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Taxing income or consumption: macroeconomic and distributional effects for Italy

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Executive summary

Reform proposals of the tax and benefits system are often at the centre of political debates. Taxes affect incentives to work, save and consume. They significantly modify the disposable income of households and thus address or exacerbate equity concerns, and are needed to fund public expenditure. Especially with the effects of the Covid-19 pandemic, governments face the necessity of boosting economic recovery and growth, while taking into account equity concerns and public budget constraints. When looking for a new design of the tax and benefits system that aims at enhancing both efficiency and equity, a consensus emerges to lower the tax burden on labour income. This is due to the fact that tax rates on labour income are high compared to the rates on consumption and the empirical literature suggests that labour and corporate income taxation are associated more often with poorer economic performance, compared to consumption and property taxation (e.g. Arnold et al., 2011).

While the idea of a reduction of labour income taxes via a “tax shift” onto other, supposedly more efficient tax types seems to enjoy widespread consensus among practitioners and possibly among the general population in Italy, it is not yet clear what such a reform should look like. A revenue-neutral reform that would reduce personal income tax (PIT) rates and compensate lost revenues via an increase in the general value-added tax (VAT) rate can hardly preserve progressivity and will likely affect relevant groups of taxpayers differently. Also, reductions in the PIT can be achieved both by changing the tax rates or the no-tax allowance (i.e. a minimum income threshold not subject to PIT), which also brings different impacts in terms of equity and of the distribution of work incentives across the income quantiles. Finally, such reforms may cause general equilibrium and dynamic effects which should also be taken into account.

The contribution of this paper is to build an analysis of potential reforms in Italy which jointly accounts for general equilibrium effects, effects across time, heterogeneous taxpayers who are differentiated by age and income levels with high granularity, and taking into account as much as possible the complex details of the real Italian tax and benefits system. We achieve this by means of an overlapping-generations computable general-equilibrium model paired with a microsimulation model of the tax and benefits system. We are thus able to overcome the limitations of the existing literature which either provides a purely microeconomic static analysis of reforms (thus disregarding any general equilibrium or dynamic effect), or an analysis based on DSGE modelling techniques, which is unable to account for the existence of many heterogeneous taxpayers and relies on stylized representations of the tax system (thus missing many of the complexities and subtle interactions of real-world tax and benefits systems). The presence of the overlapping generations on the household side breaks the Ricardian equivalence and enables a more realistic modelling of fiscal policy in the long run. Our analysis focuses on two hypothetical reform proposals that reduce PIT and obtain budget parity by increasing consumption taxes. The two studied reforms differ in the way PIT reductions are achieved: via a cut of statutory tax rates across the board or via an increase of the no-tax allowance.

Our results suggest that a tax shift reform in Italy should prioritize cutting personal income tax rates, rather than extending the no-tax allowance. More importantly and perhaps counter-intuitively, they point to the possibility that behavioural reactions may make the reform only mildly regressive, after accounting for dynamic and general equilibrium effects due in particular to increased labour supply of low-income households and overall savings. This result challenges a recurrent objection to such kind of tax shift policies, namely that they are necessarily regressive. While the latter may be true when limiting the analysis to a static representation of a national economy, our results point to large efficiency gains which are heterogeneous both across age and income and compensate for a large part of the reduction in progressivity of the tax schedule in the lower income deciles.

Taxing income or consumption: macroeconomic and distributional effects for Italy

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Abstract

We study a set of tax reforms introducing a budget-neutral tax shift in Italy, from labour income to consumption taxes. To this end we use a microsimulation model to provide the output with which to estimate the parameters of tax functions in an overlapping-generations computable general equilibrium model. In doing so we make marginal and average tax rates bivariate non-linear functions of capital income and labour income. The methodology allows for the representation of the non-linearities of the tax and social benefit system and interactions between capital and labour incomes. The linked macro model then simulates labour supply, consumption and savings in a dynamic setting, thus accounting for behavioural and general equilibrium effects within a life-cycle optimization framework. Our simulations show that a tax shift made by cutting personal income tax rates might bring significant efficiency gains in Italy, with limited regressive effects, notwithstanding the revenue-compensating increase in consumption taxes.

JEL classification: H24, H31, D15, D58.

Keywords: computable general equilibrium, overlapping generations, taxation, microsimulation, Italy, tax shift.

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The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They should not be attributed to any of the affiliated institutions.

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1 Introduction

Reform proposals of the tax and benefits system are often at the centre of political debates. Taxes affect incentives to work, save and consume. They significantly modify the disposable income of households and thus address or exacerbate equity concerns, and are needed to fund public expenditure. Especially with the effects of the COVID-19 pandemic, governments face the necessity of boosting economic recovery and growth, while taking into account equity concerns and public budget constraints. When looking for a new design of the tax and benefits system that aims at enhancing both efficiency and equity, a consensus emerges to lower the tax burden on labour income. This is due to the fact that tax rates on labour income are high compared to the rates on consumption and the empirical literature suggests that labour and corporate income taxation are associated more often with poorer economic performance, compared to consumption and property taxation (e.g. Arnold et al., 2011).

Specifically in the context of Italy, international organizations like the IMF and the European Commission have repeatedly recommended to the national authorities a reduction in labour taxation through an increase in property and consumption taxes (see for example Andrieu et al., 2018, European Commission, 2019). Workers in Italy face a larger tax wedge than other Eurozone members (see e.g. Cammeraat and Crivelli, 2020), when the wedge is computed also accounting for social security contributions and regional taxes on labour income. Italy is one of the European countries with the lowest employment rates, the lowest female participation to the workforce, and the highest unemployment rates among the young and in lagging-behind regions. Total factor productivity in Italy has also been stagnating since mid-1990s (Andrieu et al., 2018, OECD, 2019). Consequently, a reform that would lower marginal tax rates on labour income might spur employment and bring significant efficiency gains.

While the idea of a reduction of labour income taxes via a “tax shift” onto other, supposedly more efficient tax types seems to enjoy widespread consensus among practitioners and possibly among the general population in Italy, it is not yet clear what such a reform should look like. A revenue-neutral reform that would reduce personal income tax (PIT) rates and compensate lost revenues via an increase in the general value-added tax (VAT) rate can hardly preserve progressivity and will likely affect relevant groups of taxpayers differently. Also, reductions in the PIT can be achieved both by changing the tax rates or the no-tax allowance (i.e. a minimum income threshold not subject to PIT), which also brings different impacts in terms of equity and of the distribution of work incentives across the income quantiles. Finally, such reforms may cause general equilibrium and dynamic effects which should also be taken into account.

The contribution of this paper is to build an analysis of potential reforms in Italy which jointly accounts for general equilibrium effects, effects across time, heterogeneous taxpayers who are differentiated by age and income levels with high granularity, and taking into account as much as possible the complex details of the real Italian tax and benefits system. We achieve this by means of an overlapping-generations computable general-equilibrium model

paired with a microsimulation model of the tax and benefits system. We are thus able to overcome the limitations of the existing literature which either provides a purely microeconomic static analysis of reforms (thus disregarding any general equilibrium or dynamic effect), or an analysis based on DSGE modelling techniques, which is unable to account for the existence of many heterogeneous taxpayers and relies on stylized representations of the tax system (thus missing many of the complexities and subtle interactions of real-world tax and benefits systems). The presence of the overlapping generations on the household side breaks the Ricardian equivalence and enables a more realistic modelling of fiscal policy in the long run. Our analysis focuses on two hypothetical reform proposals that reduce PIT and obtain budget parity by increasing consumption taxes. The two studied reforms differ in the way PIT reductions are achieved: via a cut of statutory tax rates across the board or via an increase of the no-tax allowance.

Our results suggest that a tax shift reform in Italy should prioritize cutting personal income tax rates, rather than extending the no-tax allowance. More importantly and perhaps counter-intuitively, they point to the possibility that behavioural reactions may make the reform only mildly regressive, after accounting for dynamic and general equilibrium effects due in particular to increased labour supply of low-income households and overall savings. This result challenges a recurrent objection to such kind of tax shift policies, namely that they are necessarily regressive. While the latter may be true when limiting the analysis to a static representation of a national economy, our results point to large efficiency gains which are heterogeneous both across age and income and compensate for a large part of the reduction in progressivity of the tax schedule in the lower income deciles. Put in other words, the reform shows the potential to achieve a Pareto-improvement in the sense that all age groups and ability types see a rise in consumption with small cost in terms of increased inequality (a small social cost that, in principle, could be compensated by a simultaneous reform of social benefits, which we however did not attempt to design and simulate).

The paper is structured as follows. Section 2 summarizes past literature from both the points of view of theory and applied economic analysis. Section 3 focuses on Italy, both its current economic situation and on research employing simulation tools to evaluate PIT reforms. Sections 4 and 5 describe in more detail our methodology by first presenting the main features of EDGE-M3 overlapping-generations macro model we employ and then explaining the way the EUROMOD microsimulation model is linked to it.¹ Section 6 describes the model baseline and Section 7 explains the two tax policy simulations performed. Section 8 presents the results from the simulations of our two reform scenarios. Section 9 summarizes the main conclusions and hints at prospects for future research.

2 Literature review

Economic theory has long affirmed the concept that taxes on labour and capital income are less growth-friendly than the alternatives levied on immovable property and consumption

¹EDGE-M3 is an abbreviation for European Dynamic General Equilibrium Micro-Macro Model.

(e.g. Mankiw et al., 2009). The intuition is that production factors such as labour and capital may be more reactive to changes in relative prices (such as those induced by tax reforms) and cause cumulative distortions in time, for instance in the case of a reduction in aggregate savings which would then also reduce labour productivity in the long run. An income tax burdens future consumption to a greater degree than current consumption (Auerbach, UC Berkeley 2006, retrieved from <https://escholarship.org/uc/item/444479wh>), thus it is intrinsically more distortionary compared to a consumption tax. A consequence is that any tax on the returns to factors subject to accumulation (i.e. capital, including human capital) should converge to zero in the long-run optimum (Milesi-Ferretti and Roubini, 1998, Judd, 1999). These theoretical results however hinge on several simplifying assumptions and, when complexity is added, some prescriptions may change, for instance if tax evasion is taken into account. The heterogeneity of the population of taxpayers may also affect optimal tax design. For instance (also relevant for the discussion to follow) Erosa and Gervais (2002) show that, in a setting with overlapping generations, the optimality of uniform taxation of consumption across lifetime depends on preferences and the way productivity changes with age. Empirical evidence based on macroeconomic data seems to confirm that from the perspective of economic growth, income taxes are less desirable, see: Kneller et al. (1999), Myles (2009), Arnold et al. (2011), Gemmell et al. (2014) (a study which partly challenges these results is Baiardi et al., 2019).

Even accepting that taxes on capital and labour income should be reduced in favour of a tax shift onto consumption-based taxation, the question remains as to how to manage the equity trade-off arising from regressive taxes such as a uniform VAT. Because of the existence of bequests and possibly of other roles for accumulated wealth (e.g. as an insurance device against generic risks), savings cannot be fully considered as postponed consumption, hence the desirability for some degree of tax progressivity. Lehmann et al. (2016) argue that a more progressive tax schedule may increase overall employment, because low-income households have more elastic labour supply. Thus, it could prove efficiency-enhancing particularly in countries (like Italy) with low participation rates of the workforce. Starting from an existing tax system featuring a progressive PIT and a VAT, an important question is how to best design a tax shift from the former to the latter which brings the desired efficiency gains while also accounting for equity concerns.

Shifting the burden away from labour taxation to more pro-growth taxes has been on the policy agenda of some EU countries for many years now. In light of its policy relevance, there has been a growing number of empirical and simulation studies on this topic. This area of research typically employs either microsimulation models coupled with structural models of labour supply (and more rarely, equilibrium models of labour demand), or general equilibrium models with some degree of agent heterogeneity. Microsimulation models allow to represent the complexity and full heterogeneity of the population of taxpayers in a given country at a given point in time. Thus, they are particularly powerful in providing analysis of the distributional impact of a reform. General equilibrium models are particularly suitable to study long-term effects of a reform and its potential for efficiency gains. In the remainder of this section, we provide an overview of empirical studies done with the use of microsimulation models followed by a literature overview of the general equilibrium macro

models in the area and papers employing linked micro-macro models. Similar studies having Italy as their focus will be reviewed in the next section.

Using microsimulation analysis, Decoster et al. (2010) study the redistributive effects of fiscal devaluation² in five European countries (Belgium, Greece, Hungary, Ireland, UK) consisting in a cut in social security contributions financed by an increase in standard VAT rate. The simulation shows that less well-off groups in society are adversely affected while the richer ones benefit from the shift. O'Donoghue et al. (2004) also find a regressive impact in 12 OECD countries. Thomas and Picos-Sanchez (2012) simulate a revenue-neutral shift of 5 percent of the social security contribution burden to VAT and find increasing work incentives particularly for low-income earners across several European countries. Pestel and Sommer (2017) examine the equity-efficiency trade-off that arises in Germany from shifting taxes away from labour income to consumption. Stepwise increases in the VAT rate are compensated by revenue-neutral reductions in income-related taxes. They find, not surprisingly, a regressive impact of such a tax shift in the short run. In addition they prove that, when accounting for labour supply adjustments, the adverse distributional impact persists for PIT reductions, while the overall effects on inequality and progressivity become smaller when payroll taxes are reduced. This is partly due to increases in aggregate labour supply, resulting from higher work incentives. Due to the strongly progressive design of the personal income tax schedule, a compensated reduction of personal income taxes leads to a higher level of inequality. Low-income earners, pensioners and unemployed are found to be the main losers from the policy.

Switching now to general equilibrium models, Nishiyama and Smetters (2005) study a reform in which a progressive income tax is replaced by a flat consumption tax. They use an overlapping-generations model in which agents face idiosyncratic wage shocks and mortality risk. They find that the effects of the tax reform crucially depend on the insurability of the wage shocks. Without wage shocks, adopting a flat consumption tax produces a positive and significant amount of extra resources. However and more realistically, with uninsurable wage shocks, adopting a flat consumption tax produces an efficiency loss. Lehmus (2011) analyses the effects of a tax reform that shifts tax burden from labour to consumption with the use of a dynamic general equilibrium model with heterogeneous agents for Finland. He studies the macroeconomic and income and wealth distribution effects of such reform, finding that a tax reform that replaces progressive labour taxes with a flat-rate consumption tax leads to a significant rise in capital accumulation, a negligible change in labour supply and gross labour income distribution, but a relatively considerable increase in wealth concentration. Lizarazo et al. (2017) assesses the macroeconomic and distributional impact of personal income tax reforms in the U.S. with the use of a DSGE model with household heterogeneity. Following other authors (e.g. Benabou, 2002, Heathcote et al., 2016 and Guner et al., 2016) federal income taxes are introduced in the model using a parametric tax function, which captures the effective tax rates paid at different levels of income. They find that the shift from direct

²“Fiscal devaluation” is a revenue-neutral shift in the tax structure (e.g. from employers’ social security contributions toward value-added and property taxes) with positive effects on output (see e.g. Andrieu et al. (2021))

to indirect tax has positive impact on growth. Tax cuts for higher income groups tend to have a stronger aggregate impact than tax cuts for the middle class. However, such a tax reduction generates negative distributional effects. de Castro Fernández et al. (2018) use the European Commission’s QUEST dynamic general equilibrium model to investigate the impact of alternative tax reforms in France, shifting the tax burden away from labour or corporations and making the tax system more growth friendly. They raise VAT and simultaneously reduce either social security contributions borne by employers or corporate income taxes. They study macroeconomic, budgetary and general equilibrium effects of these tax reforms. The reforms overall entail positive and permanent effects on GDP and price competitiveness.

The main contribution of the present paper is to analyse the long-term effects of two PIT reforms in Italy that differ in terms of their implications on efficiency and equity. To this end, we apply a micro-macro model approach for Italy. To our knowledge we are the first to do this in the context of Italian income tax reforms. Our combined micro-macro approach makes it possible to exploit the advantages of both a microsimulation and a dynamic general equilibrium macro model. Purely microeconomic models face the shortcoming of being unable to account for general equilibrium effects, thus any aggregate effect that would feed back into agents’ choices (e.g. changes in aggregate savings affecting the equilibrium interest rate; changes in aggregate labour supply modifying wages) needs either to be disregarded, or to be modelled in a simplified way. For instance, using empirical elasticities and assuming a certain degree of stationarity of these relations over time (as done, for example, in Jongen et al., 2014, Jäntti et al., 2015 and in a number of older papers surveyed in Aaberge and Colombino, 2014). On the other hand, macroeconomic models, while able to properly account for general equilibrium and dynamic effects, often miss much of the heterogeneity that a micro model offers, not least because of computational issues when trying to deal with a wide set of economic agents simultaneously interacting in possibly complex ways. The idea to develop computable models with a detailed micro part fitting into a macroeconomic setting is not new, see as examples Eliasson et al. (1976), Eliasson (1977) and Eliasson (1991) for a set of models of the production sector in Sweden. The intuition is to have a micro model which accounts for heterogeneous responses to a given shock, and then a link that maps such responses into a macro model. The direction of the effects can either be from the micro to the macro model, or vice versa, and even be recursively derived to approach a stable (equilibrium-like) solution.

In the area of tax studies the micro-macro approach has seen several important developments in the last twenty years (see Peichl, 2009 for a critical review of studies up to the end of the first decade of the 2000s). Indeed the analysis of tax and benefits reforms is a field where researchers may benefit significantly from the micro-macro approach for several reasons. First, an important aspect of such analysis lies in the distributional effects of a reform, which is best captured by microsimulation models. Second, reforms dealing e.g. with capital taxation or unemployment benefits may have relevant dynamic aggregated effects, which are best modelled by macro models like dynamic computable general equilibrium or dynamic stochastic general equilibrium models. Finally, tax reforms often affect a large share of the population in a country (e.g. when statutory tax rates are changed), thus general equilibrium effects may play an important role in shaping labour supply, savings

and consumption decisions. Papers which employ a micro-macro strategy for tax and policy analysis are Aaberge et al. (2007) for Norway; Arntz et al. (2008), Peichl (2009) and Fuest et al. (2008) for Germany; Benczúr et al. (2018) for Hungary; Barrios et al. (2019) for Belgium, Italy and Poland; DeBacker et al. (2019) for the US. To our knowledge the present paper is the first to offer the approach of linking a microsimulation model with an overlapping generations model for Italy.

3 The Italian policy context

The focus of the present paper is Italy. Therefore in this section we first briefly discuss the Italian economic outlook and relevant features of its tax and benefits system. We then summarize the relevant simulation literature that specifically studies the Italian tax and benefits system.

Italian productivity and competitiveness have been stagnating in the last decades, so much that several scholars now talk of an “Italian decline” (e.g. Boeri et al., 2005). In Italy income inequality is large compared to other European countries (Skopek et al., 2014) and has been increasing in the last decades (Jappelli and Pistaferri, 2010), particularly if one looks at within-region inequality (Mussida and Parisi, 2019). Inter-generational inequality is also on the rise, as shown in Barbieri et al. (2020), Bloise and Raitano (2021) and the literature cited therein. Taken together these characteristics have led several researchers, at least from the late 1990s, to study potential reforms of the Italian tax and benefits system that would jointly address efficiency and equity concerns. Since the labour tax wedge is high in Italy as compared to the EU and the OECD average (see e.g. Kalyva et al., 2018), several research papers also discuss tax reforms consisting in shifting the tax burden away from the labour income tax to consumption tax or immovable property tax. In the remainder of the section we present an overview of these papers.

The Italian tax system generates most of its revenues from a progressive personal income tax and a flat-rate value-added tax (VAT).³ Financial and property income are mostly taxed under separate regimes which rely on linear tax rates. There are taxes on property, on corporate income, and a number of tariffs (e.g., on fuels) and duties (e.g., when selling property), which we do not detail as they are not relevant for the present paper.

Our simulations employ the year 2015, both in EUROMOD and for the calibration of the macroeconomic model. The choice of using 2015 instead of a more recent year stems from several considerations. First and foremost is the fact that in order to calibrate the model one needs many different data, which are not always updated with similar frequency. Second, even having the possibility to simulate the most recent year, the COVID-19 pandemic makes 2020 and 2021 very special years which in no way are able to represent business-as-usual conditions for the country, which is relevant both for our steady-state long-term results and for transition paths. Thus, at most, we might want to employ 2019 which is just four years after our year of choice. Third, the Italian tax and transfer system underwent only marginal

³In Italian the personal income tax is called *Imposta sul Reddito delle Persone Fisiche (IRPEF)*.

reforms since 2015, which we detail hereafter. Therefore we believe that the tax and benefits system did not change significantly enough to invalidate our results in any meaningful way. What follows is a description of the tax system in Italy for 2015, with highlights of the most meaningful reforms introduced since 2015 until the time of writing.

The Italian personal income tax is progressive and consists of five personal income tax brackets with tax rates range from 23% to 43% (see also Table 2 in Section 8), with a no-tax allowance that varies based on employment status and household characteristics. In addition, most working taxpayers are liable for social insurance contributions and, on top of these rates which are set by the national government, additional tax rates are levied by regions and municipalities on the same tax base as the personal income tax. The additional local tax rates vary between a minimum of 1.23% up to a maximum combined rate (summing up regional and municipal rates) of 3.41%. There are several exemptions, tax allowances and tax credits that are ear-marked to specific family conditions, types of spending (e.g., for the adoption of more environmentally-friendly technologies) and years. Also included under personal income tax are certain categories of capital income, such as most pension income, some property income, and the earnings from majority shareholding (see Ceriani et al., 2017). Therefore, there are clear interactions between labour and capital income in the income tax system, which further justifies the functional form explained in Section 5.3 that we adopt for representing tax functions. As an aside, note that a high marginal labour tax inevitably introduces negative incentives to work, especially among the lower paid whose labour market participation choices are typically highly responsive to marginal tax rates (see e.g. Meghir and Phillips, 2009, Blundell, 2016).

Capital income is mostly subject to separate taxation, though it is sometimes subject to the personal income tax schedule as explained above (most notably, as stated already, the latter is the case for pension income). The separate capital taxation applies to financial income as follows. In the 2011 a reform of the taxation of capital incomes changed the tax rates levied on interests from bank and postal accounts (from 27% to 20%) and on interests from long-term bonds and dividends (from 12.5% to 20%). The exception remains related to treasury bonds which are taxed at a lower 12.5% rate. From the 1st of July 2014, the standard rate increased to 26% (Ceriani et al., 2017). Financial income is therefore taxed at a flat rate of 26% or 12.5%; the exception are earnings from controlling shareholdings, which are subject to the personal income tax schedule, although only for about half of their amount. Income from property rents is normally subject to personal income tax, however since 2011 taxpayers may opt for a more advantageous flat rate tax (the “*cedolare secca*”) at a rate of 21% (or 10% for rented property under a special regulated contractual regime).

The poverty relief programs in Italy are mostly administered for employees and the elderly, in the form of unemployment benefits and family grants for the first, and social pensions for the second. Healthcare and education are generally accessible to all and mostly financed by the general public budget. Employees and some categories of self-employed and atypical workers are subject to compulsory participation to retirement pension schemes and insurance against work-related accidents. There is no general unemployment insurance scheme and, as of 2015, no general poverty relief program.

After 2015 two main reforms have been introduced. The “*bonus 80 euro*” (also nicknamed “*bonus Renzi*” after its main proponent’s name) had been introduced in 2014. Initially it was meant as a temporary relief, but was then made permanent in the following years. It granted an 80 EUR monthly tax credit to employees with yearly income up to 24,600 EUR, or a reduced amount for those with yearly income up to 26,600 EUR. Our simulated tax schedule in EUROMOD includes this credit.⁴ The other relevant reform is the so-called “*reddito di cittadinanza*”, which is a selective poverty-relief program introduced in 2019. It grants households, subject to means-testing and some other conditions related to the participation to a public labour intermediation system, a monthly sum of money up to 9,360 EUR per year. The amount is reduced based on the household’s composition, income and wealth situation.⁵

As in our simulations we modify the consumption tax to obtain budget neutral reforms, it is worth mentioning that the Italian government had planned an increase of VAT rates, which was postponed because of the COVID-19 pandemic. The rates should have been raised from the current 22% and 10% rates (these are respectively the ordinary and the reduced VAT rates), up to 25% and 12% in 2021, and further to 26.5% in 2022 for the maximum rate only. The minimum VAT rates, applied to some goods that are deemed essential or socially valuable, were and still are set at 4-5%. Thus, since 2015 no VAT change entered into effect (at least, not until the time of writing).

Starting from the fiscal year 2012, the property tax has been redesigned. The new tax was labelled *Imposta Municipale Propria* (*IMU*). The tax base for buildings registered at the cadastre is the cadastral rent value (for main residence and other buildings respectively) raised by 5% and multiplied by a coefficient that varies based on the property category (up to a maximum multiplier of 160). Tax rates are different according to the type of building and municipalities can modify them. The baseline rates are: 0.4% for the main residence and 0.76% for other buildings. In the case of main residences there is a deduction of 200 EUR plus 50 EUR for each dependent children aged 26 or less living in the household. Since 2013 the *IMU* on the main residence has been suspended. Tax rates are different according to the type of building and municipalities can modify them. In 2014 the Law introduced another reform: the *imposta unica comunale* (*IUC*) included three distinct taxes: the *IMU*, the *TASI* (*tributo per i servizi indivisibili*) and the *TARI* (*tassa sui rifiuti*). A reform introduced in 2020 further redesigned the system by abolishing the *TASI* and merging the old *IMU* and the *TARI* into a unified tribute, referred to as the *IMU 2020*.

As anticipated earlier there is a rich literature studying the effects of reforms of the Italian

⁴In 2021, this was substituted by a 100 EUR monthly tax credit for employees earning up to 28,000 EUR yearly, and a reduced amount for those earning up to 40,000 EUR/year (the latter reform, being in place only since 2021, is not included in our reform scenarios nor in the baseline).

⁵In 2021 a similar policy was introduced, called “*pensione di cittadinanza*”, which extends the grant to elderly people but without any requirements with respect to participation to the labour intermediation programme. Neither “*reddito di cittadinanza*” nor “*pensione di cittadinanza*” are included in our baseline and reform scenarios.

tax and benefits system, both looking at actual and hypothetical reforms. Aaberge et al. (2004) present a microsimulation analysis for Italy and find different labour supplies across income. In particular, the rich appear less responsive to the reforms. Annicchiarico et al. (2013), with the use of the QUEST model, study an ambitious reform package aimed at increase supply potential, improving competitiveness, ensure fiscal sustainability and enhance confidence in government ability to service its debt. One element of structural reforms the authors analyse is tax shift from labour to consumption in Italy. Annicchiarico et al. (2014) analyse the potential impact of fiscal devaluation on the Italian economy using IGE, a dynamic general equilibrium model for the Italian economy. The authors find with their simulations that output gains seem to persist in the long run. In terms of distributional analysis, they find non-negligible distributional effects across households, since taxation on consumption tends to be regressive. Astarita et al. (2016) use the EUROMOD model to simulate the impact of a refundable in-work tax credit introduced in 2014 (so-called “*bonus 80 euro*”) as well as of the exemption from the payment of the general service tax for main residences. Additionally, they study a hypothetical reform of a reduction of employer social security contributions financed by removing the exemption of the services tax for primary residences. Overall, the simulations indicate that the ‘80 euro bonus’ is expected to have a positive impact on the distribution of incomes and on the tax wedge, while the benefits of abolishing the property tax on first residences are more debatable, especially when assessed against alternative uses of the same resources.

Curci and Savegnano (2019) evaluate the day-after effects of a fiscal devaluation on the efficiency and on the equity of the Italian tax and benefits system. They simulate the increase in the VAT rate that was foreseen by the law for 2020 (the so-called *clausole di salvaguardia*, i.e. safeguard clauses) and they allocate the additional revenues to financing three alternative possible cuts of labour taxation: (i) a cut in some PIT statutory tax rates, (ii) an increase in tax credits for labour incomes, and (iii) a reduction in social security contributions. The authors focus on equity and the efficiency dimensions of the tax shift from labour to consumption using a non-behavioural microsimulation model (called BIMic). For all three reforms the paper shows an increase in efficiency and a decrease in equity (as measured by the Gini index of net incomes). In addition to that, the scenario involving the increase in tax credits for labour income shows the highest gain in efficiency and the lowest reduction in equity. Bordignon et al. (2019) provide evidence on the causal impact on employment of a reform reducing the labour tax wedge, which was implemented by the Italian government in 2007 as a first part of a strategy aimed at pursuing a fiscal devaluation. Apart from the manufacturing sector, they find a very small impact of such reform on employment and explain it with the magnitude of the tax incentive being too small (a saving of about 1% of total labour costs).

Moscarola et al. (2020) analyse the effects of a hypothetical budget-neutral reform in Italy that lowers the tax burden on labour (by increasing tax credits on low incomes), compensating for the loss in revenues with the revenue generated by the 2012 property tax reform. They apply a structural model of labour supply of both employees and self-employed and in addition a labour market equilibrium model that encompasses demand-side constraints. The microeconomic evaluation of the policy reform takes into account the details of the

tax-benefit system by using the **EUROMOD** model. The authors find an increase in employment and available income after the reform, especially for households in the lowest income deciles, and also a reduction of income inequality. The efficiency effects are more ambiguous: employment and income tend to increase in the lowest deciles, but the average income suffers a minor decrease when labour market equilibrium is taken into account.

Cammeraat and Crivelli (2020) evaluate a comprehensive reform of the Italian tax system aiming at reducing complexity, broadening the tax base, and lowering marginal tax rates, especially the tax burden on labour income. The authors use the **EUROMOD** model to assess the revenue and distributional implications of personal income, property tax and VAT reform options. They find that a substantial reduction in the tax burden on labour income can be obtained with a revenue-neutral base-broadening reform that streamlines tax expenditures and updates the property valuation system. In addition, they draw a conclusion that a comprehensive reform would benefit low- and middle-income households the most, by lowering significantly their overall current tax liability, which results in increased progressivity of the tax system.

In light of the European Commission’s Country Specific Recommendations for Italy (European Commission, 2019), European European Commission (2020) studies the effect of tax shift from labour to property. The reintroduction of the property tax (IMU) is simulated in three different scenarios using **EUROMOD** model and **QUEST** model. The authors find that although reintroducing taxes on all residences would imply a bigger tax increase for high-income households in absolute terms, low-income households would lose a higher share of their disposable income, causing a small increase in income inequality. Exempting low-value properties and eventually low-income pensioners would almost neutralise this effect. If additional revenue from exempting low-value properties was used to reduce social security contributions paid by employees with yearly income below 24,600 EUR, such a tax shift would have a slightly positive distributional effect, with a marginal decrease in the Gini index by 0.05%. Labour force participation rate would rise by 1.6% and total hours worked by 2.3% for women and 0.8% for men on average, with stronger increases for low-income workers. Based on a **QUEST** analysis, five years after the tax shift real GDP would be marginally higher (by 0.1%) compared to the baseline, thanks to higher employment and private consumption.

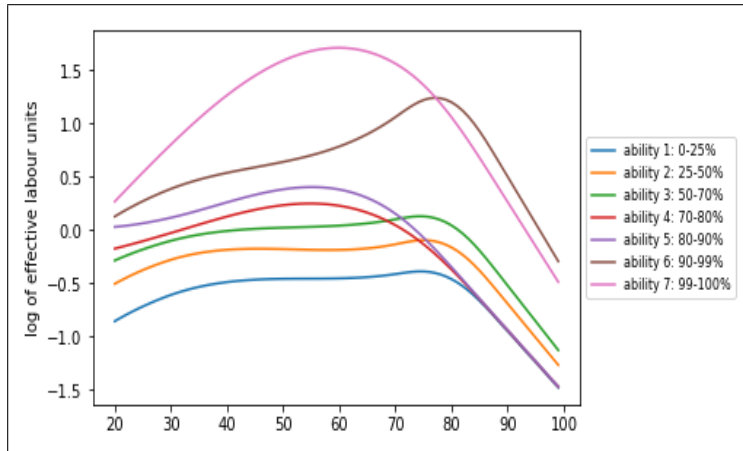
4 Model Overview

For the analysis in this paper we use **EDGE-M3** overlapping generations (OLG) model calibrated for Italy. The key features of the model are summarised in this section, with the description of the micro-macro linkage methodology in Section 5. d’Andria et al. (2020) provides full description of the model.

4.1 Earnings-ability Paths

The model allows for agent heterogeneity across ages and lifetime earnings-ability profiles. This allows the model to capture the richness of the cross-sectional and intergenerational distributions over income, wealth, labour supply, and other endogenous variables. There are seven earnings-ability groups in the model. These groups refer to a deterministic lifetime earnings-ability paths, which are shown in Figure 1. New cohorts of agents in the model are randomly assigned to each group and there is no mobility between groups. The groups are not of equal size: the first group represents the earnings-ability path for up to the 25th percentile, the next for the 25th to 50th percentile, then for 50th to 70th, 70th to 80th, 80th to 90th, 90th to 99th, and finally, the top group is for those workers with the highest one-percent of earnings-ability. Splitting earning-ability groups in this way allows us to focus on the highest earners, especially the top one percent. The earnings-ability paths are estimated econometrically. As not all labour is equally productive, we estimate effective labour units, meaning the productivity of an earnings-ability type relative to the average. (Further details on the estimation procedure are given in d’Andria et al., 2020.) The resulting estimated earnings profiles are shown in Figure 1.

Figure 1: Exogenous life cycle income ability paths $\log(e_{j,s})$ with $S = 80$ and $J = 7$



4.2 Demographics

The model includes demographic projections from Eurostat on mortality rates, fertility rates, and immigration rates.⁶ Taken together, these imply a population distribution that evolves over time according to the law of motion implied by these rates. Model agents are economically active for a maximum of S years, facing a mortality risk that is a function of their

⁶Eurostat database: Population and social conditions — Population projections (proj) — Population projections at national level (2015-2080) (proj_15n) <http://ec.europa.eu/eurostat/data/database>, access 30/08/2018.

age, s . That is, agents can die within one year with the probability of dying given by the one-period mortality rates. It is assumed that agents live no longer than age 99.

4.3 Households

Households are born each period and become economically relevant at age 20 (if they survive to that age). They live for a maximum of 100 years, and so are potentially economically active for 80 years. Households are subject to a budget constraint such that their consumption and new saving must match their labour and capital income plus transfers and bequests received, net of taxes paid. Households maximise their welfare by choosing lifetime consumption, labour supply and saving to maximise lifetime utility. Utility is received from consumption, reduced by labour and received by leaving bequests (a “warm glow” motive). It is a constant relative risk-aversion (CRRA) utility of savings, discounted by the mortality rate (to account for the probability that a household may not live to benefit from future consumption).

4.4 Firms

Firms produce output using inputs of capital and labour according to a Cobb-Douglas production function. There is constant productivity growth, which is the rate of labour-augmenting technological progress. Firms seek to maximise profits (output less labour and capital costs). These features determine the optimal demand for labour and capital.

4.5 Government

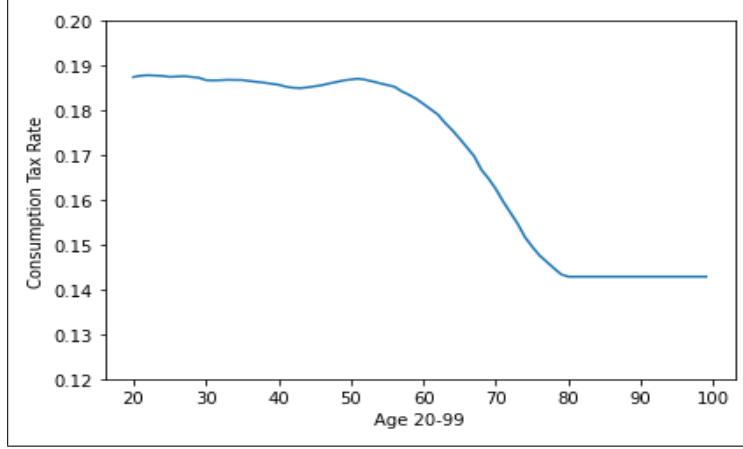
The government is not an optimizing agent in the model. The government levies taxes on households, provides transfers to households, makes other public expenditures, and engages in borrowing. All these operations influence households either directly through taxes and transfers the household budget constraint or indirectly through the effects government actions have on the equilibrium interest rate and wages.

4.5.1 Taxes

We model three types of taxes: consumption taxes, a social insurance contribution, and income taxes.

As households in the model consume only a composite consumption good, consumption taxes are modelled as the average tax paid on all goods and services. The consumption tax rate on this composite good is differentiated by age. This allows us to implicitly model variation in the basket of goods consumed by households as different points in the life cycle. For example, old ages consume more healthcare products, which are largely zero-rated for or exempt from VAT. The baseline rates of consumption tax range from around 18 percent down to around 13 percent for older ages as shown in Figure 2, which reflects this variation in the basket of goods and services over the lifecycle and its interaction with zero-rated or exempt goods and services.

Figure 2: Consumption tax rates by age



Effective and marginal rates of social insurance contributions (*SICs*) are modelled as a function of labour income. Data on social contributions were obtained from the **EUROMOD** model which, as stated previously, employs EU-SILC survey data. To get the overall social insurance contribution we sum up the contributions paid respectively by employers, employees and self-employed workers. The overall *SIC* is then divided by gross labour income to get *SIC* rate. The *SIC* rate thus computed is regressed using OLS on gross labour income (*GLI*), its squared and cubic values:

$$SIC\ rate = \alpha_i + \beta_1 GLI_i + \beta_2 GLI_i^2 + \beta_3 GLI_i^3 + \varepsilon_i \quad (1)$$

By estimating a cubic polynomial we are able to capture common characteristics of the social security systems, namely the fact that *SIC* rates tend to be lower for low incomes (this is due to the existence of various allowances), then fairly constant for a large range of incomes, and then again lower for high incomes due to the existence of ceilings in contribution. The marginal *SIC* rates are then derived employing the coefficients obtained from the OLS regression, computing *SIC* rates at the current level of income and at a 3% larger income, finally dividing the difference in *SIC* rate by the difference in incomes.

Finally, we model income taxes, which enter the OLG model as flexible, parametric functions. These functions are estimated using output from the **EUROMOD** microsimulation model. These functions account for the interaction between labour and capital income on effective and marginal tax rates. This is our principal link between the micro- and macro-economic models and is described in detail in Section 5.

4.5.2 Government budget

Government spends a fixed share of GDP on general public expenditure and also on government transfers, which are uniformly distributed across all economically active households.

The government can run surpluses or deficits in any given period. In our model, which is an open economy model, government bonds are purchased by domestic and foreign investors. We calibrate the share of new debt issues purchased by foreign investors to 32%, which is

in-line with recent purchases of Italian debt. To reflect the greater security of government bonds, the interest rate on government debt is below the rate paid on private capital. The difference between the interest rates varies over time, but it averages 2.1 percentage points in our model.

Because our model is one with forward-looking agents, we need to be careful in considering how the government budget is satisfied in the long run. We cannot obtain an equilibrium in our model if the governments interest payments exceed GDP. We thus need to ensure that government budget deficits do not grow faster than GDP in the steady state. Any given income tax policy may produce structural budget deficits that do not satisfy this requirement. We therefore close the government budget by adjusting consumption taxes in all years. This closure is also a natural choice to simulate a shift from the income tax to the consumption tax.

4.6 Market Clearing Condition

Three markets must clear in the OLG model—the labour market, the capital market, and the product market use.⁷ We also present the law of motion for bequests, which, while not technically a market clearing condition, does have similar properties.

Labour market clearing requires that aggregate labour demand equal the sum of household labour supplied (both measured in effective labour units).

Capital market clearing requires that aggregate capital demand from firms equal the sum of capital savings and investment by households. The equation must account for the capital flows associated with immigration into or out of the country. It is assumed that immigrants have the same savings (and consumption) as natives of the same age.⁸

Product market clearing requires that aggregate output equals aggregate consumption, aggregate investment, and net exports.

Total bequests are the collection of savings of household from the previous period who died at the end of the period. These savings are augmented by the interest rate because they are returned after being invested in the production process.

4.7 Equilibrium

We solve for the rational-expectations equilibrium of the OLG model in the steady-state and along the entire transition path to the steady state. An equilibrium consists of agents having expectations that are consistent with equilibrium outcomes, households and firms acting optimally given prices and these expectations, and markets clearing in each period. The solution algorithm involves solving for the steady-state equilibrium first, via a fixed point algorithm, and then solving for the transition path through the methods of Auerbach and Kotlikoff (1987).

⁷In the model, only the labour market and capital market clearing condition are included. By Walras' Law, the third market clearing condition is redundant. The product market clearing condition—also referred to as the resource constraint—is used as a check on the solution method.

⁸This assumption is necessary to constrain the dimensions of the model, as without it one would need to model immigrants separately from the rest of the population. As most immigrants are from the EU, it is not considered a strong assumption.

Note that our model has underlying growth in the population and in productivity through labour-augmenting technological change. In order to solve our model, we must make it stationary. All non-stationary variables (such as economic aggregates and wage rates, among other variables) are made stationary in order to solve the model. We present our results in terms of the stationarised values.

5 Mapping Reforms from the Micro- to the Macro-Level for Income Taxes

The link between the **EUROMOD** microsimulation model and **EDGE-M3** OLG macroeconomic model is established through parametric functions that represent average effective and marginal tax rates. These functions capture tax progressivity and are functions of capital and labour income levels and age group. A representative agent in the OLG has labour and capital incomes that are functions of the general equilibrium wages and interest rates and determined through optimal choices of the agent with respect to labour supply and savings. Marginal and effective tax rates affect these decisions through the agents' budget constraints and first order conditions. Though the use of tax rate functions in the OLG model, the tax rates associated with agents' decisions are endogenous. They are functions of the choices of labour supply and savings, which determine capital and labour income, which in turn affect the marginal and effective tax rates agents face.

Importantly, we model tax rates as bivariate functions of capital and labour income, as well as age group. In this way, many tax-relevant characteristics of an individual that are not explicitly represented in the macro model are still indirectly captured by the estimated tax functions. For instance, if different sources of capital income face different rates of taxation (as is the case in Italy), then allowing tax rates to vary according to the mix of capital and labour income and by age may help to account for portfolio differences in capital income held by households of different ages with varying mixes of capital and labour income. A modelling strategy such as this allows one to account for the maximum degree of heterogeneity the OLG model can afford when modelling average and marginal tax rates from the **EUROMOD** microsimulation model, albeit implicitly.

This section first outlines some key features of the **EUROMOD** microsimulation model followed by an outline of the methodology for mapping income taxes from the micro-model to the OLG macro-model. We then explain in detail the tax functions used and the estimation process. It is these tax functions that provide the key linkage between the macro results and the micro results.

5.1 The **EUROMOD** microsimulation model

EUROMOD is the European Union tax-benefit microsimulation model (Sutherland (2007), Sutherland and Figari (2013)). The model is a static tax and benefit calculator that makes use of representative microdata from the harmonised EU Statistics on Income and Living Conditions survey (EU-SILC) and from national statistics on income and living conditions surveys,

to simulate individual tax liabilities and social benefit entitlements according to the rules in place in each Member State. Its main distinguishing feature is that it covers all EU countries within the same framework, allowing for flexibility of the analysis and comparability of the results. Starting from gross incomes contained in the survey data, **EUROMOD** simulates most of the direct tax liabilities and benefit entitlements.⁹ **EUROMOD** represents most tax-relevant characteristics of individuals and households (including demographic and family characteristics, information on the type of labour activity, region of residence, and so on), it produces estimates of tax liabilities that take into account the full combined effects of allowances, tax credits, exemptions, additional tax rates and differential tax treatments. The model is able to represent all major tax credits and allowances, though some smaller ones are not computed due to data limitations (as an example, tax credits that are granted for very specific expenses incurred in case of home renovations improving energy efficiency cannot be tracked, as the data used to calibrate **EUROMOD** do not include such detailed breakdown of households' expenditures).

The effective tax rate on total income is calculated by simply taking income tax liabilities as a share of combined labour and capital income. These are obtained from the **EUROMOD** database, which is taken from the EU-SILC survey. Labour income is defined as earned income, which is the sum of wages, salaries, and self-employment income. Capital income is defined as the sum of income from investment, pension, and property.¹⁰ The microdata we use are at the individual level for main income earners in a household (we believe in this way we better capture the characteristics of the Italian tax system compared to household-level data) and come from the **EUROMOD** model.¹¹ **EUROMOD** can also be used to compute marginal tax rates for each agent by assuming an increase of a fixed percentage of income and recalculating the labour or capital income tax liability.¹²

5.2 Mapping income taxes from micro to macro model

As noted above, the micro-macro link is based on income levels and age group. In the overlapping generations model, the tax rates associated with this agent are determined by these endogenous income levels (as well as by age in line with age groups distinguished - see Section

⁹For more information on **EUROMOD** see the official website: <https://euromod-web.jrc.ec.europa.eu/>.

¹⁰We obtain labour income summing up **EUROMOD**'s variables *yem* (wage employment income) and *yse* (self employment income), capital income summing up *ypp* (private pension), *yiy* (investment income) and *ypr* (property income), labour taxes summing up *tinna-s* and *tinrg-s*, and capital taxes summing up *tinktcp-s*, *tinktdt-s*, *tinktdu-s*, *tinktbd-s*, *tinktgb-s*, *tprmb-s*, *tprob-s* and *tinrt-s* (all the latter variables starting with the letter *t* are for taxes and are endogenously computed by the **EUROMOD** model).

¹¹We find that there are several observations with extreme values for their effective tax rate. Since effective (marginal and average) rates are calculated as ratios, unrealistically large values might be obtained, for example when the denominator is a measure of income and this is very small. We omit such outliers by imposing the following restrictions upon the raw output of the microsimulation model. First, we exclude observations with an effective tax rate greater than 70% and observations with a marginal tax rate greater than 75% or less than 0%. Second, we drop observations from the microsimulation model where adjusted total income is less than 5 EUR.

¹²We used a 3% increase for this purpose. Sensitivity tests were performed by also computing marginal tax rates with a 0.1% increase instead, and the resulting figures were identical after winsorizing the 1% lowest and largest values.

5.3). The effective income tax rates enter into the agents’ budget constraint and the marginal tax rates enter first-order conditions for the agents’ optimization problem, thus impacting on agent behaviour (see Section 4.3 for more details). Most characteristics of an individual that are tax-relevant but not explicitly represented in the macro model are anyway indirectly captured by the estimated tax functions, for example the presence of children in the household, marital status, or type of employment are not explicitly modelled in the OLG model but their impact on tax liabilities is still captured as an average effect by the tax function estimation process (see below). Such modelling strategy allows one to account for the full range of average and marginal effects of the tax system from the **EUROMOD** microsimulation model, albeit implicitly.

5.3 Income Tax Functions

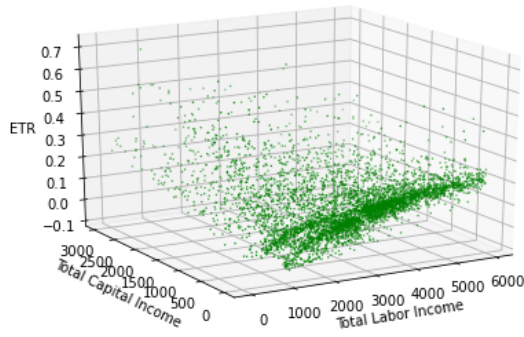
In order to represent the personal tax system, we follow the novel approach described in DeBacker et al. (2019), which make use of the microsimulation output to estimate tax functions used in the **EDGE-M3** OLG model. The method enables not only the estimation of tax functions for current policy, but also for counterfactual tax policies, including tax policy levers that are difficult or impossible to model explicitly in a general equilibrium framework. Here we focus on the functional form and how it effectively translates the information from the microsimulation output into a function that can be entered into the OLG model.

Inspection of the data indicates a clear difference between young-to-middle-aged adults and older adults. Therefore, in order to improve the accuracy of the estimation, we estimate separate tax functions for those aged 20 to 59 and for those aged 60 and over, which we refer to as the young and old tax functions, respectively. The split captures heterogeneity in tax liability that is correlated with the age of the taxpayer, beyond what is captured purely by the size of the incomes (for example, due to a different composition of assets or age-specific policies).

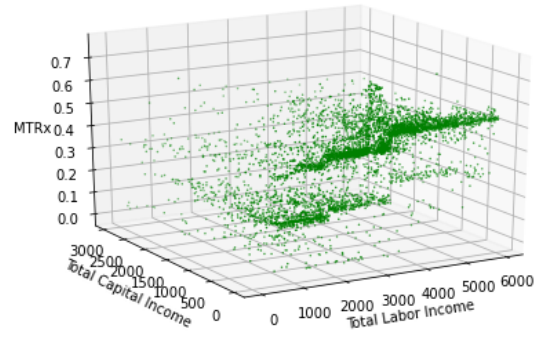
Looking first at the young-to-middle-aged adults (ages 20-59), Figure 3 shows scatter plots of effective tax rates (ETR), marginal tax rates on labour income ($MTRx$) and capital income ($MTRY$) simulated using the **EUROMOD** model, each plotted as a function of labour income and capital income in the base year 2015. Labour and capital income are truncated at 6000 EUR and 3000 EUR per month in the plots for clarity.

Figure 3(a) shows the scatterplot of the effective tax rates for each labour and capital income combination. Whilst noting some noise in the data, some key properties of the data can be clearly seen. First, those on low capital and labour incomes tend to face low $ETRs$. For those with low capital income, as labour income rises, a clear cluster of data is seen where the ETR rises but at a diminishing rate. From any level of labour income, higher capital income also raises one’s ETR for most individuals. These anticipated properties of the data lead us towards the use of a functional form that captures these key features. Following DeBacker et al. (2019) we fit to the data a Cobb-Douglas aggregator of two ratios of polynomials in labour and capital income (see eq. (2)) that we explain below. Important

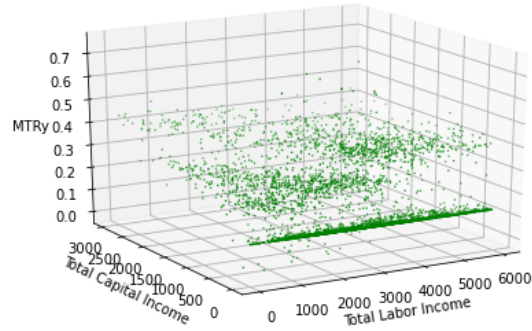
Figure 3: Scatter plot of ETR , MTR_x and MTR_y as functions of labour income and capital income (EUR per month) from microsimulation model, year 2015, ages 20-59



(a) Effective tax rates ETR



(b) Marginal tax rates on labour income MTR_x



(c) Marginal tax rates on capital income MTR_y

properties of the chosen functional form are that it produces the observed bivariate negative exponential shape and is non-decreasing in both labour income and capital income, which are consistent with the observed data.

Turning to the data for the marginal tax rates on labour income ($MTRx$), Figure 3 (b), similar properties are displayed. In particular, the data display a negative exponential shape and are monotonically increasing in labour income; also visible are the different regimes for employees and the self-employed. However, the shape is less pronounced with respect to capital income. For the marginal tax rates on capital income, Figure 3 (c), the shape of the underlying function has a clear line at low capital income with levels rising for higher capital income, which can be captured by the Cobb-Douglas aggregator. For these reasons, we estimate the same function for ETR , $MTRx$ and $MTRY$. As will be shown below, the function has sufficient flexibility to provide a good fit in each case.

The equivalent scatterplots for ages 60 and over are shown in Figure 4. The data bear some resemblance to that for young ages, however capital income is more important in this age group.¹³

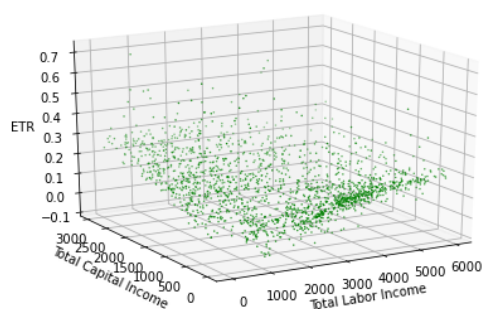
The estimation algorithm works as follows: let x be total labour income, $x \equiv w_t e_{j,s} \hat{n}_{j,s,t}$, that is the product of the wage, w , the effective labour per unit of labour, e , and the labour supply, n , by age, s and earnings-ability type, j in time, t ; let y be total capital income, $y \equiv r_t \hat{b}_{j,s,t}$, that is the product of the interest rate, r , and the stock of savings, b , by age, s and earnings-ability type, j in time, t . Our tax rate function is a Cobb-Douglas aggregator of two ratios of polynomials in labour and capital income, and is expressed as follows:

$$\begin{aligned} \tau(x, y) &= [\tau(x) + shift_x]^\phi [\tau(y) + shift_y]^{1-\phi} + shift \\ \text{where } \tau(x) &\equiv (max_x - min_x) \left(\frac{Ax^2 + Bx}{Ax^2 + Bx + 1} \right) + min_x \\ \text{and } \tau(y) &\equiv (max_y - min_y) \left(\frac{Cy^2 + Dy}{Cy^2 + Dy + 1} \right) + min_y \\ \text{where } A, B, C, D, max_x, max_y, shift_x, shift_y &> 0 \quad \text{and} \quad \phi \in [0, 1] \\ \text{and } max_x > min_x \quad \text{and} \quad max_y > min_y \end{aligned} \tag{2}$$

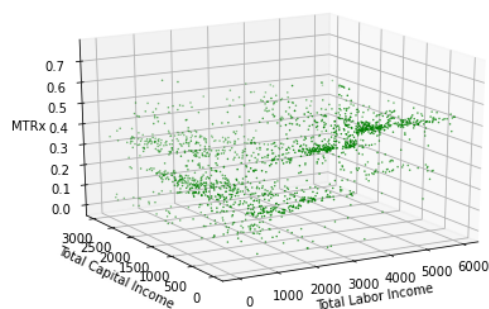
The key building blocks of the functional form equation (2) as proposed by DeBacker et al. (2019) are the $\tau(x)$ and $\tau(y)$ univariate functions. The ratio of polynomials in the $\tau(x)$ function $\frac{Ax^2+Bx}{Ax^2+Bx+1}$ with positive coefficients $A, B > 0$ and positive support for labour income $x > 0$ creates a negative-exponential-shaped function that is bounded between 0 and 1, and the curvature is governed by the ratio of quadratic polynomials. The multiplicative scalar term $(max_x - min_x)$ on the ratio of polynomials and the addition of

¹³Splitting the age groups into 59 and below and 60 and over was arrived at following extensive experimentation. Splitting the sample at an older or younger age was experimented with, but the tax function estimates were judged to be somewhat poorer in capturing the microsimulation data. Splitting within the 59 and below group was found to add little information. Splitting within the 60 and over group faces a problem with the sample size.

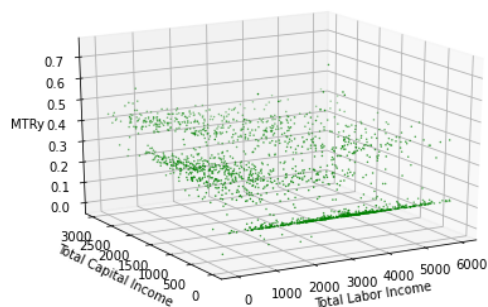
Figure 4: Scatter plot of ETR , MTR_x and MTR_y as functions of labour income and capital income (EUR per month) from microsimulation model, year 2015, ages 60+



(a) Effective tax rates ETR



(b) Marginal tax rates on labour income MTR_x



(c) Marginal tax rates on capital income MTR_y

min_x at the end of $\tau(x)$ expands the range of the univariate negative-exponential-shaped function to $\tau(x) \in [max_x, min_x]$. The $\tau(y)$ function is an analogous univariate negative-exponential-shaped function in capital income y , such that $\tau(y) \in [min_y, max_y]$. The respective $shift_x$ and $shift_y$ parameters in equation (2) are analogous to the additive constants in a Stone-Geary utility function. These constants ensure that the two sums $\tau(x) + shift_x$ and $\tau(y) + shift_y$ are both strictly positive. They allow for negative tax rates in the $\tau(x, y)$ functions despite the requirement that the arguments inside the brackets be strictly positive. The general shift parameter outside of the Cobb-Douglas brackets can then shift the tax rate function so that it can accommodate different function values (including negative tax rates, if required). The Cobb-Douglas share parameter $\phi \in [0, 1]$ controls the shape of the function between the two univariate functions $\tau(x)$ and $\tau(y)$ (DeBacker et al. (2019)). The precise shape of the function depends on these 12 parameters in (2), which are summarised in Table 1.

Table 1: Description of tax rate function $\tau(x, y)$ parameters

Symbol	Description
A	Coefficient on squared labour income term x^2 in $\tau(x)$
B	Coefficient on labour income term x in $\tau(x)$
C	Coefficient on squared capital income term y^2 in $\tau(y)$
D	Coefficient on capital income term y in $\tau(y)$
max_x	Maximum tax rate on labour income x given $y = 0$
min_x	Minimum tax rate on labour income x given $y = 0$
max_y	Maximum tax rate on capital income y given $x = 0$
min_y	Minimum tax rate on capital income y given $x = 0$
$shift_x$	$shifter > min_x $ ensures that $\tau(x) + shift_x > 0$ despite potentially negative values for $\tau(x)$
$shift_y$	$shifter > min_y $ ensures that $\tau(y) + shift_y > 0$ despite potentially negative values for $\tau(y)$
$shift$	shifter (can be negative) allows for support of $\tau(x, y)$ to include negative tax rates
ϕ	Cobb-Douglas share parameter between 0 and 1

Source: DeBacker et al. (2019)

In equation (2), we are allowing $\tau(x, y)$ to represent, alternatively, the effective and marginal tax rate functions $ETR(x, y)$, $MTRx(x, y)$ or $MTRy(x, y)$. We assume the same functional form for each of these functions. By assuming that each tax function takes the same form, we are breaking the analytical link between the effective tax rate function and the marginal tax rate functions. As DeBacker et al. (2019) point out it is useful to separately estimate the marginal and average rate functions, in order to be able to capture policy changes that have differential effects on marginal and average rates. The total tax liability function is simply the effective tax rate function times total income $\tau(x, y)(x + y)$.

$$T_{s,t}^I(x, y) \equiv \tau_{s,t}^{etr}(x, y)(x + y) = \left\{ [\tau_{s,t}(x) + shift_{x,s,t}]^{\phi_{s,t}} [\tau_{s,t}(y) + shift_{y,s,t}]^{1-\phi_{s,t}} + shift_{s,t} \right\} (x + y) \quad (3)$$

A marginal tax rate (*MTR*) is defined as the change in total tax liability from a small change income. We differentiate between the marginal tax rate on labour income (*MTRx*) and the marginal tax rate on capital income (*MTRY*).

$$\tau^{mtrx} \equiv \frac{\partial T_{s,t}^I}{\partial w_t e_{j,s} n_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial x_{j,s,t}} \quad \forall j, t \quad \text{and} \quad E + 1 \leq s \leq E + S \quad (4)$$

$$\tau^{mtry} \equiv \frac{\partial T_{s,t}^I}{\partial r_t b_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial y_{j,s,t}} \quad \forall j, t \quad \text{and} \quad E + 1 \leq s \leq E + S \quad (5)$$

The derivative of total income tax liability with respect to labour supply $\frac{\partial T_{s,t}^I}{\partial n_{j,s,t}}$ and the derivative of total tax liability next period with respect to savings $\frac{\partial T_{s+1,t+1}^I}{\partial b_{j,s+1,t+1}}$ are present in the household Euler equations for labour supply (equation 11) and savings (equation 12), respectively. Equation (6) shows the decomposition of the marginal tax rate influencing labour supply into the marginal tax rate on labour income times the household-specific wage. Equation (7) shows the decomposition of the marginal tax rate influencing savings into the marginal tax rate of capital income times the interest rate.

$$\frac{\partial T_{s,t}^I}{\partial n_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial w_t e_{j,s} n_{j,s,t}} \frac{\partial w_t e_{j,s} n_{j,s,t}}{\partial n_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial w_t e_{j,s} n_{j,s,t}} w_t e_{j,s} = \tau_{s,t}^{mtrx} w_t e_{j,s} \quad (6)$$

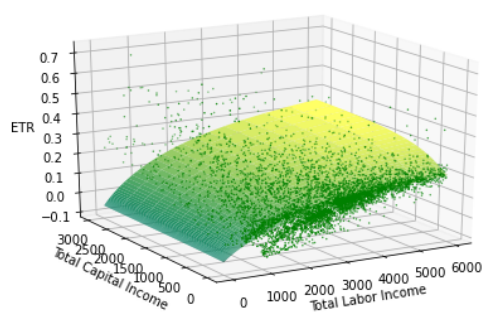
$$\frac{\partial T_{s,t}^I}{\partial b_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial r_t b_{j,s,t}} \frac{\partial r_t b_{j,s,t}}{\partial b_{j,s,t}} = \frac{\partial T_{s,t}^I}{\partial r_t b_{j,s,t}} r_t = \tau_{s,t}^{mtry} r_t \quad (7)$$

This functional form for tax rates delivers flexible parametric functions that can fit the tax rate data shown in Figures 3 and 4 as well as wide variety of policy reforms. Further, these functional forms are monotonically non-decreasing in both labour income x and capital income y . This characteristic of monotonicity does not appear to be a strong one when viewing the tax rate data.¹⁴

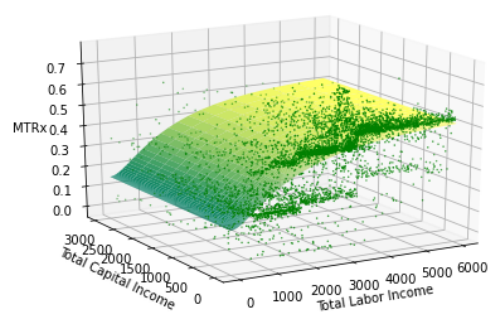
Given the degree of dispersion of the data, we require a method for solving that does not give a large weight to outliers. The chosen methodology is to solve for the least sum of weighted absolute distances between the estimated function and the data points (where the weights are the survey weights from EU SILC).¹⁵ See Maronna et al. (2018) about robust regressors in general and the rationales behind their use.

¹⁴As DeBacker et al. (2019) point out, while it does limit the potential tax systems to which one could apply our methodology, tax policies that do not satisfy this monotonicity assumption would result in non-convex

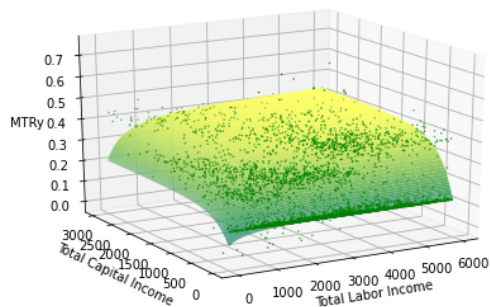
Figure 5: Estimated tax rate functions of ETR , MTR_x and MTR_y as functions of labour income and capital income from microsimulation model, year 2015, ages 20-59



(a) Effective tax rates ETR



(b) Marginal tax rates on labour income MTR_x



(c) Marginal tax rates on capital income MTR_y

Separate estimations are performed for all three tax functions (ETR , $MTRx$ and $MTRy$), for ages 20 to 59 and ages 60 and over, meaning that six estimations are made for the baseline scenario. The estimated tax functions for ages 20 to 59 are shown in Figure 5. The curved planes are shown against the scatterplots of the **EUROMOD** output for effective tax rates, marginal tax rates on labour and capital incomes, which were shown in Figure 3. It can be seen that the methodology captures salient features of the tax system. The effective tax rate, ETR , function is increasing in both labour and capital income. The marginal tax rate on labour income, $MTRx$, function captures the progressivity of the personal income tax system, accounting well for the different thresholds and different regimes between employees and the self-employed. The curve for marginal tax rates on capital income, $MTRy$, captures both the group with very low capital income and a low marginal rate and then rises to capture those with higher capital income who pay a higher marginal rate, which flattens out, reflecting the flat-rate taxes on several sources of capital income, most notably on financial income and some categories of real estate property.

The estimated tax functions for ages 60 and over are shown in Figure 6. As before, the curved planes are shown against the scatterplots of the **EUROMOD** output for effective tax rates, marginal tax rates on labour and capital incomes, which were shown in Figure 4. The effective tax rate, ETR , function is increasing in capital income, though not in labour income, which captures the data well for this age group. The marginal tax rate on labour income, $MTRx$, function captures the progressivity in the labour income dimension, whilst being a flatter function than that for those aged 20 to 59. The function for marginal tax rates on capital income, $MTRy$, is similar in shape to that for those aged 20 to 59, suggesting little is added by splitting the sample.¹⁶

We introduce a gradual transition between the young and old tax functions to avoid any sharp changes in tax liability. Up until age 55, the household faces only the young tax function. The transition begins at age 56, where a person faces a combined liability equal to 90 percent that determined by the young tax function and 10 percent by the old tax function. The share of the old tax function increases by 10 percent each age until age 65 and beyond, where only the old tax function is faced.

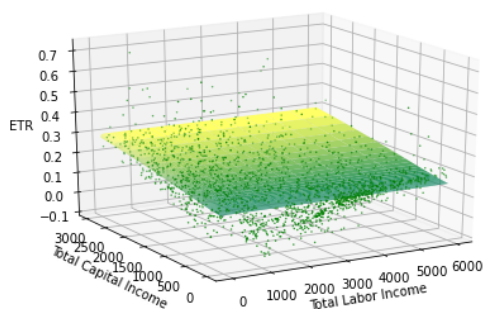
The functional forms not only provide a good approximation of the underlying microsimulation output, but also reflect well agent responses to the tax system. Whilst taxpayers may not be fully versed in all the intricacies of the tax system, they likely have a fair sense of how tax impacts their budget in general and, we argue that, the tax functions presented here capture this notion. When considering a tax reform, the functional forms for the young

budget sets, consequently they would require non-standard general equilibrium model solution methods and would not guarantee a unique equilibrium.

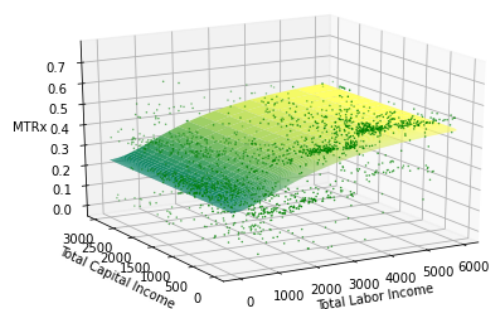
¹⁵Specifically, we use the SciPy optimise differential evolution solver. This is a global optimizer employing evolutionary Monte Carlo techniques. In our estimates the optimiser is run for up to 30,000 periods with 15 candidate solutions each. A solution is achieved when the marginal improvement over the target function for additional periods is below a tolerance threshold, we set at 10^{-10} .

¹⁶Nevertheless, the split is maintained for the $MTRy$ as differences may become important in reform scenarios.

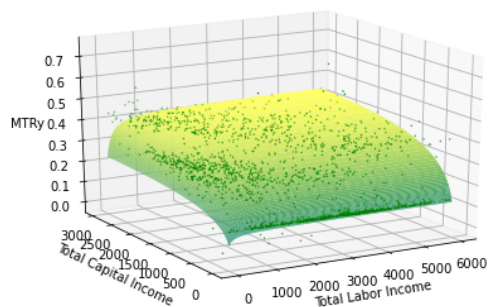
Figure 6: Estimated tax rate functions of ETR , MTR_x and MTR_y as functions of labour income and capital income from microsimulation model, year 2015, ages 60 and over



(a) Effective tax rates ETR



(b) Marginal tax rates on labour income MTR_x



(c) Marginal tax rates on capital income MTR_y

and old tax functions for ETR , $MTRx$ and $MTRy$ are re-estimated based on the microsimulation output for the reform. This allows a highly detailed reflection of the tax reform, from the microsimulation model, to be incorporated in the OLG model.

5.4 Tax transmission channels in the OLG model

The effect of individual income taxes on model agents' decisions is captured in three equations. First, total income tax paid by the model agent determines after-tax resources available for consumption and savings (budget constraint equation (8)). Second, individual income taxes influence households' decisions by introducing distortions into their optimization. Taxes affect the labour-leisure decision through the change in tax liability from a change in labour supply, $\frac{\partial \hat{T}_{s,t}^I}{\partial \hat{n}_{j,s,t}}$. Taxes affect savings through the partial derivative $\frac{\partial \hat{T}_{s+1,t+1}^I}{\partial \hat{b}_{j,s+1,t+1}}$, which reflects the additional taxes paid as a function of an additional euro of savings. The total tax paid by the model agent determines after-tax resources available for consumption and savings. Consumption taxes (mainly value added taxes and excise taxes) affect agents' decisions by determining after-tax resources available for consumption and savings as can be seen from the budget constraint equation (8). The consumption tax rate in **EDGE-M3** is differentiated by age of individuals. The consumption data are taken from the Italian Household Budget Survey (*Indagine sui Consumi delle Famiglie*), which is combined with the Italian Survey of Income and Living Conditions (IT-SILC) using statistical matching. The data and methodology are further described in Sanchez et al. (2016). The effective consumption tax is calculated as the total taxes paid divided by total expenditure.

6 Baseline

The baseline steady-state shows how the model captures the behavioural choices over the life-cycle. Figure 7 shows baseline life-cycle patterns for labour supply, consumption, stock of assets (savings), and income taxes paid by the seven representative agents distinguished by earnings ability. Different earnings-ability groups have different sizes from ability group 1 representing 25 percent of the population to ability group 7 representing only the top 1 percent (see Section 4). Figure 7.a shows labour supply that rises to a high level around age 30, and continues to rise or fall gradually until the mid-50s before falling as more households enter retirement. The figure shows the tendency for more highly paid ability types to work less, which comes from the household optimisation problem, where households trade off utility from consumption and disutility from labour. Figure 7.b shows the consumption profile, which rises to a peak between the mid-30s and mid-50s (depending on ability type) before falling gradually in older age. However, note that consumption has a flatter profile than labour supply showing agents smooth consumption through savings. As expected, higher ability types have higher levels of consumption. The consumption profile is relatively flat (especially compared with labour supply), which shows how agents smooth consumption over their lifetime. Figure 7.c shows the savings profile, which rises until around age 60 in most ability types, with the two highest ability types continuing to accumulate assets until around

age 80. After this age, all ability types stabilise or reduce their stock of savings. At older ages, savings behaviour is mostly driven by households trading off utility from consumption and utility from leaving bequests. Note that it is never optimal to end life without savings, because households gain a very large marginal utility from leaving small bequests. Figure 7.d shows income taxes paid, which rises to a peak for those of age mid-to-late 50s, corresponding to the peak in labour supply and earnings. The top one percent of earnings-ability, group seven, has higher labour and capital income and hence, much higher income taxes. Table 6 in Appendix B details calibrated values and other exogenous parameters' values of EDGE-M3 model used here.

Figure 8 presents baseline levels of individual variables in the fifth year of a dynamic solution of the model. It shows level of labour supply, consumption, savings and tax revenues paid for the seven ability types and three age groups. The three age groups are defined as young for individuals aged 20-39, mid-age for individuals aged 40-59, and old for individuals aged 60-100. Similar broad shapes can be seen to those in the steady state. In addition one can also compare different age group with this figure. For instance, in line with intuition, the middle aged pay the highest income tax as they work the most hours. It can also be seen that the richest pay very high income tax due to having the highest income from both labour and capital (the latter due to having the largest accumulation of assets).

Figure 7: Baseline steady-state values for labour supply, consumption, savings and income tax paid for seven ability types, ages 20-99

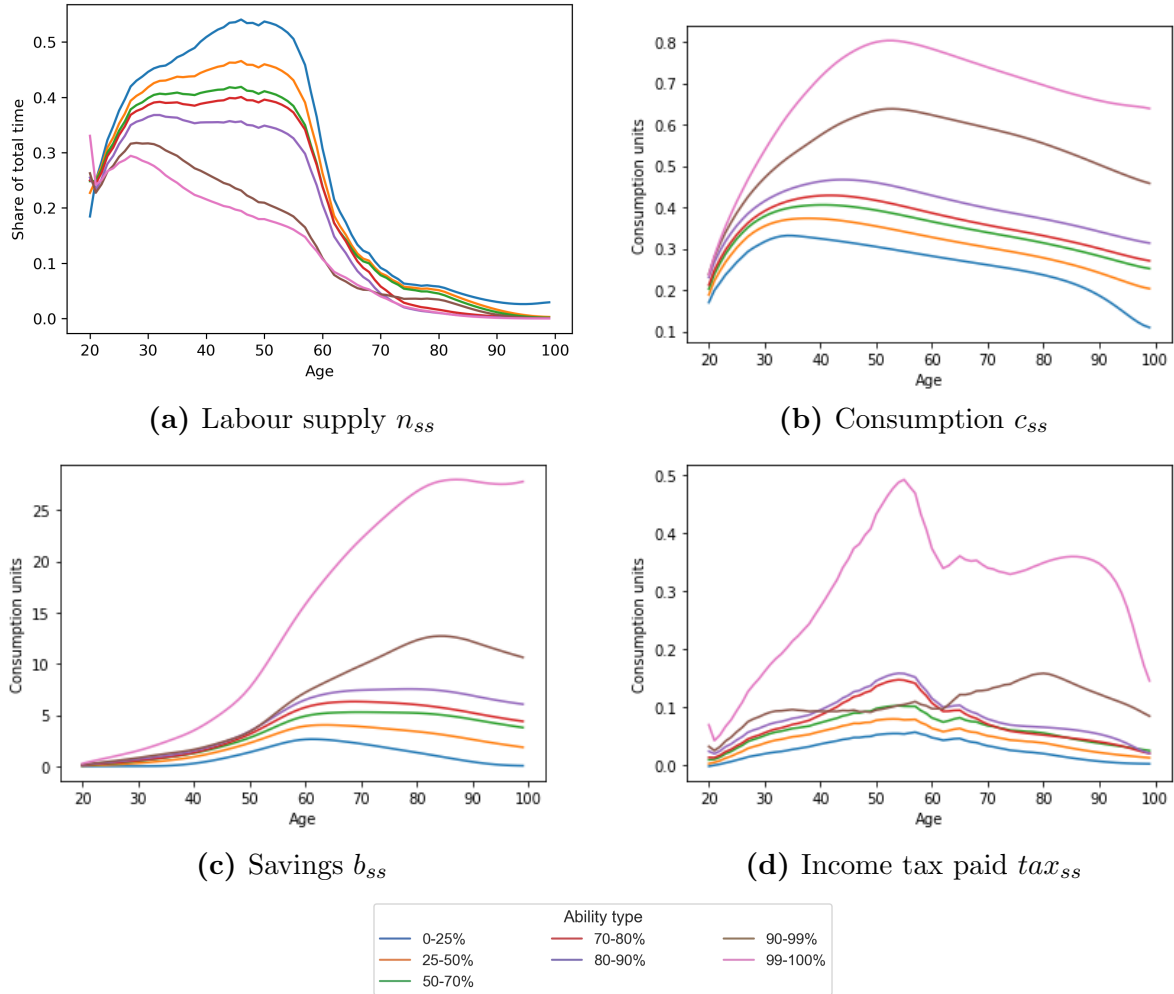
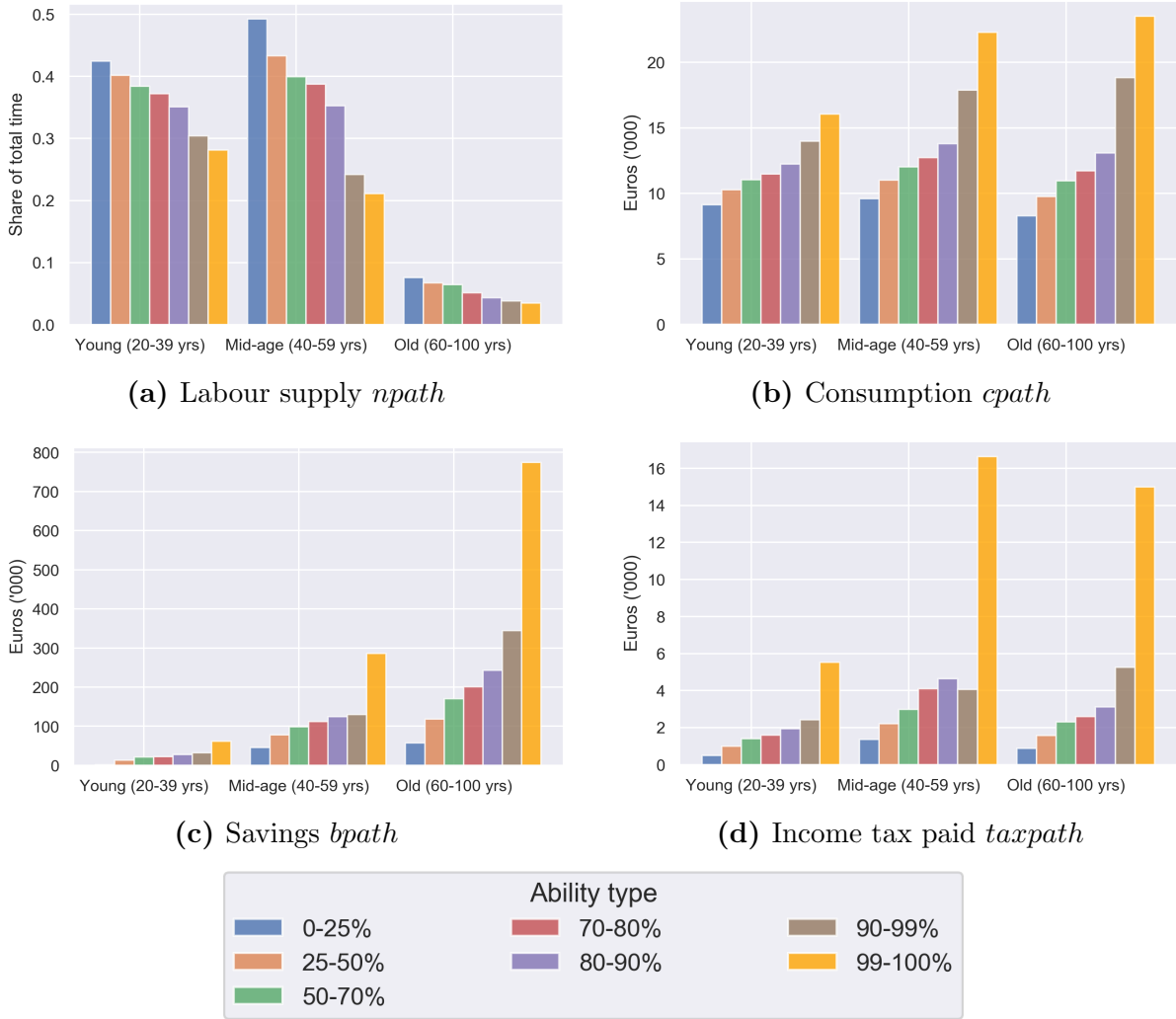


Figure 8: Labour supply, consumption, savings and income tax paid for seven ability types - 5th year of the dynamic solution



7 Simulations

We describe here the simulated policy scenarios. Each simulation involves a change in the personal income tax (PIT) schedule, which is first performed in the microsimulation model and then, using the methodology described in Section 5, the income tax function for the macro-model is re-estimated, thus incorporating the micro-level information.

Two income tax simulations are performed which we label as “2pp-cut” and “Thres-rise”:

- 2pp-cut: A 2 percentage point cut in all PIT rates
- Thres-rise: Raising the PIT threshold by EUR 2320

The reason for the choice of EUR 2,320 is that in the microsimulation model, this change in threshold has exactly the same revenue cost as the 2 percentage point cut in PIT rates.

Thus, the two reform scenarios are equivalent *ex ante* in terms of their reduction in average personal tax liability, where *ex ante* here means before considering behavioral reactions and general equilibrium effects. The reforms are described in greater detail in Tables 2 and 3.

Table 2: Statutory thresholds and marginal tax rates for personal income tax: baseline vs. 2pp-cut reform

PIT bracket (annual income in EUR)	Baseline	2pp-cut reform
up to 15,000	0.23	0.21
15,000 to 28,000	0.27	0.25
28,000 to 55,000	0.38	0.36
55,000 to 75,000	0.41	0.39
75,000 and above	0.43	0.41

Source: EUROMOD and authors

Table 3: Statutory thresholds and marginal tax rates for personal income tax: baseline vs. Thres-rise reform

PIT bracket (annual income in EUR) Baseline	PIT bracket (annual income in EUR) Thres-rise reform	Rates (Baseline and reform)
n/a	up to 2,320	0.00
up to 15,000	2,320 to 15,000	0.23
15,000 to 28,000	17,320 to 28,000	0.27
28,000 to 55,000	28,000 to 55,000	0.38
55,000 to 75,000	55,000 to 75,000	0.41
75,000 and above	75,000 and above	0.43

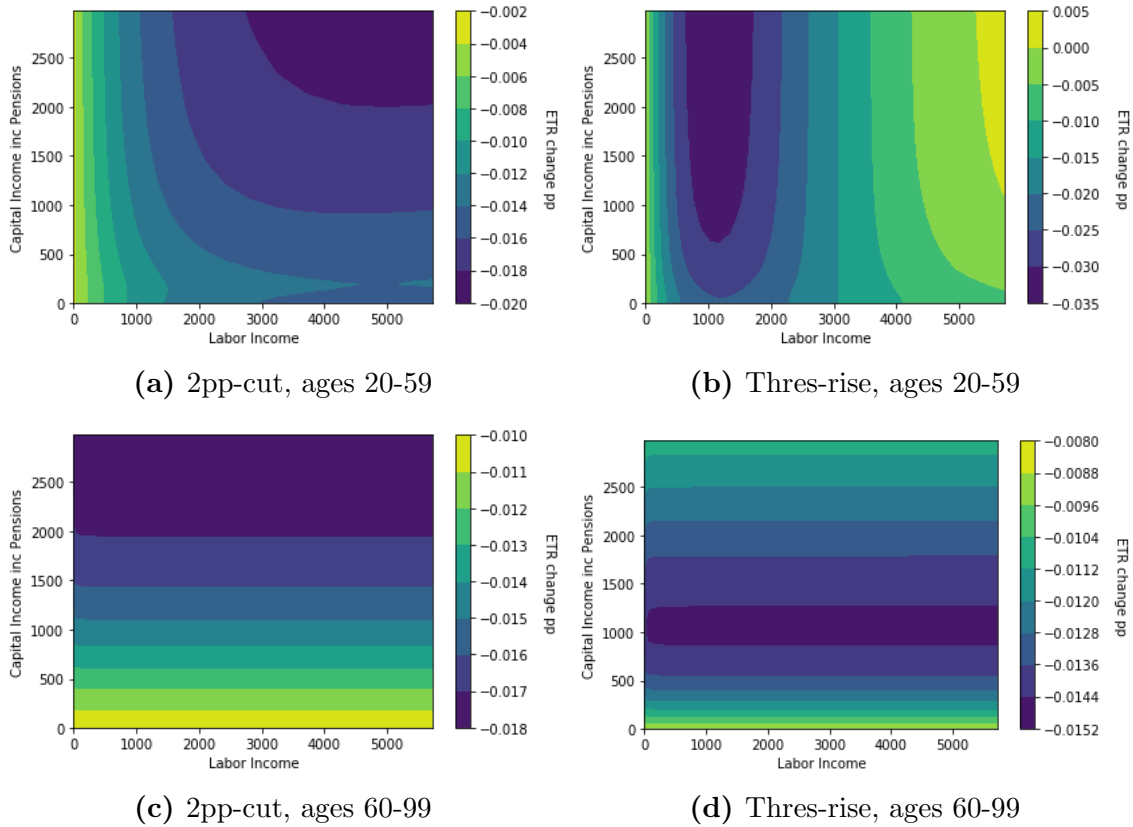
Source: EUROMOD and authors

Note that both these reforms constitute a PIT cut for all income taxpayers. Also it should be noted that reforms such as these will interact with other elements of the tax system, which are captured in the microsimulation model with a high degree of granularity.

The changes due to the re-estimated effective tax rate (ETR) function in the two tax reforms are shown in Figure 9. The estimation is carried out separately for younger and older agents in the model. The figure shows the difference between the re-estimated function and the one in the baseline. Figure 9a shows the 2pp-cut for young agents; one sees that those with a high labour income receive the greatest reduction in *ETR*, which is close to the 2 percentage points. Low-income taxpayers (the young and/or low-ability types) receive less benefit, as they were paying less income tax. In contrast, under the Thres-rise reform, Figure 9.b, the greatest benefit goes to those earning around 1000 euros per month of labour

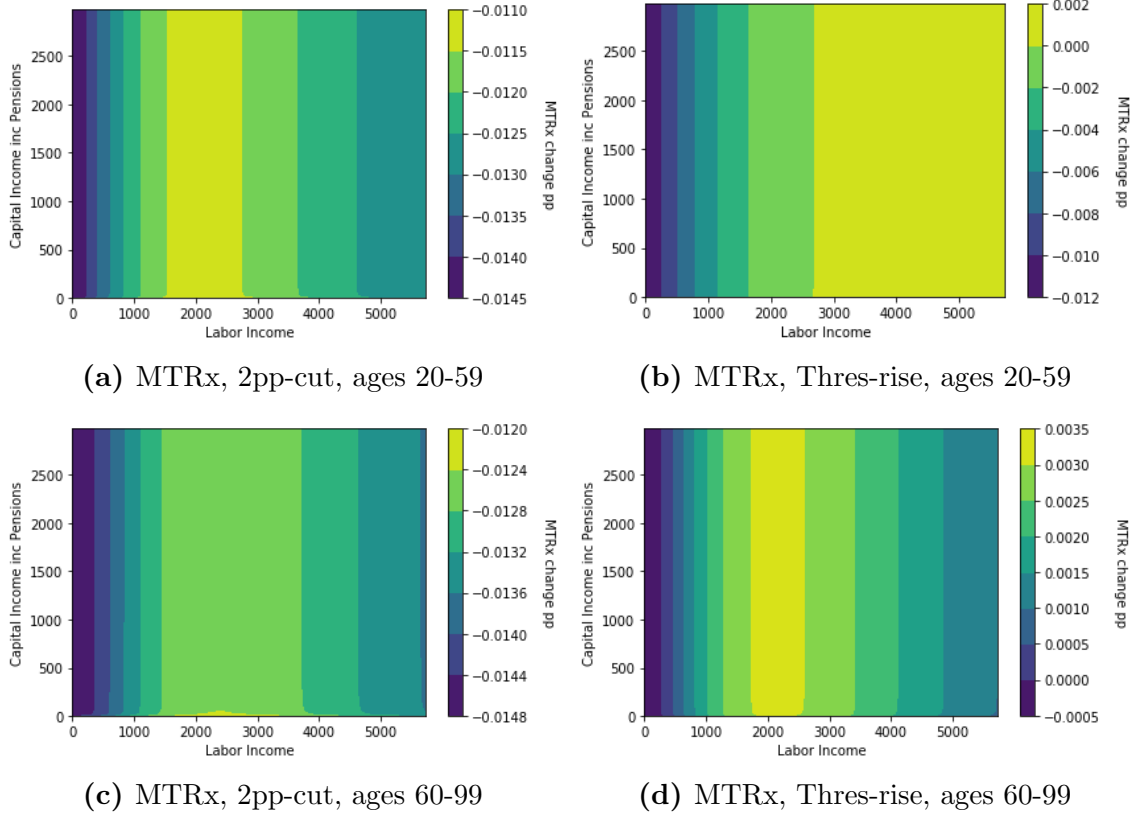
income, as they benefit from the threshold rise and this constitutes a large share of their income tax. Older taxpayers receive a reduction of between 1.0 and 1.8 percentage points in their *ETR* function in the 2pp-cut reform, Figure 9.c, with the variation present only in the capital income dimension, which is where most of their income is derived (pension income is included as capital income). The Thres-rise reform for older ages, Figure 9.d, has a similar pattern, however, the largest reduction is for those earning around 1000 euros per month of capital income.

Figure 9: Change in effective tax rate (ETR) for the two reforms (reform less baseline, EUR 1000s per month)



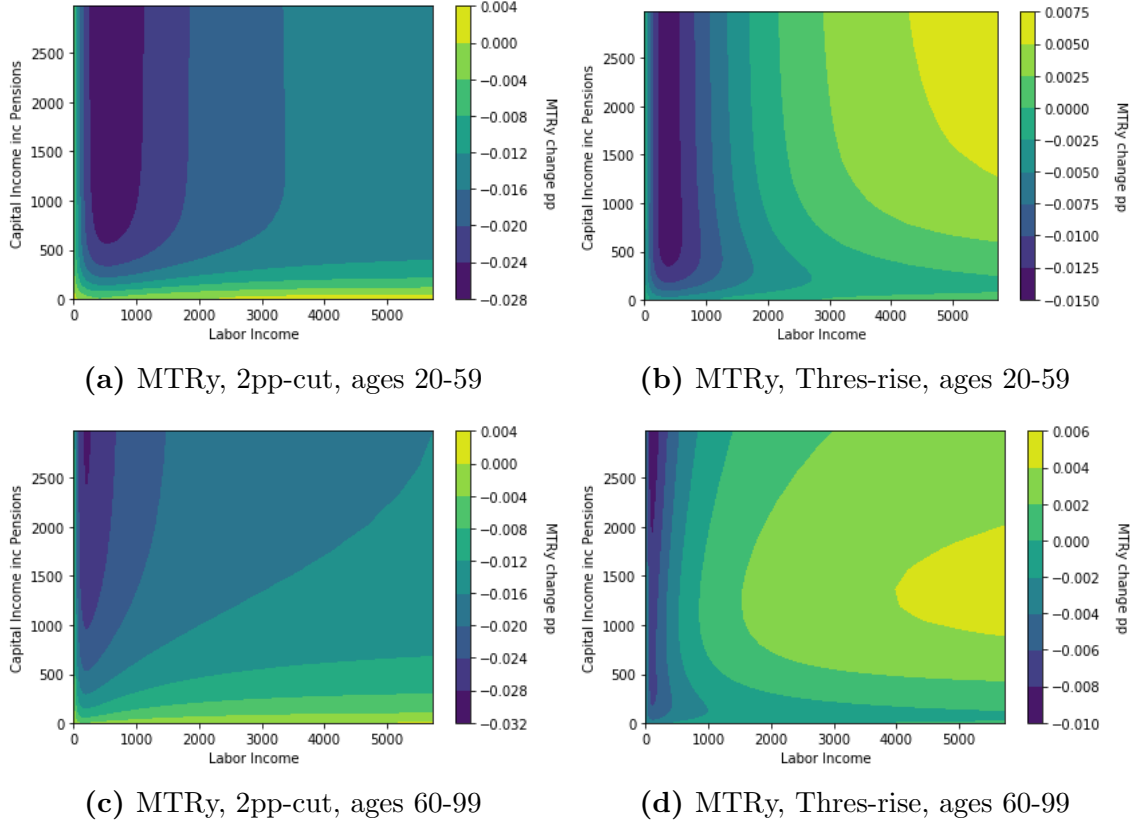
In a similar fashion, the effect of the reforms on the marginal tax rate on labour income function is shown in Figure 10. The reduction in the marginal tax rate for the 2pp-cut reform, Figures 10a and 10c, are reasonably consistent across income levels, ranging from a reduction of 1.1 to 1.5 percentage points. The variation that does exist is almost entirely in the labour income dimension. Changes in marginal tax rates are less pronounced in the Thres-rise reform, Figures 10b and 10d, with near-zero impacts apart from for young ages on low incomes. This is consistent with the nature of the reform, which directly affects the marginal rates for the first 2320 euros per year of taxable labour income, which is only marginal for low-income workers.

Figure 10: Change in marginal tax rates on labour (MTR_x) for the two reforms (reform less baseline, EUR 1000s per month)



The consequences for the marginal tax rate on capital income, MTR_y , are concentrated on lower labour income and high capital income earners (see Figure 11). The figures show how the consequence of a tax cut has different effects by income levels, but also depends on the source of income and other characteristics of the individual, which are incorporated into the EUROMOD output and then captured by the income tax function. The figures for young ages, Figures 11a and 11b, show that capital income levels have little impact on the reduction in marginal rates on capital income. Those with low labour income receive the largest reduction. As labour income rises, falls in the MTR_y from the reform become smaller, with the 2pp-cut reform showing larger benefits for high labour-income earners. For old ages, Figures 11c and 11d, some variation in the capital income dimension is seen, as pension income is typically subject to personal income tax and so would be impacted by the reforms.

Figure 11: Change in marginal tax rates on capital (MTR_y) for the two reforms (reform less baseline, EUR 1000s per month)



Generally speaking a reduction across the board of tax rates, like the ones here simulated, decreases marginal tax rates on labour income. This alone implies a substitution effect such that labour supply will increase. At the same time, income effects would imply less labour supply. Also due to the general equilibrium design of the model, gross wages and capital formation will be affected and this in turn will impact ability groups differently. The different composition of labour versus capital incomes also implies different effects by age. Overall, as will be shown, substitution effects dominate income effects in the 2pp-cut reform scenario and income effect is more pronounced in the Thres-rise reform scenario. Both reforms have different intensities across ability groups and ages.

Both the simulated reform scenarios are budget neutral for the government in the steady state and along the transition path. Given the fall in income tax revenue, we achieve budget neutrality by raising consumption taxes pro-rata across all age groups. (Recall that consumption taxes vary by age in the baseline as shown in Figure 2.) This allows us to focus on a realistic possibility for tax reform (rather than expanding the public debt further): a tax shift from income to consumption taxes.

8 Results

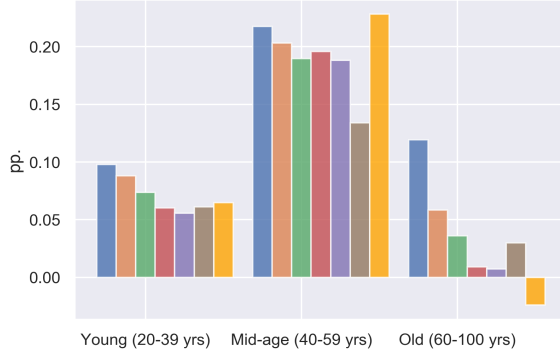
We now present and discuss the main results obtained from the simulated policy reforms. Figures 12 and 13 report the changes in labour supply (as change in the share worked out of total time endowment), consumption, savings and disposable income (as percent deviations from the baseline solution). We also report the change in income tax paid (as absolute changes, obtained as the value under the reform minus the value under the baseline) and the percentage change in consumption tax paid. These results are for the simulated tax changes in the steady-state, in comparison to baseline values. We interpret the steady-state results as long-run results of the reform, which we address first, turning to the short-run effects later in this section.

As can be seen from the graphs the effects of tax rate cuts differ based on age and ability type. The observed changes for labour supply are substantial for all working ages in the 2pp-cut reform, Figure 12a, as predicted by our choice for the functional forms for agents' utility. The reduction in marginal tax rates on labour income causes an increase in the labour supply, particularly for the low-ability agents (which is coherent with the empirical literature discussed in previous sections, e.g., Meghir and Phillips, 2009, and Blundell, 2016). In contrast, the Thres-rise reform, shown in Figure 13a, by leaving marginal tax rates on labour unchanged but raising consumption taxes, induces an overall decrease in labour supply which is stronger for low- and middle-income and younger agents. There is also some decrease in labour supply due to the income effect, as the tax cut results in higher disposable income (see Figures 12d and 13d).¹⁷

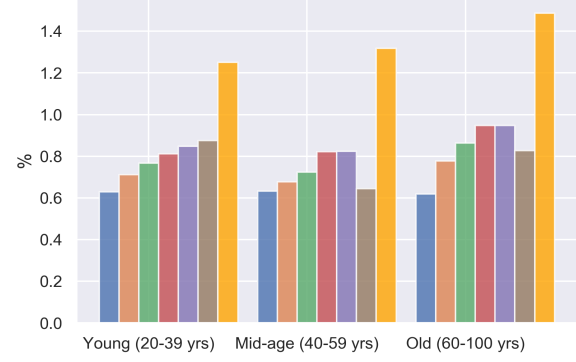
The impact on consumption, shown in Figures 12b and 13b, differs across the reforms: it increases for all agents in the 2pp-cut reform (also thanks to increases in labour supply) and more so for high-ability agents. In this respect, the 2pp-cut reform is Pareto improving. In contrast in the Thres-rise reform, consumption decreases and generally decreases more with age and ability type. This is due to the large increase in consumption tax which more than offsets the additional after-tax income from the PIT cut. The effect is stronger for higher earners, who spend more relative to the size of the income tax cut from the rise in the threshold. The changes for saving are generally positive for both reforms. In the 2pp-cut reform, Figure 12c, the percentage rise in savings is especially strong for middle and old ages. There is a reduction in savings for the lowest ability group in young adulthood, which saves less in this age group to smooth (increased) consumption across their lifetime. In the Thres-rise reform, Figure 13c, there are increases in savings for most groups, though these tend to be smaller than for the 2pp-cut reform. The lowest ability type again reduces saving in young adulthood, but then shows the largest percentage rises in middle and old ages. This rise is partly driven by the difference in the marginal utility of savings, which decreases with income.

¹⁷We define disposable income here as labour income plus capital income minus income taxes and social security contributions paid. We abstract from social transfers as they are modelled in a simplified way in the analysis presented here. They are assumed as constant percent of GDP in all periods and are distributed uniformly to all individuals. In this simplified set-up accounting for transfers would not change the conclusions in terms of the distributional aspect of analysed tax reform.

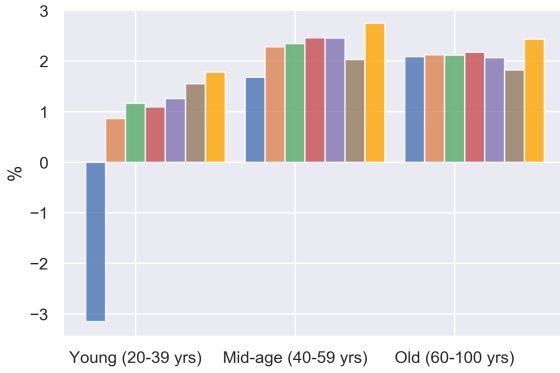
Figure 12: Effect of the 2 pp. tax rate cut reform by age groups in the steady state (all % deviation except for income tax that is absolute deviation)



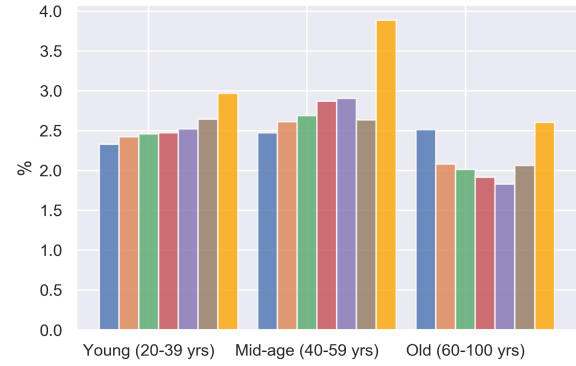
(a) Labour supply n_{ss}



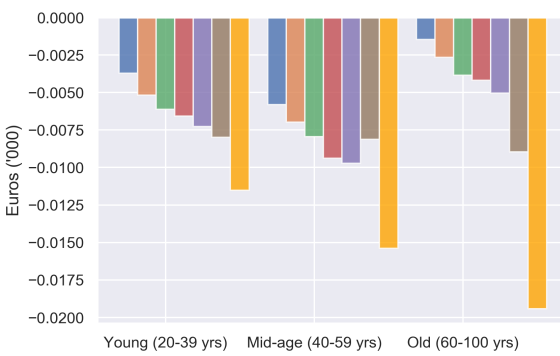
(b) Consumption c_{ss}



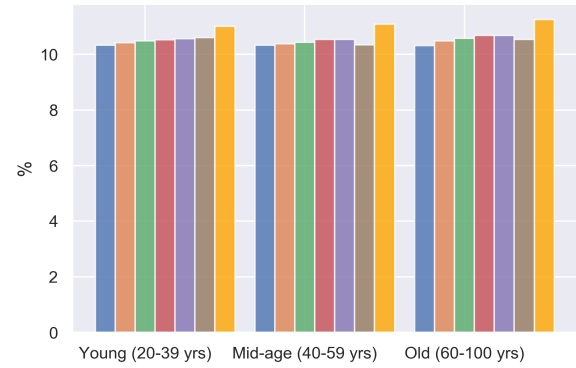
(c) Savings b_{ss}



(d) Disposable income $disp_inc_{ss}$



(e) Income tax tax_{ss}



(f) Consumption tax $ctax_{ss}$

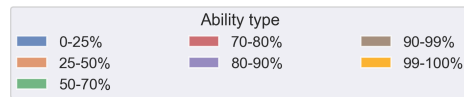
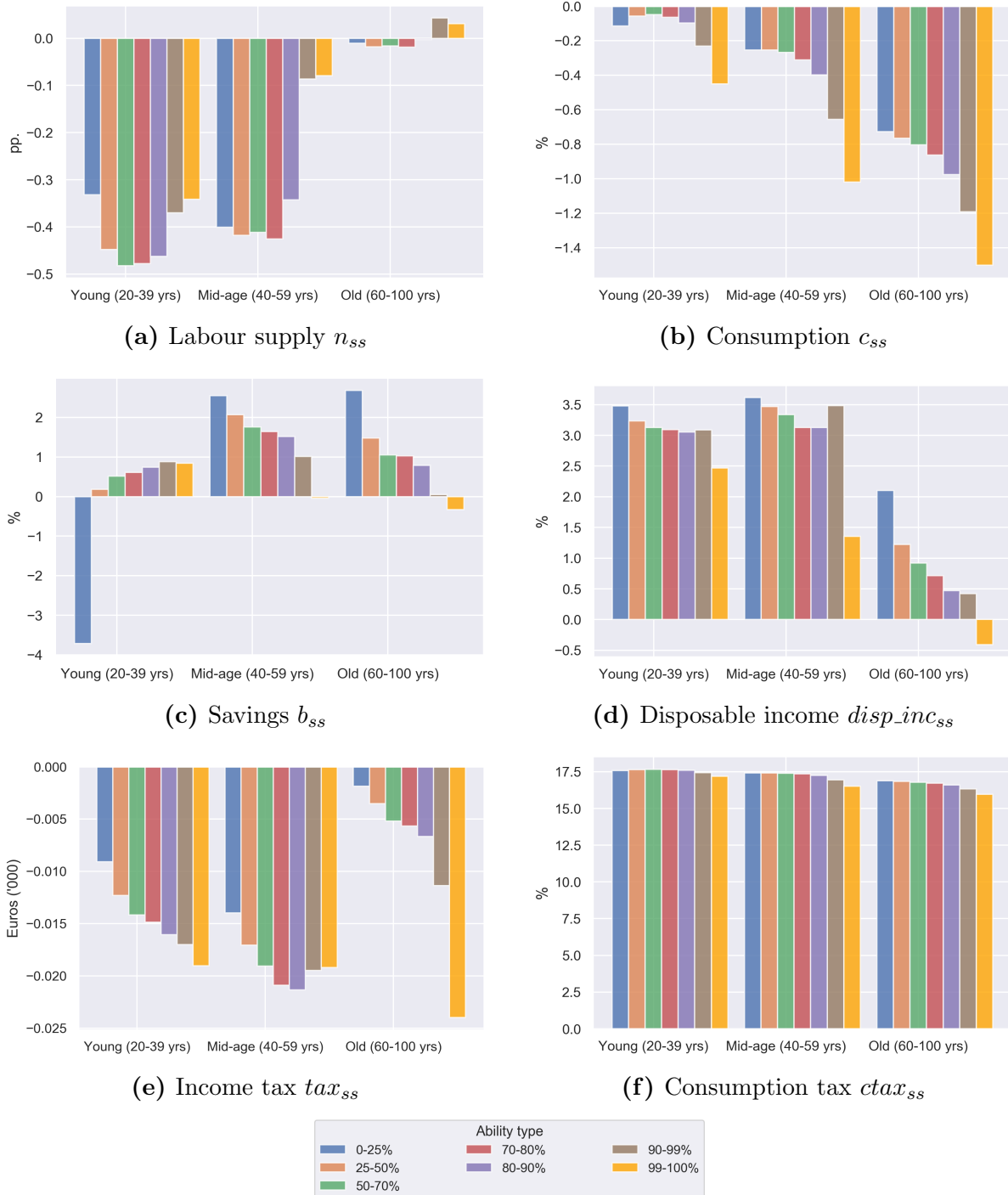


Figure 13: Effect of the 2320 EUR threshold rise reform by age groups in the steady state (all % deviation except for income tax that is absolute deviation)

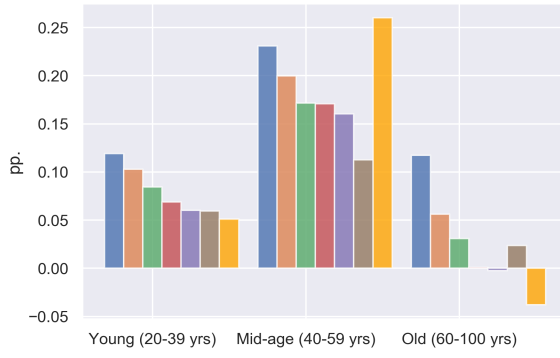


Figures 12e and 13e report the change in tax liabilities. Income tax revenues decrease for the whole population in both reforms. The income tax paid shows the results of interactions between the rate changes and the consequent changes labour supply and savings decisions.

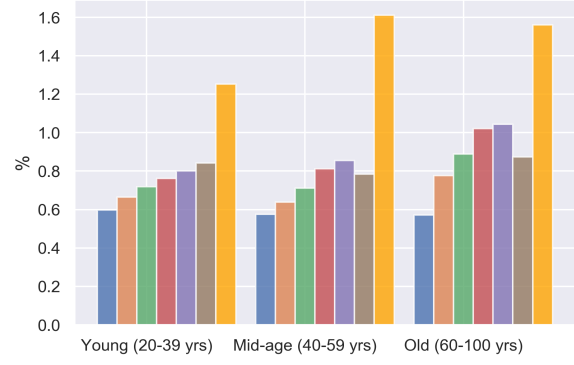
Generally, higher-ability agents are those who mostly benefit from the tax cut, as one would expect. The increases in consumption taxes paid, Figures 12f and 13f, are reasonably evenly spread across age groups and ability types. The key difference is that the Thres-rise reform involves a larger loss of income tax (once behavioural responses and general equilibrium effects are accounted for), and therefore the compensatory increase in consumption tax is greater (in the region of 17 percent increases, compared with around 10 percent increases for the 2pp-cut reform).

The long-run patterns are already largely present in the results for the 5th year after the introduction of the reform as shown in Figures 14 and 15, which we refer to as the short-run effects. This is as anticipated because the shocks are introduced in the initial time period. The variations that occur are a result of those later in adulthood not having been able to respond to the new tax system at younger ages. This also has general equilibrium effects on the macroeconomy, which can lead to different outcomes for younger ages. For example, the 2pp-cut reform shows slightly higher labour supply among young ages (except for the highest ability types) in the 5th year than in the long run. In contrast, the middle age group, ability types 2 to 6, increase their labour supply by less than the long-run increase. This pattern is also broadly present in the Thres-rise reform, however as in this case labour supply is falling, the higher short run labour supply for young ages is a smaller decrease than the long-run decrease. The lower labour supply in middle age (for ability types 2 to 7) is a larger decrease than in the long run.

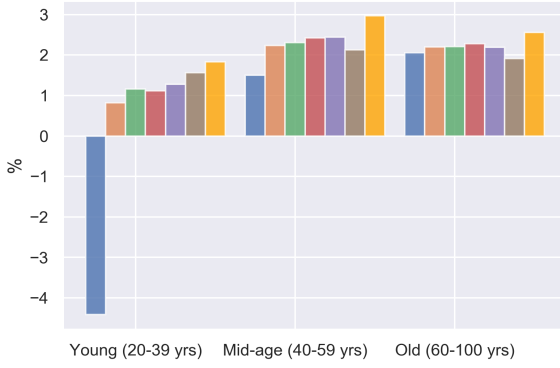
Figure 14: Effect of the 2 pp. tax rate cut reform by age groups in the 5th year after the introduction of the reform (all % deviation except for income tax that is absolute deviation)



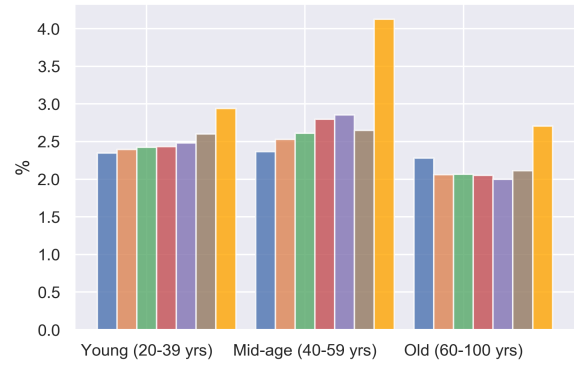
(a) Labour supply $npath_{5y}$



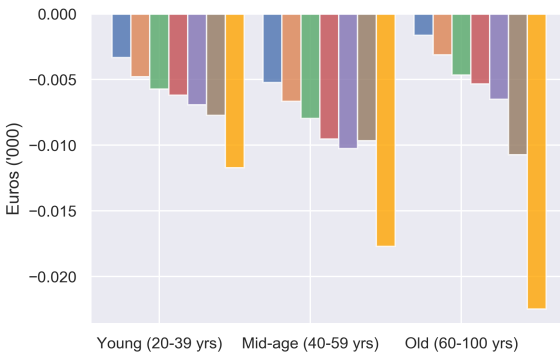
(b) Consumption $cpath_{5y}$



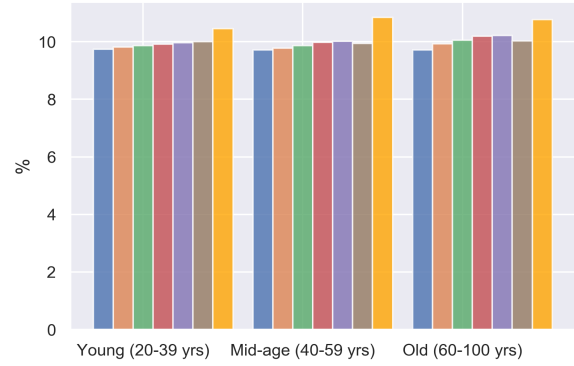
(c) Savings $bpath_{5y}$



(d) Disposable income $disp_inc_path_{5y}$



(e) Income tax tax_path_{5y}



(f) Consumption tax $ctax_path_{5y}$

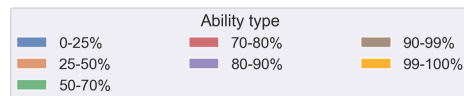
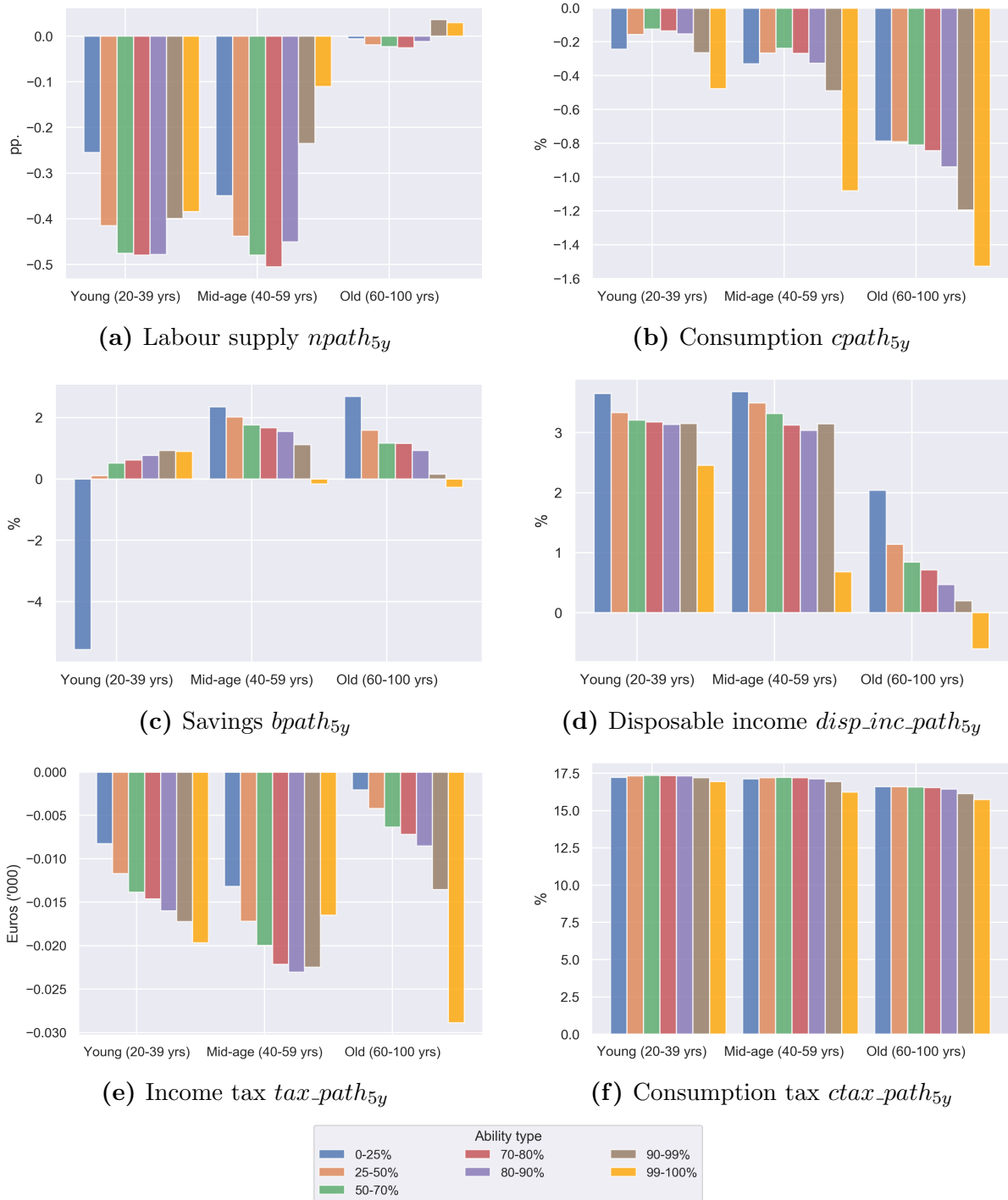


Figure 15: Effect of the 2320 EUR threshold rise reform by age groups in the 5th year after the introduction of the reform (all % deviation except for income tax that is absolute deviation)



Turning to the effects of the reforms on income inequality, Table 4 reports the impact by income decile calculated on the disposable income of the household and the change in Gini coefficients computed for the model's population. Both indicators are calculated for the

steady-state results, and are based on the model's 560 representative households (80 ages by 7 ability types). For this reason, it is not fully appropriate to compare the baseline levels to those that would be obtained using microdata. The results for both reforms show how the tax cuts broadly raise disposable income across income deciles. In the 2pp-cut reform, the greatest increase is for the 7th income decile, while the lower deciles have smaller gains. In the Thres-rise reform, the lower deciles have higher gains, but the largest percentage gains are for the higher deciles. Both reforms cause small increases in the Gini coefficient, with the 2pp-cut reform raising it by less than one percent and the Thres-rise reform by around half a percent.

Table 4: Changes by income deciles (household disposable income) and Gini coefficients - baseline and % changes from tax reforms

	Baseline	2pp-cut	Thres-rise
<i>Income decile</i>	Model units	Change	Change
I	0.0834	1.45%	2.07%
II	0.1715	1.29%	1.92%
III	0.2258	1.67%	2.05%
IV	0.2709	1.57%	1.98%
V	0.3184	2.27%	2.20%
VI	0.3781	2.68%	2.46%
VII	0.4217	3.06%	2.48%
VIII	0.4649	2.81%	2.53%
IX	0.5051	2.82%	2.55%
X	0.6015	2.49%	2.60%
Gini coeff.	0.2568	0.94%	0.52%

Source: Authors' calculation using **EDGE-M3** model

In Table 5 we present the reaction of aggregate variables to the two tax reforms as a percentage deviation from the baseline solution in the 5th year after the reform and in the long run. As can be seen, the reaction of labour, output and consumption in the 5th year after the reform is similar to that in the long run. This can be attributed to the forward-looking assumption in **EDGE-M3** model. Only capital stock reactions are stronger in the medium term, compared to the long term, due to the difference in the interest rate in the 5th year versus the long run. As can be seen from the table, income tax revenues fall much more with the Thres-rise reform than with the 2pp-cut reform due to negative change of labour in the latter case. As a consequence, consumption tax revenues are increasing more in the Thres-rise reform as we close the government budget with this variable. Interestingly, in case of the Thres-rise reform, the fall in income tax revenues is greater in the 5th year after the reform than in the long run due to the stronger negative reaction of labour supply in the 5th year.

Table 5: Changes (in % of the baseline levels) in aggregate variables as a result of the 2 pp. cut and the threshold increase reforms

Variable	2pp-cut		Thres-rise	
	5th year after the reform	Long run	5th year after the reform	Long run
<i>Output</i>	1.1	1.1	-0.05	-0.1
<i>Capital stock</i>	2.2	2.1	1.4	1.2
<i>Labour</i>	0.4	0.4	-1.0	-0.9
<i>Consumption</i>	0.8	0.8	-0.5	-0.5
<i>Income tax revenues</i>	-8.6	-8.7	-18.1	-17.5
<i>Consumption tax revenues</i>	9.9	10.4	17.0	17.2

Source: Authors' calculation using **EDGE-M3** model

This simulation exercise bring several insights for policy-making. In terms of efficiency, the 2pp-cut reform is an absolute winner with respect to its impact on consumption and savings. This is largely due to positive impact on the labour supply. If the main objective of a reform of the Italian tax system is to raise production and the overall competitiveness of the country, then a cut of marginal tax rates seems preferable. From a distributional perspective it is interesting to observe how such a reform causes only small differences across ages and income groups, which is perhaps counter-intuitive. In a static setting, the tax shift from labour income to consumption taxes would produce a clearly regressive reform, as observed already in previous studies (e.g., O'Donoghue et al., 2004, Decoster et al., 2010). However the dynamic nature of our overlapping-generations model suggests that the productivity gains achieved by increases in labour supply (which are concentrated in the lower ability groups) and in savings may instead produce an increase in disposable income, consumption and savings that are rather homogeneous across ages and income, and that these effects would be largely already present in the fifth year after the introduction of the reforms.

The Thres-rise reform, on the contrary, leads to a reduction in labour supply and consumption, and it is also less able when compared to the alternative reform to induce more savings. The reform does manage to improve disposable income (including in the short-run) significantly more for the working-age agents than for pensioners. It does even more so for low-ability agents across all ages. The latter observations hint at a greater political feasibility for a reform like the 2pp-cut, considering the demographic situation in Italy where low fertility coupled with longer life expectancy has been changing the composition of the population toward a larger share of old-age voters.

The results in our paper can be compared to other studies for EU countries, such as the Italian reform in Barrios et al. (2019). In the Appendix of their paper they present the results of a tax change for Italy combining the microsimulation model **EUROMOD** with the macroeconomic model **QUEST** via careful calibration of Frisch elasticity in the macro model

consistent with the estimated values in the discrete choice labour supply model.¹⁸ They study macroeconomic and distributional effects of the introduction of a refundable in-work tax credit for low-income earners in Italy that results in lower tax rates paid by employees on labour income. Low-skilled workers and the 2nd to the 6th income deciles benefit relatively more from the tax cut. This is close to our result for the Thres-rise reform. Similarly as in other studies (Thomas and Picos-Sanchez, 2012, Pestel and Sommer, 2017, Curci and Savegnano, 2019), we also found an equity-efficiency trade-off. That is, if we see an improvement in labour supply and employment, we also note a slight deterioration in income inequality among the seven income ability groups in EDGE-M3 model (cf. 2pp-cut reform).

9 Conclusions and Future Work

In this paper we incorporate a micro-founded representation of tax policy into a heterogeneous-agent macroeconomic model using the output from the EUROMOD microsimulation model. The specific version of the model used here was calibrated on Italian data for the year 2015. We show that the approach used for modelling tax functions is powerful enough to be able to capture the most important non-linearities of the tax code, together with the interaction effects between labour and capital incomes on both average and marginal tax rates. The macro model then provides general-equilibrium and behavioural changes (in terms of labour supply, consumption and saving decisions in a life-cycle perspective) differently by age and productivity levels of taxpayers, thanks to 560 categories of heterogeneous agents (80 ages times 7 earnings-ability types).

We then apply the linked micro-macro model to study a kind of policy reform that has been long proposed and discussed in the Italian context, namely a shift of the tax burden from personal income taxes onto consumption taxes. Our reform scenarios consist in cutting the marginal personal income tax rates across all tax brackets by two percentage points, or, alternatively, increasing the no-tax allowance. We were thus able to simultaneously study dynamic effects of the reforms over the life-cycle and its re-distributional effects. We show that the two reform scenarios affect households differently and cause different aggregate outcomes. More specifically, the 2 percentage points cut in tax rates is found to increase labour supply, consumption, and saving for most ages and earnings-ability types, while moderately increasing income inequality. The other reform, increasing the no-tax threshold, causes a decrease of labour supply and consumption (the latter particularly for older ages) while also increasing income inequality, but to a lesser extent compared to the alternative reform scenario.

It is interesting to contrast our findings with a common objection to tax shift reforms like our 2 percentage point rate cut reform. Without taking into account behavioural and general

¹⁸In EDGE-M3 we use a Frisch elasticity of labour supply of 0.9 that is appropriate for a macro model with only an intensive margin of labour and that represents a broad composition of individuals supplying labour - see Peterman (2016). Furthermore studies such as Keane and Rogerson (2015), using structural models and micro data, credibly support aggregate elasticities of this magnitude.

equilibrium effects, a cut in tax rates across the board, compensated by increases in VAT rates, as shown by many microsimulation studies, would obviously produce a clearly regressive tax reform. Thus, such a reform would face an important trade-off between efficiency gains (particularly those in the form of labour supply gains) and equity, and predictably, political resistances as well. Our simulations suggest that, after accounting for behavioural and general equilibrium effects, the increase in inequality due to this type of tax shift would be very limited.

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Appendices

A Household Problem

A measure $\omega_{1,t}$ of households is born each period, become economically relevant at age $s = E + 1$ if they survive to that age, and live for up to $E + S$ periods (S economically active periods), with the population of age- s individuals in period t being $\omega_{s,t}$. Let the age of a household be indexed by $s = \{1, 2, \dots, E + S\}$.

At birth, each household age $s = 1$ is randomly assigned one of J ability groups, indexed by j . Let λ_j represent the fraction of individuals in each ability group, such that $\sum_j \lambda_j = 1$. Note that this implies that the distribution across ability types in each age is given by $\boldsymbol{\lambda} = [\lambda_1, \lambda_2, \dots, \lambda_J]$. Once a household member is born and assigned to an ability type, he remains that ability type for his entire lifetime. Thus, it is the deterministic ability heterogeneity as an agent cannot change his ability type (for more details see Section 4). Let $e_{j,s} > 0$ be a matrix of ability-levels such that an individual of ability type j will have lifetime abilities of $[e_{j,1}, e_{j,2}, \dots, e_{j,E+S}]$. The budget constraint for the age- s household in lifetime income group j at time t is the following:

$$c_{j,s,t} (1 + \tau_{s,t}^c) + b_{j,s+1,t+1} = (1 + r_t)b_{j,s,t} + w_t e_{j,s} n_{j,s,t} + \zeta_{j,s} \frac{BQ_t}{\lambda_j \omega_{s,t}} + \eta_{j,s,t} \frac{TR_t}{\lambda_j \omega_{s,t}} - T_{j,s,t}^I - T_{j,s,t}^P$$

$$\forall j, t \quad \text{and} \quad s \geq E + 1 \quad \text{where} \quad b_{j,E+1,t} = 0 \quad \forall j, t$$
(8)

where $c_{j,s,t}$ is consumption, $\tau_{s,t}^c$ is consumption tax rate, $b_{j,s+1,t+1}$ is savings for the next period, r_t is the interest rate (return on savings), $b_{j,s,t}$ is current period wealth (savings from last period), w_t is the wage, and $n_{j,s,t}$ is labour supply.

The next term on the right-hand-side of the budget constraint (8) represents the portion of total bequests BQ_t that go to the age- s , income-group- j household. Let $\zeta_{j,s}$ be the fraction of total bequests BQ_t that go to the age- s , income-group- j household, such that $\sum_{s=E+1}^{E+S} \sum_{j=1}^J \zeta_{j,s} = 1$. We must divide that amount by the population of (j, s) households $\lambda_j \omega_{s,t}$. d'Andria et al. (2020) detail how to calibrate the $\zeta_{j,s}$ values from consumer finance data.

The penultimate term on the right-hand-side of the budget constraint (8) represents the portion of total transfers TR_t that go to the age- s , income-group- j household. Let $\eta_{j,s,t}$ be the fraction of total transfers TR_t that go to the age- s , income-group- j household, such that $\sum_{s=E+1}^{E+S} \sum_{j=1}^J \eta_{j,s,t} = 1$. We must divide that amount by the population of (j, s) households $\lambda_j \omega_{s,t}$. Section 4 details how transfers are distributed among households.

The last two terms on the right-hand-side of the budget constraint (8) represent income taxes paid by households, $T_{j,s,t}^I$, and payroll tax, $T_{j,s,t}^P$. Households choose lifetime consumption $\{c_{j,s,t+s-1}\}_{s=1}^S$, labour supply $\{n_{j,s,t+s-1}\}_{s=1}^S$, and savings $\{b_{j,s+1,t+s}\}_{s=1}^S$ to maximise lifetime utility, subject to the budget constraints and non negativity constraints. The household period utility function is the following:

$$u(c_{j,s,t}, n_{j,s,t}, b_{j,s+1,t+1}) \equiv \frac{(c_{j,s,t})^{1-\sigma} - 1}{1-\sigma} + e^{g_y t(1-\sigma)} \chi_s^n \left\{ b \left[1 - \left(\frac{n_{j,s,t}}{\tilde{l}} \right)^v \right]^{\frac{1}{v}} \right\} + \chi_j^b \rho_s \frac{(b_{j,s+1,t+1})^{1-\sigma} - 1}{1-\sigma} \quad \forall j, t \quad \text{and} \quad E+1 \leq s \leq E+S \quad (9)$$

The period utility function (9) is linearly separable in $c_{j,s,t}$, $n_{j,s,t}$, and $b_{j,s+1,t+1}$. The first term is a constant relative risk aversion (CRRA) utility of consumption. The second term is the elliptical disutility of labour.¹⁹ The constant χ_s^n adjusts the disutility of labour supply relative to consumption and can vary by age s , which is helpful for calibrating the model to match labour market moments.

It is necessary to multiply the disutility of labour in (9) by $e^{g_y(1-\sigma)}$ because labour supply $n_{j,s,t}$ is stationary, but both consumption $c_{j,s,t}$ and savings $b_{j,s+1,t+1}$ are growing at the rate of technological progress. The $e^{g_y(1-\sigma)}$ term keeps the relative utility values of consumption, labour supply, and savings in the same units.

The final term in the period utility function (9) is the “warm glow” bequest motive. It is a CRRA utility of savings, discounted by the mortality rate ρ_s .²⁰ Intuitively, it represents the utility a household gets in the event that they don’t live to the next period with probability ρ_s . It is a utility of savings beyond its usual benefit of allowing for more consumption in the next period. This utility of bequests also has constant χ_j^b which adjusts the utility of bequests relative to consumption and can vary by lifetime income group j . This is helpful for calibrating the model to match wealth distribution moments. Note that any bequest before age $E+S$ is unintentional as it was bequeathed due an event of death that was uncertain. Intentional bequests are all bequests given in the final period of life in which death is certain $b_{j,E+S+1,t}$.

The household lifetime optimisation problem is to choose consumption $c_{j,s,t}$, labour supply $n_{j,s,t}$, and savings $b_{j,s+1,t+1}$ in every period of life to maximise expected discounted lifetime utility, subject to budget constraints and upper-bound and lower-bound constraints.

$$\max_{\{(c_{j,s,t}), (n_{j,s,t}), (b_{j,s+1,t+1})\}_{s=E+1}^{E+S}} \sum_{s=1}^S \beta^{s-1} [\Pi_{u=E+1}^{E+s} (1 - \rho_u)] u(c_{j,s,t+s-1}, n_{j,s,t+s-1}, b_{j,s+1,t+s}) \quad (10)$$

$$\text{s.t.} \quad c_{j,s,t} (1 + \tau_{s,t}^c) + b_{j,s+1,t+1} = (1 + r_t) b_{j,s,t} + w_t e_{j,s} n_{j,s,t} + \zeta_{j,s} \frac{BQ_t}{\lambda_j \omega_{s,t}} + \eta_{j,s,t} \frac{TR_t}{\lambda_j \omega_{s,t}} - T_{j,s,t}^I - T_{j,s,t}^P \quad (8)$$

$$\text{and} \quad c_{j,s,t} \geq 0, \quad n_{j,s,t} \in [0, \tilde{l}], \quad \text{and} \quad b_{j,E+1,t} = 0 \quad \forall j, t, \quad \text{and} \quad E+1 \leq s \leq E+S$$

The non-negativity constraint on consumption does not bind in equilibrium because of the Inada condition $\lim_{c \rightarrow 0} u_1(c, n, b') = \infty$, which implies consumption is always strictly positive in equilibrium $c_{j,s,t} > 0$ for all j , s , and t . The warm glow bequest motive in (9) also has an Inada condition for savings at zero, so $b_{j,s,t} > 0$ for all j , s , and t . This is an implicit

¹⁹Advantages of modelling labour disutility with the elliptical functional form are discussed in Evans and Phillips (2018).

²⁰See d’Andria et al. (2020) for a detailed discussion of mortality rates in EDGE-M3.

borrowing constraint.²¹ And finally, as discussed in Evans and Phillips (2018), the elliptical disutility of labour supply functional form in (9) imposes Inada conditions on both the upper and lower bounds of labour supply such that labour supply is strictly interior in equilibrium $n_{j,s,t} \in (0, \tilde{l})$ for all j , s , and t .

The household maximisation problem can be further reduced by substituting in the household budget constraint, which binds with equality. This simplifies the household's problem to choosing labour supply $n_{j,s,t}$ and savings $b_{j,s+1,t+1}$ every period to maximise lifetime discounted expected utility. The 2S first order conditions for every type- j household that characterise the its S optimal labour supply decisions and S optimal savings decisions are the following.

$$\left(w_t e_{j,s} - \frac{\partial T_{j,s,t}^I}{\partial n_{j,s,t}} - \frac{\partial T_{j,s,t}^P}{\partial n_{j,s,t}} \right) (c_{j,s,t})^{-\sigma} \left(\frac{1}{1 + \tau_{s,t}^c} \right) = e^{g_y(1-\sigma)} \chi_s^n \left(\frac{b}{\tilde{l}} \right) \left(\frac{n_{j,s,t}}{\tilde{l}} \right)^{v-1} \left[1 - \left(\frac{n_{j,s,t}}{\tilde{l}} \right)^v \right]^{\frac{1-v}{v}} \quad \forall j, t, \quad \text{and} \quad E+1 \leq s \leq E+S \quad (11)$$

$$(c_{j,s,t})^{-\sigma} \left(\frac{1}{1 + \tau_{s,t}^c} \right) = e^{-g_y \sigma} \left(\chi_j^b \rho_s (b_{j,s+1,t+1})^{-\sigma} + \beta (1 - \rho_s) \left[1 + r_{t+1} - \frac{\partial T_{j,s+1,t+1}^I}{\partial b_{j,s+1,t+1}} \right] (c_{j,s+1,t+1})^{-\sigma} \left(\frac{1}{1 + \tau_{s+1,t+1}^c} \right) \right) \quad \forall j, t, \quad \text{and} \quad E+1 \leq s \leq E+S-1 \quad (12)$$

$$(c_{j,E+S,t})^{-\sigma} = \chi_j^b (b_{j,E+S+1,t+1})^{-\sigma} \quad \forall j, t \quad \text{and} \quad s = E+S \quad (13)$$

where the marginal income tax rate with respect to labour supply $\frac{\partial T_{s,t}^I}{\partial n_{j,s,t}}$ is described in equation (6). $\frac{\partial T_{j,s,t}^P}{\partial n_{j,s,t}}$ is the marginal rate of payroll tax with respect to labour supply.

B Exogenous Parameters and Calibrated Values

All exogenous parameters that are inputs to the model are listed in Table 6.

²¹It is important to note that savings also has an implicit upper bound $b_{j,s,t} \leq k$ above which consumption would be negative in current period. However, this upper bound on savings is taken care of by the Inada condition on consumption.

Table 6: List of exogenous parameters and baseline calibration values

Symbol	Description	Value
S	Maximum periods in economically active household life	80
E	Number of periods of youth economically outside the model	20
T_1	Number of periods to steady state for initial time path guesses	320
T_2	Maximum number of periods to steady state for nonsteady-state equilibrium	400
R	Eligible age for pension transfers	62
$\{\{\omega_{s,0}\}_{s=1}^{E+S}\}_{t=0}^{T_2+S-1}$	Initial population distribution by age	(see d’Andria et al., 2020)
$\{f_s\}_{s=1}^{E+S}$	Fertility rates by age	(see d’Andria et al., 2020)
$\{i_s\}_{s=1}^{E+S}$	Immigration rates by age	(see d’Andria et al., 2020)
$\{\rho_s\}_{s=0}^{E+S}$	Mortality rates by age	(see d’Andria et al., 2020)
$\{e_{j,s}\}_{j=1}^{J,S}$	Deterministic ability process	(see 1)
$\{\lambda_j\}_{j=1}^J$	Lifetime income group percentages	[0.25, 0.25, 0.20, 0.10, 0.10, 0.09, 0.01]
J	Number of lifetime income groups	7
$\tilde{l}$	Maximum labour supply	1
β	Discount factor	0.975
σ	Coefficient of constant relative risk aversion	2.2
b	Scale parameter in utility of leisure	0.527
v	Shape parameter in utility of leisure	1.497
	Frisch elasticity	0.9
χ_s^n	Disutility of labour level parameters	(see d’Andria et al., 2020)
χ_j^b	Utility of bequests level parameters	(see d’Andria et al., 2020)
ζ	Share of bequests received by households	(see d’Andria et al., 2020)
η	Share of transfers received by households	(see d’Andria et al., 2020)
τ_s^c	Marginal tax rate on consumption by age	(see d’Andria et al., 2020)
Z	Level parameter in production function	1.0
γ	Capital share of income	0.4
δ	Capital depreciation rate	4.4%
g_y	Growth rate of labour augmenting technological progress	1.0%

Table 7: List of optional exogenous parameters and baseline calibration values

Symbol	Description	Value
r^*	World interest rate	0.62%
τ_d	Sovereign interest rate scale parameter	0.626
μ_d	Sovereign interest rate shift parameter	0.0036
ζ_K	Foreign share of capital	0.064
ζ_D	Foreign share of new debt issues	0.32

C Endogenous Variables

Endogenous variables of EDGE-M3 OLG model are listed in Table 8.

Table 8: List of endogenous variables

Symbol	Description
$n_{j,s}$	Labour supply by age and ability
$b_{j,s}$	Savings by age and ability
$c_{j,s}$	Consumption by age and ability
$T_{j,s}^I$	Total income tax by age and ability
$T_{j,s}^C$	Total consumption tax by age and ability
r	Real interest rate
w	Real wage rate
$\tau_{j,s}^{mtrx}$	Marginal tax rate on labour income by age
$\tau_{j,s}^{mtry}$	Marginal tax rate on capital income by age
$\tau_{j,s}^{etr}$	Average tax rate on income by age
L	Aggregate labour supply
BQ	Aggregate bequests
K	Aggregate capital stock
K^d	Capital supplied domestically [Open economy option]
K^f	Capital supplied by foreign investors [Open economy option]
C	Aggregate consumption
I	Aggregate investment
Y	Aggregate output
TR	Aggregate transfers
D	Total public debt
D^d	Public debt held domestically [Open economy option]
D^f	Public debt held by foreign investors [Open economy option]
$factor_t$	Factor transforming model units into the data units

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