases the coefficient to 0.75.

The elasticities estimated by the European Commission, following the Schivardi and Romano (2000) methodology, are respectively 0,5 for intermediate goods and 0,8 for labour costs, on average for EU countries and for all industries.

Elasticity below unity implies that cash flow changes are less significant than changes in turnover, with lower reductions in the event of a negative change in revenues.

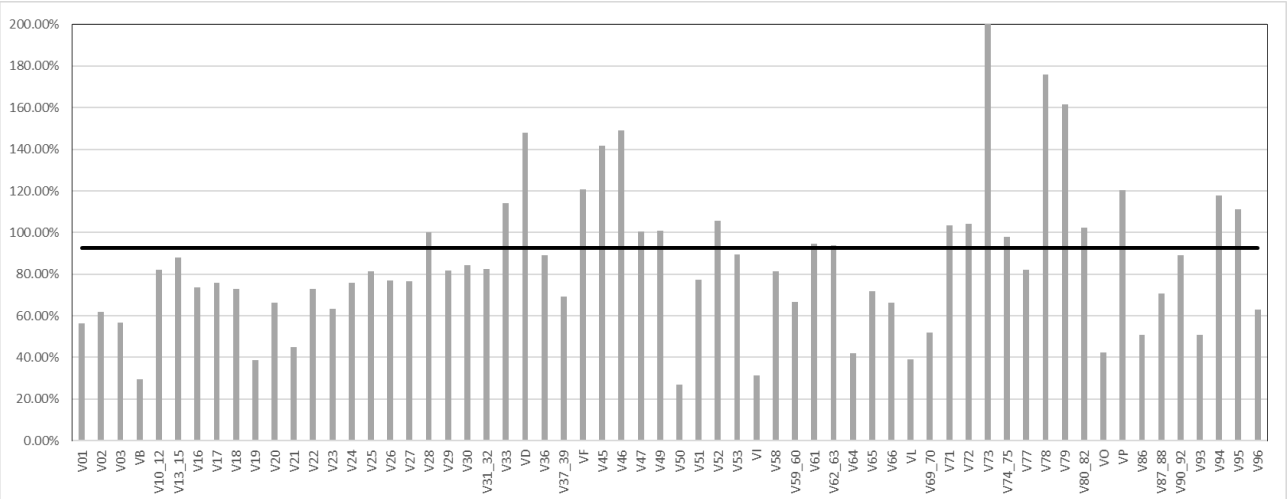
The second liquidity component, relating to bank credit, is estimated on the assumption that current liabilities are, in the absence of more specific variables, the most appropriate *proxy* for access to credit. The latter is increasing as turnover is increasing according to the ratio of current liabilities to turnover $\frac{\mathrm{CurrLiab_{j,t}}}{\mathrm{Turnover_{j,t}}}$ (average of current year and previous two years). This channel can be represented as follows:

$$\mathrm{VarWC2_{j,t}} = \frac{\mathrm{CurrLiab_{j,t}}}{\mathrm{Turnover_{j,t}}} * \mathrm{Var\%Turnover_{j,t}} * \mathrm{Turnover_{j,t}} \qquad [65]$$

At the initial level, i.e. before the shock occurs, the management situation at the level of each industry can be illustrated by the following two graphs. Figure 14 considers the ratio of short-term liabilities to the sum of long-term liabilities and net worth. This ratio is on average 92.7% but reaches 200 percent for advertising and market research (V73); 176% for Research, selection, supply of personnel (V78); 162% for travel agencies, tour operators, reservation services and related activities (V79); Wholesale trade, except of motor vehicles and motorcycles (V46, 149%);

147.8% for Electricity, gas, steam and air conditioning supply (VD); 142% for Wholesale and retail trade and repair of motor vehicles and motorcycles (V45); 121% for Construction (VF).

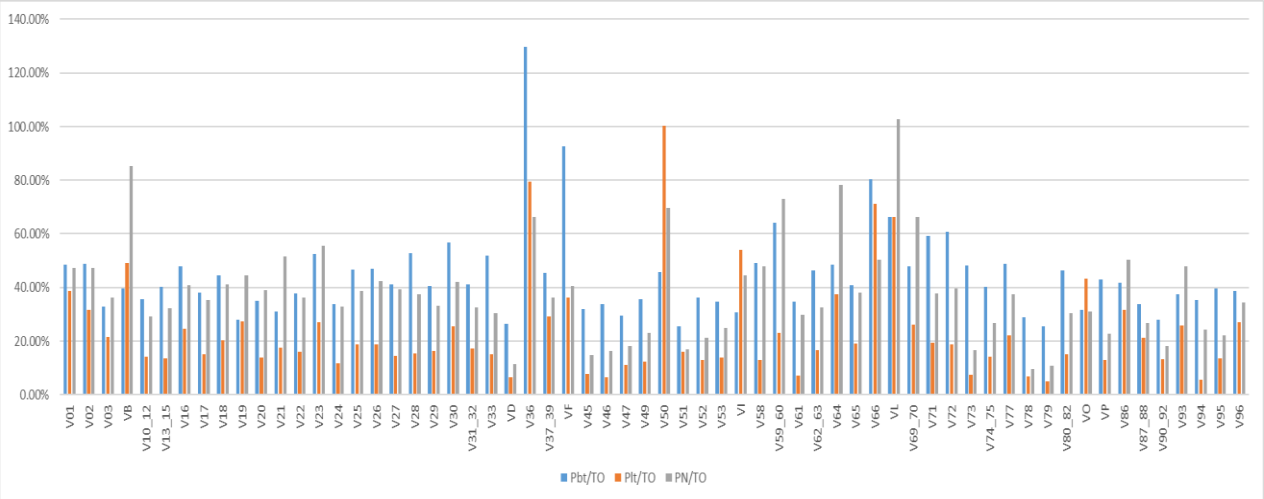
Figure 14 - s.t. liabilities on the sum of l.t. liabilities and net worth by industry



Source: Elaboration on ORBIS-BvD data.

The following graph (see Figure 15) shows for each industry the shares of short-term liabilities (P_{bt}), long-term liabilities (P_{lt}) and net worth (PN) in turnover (TO). In this case, industries that have a high ratio of net worth to turnover and, at the same time, lower shares of liabilities in relation to turnover can be described as more robust, such as the mining industry (VB); real estate activities (LV); financial services (except insurance and pension funds, V64); legal and accounting activities, activities of head offices and management consultancy (V69-70); health service activities (V86); Sports, entertainment and recreation (V93).

Figure 15 - s.t., l.t. liabilities and net worth on turnover by industry



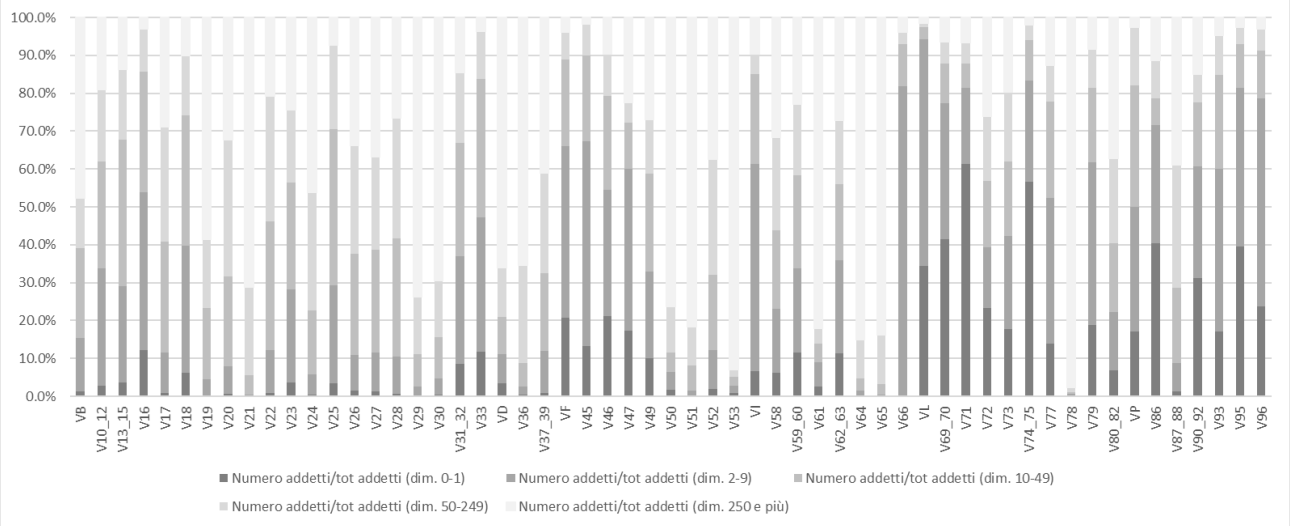
Source: Elaboration on ORBIS-BvD data.

The illiquidity condition $WC_{j,t}$ can be constructed as the starting liquidity, $WC_{j,t-1}$, together with the liquidity variation resulting from the shock:

$$WC_{j,t} = WC_{j,t-1} + \mathrm{VarWC_{j,t}} = WC_{j,t-1} + \mathrm{VarTurnover_{j,t}} - \mathrm{VarWC1_{j,t}} - \mathrm{VarWC2_{j,t}} \qquad [66]$$

The characteristics that emerge from the above Figures may depend not only on the structural characteristics of each sector but also on the number of enterprises present and their size. In particular, ISTAT data on the number of enterprises by industry and the number of employees, broken down by size class, allows to consider the weight in each industry of the size of the enterprise (see Figure 16).

Figure 16 – industry size by number of persons employed



Source: Elaboration on I.STAT data - Competitiveness of enterprises. For the sake of completeness, the shares of 0 to 1 employees are also included, but these are excluded from the analysis of the ORBIS database.

Looking at the information from Figures 14, 15 and 16, the sectors of scientific research and development, construction, repair and installation of machinery and equipment (V72, VF, V33), have an initial situation characterised by a high ratio of short-term liabilities to turnover, and above average is the ratio of short-term liabilities to the sum of long-term liabilities and net worth. Moreover, the share of micro-enterprises (with between 0 and 9 employees) is predominant in all three sectors.

These considerations are not sufficient to define these industries as characterised by the presence of 'zombie firms', that is to say, firms that are unable to cover borrowing costs with current profits over a long period of time. The analysis of zombie firms is outside the purpose of this work. Nevertheless, for the purposes of the policies that a government intends to implement, it must be considered that, in the acute phase of a crisis, policies aimed at avoiding business failures (such as increasing guarantees for obtaining loans) and the need to operate quickly, can lead to financing both profitable and less profitable companies (Schivardi, Sette, Tabellini, 2020), with the result also of delaying recovery after a crisis. According to the OECD, for example, in Italy during the financial crisis, the share of capital stock in zombie firms rose from 7% to 19% between 2007 and 2013[18]. The existence of zombie firms leads to a misallocation of resources, making these latter less available to more profitable firms. This slows the recovery after a crisis, as resources are directed towards less productive uses (Caballero, Hoshi, and Kashyap, 2008; Hsieh & Klenow 2009).

However, when looking at the results of Schivardi, Sette and Tabellini (2020), they conclude that the current pandemic crisis has hit companies with an intensity independent of their financial conditions. Distinguishing between zombie and non-zombie companies, they apply the analytical scheme used in Schivardi and Romano (2000) to identify companies experiencing illiquidity problems between March and December 2020. The results show that of course zombie firms can be immediately constrained by liquidity needs. However, given that in Italy zombie companies account for 11% of all enterprises, the number of zombie enterprises that becomes illiquid is about one third of non-zombie firms. Moreover, the latter are generally larger and therefore higher in terms of employment, with the result that the number of workers in illiquid zombie enterprises represents only 10% of non-zombie enterprises. Therefore, using the data for

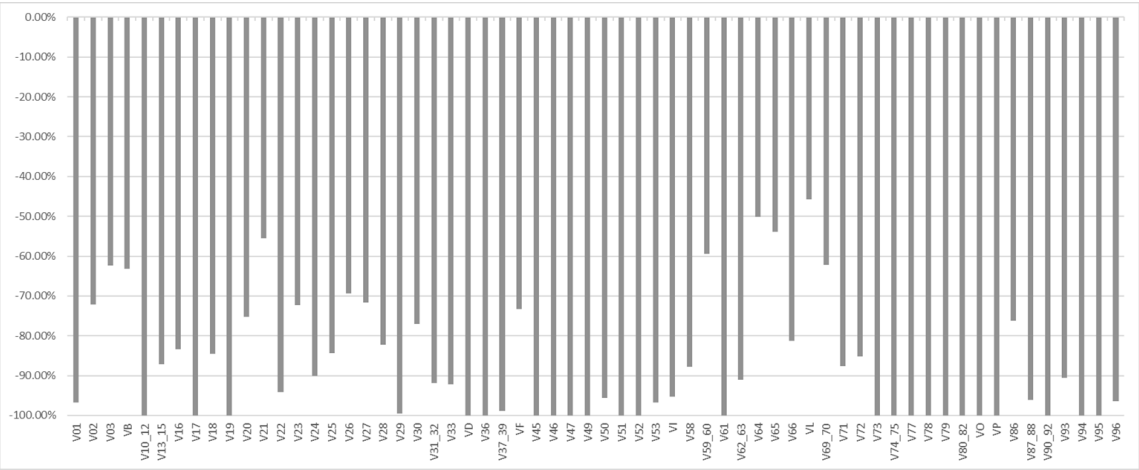
[18]Http://www.oecd.org/economy/zombie-firms-and-weak-productivity-what-role-for-policy.htm

Italy, they conclude that most of the liquidity needs during the present crisis stem from companies that were financially sound before the crisis.

Nonetheless, an assessment of these aspects will be possible once the crisis has come to an end, which has seen firms in some industries suffer from a prolonged loss of liquidity caused by the stop and slowdown in productive activity (e.g. the accommodation and catering sector), in order to assess whether some sectors will be able to recover completely and in how long.

Reverting to the formulae set out in paragraph 3.1 on the calculation of firms' liquidity position, it is theoretically possible to calculate that an average yearly percentage reduction in turnover of 20% would correspond to an average reduction of 5 percent for the labour costs, a 10 percent reduction for the cost component linked to intermediate purchases, both elements forming the first liquidity component $\mathrm{VarWC1}_{j,t}$. As for the second liquidity component, $\mathrm{VarWC2}_{j,t}$, according to the formula, a turnover contraction of 20% would turn in an equal rise of current liabilities. The above hypothesis would translate into a cancellation of available liquidity for many of the sectors, as shown in Figure 17. The sectors that appear to be in a better position would, however, experience a liquidity contraction of more than 50 percent. The only sector likely to contract less is real estate assets (LV, -46%), while financial services (V64) would have a liquidity reduction of 50 percent.

Figure 17 – Liquidity contraction carried by a 20% turnover contraction



Source: Elaboration on ORBIS data.

According to the latest data published by ISTAT and updated up to August 2020, the trend reduction in turnover in the first 8 months of the year and transformed on an annual basis is -14.8 percent. For services, the estimated reduction in turnover on the basis of ISTAT data published up to the second quarter of 2020 and transformed in annual terms is -15.8 per cent. These values already incorporate the government's intervention measures that entered into force from March onwards. By contrast, the 20 percent mentioned above is a hypothetical percentage net of any support measure.

Based on the ISTAT data on the number of firms by industry, it is possible to estimate the proportion of firms having a liquidity constraint. The following table (Table 18) summarises the number of enterprises by size: there are around 4.3 million enterprises in Italy, of which 95% are micro-enterprises, with between 0 and 9 employees. In particular, 2.6 million are enterprises without or with only one employee. However, in terms of output and, to a greater extent, value added, enterprises with 250 employees cover 35% and 40% respectively of the total.

Table 18 — Distribution of macroeconomic variables by firm class

Size class / Variable		0-1	2-9	10-19	20-49	50-249	250 and more	total
Firms	Num	2,646,022	1,442,035	134,193	53,914	22,603	3,912	4,302,679
	%	61%	34%	3%	1%	1%	0%	100%
value of production	million euro	129,324	229,073	221,261	260,246	457,236	869,236	2,166,375
	%	6%	11%	10%	12%	21%	40%	100%
value added at factor cost	million euro	77,333	144,052	77,863	85,723	140,882	280,296	806,150
	%	10%	18%	10%	11%	17%	35%	100%

Source: Elaboration on I.STAT data — Competitiveness of enterprises.

At the industry level (see Table 19), the percentage breakdown of firms by size class shows that in most producer industries the largest share of firms is between 0 and 49 employees, while for only a few industries the highest size classes see more than 10% of firms: pharmaceutical (V21, 40.8%), insurance (V65, 31.5%), manufacture of motor vehicles (V29, 14.4%), air transport (V51, 14.4%), water collection, treatment and supply (V36, 12.5%) and metallurgical activities (V24, 11.4%).

Table 19 — Distribution of firms by industry and size class

Industry	Code	No. of firms/total firms					
		(size 0-1)	(size 2-9)	(size 10-49)	(size 50-249)	(size 250 + >)	total
Agriculture, hunting and related service activities	V01	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Forestry and logging	V02	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Fishing and aquaculture	V03	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mining and quarrying	VB	30.6%	46.7%	20.3%	2.2%	0.2%	100.0%
Food products, beverages and tobacco products	V10_12	26.5%	59.1%	12.5%	1.7%	0.3%	100.0%
Textile products, wearing apparel and leather products	V13_15	34.2%	47.1%	16.8%	1.7%	0.2%	100.0%
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	V16	48.8%	43.2%	7.4%	0.5%	0.0%	100.0%
Paper products	V17	23.1%	42.3%	27.6%	5.9%	1.1%	100.0%
Printing and reproduction of recorded media	V18	39.9%	48.2%	10.8%	1.0%	0.1%	100.0%
Coke and refined petroleum products	V19	16.9%	36.8%	37.6%	4.9%	3.8%	100.0%
Chemical products	V20	24.5%	38.1%	26.9%	8.7%	1.8%	100.0%
Basic pharmaceutical products and pharmaceutical preparations	V21	25.4%	15.9%	17.9%	25.4%	15.4%	100.0%
Manufacture of rubber and plastic products	V22	20.4%	42.9%	29.2%	6.7%	0.9%	100.0%
Manufacture of other non-metallic mineral products	V23	35.4%	50.4%	12.2%	1.7%	0.3%	100.0%
Manufacture of basic metals	V24	21.5%	39.5%	27.5%	9.3%	2.1%	100.0%
Manufacture of fabricated metal products, except machinery and equipment	V25	31.6%	47.9%	18.4%	1.9%	0.2%	100.0%
Manufacture of computer, electronic and optical products	V26	34.3%	37.4%	21.7%	5.6%	0.9%	100.0%
Manufacture of electrical equipment	V27	27.9%	40.9%	25.8%	4.4%	0.9%	100.0%
Manufacture of machinery and equipment n.e.c.	V28	21.4%	37.8%	32.1%	7.4%	1.3%	100.0%
Manufacture of motor vehicles, trailers and semi-trailers	V29	21.9%	35.6%	28.1%	10.3%	4.1%	100.0%
Manufacture of other transport equipment	V30	32.6%	39.3%	20.9%	5.5%	1.7%	100.0%
Manufacture of furniture, other manufacturing	V31_32	49.8%	40.3%	8.7%	1.1%	0.2%	100.0%
Repair and installation services of machinery and equipment	V33	52.6%	37.7%	9.0%	0.7%	0.1%	100.0%
Electricity, gas, steam and air conditioning supply	VD	74.0%	20.0%	4.5%	1.1%	0.4%	100.0%
Water supply, sewerage, waste management and remediation activities	V36	54.1%	23.1%	10.3%	7.9%	4.6%	100.0%
Sewerage, waste collection, treatment and disposal activities, materials recovery, remediation activities and other waste management services	V37_39	24.3%	47.5%	22.0%	5.0%	1.2%	100.0%
Construction	VF	62.3%	33.7%	3.7%	0.2%	0.0%	100.0%
Wholesale and retail trade services, repair of vehicles and motorcycles	V45	46.0%	49.4%	4.3%	0.3%	0.0%	100.0%
Wholesale trade, except of motor vehicles and motorcycles	V46	68.4%	26.7%	4.4%	0.4%	0.1%	100.0%
Retail trade, except of motor vehicles and motorcycles	V47	55.1%	42.3%	2.3%	0.2%	0.1%	100.0%
Land transport and transport via pipelines	V49	56.2%	34.3%	8.3%	1.0%	0.1%	100.0%
Water transport	V50	54.4%	35.9%	6.8%	2.2%	0.7%	100.0%
Air transport	V51	28.7%	27.7%	29.3%	9.6%	4.8%	100.0%
Warehousing and support activities for transportation	V52	39.1%	40.0%	15.3%	4.7%	0.9%	100.0%
Postal and courier activities	V53	56.8%	34.1%	7.8%	1.0%	0.3%	100.0%
Accommodation and food service activities	VI	29.5%	62.3%	7.8%	0.3%	0.0%	100.0%
Publishing activities	V58	61.1%	30.2%	6.9%	1.5%	0.3%	100.0%
Motion picture, video and television programme production, sound recording and music publishing activities, programming and broadcasting	V59_60	67.8%	25.9%	5.5%	0.7%	0.2%	100.0%
Telecommunications	V61	58.8%	34.2%	5.7%	0.8%	0.4%	100.0%
Computer programming, consultancy and related activities, information service activities	V62_63	64.7%	29.5%	4.9%	0.8%	0.1%	100.0%
Financial service activities, except insurance and pension funding	V64	0.0%	88.4%	7.3%	3.0%	1.3%	100.0%
Insurance, reinsurance and pension funding, except compulsory social security	V65	0.0%	28.1%	40.4%	20.0%	11.5%	100.0%
Activities auxiliary to financial services and insurance activities	V66	0.0%	98.5%	1.5%	0.1%	0.0%	100.0%
Real estate activities	VL	69.6%	30.0%	0.3%	0.0%	0.0%	100.0%
Legal and accounting activities, activities of head offices, management consultancy activities	V69_70	79.6%	19.1%	1.1%	0.1%	0.0%	100.0%
Architectural and engineering activities, technical testing and analysis	V71	90.2%	9.2%	0.5%	0.1%	0.0%	100.0%
Scientific research and development	V72	83.7%	12.6%	3.1%	0.5%	0.1%	100.0%
Advertising and market research	V73	74.2%	21.8%	3.5%	0.4%	0.1%	100.0%
Other professional, scientific and technical activities, veterinary activities	V74_75	87.8%	11.2%	0.9%	0.1%	0.0%	100.0%
Rental and leasing activities	V77	57.7%	36.6%	5.0%	0.5%	0.1%	100.0%
Employment activities	V78	57.0%	26.6%	7.1%	3.0%	6.3%	100.0%
Travel agency, tour operator reservation service and related activities	V79	61.1%	35.1%	3.3%	0.3%	0.1%	100.0%
Security and investigation activities, services to buildings and landscape activities, office administrative, office support and other business support activities	V80_82	61.2%	30.2%	6.7%	1.6%	0.3%	100.0%
Public administration and defence, compulsory social security	VO	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Education	VP	66.8%	27.3%	5.4%	0.6%	0.0%	100.0%
Human health activities	V86	79.5%	19.6%	0.7%	0.1%	0.0%	100.0%
Social work activities	V87_88	37.3%	35.4%	19.5%	6.5%	1.3%	100.0%
Creative, arts and entertainment activities, libraries, archives, museums and other cultural activities, gambling and betting activities	V90_92	78.2%	19.6%	2.0%	0.2%	0.0%	100.0%
Arts, entertainment and recreation	V93	59.4%	36.0%	4.2%	0.3%	0.0%	100.0%
Activities of membership organisations	V94	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Repair of computers and personal and household goods	V95	73.5%	24.9%	1.4%	0.1%	0.0%	100.0%
Other personal service activities	V96	55.9%	42.2%	1.7%	0.2%	0.0%	100.0%

Source: Elaboration on I.STAT data — Competitiveness of enterprises.

In terms of percentage of firms involved, a 20 percent turnover reduction would constitute a crucial problem for 57 percent of total firms, with a higher concentration for the small enterprises, as evidenced in Table 20.

Table 20 – Percentage of liquidity constrained firms by firm class in case of a -20% turnover

	size 2-9	size 10-49	size 50-249	size 250 or more	Total
Firms experiencing a total loss of liquidity					
Share on the total of the class	57.31%	55.34%	52.62%	56.88%	57.04%
Composition	50.22%	6.00%	0.69%	0.13%	57.04%

Source: Elaboration on ORBIS data

In terms of the number of persons employed, industries which would experience in a year the cancellation of available liquidity in case of 20% turnover reduction employ the 58 percent of total persons employed.

3.4. Government measures in support of businesses liquidity

Having estimated the proportion of firms that could have liquidity constrains, it is interesting to assess the effectiveness of the emergency policies put in place by the Government to support companies at this time of difficulty. In particular, the effectiveness of two policies aimed at affecting firms' liquidity will be assessed at this last stage of the work: firstly, the reduction in employers' social security contributions, aimed at reducing the tax wedge, which has an impact on labour costs, thus on the first liquidity component and secondly, the increase in State guarantees to back firms' loans (as the one granted through the Guarantee Fund for SMEs), which are intended to make it easier to obtain credit and, therefore, to affect the second liquidity component linked to bank credit.

In Italy, in particular, in 2019 the tax wedge - which corresponds to the sum of personal tax on compensation of employees, including supplements, and employees' and employers' social contributions - according to OECD data amounted to 48 percent of labour costs for a single worker, without children and with an average wage. The Italian tax wedge is the third highest among the OECD countries, after Belgium and Germany.

The Budget Law for 2020 financed the reduction of the tax wedge on labour establishing a dedicated fund with a budget of EUR 3 billion in 2020 (EUR 5 billion from 2021) to increase the net amount that workers receive in pay slips, at the same cost to the employer. These resources were intended to reassess the 'Bonus IRPEF' by EUR 80 by increasing its amount and extending the number of recipients. In addition to this structural measure, several measures have been taken by the Government to reduce the employer's contribution burden, which are selective and temporary in nature to counter the economic effects of the COVID-19 pandemic. Firstly, for employers who do not apply for wage supplement benefits a partial exemption from their social security contributions is provided, equal to twice the wage supplement hours spent in May and June 2020, for a maximum period of four months. This exemption may be granted up to 31 December 2020 for employers who do not benefit from additional COVID wage subsidies. In addition, the exemption is to be extended for a further period of up to four weeks, equal to the hours of wage supplement used in June 2020, which may be used by 31 January 2021 for employers who do not apply for wage supplement measures for periods between 16 November 2020 and 31 January 2021. The application of the benefits is subject to authorisation by the European Commission.

Secondly, an exemption from contributions for permanent recruitment and temporary recruitment in the tourism and thermal industries sectors. Employers who employ, after 15 August 2020 and by 31 December 2020, permanent workers (excluding apprenticeship contracts and domestic work contracts) may benefit from an exemption from their social security contributions for a maximum period of six months and up to a maximum of EUR 8,060 on an annual basis, recalculated and applied on a monthly basis (i.e. up to a maximum of EUR 670 per month). For agricultural employers an exemption from the payment of employers' social security contributions due for the period from 1 January 2020 to 30 June 2020 and also for November is also established.

Finally, a partial exemption from 1 October 2020 to 31 December 2020, equal to 30 percent of the contributions payable by employers in the private sector is established for the most

economically disadvantaged regions. These are regions whose GDP per capita in 2018 is at least 10 % below the EU-27 average and whose employment rate is below the national average; all the Regions of Mezzogiorno and Umbria meet the requirements.

As regards the access to credit, the additional resources for granting loan guarantees through the Guarantee Fund for SMEs amount to approximately EUR 4 billion for 2020[19].

On the basis of the weekly survey carried out by the Task Force set up to promote the implementation of the liquidity measures adopted by the Government to deal with the COVID-19 outbreak[20], a total of 1,092,380 guarantee applications for a total amount of more than EUR 83.2 billion were received from the Guarantee Fund from 17 March to 22 September 2020. Of these, more than 893,588 relate to funding of up to EUR 30,000, with a guarantee of 100%, for an amount financed of around EUR 17.6 billion. As of 23 September, 1,080,380 transactions have been accepted.

From a regulatory point of view, the operation of the Guarantee Fund for SMEs has been significantly expanded to deal with the emergency[21]. In particular, the guarantee was made free of charge, with the suspension of the obligation to pay fees for access to the Fund. The case of operations under the guarantee of the Fund has also been broadened, including debt rescheduling operations and the automatic extension of the guarantee in case of a moratorium or suspension of financing for the coronavirus emergency. The maximum guaranteed amount has been increased to EUR 5 million (from the previous 2.5) and companies up to 499 employees are eligible for the guarantee. The minimum percentage of direct coverage has been increased from 80% to 90% for all funding up to 6 years, with the possibility of increasing to 100% under certain conditions. Access to the Fund may also be granted to beneficiaries who, at the date of the guarantee request,

[19] The August Decree-law increased the fund by EUR 3,300 million for 2023, EUR 2,800 million for 2024 and EUR 1,700 million for 2025.
[20] The Task Force include the Ministry of Economy and Finance, the Ministry of Economic Development, the Bank of Italy, the Italian Banking Association, Mediocredito Centrale and SACE.
[21] By Decree-Law No 18/2020 and the subsequent Decree-Law No 23/2020.

present exposures classified by the bank as ‘probable defaults’ or ‘past due or non-performing’, while firms that have exposures classified as ‘bad loans’ are excluded and therefore the conditions for a return to profitability must be met.

In particular, three main lending thresholds can be indicated: *i)* loans of up to EUR 30,000, which may reach the maximum level of 25% of the company’s revenue, are guaranteed at 100%. *ii)* Loans of up to EUR 800,000 - obtained by companies with revenues not exceeding EUR 3,2 million - may be secured by a guarantee of 100%. The amount of the guaranteed loans must not exceed 25 per cent of the company’s revenue. *iii)* Loans above EUR 800,000 are backed by a guarantee of 90% and the amount of the loan may not exceed twice the wage bill in 2019 or 25% of total turnover in the same year. Loans of up to EUR 30,000 have a maximum maturity of 10 years, with repayment of the principal starting 24 months after disbursement. Larger loans have a maximum maturity of 6 years.

3.5. The effects of supports at macroeconomic level

In order to assess the effects on macroeconomic variables of the measures implemented by the government and to consider their different multiplier effects, in this work the temporary reduction in employers’ social contributions and the increase in loan guarantees are simulated by triggering, in both cases, the same amount corresponding to 1 percent of GDP (around EUR 17.9 billion, based on 2019 figures). This makes it possible to compare more effectively the effects of different measures on consumption, investment, current account and Institutional Sectors’ income.

As regards the reduction of social security contributions paid by employers, the simulation is carried out by means of a reduction in labour costs by industry, in the first period of the time horizon. At the same time, a reduction in household transfers to the government is set up, due to

the lower payment of social contributions[22]. As a result, households continue to earn the same income, as only employers' contributions have been reduced. Results are shown in Table 21. In particular, it should be noted that the multiplier is above one, as the measure which, ex ante, amounts to 1 percent of GDP returns a GDP growth of 1.4 percent. Growth is driven by investment, which are boosted by employment growth as a result of higher economic activity. There is a slight deterioration in the current account balance, as exports remain unchanged from the benchmark, while imports increase as a result of increased economic activity.

Table 21 - Temporary reduction of employers' social security contribution by 1 percent of GDP

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.400	0.000	0.000	0.000	0.000
Households consumption	0.000	0.000	0.000	0.000	0.000
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	10.611	0.000	0.000	0.000	0.000
Exports	0.000	0.000	0.000	0.000	0.000
Imports	2.572	0.000	0.000	0.000	0.000
Unemployment	-2.121	0.000	0.000	0.000	0.000
GDP deflator	0.000	0.000	0.000	0.000	0.000
Households' financial liabilities	0.000	0.000	0.000	0.000	0.000
Firms' financial liabilities	0.000	0.000	0.000	0.000	0.000

Source: Elaboration on financial dynamic CGE model.

Unchanged prices mean that there is no change, either in quantity or in value, in financial products held by institutional sectors. The results for the following years are null and void. Decontribution measures may help to reduce the costs borne by companies, however, the short duration of the incentives, which limits the overall amount of the decontribution and the weakness of labour demand at the current juncture, may affect the effectiveness of the measure in supporting employment. Moreover, the period of validity of the measure does not give companies a lot of time to activate fixed-term contracts to be converted into open-ended positions at a later date (Banca d'Italia, 2020b).

[22] By accounting convention, it is recalled that, in the national accounts, social contributions - both employer's and employee's ones - are attributed to the institutional family sector, which then pays them to the social security authorities, insurance corporations and pension funds (Siesto, 2000).

With regard to the increase in public guarantees for facilitating firms in obtaining credit, the simulation is done as a reduction in the cost of capital borne by enterprises, while leaving the income from capital unchanged. Moreover, since the guarantee is covered by a loan which must be repaid, it has been assumed that the amount of the guarantee will be reduced in subsequent periods. This was done by taking into account the average duration, weighted by the amount of loans, of loans granted through the Guarantee Fund for SMEs between March and September 2020. This average duration is 7.4 years and a linear amortisation has been envisaged, as no further information on the repayment of the loans is available. Although the results, presented in Table 22, indicate a lower multiplicative effect than the decontribution in the first period, they nevertheless point to a lasting effect on investment, which is transferred to GDP growth. The effect on employment is also more lasting. Consumption contracted slightly as a result of the increase in the deflator, which also leads to a worsening of the current account balance.

The results also depend on the current situation of low interest rates, which can stimulate investment. The slight rise in deflators increases by around 0.3 percent institutional sectors' financial liabilities in nominal terms for the whole time horizon, while no changes are registered in real terms.

Table 22 - Raise in State guarantees to bank loans by 1 percent of GDP

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.265	0.028	0.022	0.017	0.011
Households consumption	-0.126	-0.130	-0.135	-0.140	-0.145
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	10.260	1.132	1.120	1.112	1.106
Exports	-0.296	-0.304	-0.312	-0.321	-0.330
Imports	2.259	0.170	0.165	0.159	0.154
Unemployment	-1.738	-0.089	-0.083	-0.077	-0.072
GDP deflator	0.486	0.500	0.516	0.533	0.550
Households' financial liabilities	0.288	0.292	0.297	0.302	0.308
Firms' financial liabilities	0.283	0.292	0.301	0.310	0.320

Source: Elaboration on financial dynamic CGE model.

By way of comparison with the other two types of measure referred to above, Table 23 shows the results of a one-off contribution to enterprises of 1 percent of GDP. In this case, in the first period of the time horizon, the multiplier is broadly equal to one. Compared with the case of decontribution measures, the one-off contribution to firms, as it is aimed only at investment, does not stimulate the economy also on the consumption side, and the contraction in employment in subsequent periods leads to a slowdown in consumption over the whole time horizon as a result of intertemporal effects. In subsequent periods, the slowdown in economic activity leads to both a reduction in GDP and a reduction in investment. A slight improvement in the current account balance since the second period reflects, on the one hand, a reduction in the deflator, that enhance exports and, on the other hand, the contraction in imports relative to the benchmark as a result of the contraction in economic activity. Comparing these results to the ones relating to the increase of guarantees confirms that this kind of short term support to the economy not only have a lower multiplier in the first year of the horizon, but it also has negative effects in the subsequent periods. This aspect could also be attributed to the effect on investment, suggesting that investment decisions could be brought forward to the first period of the horizon, leading to a downward trend in investment growth than the benchmark in the subsequent years.

Table 23 – One-off contribution to capital cost of firms by 1 percent of GDP

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.002	-0.161	-0.158	-0.156	-0.154
Households consumption	-0.214	-0.213	-0.211	-0.210	-0.208
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	8.197	-0.530	-0.526	-0.522	-0.520
Exports	0.094	0.097	0.100	0.102	0.105
Imports	1.857	-0.205	-0.202	-0.200	-0.197
Unemployment	-1.426	0.204	0.202	0.199	0.197
GDP deflator	-0.154	-0.158	-0.163	-0.168	-0.174

Source: Elaboration on financial dynamic CGE model.

The Government's intervention measures outlined above do not consider any coverage, so they are based on deficit and no account is taken of any charges due to cover. A very interesting aspect to consider is the source of funding for these measures: European funds, or issues of government debt securities (which may or may not be purchased by the ECB). In a crisis such as the current one, there are no limits to the opportunity for public intervention and there are no hesitations regarding the increase in public debt, as delays in action could have even more dramatic effects on the economies. However, the origin of the resources is not neutral about the effects on the economic system. With the financial model, it is possible to estimate the effects of a 1 percent of GDP issuance of government debt to finance policy measures in the economy. The table below (see Table 24) shows the results of a government debt issuance at the first period of the horizon, without adding any measures to use government debt. The simulation is modelled on the assumption that the newly issued securities are purchased by the institutional sectors, on the basis of the shares of public bonds held. Despite the increase in investment, driven by the increase in savings induced by the purchase of securities, it is clear that the loss of liquidity has a negative effect on consumption that is transmitted to GDP. The low interest rate environment means that new issuance is not reflected on prices.

Table 24 – Emission of Treasury Bonds by 1 percent of GDP

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	-0.006	-0.003	-0.003	-0.003	-0.003
Households consumption	-0.015	-0.007	-0.007	-0.007	-0.007
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	0.016	0.008	0.008	0.008	0.008
Exports	0.000	0.000	0.000	0.000	0.000
Imports	-0.002	-0.001	-0.001	-0.001	-0.001
Unemployment	0.004	0.002	0.002	0.002	0.002
GDP deflator	0.000	0.000	0.000	0.000	0.000

Source: Elaboration on financial dynamic CGE model.

If the new issues are purchased by the European Central Bank in the course of its purchase programme, this would not have the effect of subtracting liquidity from the system but, on the

contrary, would trigger liquidity as the ECB also buys on the secondary market. This effect is clearly evident in Table 25: in this case, a purchase of securities by the ECB on the secondary market was triggered, which has a positive impact on consumption-driven GDP.

Table 25 – ECB purchase of Treasury Bonds by 1 percent of GDP

Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	0.095	0.044	0.044	0.044	0.044
Households consumption	0.248	0.115	0.115	0.115	0.115
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	-0.269	-0.128	-0.132	-0.136	-0.136
Exports	0.000	0.000	0.000	0.000	0.000
Imports	0.028	0.013	0.013	0.013	0.012
Unemployment	-0.074	-0.034	-0.034	-0.035	-0.034
GDP deflator	0.000	0.000	0.000	0.000	0.000

Source:Elaboration on financial dynamic CGE model.

The same can be said for any resources coming from the European Funds as non-repayable resources. However, deficit coverage and monetary policy decisions are outside the purpose of this work and could be the object of further work on identifying the best hedging mechanisms.

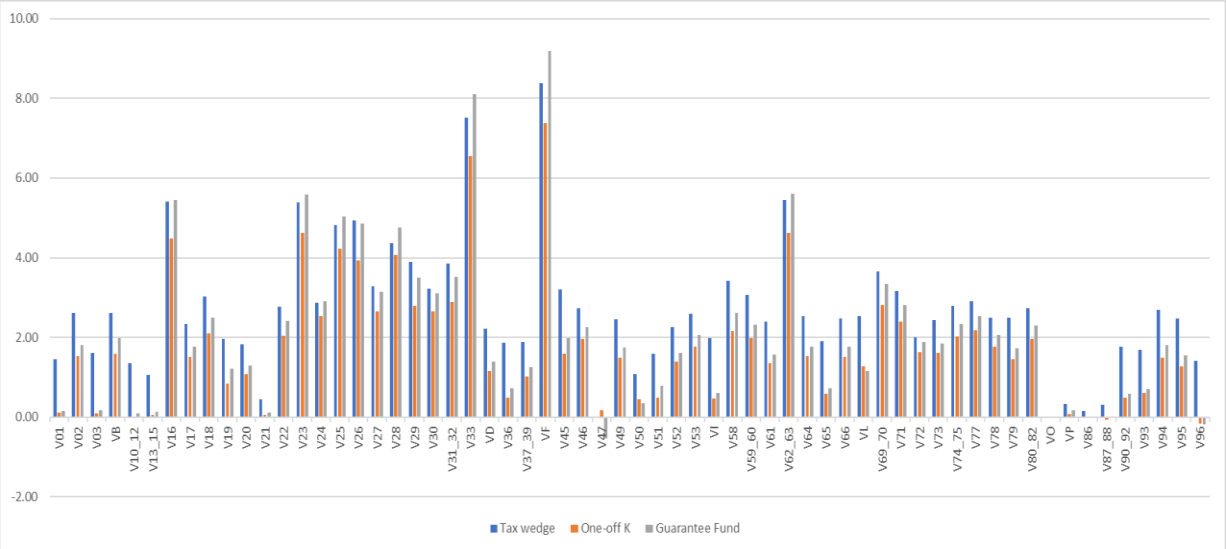
3.6. Results applied to ORBIS data

The support measures implemented by the Government can be transformed into higher turnover for companies, thus helping to face liquidity problems, which would make them less solvent and therefore subject to credit rationing. This could trigger possible failures and a sharp drop in planned and future investments, through the gross operating surplus channel (GOS), defined as the difference between turnover and the operating costs, including in costs of staff employed and of intermediate consumption. Schematically, a supply and demand shock leads to a reduction in the GOS and thus to a liquidity crisis, which in turn leads to a reduction in investment.

Being modelled as a cost reduction, Government support measures considered in section 3.5 have also positive effects on output (see Figure 18), depending on the labour or capital component of each sector. To name a few, Agriculture (V01), Forestry (V02), Fishing (V03),

Mining (VB), Food, beverages and tobacco (V10-12), Textiles, wearing apparel and leather (V13-15), as well as Financial services, except insurance and pension funding (V64), Insurance, reinsurance and pension funding services, except compulsory social security (V65), Services auxiliary to financial services and insurance services (V66), Real estate services (VL) would benefit more of decontribution measures in terms of return on output. On the other side, Construction (VF), Repair and installation services of machinery and equipment (V33), Machinery and equipment n.e.c. (V28), Computer programming, consultancy and related services, information services (V62-63) would benefit more from the raise in State loan guarantees, exception made by the Retail trade services (V47) which would suffer from the guarantees support because of the reduction of consumption. The one-off contribution to firms is less effective for all the sectors.

Figure 18 – Effects on output of Government support measures



Source: Elaboration on financial dynamic CGE model results.

In order to estimate the effects of the measures implemented by the Government, output results from the financial dynamic CGE model were applied to the turnover of companies in the ORBIS-BvD database.

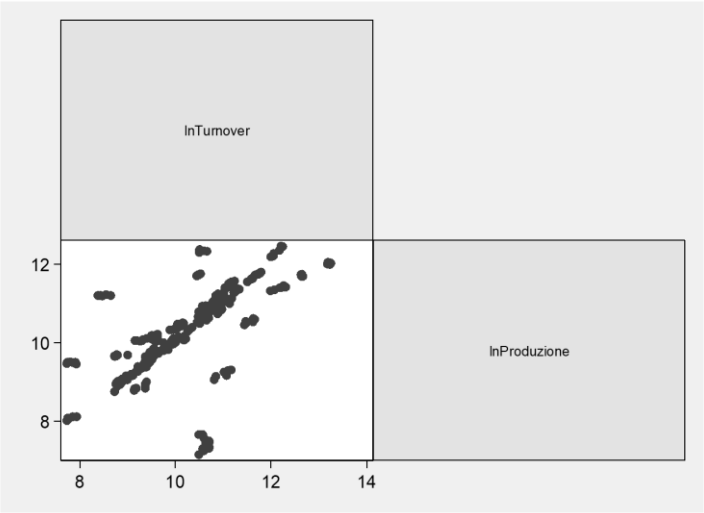
As a preliminary point, since the variation in output by industry does not coincide with the change in turnover of the same industry, but is assumed to be strongly correlated, this correlation

has been examined. In order to apply changes in output to turnover, a panel regression has been built between the time series from 2010 to 2015 of output at basic prices by NACE industry and of turnover in manufacturing and services published by ISTAT, in order to extract an elasticity of turnover to output and to transfer the results of the model to the micro database[23].

ISTAT does not publish a turnover index for all industries. In the case of forestry and fishing industries, the same turnover as agricultural enterprises was taken into account. The activities relating to financial services, insurance and related ancillary activities (V64-V66), the Public Administration (VO) and membership organisations (V94) activities, since no turnover published by ISTAT is available, have not been included and the average elasticity resulting from the regression panel will be applied to them. Households as employers (V94) are excluded from the analysis.

The two series of turnover and industrial production, converted into logarithms, have a correlation of 66%, and the trend over time is very similar, as shown by Figure 19 and 20 representing, respectively, the development of the two series as a whole and by industry, where each box relates to one industry, using the classification into 63 industry used in the CGE model.

Figure 19 - trend in turnover and output in historical series



Source: Elaboration on ISTAT data.

[23] The choice of the period of the series used stems from the need to respect the homogeneity of the national accounts data, which ISTAT reconstructed from 2010 to 2015.

Figure 20 — Change in turnover and output by industry in historical series

Source: Elaboration on ISTAT data.

The elasticity was estimated using the logarithms of the turnover $ln\_Turnover_{a,t}$ variable, regressed on the logarithm of output $ln\_OUT_{a,t}$, including also the lagged variable for turnover, for sub-samples defined by industry a and time t.

$$ln\_Turnover_{a,t} = ln\_Turnover_{a,t-1} + \beta\ ln\_OUT_{a,t} + u_{a,t} \qquad [67]$$

The results, presented in Table 26, show that turnover has an elasticity ($\varepsilon^{\frac{\text{output}}{\text{Turnover}}} = \beta$) of 82.8% to production, as evidenced in the third regression (the other regressions are considered for completeness of information); the constant is not statistically significant, in any of the regressions. Output time lags are also not statistically significant (the first lag is significant in the third regression, but with the opposite sign) and the number of observations, which is not large, is significantly reduced. The statistics for R2 and Wald-Chi2 do not change significantly unless the lagged turnover variable, which has a coefficient close to 1, is added to the regression.

Table 26 — Panel regression between turnover and production

Variable	reg1	reg2	reg3	reg4	reg5
lnProduzione					
--.	0.9016***	0.8803***	0.8278***	0.8673***	0.0043
L1.		0.0553	-0.6444***	0.2338	
L2.			-0.3467	-0.1569	
L3.			0.1617	-0.1552*	
lnTurnover					
L1.			0.9961***		0.9952***
_cons	0.9689	0.6195	0.0597	2.1362	0.0079
N	342	285	171	171	285
r2					
r2_o	0.4316	0.4304	0.9983	0.4221	0.9946
r2_b	0.4311	0.4301	0.9995	0.4217	0.9992
r2_w	0.5886	0.5829	0.5261	0.6994	0.2334
chi2	104.9510	99.0103	1.8e+05	161.3498	6.2e+04
sigma_u	0.8350	0.8464	0.0125	0.8433	0.0207
sigma_e	0.0545	0.0524	0.0310	0.0311	0.0518
rho	0.9958	0.9962	0.1409	0.9986	0.1378

legend: * p<0.05; ** p<0.01; *** p<0.001

Source: Elaboration on ISTAT data.

Having obtained an elasticity $\varepsilon^{\frac{\text{output}}{\text{Turnover}}}$ equal to 0.828, it is therefore possible to attribute to turnover the output *shock* obtained from the CGE model and, therefore, to calculate the companies' final liquidity as the sum of the initial level and adjusted liquidity flows.

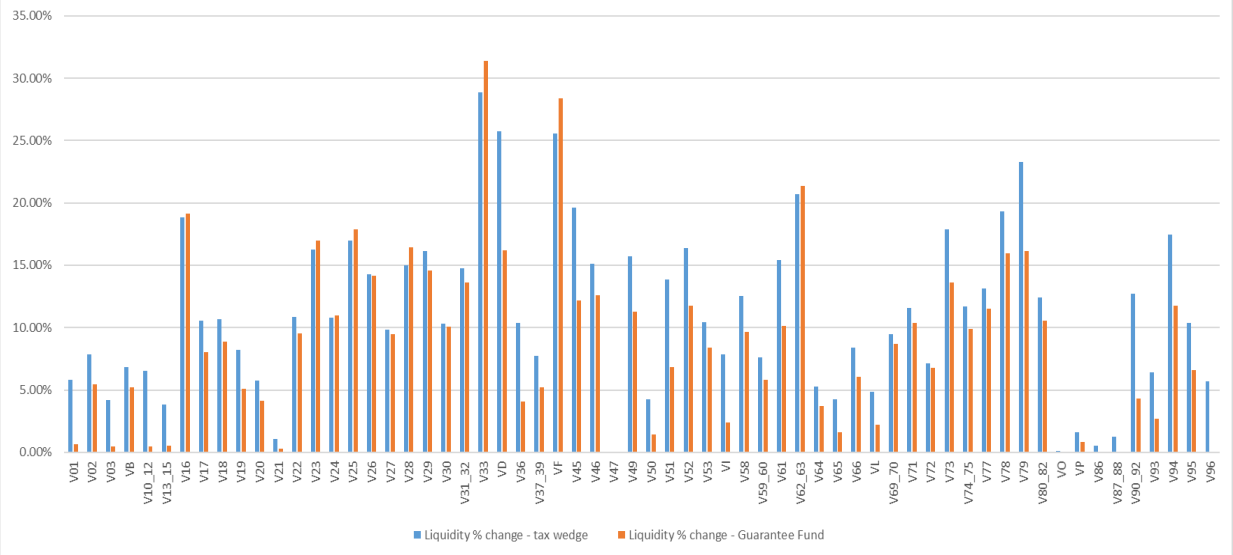
The percentage changes in output can thus be applied to operating income, resulting in a change in turnover which is then transformed into a liquidity gain. Changes in turnover are the exogenous *shock* in a microeconomic model based on the ORBIS micro-data BvD for Italian companies, which reconstruct the flow of liquidity according to turnover.

Labour costs are one of the components of the calculation of liquidity, being a negative component of short-term costs. On the contrary, the raise in State guarantees are expected to affect the second component of liquidity, related to credit component (as described in section 3.3). Therefore, while there is an increase in turnover, the cost components affecting liquidity rise less than if the Government measures were not operational.

As shown in Figure 21, the turnover gains resulting from changes in output - which are on average 2.5 per cent in the case of decontribution and 2.1 per cent in the case of guarantees for obtaining credit - turn into liquidity gains of 13.5 percent and 12.3 percent, respectively. The highest liquidity increase, higher than average, would be registered for both support measures, in

the following sectors: Wood, except furniture (V16), Other non-metallic mineral products (V23), Fabricated metal products, except machinery and equipment (V25), Computer, electronic and optical products (V26), Machinery and equipment n.e.c. (V28), Motor vehicles, trailers and semi-trailers (V29), Furniture, other manufactured goods (V31-32), Repair and installation services of machinery and equipment (V33), Electricity, gas, steam and air-conditioning (VD), Construction (VF), Wholesale trade services, except of motor vehicles and motorcycles (V46), Computer programming, consultancy and related services, information services (V62-63), Advertising and market research services (V73), Employment services (V78), Travel agency, tour operator and other reservation services and related services (V79). This long list includes the sector that, has evidenced in section 3.3, have an initial situation that can be defined as 'critical', having a high ratio of short-term liabilities to the sum of long-term liabilities and net worth.

Figure 21 — Liquidity gains by NACE industries (percentage changes)



Source: Results of financial CGE model applied to ISTAT and ORBIS data.

Considering the results from the point of view of the opportunity of implementing a policy, it is interesting to note that some sectors would benefit more from the tax wedge reduction, while others from the increase in State guarantees, depending on the structure of the sector itself. Thus, it would be appropriate to implement policies at sectoral level, to have higher benefit for the whole economic system.

3.7. Concluding: The better strategy for the short-term is a long period programme

The title of this concluding section recalls what Keynes said 80 years ago, suggesting possible ways of dealing with the economic difficulties of a great war. In synthesis, Keynes thought that the best short-term strategy is to develop a good plan for the medium to long term. As emerged from the simulations, the decontribution or the one-off contribution to firms have positive effects, with a multiplier higher or equal to one, respectively, limited to the period in which they are enacted.

On the other hand, the provision of public guarantees, especially to SMEs is an effective tool to incentivise banks to provide the liquidity needed to cope with a crisis. In major advanced economies (e.g. the United States, Germany, France, Italy, Spain) guarantees cover at least 80 percent of the loan amount. The strong reduction in expected losses encourages banks to lend or to renew existing loans, despite the increased riskiness of borrowers due to the sharp deterioration in the cyclical environment.

As we have seen above, some industries suffer from a structural lack of liquidity, as they are characterised by a lower ratio of net worth to turnover compared to average and, at the same time, higher shares of liabilities in relation to turnover. The effectiveness of the measures implemented depends, of course, on the rate of utilisation by firms of the funds made available. In the present work, they are assumed to be fully utilised, improving the liquidity of firms by 13.5 percent in the case of decontribution and by 12.3 percent in the case of an increase in government guarantees (in this case positive effects also show in subsequent periods). Measures may help to reduce the costs borne by firms, however, the short duration of the incentives and the weak demand at the current juncture may affect their effectiveness.

Moreover, the medium-term effects of public guarantees are controversial and depend both on the duration of the guarantees and on the other economic policy measures undertaken in the

meantime. At the end of a loan assisted by the public guarantee, the bank will be less convenient to renew it if the new loan no longer benefits (or will benefit to a lesser extent) from the guarantee (Gobbi G., Palazzo F., Segura A., 2020). Moreover, more vulnerable companies will find it more difficult to renew their State-guaranteed loans. The government could introduce strong tax incentives for the recapitalisation of companies, for example through the so-called ACE, increasing by this way the resilience of firms, namely for industries which emerged as liquidity constrained from the above analysis. In this respect, the effectiveness of corporate governance systems for the possible expansion of the corporate structure, as well as the availability of resources by current shareholders to carry out the recapitalisation is of particular importance.

To conclude, as highlighted in section 3.6, to have higher benefit for the whole economic system the results of the present analysis show that it would be appropriate to implement policies at sectoral level. Indeed, some sectors would benefit more from the tax wedge reduction, while others from the increase in State guarantees, depending on the structure of the sector itself.

References for Chapter 3

Ahmed I., Socci C., Severini F., Yasser Q. R., Pretaroli R. (2018), Forecasting investment and consumption behavior of economic agents through dynamic computable general equilibrium model, Financial Innovation (2018) 4:7 https://doi.org/10.1186/s40854-018-0091-3

Armington P.S. (1969). A theory of demand for products distinguished by place of production (Une théorie de demande de produits differenciés d'après leur origine). Staff Papers – IMF, 16, 159-178.

Banca d'Italia (2020a), Principali risultati dell'Indagine Straordinaria sulle Famiglie italiane nel 2020, Note Covid-19, June 2020, Banca d'Italia.

Banca d'Italia (2020b), Memoria sul Disegno di legge n. 1925, conversione in legge del decreto-legge 14 agosto 2020, n. 104 recante misure urgenti per il sostegno e il rilancio dell'economia, presentata al Senato della Repubblica 5a Commissione (Programmazione economica e Bilancio), 7th September 2020.

Blundell-Wignall A., Atkinson P., and Hoon Lee S. (2008), The Current Financial Crisis: Causes and Policy Issues, Financial Market Trends, OECD.

Caballero, R. J., Hoshi, T. & Kashyap, A. K. (2008), 'Zombie lending and depressed restructuring in Japan', American Economic Review 98, 1943–77.

Carrasco L.R., Jit M., Chen I.M., Lee V.J., Milne G., Cook A.R., 2013. Trends in parameterization, economics and host behaviour in influenza pandemic modelling: a review and reporting protocol. Emerging Themes in Epidemiology, 10(1):3.

Ciaschini M., Pretaroli R., Severini F., Socci C. (2012). Regional double dividend from environmental tax reform: An application for the Italian economy. Research in Economics, 66, 273-283.

EU Commission Staff Working Document (2020), 'Identifying Europe's recovery needs', accompanying the document: Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - Europe's move: Repair and prepares for the next generation - COM (2020) 456 FINAL

De Pauw D. J.W., Vanrolleghem P. A. (2006), Practical Aspects Of Sensitivity Analysis For Dynamic Models, Journal of Mathematical and Computer Modelling of Dynamical Systems, Volume 12, 2006.

Drechsel, T., Kalemli-Ozcan, S., (2020) A proposal for a negative SME tax, Vox.eu, 24 March 2020.

Gobbi G., Palazzo F., Segura A. (2020), Le misure di sostegno finanziario alle imprese post-covid-19 e le loro implicazioni di medio termine, Banca d'Italia, Note Covid-19, 15 aprile 2020.

Goodhart C.A.E., Sunirand P., Tsomocos D., (2004), A Model to Analyze Financial Fragility: Applications, Journal of Financial Stability, 1, 1–30.

Goodhart, C.A.E., Sunirand, P., Tsomocos, D., (2005), A Model to Analyze Financial Fragility, Economic Theory, 27, 107–142.

Grassini M. (2009), Rowing along the computable general equilibrium modelling mainstream. Stud. Russ. Econ. Dev. 20, 134–146. https://doi.org/10.1134/S1075700709020026

Hsieh, C.-T. & Klenow, P. J. (2009), 'Misallocation and manufacturing TFP in China and India', The Quarterly Journal of Economics 124(4), 1403.

Khan, A. & Thomas, J. K. (2007), Inventories and the business cycle: An equilibrium analysis of (s, s) policies, *American Economic Review* 97(4), 1165-1188.

Lau M. I., Pahlke A., Rutheford T. (2000), Approximating infinite-horizon Models in a Complementarity Format: a primer in Dynamic General Equilibrium Analysis, Journal of Economic Dynamics and Control, Vol.26, pp. 577-609.

Maldonado W.L., Tourinho O.A.F., Valli M. (2008), Financial capital in a CGE model for Brazil: formulation and implications. Available at: https://www.scribd.com/document/48350369/Financial-Capital-in-CGE-model-for-brazil

Prasad E., Rogof K., Wei S.J. (2004), Financial Globalization, Growth and Volatility in Developing Countries (NBER Working Paper n.10942).

OECD (2009), Strategic Response to the Financial and Economic Crisis – Contributions to The Global Effort.

OECD (2020), Corporate sector vulnerability during the COVID-19 outbreak: Assessment and policy responses. OECD policy briefs on Tackling Coronavirus

Pfeiffer P., Roeger W., in't Veld J. (2020), The COVID19-Pandemic in the EU: Macroeconomic transmission and economic policy response, European Economy, Discussion Paper 127 (also published in CEPR, COVID Economics, Vetted and Real-Time Papers, 2020, 30:120-145).

Ramskogler P. (2015), Tracing the origins of the financial crisis, OECD Journal: Financial Market Trends Volume 2014/2.

Saez, E., Zucman, G., (2020), Keeping Business Alive: The Government as Buyer of Last Resort, Mimeo.

Schivardi F, Sette E., Tabellini G. (2020), Identifying the Real Effects of zombie Lending, June 2020.

Scrieciu, S. (2007). How Useful are Computable General Equilibrium Models for Sustainability Impact Assessment. In: C. George and C. Kirkpatrick (eds.) Impact Assessment and Sustainable Development: European Practice and Experience. Cheltenham, Edward Elgar.

Siesto V. (2000), La contabilità nazionale italiana, ed. Il Mulino.

Taylor, L. (1990), Structuralist CGE models, Taylor L. (ed): Socially relevant Policy Analysis: Structural computable general equilibrium models for developing world. Cambridge (MA): MIT press pp. 1-70.

Thurlow J. (2008), A recursive dynamic CGE model and micro-simulation poverty module for South Africa. IFPRI, Washington Available at http://www.tips.org.za/files/2008/Thurlow_J_SA_CGE_and_microsimulation_model_Jan08.pdf

United Nations (2008) System of National Accounts. UNSO, New York.

Van der Werf, E. (2008), Production functions for climate policy modeling: an empirical analysis, Energy Economics, Vol. 30, No. 6.

Verikios G., 2020. The dynamic effects of infectious disease outbreaks: The case of pandemic influenza and human coronavirus. Elsevier Public Health Emergency Collection 71: 100898.

Verikios G., 2016. CGE Models of Infectious Diseases: With a Focus on Influenza. The WSPC Reference on Natural Resources and Environmental Policy in the Era of Global Change, 125-172.

Visco I. (2020), Le prospettive e le necessità di riforma dell'economia italiana, Intervento alla Consultazione nazionale - Roma, 13 giugno 2020.

Appendix 8: Real and Financial Products in the FSAM

Real Products

R01	Products of agriculture, hunting and related services
R02	Products of forestry, logging and related services
R03	Fish and other fishing products; aquaculture products; support services to fishing
RB	Mining and quarrying
R10_12	Food products, beverages and tobacco products
R13_15	Textiles, wearing apparel and leather products
R16	Wood and products of wood and cork, except furniture; articles of straw and plaiting materials
R17	Paper and paper products
R18	Printing and recording services
R19	Coke and refined petroleum products
R20	Chemicals and chemical products
R21	Basic pharmaceutical products and pharmaceutical preparations
R22	Rubber and plastics products
R23	Other non-metallic mineral products
R24	Basic metals
R25	Fabricated metal products, except machinery and equipment
R26	Computer, electronic and optical products
R27	Electrical equipment
R28	Machinery and equipment n.e.c.
R29	Motor vehicles, trailers and semi-trailers
R30	Other transport equipment
R31_32	Furniture; other manufactured goods
R33	Repair and installation services of machinery and equipment
RD	Electricity, gas, steam and air-conditioning
R36	Natural water; water treatment and supply services
R37_39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
RF	Constructions and construction works
R45	Wholesale and retail trade and repair services of motor vehicles and motorcycles
R46	Wholesale trade services, except of motor vehicles and motorcycles
R47	Retail trade services, except of motor vehicles and motorcycles
R49	Land transport services and transport services via pipelines
R50	Water transport services
R51	Air transport services
R52	Warehousing and support services for transportation
R53	Postal and courier services
RI	Accommodation and food services
R58	Publishing services
R59_60	Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services
R61	Telecommunications services
R62_63	Computer programming, consultancy and related services; information services
R64	Financial services, except insurance and pension funding
R65	Insurance, reinsurance and pension funding services, except compulsory social security
R66	Services auxiliary to financial services and insurance services
RL	Real estate services
R69_70	Legal and accounting services; services of head offices; management consulting services
R71	Architectural and engineering services; technical testing and analysis services
R72	Scientific research and development services
R73	Advertising and market research services
R74_75	Other professional, scientific and technical services; veterinary services
R77	Rental and leasing services
R78	Employment services
R79	Travel agency, tour operator and other reservation services and related services
R80_82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services
RO	Public administration and defence services; compulsory social security services
RP	Education services
R86	Human health services
R87_88	Social work services
R90_92	Creative, arts and entertainment services; library, archive, museum and other cultural services; gambling and betting services
R93	Sporting services and amusement and recreation services
R94	Services furnished by membership organisations
R95	Repair services of computers and personal and household goods
R96	Other personal services
RT	Services of households as employers; undifferentiated goods and services produced by households for own use

	Financial Products
1	Monetary gold and SDRs…….
2	Currency and transferable deposits, with MFIs
3	Currency and transferable deposits, with other residents
4	Currency and transferable deposits, with rest of the world
5	Other deposits, with MFIs
6	Other deposits, with other residents
7	Other deposits, with rest of the world
8	Short-term securities, with general government
9	Short-term securities, with other residents
10	Short-term securities, with rest of the world
11	Bonds, issued by MFIs
12	Bonds, issued by central grovernment: CCTs
13	Bonds, issued by central government: other
14	Bonds, issued by local government
15	Bonds, issued by other residents
16	Bonds, issued by rest of the world
17	Derivatives
18	short-term loans, of MFIs
19	short-term loans, of other financial corporations
20	short-term loans, of other residents
21	short-term loans, of rest of the world
22	Medium and long-term loans, of MFIs
23	Medium and long-term loans, other financial corporations
24	Medium and long-term loans, general government
25	Medium and long-term loans, rest of the world
26	Shares and other equity, issued by residents
27	Shares and other equity, issued by rest of the world
28	Mutual fund shares, issued by residents
29	Mutual fund shares, issued by rest of the world
30	net equity of households
31	prepayment and other claims
32	Trade credits
33	Other

Appendix 9: Parameters, variables and equations of the dynamic model

Parameters and variables

t	Time index
T	Last time period
i	Commodities by row
j	Commodities by column
is	Institutional sectors
priv	Households, Firms
gov	Public Administration
row	Rest of the world
$Q_{i,t}$	Output by commodity
$P_{i,t}$	Price of goods
δ_i^{dom}	Cost function - share of domestic goods on total production
d_i^{dom}	Share of domestic goods on total production
$Pdom_{j,t}$	Prices of domestic goods
$Qdom_{j,t}$	Quantity of domestic goods
$Tax_{j,t}^{out}$	Taxes on output by commodity
$Pm_{j,t}$	Prices of imports from the rest of the world
$M_{j,t}$	Quantity of imports from the rest of the world
$\sigma_{Q_{dom}}$	Elasticity of substitution between domestic and imported goods
$\rho_{Q_{dom}}$	Exponent of the CES production function linked to $\sigma_{Q_{dom}}$
$Pbi_{j,t}$	Prices of intermediate goods
$BI_{j,t}$	Quantities of intermediate goods
$Tax_{j,t}^{act}$	Taxes on activities
$Pva_{j,t}$	Prices of value added
$VA_{j,t}$	Quantities of value added
δ_j^D	Share of intermediate goods on total domestic production
σ_D	Elasticity of substitution between intermediate goods and value added
ρ_D	Exponent of the CES production function linked to σ_D
$P_{i,t}$	Average price on goods market from the market clearing condition
$\delta_{i,j}^{BI}$	Cost share of intermediate goods on their total cost
σ_{BI}	Elasticity of substitution between intermediate goods
PL_t	Price of labor
PK_t	Price of capital
δ_j^v	Share of labour on the total of primary factors
σ_v	Elasticity of substitution between labour and capital
δ_j^L	Share of labour costs on value added
$L_{j,t}^d$	Labor endowment
$K_{j,t}^d$	Capital endowment
δ_i^M	Share of domestic production on total production
$pmw_{i,t}$	Price of foreign goods
exr_t	Nominal exchange rate
$PLfin_{i,t}$	Price of financial liabilities
$PAfin_{j,t}$	Price of financial assets

$Lfin_{i,t}$	Quantity of financial liabilities
$Afin_{j,t}$	Quantity of financial assets
$Lfin_t^{is}$	Total Financial Liabilities for each Institutional Sector
$Afin_t^{is}$	Total Financial Assets for each Institutional Sector
Y^{is}	Primary income by Institutional sectors
ty_{inc}	Implicit income tax rates
tr	Implicit rates of transfers among Institutional Sectors
$trcap_{tras}^{priv}$	Capital transfers among Institutional Sectors
tq_j^{out}	Implicit tax rates on output
tq_j^{act}	Implicit tax rates on activities
γ_{out}^{gov}	Share of taxes on output
γ_{act}^{pub}	Share of taxes on activity
U^{is}	Utility of Institutional sectors
C_t^{is}	Consumption of Institutional sectors
S_t^{is}	Savings of Institutional sectors
Y_t^{is}	Disposable income
YF_t^{is}	Primary income
Pu^{is}	Utility price
Pc_t^{is}	Price of consumption by institutional sector
P_t^I	Price of investment
δ_i^C	Share of consumption of the ith good on total consumption for each Institutional sector
σ_C	Elasticity of substitution among goods in the consumption basket
$c_{i,t}^{is}$	Quantity of each good consumed by Institutional sector
δ_i^I	Investment share of the ith good on total investments
σ_I	Elasticity of substitution among goods in the investment basket
$I_{i,t}$	Quantity of investment by goods
e_{it}	Export demand by goods from Rest of the World
δ_i^E	Export share of ith goods on total exports to the rest of the World
σ_E	Elasticity of substitution among goods exported in the rest of the World basket
π_t	Foreign inflation rate
r	Interest rate
τ	Capital depreciation rate
g	Steady state growth path
Ks_t^{priv}	Capital endowment by institutional sector
rk_t	Return on capital
ρ	Parameter of intertemporal preference
$alpha(t)$	Coefficient of intertemporal preference in consumption
σ_{fin}	Elasticity of substitution among financial goods

Equations

$$Q_{i,t} = \left(d_i^{dom} Qdom_{i,t}^{\rho_{Q_{dom}}} + \left(1 - d_i^{dom}\right) M_{i,t}^{\rho_{Q_{dom}}}\right)^{\frac{1}{\rho_{Q_{dom}}}}$$

$$P_{i,t}\left(1 - Tax_{i,t}^{out}\right) = \left(\delta_i^{dom} Pdom_{i,t}^{\left(1-\sigma_{Q_{dom}}\right)} + \left(1 - \delta_i^{dom}\right) Pm_{i,t}^{\left(1-\sigma_{Q_{dom}}\right)}\right)^{\frac{1}{1-\sigma_{Q_{dom}}}}$$

$$Qdom_{j,t} = \left(d_j^D BI_{j,t}^{\rho_D} + \left(1 - d_j^D\right) VA_{j,t}^{\rho_D}\right)^{\frac{1}{\rho_D}}$$

$$\mathrm{Pdom_{j,t}}\left(1 - \mathrm{Tax_{j,t}^{act}}\right) = \left[\sum_{\mathrm{i}} \delta_{\mathrm{i,j}}{}^{\mathrm{D}} \mathrm{Pbi_{j,t}}^{\left(1-\sigma_{\mathrm{j}}\right)} + \sum_{\mathrm{i}} \left(1 - \delta_{\mathrm{i,j}}{}^{\mathrm{D}}\right) \mathrm{Pva_{j,t}}^{\left(1-\sigma_{\mathrm{j}}\right)}\right]^{\frac{1}{\left(1-\sigma_{\mathrm{j}}\right)}}$$

$$bi_{j,t} = \delta_j^D Qdom_{j,t} \left(\frac{Pdom_{j,t}}{Pbi_{j,t}}\right)^{\sigma_D}$$

$$VA_{j,t} = \left(1 - \delta_j^D\right) Qdom_{j,t} \left(\frac{Pdom_{j,t}}{Pva_{j,t}}\right)^{\sigma_D}$$

$$Pbi_{j,t} = \sum_i \left(\delta_{i,j} P_{j,t}^{\left(1-\sigma_{BI}\right)}\right)^{\frac{1}{1-\sigma_{BI}}}$$

$$BI_{i,j,t} = \delta_{i,j}^{BI} Qdom_{j,t} \left(\frac{Pbi_{j,t}}{P_{i,t}}\right)^{\sigma_{BI}}$$

$$Pva_{j,t} = \left(\delta_j^v \cdot {PL_t}^{1-\sigma_v} + \left(1 - \delta_j^v\right) \cdot {PK_t}^{1-\sigma_v}\right)^{\frac{1}{1-\sigma_v}}$$

$$L_{j,t}^d = \delta_j^L VA_{j,t} \left(\frac{Pva_{j,t}}{PL_t}\right)^{\sigma_v}$$

$$K_{j,t}^d = \left(1 - \delta_j^L\right) VA_{j,t} \left(\frac{Pva_{j,t}}{PK_t}\right)^{\sigma_v}$$

$$Q_{j,t} = \left(\sum_i d_{j,i}^q q_{i,j,t}\right)^{\frac{1}{1-\sigma_q}}$$

$$Pq_{dom,i,t} = \left(\sum_j d_{i,j}^q {Pdom_{j,t}}^{\left(1-\sigma_q\right)}\right)^{\frac{1}{1-\sigma_q}}$$

$$M_{i,t} = \left(1 - \delta_i^M\right) Q_{i,t} \left(\frac{P_{i,t}}{Pm_{i,t}}\right)^{\sigma_{Qdom}}$$

$$Pm_{i,t} = pmw_{i,t}(1 + \pi_t)/exr_t$$

$$PLfin_{i,t} = \sum_j \left(\delta_{i,j}^{fin} P_{j,t}^{(1-\sigma_{fin})}\right)^{\frac{1}{1-\sigma_{fin}}}$$

$$PAfin_{j,t} = \sum_i \left(\delta_{i,j}^{fin} P_{j,t}^{(1-\sigma_{fin})}\right)^{\frac{1}{1-\sigma_{fin}}}$$

$$Lfin_{i,t} = \delta_i^{fin} Qfin_{i,t} \left(\frac{Pfin_{i,t}}{P_{i,t}}\right)^{\sigma_{fin}}$$

$$Afin_{j,t} = \delta_j^{fin} Qfin_{j,t} \left(\frac{Pfin_{j,t}}{P_{i,t}}\right)^{\sigma_{fin}}$$

$$YF_t^{households} = L_t^{households} pl_t + K_t^{households} rk_t + \sum_j Lfin_{j,t}^{households} PLfin_{j,t}$$

$$YF_t^{firms} = K_t^{firms} rk_t + \sum_j Lfin_{j,t}^{firms} PLfin_{j,t}$$

$$Y_t^{priv} = YF_t^{priv}\left(1 - \sum_{inc} ty_{inc}^{priv} - \sum_{tras} tr_{tras}^{priv}\right) + \sum_{priv}\sum_{tras} tr_{tras}^{priv} YF_t^{priv} + \sum_{priv}\sum_{tras} trcap_{tras}^{priv} YF_t^{priv} + \sum_g Tr_t^g + Tr_{row}^t$$

$$Y^{priv} = \sum_t Y_t^{priv}\left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{priv} PK_{tfirst} - KS_T^{priv} PK_T \left(\frac{1}{1+r}\right)^T$$

$$PK_t = (1-\tau) PK_{t+1} + rk_t$$

$$I_{tfirst} = \frac{(\tau + g)\sum_{priv} Ks_{tfirst}^{priv} rk_{tfirst}}{\tau + r}$$

$$\tau = \frac{g\sum_{priv} Ks_{tfirst}^{priv} rk_{tfirst} - r\, I_{tfirst}}{I_{tfirst} - Ks_{tfirst}^{priv}\, rk_{tfirst}}$$

$$YF_t^{gov} = Ks_t^{gov} rk_t + \sum_j fin_{j,t}^{gov} Pfin_{j,t} + \lambda_{act}^{gov}\sum_{act}\sum_j \left(ta_j^{act} Pdom_{j,t} Q_{j,t}\right) + \lambda_{out}^{gov}\sum_{out}\sum_i \left(tq_i^{out} P_{i,t} Q_{i,t}\right) + \sum_{priv}\sum_{inc} ty_{inc}^{priv} YF_t^{priv}$$

$$Y_t^{gov} = YF_t^{gov} - \sum_{gov} Tr^{gov} - Tr^{row}$$

$$Y^{gov} = \sum_t Y_t^{gov}\left(\frac{1}{1+r}\right)^t + KS_{tfirst}^{gov} PK_{tfirst} - KS_T^{gov} PK_T \left(\frac{1}{1+r}\right)^T$$

$$maxU^{priv} = \sum_{t=0}^{T} \left[\left(\frac{1}{1+\rho} \right)^t C_t^{priv} \right]$$

$$C_t^{priv} = \sum_i c_{i,t}^{priv}$$

s.t.

$$\sum_{priv} C_t^{priv} = \sum_i Q_{i,t} - \sum_i \sum_j bi_{i,j,t} - \sum_{gov} G_g - \sum_i I_{i,t} - \sum_i e_{i,t}$$

$$KS_{t+1} = KS_t(1-\tau) + I_t$$

$$\sum_t \left(\frac{1}{1+\rho} \right)^t C_t^{priv} Pc_t^{priv} = Y^{priv}$$

$$Pu^{priv} = \prod_t \left(\frac{Pc_t^{priv}}{1+r} \right)^{alpha(t)}$$

$$alpha(t) = \frac{\left(\frac{1+g}{1+r} \right)^{t-1}}{\sum_t \left(\frac{1+g}{1+r} \right)^{t-1}}$$

$$C_t^{priv} = \frac{U^{priv}}{1+r} \left(\frac{Pu_{priv}}{Pc_t^{priv}(1+r)} \right)^{alpha(t)}$$

$$Pc_t = \left(\sum_i \delta_i^C \, P_{i,t}^{(1-\sigma_C)} \right)^{\frac{1}{1-\sigma_C}}$$

$$c_{i,t}^{priv} = \delta_i^C U^{priv} \left(\frac{Pc_t}{P_{i,t}} \right)^{\sigma_C}$$

$$U^{gov} = \sum_t \left(G_t^{gov} + def_t^{gov} \right)$$

$$P_t^I = \left(\sum_i \delta_i^I \, P_{i,t}^{(1-\sigma_I)} \right)^{\frac{1}{1-\sigma_I}}$$

$$I_{i,t} = \delta_i^I \, I_t \left(\frac{P_t^I}{P_{i,t}} \right)^{\sigma_I}$$

$$e_{i,t} = \delta_i^E Y_{tfirst}^{row} (1+g^{row})^t \left(\frac{pmw_i(1+\pi_t)/exr_t}{P_{i,t}} \right)^{\sigma_E}$$

$$Q_{i,t} = \sum_{j} bi_{i,j,t} + \sum_{hh} C_{i,t}^{hh} + \sum_{pub} G_{i,t}^{pub} + I_{i,t} + E_{i,t}^{row}$$

$$\sum_{is} S_t^{is} + \sum_{is} \Delta L_t^{is} = \sum_{i} I_{i,t} + \sum_{is} \Delta A_t^{is}$$

$$\sum_{i} M_{i,t} + \sum_{priv} tr^{priv,row} YF_t^{priv} + \sum_{gov} Tr_t^{gov,row} + L^{row} PL_t + K^{row} PK_t = \sum_{i} e_{it} + \sum_{row} Tr^{priv,row} + \sum_{row} Tr_t^{gov,row} + S_t^{row}$$

$$\sum_{is} S_t^{is} + \sum_{is} \Delta Lfin_t^{is} = \sum_{i} I_{i,t} + \sum_{is} \Delta Afin_t^{is}$$

$$L_t^d = L_t^s$$

$$K_t^d = K_t^s$$

$$KS_{t+1} = (1 - \tau) KS_t + I_t$$

$$\frac{I_T}{I_{T-1}} = \frac{Q_T}{Q_{T-1}}$$

Appendix 10. Sensitivity analysis – Chapter 3

Sensitivity analysis, as already explained in Appendix 7 to Chapter 2, is carried out using the methodology of De Pauw and Vanrolleghem (2006), which is based on the 'local level' analysis, tested using the final difference method, according to the following formula:

$$\frac{\partial y_i}{\partial \sigma_v} = \lim_{\Delta\sigma_v \to 0} \frac{y_i(t, \sigma_v + \Delta\sigma_v) - y_i(t, \sigma_v)}{\Delta\sigma_v}$$

where y_i represents the vector of the interest variables of which we want to test the sensitivity, whereas σ_v represents the elasticity of capital and labour.

Sensitivity analysis allows quantifying the response of the model to the exogenous parameters, i.e. how sensitive the model is to changes in the parameters themselves. The sensitivity analysis is conducted on the main parameter affecting the production function, i.e. the elasticity between capital and labour, which, in this model, is 0.5128, according to the methodology followed by Van Der Werf (2008).

For the decontribution hypothesis, the following table indicate no major changes in results when the elasticity of capital and labour is varied:

Table 27 – Sensitivity analysis- Temporary reduction of employers' social security contribution by 1 percent of GDP

$\sigma_v - (\sigma_v/2)$					
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.503	0.000	0.000	0.000	0.000
Households consumption	0.000	0.000	0.000	0.000	0.000
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	11.167	0.000	0.000	0.000	0.000
Exports	0.000	0.000	0.000	0.000	0.000
Imports	2.581	0.000	0.000	0.000	0.000
Employment	2.101	0.000	0.000	0.000	0.000
GDP deflator	0.000	0.000	0.000	0.000	0.000
σ_v					
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.400	0.000	0.000	0.000	0.000
Households consumption	0.000	0.000	0.000	0.000	0.000
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	10.611	0.000	0.000	0.000	0.000
Exports	0.000	0.000	0.000	0.000	0.000
Imports	2.572	0.000	0.000	0.000	0.000
Employment	2.121	0.000	0.000	0.000	0.000
GDP deflator	0.000	0.000	0.000	0.000	0.000
$\sigma_v + (\sigma_v/2)$					
Real Variables	***t1***	***t2***	***t3***	***t4***	***t5***
Real GDP	1.322	0.000	0.000	0.000	0.000
Households consumption	0.000	0.000	0.000	0.000	0.000
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	10.187	0.000	0.000	0.000	0.000
Exports	0.000	0.000	0.000	0.000	0.000
Imports	2.565	0.000	0.000	0.000	0.000
Employment	2.139	0.000	0.000	0.000	0.000
GDP deflator	0.000	0.000	0.000	0.000	0.000

Even in the case of an increase in public guarantees, as shown in Table 25, the changes retain the same time profile and the same effects.

Under both simulated assumptions, changes in results are limited compared to the variation in elasticity: Compared with a change of σ_v of 50 percent, there are very small changes, with the exception of exports, which under

the assumption of government guarantees is driven by a rise in deflators. It can be seen that the variables show greater variation when the elasticity is reduced by 50 percent, rather than when the elasticity itself is increased by 50 percent.

Table 28 – Sensitivity analysis - Raise in State guarantees to bank loans by 1 percent of GDP

$\sigma_v - (\sigma_v / 2)$					
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.033	-0.044	-0.050	-0.057	-0.063
Households consumption	-0.135	-0.140	-0.145	-0.150	-0.156
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	9.045	0.837	0.826	0.818	0.810
Exports	-0.411	-0.421	-0.432	-0.444	-0.455
Imports	2.140	0.100	0.093	0.087	0.080
Employment	1.669	0.030	0.023	0.016	0.009
GDP deflator	0.664	0.682	0.702	0.724	0.745
σ_v					
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.265	0.028	0.022	0.017	0.011
Households consumption	-0.126	-0.130	-0.135	-0.140	-0.145
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	10.260	1.132	1.120	1.112	1.106
Exports	-0.296	-0.304	-0.312	-0.321	-0.330
Imports	2.259	0.170	0.165	0.159	0.154
Employment	1.738	0.089	0.083	0.077	0.072
GDP deflator	0.486	0.500	0.516	0.533	0.550
$\sigma_v + (\sigma_v / 2)$					
Real Variables	**t1**	**t2**	**t3**	**t4**	**t5**
Real GDP	1.518	0.089	0.084	0.079	0.075
Households consumption	-0.120	-0.124	-0.128	-0.132	-0.137
Public expenditure	0.000	0.000	0.000	0.000	0.000
Investment	11.619	1.411	1.398	1.389	1.384
Exports	-0.232	-0.238	-0.245	-0.252	-0.259
Imports	2.347	0.216	0.212	0.207	0.203
Employment	1.778	0.125	0.120	0.115	0.111
GDP deflator	0.385	0.396	0.409	0.423	0.437