Essays on Labor Supply and Macroeconomic Stabilization

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Introduction

Macroeconomic stabilization policies in general and automatic stabilizers in particular have seen an increased focus from researchers, especially since the 2007–2008 financial crisis and the following recession. At the same time, the crisis in Europe has urged academics to better understand the economies of the EU and the European Monetary Union. This thesis consists of four papers analyzing European economies, with a focus on automatic stabilization. Automatic stabilizers are elements of fiscal policy that have the potential to smooth the business cycle by automatically adjusting government spending and revenue.

The first chapter, *Crisis, Austerity and Automatic Stabilization*, analyzes the changes of the automatic stabilizers in Europe after the crisis, a period dominated by austerity and political change. We analyze how reforms of tax-benefit systems in the period 2007–2014 have affected the automatic stabilization capacity in the EU27. Our analysis sheds light on the effect of fiscal consolidation measures on automatic stabilizers. Our results show that automatic stabilizers are heterogeneous across EU countries. Income stabilization coefficients range from 20-30 percent in some Eastern and Southern European countries to around 60 percent in Belgium, Germany, and Denmark. Our analysis shows that automatic stabilizers could operate freely in the early phase of the financial and economic crisis, but have been constrained in some EU countries by subsequent fiscal consolidation measures. A comparison of our estimates of automatic stabilizers with macro measures such as changes in the cyclical and the cyclically-adjusted budget balance reveals that micro-based estimates can provide more precise information about the degree of household income stabilization.

The second chapter, *Labor Supply and Automatic Stabilization*, moves away from the context of the recent crisis and enriches the static model of the previous chapter by a household labor supply model to isolate a specific channel through which automatic stabilizers work: a marginal incentives channel, coming from the decrease in a progressive tax system's marginal tax rate. In this case, the tax rate that a household faces will fall following an income decline in a recession, thereby increasing work incentives and hence labor supply. This effect offsets part of the initial income decline, stabilizing aggregate income and output. The magnitude of the effect depends on the responsiveness of the marginal tax rate after changes in gross income, and the elasticity of labor supply. We estimate a structural discrete choice labor supply model and individual tax rates for households in the EU based on EU-SILC data using the microsimulation model EUROMOD.

The third chapter *Dynamic Scoring of Tax Reforms in the EU* is not directly concerned with macroeconomic stabilization, but instead focuses on the more general question of how to evaluate tax reforms in the European context. We use a labor supply model to inform and calibrate realistically the macro DSGE model QUEST that is used for policy analyses by EU institutions. It provides a bridge between the micro and macro approaches encompassed in this thesis. It is the first dynamic scoring exercise linking a microsimulation and a dynamic general equilibrium model for Europe. We illustrate our novel methodology by analyzing hypothetical reforms of the social insurance contributions system in Belgium. Our approach takes into account the feedback effects resulting from adjustments and behavioral responses in the labor market and the economy-wide reaction to the tax policy changes essential for a comprehensive evaluation of the reforms. We find that the self-financing effect of a reduction in employers' social insurance contribution is substantially larger than that of a comparable reduction in employees' social insurance contributions.

The fourth chapter, *Automatic Stabilizers in Monetary and Fiscal Unions*, develops a multi-country New-Keynesian model with heterogeneous agents and incomplete markets calibrated to the Euro area to assess the role of automatic stabilizers in a monetary union when countries are affected by country specific shocks. In a monetary union, monetary policy is constrained in two ways. First, it cannot condition on country specific shocks. Second, countries cannot resort to nominal devaluation of the exchange rate. Recent literature shows that automatic stabilizers are particularly important when monetary policy is constrained. Another feature of the model are trade linkages between countries to account for positive spillovers within the closely connected countries in the Euro area. I propose a model experiment by shutting off automatic stabilizers to gauge their effect on the EU business cycle. The model developed in this chapter provides a framework to analyze several important questions in the future, such as whether there are benefits of a unified fiscal authority.

1. Crisis, Austerity and Automatic Stabilization[1]

1.1. Introduction

The Great Recession and the resulting sovereign debt crisis in Europe have led to budget consolidation measures in many EU countries. In some cases, fundamental changes in the structure of tax and transfer systems have taken place. Tax increases and spending cuts aimed at reducing soaring government budget deficits, but in many cases exacerbated losses in household incomes. This paper is the first to investigate the short and long-run effects of fiscal consolidation measures in Europe ("austerity measures") on the automatic stabilizers inherent in tax and transfer systems. Our analysis allows to disentangle *automatic* changes from those that take place after explicit government legislature (*discretionary* changes).

Automatic stabilizers are those elements of the tax and transfer system that mitigate fluctuations in output without discretionary government action. The analysis of the automatic stabilization capacity of existing tax-benefit systems in Europe is particularly relevant in the context of the recent economic crisis, as monetary policy is near or at the zero lower bound. In these cases, the importance of automatic stabilizers for overall macroeconomic stabilization increases (McKay and Reis, 2016).

Previous work on automatic stabilizers has mostly relied on macro data (see, e.g., Fatás and Mihov, 2001; in't Veld et al., 2013; Di Maggio and Kermani, 2016) or structural models (McKay and Reis, 2016). Approaches based on macro data typically use aggregate variables on government revenue and spending as proxies for automatic stabilizers. However, these variables are endogenous to changes in household incomes as tax payments decrease (for a given progressive tax system) or (unemployment) benefits increase when households earn lower incomes or become unemployed. Therefore, studies based on macro regressions (e.g. regressing changes in fiscal variables on the growth rate of GDP), such as Sala-i-Martin and Sachs (1992) and Bayoumi and Masson (1995), can be biased from

[1]This paper is joint work and circulates as Dolls, Fuest, Peichl, and Wittneben (2019).

endogenous regressors and, moreover, cannot distinguish automatic stabilizer effects from discretionary policy measures.[2]

To circumvent these problems, we follow the approach of Auerbach and Feenberg (2000) and Dolls et al. (2012) in using micro data for our analysis.[3] The use of harmonized European micro data and counterfactual simulation techniques allows us to identify the cushioning effect of tax-benefit systems against exogenous income and unemployment shocks. Specifically, we analyze how changes in tax-benefit systems over the period 2007–2014 have affected the workings of automatic stabilizers in the EU27. We combine 2007 pre-crisis micro data from the EU Statistics on Income and Living Conditions (EU-SILC) with the different tax-benefit rules in the period under investigation. This allows us to disentangle the effect of changes in the tax and transfer systems (i.e. the "policy effect") from changes in actual incomes and demographics and to assess the shock-absorption capacity of the tax and transfer systems.

We use the measure of the *normalized tax change* (Pechman, 1973, 1987; Auerbach and Feenberg, 2000) as a metric for automatic stabilization. Following Dolls et al. (2012), this measure of the stabilizing effect of the tax and transfer system is calculated for two counterfactual scenarios. The first is a stylized proportional shock of 5 percent to household gross incomes. The shock is the same in all countries and affects all households equally. The second scenario is an idiosyncratic unemployment shock leading to an increase in the national unemployment rate and the same aggregate income loss as in the first scenario. For both scenarios, we compute how direct taxes, social insurance contributions as well as transfers change in response to the simulated income change. Relating the change in taxes and benefits to the income change yields the *income stabilization coefficient* as a measure of automatic stabilization. We also compute *short-term stabilizing coefficients* taking into account that the actual stabilization provided by the tax-benefit system can be weaker (stronger) than in steady-state if tax hikes or cuts in benefits (tax reductions or benefit extensions) coincide with macroeconomic shocks.

Our results show that automatic stabilizers are heterogeneous across EU countries. Income stabilization coefficients range from 20-30 percent in some Eastern and Southern European countries to around 60 percent in Belgium, Germany, and Denmark. Our analysis shows that automatic stabilizers could operate freely in the early phase of the financial and economic crisis, but have been constrained in some EU countries by subsequent fiscal consolidation measures. A comparison of our estimates of automatic

[2] Other macro studies focus on the relation between output volatility, public sector size and openness of the economy (Galí, 1994; Fatás and Mihov, 2001; Auerbach and Hassett, 2002).

[3] Other micro studies include Kniesner and Ziliak (2002a,b).

stabilizers inherent in tax-benefit systems with macro measures such as changes in the cyclical and the cyclically-adjusted budget balance reveals that micro-based estimates can provide more precise information about the degree of household income stabilization.

Our contribution to the literature is threefold. First, we analyze how the automatic stabilization capacities of tax and transfer systems in the EU27 have changed since the beginning of the financial and economic crisis in 2007. We extend the analysis of Dolls et al. (2012), who assess the effectiveness of automatic stabilizers for 19 EU countries and the United States, by using more recent data and a larger set of countries and policy years.[4] Second, we shed light on the short-term effects of policy changes on household income stabilization. This analysis shows to what extent automatic stabilizers could operate freely over the period under consideration. Third, our paper provides new evidence on the relationship between our micro-based estimates of automatic stabilizers and more conventional macro measures which are used in the EU fiscal governance framework (Deroose et al., 2008; Mourre et al., 2014). We show that micro-based estimates provide complementary information to the macroeconomic indicators.

We proceed as follows. Section 1.2 presents the theoretical framework. In section 1.3 we discuss the data and our empirical approach. Section 1.4 presents the results and section 1.5 concludes.

1.2. Framework

In this section we describe the framework used to measure automatic stabilizers.

1.2.1. Income Stabilization

Household income stabilization provided by tax-benefit systems is measured by a coefficient showing how household disposable income varies with respect to changes in gross income. We use the measure of *the tax system's built-in flexibility*, also denoted as *normalized tax change*, proposed by Pechman (1973) and employed by Auerbach and Feenberg (2000), Mabbett and Schelkle (2007) and extended by Dolls et al. (2012) to account for social insurance contributions and benefits in addition to direct taxes. It is denoted as *income stabilization coefficient* and measures the ratio of changes in disposable

[4] Callan et al. (2018) and Paulus and Tasseva (2018) analyze the automatic stabilization effect of tax-benefit systems on the income distribution for a subset of countries we focus on.

income to changes in gross income.[5][6]

The mechanism behind the stabilizers is as follows. Consider a household that has to pay a proportional tax of 30 percent and faces a decline in gross income of 100 Euros. Then 30 percent of the shock would be absorbed by the proportional tax, leaving a decline of 70 Euros of disposable income. For a progressive tax system, as is in place in the majority of the European countries, the stabilizing effect would be larger (Dolls et al., 2012). Let the aforementioned household be subject to progressive taxation, and after the initial shock, her marginal tax rate drop to 25 percent. Then this provides an additional cushioning of the decline in disposable income.

Market income which is equal to gross income in our context is defined as

$$Y_i^M = Y_i^E + Y_i^Q + Y_i^I + Y_i^P + Y_i^O, \tag{1.2.1}$$

where Y_i^E denotes labor income, Y_i^Q business income, Y_i^I capital income, Y_i^P property income, and Y_i^O other income. Disposable income is equal to market income minus net government intervention, which consists of direct taxes $T(Y_{it}^M, X_i, \chi_t)$, social insurance contributions $S(Y_{it}^M, X_i, \chi_t)$ and social benefits $B(Y_{it}^M, X_i, \chi_t)$, for example unemployment benefits. We define tax payments, social insurance contributions and benefit payments to be functions of market income Y_i^M,[7] household characteristics X_i (e.g. number of children, marital status, age) and parameters of the tax-benefit system χ_t (e.g. tax rate, bracket thresholds, deduction). Defining net government intervention as $G(Y_{it}^M, X_i, \chi_t) = T(Y_{it}^M, X_i, \chi_t) + S(Y_{it}^M, X_i, \chi_t) - B(Y_{it}^M, X_i, \chi_t)$, disposable income can

[5] Dolls et al. (2012) also estimate a stabilization effect on the demand for goods and services (*demand stabilization coefficient*). It depends on how households adjust consumption expenditure to fluctuations in disposable income. However, McKay and Reis (2016) find the demand stabilization effect to be small over the business cycle, and the income stabilization effect to be quantitatively more important. Therefore, in this paper we focus on the income stabilization coefficient only.

[6] An alternative measure is the elasticity of taxes with respect to income changes (see Auerbach and Feenberg, 2000), with a proportional tax system having an elasticity of one, and progressive taxes having an elasticity greater than one. The magnitude of this elasticity serves as a measure of the degree of progressivity of the tax system. The drawback of using it as an indicator of the stabilizing effect is its definition as a relative measure, relating the percent change of taxes to a one-percent change in income. The elasticity neglects information on the share of income to be payed as taxes. This information, however, is important, as a large share of taxes relative to aggregate income means that taxes can serve as a more effective automatic stabilizer.

[7] Note that, for simplicity of notation, we write a dependence on market income Y_i^M only and not a dependence on each of its components (see equation (1.2.1)), although our simulations based on EUROMOD respect the different income types (see section 1.3.1).

be written as

$$
\begin{aligned}
Y^D(Y_{it}^M, X_i, \chi_t) &= Y_i^M - G(Y_{it}^M, X_i, \chi_t) && (1.2.2)\\
&= Y_i^M - \Big(T(Y_{it}^M, X_i, \chi_t) + S(Y_{it}^M, X_i, \chi_t) - B(Y_{it}^M, X_i, \chi_t)\Big). && (1.2.3)
\end{aligned}
$$

The income stabilization coefficient is denoted by τ^I and measures how changes in market income ΔY^M translate into changes in households' disposable income ΔY^D. In the empirical analysis, we will follow Dolls et al. (2012) and consider two stylized scenarios where gross incomes are reduced by 5% (cf. section 1.3):

$$\sum_i \Delta Y_i^D = \sum_i \Big(Y^D(0.95Y_{it}^M, X_i, \chi_t) - Y^D(Y_{it}^M, X_i, \chi_t)\Big) = \Big(1 - \tau^I\Big) \sum_i \Delta Y^M$$

The income stabilization coefficient can be written as

$$
\begin{aligned}
\sum_i \Delta Y_i^D &= (1 - \tau^I) \sum_i \Delta Y_i^M \\
\Leftrightarrow \tau^I &= 1 - \frac{\sum_i \Delta Y_i^D}{\sum_i \Delta Y_i^M}.
\end{aligned}
$$

τ^I can be interpreted as the fraction of a shock that is absorbed by the tax-benefit system.

Using (1.2.2), it is possible to decompose the income stabilization coefficient into the stabilizing effects provided by taxes, social insurance contributions and benefits:

$$\tau^I = \tau_T^I + \tau_S^I + \tau_B^I = \frac{\sum_i \Delta T_i}{\sum_i \Delta Y_i^M} + \frac{\sum_i \Delta S_i}{\sum_i \Delta Y_i^M} - \frac{\sum_i \Delta B_i}{\sum_i \Delta Y_i^M}. \qquad (1.2.4)$$

Throughout the paper, we will make the assumption that all taxes and transfers are borne by employees and that employers have to bear their share of the social insurance contributions. Hence, employers' social insurance contributions are assumed not to be shifted to employees, so that they will not affect employees' wages. The stabilizing effects of social insurance contributions will thus only reflect employees' social insurance contributions.[8]

[8] Dolls et al. (2012) calculate income stabilization coefficients with and without social insurance contributions by employers and find that the inclusion of employers' social insurance contributions does change the country ranking only slightly. Results including employers' social insurance contributions are available upon request.

1.2.2. Short-Term Effects of Discretionary Policy Changes

The income stabilization coefficient presented above measures the cushioning effect of the tax-benefit system under the assumption of constant policy, i.e., it relates the change in taxes, social insurance contributions and benefits following the shock to market income to the change in market income. It does not take into account the additional effect on household disposable incomes that may occur when the income shock coincides with changes in the tax and transfer system.

Consider as an illustration a tax hike which is introduced as a fiscal consolidation measure in an economic downturn with declining market incomes. The income stabilization coefficient estimated after the policy change has been implemented would indicate an increase in the automatic stabilization capacity of the tax system. If the tax hike coincides with the decline in market incomes, however, the overall fiscal impulse is less counter-cyclical than the effect of automatic stabilizers alone.[9] Arguably, the income stabilization coefficient can be interpreted as measuring the long-term ('steady state') stabilization capacity of a tax and transfer system.

In the short-run, discretionary fiscal policy might constrain the ability of the tax system to act as an automatic stabilizer. We therefore complement the income stabilization coefficient by a new measure that takes into account that taxes, social insurance contributions and benefits might change at the same time as market incomes. More precisely, we calculate the difference in disposable incomes for household i when subject to tax policy in period t (before the change in market income) and when subject to tax policy in period $t+1$ (after the change in market income). Again, let $T(Y_{it}^M, X_i, \chi_t)$ be the tax function. We can write the *short-term stabilization coefficient* as

$$\theta_{t+1}^{I,T} = \frac{\sum_i \Big(T(0.95Y_i^M, X_i, \chi_{t+1}) - T(Y_i^M, X_i, \chi_t)\Big)}{\sum_i \Delta Y_i^M} \tag{1.2.5}$$

$$= \frac{\sum_i \Big(T(0.95Y_i^M, X_i, \chi_{t+1}) - T(Y_i^M, X_i, \chi_t)\Big)}{\sum_i 0.05Y_i^M} \tag{1.2.6}$$

[9] See for example Deroose et al. (2008) or Fatás and Mihov (2009) for a discussion how the overall fiscal impulse can be decomposed into discretionary fiscal policy and automatic stabilizers.

Using shorthand notation for the equations above, we can write:

$$\begin{aligned}
\theta^I_{t+1} &= \frac{\sum_i (T^1_{i,t+1} - T^0_{i,t}) + \sum_i (S^1_{i,t+1} - S^0_{i,t}) - \sum_i (B^1_{i,t+1} - B^0_{i,t})}{\sum_i \Delta Y^M_{i,t}} \qquad (1.2.7)\\
&= \frac{\sum_i \left(T^1_{i,t+1} + S^1_{i,t+1} - B^1_{i,t+1}\right) - \sum_i \left(T^0_t + S^0_t - B^0_t\right)}{\sum_i \left(Y^{M1}_{i,t} - Y^{M0}_{i,t}\right)}\\
&= \frac{\sum_i \left(Y^{M1}_{i,t+1} - Y^{D1}_{i,t+1}\right) - \sum_i \left(Y^{M0}_{i,t} - Y^{D0}_{i,t}\right)}{\sum_i \left(Y^{M1}_{i,t} - Y^{M0}_{i,t}\right)}\\
&= \frac{\sum_i \left(Y^{M1}_{i,t+1} - Y^{M0}_{i,t}\right) - \sum_i \left(Y^{D1}_{i,t+1} - Y^{D0}_{i,t}\right)}{\sum_i \left(Y^{M1}_{i,t} - Y^{M0}_{i,t}\right)}
\end{aligned}$$

Analogously to the decomposition of the income stabilization coefficient, we decompose the short-term stabilization coefficient θ^I_t into its components:

$$\begin{aligned}
\theta^I_{i,t+1} &= \frac{\sum_i (T^1_{i,t+1} - T^0_{i,t}) + \sum_i (S^1_{i,t+1} - S^0_{i,t}) - \sum_i (B^1_{i,t+1} - B^0_{i,t})}{\sum_i \Delta Y^M_{i,t}}\\
&= \theta^T_{i,t+1} + \theta^S_{i,t+1} - \theta^B_{i,t+1} \qquad (1.2.8)
\end{aligned}$$

The short-term stabilization coefficient reflects how discretionary policy changes affect the cushioning effect of the tax-benefit system, or in other words, to what extent automatic stabilizers can operate freely. In an economic downturn, the following stylized scenarios can be differentiated (symmetrically in an economic upturn).

Automatic stabilizers operate freely. If there is no policy change from one year to the other, the government allows for intertemporal stabilization by incurring debt. The automatic stabilizers of the tax-benefit system typically lead to a reduction in tax revenue if taxable income declines or to an increase in benefit expenditure if unemployment goes up ($T^1_{t+1} < T^0_t$ or $B^1_{t+1} > B^0_t$). In such a situation, the short-term stabilization coefficient equals the income stabilization coefficient: $\theta^T_{t+1} = \tau^T_t$. If governments pursue expansionary fiscal policy, for example by cutting taxes or raising benefits, the short-term stabilization coefficient will exceed the income stabilization coefficient: $\theta^T_{t+1} > \tau^T_t$.

Automatic stabilization channel constrained or shut down. If governments pursue contractionary fiscal policy, but still allow for a reduction in tax revenue or an increase in benefit expenditure from one year to the other, the short-term stabilization coefficient will be larger than zero, but smaller than the income stabilization coefficient:

$0 < \theta^T_{t+1} < \tau^T_t$. If governments are credit-constrained and have to keep tax revenue or benefit expenditure constant from one year to the other ($T^1_{t+1} = T^0_t$ or $B^1_{t+1} = B^0_t$), the automatic stabilization channel is shut down through discretionary policy changes: $\theta^T_{t+1} = 0$. In the most severe scenario of contractionary fiscal policy, discretionary policy changes lead to an increase in revenue or a decrease in benefit expenditure even though the economy experiences a slump ($T^1_{t+1} > T^0_t$ or $B^1_{t+1} < B^0_t$). It can be seen that in this case $\theta^T_{t+1} < 0$.

1.3. Data and Empirical Approach

In the empirical analysis, we analyze the workings of automatic stabilizers in the EU27 over the period 2007–2014 and how they were affected by discretionary changes in tax-benefit systems. Our analysis is based on EU-SILC household micro data and the European microsimulation model EUROMOD.

1.3.1. EUROMOD

In our simulations, we use EUROMOD (version G4.0) in order to calculate household disposable incomes (see Sutherland and Figari, 2013; Sutherland, 2018). EUROMOD contains the tax and benefit rules present in the EU27 for different years and takes EU-SILC household micro data as input. EU-SILC is a harmonized, cross-sectional household micro dataset for the EU member states provided by Eurostat (2012). In addition, we construct an unemployment benefit calculator that incorporates all important policy rules such as replacement rates, eligibility criteria and maximum benefit durations.[10] EU-SILC data contain rich information about the different income sources (e.g. employment income, capital income, income from self-employment) and household demographics that may influence tax and transfer policies (for instance marital status, number of children or age).

The microsimulation approach allows us to separate the dataset containing market incomes and demographics from the rules of the tax and transfer systems. We use EU-SILC household data with an income reference period of 2007 for the whole analysis, and simulate income taxes, social insurance contributions and benefits following the

[10] The EUROMOD version used in this paper does not simulate unemployment benefits, but takes unemployment benefits from the input data. As explained below, we aim at simulating counterfactual disposable incomes for different years and therefore need to make use of an unemployment benefit calculator. Detailed policy rules are collected from country chapters of the OECD series "Benefits and Wages" (http://www.oecd.org/social/benefits-and-wages.htm) and from the EU's MISSOC-Comparative Tables Database (http://ec.europa.eu/social/main.jsp?langId=en&catId=815).

tax-benefit policy parameters of the years 2007–2014.[11] That is, we hold household characteristics X_i and market income Y_i^M constant (through the use of the same baseline dataset), and only vary the parameters of the tax-benefit system χ_t over time, yielding counterfactual disposable incomes that would have prevailed if household demographics and market incomes would not have changed over time.[12] This approach provides us–for each EU27 country–with a sample of repeated cross-sections reflecting market incomes and household demographics from 2007 and disposable incomes based on tax-benefit policies of the period 2007–2014.

Keeping market incomes and demographics constant at their pre-crisis level allows us to isolate the effect of policy changes on the automatic stabilization effect of tax-benefit systems.[13] If both input data and tax-benefit policies were changed at the same time, it would not be possible to disentangle the effect of changing market incomes and demographics from the effect of changing tax-benefit policy parameters.

1.3.2. Scenarios

Following Dolls et al. (2012), we simulate two stylized shocks: First, a proportional decline of household gross incomes by 5% affecting all households equally (*income shock*), and second, an idiosyncratic shock affecting only some individuals who lose their job. This *unemployment shock* is calibrated such that total household income decreases by 5% as well. Thereby, the severity of the two shock scenarios is comparable in terms of the aggregate income loss. Both shocks are simulated on the same (pre-crisis) household micro datasets reflecting market incomes and household demographics as of 2007, but with tax-benefit policies spanning the period 2007–2014 (see section 1.3.1). The unemployment shock is modeled by increasing (decreasing) the weight of unemployed (employed) individuals in our sample, while the aggregate counts of individual and household characteristics are kept constant (Immervoll et al., 2006). The implicit assumption behind this approach is that the socio-demographic characteristics of the newly unemployed correspond to the existing pool of unemployed. This is done on purpose to avoid capturing changes in unemployment benefit eligibility over time which are induced by changes in the characteristics of the unemployed, for example a larger share of long-term unemployed in some countries in

[11] The EUROMOD version used in this paper allows for some countries the simulation of tax-benefit systems up until 2015. For France and Malta, the 2006 and 2008 EU-SILC versions are used, respectively. Croatia is excluded from the analysis as no pre-crisis data have been available to us.

[12] Changes in tax-benefit systems include both structural changes and uprating of monetary parameters according to the rules in each country (Paulus et al., 2019).

[13] See e.g. Bargain and Callan (2010), Bargain et al. (2015) or Paulus et al. (2017) who use similar simulation techniques to estimate distributional effects of changes in tax-benefit systems.

the more recent years of the simulation period. Instead, our results solely reflect changes in tax-benefit policy parameters over time.

Note that we do not strive to replicate actual changes in income and unemployment as observed over the simulation period. Economic conditions are endogenous to the overall fiscal impulse (discretionary fiscal policy and automatic stabilizers). The aim of the paper is to explore how effective built-in automatic stabilizers are to cushion (stylized and exogenous) income and unemployment shocks that are comparable across countries and to assess to what extent discretionary policy changes have had an impact on the workings of automatic stabilizers.

1.4. Results

We first present income stabilization coefficients for the period 2007–2014 and then show how discretionary changes in tax-benefit parameters have affected the degree to which automatic stabilizers could operate over this period.

1.4.1. Income Stabilization Coefficients

Income shock. Figure 1.1 depicts the change in the income stabilization coefficient from 2007 to 2014 on the x-axis and its 2007 level on the y-axis. Focusing first on the *levels* of the income stabilization coefficients in 2007, we find strong differences across countries with coefficients ranging from 0.22 in Cyprus to 0.54 in Belgium. The (population-weighted) average EA19 (EU27) income stabilization coefficient amounts to 0.38 (0.39) as shown in Table A.1 in the Appendix. Generally, coefficients tend to be higher in Western European and Nordic countries and lower in Baltic, Eastern and Southern European countries, with Hungary being a notable exception.

The largest *change* occurred in Hungary with a reduction in the income stabilization coefficient of 0.16 percentage points from 2007 to 2014. Hungary adopted a flat tax which reduced the stabilizing effect of the income tax considerably from 0.34 in 2007 to 0.16 in 2014 (cf. Table A.1). On the other side of the spectrum, countries such as Ireland, Greece, Portugal and Cyprus raised taxes and/or social insurance contributions which led to an increase in the income stabilization coefficient.[14] The negative slope of the regression line in Figure 1.1 indicates that the dispersion of income stabilization coefficients across countries has become more compressed, that is, countries with a relatively low (high)

[14] The European Commission's LABREF database provides an overview of tax-benefit reforms undertaken in the period under consideration (see also Turrini et al., 2015, for an overview).

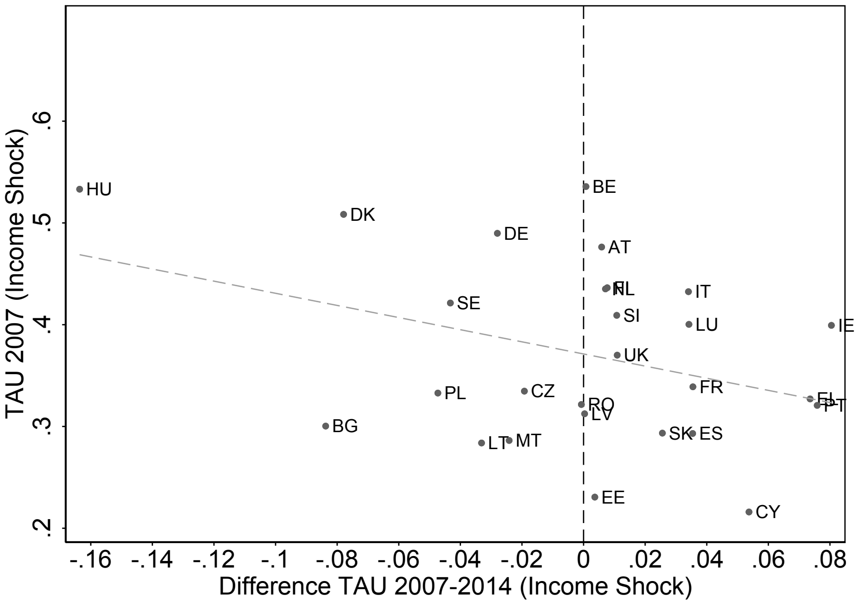
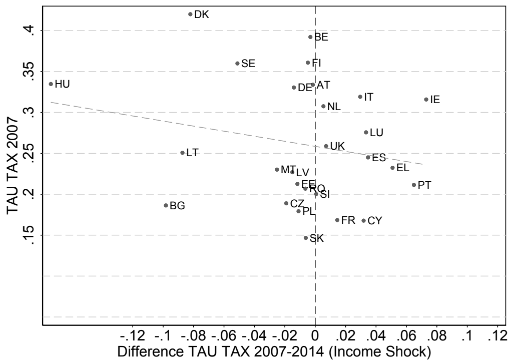


Figure 1.1.: Change in τ (Income Shock Scenario): 2014 vs. 2007

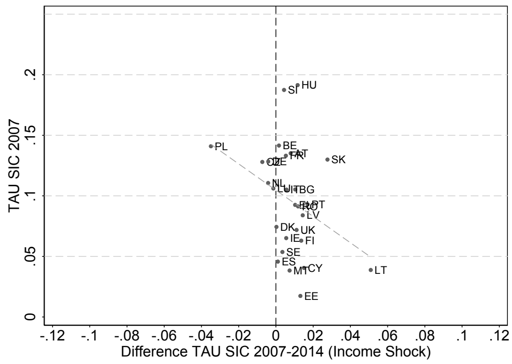
Notes: The graph shows the level of the income stabilization coefficient in 2007 following a proportional income shock on the vertical axis and the change from 2007 to 2014 on the horizontal axis. The dashed line indicates fitted values of a linear regression of the variable on the vertical axis on the variable on the horizontal axis. *Source:* Own calculations using EUROMOD.

stabilization coefficient in 2007 have been more likely to raise (reduce) taxes and social insurance contributions.

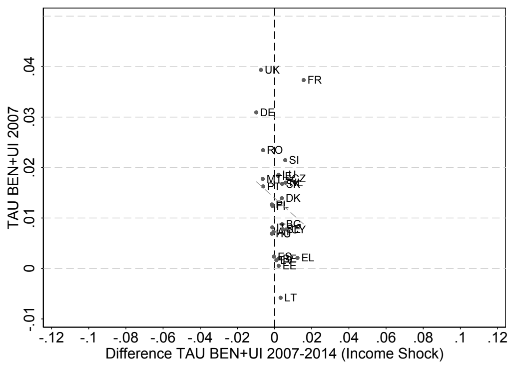
Next, we decompose the overall change in the income stabilization coefficient into its components. As can be seen in Figure 1.2, in particular changes in income taxes and to a smaller extent in social insurance contributions have affected the stabilizing potential of tax-benefit systems. Benefits are of minor importance in the case of an (intensive margin) income shock.



(a) TAX



(b) SIC



(c) Benefits

Figure 1.2.: Change in τ by Component (Income Shock Scenario): 2014 vs. 2007

Notes: The graph shows the level of the income stabilization coefficient by component in 2007 following a proportional income shock on the vertical axis and the change from 2007 to 2014 on the horizontal axis. The dashed line indicates fitted values of a linear regression of the variable on the vertical axis on the variable on the horizontal axis. *Source:* Own calculations using EUROMOD.

Unemployment shock. Figure 1.3 shows the relation between the income stabilization coefficient in 2007 and its change from 2007 to 2014 for the unemployment shock. Income stabilization coefficients in 2007 range from 0.17 in Cyprus to 0.65 in Belgium. The (population-weighted) average EA19 (EU27) income stabilization coefficient amounts to 0.42 (0.44) (cf. Table A.2 in the Appendix). As in the income shock scenario, we find highest (lowest) coefficients in Nordic and Western European (Baltic, Southern and Eastern European countries) and a negative relation between the income stabilization coefficient in 2007 and its change from 2007 to 2014.

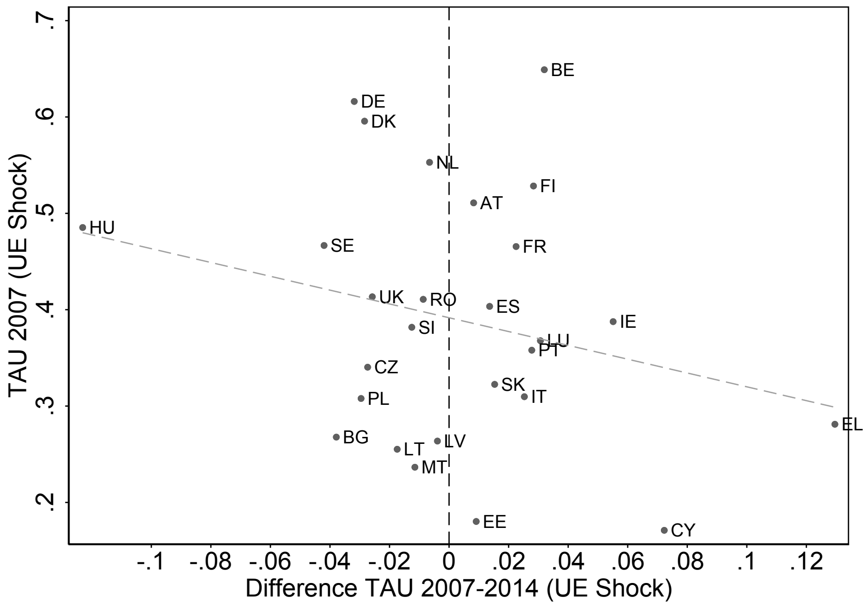
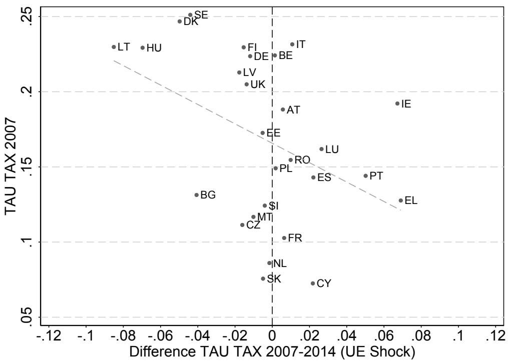


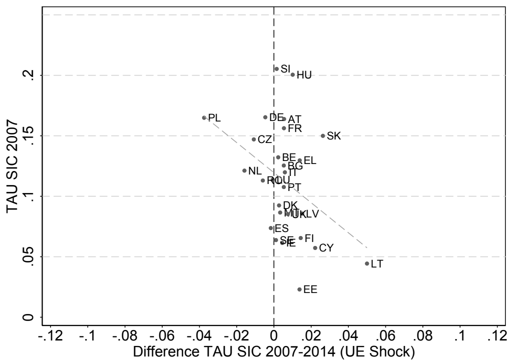
Figure 1.3.: Change in τ (Unemployment Shock Scenario): 2014 vs. 2007

Notes: The graph shows the level of the stabilization coefficient after an unemployment shock on the vertical axis and the change from 2007 to 2014 on the horizontal axis. *Source:* Own calculations using EUROMOD.

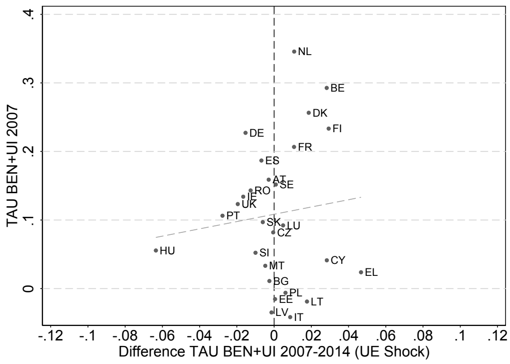
Figure 1.4 plots levels and changes in each component of the tax and transfer system. While income taxes and social insurance contributions play a key role in smoothing intensive margin income shocks (Figure 1.2), unemployment benefits are much more important in the case of extensive margin unemployment shocks (Dolls et al., 2012; Di Maggio and Kermani, 2016). While our results suggest a compression in the dispersion of income stabilization coefficients for income taxes and social insurance contributions, we find a positive correlation between the level and the change of the stabilization potential through benefits, in particular unemployment benefits. Countries with initially stronger automatic stabilizers in their unemployment insurance system tend to have made them more countercyclical compared to countries with initially weaker automatic stabilizers.



(a) TAX



(b) SIC



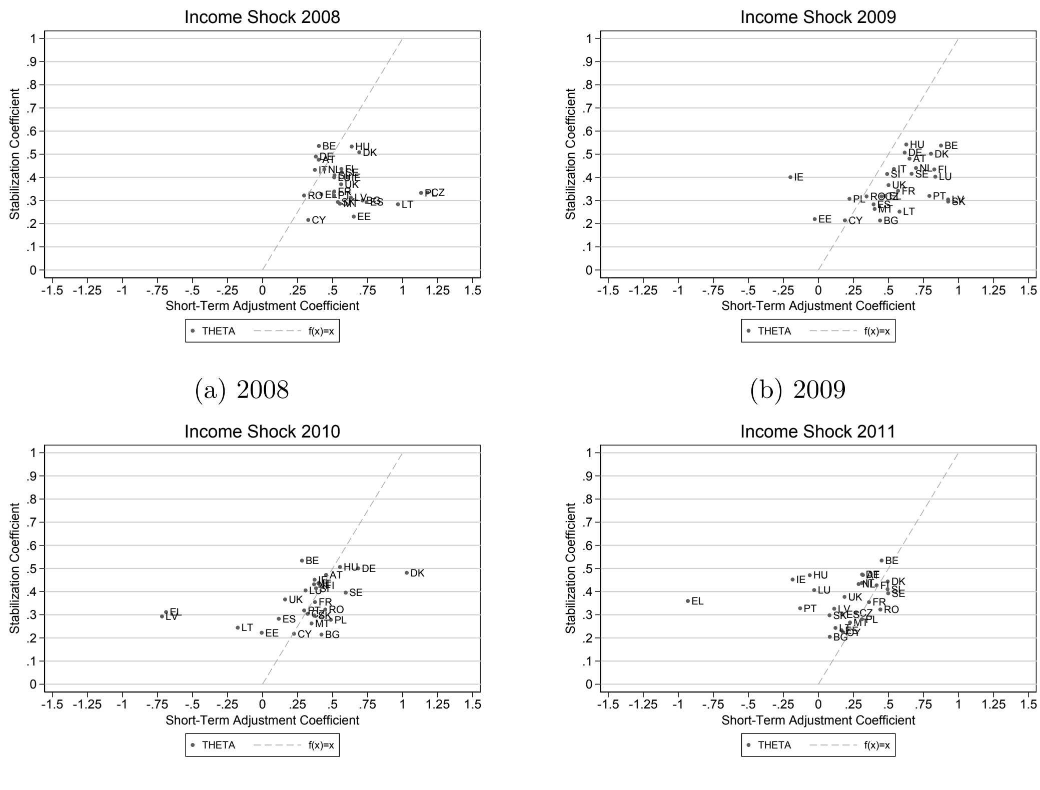
(c) Benefits

Figure 1.4.: Change in τ by Component (Unemployment Shock Scenario): 2014 vs. 2007

Notes: The graph shows the level of the stabilization coefficient after an unemployment shock by the respective component of net government intervention on the vertical axis and the change from 2007 to 2014 on the horizontal axis. *Source:* Own calculations using EUROMOD.

1.4.2. The Effect of Discretionary Policy Changes on the Workings of Automatic Stabilizers

This section first correlates income and short-term stabilization coefficients for the years 2008–2014 in order to show how discretionary policy changes have affected the cushioning effects of tax-benefit systems in the EU27. In the subsequent analysis, we study the relationship between our micro-based estimates of fiscal stabilization and conventional measures based on macroeconomic variables. For the latter, we consider year-on-year changes in the cyclical and the cyclically-adjusted budget balance which are often used to decompose the overall fiscal impulse into its components, in particular to assess the size of automatic stabilizers and discretionary fiscal policy measures (Deroose et al., 2008; Mourre et al., 2014).



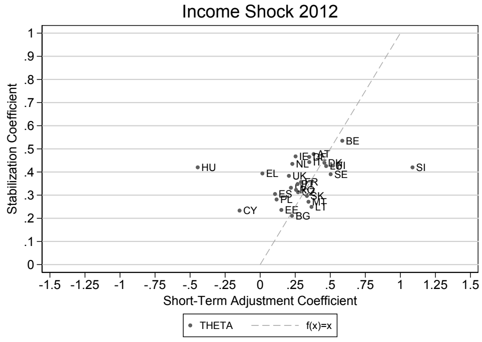
(a) 2008

(b) 2009

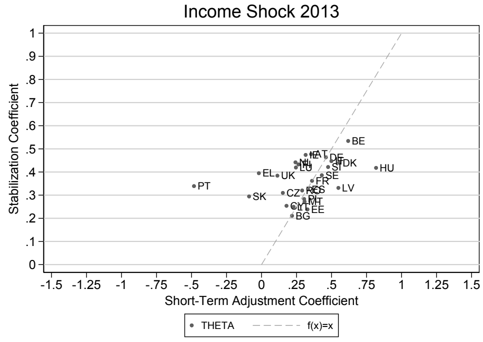
(c) 2010

(d) 2011

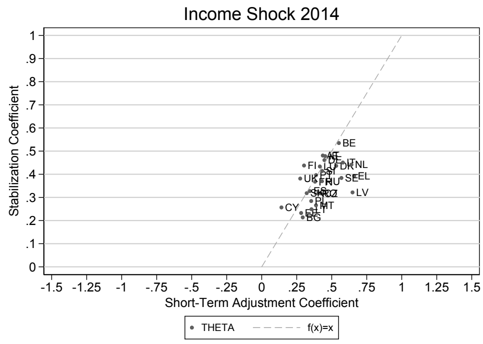
Figure 1.5.: Income vs. Short-Term Stabilization Coefficient: Income Shock



(e) 2012



(f) 2013



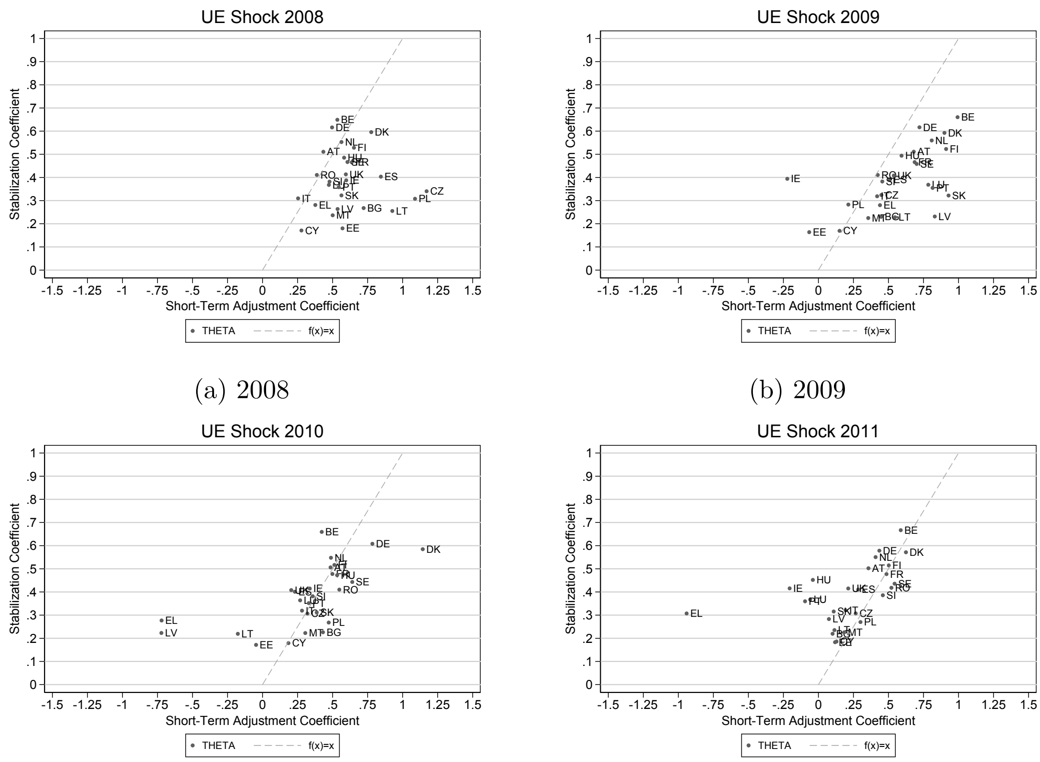
(g) 2014

Income vs. Short-Term Stabilization Coefficient: Income Shock

Notes: The figure plots short-term stabilization coefficients on the x-axis and income stabilization coefficients on the y-axis. Short-term stabilization coefficients for year t capture policy changes from $t-1$ to t. Short-term stabilization coefficients to the right (left) of the dashed 45 degree line imply expansionary (contractionary) discretionary changes in the tax-benefit system. *Source:* Own calculations using EUROMOD.

Income vs. short-term stabilization coefficients. Figures 1.5 and 1.6 plot the stabilization coefficient against the short-term adjustment coefficient by year for the income shock and the unemployment shock, respectively. Countries to the right (left) of the dashed 45 degree line imply that the short-term adjustment coefficient is larger (smaller) than the stabilization coefficient, pointing to expansionary (contractionary) discretionary changes in the tax-benefit system. Panel (a) shows that in 2008, most countries are relatively close to and, in the majority of cases, to the right of the dashed line. The dispersion is somewhat larger in the unemployment shock scenario. Discretionary changes in tax-benefit policies have been expansionary in the early phase of the crisis (European Central Bank, 2010).

This is confirmed in panel (b), showing that at the height of the economic crisis in 2009, more short-term stabilization coefficients moved further right of the dashed line. Notable exceptions are Ireland, Estonia, Cyprus and Poland. Starting in 2010, the short-term stabilization coefficient becomes smaller than the income stabilization coefficient in a larger number of countries, hinting at contractionary discretionary policy changes. In some countries, the short-term stabilization coefficient even turns negative, for example in Greece in 2010 and 2011, in Latvia in 2010, in Ireland in 2011 and in Portugal in 2013 (both in the income and unemployment shock scenarios), indicating that the workings of automatic stabilizers have been heavily constrained in those years. In more recent years, short-term stabilization coefficients are again close to the dashed 45 degree line.



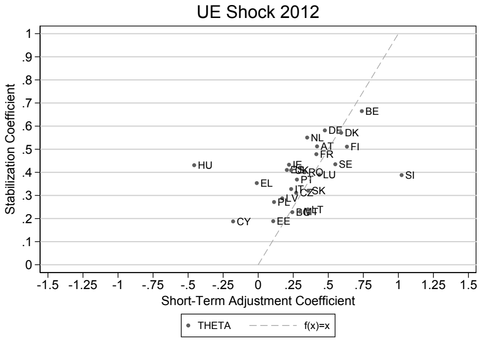
(a) 2008

(b) 2009

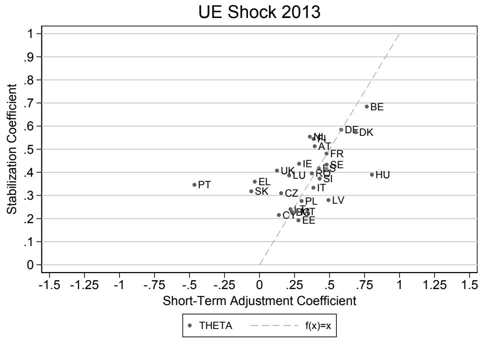
(c) 2010

(d) 2011

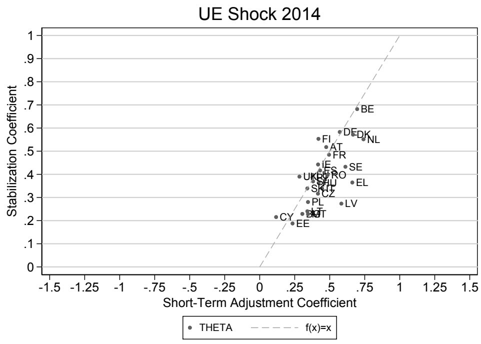
Figure 1.6.: Income vs. Short-Term Stabilization Coefficient: Unemployment Shock



(e) 2012



(f) 2013



(g) 2014

Income vs. Short-Term Stabilization Coefficient: Unemployment Shock

Notes: The figure plots short-term stabilization coefficients on the x-axis and income stabilization coefficients on the y-axis. Short-term stabilization coefficients for year t capture policy changes from $t-1$ to t. Short-term stabilization coefficients to the right (left) of the dashed 45 degree line imply expansionary (contractionary) discretionary changes in the tax-benefit system. *Source:* Own calculations using EUROMOD.

Micro vs. macro estimates of fiscal stabilization. Figure 1.7 sheds light on the question of how our estimates of fiscal stabilization (for the income shock scenario) based on household micro data compare to the overall fiscal impulse. We derive a micro estimate of the degree of fiscal stabilization through changes in the tax-benefit system by calculating the difference between the short-term stabilization coefficient, θ_t^T, and the income stabilization coefficient, τ_t^T.[15] As described in section 1.2.2, the short-term stabilization coefficient equals the income stabilization coefficient if there are no changes in the tax-benefit system from year $t-1$ to t. In this case, the difference between the two measures is zero and the fiscal impulse stemming from changes in tax-benefit policies can be characterized as being neutral. The short-term stabilization coefficient is larger (smaller) than the income stabilization coefficient and hence the difference between the two is positive (negative) if there are expansionary (contractionary) policy changes in the tax-benefit system.

For the aggregate fiscal impulse, we consider its two subcomponents: automatic stabilizers measured by the year-on-year change in cyclical net borrowing[16] and discretionary fiscal policy expressed as the year-on-year change in cyclically-adjusted net borrowing.[17]

In Figure 1.7 the difference between the short-term and the income stabilization coefficient is depicted on the y-axis, the change in cyclical and cyclically-adjusted net borrowing from year $t-1$ to t on the x-axis, respectively. If both the micro and the macro measure point to expansionary (contractionary) changes in fiscal policy, countries will find themselves in the upper right (lower left) quadrant. If the micro and the macro estimates indicate opposite effects of fiscal policy, country dots will be in the upper left or lower right quadrant.

Panels (a) and (b) show that in 2008 and 2009 the fiscal impulse was expansionary in the majority of member states, exemplified by an increase in both the cyclical and the cyclically-adjusted budget deficit. Our micro-based estimates of fiscal stabilization point in the same direction so that in panels (a) and (b) most countries are in the upper right quadrant. The correlation between the micro and the two macro measures of fiscal stabilization is positive in these two years.

[15] Note that θ_t^T reflects the effect of changes in the tax-benefit system on income stabilization from year $t-1$ to t.

[16] The cyclical balance, CC, shows the extent to which budgetary revenues and expenditures react to the economic cycle. Formally, CC can be written as $\varepsilon * OG$, where ε stands for the semi-elasticity of the overall budget with respect to changes in output and $OG = \frac{Y-Y^p}{Y^p}$ denotes the output gap. Semi-elasticities are estimated for specific time-periods and are assumed to be time-invariant over this period.

[17] The cyclically-adjusted budget can be derived from the following expression: $CAB = (B/Y) - CC$ where B denotes net borrowing and Y is output.

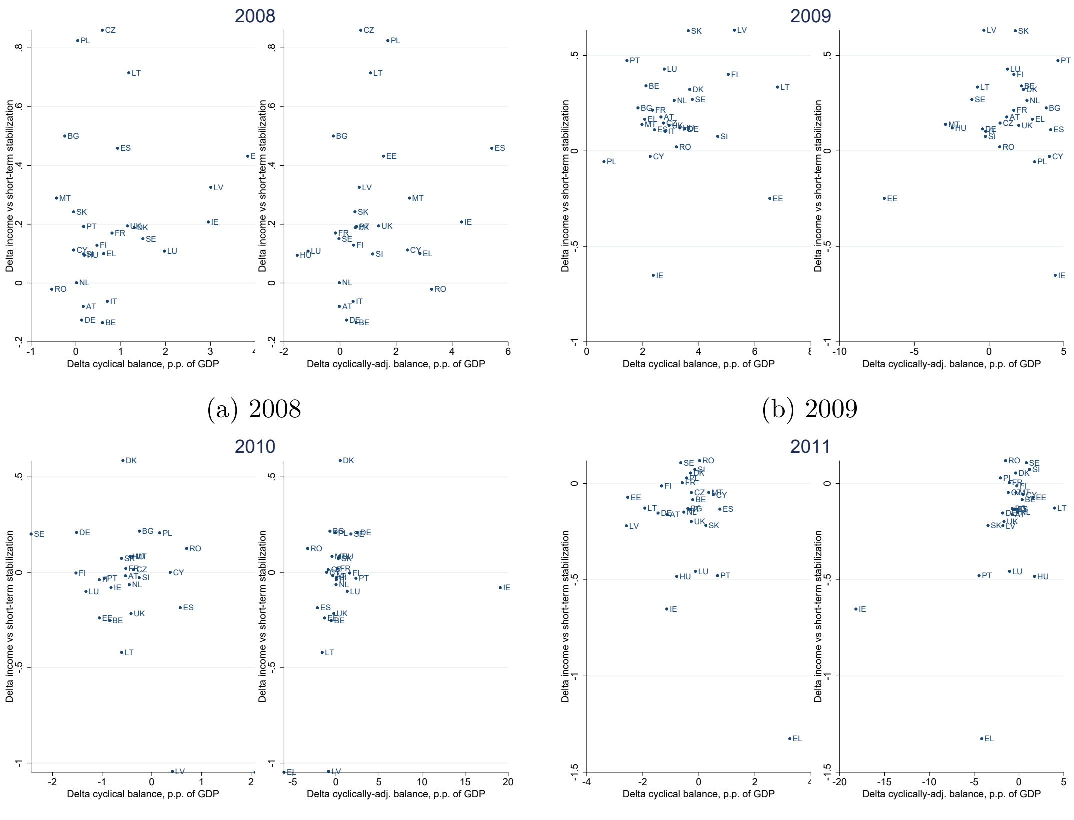
Ireland stands out as a notable exception being in the lower right quadrant both in the left and right figure of panel (b). We find a short-term stabilization coefficient of -0.2 in 2009 and a resulting negative difference between the short-term stabilization coefficient and the income stabilization coefficient of -0.65. While our micro measure of fiscal stabilization suggests for Ireland a fiscal tightening in 2009, changes in the budget balance point to a significant fiscal loosening. From 2008 to 2009, Ireland's cyclical and cyclically-adjusted budget deficit increased by 2.4 and 4.4 percentage points of GDP, respectively.

How can these seemingly contrasting results be reconciled? At the height of the financial crisis, Ireland experienced the burst of a property bubble and recapitalized its banking system in response. This accounts for a large part of the increase in the budget deficit in the years 2008–2010. While Ireland's budget was balanced in 2007, its deficit had risen to an unprecedented level of 32% of GDP in 2010. At the same time, Ireland started a process of fiscal consolidation in 2009 which lasted until 2013 and included measures such as hikes in income taxes and social insurance contributions as well as cuts in unemployment benefits (Alesina et al., 2015; Devries et al., 2011; Turrini et al., 2015). These fiscal consolidation measures had an adverse impact on household income stabilization explaining why our micro-based results point in the opposite direction compared to the two macro measures.

Other interesting examples are Estonia in 2009 and Greece in 2011. Focus first on Estonia in 2009. While cyclical net borrowing rose by 6.5 percentage points of GDP in 2009, the cyclically-adjusted balance improved by 7 percentage points of GDP so that the overall fiscal impulse was contractionary. This contractionary effect is mirrored by a negative short-term stabilization coefficient in 2009. As a consequence, Estonia is displayed in the lower left quadrant in the right figure of panel (b), but in the lower right quadrant in the left figure of panel (b).

A similar picture emerges for Greece. In 2011, Greece was still in a recession, with its cyclical deficit rising from -1.8% to -5%. At the same time, its structural deficit improved from -9.4% to -5.2% so that the overall fiscal impulse was contractionary. In line with the contractionary fiscal stance, our micro-based short-term stabilization coefficient amounts to -0.7 in 2011 (and the difference between the short-term stabilization coefficient and the income stabilization coefficient to -1). It follows that as in the Estonian case in 2009, Greece shows up in the lower left quadrant in the right figure of panel (d), but in the lower right in the left figure. These two examples indicate that automatic stabilizers in Greece (2011) and Estonia (2009) could only operate along the consolidation path. Overall, for the years 2010–2013 we find positive (negative) correlations between our micro-measure of fiscal stabilization and discretionary fiscal policy changes (automatic stabilizers). One interpretation of these correlations is that the workings of automatic stabilizers has been constrained in those years.

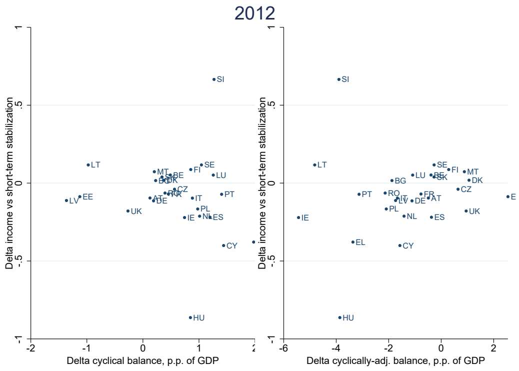
Our results suggest that micro-based estimates of household income stabilization provide valuable and complementary information to conventional macro measures of fiscal stabilization. If one wants to estimate the cushioning effect of (changes in) tax-benefit systems, a sole focus on time-invariant semi-elasticities and changes in the budget balance may provide an incomplete picture. It should be noted, however, that the above comparison of micro and macro-based estimates of fiscal stabilization should be taken with a grain of salt given their conceptual differences, in particular with regard to the limited number of revenue and spending categories included in our simulations.



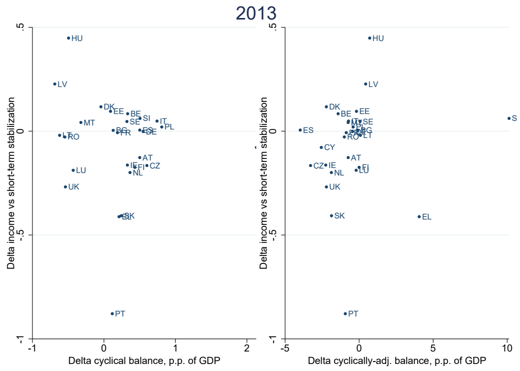
(a) 2008 (b) 2009

(c) 2010 (d) 2011

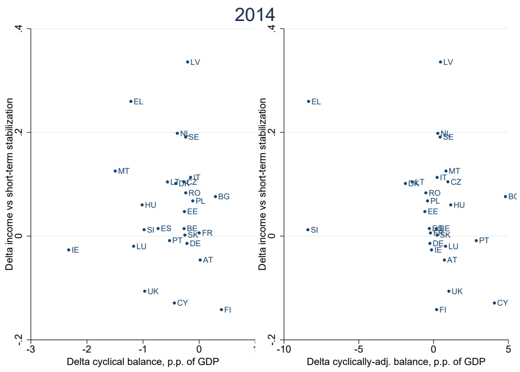
Figure 1.7.: Micro vs. Macro Estimates of Fiscal Stabilization: Income Shock



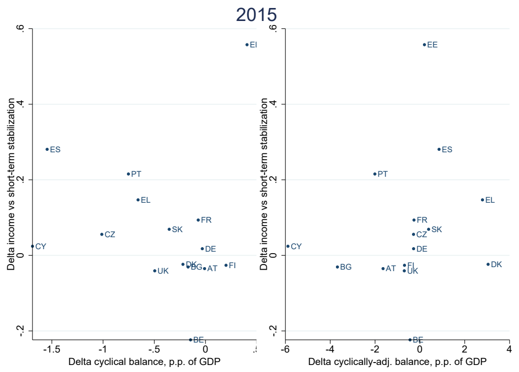
(e) 2012



(f) 2013



(g) 2014



(h) 2015

Micro vs. Macro Estimates of Fiscal Stabilization: Income Shock

Notes: The figure plots the difference between income and short-term stabilization coefficients on the y-axis and changes in cyclical and cyclically-adjusted net borrowing on the x-axis. Short-term stabilization coefficients for year t capture policy changes from $t-1$ to t. *Source:* Own calculations using EUROMOD. Data on cyclical and cyclically-adjusted net borrowing are from the AMECO database.

1.5. Conclusion

We analyze how reforms of tax-benefit systems in the period 2007–2014 have affected the automatic stabilizers in the EU27. Based on harmonized European micro data and counterfactual simulation techniques, we isolate the automatic cushioning effect from discretionary fiscal policy measures as well as behavioral responses of households. In our simulations, we hold constant pre-crisis household income data and demographic characteristics, but apply the tax and benefit rules in place during 2007–2014.

We find that the size of automatic stabilizers varies significantly across countries. Income stabilization coefficients range from 20-30 percent in some Eastern and Southern European countries to around 60 percent in Belgium, Germany, and Denmark. We further analyze to what extent EU countries let their automatic stabilizers work during the crisis and its aftermath. Our results suggest that automatic stabilizers could operate freely until 2009, but have been constrained in some countries in subsequent years.

A comparison of our estimates of automatic stabilizers inherent in tax-benefit systems with macro measures such as changes in the cyclical and the cyclically-adjusted budget balance reveals that micro-based estimates can provide more precise information about the degree of household income stabilization and should be used as complements to the macro measures.

A. Additional Results

Table A.1.: Income Stabilization Coefficients – Income Shock.

		2007	2008	2009	2010	2011	2012	2013	2014	2015
AT	τ^{TAX}	0.334	0.336	0.326	0.324	0.327	0.330	0.331	0.332	0.332
	τ^{SIC}	0.135	0.139	0.140	0.141	0.142	0.140	0.143	0.143	0.145
	τ^{BEN+UI}	0.007	0.006	0.006	0.007	0.009	0.007	0.007	0.007	0.008
	τ	0.476	0.481	0.472	0.471	0.478	0.477	0.481	0.482	0.485
BE	τ^{TAX}	0.392	0.394	0.386	0.390	0.391	0.391	0.388	0.389	0.408
	τ^{SIC}	0.142	0.142	0.145	0.142	0.142	0.141	0.144	0.143	0.138
	τ^{BEN+UI}	0.002	0.002	0.004	0.002	0.002	0.002	0.003	0.004	0.004
	τ	0.536	0.537	0.534	0.534	0.535	0.534	0.535	0.537	0.550
BG	τ^{TAX}	0.186	0.087	0.087	0.088	0.087	0.087	0.087	0.088	0.087
	τ^{SIC}	0.105	0.116	0.114	0.105	0.112	0.111	0.113	0.116	0.118
	τ^{BEN+UI}	0.009	0.011	0.013	0.011	0.012	0.012	0.013	0.013	0.015
	τ	0.300	0.214	0.214	0.205	0.211	0.211	0.214	0.217	0.219
CY	τ^{TAX}	0.168	0.167	0.166	0.169	0.180	0.196	0.199	0.200	0.197
	τ^{SIC}	0.041	0.041	0.045	0.045	0.045	0.047	0.048	0.056	0.056
	τ^{BEN+UI}	0.008	0.007	0.008	0.010	0.008	0.010	0.009	0.014	0.015
	τ	0.216	0.214	0.218	0.224	0.233	0.254	0.257	0.270	0.268
CZ	τ^{TAX}	0.189	0.164	0.163	0.164	0.168	0.165	0.172	0.170	0.169
	τ^{SIC}	0.128	0.132	0.118	0.121	0.122	0.120	0.121	0.121	0.120
	τ^{BEN+UI}	0.018	0.021	0.023	0.024	0.023	0.025	0.025	0.025	0.026
	τ	0.335	0.318	0.304	0.309	0.313	0.310	0.318	0.315	0.315
DE	τ^{TAX}	0.331	0.343	0.339	0.318	0.312	0.314	0.315	0.316	0.316
	τ^{SIC}	0.128	0.134	0.132	0.134	0.130	0.128	0.126	0.124	0.126
	τ^{BEN+UI}	0.031	0.030	0.030	0.022	0.023	0.021	0.020	0.021	0.022

	τ	0.490	0.507	0.500	0.474	0.465	0.464	0.461	0.462	0.463
DK	τ^{TAX}	0.420	0.414	0.393	0.353	0.349	0.349	0.344	0.338	0.339
	τ^{SIC}	0.074	0.074	0.074	0.074	0.074	0.075	0.075	0.075	0.075
	τ^{BEN+UI}	0.014	0.014	0.014	0.017	0.017	0.017	0.018	0.018	0.018
	τ	0.508	0.502	0.481	0.444	0.440	0.440	0.436	0.430	0.431
EE	τ^{TAX}	0.213	0.202	0.203	0.200	0.200	0.199	0.201	0.201	0.192
	τ^{SIC}	0.017	0.017	0.019	0.033	0.035	0.038	0.031	0.031	0.027
	τ^{BEN+UI}	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.005
	τ	0.231	0.220	0.222	0.233	0.236	0.238	0.232	0.234	0.223
EL	τ^{TAX}	0.232	0.226	0.215	0.268	0.299	0.300	0.284	0.283	0.278
	τ^{SIC}	0.093	0.092	0.092	0.091	0.093	0.095	0.103	0.103	0.099
	τ^{BEN+UI}	0.002	0.001	0.004	0.001	0.002	0.001	0.006	0.014	0.009
	τ	0.327	0.320	0.312	0.360	0.394	0.395	0.393	0.401	0.387
ES	τ^{TAX}	0.245	0.236	0.233	0.251	0.257	0.278	0.279	0.280	0.265
	τ^{SIC}	0.046	0.045	0.046	0.046	0.045	0.045	0.046	0.047	0.047
	τ^{BEN+UI}	0.002	0.002	0.004	0.005	0.003	0.002	0.002	0.002	0.003
	τ	0.293	0.283	0.283	0.302	0.305	0.325	0.327	0.329	0.314
FI	τ^{TAX}	0.361	0.363	0.353	0.349	0.348	0.348	0.355	0.356	0.358
	τ^{SIC}	0.063	0.059	0.059	0.065	0.068	0.072	0.071	0.077	0.078
	τ^{BEN+UI}	0.012	0.013	0.014	0.013	0.012	0.013	0.011	0.011	0.011
	τ	0.436	0.434	0.426	0.427	0.428	0.433	0.438	0.444	0.448
FR	τ^{TAX}	0.168	0.169	0.168	0.170	0.173	0.179	0.181	0.183	0.180
	τ^{SIC}	0.133	0.133	0.134	0.134	0.133	0.134	0.136	0.139	0.140
	τ^{BEN+UI}	0.037	0.040	0.053	0.051	0.050	0.049	0.050	0.053	0.056
	τ	0.339	0.342	0.355	0.355	0.357	0.362	0.368	0.374	0.377
HU	τ^{TAX}	0.335	0.339	0.311	0.271	0.225	0.209	0.161	0.161	.
	τ^{SIC}	0.191	0.196	0.190	0.195	0.191	0.204	0.203	0.203	.
	τ^{BEN+UI}	0.007	0.007	0.005	0.005	0.004	0.006	0.006	0.005	.
	τ	0.533	0.542	0.506	0.471	0.420	0.418	0.370	0.369	.
IE	τ^{TAX}	0.316	0.314	0.330	0.327	0.384	0.388	0.388	0.389	.
	τ^{SIC}	0.065	0.065	0.102	0.101	0.067	0.067	0.070	0.071	.
	τ^{BEN+UI}	0.018	0.021	0.019	0.024	0.016	0.019	0.020	0.020	.
	τ	0.399	0.401	0.451	0.452	0.468	0.474	0.478	0.480	.

IT	τ^{TAX}	0.319	0.322	0.322	0.323	0.329	0.331	0.334	0.349	.
	τ^{SIC}	0.105	0.106	0.106	0.106	0.106	0.109	0.110	0.111	.
	τ^{BEN+UI}	0.008	0.008	0.008	0.008	0.007	0.007	0.007	0.007	.
	τ	0.432	0.436	0.436	0.437	0.443	0.447	0.450	0.466	.
LT	τ^{TAX}	0.251	0.226	0.163	0.162	0.161	0.161	0.161	0.163	.
	τ^{SIC}	0.039	0.037	0.087	0.088	0.090	0.090	0.090	0.090	.
	τ^{BEN+UI}	-0.006	-0.011	-0.006	-0.007	-0.001	-0.001	-0.002	-0.003	.
	τ	0.284	0.252	0.244	0.243	0.249	0.250	0.249	0.251	.
LU	τ^{TAX}	0.276	0.280	0.271	0.275	0.297	0.295	0.309	0.309	.
	τ^{SIC}	0.106	0.105	0.108	0.107	0.107	0.105	0.104	0.105	.
	τ^{BEN+UI}	0.019	0.018	0.026	0.025	0.021	0.020	0.021	0.021	.
	τ	0.400	0.403	0.405	0.407	0.426	0.419	0.434	0.435	.
LV	τ^{TAX}	0.227	0.222	0.202	0.235	0.220	0.221	0.212	0.212	.
	τ^{SIC}	0.084	0.081	0.088	0.087	0.108	0.107	0.107	0.098	.
	τ^{BEN+UI}	0.002	0.002	0.003	0.004	0.003	0.004	0.003	0.003	.
	τ	0.312	0.305	0.293	0.326	0.332	0.331	0.322	0.313	.
MT	τ^{TAX}	0.230	0.216	0.213	0.217	0.220	0.222	0.213	0.205	.
	τ^{SIC}	0.038	0.037	0.037	0.036	0.040	0.041	0.045	0.046	.
	τ^{BEN+UI}	0.018	0.011	0.012	0.013	0.012	0.009	0.008	0.011	.
	τ	0.286	0.263	0.262	0.266	0.271	0.272	0.266	0.262	.
NL	τ^{TAX}	0.308	0.313	0.314	0.312	0.314	0.323	0.312	0.313	.
	τ^{SIC}	0.111	0.105	0.089	0.091	0.090	0.089	0.099	0.106	.
	τ^{BEN+UI}	0.017	0.023	0.029	0.029	0.031	0.029	0.031	0.023	.
	τ	0.435	0.440	0.432	0.433	0.435	0.442	0.442	0.442	.
PL	τ^{TAX}	0.179	0.191	0.165	0.166	0.167	0.168	0.169	0.168	.
	τ^{SIC}	0.141	0.105	0.104	0.104	0.104	0.104	0.105	0.106	.
	τ^{BEN+UI}	0.013	0.011	0.010	0.011	0.010	0.011	0.011	0.011	.
	τ	0.333	0.307	0.278	0.281	0.281	0.283	0.284	0.286	.
PT	τ^{TAX}	0.211	0.210	0.204	0.211	0.237	0.218	0.277	0.276	0.273
	τ^{SIC}	0.093	0.093	0.094	0.096	0.093	0.108	0.110	0.110	0.109
	τ^{BEN+UI}	0.016	0.017	0.021	0.021	0.018	0.013	0.009	0.010	0.009
	τ	0.321	0.320	0.319	0.328	0.348	0.339	0.396	0.397	0.392
RO	τ^{TAX}	0.207	0.209	0.199	0.201	0.199	0.200	0.201	0.200	.

	τ^{SIC}	0.091	0.088	0.096	0.096	0.106	0.105	0.102	0.103	.
	τ^{BEN+UI}	0.023	0.021	0.027	0.026	0.018	0.015	0.015	0.017	.
	τ	0.322	0.318	0.322	0.323	0.323	0.320	0.318	0.321	.
SE	τ^{TAX}	0.360	0.354	0.332	0.331	0.328	0.321	0.317	0.309	.
	τ^{SIC}	0.054	0.054	0.055	0.055	0.055	0.056	0.057	0.057	.
	τ^{BEN+UI}	0.008	0.008	0.008	0.008	0.008	0.010	0.010	0.012	.
	τ	0.421	0.415	0.396	0.393	0.390	0.386	0.384	0.378	.
SI	τ^{TAX}	0.200	0.206	0.204	0.197	0.207	0.209	0.203	0.201	.
	τ^{SIC}	0.187	0.187	0.188	0.189	0.190	0.186	0.185	0.192	.
	τ^{BEN+UI}	0.021	0.022	0.023	0.024	0.023	0.026	0.026	0.027	.
	τ	0.409	0.415	0.415	0.410	0.420	0.422	0.414	0.420	.
SK	τ^{TAX}	0.147	0.147	0.136	0.136	0.147	0.148	0.143	0.141	0.139
	τ^{SIC}	0.130	0.131	0.130	0.131	0.126	0.127	0.156	0.158	0.171
	τ^{BEN+UI}	0.017	0.017	0.031	0.031	0.023	0.020	0.020	0.021	0.018
	τ	0.293	0.296	0.297	0.298	0.297	0.294	0.318	0.319	0.327
UK	τ^{TAX}	0.259	0.249	0.243	0.255	0.263	0.265	0.266	0.266	0.265
	τ^{SIC}	0.072	0.077	0.080	0.080	0.085	0.085	0.083	0.083	0.084
	τ^{BEN+UI}	0.039	0.041	0.042	0.042	0.036	0.035	0.032	0.032	0.033
	τ	0.370	0.367	0.366	0.377	0.383	0.384	0.381	0.381	0.381
EU	τ^{TAX}	0.264	0.263	0.256	0.256	0.260	0.263	0.264	0.266	0.262
	τ^{SIC}	0.104	0.103	0.104	0.104	0.104	0.104	0.105	0.106	0.107
	τ^{BEN+UI}	0.020	0.021	0.023	0.022	0.021	0.020	0.020	0.020	0.026
	τ	0.388	0.386	0.383	0.383	0.385	0.388	0.389	0.393	0.395
EA	τ^{TAX}	0.259	0.258	0.256	0.262	0.270	0.276	0.278	0.282	0.245
	τ^{SIC}	0.102	0.102	0.103	0.103	0.102	0.103	0.106	0.107	0.108
	τ^{BEN+UI}	0.016	0.017	0.021	0.021	0.020	0.019	0.020	0.020	0.026
	τ	0.377	0.377	0.380	0.386	0.391	0.398	0.403	0.409	0.379

Note: A missing value in the 2015 column indicates that the tax policy is not available in EUROMOD G4.0. EU and EA averages are population weighted. *Source*: Own calculations using EUROMOD.

Table A.2.: Income Stabilization Coefficients – Unemployment Shock.

		2007	2008	2009	2010	2011	2012	2013	2014	2015
AT	τ^{TAX}	0.188	0.192	0.185	0.182	0.186	0.190	0.192	0.194	0.194
	τ^{SIC}	0.164	0.165	0.166	0.166	0.167	0.166	0.169	0.169	0.170
	τ^{BEN+UI}	0.159	0.155	0.156	0.154	0.159	0.157	0.157	0.156	0.156
	τ	0.511	0.511	0.506	0.502	0.512	0.513	0.518	0.519	0.521
BE	τ^{TAX}	0.224	0.227	0.218	0.227	0.229	0.228	0.226	0.226	0.239
	τ^{SIC}	0.132	0.135	0.135	0.135	0.135	0.135	0.134	0.135	0.129
	τ^{BEN+UI}	0.293	0.299	0.307	0.305	0.301	0.322	0.321	0.321	0.318
	τ	0.649	0.660	0.659	0.667	0.665	0.685	0.682	0.681	0.686
BG	τ^{TAX}	0.131	0.091	0.091	0.092	0.091	0.091	0.091	0.091	0.091
	τ^{SIC}	0.125	0.133	0.130	0.120	0.128	0.128	0.129	0.131	0.132
	τ^{BEN+UI}	0.011	0.006	0.005	0.007	0.009	0.009	0.009	0.009	0.009
	τ	0.268	0.230	0.226	0.220	0.228	0.228	0.229	0.230	0.231
CY	τ^{TAX}	0.073	0.071	0.070	0.074	0.077	0.093	0.092	0.094	0.092
	τ^{SIC}	0.057	0.057	0.063	0.063	0.063	0.068	0.069	0.079	0.080
	τ^{BEN+UI}	0.041	0.041	0.047	0.049	0.048	0.054	0.054	0.070	0.070
	τ	0.171	0.169	0.179	0.186	0.188	0.215	0.215	0.243	0.242
CZ	τ^{TAX}	0.111	0.089	0.089	0.089	0.094	0.092	0.099	0.095	0.095
	τ^{SIC}	0.147	0.149	0.135	0.136	0.137	0.136	0.136	0.136	0.136
	τ^{BEN+UI}	0.082	0.086	0.084	0.083	0.080	0.082	0.082	0.081	0.079
	τ	0.340	0.324	0.307	0.307	0.311	0.310	0.316	0.313	0.311
DE	τ^{TAX}	0.224	0.228	0.223	0.206	0.208	0.211	0.212	0.212	0.211
	τ^{SIC}	0.165	0.164	0.162	0.163	0.165	0.164	0.161	0.161	0.161
	τ^{BEN+UI}	0.227	0.225	0.223	0.210	0.209	0.210	0.211	0.212	0.213
	τ	0.616	0.617	0.608	0.578	0.582	0.585	0.583	0.584	0.585
DK	τ^{TAX}	0.247	0.240	0.229	0.210	0.207	0.207	0.201	0.197	0.196
	τ^{SIC}	0.092	0.093	0.093	0.094	0.094	0.095	0.095	0.095	0.095
	τ^{BEN+UI}	0.256	0.259	0.263	0.268	0.270	0.272	0.276	0.275	0.280
	τ	0.596	0.592	0.585	0.571	0.571	0.574	0.571	0.567	0.572
EE	τ^{TAX}	0.173	0.158	0.165	0.163	0.164	0.165	0.168	0.167	0.158
	τ^{SIC}	0.023	0.023	0.023	0.037	0.040	0.044	0.037	0.037	0.033

	τ^{BEN+UI}	-0.015	-0.017	-0.016	-0.017	-0.016	-0.017	-0.017	-0.015	-0.020
	τ	0.180	0.164	0.172	0.183	0.189	0.192	0.188	0.189	0.171
	τ^{TAX}	0.128	0.125	0.119	0.152	0.196	0.198	0.198	0.197	0.191
	τ^{SIC}	0.130	0.131	0.132	0.131	0.135	0.138	0.144	0.144	0.141
EL	τ^{BEN+UI}	0.024	0.024	0.026	0.024	0.023	0.024	0.023	0.070	0.072
	τ	0.281	0.280	0.277	0.307	0.354	0.360	0.365	0.411	0.404
	τ^{TAX}	0.143	0.132	0.129	0.144	0.148	0.163	0.166	0.165	0.153
	τ^{SIC}	0.074	0.073	0.074	0.074	0.074	0.071	0.071	0.072	0.073
ES	τ^{BEN+UI}	0.187	0.186	0.197	0.192	0.188	0.183	0.180	0.180	0.181
	τ	0.403	0.391	0.401	0.410	0.410	0.417	0.417	0.417	0.406
	τ^{TAX}	0.230	0.232	0.218	0.215	0.214	0.208	0.213	0.214	0.216
	τ^{SIC}	0.065	0.061	0.062	0.068	0.071	0.075	0.075	0.080	0.081
FI	τ^{BEN+UI}	0.233	0.230	0.237	0.232	0.227	0.261	0.265	0.263	0.264
	τ	0.528	0.523	0.517	0.515	0.511	0.545	0.553	0.557	0.561
	τ^{TAX}	0.103	0.103	0.103	0.103	0.105	0.108	0.109	0.109	0.107
	τ^{SIC}	0.156	0.156	0.157	0.157	0.157	0.157	0.160	0.162	0.162
FR	τ^{BEN+UI}	0.207	0.207	0.218	0.217	0.217	0.216	0.216	0.217	0.218
	τ	0.466	0.466	0.478	0.477	0.479	0.481	0.485	0.488	0.487
	τ^{TAX}	0.229	0.233	0.218	0.194	0.177	0.187	0.160	0.160	.
	τ^{SIC}	0.201	0.205	0.196	0.202	0.197	0.212	0.211	0.211	.
HU	τ^{BEN+UI}	0.056	0.056	0.059	0.056	0.057	-0.008	-0.008	-0.008	.
	τ	0.485	0.494	0.473	0.452	0.431	0.390	0.363	0.362	.
	τ^{TAX}	0.192	0.191	0.206	0.203	0.255	0.259	0.259	0.259	.
	τ^{SIC}	0.061	0.062	0.091	0.090	0.061	0.062	0.066	0.066	.
IE	τ^{BEN+UI}	0.134	0.141	0.118	0.122	0.117	0.117	0.118	0.117	.
	τ	0.388	0.394	0.415	0.416	0.433	0.437	0.442	0.443	.
	τ^{TAX}	0.232	0.235	0.236	0.238	0.244	0.247	0.247	0.242	.
	τ^{SIC}	0.120	0.121	0.121	0.121	0.121	0.124	0.125	0.126	.
IT	τ^{BEN+UI}	-0.042	-0.037	-0.037	-0.037	-0.038	-0.038	-0.033	-0.033	.
	τ	0.310	0.319	0.319	0.321	0.328	0.333	0.339	0.335	.
	τ^{TAX}	0.230	0.211	0.146	0.147	0.147	0.148	0.148	0.145	.
	τ^{SIC}	0.044	0.045	0.092	0.091	0.094	0.094	0.094	0.094	.
LT	τ^{BEN+UI}	-0.019	-0.027	-0.019	-0.002	-0.002	-0.001	-0.002	-0.001	.

	τ	0.255	0.228	0.219	0.235	0.240	0.241	0.240	0.238	.
	τ^{TAX}	0.162	0.168	0.159	0.163	0.178	0.177	0.188	0.188	.
	τ^{SIC}	0.114	0.114	0.115	0.115	0.115	0.114	0.113	0.113	.
LU	τ^{BEN+UI}	0.092	0.087	0.090	0.090	0.096	0.096	0.096	0.097	.
	τ	0.368	0.368	0.364	0.367	0.389	0.387	0.397	0.398	.
	τ^{TAX}	0.213	0.200	0.182	0.225	0.209	0.210	0.202	0.195	.
	τ^{SIC}	0.086	0.086	0.088	0.087	0.107	0.107	0.107	0.101	.
LV	τ^{BEN+UI}	-0.035	-0.055	-0.047	-0.029	-0.029	-0.037	-0.035	-0.036	.
	τ	0.264	0.231	0.223	0.283	0.287	0.280	0.273	0.260	.
	τ^{TAX}	0.117	0.109	0.107	0.110	0.112	0.113	0.111	0.107	.
	τ^{SIC}	0.087	0.085	0.085	0.085	0.086	0.087	0.089	0.090	.
MT	τ^{BEN+UI}	0.033	0.030	0.031	0.031	0.031	0.029	0.028	0.029	.
	τ	0.237	0.225	0.223	0.226	0.230	0.230	0.228	0.225	.
	τ^{TAX}	0.086	0.090	0.090	0.088	0.090	0.096	0.085	0.085	.
	τ^{SIC}	0.121	0.117	0.100	0.102	0.101	0.102	0.108	0.105	.
NL	τ^{BEN+UI}	0.346	0.352	0.358	0.361	0.359	0.357	0.359	0.356	.
	τ	0.553	0.560	0.548	0.550	0.550	0.554	0.551	0.546	.
	τ^{TAX}	0.149	0.161	0.147	0.146	0.147	0.151	0.152	0.151	.
	τ^{SIC}	0.165	0.124	0.125	0.124	0.125	0.126	0.127	0.127	.
PL	τ^{BEN+UI}	-0.006	-0.002	-0.004	0.000	-0.001	-0.001	0.002	0.000	.
	τ	0.308	0.283	0.268	0.270	0.272	0.276	0.280	0.278	.
	τ^{TAX}	0.144	0.143	0.138	0.143	0.161	0.145	0.195	0.194	0.189
	τ^{SIC}	0.108	0.108	0.108	0.108	0.110	0.112	0.113	0.113	0.112
PT	τ^{BEN+UI}	0.106	0.105	0.106	0.109	0.098	0.088	0.078	0.079	0.078
	τ	0.358	0.355	0.352	0.360	0.369	0.346	0.386	0.386	0.379
	τ^{TAX}	0.155	0.158	0.148	0.151	0.161	0.163	0.164	0.164	.
	τ^{SIC}	0.113	0.110	0.122	0.122	0.107	0.107	0.107	0.107	.
RO	τ^{BEN+UI}	0.143	0.142	0.141	0.145	0.132	0.125	0.126	0.131	.
	τ	0.411	0.411	0.410	0.418	0.400	0.396	0.397	0.402	.
	τ^{TAX}	0.251	0.243	0.227	0.222	0.221	0.217	0.216	0.207	.
	τ^{SIC}	0.064	0.064	0.064	0.064	0.064	0.064	0.065	0.065	.
SE	τ^{BEN+UI}	0.152	0.151	0.151	0.150	0.150	0.152	0.152	0.153	.
	τ	0.467	0.458	0.443	0.436	0.435	0.433	0.433	0.425	.

	τ^{TAX}	0.124	0.126	0.123	0.122	0.123	0.123	0.120	0.120	.
	τ^{SIC}	0.205	0.206	0.206	0.207	0.207	0.207	0.207	0.207	.
SI	τ^{BEN+UI}	0.052	0.052	0.052	0.057	0.058	0.043	0.043	0.042	.
	τ	0.382	0.383	0.381	0.386	0.388	0.373	0.370	0.369	.
	τ^{TAX}	0.076	0.076	0.061	0.061	0.074	0.075	0.073	0.071	0.071
	τ^{SIC}	0.150	0.152	0.151	0.152	0.149	0.149	0.174	0.176	0.175
SK	τ^{BEN+UI}	0.097	0.094	0.099	0.102	0.098	0.094	0.092	0.091	0.091
	τ	0.323	0.322	0.312	0.316	0.321	0.318	0.339	0.338	0.336
	τ^{TAX}	0.205	0.198	0.193	0.200	0.200	0.198	0.193	0.191	0.187
	τ^{SIC}	0.085	0.088	0.089	0.090	0.093	0.093	0.093	0.093	0.093
UK	τ^{BEN+UI}	0.123	0.123	0.125	0.124	0.116	0.116	0.104	0.104	0.104
	τ	0.413	0.408	0.408	0.415	0.409	0.408	0.390	0.388	0.383
	τ^{TAX}	0.177	0.176	0.170	0.170	0.175	0.178	0.177	0.176	0.168
	τ^{SIC}	0.125	0.122	0.123	0.123	0.123	0.123	0.124	0.125	0.129
EU	τ^{BEN+UI}	0.134	0.135	0.137	0.135	0.133	0.132	0.131	0.132	0.174
	τ	0.436	0.432	0.430	0.429	0.431	0.433	0.433	0.433	0.471
	τ^{TAX}	0.157	0.157	0.155	0.160	0.167	0.172	0.173	0.172	0.146
	τ^{SIC}	0.121	0.121	0.121	0.121	0.121	0.121	0.123	0.124	0.128
EA	τ^{BEN+UI}	0.137	0.138	0.143	0.142	0.141	0.141	0.141	0.143	0.192
	τ	0.415	0.415	0.419	0.424	0.429	0.434	0.438	0.439	0.466

Note: A missing value in the 2015 column indicates that the tax policy is not available in EUROMOD G4.0. EU and EA averages are population weighted. *Source*: Own calculations using EUROMOD.

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2. Labor Supply and Automatic Stabilization[1]

2.1. Introduction

Tax and transfer systems redistribute incomes across households. They also serve as automatic stabilizers providing insurance against income fluctuations over the business cycle (Dolls et al., 2012). While there is still considerable disagreement about the benefits of discretionary countercyclical fiscal policy, most economists agree that automatic stabilizers are an important part of macroeconomic policy. This paper extends previous research on automatic stabilizers and is the first to estimate the automatic stabilization effect of tax and transfers systems through a marginal incentives channel for many European countries: When income taxes are progressive, the tax rate that a household faces falls following an income decline in a recession, thereby increasing work incentives and hence labor supply (Christiano, 1984). This effect offsets part of the initial income decline and thus further stabilizes aggregate income and output. The magnitude of the effect depends on the change in the marginal tax rate after a change in gross income, as well as the elasticity of labor supply with respect to a change in the after-tax wage.

McKay and Reis (2016) classify four channels through which the stabilizing power of taxes and transfers can work: the disposable income channel, the marginal incentives channel, the redistribution channel and the social insurance channel. The disposable income channel works through a mechanical effect of the tax system to absorb fluctuations in gross income, which stabilizes aggregate demand through the stabilizing effect on disposable income (Pechman, 1973; Auerbach and Feenberg, 2000; Dolls et al., 2012). The marginal incentives channel works through the change in the marginal tax rate when a household is subject to an income shock: In a progressive tax and benefit system this will lead to an increase in work incentives, which increases labor supply. The redistribution channel takes into account that benefit recipients may have higher propensities to spend their income, which leads to stabilization of aggregate demand. Through the social

[1] This paper is joint work and circulates as Dolls, Fuest, Peichl, and Wittneben (2019a).

insurance channel, automatic stabilizers influence precautionary savings. In particular, they may reduce the need for precautionary savings, which increases welfare from increased consumption.

This paper focuses on the marginal incentives channel. We estimate labor supply elasticities for households in the EU27 as well as the responsiveness of the tax and transfer system. In particular, we estimate the change of the marginal tax rate with respect to a percentage change in the gross income. The marginal tax itself gives an indication of the tax system's automatic stabilization capacity according to the disposable incomes channel (Pechman, 1973; Auerbach and Feenberg, 2000; Dolls et al., 2012). When households face a sudden and temporary income decline, they may temporarily be subject to a lower marginal tax rate. This triggers an inter-temporal substitution of labor. The magnitude of this effect is mainly driven by the change in the marginal tax rate that follows the income shock, and the elasticity of labor supply with respect to the net wage.

Our first contribution is the estimation of labor supply elasticities in a consistent manner for a large set of European countries. Secondly, we contribute to the literature that assesses the incentive effects of the tax system by providing estimates of effective marginal tax rates and the progressivity of the tax and transfer system (see Auerbach and Feenberg, 2000; Saez, 2002; Immervoll et al., 2007; Wallenius, 2013). Thirdly, we contribute to the literature by estimating for the first time the automatic stabilization effect that operates through the marginal incentives channel for many European countries.

We find between five and ten percent of stabilization through labor supply in Germany, Italy, Hungary, Sweden, Spain, Slovenia, Portugal and Greece. Stabilization is largest in Germany, where 25 percent of an initial income decline is dampened. For countries with a very flat system, as many countries in eastern Europe, this effect is small or zero, because marginal incentives do not change when income changes.

Our paper relates to several strands of literature. Empirical micro studies on automatic stabilizers (Auerbach and Feenberg, 2000; Auerbach, 2009; Dolls et al., 2011, 2012, 2019b) estimate their size in different countries.[2] Using quantitative macro models, Oh and Reis (2012) and Mattesini and Rossi (2012) analyze the stabilizing role of transfers and taxes, respectively. Similarly, McKay and Reis (2016) analyze the effect of automatic stabilizers on business cycle volatility in the US. In a follow-up paper, McKay and Reis (2017) solve for the optimal automatic stabilizers (unemployment insurance and tax progressivity), taking into account aggregate volatility and the state of the labor market. Kniesner and Ziliak (2002b,a) exploit variation from US tax reforms using household panel data to estimate consumption smoothing effects. In the labor supply literature, Blundell and

[2] Macro-econometric studies (Fatás and Mihov, 2001) rely on correlations of aggregate variables.

MaCurdy (1999), MaCurdy et al. (1990), Ziliak and Kniesner (1999), Bargain et al. (2014) and Bargain and Peichl (2013) study questions of taxation and labor supply.

This paper is structured as follows. In section 2.2 we explain our measure of supply side stabilization. Section 2.3 presents the structural econometric model. In section 2.4, we describe the datasets and preparation. Section 2.5 presents results and section 2.6 concludes.

2.2. Measuring Supply Side Stabilization

2.2.1. Theoretical Framework

The literature uses the "normalized tax change" (see Pechman, 1973, 1987) as a measure of income stabilization (Auerbach and Feenberg, 2000; Dolls et al., 2012). It is defined as the ratio of how a household's tax payment (or benefit receipt) and thus, disposable income, varies with changes in the gross income and thus measures the stabilization (or income insurance) provided by a given tax and benefit system.

In this paper, we provide an additional metric of stabilization through changes in labor supply, i.e. the marginal incentives channel. For example, consider a household who has to pay a 30 percent marginal tax rate. Suppose the household experiences a decline in gross income and, because of the progressive tax system, her marginal tax rate drops to 25 percent after the shock. This increases work incentives at the margin and provides an additional cushioning of the decline in disposable income. Contrary to the income stabilization channel, for the marginal incentives channel to work in a stabilizing way, the tax system must be progressive, because in a flat tax system, there is no change in the marginal tax rate after a shock to household income.[3]

The mechanism is illustrated in Figure 2.1, with the initial labor market equilibrium consisting of labor L and wage w at point A. Given that the shock is temporary and employment is determined by aggregate labor supply, a decline in gross income will lead to increased employment when the tax system is progressive. When the shock is temporary, the change in the after-tax wage is small relative to life-time income, which emphasizes the stabilization effect, because there is no income effect that would counteract the outward shift in labor supply. After a negative productivity shock which reduces labor demand, the resulting labor market equilibrium would be point B, if the marginal tax

[3]This income stabilization coefficient is closely related to the incentive measure, as it is very similar to an average effective marginal tax rate (see Dolls et al., 2012) and the *change* in the effective marginal tax rate is one significant driver of the marginal incentives channel, as we will see below. In a regressive system, the effect would be destabilizing.

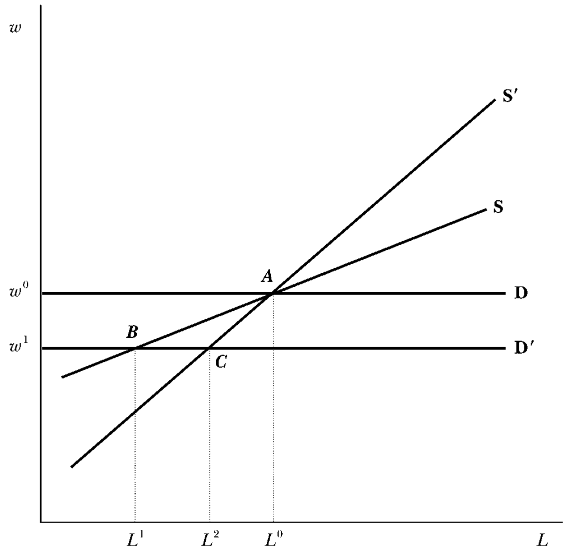


Figure 2.1.: Labor Supply Stabilization Effect

Source: Auerbach and Feenberg (2000, p. 49)

rate could not adjust. But when the marginal tax rate declines, this makes the labor supply curve steeper. The resulting equilibrium is at point C.

2.2.2. Income Concepts and Marginal Tax Rates

To estimate marginal tax rates, we simulate a shock to market income, which is defined as

$$Y_i^M = wh + y = \underbrace{Y_i^E}_{=w\cdot h} + \underbrace{Y_i^Q + Y_i^I + Y_i^P + Y_i^O}_{=y}, \tag{2.2.1}$$

where $Y_i^E, Y_i^Q, Y_i^I, Y_i^P, Y_i^O$, respectively denote labor income, business income, capital income, property income, and other income.

We define tax payments, social insurance contributions and benefit payments to be functions of market income[4] Y_i^M, of household demographic characteristics $\mathbf{X}$ that determine taxes or transfers (for instance, number of children, marital status, age), as well as the parameters of the tax and transfer system $\mathcal{T}$ (e.g. tax rate, bracket thresholds, deduction). Disposable income is equal to the market income minus net government intervention $\mathcal{T}(w_m h_m, w_f h_f, y; \mathbf{X})$, which consists of direct taxes and social insurance

[4] Note that, for simplicity of notation, we write a dependence on market income Y_i^M only and not a dependence on each component (see equation (2.2.1)),although our calculations using EUROMOD respect the different income types.

contributions minus social benefits. We perturb household market incomes Y_i^M at the observed and a hypothetical (five percent reduced) income to obtain two marginal tax rates (one actual and one hypothetical, respectively) to be able to calculate also the *change* in the marginal tax rate as the difference between these two marginal tax rates.

Figure 2.2 shows the effective marginal tax rates in the EU27, calculated as the change in taxes, transfers, and social insurance contributions with respect to a change in gross income, averaged over the population.

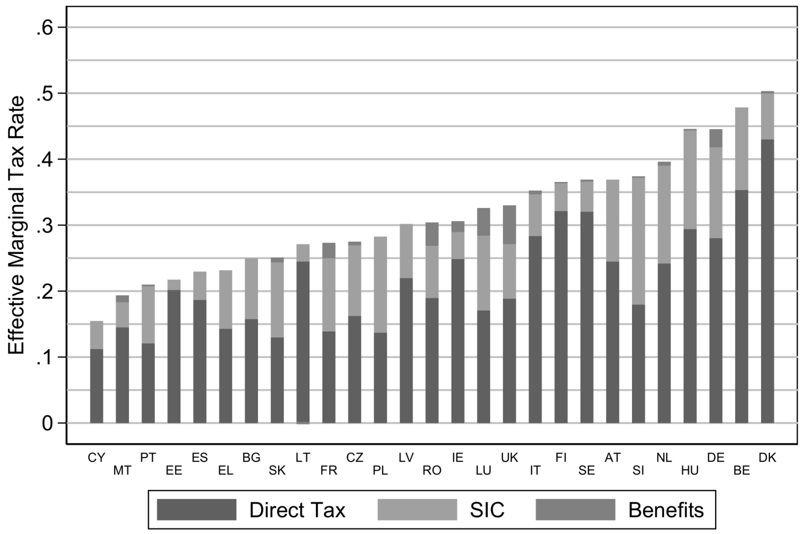


Figure 2.2.: Effective Marginal Tax Rates

Notes: Effective marginal tax rates are computed as the change in income taxes, social insurance contributions and benefits divided by the change in gross income. *Source:* Own calculations using EUROMOD.

2.2.3. Supply Side Stabilization

We now turn to the labor supply stabilization coefficient. We follow Auerbach and Feenberg (2000) by deriving the measure for stabilization:

$$\tau^S = -w \cdot \frac{\mathrm{d}\mathcal{T}'(wh, y; \mathbf{X})}{\mathrm{d}Y^M} \cdot \frac{w\mathrm{d}h}{\mathrm{d}\left[wh - \mathcal{T}(wh, y; \mathbf{X})\right]} \tag{2.2.2}$$

Equation (2.2.2) gives the general formula for the supply side stabilization coefficient τ^S. $\mathcal{T}'$ denotes the marginal tax rate. The first part is the change in the after-tax wage with respect to a change in income (keeping the before-tax wage fixed). The second part is the change in labor income with respect to a change in the after tax wage. This effect is determined by the change in labor supply.

Equation (2.2.2) can be rearranged to yield an equation that consists of components with a more intuitive interpretation:

$$\tau^S = \underbrace{\frac{\mathrm{d}\mathcal{T}'(Y^M;\mathbf{X})}{\mathrm{d}\ln Y^M}}_{\substack{=\mathcal{T}''(Y^M;\mathbf{X}) \\ \text{Change in MTR} \\ \text{w.r.t. 1\% change in } Y}} \cdot \underbrace{\frac{\alpha}{1-\mathcal{T}'(wh,y;\mathbf{X})}}_{\substack{\text{Labor income share} \\ \text{over net of tax rate}}} \cdot \underbrace{\frac{\frac{\mathrm{d}h}{h}}{\frac{\mathrm{d}w}{w}}}_{\substack{\text{Labor Supply} \\ \text{Elasticity}}} \tag{2.2.3}$$

The first term is the change in the marginal tax rate with respect to a one percent change in market income, the second term is the labor income share divided by the net of tax rate and the third term is the labor supply elasticity (with respect to changes in the *net* wage).

The resulting stabilization coefficient is interpreted as the fraction of the initial shock that is absorbed by the labor supply shift induced by the change in the marginal tax rate (see Auerbach and Feenberg, 2000).

2.3. Labor Supply Estimation

We estimate a discrete choice household labor supply model as in Aaberge et al. (1995); van Soest (1995); Bargain et al. (2014) to analyze the behavioral response to changes in wages (i.e., labor supply elasticities).[5] We follow especially Bargain et al. (2014) and update their results to more countries and more recent years. In particular, we employ a random utility maximization model to estimate utility functions that yield a distribution of choice probabilities (see McFadden, 1974). Utility consists of a deterministic part, which is a function of observable variables, and an error term that reflects optimization errors, measurement error, or unobserved characteristics. For the deterministic part, we specify a utility function that depends on both household characteristics and characteristics of the hours category (most notably the associated work and leisure times and the disposable income from working the respective amount of time, but also fix costs of taking up work). By letting household characteristics enter the utility function, we allow for heterogeneity in household preferences. Household characteristics also influence how gross income translates into disposable income through the tax-benefit function. In general, disposable income is a function of household (labor) earnings, non-labor income, and household

[5] Other contributions include Blundell et al. (2000) for Europe and Hoynes (1996); Keane and Moffitt (1998) for the US.

demographics, like age, marital status, and the number of kids. We use the European Union Statistics on Income and Living Conditions (EU-SILC) for household incomes and demographics and the microsimulation model EUROMOD to calculate direct taxes, social insurance contributions and received benefits to obtain disposable incomes.[6]

As is common in the literature, we estimate labor supply functions of single men, single women, and couples separately, as their labor supply behavior differs significantly. Our preferred specification is a choice set of seven individual choices (meaning 49 choice categories for couples), but we check the robustness of results with a smaller choice set of four choices. Married couples are assumed to maximize a joint utility function, which means that each combination of the two parters' hours is a distinct category (resulting in 49 categories for couples, compared to seven for singles).[7] Blundell and Shephard (2012) specify a set of six choices, with a particular focus on women in the UK. Estimating the model with thirteen choices (for singles) is possible, but extremely time consuming, because the choice set becomes very large for couples (169 categories).

Our hours specifications are as follows. Single households choose weekly hours of work h from a finite set $\mathcal{H} = \{0, 10, 20, 30, 40, 50, 60\}$, which correspond to (empirical) hours ranges $0-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55+$ in case of seven choices respectively. In case of four choices, the set is $\mathcal{H} = \{0, 20, 40, 60\}$, corresponding to the ranges $0-9, 10-29, 30-49, 50+$. Couples, who maximize joint utility, choose from the set $\mathcal{H} \times \mathcal{H}$.

We impose a quadratic utility function with fixed costs of work as the deterministic part of the utility function.[8] The utility function for a couple household is

$$
\begin{aligned}
U(C, h_m, h_f; \mathbf{X}, \varepsilon) = {} & \alpha_c(\mathbf{X}, \varepsilon) C(h; \mathcal{T}, y, \mathbf{X}) + \alpha_{cc} C(h; \mathcal{T}, y, \mathbf{X})^2 && (2.3.1)\\
& + \alpha_{h_f}(\mathbf{X}) h_f + \alpha_{h_m}(\mathbf{X}) h_m + \alpha_{h_{ff}}(h_f)^2 + \alpha_{h_{mm}}(h_m)^2 && (2.3.2)\\
& + \alpha_{ch_f} C(h; \mathcal{T}, y, \mathbf{X}) h_f + \alpha_{ch_m} C(h; \mathcal{T}, y, \mathbf{X}) h_m + \alpha_{h_m h_f} h_f h_m && (2.3.3)\\
& \sum_s \left(\kappa_{s,f} \cdot \mathbb{1}(h_f \in \mathcal{S}_s) + \kappa_{s,m} \cdot \mathbb{1}(h_m \in \mathcal{S}_s) \right) && (2.3.4)
\end{aligned}
$$

where $C(\cdot)$ denotes household consumption and h_f and h_m denote the partners' hours

[6]Harmonized versions of EU-SILC are also provided by EUROMOD. For the UK, the Family Resources Survey (FRS) is used instead of EU-SILC.

[7]Estimating the model with more discrete choices is much more time consuming, as the estimation takes longer and more points of the budget set have to be evaluated. Bargain et al. (2014) estimate models with four, seven, and thirteen discrete choices and find that the estimated elasticities do not differ fundamentally.

[8]Other common specifications include log or translog utility. Löffler et al. (2018) show that the choice of the functional form is not a significant driver of labor supply elasticities.

of work. The last expression $\kappa_{s,.}$ denotes dummies for subsets of the choice set.[9] Let J denote the number of choices for a couple. These choices ($\mathcal{H} \times \mathcal{H}$) correspond to all combinations of the spouses' discrete hours (for singles, the model above simplifies to only one hour term h_i, and J is the number of discrete choice from $\mathcal{H}$ for this person, i.e. seven or four).

As described earlier, we allow the coefficients on consumption and work hours to vary (linearly) with household characteristics:

$$\alpha_c(\mathbf{X}, \varepsilon) = \alpha_c^0 + X_c'\alpha_c + \varepsilon \tag{2.3.5}$$

$$\alpha_{h_f}(\mathbf{X}) = \alpha_{h_f}^0 + X_f'\alpha_{h_f} \tag{2.3.6}$$

$$\alpha_{h_m}(\mathbf{X}) = \alpha_{h_m}^0 + X_m'\alpha_{h_m}, \tag{2.3.7}$$

These "taste-shifters" $\mathbf{X}$ include age, age squared, as well as dummies for dependent children and the degree of education obtained by the household member. Further, we include fixed costs of work into the model. These costs, denoted by κ_k for $k = f, m$, are non-zero for positive hours choices. Introducing fixed costs of work, estimated as model parameters as in Bargain et al. (2014), Callan et al. (2009) or Blundell et al. (2000), improves the fit of the model.

In general, the approach is very flexible and allows to impose few constraints (see Bargain et al., 2014; van Soest, 1995). One restriction sometimes imposed in the literature is to require the utility function to be monotonically increasing in consumption, as it can be seen as a minimum consistency requirement of the econometric model with economic theory. When the fraction of observations with an implied negative marginal utility of consumption is more than 5%, we impose positive marginal utility as a constraint in the likelihood function.[10]

Wage imputation. Non-participation is included as a category ($h_0 = 0$) in our choice set, and individuals or households that are in principle labor supply flexible but choose not to work are included in our estimation samples. As the wage for these individuals is typically not observed, but still necessary for calculating disposable income in categories with positive hours, we must make assumptions on how to obtain additional wage information. Hence, in a first step, we obtain wage rates for individuals by dividing

[9] We include dummies for being in work, working part time or working full time, meaning we have $\mathcal{S}_0 = \{10, 20, 30, 40, 50, 60\}$, $\mathcal{S}_1 = \{10, 20, 30\}$, $\mathcal{S}_2 = \{40\}$. See also Aaberge and Colombino (2018).

[10] We increase the multiplier iteratively and choose the lowest multiplier that ensures at least 95% of the observations with positive marginal utility of consumption through an iterative procedure. To speed up estimation, we refrain from estimating the model with unobserved heterogeneity in these cases, that is, we do not include an error term in the coefficient α_{ci}.

earnings by working hours in the choice category. We choose to impute wages by estimating a Heckman selection model, which controls for selection into the labor market.

Hourly wages for those who work are calculated by dividing monthly earnings by "normalized" working hours. We normalize hours by rounding them to the nearest hours category to reduce division bias, see Bargain et al. (2014). We use predicted wages for all observations.[11]

It is common practice to first estimate wage rates and then use them in a labor supply estimation (see Creedy and Kalb, 2005, 2006; Bargain et al., 2014; Löffler et al., 2018). The results of the wage estimations are presented in appendix section B.

Disposable incomes and choice probabilities. For each hours choice, disposable income is a function of household labor earnings, non-labor income y_i and household demographic characteristics $\mathbf{X}$:

$$C(h; \mathcal{T}, y, \mathbf{X}) = w_m h_m + w_f h_f + y - \mathcal{T}(w_m h_m, w_f h_f, y; \mathbf{X}).$$

We denote disposable income by the letter C to stress its equivalence with consumption.[12]. We simulate the tax-benefit function $\mathcal{T}(\cdot)$ using the tax-benefit calculator EUROMOD, which we present in the next section.

As the model is stochastic in nature, the full specification of the labor supply model is given by including i.i.d. error terms ϵ for each choice from $\mathcal{H} \times \mathcal{H}$. That is, total utility at each alternative is

$$V(c, h_m, h_f; \mathbf{X}, \varepsilon) = U(C, h_m, h_f; \mathbf{X}, \varepsilon) + \epsilon,$$

with the observable part of utility $U(\cdot)$ being defined as in equation (2.3.1). The error terms can represent measurement errors or optimization errors of the household. McFadden (1974) showed that, if errors follow an extreme value type I (EV-I) distribution, the probability for each household of choosing an alternative j can be expressed as:[13]

$$\mathcal{P}_j(\mathbf{X}, \varepsilon) = Pr(h = h_j \mid \mathbf{X}, \varepsilon) = \frac{\exp\left(U(C, h_{mj}, h_{fj}; \mathbf{X}, \varepsilon)\right)}{\sum_{k=1}^{J} \exp\left(U(C, h_{mk}, h_{fk}; \mathbf{X}, \varepsilon)\right)}$$

[11] Using predicted wages for all observations further reduces selection bias. See also (Borjas, 1980; Ziliak and Kniesner, 1999) regarding the issue of division bias, MaCurdy et al. (1990) on imputing wages for the whole or only parts of the sample, as well as Löffler et al. (2018) for a discussion of these approaches in the context of discrete choice modeling.

[12] In this static setting, we do not model a savings decision of the household, and the elasticities we estimate are hence Marshallian elasticities. Hicksian elasticities can be obtained by additionally estimating income elasticities and using the Slutsky decomposition.

[13] See also Creedy and Kalb (2006); Blundell and Shephard (2012); Bargain et al. (2014)

Identification. As the tax-benefit calculator accounts for a realistic description of policies, we make use of the variation provided by nonlinearities and discontinuities inherent in these policies, as well as tax policy changes over time. 2008–2014 saw numerous changes in tax policies. Pooling the data allows us to use the variation in after-tax earnings to identify the econometric model. Effective tax rates vary with household characteristics (such as marital status, age, family composition, virtual income, etc.). Although we include some of these characteristics in the estimated utility functions, tax-benefit rules condition on a richer variety of household characteristics (for example, detailed age of children, regional information or home-ownership status).

Elasticities. Labor supply elasticities cannot be derived analytically in this nonlinear econometric model. However, using the estimated structural utility function, we can calculate choice probabilities for varying simulated incomes. We calculate the elasticities by simulating a marginal increase in the wage rate and predicting the probability distribution over the choice categories for the increased wage rate. The wage elasticity is defined as the change in expected working hours (that is, the probability-weighted average of working hours) with respect to the change in the wage rate. Similarly, we calculate expected incomes, benefits, and tax payments before and after the simulated income change. Labor supply elasticities are then calculated as

$$\eta = \frac{\Delta \widehat{H}'}{\widehat{H}} \cdot \frac{w}{\Delta w'}, \tag{2.3.8}$$

where $\widehat{H}$ is the expected value of working hours (in other words, the probability-weighted sum of hours categories) and Δ denotes the difference of the variable from its simulated counterpart.[14]

2.4. Data

In this study, we analyze the EU27.[15] The datasets we use are based on EU-SILC, a harmonized European household survey, and the FRS for the UK. They are provided by Eurostat and have been further harmonized by the EUROMOD team to make income types comparable and consistent with the legal definitions in each country, and converted from annual to monthly incomes. EUROMOD is a European tax-benefit calculator that

[14] See also Blundell et al. (2013).

[15] The most recent EU member state Croatia has less datasets available, so we exclude it from the analysis.

provides a framework to simulate direct taxes[16], social insurance contributions, and social benefits and family transfers (see Sutherland and Figari, 2013).

2.4.1. Household Data and Estimation Samples

We use data with an income reference year of 2007, 2009, 2011 and 2013, unless stated otherwise, and use the tax-benefit system of that respective year for the simulation of taxes and transfers. For the labor supply estimation, we pool the year datasets available for each country. For each discrete choice hours category h and each household, disposable income $C(\cdot)$ is calculated by aggregating all types of household income, adding received benefits (family and social transfers), while subtracting direct taxes (on labor and capital income) and social security contributions. We denote these tax-benefit calculations by function $\mathcal{T}(\cdot)$ as defined below. In practice, we use the tax-benefit model EUROMOD for these calculations, based on the information on income and household demographic characteristics X_i. We introduce EUROMOD in the next section.

For the purpose of the labor supply estimation, we divide the base sample into three subsamples for each country, depending on the household type: couples, single men and single women (the latter two including single parents) separately. We restrict each estimation sample to adults aged between 18 and 60 that are available to take part flexibly in the labor market, thereby excluding disabled or retired people, those in education, self-employed, or farmers.[17] Descriptive statistics of the sample are reported in the tables in section B.

2.4.2. Tax-Benefit Simulation and Hypothetical Incomes

For the discrete choice estimation, it is necessary to calculate the disposable incomes in each hours category. To do this, we use the European microsimulation model EUROMOD and the data based on the EU-SILC harmonized datasets of EU27 households that come with it. Sutherland and Figari (2013) provide an overview of the recent version of EUROMOD. In this paper, we use version G4.0+ of EUROMOD. It includes multi-year datasets and the tax and benefit systems 2008–2014 for 28 countries of the European Union. Using EUROMOD, we calculate the counterfactual disposable incomes that are necessary for the structural econometric model (see section 2.3). EUROMOD applies the appropriate tax rules to calculate household after-tax incomes and then simulate social

[16] There are recent attempts to reflect value added taxes to the project, see Decoster (2014).

[17] For the Heckman-corrected wage estimation, we apply the same restrictions on the sample, but estimate the sample separately for women and men.

insurance contributions as well as benefits and pensions the individual may be eligible for.

2.5. Results

This section presents the estimated labor supply elasticities and the stabilization coefficient.

2.5.1. Labor Supply Elasticities

We estimate the labor supply elasticities separately for each country for single men, single women, and couples. We aggregate the results at individual or household level to derive an estimate for the whole population. The covariates in each estimation are the same across countries. The fit is good even with only four choices.

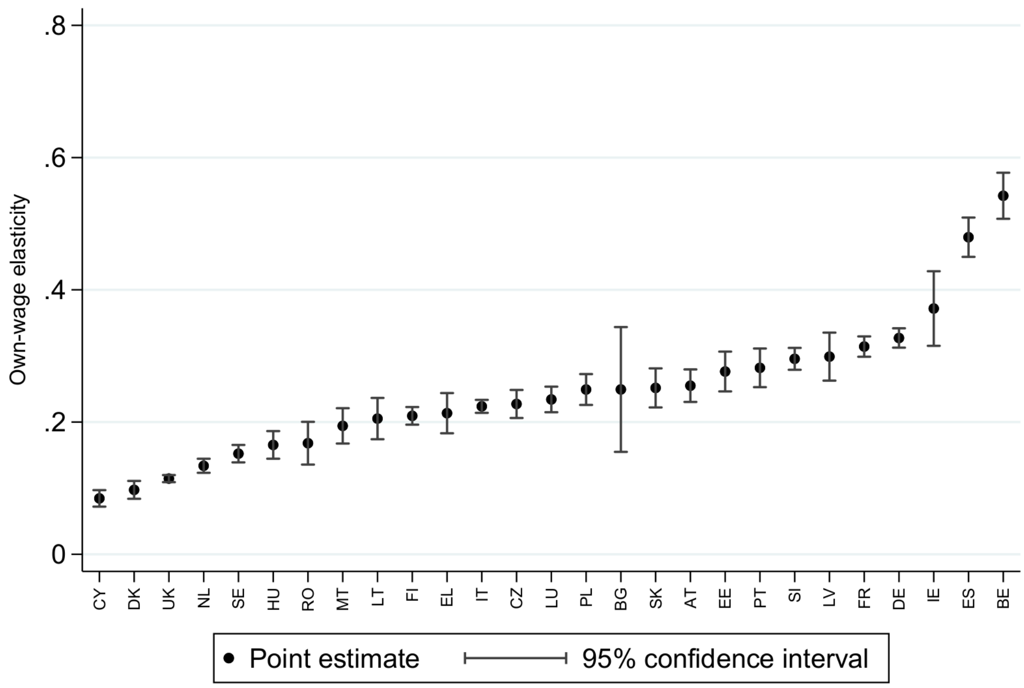


Figure 2.3.: Own Wage Elasticity

Own Wage Elasticities. In figure 2.3 we present the results for own wage elasticities for the European countries. Generally, the elasticities are in line with the literature, ranging from 0 to around 0.6. The labor supply elasticities are small (below 0.2) in

Luxembourg, Netherlands, Cyprus, Denmark, Sweden, Hungary and the UK. We find the largest elasticities for Romania, Spain, Latvia, Belgium, Estonia, and Bulgaria (between 0.4 and 0.6).

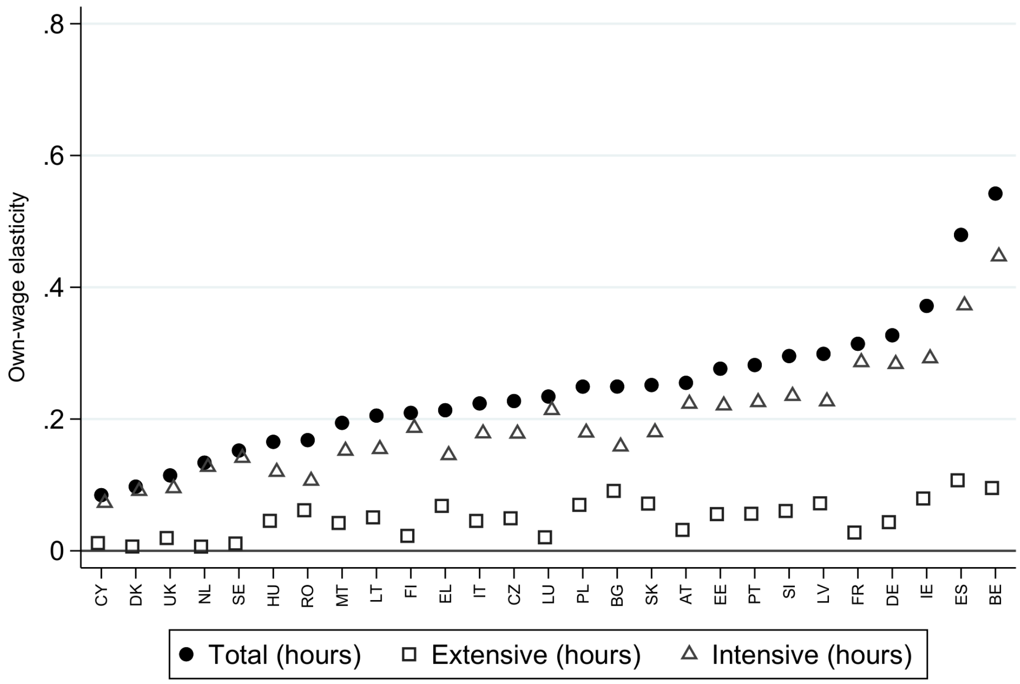


Figure 2.4.: Own Wage Elasticity: Extensive vs. Intensive Margin

Intensive and Extensive Margin. We follow Bargain et al. (2014) in defining the hours elasticity for participants as the intensive margin elasticity. The extensive margin is expressed as the hours changes corresponding to participation responses in relation to total hours, so the extensive and the intensive margin sum up to the total elasticity. Figure 2.4 shows the results. We comment first on the general magnitude of the estimated elasticities before going into country details.

Contrary to Bargain et al. (2014), who find intensive margin elasticities close to zero for many countries, our estimates of intensive margin elasticities are relatively large, often larger than the extensive margin. This results is consistent with findings in the literature. For instance, in recent studies, Chetty et al. (2011) conclude from meta analyses that the intensive margin Hicksian micro elasticity is 0.33, while its extensive margin counterpart is 0.26. Similarly, Attanasio et al. (2018) find that the extensive margin makes up about half of the response for younger women, but that share declines with age.

There are several possible explanations that reconcile the different magnitudes of the estimated intensive margin elasticities in Bargain et al. (2014) and this paper. The most straightforward explanation could simply be our use of different data sources and the newer datasets. Also, more availability of part-time work over the last decade could have increased hours flexibility on the household side. Another reason may be the slightly different approach in Bargain et al. (2014) regarding wage prediction. To increase the variation in the distribution of predicted wage rates, Bargain et al. (2014) add a single random error term to each wage. While this helps to increase the variance of the wage distribution, it is ad hoc and the effect on the wage prediction remains unclear.[18]

Furthermore, we pool multiple years for each country. The reported pooled elasticities in Bargain et al. (2014) are also lower than non-pooled (except for Ireland, see Bargain et al., 2014).

In general, elasticities lie between 0.1 and 0.6, which is the usual range seen in other studies. We find the lowest elasticities in Cyprus, Denmark, UK, Netherlands and Sweden (all below 0.2). In these countries, the extensive hours elasticities are virtually zero. Hungary and Romania also have elasticities below 0.2 but the extensive margin makes up a larger share. Elasticities are particularly large in Belgium, Spain and Ireland (above 0.4). The other countries lie in between.

We also provide the disaggregated results from the elasticity estimations in figure 2.5. Married men have the lowest overall elasticities, and they vary little at the extensive margin. Married women have higher elasticities, but are still below values often seen in the literature. Singles generally have a higher elasticity at the extensive margin, with particularly high elasticities for single men.

Gross vs. net elasticities. So far, we have looked at gross wage elasticities. We also estimate net wage elasticities as the change in expected hours divided by the change in the net wage. Because a fraction of the change in the gross wage is dampened by the tax and transfer system, the change in the net wage will generally be less than the change in the gross wage, which is why net elasticities normally are larger than their gross wage counterparts. Figure 2.6 plots net wage elasticities against the gross wage elasticities. The elasticities generally lie above the 45 degree line.

[18] Results in Löffler et al. (2014) indicate that this procedure can downward-bias elasticities significantly.

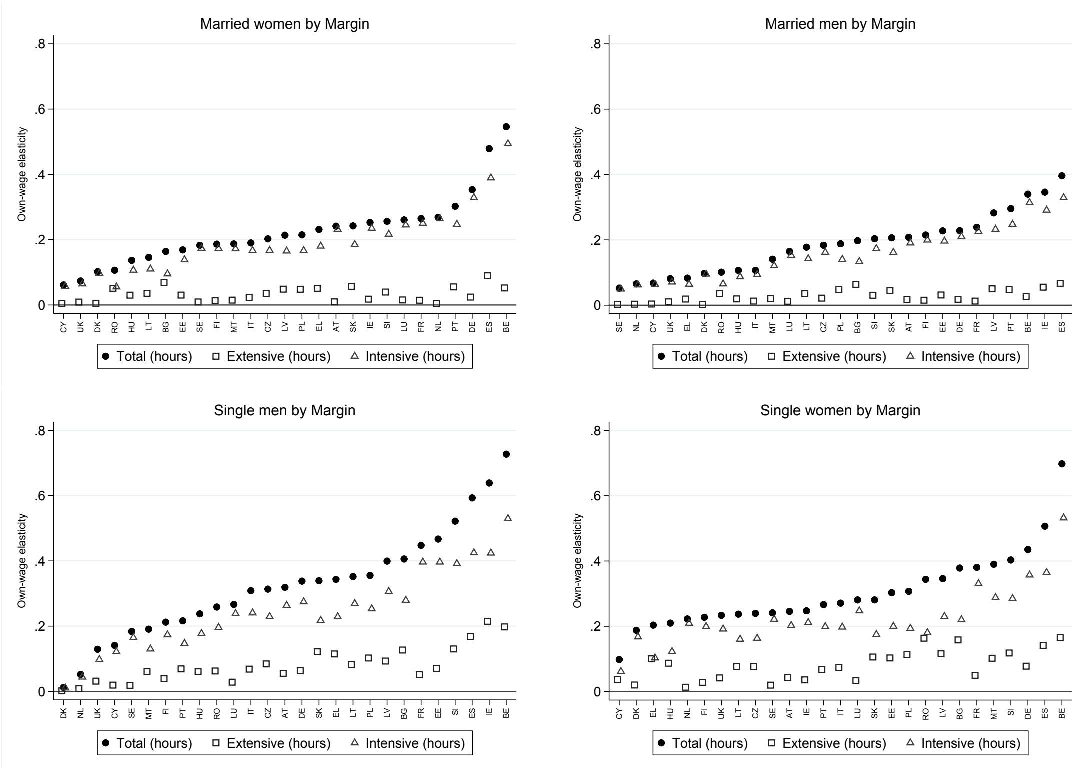


Figure 2.5.: Labor Supply Elasticities by Household Type

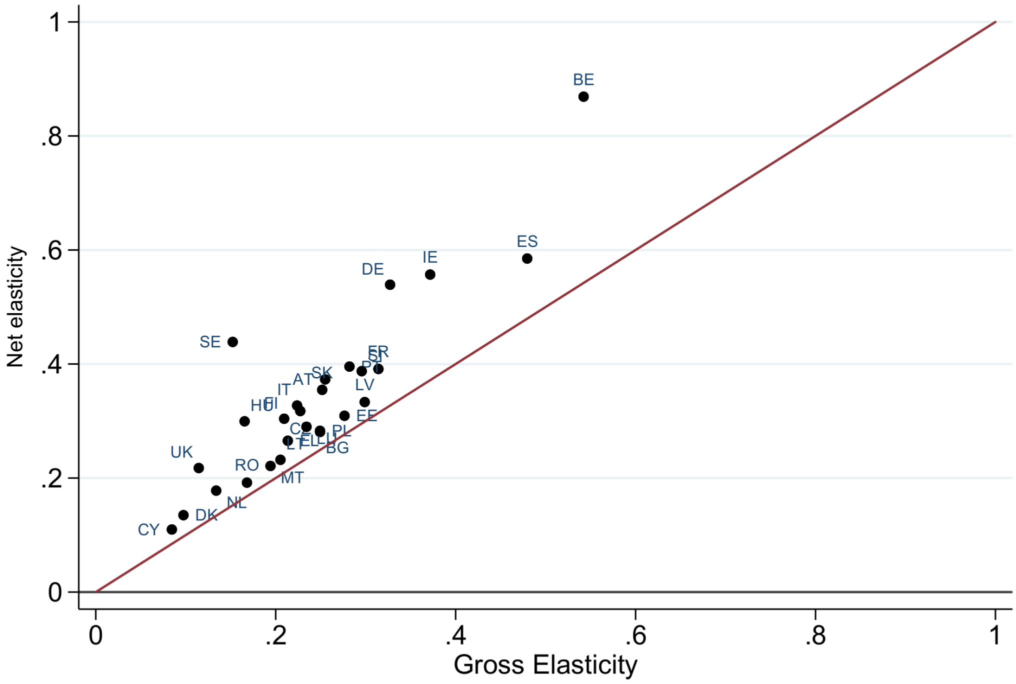


Figure 2.6.: Gross vs. Net Wage Elasticity

Notes: Plots net wage elasticity against gross wage elasticity. The net wage elasticities are calculated as the change in expected hours divided by the change in the net wage. Because a fraction of the change in the gross wage is dampened by the tax and transfer system, the net wage elasticity is larger than the gross wage elasticity.

2.5.2. Automatic Stabilizers

This section presents our main results, the estimates of the labor supply stabilization coefficient. The supply side stabilization coefficient is largest in Germany, where 25 percent of an initial income decline is dampened. This strong stabilization effect is induced by the large average labor supply elasticity (0.539), as well as the stark drop in the marginal tax rate after an income change (0.413). While many tax systems apply tax brackets, where marginal tax rates only change when income changes across thresholds, the German tax system interpolates marginal rates between thresholds, so that the marginal rate changes continuously as taxable income shifts. Regarding the rest of Europe, Italy (0.116), Hungary (0.095), Sweden (0.08), Spain(0.073), Slovenia (0.072), Portugal (0.06), Greece (0.051) and Ireland (0.05) have high stabilizers (larger than 0.05). Countries with a high second derivative of the tax function are Denmark (0.228), Greece (0.168), Italy (0.328) and Sweden (0.185). In the other countries, the overall labor supply stabilization effect is rather modest, ranging from 0 to 0.05.

Bulgaria and Luxembourg have a negative stabilizer, meaning that the tax and transfer system overall is actually a de-stabilizer. This is the case because the tax rates in both countries are regressive when taxes benefits and social security contributions are combined. France and UK are also slightly de-stabilizing, but the coefficient is near zero. While Bulgaria is regressive at the top, in Luxembourg, France and UK, benefit withdrawal causes the tax system to be regressive.[19]

Accounting for the state of the labor market. One might argue that households are not free to choose hours at their will during recessions, the time when we are especially interested in automatic stabilizers. In times of recessions, unemployment typically increases and the labor market becomes more slack and less tight.[20] This means that the cost of vacancies go down and firms find it easier to hire workers, while the converse is true for households, who have a harder time finding jobs.

Two points support our interpretation of the results. First, our simulated income shock can be interpreted as happening at the extensive margin, because for the marginal incentives channel to play a role, we only require a shock to taxable income, which

[19]We provide illustrations of the progressivity of the tax systems in the appendix (graph B.1 in section B), by plotting marginal tax rates against gross incomes.

[20]It can also be argued that what matters is not only the unemployment rate, as conventionally measured, but "Rather, assessments of the employment gap should reflect the incidence of underemployment (that is, people working part time who want a full-time job) and the extent of hidden unemployment (that is, people who are not actively searching but who would rejoin the workforce if the job market were stronger)" (see Blanchflower and Levin, 2015).

Table 2.1.: Supply Side Stabilization Coefficients

	Components				
	α	$(1-\tau)$	$\frac{d\tau}{\ln Y}$	$\eta_{l,\tilde{w}}$	Result
AT	0.731	0.628	0.062	0.373	-0.027
BE	0.638	0.501	0.040	0.869	-0.044
BG	0.849	0.737	-0.281	0.281	0.091
CY	0.868	0.838	0.160	0.110	-0.018
CZ	0.878	0.718	0.076	0.318	-0.029
DE	0.593	0.516	0.413	0.539	-0.256
DK	0.714	0.491	0.228	0.135	-0.045
EE	0.814	0.774	0.029	0.309	-0.009
EL	0.869	0.764	0.168	0.265	-0.051
ES	0.718	0.768	0.134	0.585	-0.073
FI	0.723	0.614	0.105	0.304	-0.037
FR	0.622	0.713	-0.075	0.391	0.026
HU	0.929	0.541	0.185	0.300	-0.095
IE	0.697	0.662	0.085	0.557	-0.050
IT	0.685	0.633	0.328	0.327	-0.116
LT	0.900	0.729	-0.006	0.232	0.002
LU	0.763	0.663	-0.276	0.290	0.092
LV	0.928	0.689	0.008	0.333	-0.004
MT	0.438	0.788	0.070	0.221	-0.009
NL	0.704	0.589	0.060	0.178	-0.013
PL	0.958	0.709	0.019	0.283	-0.007
PT	0.845	0.772	0.139	0.395	-0.060
RO	0.916	0.685	-0.011	0.192	0.003
SE	0.614	0.620	0.185	0.439	-0.080
SI	0.836	0.615	0.137	0.387	-0.072
SK	0.924	0.731	0.026	0.355	-0.012
UK	0.582	0.655	-0.080	0.218	0.016

Notes: Negative stabilizer value in the last column indicates stabilization. It is the fraction of the shock that is absorbed. From left to right, the variables are labor share, net-of-tax rate, tax elasticity, net wage elasticity. *Source:* Own calculations.

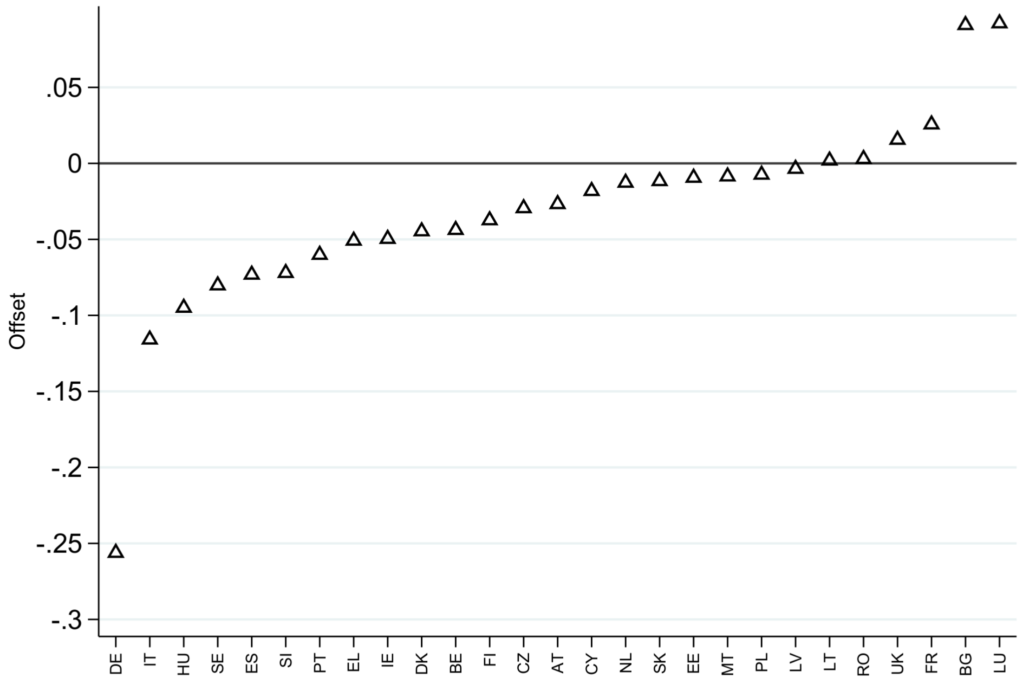


Figure 2.7.: Labor Supply Stabilization Coefficients

Notes: Labor supply stabilization coefficients. Interpreted as the fraction of the initial shock that is offset through labor supply. Negative value indicates stabilization. See Table 2.1. *Source:* Own calculations.

could come from working less than the desired hours. Second, our inclusion of choice-specific dummies (cost of work) in our estimations can be interpreted as representing the availability of a specific choice or job opportunities, and hence can be seen as accounting for labor market tightness. Aaberge et al. (1999); Aaberge and Colombino (2018) show that the dummy-specification is equivalent to a random utility job choice model when systematic utility is weighted by the frequency of jobs available.

2.6. Conclusion

In this paper, we estimate discrete choice models of household labor supply and use the microsimulation model EUROMOD to estimate the marginal incentives channel of the automatic stabilization effect of tax and transfer systems of the EU27. We calculate the changes in the effective marginal tax rates and combine them with the estimated labor supply elasticities to quantify how much of the initial decline in output is absorbed by automatic stabilization through labor supply.

Our results confirm the back-of-the-envelope calculations in Auerbach and Feenberg (2000), that roughly 10 percent of a decline can be offset by labor supply stabilization. The automatic stabilization effect of the marginal incentive channel is heterogeneous across countries. Countries with flat tax systems exhibit hardly any stabilization, while Germany has a large supply side stabilizer (0.25), in part because of its marginal tax rates adjusting continuously to taxable income.

In future work, we will analyze the change in elasticities and tax-benefit policies over time by estimating utility functions for each year separately instead of pooling together all data years. While pooling allows us to exploit more variation in income and hours caused by tax policy changes, it would be interesting to see how preferences for labor supply changed over time and how this affected labor supply stabilization.

B. Additional Results

This appendix collects descriptive statistics and results of the regressions. Sample descriptives on demographics, regressors, and sample size are provided in tables B.1 and B.2. These tables also show mean and standard deviation of our wage rate imputations, obtained by Heckman estimations. The estimations and coefficients themselves, differentiated by gender, can be found in this section in tables B.3 and B.4. Figure B.1 plots empirical effective marginal tax rates in 2008 for our estimation samples to illustrate the progressivity of the tax systems (for 2008 policy years).[1] The graphs show the median marginal tax rate for each gross income bin of the actual income distribution. Tables B.5, B.6 and B.7 show the results of the labor supply estimations for single women, single men and couples, respectively.

Table B.1.: Wage Subsample: Women – 7 choices

						Education		Imputed Wage		
		Age	H	$H_{H>0}$	LFP	high	medium	predicted (sd)	actual (sd)	N
AT	2008	38.95	33.26	34.54	0.96	0.18	0.66	14.07 (3.54)	13.51 (16.00)	2,422
AT	2010	39.64	33.15	34.20	0.97	0.18	0.64	15.66 (3.43)	14.44 (13.39)	2,617
AT	2012	39.84	32.79	34.00	0.96	0.17	0.66	17.74 (4.00)	14.40 (13.08)	2,685
AT	2014	40.32	31.73	33.39	0.95	0.30	0.53	18.34 (4.32)	16.25 (12.18)	2,500
BE	2008	39.25	30.04	33.27	0.90	0.44	0.35	16.72 (3.05)	15.37 (7.55)	2,894
BE	2010	39.72	32.07	35.22	0.91	0.45	0.35	16.64 (3.25)	16.91 (8.08)	2,744
BE	2012	40.00	31.59	34.13	0.93	0.48	0.35	17.69 (3.81)	17.90 (13.28)	2,585
BG	2008	39.47	36.77	41.27	0.89	0.23	0.56	1.31 (0.28)	1.25 (1.10)	2,437
BG	2010	40.17	35.95	39.87	0.90	0.30	0.53	1.77 (0.41)	1.70 (1.29)	3,325
BG	2012	40.88	36.38	40.41	0.90	0.33	0.53	1.79 (0.33)	1.68 (1.10)	2,933
BG	2014	41.02	36.31	39.96	0.91	0.33	0.51	2.38 (0.44)	1.94 (1.37)	2,482
CY	2008	37.78	38.08	38.96	0.98	0.44	0.41	9.57 (3.56)	8.87 (6.10)	1,781
CY	2010	37.63	37.39	38.80	0.96	0.42	0.39	8.72 (4.11)	9.06 (7.38)	2,127
CY	2012	37.45	35.34	37.97	0.93	0.45	0.38	8.90 (4.18)	9.68 (8.01)	2,866
CY	2014	37.45	33.40	37.72	0.89	0.48	0.39	8.40 (3.81)	9.63 (7.53)	2,444

[1] To save space, we don't provide the scatter plots for the more recent years, but results are available on request.

CZ	2008	40.05	36.38	40.20	0.91	0.13	0.76	3.78 (0.73)	3.77 (1.74)	4,867
CZ	2010	40.31	36.36	40.01	0.91	0.16	0.75	4.25 (0.76)	4.12 (2.34)	3,904
CZ	2012	40.35	36.05	39.73	0.91	0.18	0.74	4.69 (0.88)	4.17 (2.64)	3,672
DE	2008	40.69	30.80	33.81	0.91	0.37	0.53	14.97 (3.96)	12.90 (7.59)	5,743
DE	2010	41.03	31.50	34.00	0.93	0.34	0.54	15.40 (4.13)	13.05 (8.10)	5,829
DE	2012	41.33	31.63	33.79	0.94	0.35	0.56	15.61 (3.63)	13.42 (8.07)	5,823
DK	2008	41.03	36.13	37.14	0.97	0.36	0.42	20.84 (3.63)	19.58 (8.43)	3,208
DK	2012	41.53	35.64	37.16	0.96	0.44	0.42	23.85 (4.22)	23.20 (12.51)	2,842
EE	2008	40.89	39.52	39.87	0.99	0.43	0.51	3.26 (0.70)	3.42 (2.06)	2,660
EE	2010	40.87	36.01	38.57	0.93	0.45	0.48	3.75 (0.78)	3.83 (2.83)	2,759
EE	2012	40.87	36.93	39.18	0.94	0.46	0.46	4.02 (0.80)	3.96 (2.49)	2,799
EL	2008	36.63	32.69	36.85	0.89	0.36	0.42	8.57 (3.30)	8.79 (6.29)	2,184
EL	2010	37.39	31.87	35.75	0.89	0.40	0.44	10.61 (2.84)	9.59 (6.74)	2,327
EL	2012	37.81	24.26	33.63	0.72	0.38	0.43	12.29 (2.15)	11.25 (12.04)	1,805
EL	2014	37.89	24.02	37.12	0.65	0.40	0.46	9.55 (1.72)	6.89 (4.17)	2,957
ES	2008	37.50	34.20	36.46	0.94	0.40	0.26	8.86 (2.48)	9.03 (5.54)	6,180
ES	2010	38.20	31.41	35.95	0.87	0.38	0.28	9.22 (2.87)	9.52 (6.30)	6,999
ES	2012	39.29	28.23	34.95	0.81	0.40	0.26	9.10 (2.48)	9.40 (5.24)	6,169
ES	2014	40.05	28.71	34.90	0.82	0.44	0.21	9.69 (3.36)	10.08 (6.80)	6,157
FI	2008	41.29	35.86	37.26	0.96	0.40	0.46	13.93 (2.91)	13.78 (6.50)	4,888
FI	2010	41.83	36.09	37.97	0.95	0.46	0.43	15.62 (2.86)	15.52 (6.43)	4,909
FI	2012	41.71	35.86	37.99	0.94	0.50	0.41	16.50 (3.15)	16.61 (7.06)	4,478
FI	2014	41.27	35.23	37.26	0.95	0.51	0.42	17.48 (3.36)	17.84 (8.51)	4,830
FR	2007	39.27	33.78	35.80	0.94	0.34	0.42	11.39 (2.77)	11.25 (6.22)	5,048
FR	2010	39.57	34.46	35.91	0.96	0.37	0.43	12.68 (2.93)	12.22 (7.16)	5,229
FR	2012	39.96	34.65	35.92	0.96	0.39	0.46	13.31 (3.01)	13.12 (9.83)	5,686
HR	2014	39.18	29.85	39.18	0.76	0.24	0.62	5.41 (1.11)	4.19 (2.62)	2,558
HU	2008	39.85	37.32	39.81	0.94	0.24	0.59	2.90 (1.04)	3.08 (2.21)	3,825
HU	2010	41.04	38.13	40.83	0.93	0.26	0.57	2.64 (0.34)	2.75 (1.28)	4,458
HU	2012	41.29	35.17	38.09	0.92	0.28	0.57	3.17 (0.87)	3.10 (2.02)	5,466
IE	2008	37.55	30.39	31.67	0.96	0.43	0.37	18.42 (5.56)	18.15 (15.87)	1,869
IE	2010	38.26	27.45	30.09	0.91	0.48	0.36	21.74 (5.17)	20.13 (13.44)	1,696
IE	2012	38.39	27.64	30.95	0.89	0.51	0.35	18.74 (4.97)	19.49 (15.01)	1,862
IT	2008	38.86	32.58	35.54	0.92	0.22	0.48	12.37 (2.63)	11.95 (6.32)	7,355
IT	2010	39.60	32.88	36.03	0.91	0.22	0.48	14.83 (2.86)	11.75 (7.54)	7,026
IT	2012	40.60	33.10	35.31	0.94	0.24	0.50	14.92 (2.64)	11.79 (7.06)	7,055
IT	2014	41.46	31.99	35.07	0.91	0.26	0.50	15.53 (2.45)	12.09 (7.18)	7,321
LT	2008	39.82	38.38	39.40	0.97	0.42	0.53	2.94 (0.85)	2.82 (1.88)	2,367
LT	2010	39.61	34.56	38.52	0.90	0.45	0.50	3.98 (1.13)	3.09 (2.72)	2,756
LT	2012	40.94	35.84	39.00	0.92	0.45	0.50	3.47 (0.93)	3.27 (2.30)	2,628
LT	2014	41.51	35.61	38.41	0.93	0.45	0.51	3.87 (0.91)	3.47 (2.28)	2,435
LU	2008	38.08	33.34	34.18	0.98	0.28	0.38	19.85 (6.07)	19.14 (11.11)	1,715
LU	2010	38.46	33.50	34.79	0.96	0.30	0.35	22.61 (7.65)	20.83 (12.67)	2,150
LU	2012	38.81	33.24	34.88	0.95	0.30	0.36	24.30 (8.17)	22.08 (13.95)	2,763

LV	2008	39.90	39.35	40.55	0.97	0.31	0.58	2.47 (0.79)	2.37 (1.93)	2,707
LV	2010	39.94	34.58	39.03	0.89	0.35	0.55	2.17 (0.81)	2.44 (1.91)	3,218
LV	2012	41.01	34.23	38.72	0.88	0.39	0.53	2.90 (0.75)	2.50 (2.09)	3,238
LV	2015	41.36	37.27	38.95	0.96	0.42	0.48	4.49 (1.15)	4.37 (3.48)	2,781
MT	2009	34.41	34.46	36.51	0.94	0.26	0.30	7.16 (1.93)	6.83 (3.81)	1,241
MT	2010	34.58	36.22	37.40	0.97	0.28	0.28	7.90 (2.28)	7.88 (5.57)	1,194
MT	2012	35.31	35.93	36.89	0.97	0.30	0.35	8.41 (2.19)	8.33 (4.05)	1,548
MT	2014	36.33	35.87	36.37	0.99	0.35	0.32	9.19 (2.24)	9.05 (5.20)	1,650
NL	2008	39.40	27.47	27.79	0.99	0.34	0.45	18.06 (4.11)	17.19 (11.29)	4,990
NL	2010	39.76	27.51	27.98	0.98	0.37	0.44	19.33 (4.54)	18.62 (12.87)	4,874
NL	2012	40.06	27.26	27.70	0.98	0.39	0.43	20.10 (4.49)	18.68 (11.10)	5,025
PL	2008	37.33	35.10	38.53	0.91	0.30	0.65	3.48 (1.24)	3.74 (3.58)	6,119
PL	2010	38.09	35.85	39.02	0.92	0.34	0.60	3.57 (1.30)	3.80 (2.94)	5,497
PL	2012	38.34	34.42	38.46	0.89	0.34	0.55	3.71 (1.18)	3.91 (2.83)	6,208
PL	2014	38.82	34.74	39.13	0.89	0.37	0.52	3.70 (1.14)	4.12 (2.96)	6,089
PT	2008	38.18	36.17	38.98	0.93	0.21	0.19	5.69 (3.01)	5.94 (5.94)	1,988
PT	2010	38.44	34.26	38.33	0.89	0.21	0.21	5.84 (2.96)	6.70 (7.30)	2,395
PT	2012	39.08	33.99	39.65	0.86	0.24	0.25	5.79 (2.66)	6.36 (6.14)	3,123
PT	2014	40.04	32.95	40.43	0.81	0.27	0.25	5.56 (2.37)	6.05 (4.95)	3,532
RO	2008	38.22	40.05	41.58	0.96	0.23	0.63	1.54 (0.52)	1.53 (1.07)	2,395
RO	2010	38.48	39.93	41.87	0.95	0.26	0.62	1.66 (0.49)	1.64 (1.00)	2,324
RO	2012	38.77	39.45	41.42	0.95	0.30	0.60	1.66 (0.43)	1.60 (0.88)	2,169
RO	2014	39.44	39.52	41.47	0.95	0.23	0.62	1.82 (0.38)	1.76 (0.96)	2,226
SE	2008	40.24	32.46	33.27	0.98	0.39	0.53	15.82 (3.82)	14.92 (11.61)	3,997
SE	2010	40.56	33.01	33.89	0.97	0.42	0.51	17.50 (4.29)	16.53 (13.53)	3,716
SE	2012	40.64	34.40	35.58	0.97	0.46	0.48	23.18 (4.59)	18.77 (18.09)	3,392
SI	2008	39.40	36.50	39.81	0.92	0.28	0.55	8.18 (2.41)	7.58 (4.55)	6,156
SI	2010	39.86	35.22	38.73	0.91	0.31	0.55	9.68 (2.69)	8.33 (5.01)	6,237
SI	2012	40.10	34.22	38.24	0.89	0.35	0.52	10.88 (2.77)	8.83 (5.21)	6,000
SI	2014	40.32	34.56	39.50	0.87	0.39	0.50	10.96 (2.30)	8.75 (5.12)	5,803
SK	2008	39.52	37.60	40.40	0.93	0.20	0.74	3.13 (0.44)	2.89 (1.29)	3,667
SK	2010	40.36	36.04	40.06	0.90	0.24	0.70	3.51 (0.48)	3.35 (1.66)	3,608
SK	2012	40.61	35.81	40.07	0.89	0.27	0.68	4.03 (0.64)	3.81 (1.82)	3,538
SK	2014	40.59	35.27	39.99	0.88	0.29	0.65	3.95 (0.68)	3.77 (3.23)	3,468
UK	2008	38.60	31.90	33.88	0.94	0.24	0.26	13.82 (3.61)	13.40 (10.17)	9,878
UK	2009	38.95	31.20	33.52	0.93	0.24	0.26	12.80 (3.25)	12.21 (8.08)	9,962
UK	2012	38.95	30.80	33.71	0.91	0.27	0.28	14.64 (3.64)	14.51 (13.46)	8,051
UK	2013	38.96	31.23	33.65	0.93	0.29	0.28	14.12 (3.44)	13.69 (10.43)	8,050

Notes: Summary statistics of the wage estimation subsample. Variables: Mean age, mean working hours, mean working hours conditional on hours being positive, labor force participation rate, fraction of highly and medium educated, predicted wage (standard deviation), observed wage (standard deviation), sample size. Nominal variables are denominated in Euro. *Source*: Own calculations using EU-SILC.

Table B.2.: Wage Subsample: Men – 7 choices

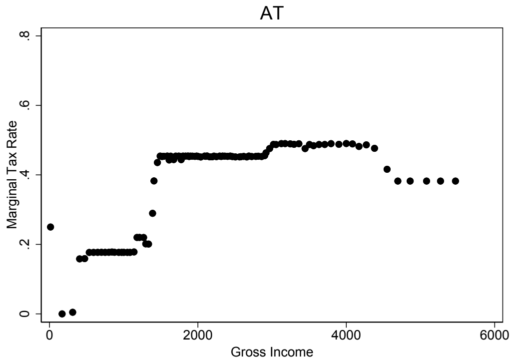
		Age	H	$H_{H>0}$	LFP	Education		Imputed Wage		N
						high	medium	predicted (sd)	actual (sd)	
AT	2008	38.77	40.77	42.55	0.96	0.19	0.68	17.50 (3.99)	16.35 (11.26)	2,799
AT	2010	38.94	40.32	41.97	0.96	0.20	0.66	18.42 (4.40)	17.67 (12.60)	2,922
AT	2012	39.29	40.87	42.22	0.97	0.21	0.67	21.37 (5.79)	17.80 (13.66)	2,890
AT	2014	39.60	39.44	41.21	0.96	0.29	0.58	22.41 (6.00)	19.68 (12.33)	2,699
BE	2008	39.36	38.51	41.15	0.94	0.35	0.40	17.96 (3.75)	16.87 (8.77)	2,996
BE	2010	39.84	39.44	42.57	0.93	0.36	0.38	18.79 (3.90)	17.89 (8.29)	2,884
BE	2012	40.02	38.03	41.50	0.92	0.39	0.39	19.00 (4.27)	19.14 (11.70)	2,624
BG	2008	38.36	39.71	42.65	0.93	0.13	0.63	1.83 (0.28)	1.56 (1.08)	2,582
BG	2010	38.62	38.19	41.27	0.93	0.16	0.64	2.18 (0.45)	2.00 (1.50)	3,499
BG	2012	39.25	36.81	41.27	0.89	0.18	0.65	2.27 (0.36)	2.08 (1.65)	3,069
BG	2014	39.74	37.00	40.99	0.90	0.19	0.61	2.92 (0.49)	2.36 (2.47)	2,509
CY	2008	39.32	43.03	43.60	0.99	0.34	0.44	11.79 (3.12)	11.57 (7.43)	1,846
CY	2010	38.25	41.77	42.78	0.98	0.32	0.44	13.13 (3.61)	11.82 (7.43)	2,056
CY	2012	38.28	39.62	41.70	0.95	0.33	0.46	14.30 (4.39)	12.94 (11.51)	2,674
CY	2014	38.61	36.77	40.62	0.91	0.34	0.46	14.03 (4.24)	11.56 (9.78)	2,404
CZ	2008	38.80	40.76	43.66	0.93	0.15	0.78	4.87 (0.98)	4.92 (2.56)	5,526
CZ	2010	38.95	40.24	43.06	0.93	0.16	0.78	5.36 (1.04)	5.24 (2.87)	4,334
CZ	2012	38.98	40.05	42.73	0.94	0.18	0.76	5.80 (1.32)	5.48 (3.30)	3,978
DE	2008	40.80	40.08	43.58	0.92	0.41	0.50	18.08 (5.73)	16.68 (10.98)	5,781
DE	2010	40.78	40.34	43.27	0.93	0.40	0.50	18.29 (6.00)	16.72 (10.76)	5,901
DE	2012	41.11	40.40	43.02	0.94	0.39	0.52	18.89 (5.78)	17.52 (10.59)	5,761
DK	2008	40.07	40.44	40.99	0.99	0.28	0.49	23.74 (5.61)	22.41 (12.63)	3,046
DK	2012	40.59	40.04	41.31	0.97	0.33	0.48	25.94 (6.79)	25.16 (23.14)	2,669
EE	2008	38.05	40.18	41.37	0.97	0.23	0.62	4.88 (0.84)	4.84 (2.92)	2,688
EE	2010	38.36	36.54	40.93	0.89	0.25	0.60	5.26 (0.93)	5.24 (4.91)	2,765
EE	2012	38.40	39.12	41.52	0.94	0.26	0.60	5.89 (0.93)	5.53 (3.52)	2,848
EL	2008	38.50	40.26	42.83	0.94	0.26	0.45	10.71 (3.52)	9.75 (7.12)	2,602
EL	2010	38.81	35.68	39.51	0.90	0.28	0.47	11.31 (3.48)	11.33 (9.23)	2,685
EL	2012	38.77	29.52	38.84	0.76	0.28	0.48	9.87 (2.72)	11.09 (10.49)	2,038
EL	2014	39.36	30.25	41.14	0.74	0.32	0.47	9.54 (2.23)	8.02 (5.89)	3,356
ES	2008	38.16	40.66	42.33	0.96	0.32	0.23	11.21 (2.36)	10.41 (5.85)	7,112
ES	2010	38.76	35.98	40.99	0.88	0.30	0.26	12.71 (2.52)	10.54 (6.69)	7,628
ES	2012	39.63	32.63	39.52	0.83	0.31	0.25	13.39 (2.17)	10.60 (5.93)	6,846
ES	2014	40.34	33.65	39.90	0.84	0.33	0.23	11.59 (3.77)	11.58 (8.12)	6,417
FI	2008	40.00	38.26	40.37	0.95	0.32	0.51	18.79 (4.79)	16.99 (9.16)	4,657
FI	2010	40.08	37.33	40.24	0.93	0.32	0.52	19.77 (4.97)	18.92 (10.98)	4,673
FI	2012	40.18	37.32	40.31	0.93	0.36	0.50	21.22 (4.94)	19.68 (9.88)	4,348
FI	2014	40.18	36.21	40.02	0.90	0.37	0.49	22.44 (5.45)	21.24 (21.14)	4,618
FR	2007	37.94	39.56	41.65	0.95	0.27	0.50	12.88 (3.27)	13.03 (12.96)	5,192

FR	2010	38.67	39.03	40.70	0.96	0.29	0.49	14.25 (3.53)	14.54 (13.30)	5,429
FR	2012	38.97	39.38	41.00	0.96	0.31	0.52	15.11 (3.64)	15.05 (10.55)	5,843
HR	2014	39.01	34.23	40.92	0.84	0.14	0.74	5.60 (1.02)	4.79 (3.16)	2,810
HU	2008	37.44	39.23	41.09	0.95	0.16	0.68	3.19 (1.25)	3.39 (2.58)	4,213
HU	2010	38.97	40.38	42.91	0.94	0.15	0.69	2.76 (0.50)	2.95 (1.52)	4,638
HU	2012	39.56	36.82	39.50	0.93	0.16	0.69	3.57 (1.01)	3.43 (2.41)	5,578
IE	2008	37.12	34.85	39.29	0.89	0.30	0.36	22.17 (6.56)	20.70 (16.09)	1,972
IE	2010	37.86	28.09	36.65	0.77	0.38	0.32	20.76 (6.28)	21.83 (14.06)	1,912
IE	2012	38.42	27.49	37.69	0.73	0.45	0.31	18.22 (5.99)	21.47 (14.25)	2,036
IT	2008	39.12	39.23	41.89	0.94	0.13	0.44	12.86 (3.07)	12.73 (6.91)	8,888
IT	2010	39.43	38.81	41.56	0.93	0.13	0.45	14.97 (3.34)	12.51 (7.98)	8,408
IT	2012	39.97	36.90	40.34	0.91	0.13	0.46	15.81 (3.26)	13.03 (11.11)	8,440
IT	2014	40.80	35.71	39.87	0.90	0.18	0.45	16.64 (3.26)	13.72 (9.75)	8,394
LT	2008	38.89	39.53	41.39	0.95	0.24	0.67	3.91 (0.93)	3.81 (2.73)	2,325
LT	2010	38.46	33.11	39.69	0.83	0.27	0.58	5.02 (1.03)	3.47 (3.15)	2,577
LT	2012	39.43	35.73	39.88	0.90	0.28	0.59	4.10 (0.76)	3.65 (2.25)	2,418
LT	2014	39.44	37.31	39.68	0.94	0.30	0.61	4.31 (0.86)	4.21 (3.24)	2,233
LU	2008	39.13	41.31	42.28	0.98	0.24	0.42	23.01 (7.71)	24.52 (15.61)	2,251
LU	2010	39.40	40.11	41.76	0.96	0.24	0.42	25.20 (8.86)	24.65 (16.54)	2,672
LU	2012	39.00	39.71	41.39	0.96	0.27	0.41	25.86 (9.11)	24.95 (17.06)	3,278
LV	2008	37.86	40.81	42.34	0.96	0.17	0.59	3.19 (0.86)	2.84 (2.61)	2,580
LV	2010	38.15	33.53	40.67	0.82	0.19	0.59	2.64 (0.96)	2.87 (2.37)	2,995
LV	2012	39.07	33.46	40.18	0.83	0.20	0.61	3.76 (0.69)	2.96 (2.85)	2,888
LV	2015	39.30	37.79	40.28	0.94	0.22	0.60	5.67 (1.28)	5.16 (3.80)	2,623
MT	2009	38.31	39.41	41.99	0.94	0.17	0.29	7.80 (2.20)	7.55 (4.09)	2,138
MT	2010	38.45	39.76	42.08	0.94	0.17	0.28	8.27 (2.13)	8.25 (4.53)	2,043
MT	2012	38.67	40.24	42.27	0.95	0.19	0.34	9.05 (2.51)	9.17 (5.35)	2,444
MT	2014	38.94	39.49	41.82	0.94	0.22	0.26	10.28 (3.08)	10.53 (7.12)	2,522
NL	2008	40.23	38.24	38.73	0.99	0.34	0.42	21.22 (6.98)	21.02 (19.60)	5,517
NL	2010	40.29	37.66	38.25	0.98	0.34	0.41	22.06 (7.11)	21.06 (14.40)	5,182
NL	2012	40.52	37.51	38.27	0.98	0.37	0.39	22.63 (7.36)	21.62 (15.92)	5,219
PL	2008	37.28	40.63	42.64	0.95	0.17	0.76	3.90 (1.14)	4.06 (3.62)	6,880
PL	2010	38.09	40.30	43.54	0.93	0.20	0.71	3.84 (1.14)	3.99 (2.89)	5,945
PL	2012	37.91	38.55	41.70	0.92	0.19	0.62	4.60 (1.04)	4.25 (3.11)	6,833
PL	2014	38.01	38.97	42.59	0.92	0.20	0.60	4.18 (1.19)	4.50 (3.48)	6,585
PT	2008	38.16	40.58	42.92	0.95	0.10	0.16	6.79 (2.68)	6.89 (7.08)	2,218
PT	2010	38.55	37.85	41.53	0.91	0.11	0.19	6.54 (2.59)	7.45 (6.34)	2,458
PT	2012	39.27	37.08	42.38	0.87	0.13	0.22	6.35 (2.65)	7.36 (7.97)	3,037
PT	2014	39.75	36.09	43.30	0.83	0.16	0.24	6.39 (2.49)	7.18 (5.85)	3,341
RO	2008	37.63	40.26	43.18	0.93	0.15	0.73	1.72 (0.55)	1.76 (1.32)	3,230
RO	2010	38.26	39.99	43.05	0.93	0.17	0.70	1.87 (0.51)	1.85 (0.98)	3,104
RO	2012	39.13	39.50	42.52	0.93	0.21	0.67	1.85 (0.47)	1.83 (0.97)	2,922
RO	2014	39.62	39.45	42.50	0.93	0.14	0.67	2.09 (0.38)	1.99 (1.11)	2,886
SE	2008	39.33	37.65	38.91	0.97	0.27	0.60	18.94 (4.45)	16.22 (11.78)	3,910

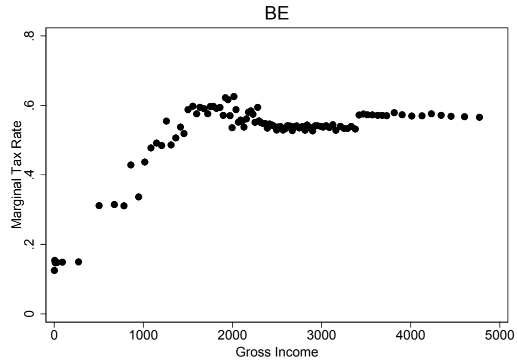
SE	2010	39.60	37.43	38.51	0.97	0.30	0.60	21.38 (5.05)	18.29 (12.96)	3,630
SE	2012	40.14	36.40	37.43	0.97	0.31	0.59	28.02 (5.99)	23.34 (21.31)	3,201
SI	2008	39.73	38.45	41.19	0.93	0.17	0.64	8.70 (2.50)	7.96 (9.59)	6,774
SI	2010	39.99	37.22	40.14	0.93	0.18	0.66	10.34 (3.06)	8.77 (6.05)	6,642
SI	2012	40.11	36.06	39.53	0.91	0.20	0.65	11.42 (2.87)	9.21 (5.77)	6,238
SI	2014	40.25	37.63	40.98	0.92	0.23	0.64	11.59 (2.64)	9.29 (6.09)	6,116
SK	2008	38.60	41.06	42.90	0.96	0.18	0.77	3.82 (0.63)	3.59 (1.86)	3,669
SK	2010	38.87	37.72	42.09	0.90	0.21	0.74	4.19 (0.70)	4.18 (4.53)	3,626
SK	2012	38.76	37.77	42.08	0.90	0.21	0.74	4.91 (0.72)	4.60 (2.42)	3,435
SK	2014	39.33	37.16	41.92	0.89	0.20	0.74	4.97 (0.78)	4.52 (2.86)	3,362
UK	2008	38.14	38.36	41.85	0.92	0.25	0.23	18.01 (4.73)	17.01 (12.14)	9,731
UK	2009	38.17	36.54	41.46	0.88	0.24	0.23	16.54 (4.44)	15.52 (11.55)	9,556
UK	2012	38.58	36.23	41.18	0.88	0.25	0.25	18.44 (4.80)	17.45 (13.30)	7,688
UK	2013	38.55	37.69	41.51	0.91	0.28	0.25	17.84 (4.86)	16.92 (13.18)	7,559

Notes: Summary statistics of the wage estimation subsample. Variables: Mean age, mean working hours, mean working hours conditional on hours being positive, labor force participation rate, fraction of highly and medium educated, predicted wage (standard deviation), observed wage (standard deviation), sample size. Nominal variables are denominated in Euro. *Source*: Own calculations using EU-SILC.

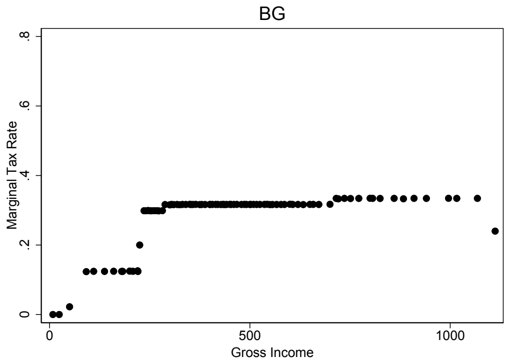
(a) AT 2008



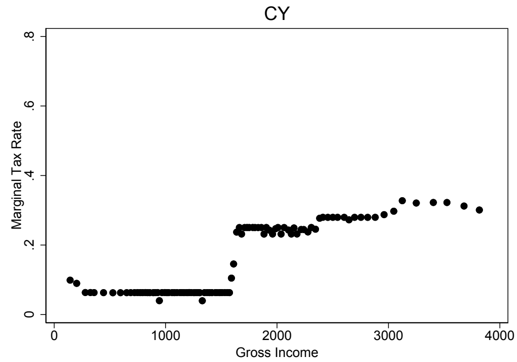
(b) BE 2008



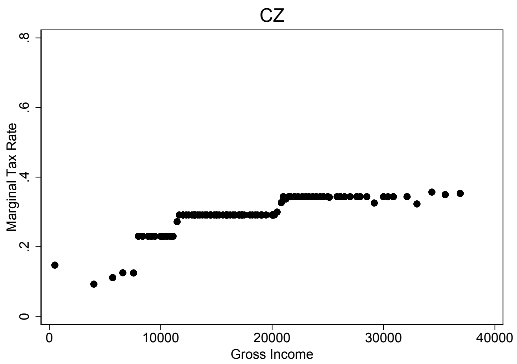
(c) BG 2008



(d) CY 2008



(e) CZ 2008



(f) DE 2008

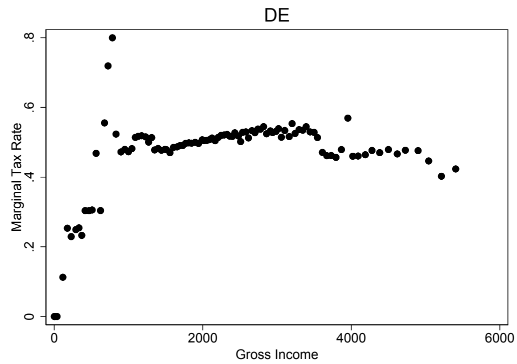
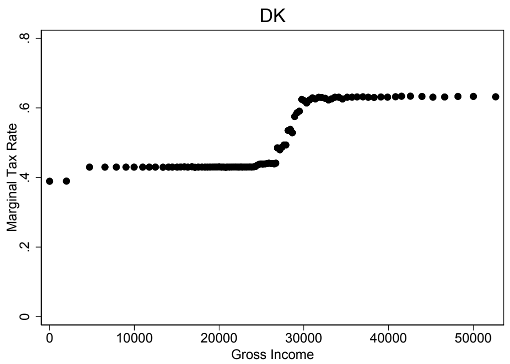
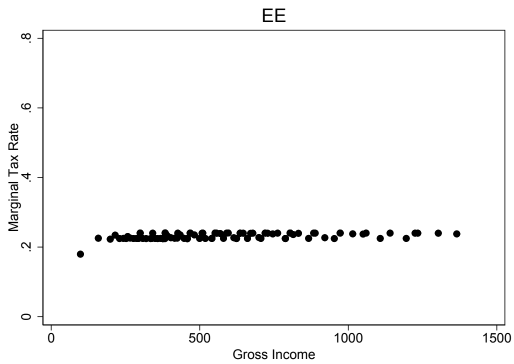


Figure B.1.: Observed Marginal Tax Rates

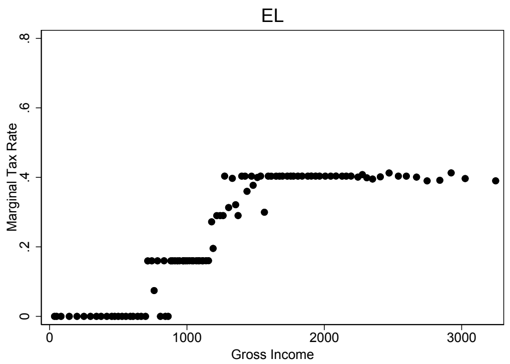
(g) DK 2008



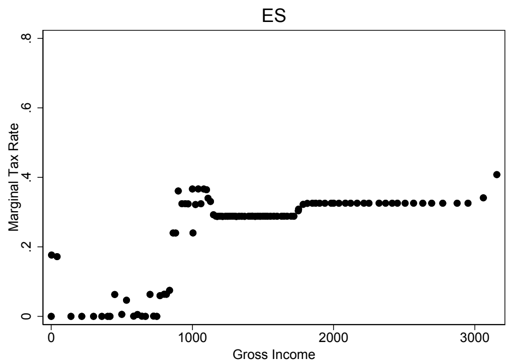
(h) EE 2008



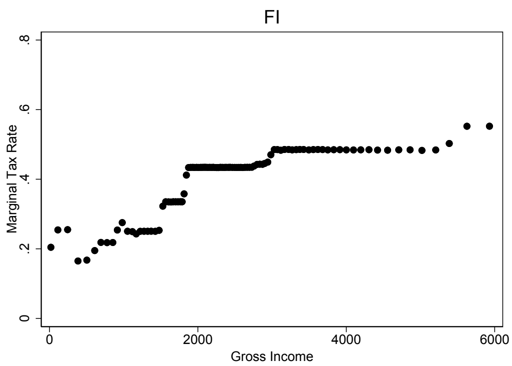
(i) EL 2008



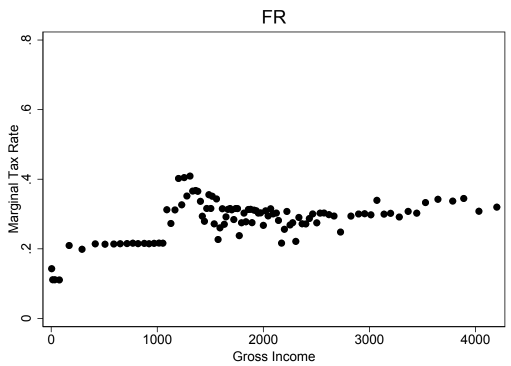
(j) ES 2008



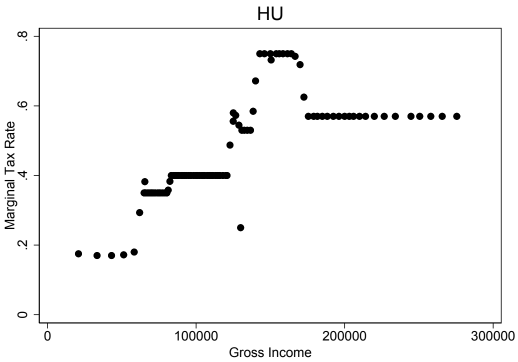
(k) FI 2008



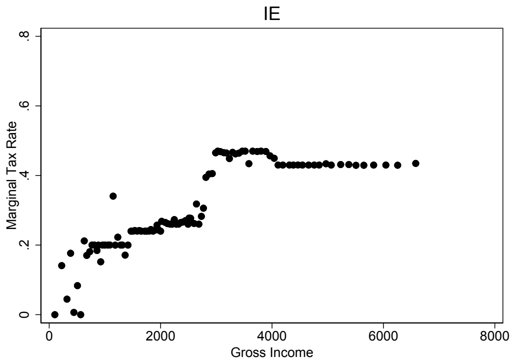
(l) FR 2007



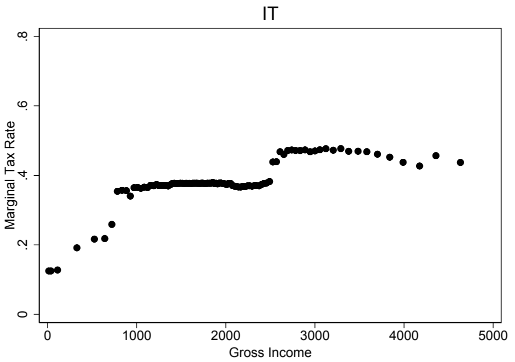
(m) HU 2008



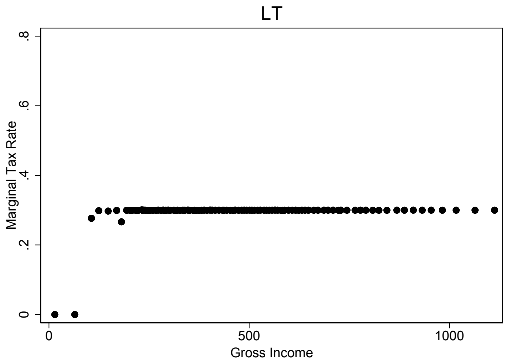
(n) IE 2008



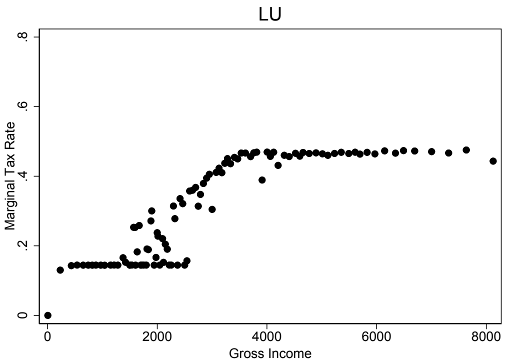
(o) IT 2008



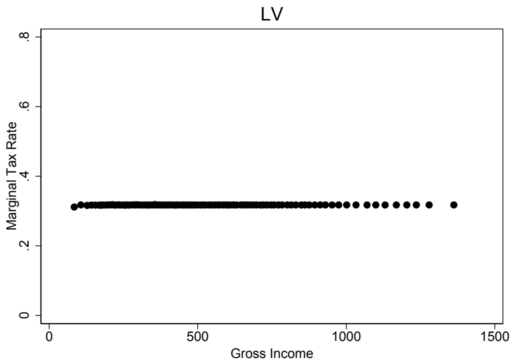
(p) LT 2008



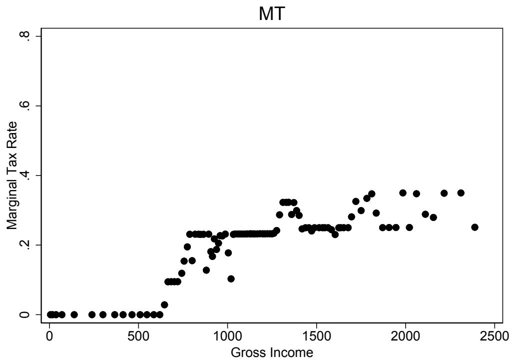
(q) LU 2008



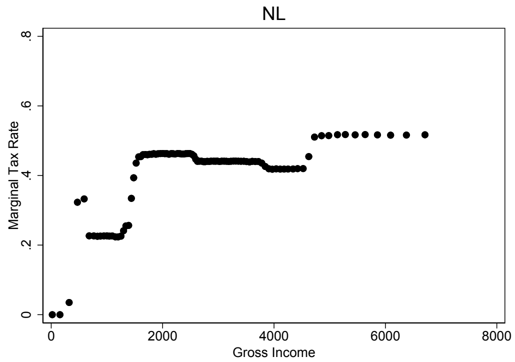
(r) LV 2008



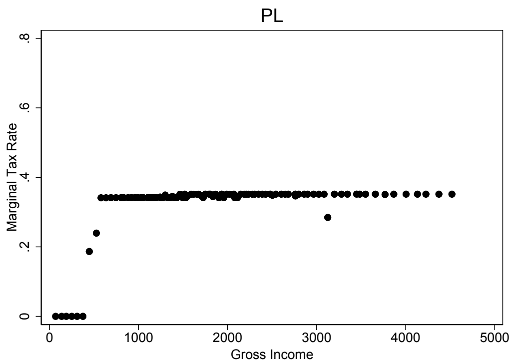
(s) MT 2009



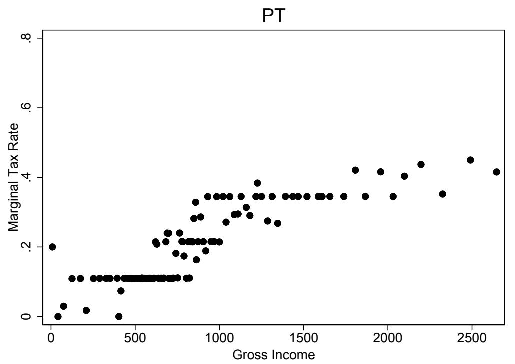
(t) NL 2008



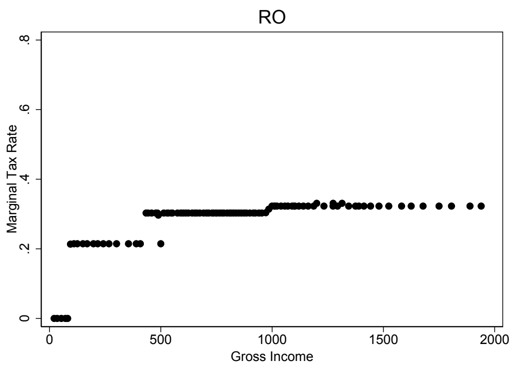
(u) PL 2008



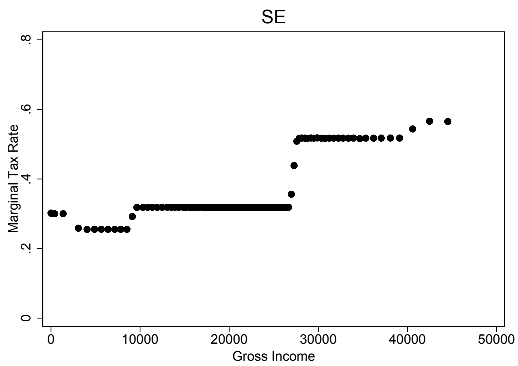
(v) PT 2008



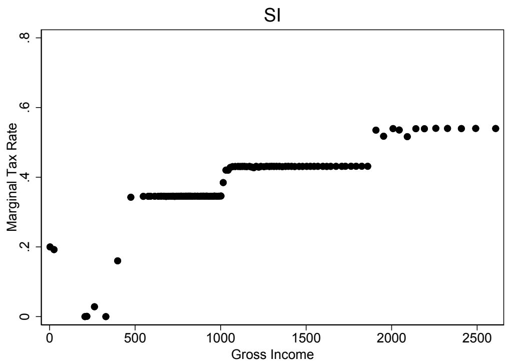
(w) RO 2008



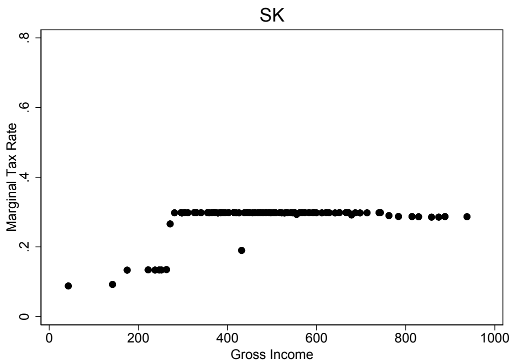
(x) SE 2008



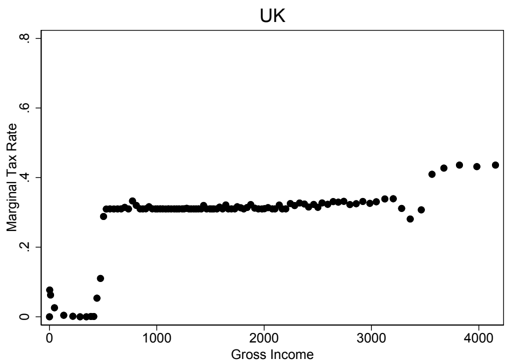
(y) SI 2008



(z) SK 2008



(aa) UK 2008



Source: Own calculations based on EUROMOD.

Table B.3.: Wage Estimation: Women

	AT 2008	AT 2010	AT 2012	AT 2014	BE 2008	BE 2010	BE 2012	BG 2008	BG 2010	BG 2012	BG 2014	CY 2008
ln w Equation												
Age	0.039***	0.034***	0.033***	0.031***	0.054***	0.040***	0.041***	-0.000	0.005	-0.004	-0.033***	0.006
	(0.007)	(0.007)	(0.008)	(0.009)	(0.007)	(0.007)	(0.007)	(0.009)	(0.007)	(0.007)	(0.010)	(0.011)
Age^2	-0.038***	-0.029**	-0.024*	-0.018	-0.048***	-0.035***	-0.033***	0.002	-0.003	0.005	0.037**	0.018
	(0.010)	(0.010)	(0.011)	(0.011)	(0.009)	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.012)	(0.014)
Education: medium	0.334***	0.279***	0.223***	0.234***	0.059*	0.141***	0.125***	0.115*	0.247***	0.097**	0.053	0.393***
	(0.035)	(0.032)	(0.038)	(0.039)	(0.028)	(0.026)	(0.028)	(0.050)	(0.034)	(0.035)	(0.043)	(0.043)
Education: high	0.707***	0.547***	0.502***	0.485***	0.250***	0.403***	0.415***	0.479***	0.606***	0.435***	0.372***	0.923***
	(0.041)	(0.038)	(0.045)	(0.042)	(0.028)	(0.027)	(0.031)	(0.059)	(0.040)	(0.038)	(0.046)	(0.044)
Married	-0.069**	-0.112***	-0.104***	-0.090***	-0.023	0.019	-0.009	-0.020	-0.052*	-0.057*	-0.098**	0.204***
	(0.023)	(0.022)	(0.025)	(0.025)	(0.019)	(0.017)	(0.018)	(0.031)	(0.023)	(0.022)	(0.031)	(0.039)
Constant	3.557***	3.788***	3.852***	3.855***	3.549***	3.789***	3.752***	2.968***	3.047***	3.387***	4.272***	3.050***
	(0.142)	(0.141)	(0.163)	(0.171)	(0.140)	(0.142)	(0.154)	(0.209)	(0.163)	(0.162)	(0.207)	(0.202)
Participation												
Age	0.040	0.075**	0.062**	0.084***	0.138***	0.194***	0.123***	0.107***	0.119***	0.140***	0.123***	0.130***
	(0.027)	(0.024)	(0.021)	(0.025)	(0.023)	(0.026)	(0.027)	(0.020)	(0.017)	(0.019)	(0.020)	(0.029)
Age^2	-0.039	-0.092**	-0.063*	-0.106***	-0.185***	-0.246***	-0.146***	-0.128***	-0.131***	-0.155***	-0.139***	-0.149***
	(0.036)	(0.031)	(0.028)	(0.032)	(0.029)	(0.032)	(0.034)	(0.026)	(0.022)	(0.024)	(0.024)	(0.037)
Education: medium	0.535***	0.436***	0.602***	0.401***	0.465***	0.449***	0.336***	0.861***	0.641***	0.754***	0.709***	0.207
	(0.094)	(0.085)	(0.079)	(0.090)	(0.075)	(0.081)	(0.088)	(0.071)	(0.065)	(0.073)	(0.073)	(0.110)
Education: high	0.509***	0.530***	0.683***	0.670***	1.027***	0.922***	0.815***	1.255***	1.192***	1.168***	1.168***	0.346**
	(0.125)	(0.114)	(0.103)	(0.106)	(0.087)	(0.088)	(0.094)	(0.101)	(0.085)	(0.087)	(0.090)	(0.117)
Elderly	-0.150	-0.113	-0.259**	0.057	-0.328**	-0.076	-0.151	-0.009	-0.115*	-0.105	0.064	-0.240*
	(0.119)	(0.115)	(0.092)	(0.118)	(0.103)	(0.116)	(0.110)	(0.067)	(0.055)	(0.058)	(0.058)	(0.106)
Married	0.038	0.097	0.128	0.200*	0.213**	0.287***	0.395***	-0.072	0.005	0.004	0.017	-0.279*
	(0.085)	(0.079)	(0.072)	(0.080)	(0.071)	(0.075)	(0.078)	(0.080)	(0.067)	(0.066)	(0.067)	(0.116)
Other Income	0.031*	0.043***	0.019	0.012	-0.003	-0.020	-0.005	0.066**	0.040***	0.055***	0.047***	0.032
	(0.015)	(0.011)	(0.011)	(0.013)	(0.012)	(0.016)	(0.015)	(0.020)	(0.011)	(0.011)	(0.010)	(0.018)
Assets	0.011**	0.004*	0.001	0.009***	0.005**	0.000	0.002	-0.003	-0.001	0.002	-0.000	-0.001
	(0.004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.000)	(0.002)	(0.009)	(0.002)	(0.005)	(0.001)	(0.001)
Children: 0-2	-0.565***	-0.563***	-0.438***	-0.590***	-0.266**	-0.282**	-0.144	-0.465***	-0.421***	-0.287**	-0.085	0.048
	(0.143)	(0.139)	(0.120)	(0.148)	(0.095)	(0.105)	(0.106)	(0.094)	(0.090)	(0.105)	(0.104)	(0.139)
Children: 3-6	-0.425***	-0.197	-0.255**	-0.203*	-0.208*	-0.110	-0.224*	-0.229**	-0.165*	-0.053	0.004	-0.064
	(0.105)	(0.103)	(0.082)	(0.104)	(0.089)	(0.100)	(0.099)	(0.085)	(0.082)	(0.088)	(0.084)	(0.106)
Children: 7-12	-0.192*	-0.036	-0.144	-0.064	-0.204*	-0.148	0.063	0.015	0.079	-0.013	-0.060	-0.114
	(0.094)	(0.091)	(0.078)	(0.091)	(0.081)	(0.094)	(0.099)	(0.079)	(0.071)	(0.073)	(0.069)	(0.095)
Children: 13-17	-0.025	-0.090	0.075	-0.175*	-0.098	-0.167	-0.017	0.018	-0.077	0.263**	0.016	0.063
	(0.095)	(0.089)	(0.079)	(0.089)	(0.083)	(0.095)	(0.100)	(0.078)	(0.067)	(0.080)	(0.073)	(0.093)
Children: 18+	0.008	-0.042	0.337*	0.090	0.141	0.155	-0.139	-0.065	0.138	0.098	0.159	0.269*
	(0.151)	(0.133)	(0.144)	(0.136)	(0.107)	(0.114)	(0.107)	(0.108)	(0.087)	(0.091)	(0.100)	(0.110)
Constant	0.059	-0.570	-0.800*	-0.750	-1.887***	-3.046***	-1.842***	-1.807***	-2.296***	-2.938***	-2.622***	-1.190*
	(0.480)	(0.436)	(0.384)	(0.459)	(0.433)	(0.478)	(0.505)	(0.379)	(0.330)	(0.365)	(0.387)	(0.513)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.27	-0.55	-0.80	-0.68	-0.66	0.04	0.02	-0.37	-0.41	-0.49	-0.81	-0.96
σ	0.51	0.53	0.60	0.59	0.47	0.40	0.41	0.54	0.48	0.46	0.62	0.62
λ	-0.14	-0.29	-0.48	-0.40	-0.31	0.02	0.01	-0.20	-0.20	-0.23	-0.50	-0.60
N	2,422	2,617	2,685	2,500	2,894	2,744	2,585	2,437	3,325	2,933	2,482	1,781

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	CY 2010	CY 2012	CY 2014	CZ 2008	CZ 2010	CZ 2012	DE 2008	DE 2010	DE 2012	DK 2008	DK 2012	EE 2008
ln w Equation												
Age	0.063***	0.069***	0.097***	0.017***	0.013**	0.037***	0.087***	0.085***	0.070***	0.067***	0.073***	0.009
	(0.011)	(0.010)	(0.012)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Age^2	-0.044**	-0.048***	-0.085***	-0.018**	-0.012*	-0.036***	-0.086***	-0.088***	-0.071***	-0.067***	-0.074***	-0.020**
	(0.014)	(0.013)	(0.015)	(0.005)	(0.006)	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Education: medium	0.515***	0.479***	0.435***	0.229***	0.252***	0.214***	0.253***	0.247***	0.121***	0.136***	0.149***	0.122***
	(0.042)	(0.039)	(0.046)	(0.023)	(0.028)	(0.042)	(0.031)	(0.029)	(0.031)	(0.024)	(0.025)	(0.035)
Education: high	1.143***	1.096***	1.089***	0.660***	0.627***	0.579***	0.475***	0.557***	0.418***	0.278***	0.321***	0.505***
	(0.043)	(0.039)	(0.046)	(0.027)	(0.032)	(0.046)	(0.032)	(0.031)	(0.032)	(0.024)	(0.025)	(0.036)
Married	0.286***	0.248***	0.219***	-0.018	-0.042**	-0.082***	-0.169***	-0.169***	-0.164***	-0.023	0.008	-0.075***
	(0.036)	(0.032)	(0.035)	(0.013)	(0.014)	(0.020)	(0.018)	(0.017)	(0.017)	(0.019)	(0.018)	(0.017)
Constant	1.556***	1.455***	0.903***	6.125***	6.300***	5.804***	2.542***	2.678***	3.120***	5.526***	5.536***	5.841***
	(0.220)	(0.202)	(0.239)	(0.087)	(0.103)	(0.147)	(0.108)	(0.110)	(0.111)	(0.118)	(0.115)	(0.110)
Participation												
Age	0.196***	0.196***	0.214***	0.093***	0.088***	0.116***	0.024	0.047**	0.057***	-0.017	0.050	0.074*
	(0.026)	(0.020)	(0.021)	(0.022)	(0.021)	(0.021)	(0.016)	(0.015)	(0.016)	(0.030)	(0.026)	(0.030)
Age^2	-0.214***	-0.215***	-0.245***	-0.106***	-0.097***	-0.132***	-0.052**	-0.064***	-0.072***	0.030	-0.053	-0.083*
	(0.034)	(0.026)	(0.027)	(0.028)	(0.027)	(0.026)	(0.020)	(0.019)	(0.020)	(0.038)	(0.032)	(0.039)
Education: medium	0.475***	0.258**	0.154	0.795***	0.710***	0.719***	0.133*	0.288***	0.351***	0.313**	0.296**	0.191
	(0.099)	(0.082)	(0.089)	(0.077)	(0.082)	(0.087)	(0.068)	(0.062)	(0.068)	(0.098)	(0.095)	(0.151)
Education: high	0.761***	0.480***	0.509***	1.179***	0.984***	0.988***	0.324***	0.350***	0.523***	0.503***	0.558***	0.387*
	(0.110)	(0.088)	(0.095)	(0.133)	(0.115)	(0.117)	(0.075)	(0.070)	(0.078)	(0.108)	(0.100)	(0.168)
Elderly	0.666***	0.454***	0.463***	-0.056	-0.095	-0.136	-0.171*	-0.053	-0.132	-0.512***	-0.345**	-0.256*
	(0.115)	(0.080)	(0.080)	(0.086)	(0.083)	(0.077)	(0.067)	(0.073)	(0.074)	(0.142)	(0.131)	(0.117)
Married	0.008	0.010	0.080	0.023	0.103	-0.097	0.373***	0.296***	0.342***	0.136	0.402***	-0.044
	(0.099)	(0.072)	(0.073)	(0.069)	(0.063)	(0.064)	(0.053)	(0.052)	(0.055)	(0.092)	(0.077)	(0.102)
Other Income	0.060***	0.011	-0.011*	0.005**	0.002	0.009***	0.014**	0.033***	0.032***	-0.000	-0.002*	0.010*
	(0.016)	(0.007)	(0.005)	(0.002)	(0.001)	(0.001)	(0.005)	(0.006)	(0.006)	(0.001)	(0.001)	(0.005)
Assets	-0.000	-0.000	0.005	-0.002*	0.005	-0.000	0.014***	0.005***	0.002***	0.000	0.000	0.003
	(0.001)	(0.001)	(0.006)	(0.001)	(0.006)	(0.000)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.004)
Children: 0-2	0.289	0.047	-0.211*	0.065	-0.702***	-0.458***	-0.357***	-0.189*	-0.346***	-0.071	-0.037	-0.239
	(0.154)	(0.092)	(0.086)	(0.185)	(0.127)	(0.126)	(0.096)	(0.088)	(0.092)	(0.127)	(0.133)	(0.177)
Children: 3-6	-0.012	0.009	-0.000	-0.381***	-0.409***	-0.450***	-0.231**	-0.220***	-0.198**	0.176	0.064	-0.179
	(0.120)	(0.090)	(0.081)	(0.084)	(0.078)	(0.072)	(0.071)	(0.066)	(0.070)	(0.118)	(0.121)	(0.140)
Children: 7-12	0.068	-0.014	-0.204**	-0.257***	-0.164*	-0.068	-0.076	-0.159**	-0.104	-0.156	-0.104	0.195
	(0.095)	(0.074)	(0.076)	(0.074)	(0.071)	(0.068)	(0.060)	(0.057)	(0.062)	(0.100)	(0.097)	(0.137)
Children: 13-17	-0.076	-0.023	-0.067	-0.108	-0.147*	-0.216**	-0.214***	-0.092	-0.146*	0.108	0.126	-0.320**
	(0.085)	(0.067)	(0.070)	(0.071)	(0.070)	(0.068)	(0.056)	(0.060)	(0.062)	(0.100)	(0.089)	(0.105)
Children: 18+	-0.106	-0.120	-0.025	0.052	0.154	0.027	0.083	0.093	0.033	-0.080	0.087	0.251
	(0.094)	(0.068)	(0.076)	(0.086)	(0.082)	(0.080)	(0.076)	(0.082)	(0.092)	(0.136)	(0.119)	(0.134)
Constant	-3.642***	-3.546***	-3.837***	-1.138**	-1.304***	-1.875***	0.723*	-0.185	-0.397	1.426**	-0.312	0.024
	(0.471)	(0.370)	(0.396)	(0.405)	(0.394)	(0.387)	(0.313)	(0.291)	(0.303)	(0.544)	(0.479)	(0.531)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	0.71	0.71	0.71	-0.52	-0.44	-0.84	-0.84	-0.83	-0.85	-0.74	0.03	-0.33
σ	0.65	0.66	0.66	0.39	0.38	0.56	0.62	0.62	0.60	0.46	0.39	0.43
λ	0.46	0.47	0.47	-0.21	-0.17	-0.47	-0.52	-0.51	-0.51	-0.34	0.01	-0.14
N	2,127	2,866	2,444	4,867	3,904	3,672	5,743	5,829	5,823	3,208	2,842	2,660

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	EE 2010	EE 2012	EL 2008	EL 2010	EL 2012	EL 2014	ES 2008	ES 2010	ES 2012	ES 2014	FI 2008	FI 2010
ln w Equation												
Age	0.019**	0.027***	0.079***	0.028*	-0.008	0.018	0.034***	0.028***	0.030***	0.049***	0.022***	0.033***
	(0.007)	(0.007)	(0.011)	(0.012)	(0.016)	(0.011)	(0.005)	(0.005)	(0.006)	(0.008)	(0.004)	(0.004)
Age^2	-0.028***	-0.037***	-0.074***	-0.020	0.017	-0.006	-0.026***	-0.017**	-0.019**	-0.035***	-0.017**	-0.031***
	(0.008)	(0.008)	(0.013)	(0.014)	(0.019)	(0.013)	(0.006)	(0.006)	(0.007)	(0.009)	(0.006)	(0.005)
Education: medium	-0.003	0.099*	0.285***	0.094**	-0.115*	0.163***	0.217***	0.235***	0.189***	0.201***	0.100***	0.101***
	(0.038)	(0.040)	(0.034)	(0.036)	(0.048)	(0.040)	(0.021)	(0.020)	(0.021)	(0.028)	(0.023)	(0.023)
Education: high	0.393***	0.459***	0.791***	0.520***	0.140**	0.338***	0.568***	0.631***	0.552***	0.641***	0.429***	0.391***
	(0.041)	(0.043)	(0.036)	(0.038)	(0.051)	(0.042)	(0.023)	(0.020)	(0.021)	(0.026)	(0.024)	(0.025)
Married	-0.050*	-0.040*	0.010	0.111***	0.058	0.049	0.008	0.031*	0.014	-0.023	0.018	-0.005
	(0.019)	(0.020)	(0.028)	(0.031)	(0.041)	(0.028)	(0.015)	(0.014)	(0.016)	(0.020)	(0.015)	(0.013)
Constant	5.828***	2.875***	2.023***	3.382***	4.426***	3.409***	3.124***	3.169***	3.135***	2.510***	3.991***	3.957***
	(0.162)	(0.149)	(0.225)	(0.247)	(0.324)	(0.219)	(0.111)	(0.114)	(0.133)	(0.169)	(0.087)	(0.089)
Participation												
Age	0.087***	0.093***	0.145***	0.158***	0.160***	0.135***	0.035*	0.078***	0.090***	0.081***	0.045*	0.069***
	(0.020)	(0.021)	(0.025)	(0.024)	(0.025)	(0.019)	(0.014)	(0.012)	(0.013)	(0.013)	(0.019)	(0.018)
Age^2	-0.092***	-0.096***	-0.151***	-0.169***	-0.171***	-0.138***	-0.036	-0.087***	-0.091***	-0.083***	-0.072**	-0.082***
	(0.026)	(0.026)	(0.033)	(0.031)	(0.033)	(0.025)	(0.019)	(0.016)	(0.017)	(0.017)	(0.024)	(0.022)
Education: medium	0.078	0.199*	0.342***	0.036	-0.107	0.244***	0.344***	0.448***	0.443***	0.316***	0.344***	0.483***
	(0.099)	(0.100)	(0.086)	(0.087)	(0.090)	(0.073)	(0.050)	(0.043)	(0.045)	(0.046)	(0.073)	(0.071)
Education: high	0.473***	0.661***	0.535***	0.376***	0.402***	0.732***	0.782***	0.729***	0.786***	0.723***	0.693***	0.894***
	(0.107)	(0.110)	(0.097)	(0.096)	(0.097)	(0.077)	(0.052)	(0.042)	(0.042)	(0.041)	(0.081)	(0.076)
Elderly	-0.142	-0.247**	-0.242**	-0.256***	-0.107	-0.271***	-0.176**	-0.055	-0.070	-0.099*	-0.281**	-0.096
	(0.075)	(0.075)	(0.082)	(0.074)	(0.071)	(0.050)	(0.055)	(0.048)	(0.047)	(0.047)	(0.098)	(0.094)
Married	0.011	-0.083	0.094	-0.079	-0.241**	-0.165**	-0.085	0.021	0.064	-0.003	0.287***	0.153**
	(0.064)	(0.066)	(0.090)	(0.089)	(0.084)	(0.061)	(0.048)	(0.039)	(0.041)	(0.040)	(0.062)	(0.056)
Other Income	-0.002	0.024	-0.012	0.037**	0.093***	0.028**	-0.011	-0.034***	-0.080***	-0.059***	-0.028***	-0.006*
	(0.003)	(0.037)	(0.008)	(0.012)	(0.014)	(0.009)	(0.013)	(0.010)	(0.010)	(0.008)	(0.007)	(0.002)
Assets	0.000	0.006	0.012	0.001	0.008	0.001	-0.003	0.001	0.009	0.003**	0.001**	0.000
	(0.000)	(0.005)	(0.010)	(0.004)	(0.007)	(0.002)	(0.002)	(0.002)	(0.005)	(0.001)	(0.000)	(0.000)
Children: 0-2	-0.325**	-0.358***	0.069	0.054	0.014	0.113	-0.146*	-0.197***	-0.110	-0.036	-0.360**	0.099
	(0.106)	(0.106)	(0.133)	(0.107)	(0.102)	(0.075)	(0.069)	(0.055)	(0.060)	(0.061)	(0.127)	(0.123)
Children: 3-6	-0.148	-0.038	-0.075	-0.084	-0.034	0.126*	-0.034	-0.099*	-0.047	-0.055	-0.048	-0.123
	(0.086)	(0.088)	(0.104)	(0.098)	(0.092)	(0.064)	(0.061)	(0.050)	(0.052)	(0.052)	(0.100)	(0.085)
Children: 7-12	-0.194*	-0.167*	-0.113	0.042	0.045	0.019	-0.087	-0.042	-0.161***	-0.029	-0.024	-0.040
	(0.076)	(0.079)	(0.094)	(0.088)	(0.080)	(0.056)	(0.053)	(0.045)	(0.046)	(0.047)	(0.081)	(0.074)
Children: 13-17	-0.002	-0.036	-0.026	-0.033	-0.001	0.047	0.092	-0.103*	-0.038	-0.118*	0.107	0.094
	(0.071)	(0.076)	(0.089)	(0.086)	(0.081)	(0.057)	(0.054)	(0.045)	(0.047)	(0.047)	(0.072)	(0.065)
Children: 18+	-0.036	0.075	-0.070	-0.179	-0.051	0.143*	0.095	0.179**	0.079	0.077	0.120	0.105
	(0.074)	(0.082)	(0.114)	(0.103)	(0.111)	(0.071)	(0.066)	(0.054)	(0.052)	(0.050)	(0.102)	(0.094)
Constant	-1.005**	-1.174**	-2.192***	-2.593***	-3.071***	-2.997***	-0.212	-1.508***	-2.079***	-1.757***	0.494	-0.722*
	(0.367)	(0.373)	(0.445)	(0.439)	(0.482)	(0.365)	(0.269)	(0.235)	(0.264)	(0.263)	(0.343)	(0.327)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.17	-0.33	0.27	-0.31	-0.63	-0.82	0.09	0.13	0.17	0.14	0.00	0.04
σ	0.45	0.48	0.48	0.54	0.58	0.52	0.50	0.48	0.47	0.60	0.45	0.38
λ	-0.08	-0.16	0.13	-0.16	-0.36	-0.43	0.04	0.06	0.08	0.08	0.00	0.02
N	2,759	2,799	2,184	2,327	1,805	2,957	6,180	6,999	6,169	6,157	4,888	4,909

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	FI 2012	FI 2014	FR 2007	FR 2010	FR 2012	HR 2014	HU 2008	HU 2010	HU 2012	IE 2008	IE 2010	IE 2012
ln w Equation												
Age	0.023***	0.024***	0.036***	0.017**	0.033***	-0.026**	0.024***	0.013***	0.013**	0.069***	0.027**	0.059***
	(0.004)	(0.004)	(0.006)	(0.006)	(0.006)	(0.009)	(0.006)	(0.003)	(0.005)	(0.008)	(0.010)	(0.010)
Age^2	-0.019***	-0.023***	-0.028***	-0.007	-0.028***	0.041***	-0.018*	-0.011**	-0.008	-0.070***	-0.019	-0.057***
	(0.005)	(0.005)	(0.007)	(0.008)	(0.008)	(0.011)	(0.007)	(0.004)	(0.006)	(0.010)	(0.012)	(0.013)
Education: medium	0.051*	0.068*	0.196***	0.239***	0.148***	0.112**	0.315***	0.078***	0.167***	0.235***	0.114*	0.198***
	(0.025)	(0.027)	(0.021)	(0.024)	(0.026)	(0.040)	(0.024)	(0.012)	(0.021)	(0.037)	(0.044)	(0.050)
Education: high	0.379***	0.398***	0.538***	0.545***	0.483***	0.472***	0.875***	0.288***	0.612***	0.658***	0.506***	0.575***
	(0.027)	(0.028)	(0.022)	(0.026)	(0.027)	(0.046)	(0.027)	(0.013)	(0.025)	(0.036)	(0.043)	(0.050)
Married	-0.003	0.015	-0.044**	-0.053**	-0.012	-0.051	-0.031*	-0.008	-0.055***	0.008	0.007	0.082**
	(0.012)	(0.013)	(0.015)	(0.017)	(0.017)	(0.033)	(0.016)	(0.008)	(0.012)	(0.027)	(0.030)	(0.030)
Constant	4.230***	4.266***	3.375***	3.810***	3.568***	6.023***	7.626***	8.370***	8.311***	3.152***	4.185***	3.279***
	(0.081)	(0.083)	(0.114)	(0.129)	(0.129)	(0.189)	(0.117)	(0.059)	(0.105)	(0.156)	(0.194)	(0.231)
Participation												
Age	0.064***	0.065***	0.125***	0.115***	0.113***	0.129***	0.052*	0.071***	0.146***	0.057	0.047	0.080**
	(0.019)	(0.019)	(0.018)	(0.018)	(0.016)	(0.018)	(0.022)	(0.016)	(0.016)	(0.030)	(0.027)	(0.026)
Age^2	-0.081***	-0.092***	-0.151***	-0.128***	-0.123***	-0.144***	-0.040	-0.065**	-0.161***	-0.044	-0.042	-0.080*
	(0.024)	(0.023)	(0.023)	(0.023)	(0.021)	(0.023)	(0.029)	(0.021)	(0.020)	(0.040)	(0.034)	(0.034)
Education: medium	0.555***	0.471***	0.316***	0.441***	0.345***	0.501***	0.699***	0.467***	0.710***	0.450***	0.393***	0.415***
	(0.081)	(0.084)	(0.060)	(0.059)	(0.060)	(0.074)	(0.071)	(0.057)	(0.055)	(0.128)	(0.106)	(0.113)
Education: high	1.117***	0.905***	0.681***	0.682***	0.682***	0.922***	1.314***	1.202***	1.203***	0.398**	0.513***	0.593***
	(0.089)	(0.088)	(0.073)	(0.068)	(0.068)	(0.092)	(0.103)	(0.071)	(0.071)	(0.131)	(0.106)	(0.115)
Elderly	-0.054	-0.078	-0.227**	-0.227**	-0.272***	-0.019	0.012	-0.048	-0.202***	-0.333**	-0.183	-0.373**
	(0.105)	(0.100)	(0.084)	(0.078)	(0.076)	(0.048)	(0.065)	(0.043)	(0.053)	(0.127)	(0.117)	(0.117)
Married	0.092	0.280***	0.280***	0.235***	0.215***	0.029	0.081	0.114*	0.199***	0.188	0.221*	0.356***
	(0.062)	(0.058)	(0.056)	(0.052)	(0.049)	(0.073)	(0.064)	(0.047)	(0.049)	(0.109)	(0.090)	(0.084)
Other Income	-0.019**	-0.010**	-0.086***	-0.023***	-0.021***	0.010**	-0.000	0.000	0.000	0.011	0.052***	-0.014
	(0.006)	(0.004)	(0.012)	(0.005)	(0.004)	(0.003)	(0.000)	(0.000)	(0.000)	(0.016)	(0.015)	(0.012)
Assets	0.000*	0.000	0.001	0.000	0.000	0.004**	-0.000	-0.000	0.000	0.000	0.003	0.002
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.006)	(0.004)
Children: 0-2	-0.301*	0.024	0.007	0.074	-0.071	-0.350***	-0.283	-0.214**	-0.442***	0.092	-0.011	0.081
	(0.122)	(0.120)	(0.089)	(0.083)	(0.074)	(0.082)	(0.147)	(0.081)	(0.110)	(0.191)	(0.117)	(0.118)
Children: 3-6	-0.104	-0.375***	-0.258***	-0.036	-0.048	-0.140	-0.143	-0.163**	-0.115	0.082	0.142	-0.001
	(0.096)	(0.085)	(0.071)	(0.072)	(0.068)	(0.072)	(0.086)	(0.053)	(0.069)	(0.165)	(0.110)	(0.104)
Children: 7-12	-0.043	0.107	-0.172**	-0.049	-0.008	0.076	0.023	0.005	-0.173**	-0.007	0.068	-0.190*
	(0.082)	(0.080)	(0.064)	(0.066)	(0.060)	(0.062)	(0.073)	(0.048)	(0.058)	(0.133)	(0.093)	(0.091)
Children: 13-17	0.009	0.027	-0.041	0.021	-0.070	-0.177**	-0.017	-0.035	-0.120*	0.036	-0.016	0.086
	(0.071)	(0.069)	(0.064)	(0.065)	(0.060)	(0.057)	(0.069)	(0.044)	(0.055)	(0.122)	(0.092)	(0.100)
Children: 18+	0.166	0.070	0.110	0.043	0.002	0.085	-0.048	-0.106*	0.059	-0.413**	0.052	-0.011
	(0.104)	(0.092)	(0.081)	(0.078)	(0.078)	(0.064)	(0.078)	(0.048)	(0.060)	(0.149)	(0.134)	(0.133)
Constant	-0.390	-0.301	-1.601***	-1.798***	-1.760***	-2.992***	-1.068**	-1.587***	-2.858***	-0.359	-0.699	-1.253**
	(0.347)	(0.344)	(0.333)	(0.325)	(0.302)	(0.348)	(0.404)	(0.304)	(0.295)	(0.541)	(0.490)	(0.477)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	0.18	0.40	0.04	0.05	0.08	-0.79	0.54	0.92	-0.34	-0.47	-0.74	0.26
σ	0.36	0.39	0.50	0.56	0.58	0.52	0.43	0.25	0.40	0.53	0.56	0.54
λ	0.07	0.16	0.02	0.03	0.04	-0.41	0.24	0.23	-0.14	-0.25	-0.41	0.14
N	4,478	4,830	5,048	5,229	5,686	2,558	3,825	4,458	5,466	1,869	1,696	1,862

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	IT 2008	IT 2010	IT 2012	IT 2014	LT 2008	LT 2010	LT 2012	LT 2014	LU 2008	LU 2010	LU 2012	LV 2008
ln w Equation												
Age	0.015***	-0.007	0.008	0.016**	0.016*	0.031**	0.021**	-0.002	0.029**	0.031***	0.038***	0.001
	(0.004)	(0.006)	(0.006)	(0.006)	(0.007)	(0.012)	(0.008)	(0.009)	(0.011)	(0.009)	(0.008)	(0.008)
Age^2	-0.004	0.021**	0.002	-0.008	-0.015	-0.026	-0.017	0.009	-0.018	-0.018	-0.030**	-0.005
	(0.005)	(0.007)	(0.007)	(0.007)	(0.009)	(0.014)	(0.010)	(0.011)	(0.014)	(0.012)	(0.010)	(0.010)
Education: medium	0.240***	0.191***	0.187***	0.153***	0.071	-0.033	-0.011	-0.181*	0.358***	0.357***	0.359***	0.008
	(0.013)	(0.018)	(0.018)	(0.018)	(0.055)	(0.078)	(0.065)	(0.074)	(0.033)	(0.029)	(0.025)	(0.042)
Education: high	0.489***	0.448***	0.426***	0.368***	0.633***	0.519***	0.520***	0.297***	0.717***	0.774***	0.786***	0.634***
	(0.016)	(0.022)	(0.021)	(0.021)	(0.057)	(0.079)	(0.068)	(0.076)	(0.033)	(0.030)	(0.027)	(0.045)
Married	0.024*	0.030	0.026	0.006	-0.044	-0.033	0.014	-0.024	-0.046	-0.074**	-0.019	-0.001
	(0.011)	(0.016)	(0.015)	(0.015)	(0.024)	(0.037)	(0.025)	(0.026)	(0.028)	(0.025)	(0.022)	(0.024)
Constant	3.972***	4.624***	4.284***	4.178***	3.821***	3.602***	3.815***	4.621***	3.954***	4.013***	3.928***	2.794***
	(0.097)	(0.116)	(0.117)	(0.120)	(0.149)	(0.247)	(0.188)	(0.201)	(0.199)	(0.177)	(0.155)	(0.150)
Participation												
Age	0.095***	0.096***	0.086***	0.083***	0.036	0.065**	0.066**	0.067**	0.062	0.125***	0.101***	0.043
	(0.014)	(0.013)	(0.013)	(0.013)	(0.030)	(0.021)	(0.023)	(0.024)	(0.034)	(0.028)	(0.027)	(0.024)
Age^2	-0.078***	-0.083***	-0.077***	-0.070***	-0.051	-0.068**	-0.065*	-0.072*	-0.060	-0.139***	-0.104**	-0.054
	(0.018)	(0.016)	(0.016)	(0.015)	(0.037)	(0.026)	(0.029)	(0.029)	(0.045)	(0.036)	(0.035)	(0.030)
Education: medium	0.369***	0.302***	0.324***	0.389***	0.667***	0.369**	0.568***	0.578***	0.147	0.272**	0.454***	0.309**
	(0.043)	(0.039)	(0.040)	(0.040)	(0.141)	(0.113)	(0.128)	(0.145)	(0.099)	(0.086)	(0.083)	(0.098)
Education: high	0.459***	0.351***	0.384***	0.528***	1.173***	0.860***	1.081***	1.137***	0.334**	0.315**	0.459***	0.628***
	(0.057)	(0.050)	(0.049)	(0.049)	(0.156)	(0.119)	(0.134)	(0.151)	(0.116)	(0.099)	(0.098)	(0.119)
Elderly	-0.177***	-0.146***	-0.152***	-0.196***	-0.213*	-0.107	-0.064	-0.086	0.108	-0.067	-0.186	-0.120
	(0.048)	(0.038)	(0.039)	(0.038)	(0.089)	(0.061)	(0.075)	(0.071)	(0.149)	(0.105)	(0.103)	(0.082)
Married	0.013	0.049	0.024	-0.086*	-0.001	0.074	0.168*	0.139	0.114	0.154	0.224**	-0.068
	(0.044)	(0.039)	(0.037)	(0.037)	(0.102)	(0.068)	(0.075)	(0.076)	(0.093)	(0.084)	(0.078)	(0.077)
Other Income	0.003	0.009	0.005	0.035***	0.040	0.036**	0.041*	0.021	0.014	0.023*	0.019*	0.438***
	(0.005)	(0.006)	(0.004)	(0.007)	(0.022)	(0.013)	(0.017)	(0.013)	(0.011)	(0.011)	(0.009)	(0.083)
Assets	0.018***	0.012***	0.018***	0.011***	0.002	0.004	0.001	0.054*	0.013	0.019*	0.002**	0.111
	(0.003)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.001)	(0.027)	(0.007)	(0.008)	(0.001)	(0.134)
Children: 0-2	-0.082	-0.089	0.094	0.134*	-0.805***	-0.630***	-0.866***	-0.394**	-0.232*	0.141	-0.221*	-0.176
	(0.060)	(0.049)	(0.056)	(0.054)	(0.133)	(0.087)	(0.109)	(0.122)	(0.103)	(0.105)	(0.093)	(0.125)
Children: 3-6	-0.008	0.047	0.010	0.039	-0.001	-0.143	-0.082	-0.167	-0.023	-0.241**	-0.064	-0.009
	(0.057)	(0.048)	(0.049)	(0.046)	(0.146)	(0.084)	(0.100)	(0.101)	(0.100)	(0.085)	(0.087)	(0.107)
Children: 7-12	-0.036	0.057	-0.005	0.041	-0.108	0.023	-0.083	0.030	-0.180	-0.006	-0.148	-0.372***
	(0.052)	(0.043)	(0.043)	(0.040)	(0.107)	(0.072)	(0.089)	(0.088)	(0.095)	(0.087)	(0.079)	(0.087)
Children: 13-17	-0.024	-0.012	-0.050	-0.062	0.047	-0.029	0.212*	0.034	-0.145	-0.068	-0.166	-0.027
	(0.052)	(0.043)	(0.043)	(0.040)	(0.103)	(0.066)	(0.088)	(0.081)	(0.108)	(0.090)	(0.088)	(0.082)
Children: 18+	0.053	0.137**	0.144**	0.110*	0.132	0.047	-0.011	0.151	-0.013	-0.154	-0.035	0.111
	(0.062)	(0.051)	(0.051)	(0.045)	(0.118)	(0.068)	(0.083)	(0.091)	(0.156)	(0.103)	(0.105)	(0.121)
Constant	-2.228***	-2.241***	-2.013***	-1.998***	0.127	-1.133**	-1.425**	-1.372**	-0.208	-1.607**	-1.213*	0.154
	(0.255)	(0.239)	(0.256)	(0.253)	(0.575)	(0.402)	(0.444)	(0.477)	(0.586)	(0.495)	(0.480)	(0.430)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.35	-0.84	-0.80	-0.83	-0.42	-0.79	-0.44	-0.66	-0.86	-0.86	-0.77	-0.65
σ	0.40	0.57	0.54	0.55	0.46	0.76	0.51	0.53	0.56	0.55	0.53	0.60
λ	-0.14	-0.48	-0.43	-0.46	-0.19	-0.60	-0.22	-0.35	-0.48	-0.47	-0.41	-0.39
N	7,355	7,026	7,055	7,321	2,367	2,756	2,628	2,435	1,715	2,150	2,763	2,707

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	LV 2010	LV 2012	LV 2015	MT 2009	MT 2010	MT 2012	MT 2014	NL 2008	NL 2010	NL 2012	PL 2008	PL 2010
ln w Equation												
Age	0.036***	0.007	0.020**	0.044***	0.060***	0.033***	0.028***	0.064***	0.066***	0.061***	0.041***	0.056***
	(0.008)	(0.008)	(0.008)	(0.013)	(0.011)	(0.008)	(0.008)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Age^2	-0.040***	-0.009	-0.026**	-0.045**	-0.070***	-0.033***	-0.027**	-0.064***	-0.066***	-0.060***	-0.034***	-0.051***
	(0.010)	(0.010)	(0.009)	(0.016)	(0.014)	(0.010)	(0.010)	(0.006)	(0.006)	(0.006)	(0.007)	(0.008)
Education: medium	0.270***	0.103*	-0.017	0.302***	0.330***	0.319***	0.279***	0.192***	0.190***	0.173***	0.405***	0.304***
	(0.047)	(0.047)	(0.040)	(0.047)	(0.040)	(0.029)	(0.031)	(0.019)	(0.019)	(0.019)	(0.037)	(0.040)
Education: high	0.948***	0.599***	0.481***	0.582***	0.646***	0.627***	0.591***	0.481***	0.501***	0.474***	1.030***	0.956***
	(0.051)	(0.049)	(0.042)	(0.049)	(0.041)	(0.031)	(0.032)	(0.019)	(0.019)	(0.019)	(0.042)	(0.044)
Married	-0.003	0.006	0.010	0.002	-0.100*	0.027	-0.003	-0.078***	-0.089***	-0.052***	-0.023	-0.035
	(0.023)	(0.023)	(0.021)	(0.052)	(0.044)	(0.031)	(0.030)	(0.014)	(0.013)	(0.014)	(0.017)	(0.019)
Constant	1.594***	2.741***	3.095***	2.871***	2.846***	3.242***	3.453***	3.411***	3.410***	3.570***	3.024***	2.965***
	(0.175)	(0.167)	(0.156)	(0.238)	(0.197)	(0.144)	(0.150)	(0.099)	(0.092)	(0.091)	(0.121)	(0.134)
Participation												
Age	0.084***	0.039*	0.077***	0.164***	0.137***	0.199***	0.146***	0.098**	0.100***	0.062**	0.121***	0.128***
	(0.018)	(0.018)	(0.022)	(0.033)	(0.038)	(0.037)	(0.039)	(0.030)	(0.024)	(0.024)	(0.015)	(0.016)
Age^2	-0.095***	-0.040	-0.096***	-0.180***	-0.151**	-0.238***	-0.164**	-0.128***	-0.124***	-0.073*	-0.143***	-0.143***
	(0.022)	(0.022)	(0.027)	(0.044)	(0.051)	(0.049)	(0.051)	(0.037)	(0.030)	(0.029)	(0.020)	(0.021)
Education: medium	0.466***	0.372***	0.177	0.590***	0.359*	0.569***	0.748***	0.351***	0.254**	0.214**	0.781***	0.755***
	(0.079)	(0.084)	(0.098)	(0.144)	(0.155)	(0.152)	(0.162)	(0.095)	(0.081)	(0.080)	(0.069)	(0.072)
Education: high	1.091***	0.957***	0.756***	0.196	0.427*	0.488**	1.035***	0.399***	0.524***	0.272**	1.487***	1.513***
	(0.090)	(0.093)	(0.110)	(0.143)	(0.177)	(0.165)	(0.200)	(0.106)	(0.092)	(0.087)	(0.086)	(0.087)
Elderly	-0.042	-0.243***	-0.046	-0.115	-0.247	-0.290*	0.139	-0.416**	-0.059	0.019	0.076	-0.018
	(0.058)	(0.056)	(0.077)	(0.137)	(0.150)	(0.142)	(0.192)	(0.159)	(0.149)	(0.158)	(0.047)	(0.050)
Married	0.114*	0.005	0.070	0.284	0.247	0.394**	0.172	0.345***	0.145	0.169*	-0.048	0.073
	(0.053)	(0.055)	(0.070)	(0.147)	(0.164)	(0.144)	(0.155)	(0.089)	(0.074)	(0.067)	(0.052)	(0.053)
Other Income	-0.191***	0.172**	0.089*	0.017	0.095	0.022	0.023	-0.025**	-0.013	-0.007	-0.016***	-0.023***
	(0.047)	(0.053)	(0.042)	(0.047)	(0.053)	(0.023)	(0.023)	(0.010)	(0.009)	(0.006)	(0.004)	(0.004)
Assets	0.014	0.520	0.058	-0.000	-0.001	0.000	-0.001	0.001	-0.000	0.003	0.003	0.001
	(0.011)	(0.294)	(0.043)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.000)	(0.001)	(0.003)	(0.001)
Children: 0-2	-0.031	-0.174*	-0.513***	-0.039	-0.131	-0.148	0.185	0.213	0.049	0.206	-0.368***	-0.336***
	(0.078)	(0.087)	(0.107)	(0.183)	(0.234)	(0.218)	(0.245)	(0.169)	(0.133)	(0.117)	(0.063)	(0.065)
Children: 3-6	0.082	-0.031	-0.254**	0.000	-0.148	0.033	-0.110	0.007	0.049	0.219*	-0.061	0.039
	(0.069)	(0.068)	(0.089)	(.)	(0.201)	(0.255)	(0.213)	(0.136)	(0.112)	(0.106)	(0.058)	(0.064)
Children: 7-12	-0.020	0.010	-0.106	0.169	0.607*	-0.196	0.023	-0.257*	-0.246**	-0.093	-0.104*	-0.076
	(0.065)	(0.063)	(0.083)	(0.135)	(0.245)	(0.176)	(0.188)	(0.110)	(0.094)	(0.089)	(0.050)	(0.054)
Children: 13-17	-0.011	-0.015	-0.043	0.000	0.015	0.092	0.065	-0.243*	0.036	0.088	-0.085	-0.012
	(0.062)	(0.067)	(0.088)	(.)	(0.182)	(0.177)	(0.169)	(0.105)	(0.092)	(0.086)	(0.048)	(0.053)
Children: 18+	0.081	0.218**	0.185	-0.118	-0.294	0.831*	0.145	0.067	0.111	0.226*	-0.008	0.140*
	(0.074)	(0.073)	(0.122)	(0.156)	(0.196)	(0.400)	(0.232)	(0.155)	(0.126)	(0.113)	(0.054)	(0.064)
Constant	-1.584***	-0.615	-0.616	-2.281***	-1.591*	-2.596***	-1.760*	-0.067	-0.420	0.047	-2.155***	-2.481***
	(0.322)	(0.345)	(0.411)	(0.545)	(0.656)	(0.643)	(0.703)	(0.569)	(0.445)	(0.434)	(0.272)	(0.291)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	0.60	-0.72	-0.40	0.04	0.07	0.08	0.14	-0.35	-0.02	-0.36	0.45	0.28
σ	0.58	0.60	0.52	0.64	0.54	0.45	0.48	0.46	0.43	0.44	0.51	0.52
λ	0.35	-0.43	-0.21	0.03	0.04	0.04	0.07	-0.16	-0.01	-0.16	0.23	0.15
N	3,218	3,238	2,781	1,241	1,194	1,548	1,650	4,990	4,874	5,025	6,119	5,497

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	PL 2012	PL 2014	PT 2008	PT 2010	PT 2012	PT 2014	RO 2008	RO 2010	RO 2012	RO 2014	SE 2008	SE 2010
ln w Equation												
Age	0.053***	0.060***	0.050***	0.040***	0.056***	0.061***	0.028***	0.002	0.001	0.009	0.094***	0.097***
	(0.006)	(0.005)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Age^2	-0.050***	-0.058***	-0.043***	-0.032**	-0.049***	-0.052***	-0.024*	0.007	0.006	-0.005	-0.092***	-0.093***
	(0.007)	(0.006)	(0.011)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)	(0.010)
Education: medium	-0.039	-0.115***	0.377***	0.375***	0.360***	0.344***	0.318***	0.240***	0.270***	-0.124***	0.096*	0.079
	(0.026)	(0.023)	(0.031)	(0.030)	(0.026)	(0.024)	(0.029)	(0.027)	(0.030)	(0.028)	(0.047)	(0.050)
Education: high	0.566***	0.461***	1.098***	1.075***	0.990***	0.915***	0.917***	0.780***	0.740***	0.343***	0.217***	0.177***
	(0.030)	(0.025)	(0.029)	(0.030)	(0.026)	(0.024)	(0.034)	(0.030)	(0.033)	(0.032)	(0.049)	(0.052)
Married	-0.020	-0.015	0.007	0.007	-0.010	0.045*	-0.016	-0.032	-0.028	-0.005	0.014	0.011
	(0.018)	(0.016)	(0.027)	(0.027)	(0.021)	(0.020)	(0.024)	(0.021)	(0.022)	(0.022)	(0.024)	(0.025)
Constant	3.479***	3.335***	2.285***	2.498***	2.158***	1.922***	2.748***	3.566***	3.676***	3.996***	4.706***	4.765***
	(0.128)	(0.107)	(0.173)	(0.158)	(0.168)	(0.160)	(0.154)	(0.143)	(0.155)	(0.161)	(0.156)	(0.164)
Participation												
Age	0.162***	0.166***	0.155***	0.092***	0.134***	0.147***	0.154***	0.177***	0.222***	0.218***	0.089***	0.114***
	(0.014)	(0.014)	(0.025)	(0.020)	(0.018)	(0.017)	(0.036)	(0.032)	(0.034)	(0.031)	(0.021)	(0.020)
Age^2	-0.192***	-0.194***	-0.191***	-0.099***	-0.148***	-0.162***	-0.192***	-0.210***	-0.255***	-0.251***	-0.088**	-0.119***
	(0.018)	(0.017)	(0.032)	(0.025)	(0.023)	(0.022)	(0.046)	(0.042)	(0.043)	(0.039)	(0.028)	(0.027)
Education: medium	0.084	-0.034	0.121	0.334***	0.282***	0.309***	0.151	-0.004	0.270*	0.022	0.508***	0.484***
	(0.058)	(0.057)	(0.101)	(0.078)	(0.065)	(0.060)	(0.125)	(0.132)	(0.134)	(0.124)	(0.097)	(0.102)
Education: high	0.848***	0.750***	0.332**	0.771***	0.608***	0.654***	0.853***	0.170	0.222	0.115	0.902***	0.941***
	(0.069)	(0.069)	(0.114)	(0.095)	(0.076)	(0.068)	(0.219)	(0.161)	(0.152)	(0.151)	(0.113)	(0.114)
Elderly	-0.013	-0.029	-0.160	0.090	-0.151*	-0.011	-0.079	-0.248*	-0.263**	-0.271**	-0.258	-0.103
	(0.046)	(0.043)	(0.086)	(0.065)	(0.063)	(0.061)	(0.112)	(0.099)	(0.098)	(0.102)	(0.152)	(0.166)
Married	0.082	0.029	0.161	0.093	0.159**	0.317***	0.183	-0.083	-0.108	-0.081	0.125	0.149*
	(0.047)	(0.049)	(0.088)	(0.067)	(0.056)	(0.051)	(0.128)	(0.124)	(0.120)	(0.117)	(0.073)	(0.069)
Other Income	-0.013***	-0.031***	-0.036	-0.065***	-0.078***	-0.114***	0.057	0.062	0.202***	0.159***	-0.001	-0.000
	(0.003)	(0.004)	(0.021)	(0.016)	(0.014)	(0.014)	(0.055)	(0.044)	(0.041)	(0.038)	(0.001)	(0.001)
Assets	0.001	0.000	0.028	0.000	0.002	0.002	0.002	-0.038	0.091	-0.015	0.000	0.000
	(0.001)	(0.000)	(0.015)	(0.002)	(0.004)	(0.002)	(0.016)	(0.075)	(0.127)	(0.035)	(0.000)	(0.000)
Children: 0-2	-0.299***	-0.103	-0.255	-0.113	-0.026	-0.033	-0.295	-0.527*	-0.919***	-0.592**	0.046	0.113
	(0.059)	(0.061)	(0.133)	(0.096)	(0.086)	(0.084)	(0.227)	(0.215)	(0.171)	(0.210)	(0.118)	(0.118)
Children: 3-6	-0.194***	-0.143**	-0.059	-0.130	0.070	-0.091	0.159	0.030	0.055	0.064	0.157	0.020
	(0.054)	(0.051)	(0.117)	(0.076)	(0.078)	(0.069)	(0.195)	(0.152)	(0.157)	(0.174)	(0.116)	(0.107)
Children: 7-12	-0.141**	-0.110*	-0.175	-0.191**	-0.048	-0.072	-0.188	-0.159	-0.234	-0.272*	-0.080	-0.045
	(0.050)	(0.048)	(0.091)	(0.062)	(0.064)	(0.060)	(0.133)	(0.124)	(0.128)	(0.120)	(0.092)	(0.093)
Children: 13-17	-0.102*	-0.018	-0.057	-0.098	-0.152*	-0.116	-0.226	-0.163	-0.241	0.026	0.003	-0.126
	(0.048)	(0.047)	(0.091)	(0.064)	(0.063)	(0.060)	(0.132)	(0.123)	(0.133)	(0.131)	(0.081)	(0.079)
Children: 18+	0.109	0.104	0.042	0.109	-0.066	-0.032	0.071	0.241	0.023	0.051	-0.197	-0.149
	(0.060)	(0.063)	(0.121)	(0.082)	(0.079)	(0.071)	(0.144)	(0.140)	(0.136)	(0.135)	(0.133)	(0.115)
Constant	-2.480***	-2.547***	-1.823***	-1.288***	-2.216***	-2.654***	-1.372*	-1.708**	-3.223***	-2.901***	-1.058**	-1.619***
	(0.258)	(0.256)	(0.452)	(0.364)	(0.329)	(0.327)	(0.640)	(0.591)	(0.640)	(0.601)	(0.361)	(0.358)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	0.19	0.63	0.32	0.80	0.37	0.36	-0.50	-0.41	-0.69	-0.52	0.01	0.04
σ	0.51	0.49	0.46	0.53	0.48	0.47	0.46	0.39	0.41	0.42	0.72	0.69
λ	0.10	0.31	0.15	0.42	0.18	0.17	-0.23	-0.16	-0.28	-0.22	0.01	0.03
N	6,208	6,089	1,988	2,395	3,123	3,532	2,395	2,324	2,169	2,226	3,997	3,716

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	SE 2012	SI 2008	SI 2010	SI 2012	SI 2014	SK 2008	SK 2010	SK 2012	SK 2014	UK 2008	UK 2009	UK 2012
ln w Equation												
Age	0.048***	-0.008	0.004	-0.029***	-0.016*	0.002	-0.010	-0.004	0.002	0.064***	0.065***	0.063***
	(0.009)	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)	(0.005)	(0.005)	(0.006)	(0.003)	(0.004)	(0.004)
Age^2	-0.038***	0.028***	0.017*	0.055***	0.036***	0.001	0.016*	0.007	0.001	-0.070***	-0.069***	-0.065***
	(0.011)	(0.007)	(0.008)	(0.009)	(0.009)	(0.008)	(0.007)	(0.006)	(0.007)	(0.004)	(0.004)	(0.005)
Education: medium	0.024	0.303***	0.217***	0.174***	0.136***	0.187***	0.102*	0.228***	0.082	0.173***	0.166***	0.175***
	(0.061)	(0.018)	(0.022)	(0.025)	(0.028)	(0.036)	(0.043)	(0.041)	(0.049)	(0.013)	(0.014)	(0.015)
Education: high	0.127*	0.769***	0.637***	0.566***	0.476***	0.475***	0.389***	0.529***	0.407***	0.494***	0.486***	0.469***
	(0.061)	(0.020)	(0.024)	(0.027)	(0.029)	(0.039)	(0.045)	(0.043)	(0.052)	(0.014)	(0.014)	(0.016)
Married	-0.001	-0.012	0.016	-0.025	-0.000	-0.026	0.001	0.048**	-0.006	-0.022*	-0.027*	0.007
	(0.029)	(0.014)	(0.017)	(0.018)	(0.018)	(0.020)	(0.017)	(0.016)	(0.017)	(0.011)	(0.011)	(0.013)
Constant	5.854***	3.744***	3.610***	4.437***	4.295***	6.411***	3.423***	3.276***	3.295***	3.002***	2.982***	3.000***
	(0.185)	(0.109)	(0.130)	(0.142)	(0.158)	(0.111)	(0.112)	(0.108)	(0.128)	(0.069)	(0.071)	(0.085)
Participation												
Age	0.093***	0.199***	0.148***	0.167***	0.191***	0.080***	0.149***	0.128***	0.134***	0.120***	0.126***	0.158***
	(0.021)	(0.017)	(0.016)	(0.015)	(0.016)	(0.021)	(0.020)	(0.020)	(0.020)	(0.014)	(0.013)	(0.014)
Age^2	-0.110***	-0.256***	-0.184***	-0.209***	-0.218***	-0.091***	-0.170***	-0.133***	-0.144***	-0.132***	-0.138***	-0.179***
	(0.027)	(0.022)	(0.020)	(0.019)	(0.019)	(0.027)	(0.026)	(0.025)	(0.025)	(0.018)	(0.017)	(0.018)
Education: medium	0.459***	0.281***	0.415***	0.347***	0.380***	0.619***	1.168***	0.891***	0.999***	0.151**	0.207***	0.197***
	(0.101)	(0.052)	(0.050)	(0.051)	(0.055)	(0.093)	(0.103)	(0.113)	(0.109)	(0.052)	(0.049)	(0.053)
Education: high	0.798***	0.718***	0.880***	0.884***	0.763***	1.028***	1.554***	1.224***	1.333***	0.259***	0.196***	0.210***
	(0.110)	(0.066)	(0.061)	(0.060)	(0.060)	(0.124)	(0.122)	(0.126)	(0.122)	(0.060)	(0.053)	(0.058)
Elderly	-0.159	-0.119**	-0.046	-0.037	-0.172***	-0.233***	-0.247***	-0.161**	-0.141*	-0.171*	-0.270***	-0.204*
	(0.128)	(0.042)	(0.038)	(0.036)	(0.035)	(0.059)	(0.061)	(0.062)	(0.064)	(0.086)	(0.072)	(0.080)
Married	-0.010	0.044	0.046	0.116**	0.055	-0.142	-0.161*	-0.113	0.034	0.369***	0.313***	0.276***
	(0.066)	(0.047)	(0.043)	(0.041)	(0.040)	(0.081)	(0.074)	(0.072)	(0.067)	(0.046)	(0.044)	(0.049)
Other Income	0.001	0.024***	0.009**	0.008*	0.012***	0.004***	0.097***	0.051**	0.022	0.004	0.035***	0.055***
	(0.001)	(0.007)	(0.004)	(0.003)	(0.003)	(0.001)	(0.019)	(0.017)	(0.015)	(0.008)	(0.008)	(0.012)
Assets	0.000	0.000	0.005**	0.007***	0.001**	-0.000	0.074	0.016	0.093	0.002*	0.001	0.001
	(0.000)	(0.001)	(0.002)	(0.002)	(0.000)	(0.001)	(0.089)	(0.024)	(0.078)	(0.001)	(0.001)	(0.001)
Children: 0-2	-0.354***	-0.283***	-0.340***	-0.260***	-0.376***	-0.667***	-0.404***	-0.406***	-0.592***	-0.114	-0.081	-0.023
	(0.096)	(0.065)	(0.051)	(0.050)	(0.050)	(0.091)	(0.113)	(0.123)	(0.112)	(0.065)	(0.059)	(0.070)
Children: 3-6	-0.022	-0.006	-0.080	0.022	0.067	-0.129	-0.223**	-0.365***	-0.310***	-0.233***	-0.306***	-0.274***
	(0.089)	(0.060)	(0.050)	(0.048)	(0.047)	(0.079)	(0.084)	(0.083)	(0.082)	(0.058)	(0.053)	(0.058)
Children: 7-12	-0.168*	-0.067	0.044	0.091*	0.016	-0.198**	-0.195**	-0.025	-0.214**	-0.198***	-0.269***	-0.302***
	(0.078)	(0.053)	(0.045)	(0.044)	(0.043)	(0.066)	(0.072)	(0.073)	(0.075)	(0.053)	(0.049)	(0.055)
Children: 13-17	-0.167*	-0.051	-0.042	0.017	-0.058	-0.174**	-0.146*	-0.181**	0.034	-0.296***	-0.264***	-0.184**
	(0.070)	(0.050)	(0.043)	(0.042)	(0.041)	(0.059)	(0.065)	(0.064)	(0.074)	(0.051)	(0.049)	(0.056)
Children: 18+	-0.024	0.145**	0.107**	0.091*	0.091*	0.050	0.011	0.180**	0.038	-0.232*	-0.172	-0.132
	(0.102)	(0.045)	(0.039)	(0.037)	(0.037)	(0.065)	(0.063)	(0.062)	(0.068)	(0.103)	(0.099)	(0.103)
Constant	-0.947*	-2.913***	-2.393***	-2.958***	-3.772***	-0.950*	-2.988***	-2.763***	-3.002***	-0.788**	-1.309***	-1.990***
	(0.387)	(0.322)	(0.301)	(0.291)	(0.299)	(0.371)	(0.373)	(0.365)	(0.370)	(0.251)	(0.231)	(0.259)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.78	-0.72	-0.87	-0.88	-0.87	-0.82	-0.65	-0.60	-0.37	-0.61	-0.69	-0.44
σ	0.79	0.45	0.54	0.57	0.59	0.46	0.41	0.37	0.41	0.51	0.53	0.53
λ	-0.61	-0.32	-0.47	-0.51	-0.51	-0.38	-0.26	-0.22	-0.15	-0.31	-0.36	-0.23
N	3,392	6,156	6,237	6,000	5,803	3,667	3,608	3,538	3,468	9,878	9,962	8,051

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Women – Continued

	UK 2013
ln w Equation	
Age	0.067***
	(0.004)
Age^2	-0.071***
	(0.005)
Education: medium	0.134***
	(0.015)
Education: high	0.448***
	(0.015)
Married	0.003
	(0.012)
Constant	2.984***
	(0.083)
Participation	
Age	0.135***
	(0.015)
Age^2	-0.145***
	(0.019)
Education: medium	0.270***
	(0.055)
Education: high	0.282***
	(0.060)
Elderly	-0.282***
	(0.084)
Married	0.228***
	(0.051)
Other Income	0.065***
	(0.013)
Assets	0.001
	(0.001)
Children: 0-2	-0.001
	(0.068)
Children: 3-6	-0.338***
	(0.058)
Children: 7-12	-0.284***
	(0.055)
Children: 13-17	-0.253***
	(0.057)
Children: 18+	-0.298**
	(0.098)
Constant	-1.489***
	(0.272)
Regional dummies	Yes
ρ	-0.61
σ	0.53
λ	-0.32
N	8,050

Notes: Stars denote significance levels at 5%, 1% and 0.1%.
Source: Own calculations based on EUROMOD and EU-SILC.

Table B.4.: Wage Estimation: Men

	AT 2008	AT 2010	AT 2012	AT 2014	BE 2008	BE 2010	BE 2012	BG 2008	BG 2010	BG 2012	BG 2014	CY 2008
$\ln w$ Equation												
Age	0.048***	0.049***	0.057***	0.067***	0.054***	0.032***	0.042***	0.041***	0.018**	0.025***	0.008	0.054***
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.008)	(0.007)	(0.008)	(0.011)	(0.007)
Age^2	-0.043***	-0.044***	-0.049***	-0.063***	-0.048***	-0.022**	-0.033***	-0.051***	-0.021**	-0.033***	-0.013	-0.044***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.008)	(0.007)	(0.008)	(0.011)	(0.008)	(0.009)	(0.013)	(0.009)
Education: medium	0.316***	0.277***	0.224***	0.183***	0.084***	0.093***	0.134***	0.005	0.139***	0.063	0.111*	0.110***
	(0.036)	(0.031)	(0.039)	(0.040)	(0.022)	(0.021)	(0.024)	(0.034)	(0.028)	(0.034)	(0.044)	(0.027)
Education: high	0.562***	0.536***	0.492***	0.431***	0.289***	0.317***	0.368***	0.303***	0.531***	0.394***	0.450***	0.432***
	(0.041)	(0.036)	(0.044)	(0.042)	(0.023)	(0.021)	(0.026)	(0.048)	(0.036)	(0.041)	(0.054)	(0.029)
Married	-0.009	0.014	-0.002	0.031	0.022	0.044**	0.037*	0.049	0.045	0.005	-0.072*	0.041
	(0.022)	(0.020)	(0.024)	(0.023)	(0.018)	(0.016)	(0.018)	(0.034)	(0.023)	(0.025)	(0.035)	(0.036)
Constant	3.543***	3.624***	3.523***	3.362***	3.587***	4.052***	3.819***	2.573***	3.117***	3.109***	3.569***	3.023***
	(0.121)	(0.115)	(0.133)	(0.136)	(0.118)	(0.115)	(0.141)	(0.164)	(0.133)	(0.159)	(0.218)	(0.140)
Participation												
Age	0.038	0.083***	0.075***	0.024	0.119***	0.110***	0.137***	0.087***	0.143***	0.145***	0.137***	0.063
	(0.025)	(0.021)	(0.019)	(0.021)	(0.023)	(0.022)	(0.023)	(0.018)	(0.015)	(0.016)	(0.018)	(0.034)
Age^2	-0.061	-0.096***	-0.089***	-0.032	-0.167***	-0.130***	-0.168***	-0.099***	-0.161***	-0.163***	-0.157***	-0.063
	(0.031)	(0.027)	(0.024)	(0.027)	(0.029)	(0.027)	(0.028)	(0.023)	(0.018)	(0.020)	(0.023)	(0.043)
Education: medium	0.681***	0.608***	0.414***	0.453***	0.429***	0.431***	0.391***	0.589***	0.523***	0.651***	0.664***	0.141
	(0.101)	(0.088)	(0.088)	(0.092)	(0.079)	(0.075)	(0.081)	(0.065)	(0.058)	(0.064)	(0.067)	(0.125)
Education: high	0.724***	0.669***	0.500***	0.711***	0.865***	0.858***	0.736***	0.907***	0.919***	0.990***	0.999***	0.345*
	(0.132)	(0.118)	(0.110)	(0.111)	(0.101)	(0.088)	(0.091)	(0.122)	(0.095)	(0.093)	(0.102)	(0.151)
Elderly	-0.149	-0.288**	-0.254**	-0.260**	-0.332**	-0.272**	-0.276**	-0.145*	-0.223***	-0.203***	-0.288***	-0.264
	(0.115)	(0.107)	(0.090)	(0.094)	(0.108)	(0.095)	(0.102)	(0.058)	(0.050)	(0.053)	(0.055)	(0.164)
Married	0.358***	0.329***	0.207**	0.225**	0.467***	0.150*	0.313***	-0.079	-0.069	0.076	0.090	0.105
	(0.090)	(0.082)	(0.072)	(0.079)	(0.080)	(0.074)	(0.079)	(0.077)	(0.063)	(0.062)	(0.065)	(0.175)
Other Income	0.044*	0.000	-0.001	-0.004	-0.007	-0.018	-0.024	0.156***	0.046***	0.065***	0.051***	-0.055**
	(0.018)	(0.009)	(0.012)	(0.013)	(0.019)	(0.015)	(0.016)	(0.022)	(0.011)	(0.010)	(0.011)	(0.019)
Assets	0.015***	0.009***	0.002***	0.007***	0.007**	0.001	0.001	-0.021	0.002	-0.002	-0.002	-0.006**
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.013)	(0.003)	(0.001)	(0.001)	(0.002)
Children	0.007	0.129	0.077	0.110	0.042	0.254***	0.140	0.107	0.052	-0.069	-0.040	0.297*
	(0.089)	(0.084)	(0.067)	(0.070)	(0.079)	(0.070)	(0.081)	(0.074)	(0.061)	(0.062)	(0.062)	(0.134)
Constant	0.276	-0.914*	-0.776*	0.295	-1.337**	-1.706***	-2.083***	-1.432***	-2.533***	-2.966***	-2.693***	-0.035
	(0.461)	(0.377)	(0.352)	(0.397)	(0.434)	(0.418)	(0.434)	(0.336)	(0.277)	(0.316)	(0.353)	(0.617)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.51	-0.47	-0.78	-0.83	-0.64	-0.60	-0.02	-0.70	-0.58	-0.56	-0.77	-0.52
σ	0.50	0.47	0.57	0.56	0.44	0.38	0.39	0.63	0.52	0.51	0.69	0.44
λ	-0.26	-0.22	-0.44	-0.47	-0.28	-0.23	-0.01	-0.44	-0.30	-0.29	-0.53	-0.23
N	2,799	2,922	2,890	2,699	2,996	2,884	2,624	2,582	3,499	3,069	2,509	1,846

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	CY 2010	CY 2012	CY 2014	CZ 2008	CZ 2010	CZ 2012	DE 2008	DE 2010	DE 2012	DK 2008	DK 2012	EE 2008
$\ln w$ Equation												
Age	0.038***	0.053***	0.046***	0.045***	0.054***	0.083***	0.114***	0.104***	0.112***	0.090***	0.091***	0.041***
	(0.008)	(0.008)	(0.010)	(0.004)	(0.004)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)
Age^2	-0.024*	-0.041***	-0.031*	-0.054***	-0.066***	-0.096***	-0.115***	-0.105***	-0.115***	-0.096***	-0.095***	-0.061***
	(0.010)	(0.010)	(0.012)	(0.004)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.008)
Education: medium	0.128***	0.072*	0.017	0.198***	0.164***	0.162***	0.381***	0.355***	0.162***	0.156***	0.113***	0.185***
	(0.029)	(0.031)	(0.038)	(0.027)	(0.032)	(0.040)	(0.030)	(0.027)	(0.029)	(0.023)	(0.025)	(0.032)
Education: high	0.471***	0.453***	0.384***	0.605***	0.544***	0.547***	0.665***	0.683***	0.486***	0.372***	0.405***	0.436***
	(0.031)	(0.033)	(0.040)	(0.031)	(0.035)	(0.043)	(0.031)	(0.028)	(0.030)	(0.025)	(0.027)	(0.039)
Married	0.073*	0.130***	0.105**	0.037**	0.035*	0.027	0.000	0.019	0.018	0.034	0.061**	0.046*
	(0.035)	(0.032)	(0.037)	(0.012)	(0.014)	(0.017)	(0.017)	(0.016)	(0.016)	(0.019)	(0.019)	(0.023)
Constant	3.397***	3.118***	3.228***	5.887***	5.875***	5.232***	1.913***	2.169***	2.233***	5.195***	5.220***	5.663***
	(0.152)	(0.160)	(0.209)	(0.075)	(0.095)	(0.113)	(0.093)	(0.091)	(0.092)	(0.103)	(0.107)	(0.122)
Participation												
Age	0.153***	0.123***	0.143***	0.083***	0.170***	0.149***	0.021	0.048***	0.020	0.052	0.032	0.042*
	(0.024)	(0.019)	(0.019)	(0.019)	(0.017)	(0.018)	(0.016)	(0.015)	(0.017)	(0.028)	(0.022)	(0.021)
Age^2	-0.167***	-0.127***	-0.159***	-0.101***	-0.201***	-0.176***	-0.047*	-0.072***	-0.042*	-0.068	-0.033	-0.053
	(0.030)	(0.024)	(0.024)	(0.024)	(0.021)	(0.023)	(0.019)	(0.018)	(0.020)	(0.035)	(0.028)	(0.027)
Education: medium	0.310***	0.572***	0.465***	0.910***	0.876***	0.704***	0.104	0.214**	0.422***	0.281*	0.262**	0.335***
	(0.089)	(0.073)	(0.071)	(0.087)	(0.087)	(0.099)	(0.078)	(0.069)	(0.074)	(0.112)	(0.093)	(0.088)
Education: high	0.403***	0.666***	0.802***	1.232***	1.362***	1.062***	0.343***	0.422***	0.743***	0.277*	0.529***	0.837***
	(0.099)	(0.080)	(0.079)	(0.136)	(0.130)	(0.134)	(0.086)	(0.077)	(0.087)	(0.130)	(0.109)	(0.141)
Elderly	-0.425***	-0.242**	-0.390***	-0.172*	-0.281***	-0.355***	-0.183*	-0.305***	-0.057	-0.398*	-0.238	-0.303***
	(0.103)	(0.092)	(0.082)	(0.076)	(0.067)	(0.069)	(0.087)	(0.081)	(0.098)	(0.155)	(0.141)	(0.083)
Married	0.129	-0.047	-0.028	0.275***	0.286***	0.203**	0.565***	0.508***	0.507***	0.342**	0.387***	0.193*
	(0.117)	(0.095)	(0.086)	(0.073)	(0.064)	(0.068)	(0.058)	(0.056)	(0.059)	(0.109)	(0.087)	(0.077)
Other Income	-0.015	-0.021*	-0.017**	0.001	-0.002	-0.002	-0.028***	-0.005	-0.006	-0.002	-0.009***	0.002
	(0.011)	(0.010)	(0.006)	(0.002)	(0.001)	(0.002)	(0.006)	(0.006)	(0.006)	(0.001)	(0.001)	(0.004)
Assets	0.002	-0.001	-0.022**	-0.002	0.004	0.000	0.016***	0.007***	0.011***	0.000	0.000	0.018*
	(0.003)	(0.002)	(0.008)	(0.001)	(0.003)	(0.000)	(0.002)	(0.001)	(0.001)	(0.000)	(0.000)	(0.009)
Children	0.044	0.077	0.158*	0.084	0.005	0.027	0.129*	0.058	0.147**	0.236*	0.220*	0.203*
	(0.098)	(0.075)	(0.070)	(0.075)	(0.065)	(0.068)	(0.053)	(0.052)	(0.056)	(0.106)	(0.087)	(0.085)
Constant	-2.296***	-2.162***	-2.776***	-0.940**	-2.946***	-2.251***	0.710*	-0.056	0.392	0.459	0.372	-0.009
	(0.438)	(0.364)	(0.369)	(0.364)	(0.319)	(0.354)	(0.315)	(0.284)	(0.328)	(0.509)	(0.409)	(0.374)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.78	-0.65	-0.73	-0.35	-0.50	-0.69	-0.76	-0.77	-0.80	-0.57	0.10	-0.46
σ	0.48	0.52	0.59	0.38	0.39	0.48	0.54	0.53	0.52	0.46	0.42	0.52
λ	-0.37	-0.34	-0.43	-0.13	-0.20	-0.33	-0.41	-0.41	-0.42	-0.26	0.04	-0.24
N	2,056	2,674	2,404	5,526	4,334	3,978	5,781	5,901	5,761	3,046	2,669	2,688

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	EE 2010	EE 2012	EL 2008	EL 2010	EL 2012	EL 2014	ES 2008	ES 2010	ES 2012	ES 2014	FI 2008	FI 2010
$\ln w$ Equation												
Age	0.056***	0.056***	0.033***	0.056***	0.027	0.006	0.028***	0.017***	0.019***	0.062***	0.031***	0.051***
	(0.008)	(0.008)	(0.008)	(0.010)	(0.014)	(0.010)	(0.004)	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)
Age^2	-0.076***	-0.076***	-0.018	-0.045***	-0.014	0.012	-0.018***	-0.006	-0.010	-0.049***	-0.024***	-0.050***
	(0.010)	(0.010)	(0.010)	(0.013)	(0.017)	(0.012)	(0.005)	(0.006)	(0.006)	(0.009)	(0.006)	(0.006)
Education: medium	0.051	0.059	0.269***	0.041	0.042	0.099**	0.129***	0.060***	0.092***	0.244***	0.072**	0.061**
	(0.035)	(0.034)	(0.025)	(0.029)	(0.036)	(0.032)	(0.015)	(0.017)	(0.018)	(0.025)	(0.023)	(0.022)
Education: high	0.352***	0.304***	0.633***	0.437***	0.412***	0.364***	0.323***	0.318***	0.264***	0.479***	0.440***	0.419***
	(0.045)	(0.042)	(0.028)	(0.034)	(0.043)	(0.035)	(0.014)	(0.016)	(0.017)	(0.025)	(0.024)	(0.024)
Married	0.038	0.026	0.025	0.079**	0.138***	0.066*	-0.010	0.008	-0.009	0.090***	0.037*	0.056***
	(0.025)	(0.024)	(0.028)	(0.031)	(0.035)	(0.026)	(0.015)	(0.016)	(0.017)	(0.021)	(0.017)	(0.015)
Constant	5.483***	2.858***	3.198***	2.913***	3.286***	3.617***	3.617***	3.915***	3.961***	2.558***	4.044***	3.803***
	(0.180)	(0.154)	(0.157)	(0.232)	(0.309)	(0.221)	(0.081)	(0.097)	(0.109)	(0.173)	(0.095)	(0.094)
Participation												
Age	0.099***	0.086***	0.164***	0.176***	0.198***	0.190***	0.056***	0.076***	0.083***	0.099***	0.079***	0.089***
	(0.017)	(0.018)	(0.023)	(0.020)	(0.022)	(0.017)	(0.012)	(0.010)	(0.011)	(0.012)	(0.016)	(0.015)
Age^2	-0.116***	-0.099***	-0.182***	-0.203***	-0.227***	-0.211***	-0.070***	-0.080***	-0.091***	-0.111***	-0.114***	-0.114***
	(0.021)	(0.023)	(0.029)	(0.025)	(0.027)	(0.021)	(0.015)	(0.013)	(0.014)	(0.015)	(0.021)	(0.019)
Education: medium	0.280***	0.335***	0.033	0.219**	0.241***	0.420***	0.356***	0.532***	0.434***	0.457***	0.215**	0.450***
	(0.069)	(0.073)	(0.079)	(0.067)	(0.072)	(0.060)	(0.050)	(0.040)	(0.041)	(0.044)	(0.066)	(0.061)
Education: high	0.737***	0.780***	0.167	0.541***	0.591***	0.802***	0.659***	0.745***	0.781***	0.813***	0.666***	1.051***
	(0.096)	(0.106)	(0.094)	(0.084)	(0.088)	(0.068)	(0.052)	(0.042)	(0.042)	(0.044)	(0.084)	(0.076)
Elderly	-0.230***	-0.456***	-0.352***	-0.366***	-0.408***	-0.463***	-0.371***	-0.241***	-0.248***	-0.136**	-0.455***	-0.524***
	(0.065)	(0.064)	(0.071)	(0.066)	(0.069)	(0.050)	(0.046)	(0.039)	(0.038)	(0.047)	(0.086)	(0.087)
Married	0.141*	0.185**	0.271**	0.316***	0.149	0.117	0.330***	0.213***	0.197***	0.271***	0.402***	0.507***
	(0.059)	(0.063)	(0.090)	(0.082)	(0.089)	(0.064)	(0.048)	(0.039)	(0.041)	(0.043)	(0.063)	(0.056)
Other Income	-0.009**	0.041	-0.034***	-0.005	-0.018	-0.009	-0.030**	-0.065***	-0.091***	-0.143***	-0.036***	-0.082***
	(0.003)	(0.041)	(0.007)	(0.009)	(0.013)	(0.009)	(0.011)	(0.009)	(0.008)	(0.009)	(0.008)	(0.008)
Assets	0.008***	0.004	0.027	0.001	0.003	0.008*	0.002	0.008**	0.004	0.005***	0.002**	0.003***
	(0.002)	(0.003)	(0.018)	(0.005)	(0.008)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)
Children	0.148*	0.187**	0.212**	-0.097	-0.041	0.013	0.074	0.068	0.153***	0.138**	0.146*	0.146**
	(0.065)	(0.066)	(0.079)	(0.075)	(0.079)	(0.054)	(0.044)	(0.035)	(0.035)	(0.042)	(0.059)	(0.055)
Constant	-1.667***	-1.214***	-2.157***	-2.836***	-3.601***	-3.888***	-0.569*	-1.453***	-1.790***	-2.043***	-0.293	-1.115***
	(0.298)	(0.331)	(0.433)	(0.379)	(0.440)	(0.339)	(0.239)	(0.209)	(0.222)	(0.242)	(0.303)	(0.271)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.34	-0.45	-0.65	0.05	0.18	-0.62	-0.75	-0.78	-0.81	0.03	-0.65	-0.31
σ	0.52	0.56	0.50	0.52	0.49	0.49	0.48	0.52	0.51	0.59	0.51	0.41
λ	-0.18	-0.25	-0.32	0.03	0.09	-0.31	-0.36	-0.40	-0.41	0.02	-0.33	-0.13
N	2,765	2,848	2,602	2,685	2,038	3,356	7,112	7,628	6,846	6,417	4,657	4,673

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	FI 2012	FI 2014	FR 2007	FR 2010	FR 2012	HR 2014	HU 2008	HU 2010	HU 2012	IE 2008	IE 2010	IE 2012
$\ln w$ Equation												
Age	0.043***	0.059***	0.050***	0.054***	0.037***	0.003	0.055***	0.033***	0.026***	0.060***	0.069***	0.080***
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)	(0.006)	(0.003)	(0.005)	(0.008)	(0.010)	(0.011)
Age^2	-0.040***	-0.057***	-0.044***	-0.048***	-0.029***	0.006	-0.063***	-0.038***	-0.027***	-0.057***	-0.067***	-0.080***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.010)	(0.007)	(0.004)	(0.006)	(0.010)	(0.013)	(0.013)
Education: medium	0.034	0.075**	0.120***	0.119***	0.068**	0.096*	0.315***	0.119***	0.223***	0.132***	0.223***	0.216***
	(0.022)	(0.025)	(0.017)	(0.020)	(0.021)	(0.037)	(0.027)	(0.014)	(0.024)	(0.035)	(0.053)	(0.046)
Education: high	0.360***	0.388***	0.436***	0.400***	0.380***	0.436***	0.990***	0.455***	0.733***	0.445***	0.508***	0.575***
	(0.023)	(0.027)	(0.019)	(0.022)	(0.023)	(0.046)	(0.033)	(0.017)	(0.028)	(0.035)	(0.066)	(0.045)
Married	0.082***	0.040*	0.058***	0.052***	0.093***	0.024	0.066***	0.040***	0.043**	0.109***	0.177***	0.166***
	(0.014)	(0.016)	(0.013)	(0.015)	(0.014)	(0.029)	(0.019)	(0.010)	(0.015)	(0.031)	(0.038)	(0.035)
Constant	4.025***	3.708***	3.257***	3.282***	3.682***	5.539***	7.216***	7.995***	8.167***	3.589***	3.182***	2.766***
	(0.089)	(0.107)	(0.095)	(0.108)	(0.106)	(0.171)	(0.116)	(0.062)	(0.105)	(0.157)	(0.246)	(0.230)
Participation												
Age	0.071***	0.104***	0.135***	0.116***	0.127***	0.176***	0.066***	0.137***	0.129***	0.038	0.016	0.066***
	(0.015)	(0.014)	(0.015)	(0.014)	(0.014)	(0.016)	(0.018)	(0.013)	(0.014)	(0.021)	(0.020)	(0.020)
Age^2	-0.093***	-0.130***	-0.168***	-0.136***	-0.146***	-0.203***	-0.080***	-0.162***	-0.152***	-0.038	-0.006	-0.071**
	(0.019)	(0.018)	(0.020)	(0.019)	(0.018)	(0.020)	(0.023)	(0.017)	(0.017)	(0.026)	(0.026)	(0.025)
Education: medium	0.343***	0.326***	0.404***	0.301***	0.356***	0.528***	0.605***	0.492***	0.742***	0.515***	0.475***	0.408***
	(0.066)	(0.067)	(0.059)	(0.055)	(0.057)	(0.075)	(0.064)	(0.053)	(0.053)	(0.084)	(0.081)	(0.082)
Education: high	0.863***	0.766***	0.647***	0.661***	0.700***	0.890***	1.136***	1.456***	1.125***	0.881***	0.905***	0.811***
	(0.080)	(0.075)	(0.075)	(0.068)	(0.069)	(0.105)	(0.108)	(0.077)	(0.082)	(0.103)	(0.082)	(0.079)
Elderly	-0.513***	-0.530***	-0.247**	-0.363***	-0.409***	-0.108*	-0.054	-0.053	-0.296***	-0.327***	-0.439***	-0.265**
	(0.091)	(0.088)	(0.075)	(0.067)	(0.066)	(0.051)	(0.059)	(0.035)	(0.049)	(0.091)	(0.102)	(0.102)
Married	0.346***	0.288***	0.231***	0.190***	0.234***	0.201**	0.124*	0.125**	0.241***	0.274***	0.403***	0.481***
	(0.059)	(0.054)	(0.058)	(0.052)	(0.051)	(0.069)	(0.062)	(0.047)	(0.049)	(0.083)	(0.079)	(0.074)
Other Income	-0.067***	-0.014***	-0.093***	-0.040***	-0.033***	0.003	-0.000*	-0.000	0.000	-0.035**	-0.022	-0.045***
	(0.008)	(0.003)	(0.011)	(0.006)	(0.005)	(0.004)	(0.000)	(0.000)	(0.000)	(0.011)	(0.013)	(0.013)
Assets	0.004***	0.000*	-0.000	0.000	0.000*	0.008***	0.000	-0.000	0.000	0.003***	0.037*	0.010
	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.001)	(0.015)	(0.005)
Children	0.187***	0.171**	-0.015	0.094	0.063	0.234***	0.131*	0.055	-0.101	0.181*	-0.150	-0.218**
	(0.056)	(0.054)	(0.059)	(0.052)	(0.052)	(0.061)	(0.065)	(0.040)	(0.053)	(0.079)	(0.080)	(0.069)
Constant	-0.581*	-1.404***	-1.615***	-1.509***	-1.730***	-3.896***	-0.969**	-2.632***	-2.279***	-0.494	-0.610	-1.380***
	(0.285)	(0.271)	(0.290)	(0.275)	(0.269)	(0.326)	(0.332)	(0.254)	(0.264)	(0.392)	(0.392)	(0.384)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.55	-0.35	0.02	0.10	0.02	-0.65	0.44	0.94	-0.43	-0.67	0.02	0.60
σ	0.41	0.44	0.42	0.49	0.49	0.49	0.50	0.29	0.44	0.55	0.55	0.57
λ	-0.22	-0.15	0.01	0.05	0.01	-0.32	0.22	0.28	-0.19	-0.37	0.01	0.35
N	4,348	4,618	5,192	5,429	5,843	2,810	4,213	4,638	5,578	1,972	1,912	2,036

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	IT 2008	IT 2010	IT 2012	IT 2014	LT 2008	LT 2010	LT 2012	LT 2014	LU 2008	LU 2010	LU 2012	LV 2008
ln w Equation												
Age	0.034***	0.016***	0.013**	0.021***	0.033***	0.010	0.031***	0.045***	0.036***	0.049***	0.048***	0.013
	(0.003)	(0.005)	(0.005)	(0.005)	(0.007)	(0.012)	(0.009)	(0.008)	(0.008)	(0.007)	(0.006)	(0.009)
Age^2	-0.024***	-0.002	-0.000	-0.011	-0.041***	-0.012	-0.035***	-0.051***	-0.022*	-0.035***	-0.035***	-0.018
	(0.004)	(0.006)	(0.006)	(0.006)	(0.009)	(0.015)	(0.010)	(0.010)	(0.010)	(0.009)	(0.007)	(0.011)
Education: medium	0.170***	0.164***	0.131***	0.117***	0.129**	-0.116	0.014	-0.003	0.329***	0.329***	0.328***	0.151***
	(0.009)	(0.014)	(0.014)	(0.015)	(0.044)	(0.062)	(0.047)	(0.057)	(0.024)	(0.020)	(0.019)	(0.034)
Education: high	0.480***	0.465***	0.432***	0.385***	0.595***	0.323***	0.381***	0.373***	0.725***	0.713***	0.706***	0.687***
	(0.014)	(0.021)	(0.020)	(0.019)	(0.049)	(0.068)	(0.052)	(0.063)	(0.025)	(0.023)	(0.021)	(0.046)
Married	0.041***	0.002	0.039**	0.013	0.039	-0.069	-0.051	-0.032	0.081***	0.056**	0.052**	0.044
	(0.010)	(0.015)	(0.014)	(0.014)	(0.035)	(0.055)	(0.038)	(0.037)	(0.021)	(0.020)	(0.018)	(0.030)
Constant	3.573***	4.088***	4.238***	4.189***	3.852***	4.649***	4.078***	3.850***	3.846***	3.691***	3.752***	2.767***
	(0.073)	(0.094)	(0.099)	(0.104)	(0.146)	(0.240)	(0.173)	(0.184)	(0.144)	(0.130)	(0.111)	(0.159)
Participation												
Age	0.164***	0.131***	0.182***	0.169***	0.027	0.058***	0.047*	0.060**	0.052	0.085**	0.133***	0.032
	(0.012)	(0.011)	(0.010)	(0.011)	(0.023)	(0.017)	(0.019)	(0.021)	(0.031)	(0.026)	(0.023)	(0.020)
Age^2	-0.177***	-0.138***	-0.201***	-0.182***	-0.029	-0.056**	-0.050*	-0.070**	-0.072	-0.102**	-0.165***	-0.042
	(0.015)	(0.014)	(0.013)	(0.013)	(0.029)	(0.021)	(0.024)	(0.026)	(0.040)	(0.034)	(0.030)	(0.025)
Education: medium	0.230***	0.216***	0.308***	0.404***	0.348**	0.494***	0.602***	0.528***	0.271**	0.428***	0.246**	0.187**
	(0.040)	(0.035)	(0.034)	(0.035)	(0.111)	(0.076)	(0.086)	(0.111)	(0.096)	(0.083)	(0.078)	(0.071)
Education: high	0.153*	0.134*	0.413***	0.586***	0.906***	0.937***	1.115***	1.030***	0.505***	0.499***	0.475***	0.558***
	(0.064)	(0.056)	(0.053)	(0.050)	(0.150)	(0.092)	(0.107)	(0.131)	(0.120)	(0.105)	(0.112)	(0.122)
Elderly	-0.358***	-0.316***	-0.338***	-0.383***	-0.377***	-0.234***	-0.292***	-0.189*	-0.239	-0.273*	-0.192	-0.305***
	(0.045)	(0.037)	(0.037)	(0.038)	(0.077)	(0.054)	(0.063)	(0.074)	(0.144)	(0.107)	(0.100)	(0.065)
Married	0.139**	0.088*	0.127**	0.087*	0.333**	0.290***	0.469***	0.475***	0.296**	0.185*	0.237**	0.085
	(0.048)	(0.042)	(0.040)	(0.039)	(0.102)	(0.077)	(0.082)	(0.087)	(0.099)	(0.087)	(0.080)	(0.071)
Other Income	-0.015**	0.009	-0.001	0.006	0.037	0.031**	0.012	-0.001	-0.006	-0.024*	-0.023*	0.321***
	(0.006)	(0.007)	(0.003)	(0.006)	(0.022)	(0.011)	(0.014)	(0.016)	(0.015)	(0.011)	(0.011)	(0.067)
Assets	0.023***	0.025***	0.030***	0.022***	0.017*	0.000	0.021**	0.012*	0.032***	0.022**	0.021***	-0.002
	(0.004)	(0.003)	(0.003)	(0.003)	(0.008)	(0.001)	(0.007)	(0.006)	(0.009)	(0.007)	(0.003)	(0.003)
Children	0.138**	0.110**	0.128***	0.173***	0.115	0.068	0.030	0.103	-0.134	-0.084	-0.009	0.071
	(0.046)	(0.037)	(0.036)	(0.036)	(0.089)	(0.056)	(0.071)	(0.079)	(0.100)	(0.088)	(0.084)	(0.070)
Constant	-3.049***	-2.528***	-3.856***	-3.858***	-0.041	-1.602***	-1.196**	-1.269**	0.307	-0.506	-1.457***	0.223
	(0.231)	(0.218)	(0.206)	(0.217)	(0.451)	(0.319)	(0.367)	(0.406)	(0.577)	(0.486)	(0.436)	(0.359)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.27	-0.80	-0.76	-0.76	-0.63	-0.83	-0.69	-0.39	-0.67	-0.64	-0.73	-0.78
σ	0.37	0.55	0.52	0.52	0.53	0.82	0.55	0.52	0.46	0.43	0.44	0.68
λ	-0.10	-0.44	-0.40	-0.40	-0.33	-0.68	-0.38	-0.20	-0.31	-0.28	-0.32	-0.53
N	8,888	8,408	8,440	8,394	2,325	2,577	2,418	2,233	2,251	2,672	3,278	2,580

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	LV 2010	LV 2012	LV 2015	MT 2009	MT 2010	MT 2012	MT 2014	NL 2008	NL 2010	NL 2012	PL 2008	PL 2010
ln w Equation												
Age	0.028**	0.036***	0.031***	0.070***	0.056***	0.041***	0.047***	0.103***	0.103***	0.091***	0.071***	0.075***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.007)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)
Age^2	-0.035**	-0.046***	-0.042***	-0.070***	-0.055***	-0.038***	-0.044***	-0.101***	-0.102***	-0.087***	-0.079***	-0.081***
	(0.013)	(0.012)	(0.011)	(0.011)	(0.008)	(0.007)	(0.007)	(0.005)	(0.005)	(0.005)	(0.007)	(0.008)
Education: medium	0.256***	0.072	0.114**	0.226***	0.242***	0.268***	0.265***	0.147***	0.159***	0.174***	0.250***	0.248***
	(0.055)	(0.043)	(0.036)	(0.033)	(0.026)	(0.022)	(0.025)	(0.015)	(0.016)	(0.016)	(0.027)	(0.032)
Education: high	0.873***	0.427***	0.543***	0.511***	0.498***	0.625***	0.642***	0.507***	0.501***	0.508***	0.769***	0.750***
	(0.089)	(0.052)	(0.043)	(0.040)	(0.031)	(0.027)	(0.027)	(0.016)	(0.016)	(0.016)	(0.033)	(0.038)
Married	0.154***	0.039	0.018	0.143***	0.094**	0.129***	0.057*	0.080***	0.070***	0.076***	0.085***	0.096***
	(0.035)	(0.032)	(0.027)	(0.041)	(0.032)	(0.029)	(0.028)	(0.013)	(0.013)	(0.013)	(0.020)	(0.023)
Constant	2.105***	2.566***	3.099***	2.332***	2.769***	3.111***	3.149***	2.546***	2.613***	2.825***	2.853***	2.902***
	(0.269)	(0.189)	(0.168)	(0.184)	(0.138)	(0.119)	(0.122)	(0.079)	(0.085)	(0.084)	(0.121)	(0.141)
Participation												
Age	0.040**	0.052**	0.085***	0.139***	0.091***	0.065**	0.095***	0.066*	0.078***	0.114***	0.147***	0.146***
	(0.016)	(0.016)	(0.019)	(0.023)	(0.024)	(0.024)	(0.023)	(0.029)	(0.021)	(0.019)	(0.014)	(0.013)
Age^2	-0.046*	-0.067**	-0.107***	-0.161***	-0.104***	-0.071*	-0.103***	-0.087*	-0.095***	-0.143***	-0.177***	-0.175***
	(0.020)	(0.021)	(0.024)	(0.030)	(0.030)	(0.030)	(0.029)	(0.036)	(0.026)	(0.023)	(0.018)	(0.017)
Education: medium	0.406***	0.375***	0.171*	0.687***	0.555***	0.582***	0.788***	0.147	0.221**	0.182*	0.446***	0.578***
	(0.060)	(0.063)	(0.076)	(0.106)	(0.106)	(0.090)	(0.111)	(0.110)	(0.081)	(0.077)	(0.064)	(0.061)
Education: high	1.010***	0.899***	0.647***	0.953***	0.833***	1.136***	1.048***	0.174	0.336***	0.248**	0.819***	1.070***
	(0.089)	(0.090)	(0.109)	(0.173)	(0.167)	(0.168)	(0.146)	(0.113)	(0.090)	(0.082)	(0.091)	(0.085)
Elderly	-0.153*	-0.294***	-0.446***	-0.038	-0.037	-0.147	-0.264*	-0.246	-0.073	-0.114	-0.133**	-0.061
	(0.062)	(0.053)	(0.066)	(0.114)	(0.110)	(0.103)	(0.103)	(0.184)	(0.170)	(0.145)	(0.048)	(0.048)
Married	0.217***	0.284***	0.206**	0.426***	0.548***	0.729***	0.498***	0.280**	0.170*	0.298***	0.329***	0.363***
	(0.056)	(0.055)	(0.065)	(0.113)	(0.111)	(0.103)	(0.103)	(0.104)	(0.081)	(0.072)	(0.057)	(0.058)
Other Income	-0.107	0.184***	0.114**	-0.117***	-0.086***	0.001	0.016	-0.085***	-0.089***	-0.029***	-0.031***	-0.065***
	(0.060)	(0.052)	(0.037)	(0.034)	(0.025)	(0.016)	(0.014)	(0.015)	(0.012)	(0.007)	(0.006)	(0.006)
Assets	0.062	0.751**	0.020	0.005	0.007*	-0.001	-0.001	0.001	0.003*	0.001	0.000	0.003
	(0.048)	(0.263)	(0.020)	(0.003)	(0.003)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Children	0.139*	0.049	0.045	0.147	0.041	-0.050	0.017	0.419***	0.196*	0.114	0.257***	0.231***
	(0.058)	(0.054)	(0.067)	(0.117)	(0.120)	(0.106)	(0.105)	(0.104)	(0.078)	(0.070)	(0.057)	(0.056)
Constant	-0.927**	-0.950**	-0.914*	-2.014***	-1.062*	-0.793	-1.283**	0.737	0.056	-0.737*	-2.210***	-2.426***
	(0.291)	(0.311)	(0.368)	(0.430)	(0.458)	(0.456)	(0.449)	(0.570)	(0.402)	(0.359)	(0.253)	(0.250)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	0.18	-0.74	-0.64	0.02	-0.01	0.11	0.05	0.01	-0.05	0.00	0.21	0.22
σ	0.63	0.70	0.61	0.58	0.45	0.42	0.44	0.42	0.41	0.41	0.51	0.54
λ	0.11	-0.52	-0.39	0.01	-0.00	0.05	0.02	0.00	-0.02	0.00	0.10	0.12
N	2,995	2,888	2,623	2,138	2,043	2,444	2,522	5,517	5,182	5,219	6,880	5,945

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	PL 2012	PL 2014	PT 2008	PT 2010	PT 2012	PT 2014	RO 2008	RO 2010	RO 2012	RO 2014	SE 2008	SE 2010
ln w Equation												
Age	0.045***	0.072***	0.056***	0.081***	0.081***	0.078***	0.031***	0.015**	0.015*	0.018**	0.098***	0.091***
	(0.006)	(0.005)	(0.008)	(0.008)	(0.008)	(0.009)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Age^2	-0.046***	-0.078***	-0.053***	-0.085***	-0.080***	-0.074***	-0.032***	-0.013	-0.013	-0.016	-0.103***	-0.092***
	(0.007)	(0.006)	(0.010)	(0.010)	(0.010)	(0.011)	(0.008)	(0.007)	(0.007)	(0.008)	(0.008)	(0.009)
Education: medium	-0.081***	-0.086***	0.387***	0.327***	0.395***	0.339***	0.237***	0.130***	0.150***	-0.161***	0.014	0.018
	(0.021)	(0.018)	(0.033)	(0.033)	(0.027)	(0.027)	(0.030)	(0.027)	(0.027)	(0.024)	(0.035)	(0.040)
Education: high	0.368***	0.444***	0.903***	0.900***	0.924***	0.824***	0.856***	0.686***	0.648***	0.293***	0.229***	0.204***
	(0.026)	(0.023)	(0.039)	(0.041)	(0.033)	(0.032)	(0.037)	(0.032)	(0.031)	(0.032)	(0.039)	(0.043)
Married	-0.008	0.080***	0.023	0.029	0.020	0.064*	0.044	0.058**	0.043*	0.024	0.043	0.047
	(0.022)	(0.019)	(0.032)	(0.031)	(0.027)	(0.026)	(0.023)	(0.021)	(0.021)	(0.022)	(0.023)	(0.024)
Constant	4.064***	3.331***	2.566***	2.008***	1.868***	1.854***	2.968***	3.577***	3.695***	4.053***	5.059***	5.231***
	(0.118)	(0.097)	(0.148)	(0.157)	(0.163)	(0.193)	(0.130)	(0.123)	(0.129)	(0.137)	(0.128)	(0.143)
Participation												
Age	0.168***	0.151***	0.075***	0.121***	0.129***	0.148***	0.139***	0.185***	0.182***	0.194***	0.105***	0.130***
	(0.012)	(0.012)	(0.022)	(0.017)	(0.016)	(0.015)	(0.022)	(0.022)	(0.022)	(0.022)	(0.017)	(0.018)
Age^2	-0.202***	-0.177***	-0.096***	-0.142***	-0.149***	-0.170***	-0.164***	-0.217***	-0.201***	-0.218***	-0.119***	-0.154***
	(0.015)	(0.015)	(0.028)	(0.022)	(0.020)	(0.019)	(0.029)	(0.028)	(0.028)	(0.027)	(0.022)	(0.023)
Education: medium	0.047	0.093	0.183	0.443***	0.348***	0.396***	0.638***	0.604***	0.421***	0.289***	0.395***	0.396***
	(0.050)	(0.048)	(0.110)	(0.084)	(0.068)	(0.062)	(0.086)	(0.085)	(0.093)	(0.085)	(0.078)	(0.084)
Education: high	0.538***	0.623***	0.333*	0.861***	0.869***	0.714***	1.153***	0.845***	0.709***	0.401**	0.643***	0.630***
	(0.076)	(0.072)	(0.149)	(0.113)	(0.100)	(0.085)	(0.167)	(0.131)	(0.131)	(0.128)	(0.101)	(0.105)
Elderly	-0.274***	-0.151***	-0.206*	0.016	-0.181**	-0.162*	-0.353***	-0.257***	-0.409***	-0.507***	-0.332**	-0.403***
	(0.041)	(0.043)	(0.087)	(0.058)	(0.063)	(0.063)	(0.075)	(0.074)	(0.074)	(0.071)	(0.115)	(0.117)
Married	0.414***	0.444***	0.303**	0.206**	0.347***	0.369***	0.174	0.233**	0.132	0.253**	0.038	0.150*
	(0.050)	(0.050)	(0.096)	(0.069)	(0.062)	(0.057)	(0.094)	(0.089)	(0.088)	(0.085)	(0.067)	(0.067)
Other Income	-0.011***	-0.031***	-0.046*	-0.094***	-0.121***	-0.172***	0.106*	0.086**	0.156***	0.184***	-0.001	-0.003*
	(0.003)	(0.004)	(0.020)	(0.017)	(0.015)	(0.016)	(0.045)	(0.032)	(0.033)	(0.028)	(0.001)	(0.001)
Assets	0.001	0.000	0.020	0.005	0.015*	0.004	0.008	4.290	0.039	-0.035	0.000	0.000***
	(0.001)	(0.000)	(0.016)	(0.006)	(0.006)	(0.002)	(0.021)	(9.400e+08)	(0.084)	(0.084)	(0.000)	(0.000)
Children	0.136**	0.271***	0.077	0.070	0.054	0.164**	-0.176*	-0.111	0.010	-0.185*	-0.146*	-0.205**
	(0.049)	(0.047)	(0.091)	(0.058)	(0.058)	(0.055)	(0.089)	(0.083)	(0.078)	(0.075)	(0.063)	(0.067)
Constant	-2.474***	-2.412***	-0.307	-1.694***	-2.155***	-2.677***	-2.005***	-3.039***	-3.253***	-3.120***	-1.063***	-1.494***
	(0.234)	(0.231)	(0.418)	(0.331)	(0.309)	(0.300)	(0.412)	(0.420)	(0.445)	(0.438)	(0.302)	(0.316)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.57	0.61	-0.33	0.89	0.52	0.47	-0.39	-0.55	-0.51	-0.68	-0.77	-0.79
σ	0.58	0.52	0.51	0.58	0.51	0.53	0.46	0.41	0.40	0.44	0.67	0.69
λ	-0.33	0.32	-0.16	0.52	0.27	0.25	-0.18	-0.23	-0.20	-0.30	-0.52	-0.55
N	6,833	6,585	2,218	2,458	3,037	3,341	3,230	3,104	2,922	2,886	3,910	3,630

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	SE 2012	SI 2008	SI 2010	SI 2012	SI 2014	SK 2008	SK 2010	SK 2012	SK 2014	UK 2008	UK 2009	UK 2012
ln w Equation												
Age	0.079***	0.014**	0.017***	0.011	0.001	0.031***	0.043***	0.016**	0.037***	0.081***	0.081***	0.074***
	(0.008)	(0.005)	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.005)
Age^2	-0.078***	-0.005	-0.009	0.000	0.009	-0.038***	-0.052***	-0.019**	-0.046***	-0.087***	-0.086***	-0.076***
	(0.010)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.005)	(0.005)	(0.006)
Education: medium	0.088	0.214***	0.160***	0.116***	0.126***	0.273***	0.018	0.096*	0.034	0.127***	0.113***	0.119***
	(0.046)	(0.017)	(0.019)	(0.022)	(0.024)	(0.040)	(0.046)	(0.046)	(0.045)	(0.015)	(0.016)	(0.017)
Education: high	0.215***	0.739***	0.714***	0.572***	0.545***	0.604***	0.357***	0.389***	0.311***	0.373***	0.377***	0.374***
	(0.049)	(0.021)	(0.023)	(0.026)	(0.027)	(0.044)	(0.050)	(0.048)	(0.048)	(0.015)	(0.015)	(0.017)
Married	0.070*	0.011	0.015	0.023	0.020	0.006	0.023	0.052*	0.049*	0.060***	0.046***	0.046**
	(0.028)	(0.015)	(0.016)	(0.017)	(0.017)	(0.024)	(0.022)	(0.021)	(0.021)	(0.012)	(0.013)	(0.015)
Constant	5.541***	3.589***	3.676***	3.920***	4.140***	6.004***	2.717***	3.301***	2.974***	2.776***	2.819***	2.944***
	(0.170)	(0.092)	(0.099)	(0.112)	(0.118)	(0.105)	(0.125)	(0.125)	(0.121)	(0.075)	(0.079)	(0.092)
Participation												
Age	0.151***	0.149***	0.152***	0.154***	0.182***	0.094***	0.181***	0.171***	0.163***	0.097***	0.121***	0.137***
	(0.018)	(0.013)	(0.012)	(0.013)	(0.012)	(0.019)	(0.018)	(0.018)	(0.017)	(0.011)	(0.011)	(0.012)
Age^2	-0.171***	-0.192***	-0.192***	-0.193***	-0.221***	-0.111***	-0.209***	-0.196***	-0.183***	-0.108***	-0.134***	-0.154***
	(0.023)	(0.017)	(0.016)	(0.016)	(0.016)	(0.025)	(0.023)	(0.023)	(0.021)	(0.014)	(0.014)	(0.016)
Education: medium	0.415***	0.319***	0.317***	0.305***	0.263***	0.698***	1.048***	0.744***	0.899***	0.167***	0.284***	0.210***
	(0.088)	(0.046)	(0.046)	(0.048)	(0.050)	(0.105)	(0.097)	(0.111)	(0.100)	(0.048)	(0.046)	(0.051)
Education: high	0.554***	0.656***	0.739***	0.839***	0.708***	1.200***	1.553***	1.010***	1.442***	0.355***	0.438***	0.350***
	(0.103)	(0.070)	(0.067)	(0.066)	(0.065)	(0.144)	(0.124)	(0.128)	(0.124)	(0.055)	(0.050)	(0.056)
Elderly	-0.600***	-0.078	-0.124***	-0.168***	-0.194***	-0.246***	-0.249***	-0.234***	-0.299***	-0.608***	-0.501***	-0.633***
	(0.121)	(0.041)	(0.037)	(0.035)	(0.035)	(0.062)	(0.060)	(0.059)	(0.059)	(0.052)	(0.052)	(0.059)
Married	0.030	0.122**	0.206***	0.124**	0.117**	0.149	0.152*	0.161*	0.044	0.358***	0.346***	0.511***
	(0.069)	(0.046)	(0.044)	(0.042)	(0.040)	(0.090)	(0.077)	(0.075)	(0.071)	(0.044)	(0.040)	(0.046)
Other Income	0.001	0.011	0.004	0.008*	0.008*	0.002**	0.060**	0.041*	0.047***	0.005	0.040***	0.020*
	(0.001)	(0.007)	(0.003)	(0.004)	(0.004)	(0.001)	(0.019)	(0.016)	(0.012)	(0.011)	(0.011)	(0.010)
Assets	0.000	0.006***	0.002**	0.002***	0.001***	0.003*	0.059	0.005	0.020	0.003***	0.003***	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.084)	(0.032)	(0.033)	(0.001)	(0.001)	(0.000)
Children	-0.055	0.302***	0.137**	0.080*	0.258***	-0.149	0.040	-0.007	0.043	-0.107**	-0.028	-0.080
	(0.070)	(0.049)	(0.044)	(0.040)	(0.038)	(0.088)	(0.078)	(0.074)	(0.069)	(0.041)	(0.038)	(0.044)
Constant	-2.244***	-2.197***	-2.414***	-2.502***	-3.259***	-1.214***	-3.724***	-3.389***	-3.547***	-0.685**	-1.618***	-2.000***
	(0.336)	(0.256)	(0.240)	(0.245)	(0.244)	(0.366)	(0.348)	(0.354)	(0.338)	(0.220)	(0.203)	(0.233)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ρ	-0.66	-0.62	-0.78	-0.86	-0.84	-0.76	-0.41	-0.56	-0.59	-0.72	-0.70	-0.64
σ	0.71	0.48	0.51	0.55	0.56	0.46	0.41	0.42	0.42	0.55	0.56	0.56
λ	-0.47	-0.30	-0.40	-0.47	-0.47	-0.35	-0.17	-0.23	-0.25	-0.40	-0.39	-0.36
N	3,201	6,774	6,642	6,238	6,116	3,669	3,626	3,435	3,362	9,731	9,556	7,688

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Wage Estimation: Men – Continued

	UK 2013
ln w Equation	
Age	0.077***
	(0.005)
Age^2	-0.079***
	(0.006)
Education: medium	0.115***
	(0.017)
Education: high	0.392***
	(0.017)
Married	0.036*
	(0.014)
Constant	2.910***
	(0.090)
Participation	
Age	0.102***
	(0.013)
Age^2	-0.114***
	(0.017)
Education: medium	0.200***
	(0.054)
Education: high	0.289***
	(0.057)
Elderly	-0.558***
	(0.063)
Married	0.393***
	(0.048)
Other Income	0.022
	(0.012)
Assets	0.001**
	(0.000)
Children	-0.077
	(0.046)
Constant	-1.274***
	(0.250)
Regional dummies	Yes
ρ	-0.65
σ	0.56
λ	-0.36
N	7,559

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Table B.5.: Labor Supply Estimation: Single Women

	AT (pooled)	BE (pooled)	BG (pooled)	CY (pooled)	CZ (pooled)	DE (pooled)	DK (pooled)	EE (pooled)	EL (pooled)	ES (pooled)
Cx										
Age_f	0.000	-0.002***	0.002*	-0.001	0.000**	0.000*	0.000	0.001	0.000	0.001**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Age_f^2	-0.001	0.003***	-0.003*	0.001	-0.000**	-0.001*	-0.000*	-0.001	-0.000	-0.001*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.001)	(0.000)
Elderly	0.007***	0.006***	0.017***	0.003***	0.002***	0.002**	0.000	0.034***	0.003*	-0.000
	(0.001)	(0.002)	(0.003)	(0.001)	(0.000)	(0.001)	(0.000)	(0.004)	(0.001)	(0.001)
Semi-Flexible	-0.002*	-0.007***	0.001	-0.001	-0.000*	-0.004***	-0.001***	-0.004	-0.001	-0.000
	(0.001)	(0.001)	(0.003)	(0.001)	(0.000)	(0.001)	(0.000)	(0.004)	(0.001)	(0.001)
Constant	0.002	0.052***	-0.040	0.013*	-0.001	0.008	-0.001	0.019	-0.005	-0.002
	(0.007)	(0.008)	(0.021)	(0.006)	(0.001)	(0.005)	(0.001)	(0.027)	(0.009)	(0.004)
CxC										
Constant	-0.000	-0.000	0.000	-0.000	-0.000	-0.000***	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1										
Constant	0.000	-0.000	0.000*	0.000	-0.000	-0.000	0.000	0.000	0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x										
Age_f	-0.001	-0.018***	0.000	0.002	0.005	0.001	0.006	-0.002	0.001	0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.001)	(0.005)	(0.003)	(0.003)	(0.001)
Age_f^2	0.001	0.025***	-0.001	-0.004*	-0.008*	-0.001	-0.007	0.000	-0.003	-0.002
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)	(0.006)	(0.003)	(0.004)	(0.002)
Elderly	0.116***	0.099***	0.094***	0.087***	0.150***	0.032***	0.040*	0.151***	0.069***	0.056***
	(0.010)	(0.014)	(0.006)	(0.005)	(0.009)	(0.006)	(0.018)	(0.011)	(0.010)	(0.006)
Semi-Flexible	-0.011	-0.034***	0.006	0.010	-0.011	-0.030***	-0.067***	0.011	0.008	0.014**
	(0.008)	(0.009)	(0.007)	(0.005)	(0.007)	(0.005)	(0.014)	(0.010)	(0.009)	(0.005)
Constant	0.212***	0.562***	0.503***	0.287***	0.528***	0.264***	0.285**	0.473***	0.160*	0.136***
	(0.056)	(0.060)	(0.055)	(0.041)	(0.065)	(0.032)	(0.101)	(0.065)	(0.067)	(0.032)
L1xL1										
Constant	-0.003***	-0.003***	-0.008***	-0.005***	-0.009***	-0.003***	-0.004***	-0.006***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND										
$H > 0$	-6.314***	-6.547***	-19.885***	-12.630***	-20.073***	-4.671***	-6.431***	-16.008***	-11.103***	-9.638***
	(0.261)	(0.310)	(0.681)	(0.521)	(0.526)	(0.184)	(0.517)	(0.594)	(0.397)	(0.235)
Parttime (f)	3.239***	3.307***	6.511***	4.130***	6.228***	1.650***	1.953***	6.376***	4.274***	4.341***
	(0.143)	(0.178)	(0.275)	(0.223)	(0.212)	(0.103)	(0.212)	(0.242)	(0.190)	(0.126)
Fulltime (f)	2.345***	2.192***	2.640***	2.460***	2.664***	1.118***	1.936***	3.170***	2.374***	2.926***
	(0.105)	(0.130)	(0.119)	(0.134)	(0.093)	(0.068)	(0.154)	(0.131)	(0.129)	(0.091)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.01	0.00	0.00	0.04	0.06	0.01	0.15	0.00	0.06	0.00
λ	0.10	0.10	1.10	1.10	2.60	0.10	5.10	1.10	0.60	0.10
N	4253	3116	3127	2681	4509	7302	1849	2905	3445	8011

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Single Women – Continued

	FI (pooled)	FR (pooled)	HU (pooled)	IE (pooled)	IT (pooled)	LT (pooled)	LU (pooled)	LV (pooled)	MT (pooled)	NL (pooled)
Cx										
Age_f	0.000	0.000	0.000	0.000	0.001***	0.003**	0.000	0.000	-0.001	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Age_f^2	-0.000	-0.000	-0.000*	-0.000	-0.001**	-0.004**	-0.000	-0.000	0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Elderly	0.007***	0.006***	0.000***	0.000	0.004***	0.019***	0.001	0.016***	-0.004	0.004*
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.001)	(0.003)	(0.002)	(0.002)
Semi-Flexible	-0.000	-0.001	-0.000*	0.002*	0.001*	0.000	-0.002**	-0.005	-0.008***	0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.003)	(0.001)	(0.003)	(0.002)	(0.001)
Constant	-0.008	-0.001	0.000	0.008	-0.017***	-0.045	0.001	0.024	0.041**	-0.002
	(0.005)	(0.006)	(0.000)	(0.007)	(0.005)	(0.024)	(0.006)	(0.013)	(0.016)	(0.007)
CxC										
Constant	-0.000	-0.000	-0.000***	-0.000***	0.000*	-0.000	0.000**	-0.000*	-0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1										
Constant	0.000	-0.000	-0.000***	-0.000*	0.000*	0.000	0.000***	-0.000	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x										
Age_f	-0.005*	-0.001	-0.000	0.001	0.008***	0.004	0.003	-0.003	-0.000	-0.005
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)
Age_f^2	0.007**	0.002	-0.000	-0.001	-0.010***	-0.007*	-0.004	0.002	-0.002	0.008*
	(0.002)	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.002)	(0.004)	(0.004)
Elderly	0.089***	0.076***	0.137***	0.042**	0.110***	0.092***	0.027**	0.111***	0.047***	0.077***
	(0.010)	(0.006)	(0.006)	(0.013)	(0.007)	(0.007)	(0.009)	(0.006)	(0.013)	(0.018)
Semi-Flexible	-0.007	-0.001	-0.007	0.023*	0.033***	0.001	-0.012	0.003	-0.033***	0.041***
	(0.006)	(0.006)	(0.006)	(0.011)	(0.006)	(0.007)	(0.008)	(0.006)	(0.010)	(0.010)
Constant	0.301***	0.149***	0.104*	0.215**	0.149**	0.195**	0.190**	0.270***	0.233**	0.340***
	(0.038)	(0.041)	(0.052)	(0.077)	(0.045)	(0.063)	(0.066)	(0.037)	(0.086)	(0.076)
L1xL1										
Constant	-0.004***	-0.002***	-0.002***	-0.002***	-0.005***	-0.005***	-0.004***	-0.004***	-0.002***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND										
$H > 0$	-11.471***	-5.978***	-9.487***	-6.712***	-10.190***	-17.039***	-8.688***	-13.640***	-7.688***	-4.091***
	(0.262)	(0.223)	(0.318)	(0.315)	(0.205)	(0.543)	(0.422)	(0.410)	(0.514)	(0.236)
Parttime (f)	5.382***	3.424***	4.680***	4.076***	3.534***	7.228***	3.743***	6.031***	3.162***	3.076***
	(0.118)	(0.128)	(0.155)	(0.239)	(0.090)	(0.231)	(0.208)	(0.186)	(0.286)	(0.172)
Fulltime (f)	3.492***	2.698***	3.274***	2.606***	2.075***	3.840***	1.715***	3.589***	2.417***	2.548***
	(0.089)	(0.093)	(0.095)	(0.188)	(0.067)	(0.140)	(0.136)	(0.112)	(0.204)	(0.152)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.00	0.00	0.07	0.03	0.01	0.01	0.01	0.00	0.05	0.00
λ	0.10	0.10	5.10	0.10	0.10	0.10	0.10	0.10	1.10	0.10
N	8269	5615	5348	2151	12042	3623	2044	4851	1344	4746

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Single Women – Continued

	PL (pooled)	PT (pooled)	RO (pooled)	SE (pooled)	SI (pooled)	SK (pooled)	UK (pooled)
Cx							
Age_f	0.001***	-0.000	0.001	0.000	0.001	0.004*	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.002)	(0.000)
Age_f^2	-0.001***	0.001	-0.001	-0.000	-0.001	-0.005**	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.002)	(0.000)
Elderly	0.004***	-0.003*	0.021***	0.001**	0.009***	0.026***	-0.004***
	(0.000)	(0.001)	(0.003)	(0.000)	(0.001)	(0.004)	(0.001)
Semi-Flexible	-0.001*	-0.007***	-0.002	-0.000*	-0.005***	-0.009*	-0.005***
	(0.000)	(0.001)	(0.003)	(0.000)	(0.001)	(0.004)	(0.000)
Constant	-0.005	0.007	-0.007	0.000	-0.019	-0.052	0.012***
	(0.004)	(0.010)	(0.015)	(0.001)	(0.012)	(0.034)	(0.004)
CxC							
Constant	-0.000***	0.000	-0.000	0.000	0.000***	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1							
Constant	0.000	0.000*	0.000	0.000	0.000***	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x							
Age_f	0.004**	-0.002	-0.003	-0.000	-0.005	0.002	-0.005***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)
Age_f^2	-0.007***	0.002	0.002	0.001	0.007*	-0.004	0.005***
	(0.002)	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)
Elderly	0.080***	0.051***	0.132***	0.086***	0.101***	0.101***	0.014**
	(0.004)	(0.005)	(0.011)	(0.019)	(0.006)	(0.006)	(0.005)
Semi-Flexible	0.005	-0.015***	0.009	-0.012	-0.022***	-0.006	-0.029***
	(0.004)	(0.004)	(0.012)	(0.010)	(0.005)	(0.006)	(0.003)
Constant	0.280***	0.244***	0.725***	0.208**	0.478***	0.512***	0.295***
	(0.035)	(0.042)	(0.077)	(0.070)	(0.063)	(0.063)	(0.021)
L1xL1							
Constant	-0.005***	-0.004***	-0.011***	-0.005***	-0.007***	-0.008***	-0.003***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
IND							
$H > 0$	-13.592***	-13.694***	-29.579***	-18.931***	-20.851***	-21.626***	-8.367***
	(0.320)	(0.484)	(1.193)	(0.588)	(0.533)	(0.640)	(0.141)
Parttime (f)	4.789***	5.262***	8.923***	10.783***	7.857***	7.328***	4.076***
	(0.135)	(0.217)	(0.505)	(0.285)	(0.215)	(0.259)	(0.086)
Fulltime (f)	2.445***	3.118***	3.433***	5.333***	3.547***	3.401***	2.604***
	(0.077)	(0.128)	(0.141)	(0.224)	(0.109)	(0.120)	(0.067)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.03	0.03	0.00	0.00	0.00	0.06	0.02
λ	0.10	0.10	1.10	0.10	0.10	0.60	1.60
N	7669	3413	2665	3613	5768	3993	15001

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Table B.6.: Labor Supply Estimation: Single Men

	AT (pooled)	BE (pooled)	BG (pooled)	CY (pooled)	CZ (pooled)	DE (pooled)	DK (pooled)	EE (pooled)	EL (pooled)	ES (pooled)
Cx										
Age_m	0.001*	0.002***	0.002*	-0.001	0.000*	-0.000	0.000	0.002	0.001*	0.001***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Age_m^2	-0.001**	-0.002***	-0.003**	0.000	-0.000**	-0.000	-0.000	-0.003	-0.001*	-0.001***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
Semi-Flexible	-0.002*	-0.002	-0.005	-0.001	-0.000	-0.002***	-0.000	-0.006	-0.004***	-0.002***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)	(0.000)	(0.004)	(0.001)	(0.001)
Constant	-0.012*	-0.032***	-0.042*	0.020**	-0.002**	0.008	-0.001	-0.037	-0.014	-0.007
	(0.006)	(0.006)	(0.019)	(0.007)	(0.001)	(0.004)	(0.001)	(0.023)	(0.011)	(0.005)
CxC										
Constant	0.000***	0.000*	0.000***	-0.000**	0.000***	0.000	0.000*	0.000*	0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1										
Constant	0.000***	0.000***	0.000***	0.000**	0.000***	0.000**	0.000***	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x										
Age_m	0.006**	0.011***	0.004	-0.002	0.007**	-0.001	-0.005	0.010*	0.006	0.008***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)	(0.003)	(0.002)
Age_m^2	-0.008**	-0.010**	-0.007**	0.001	-0.010**	0.002	0.006	-0.013**	-0.007*	-0.008***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.005)	(0.005)	(0.004)	(0.002)
Semi-Flexible	-0.040***	-0.020*	-0.035***	-0.032***	-0.046***	-0.051***	-0.030*	-0.048***	-0.035***	-0.028***
	(0.007)	(0.009)	(0.007)	(0.006)	(0.009)	(0.004)	(0.014)	(0.013)	(0.007)	(0.005)
Constant	0.178***	0.011	0.328***	0.378***	0.285***	0.615***	0.375***	0.077	0.149*	0.268***
	(0.046)	(0.053)	(0.058)	(0.058)	(0.056)	(0.031)	(0.081)	(0.083)	(0.069)	(0.039)
L1xL1										
Constant	-0.006***	-0.005***	-0.007***	-0.005***	-0.008***	-0.009***	-0.005***	-0.005***	-0.004***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND										
$H > 0$	-15.624***	-14.975***	-18.031***	-14.825***	-23.450***	-17.908***	-15.200***	-19.716***	-13.974***	-17.066***
	(0.474)	(0.602)	(0.715)	(0.647)	(0.714)	(0.431)	(0.848)	(0.805)	(0.459)	(0.368)
Parttime (m)	5.092***	5.079***	5.439***	4.940***	6.642***	4.427***	4.992***	7.249***	3.960***	5.052***
	(0.200)	(0.255)	(0.293)	(0.280)	(0.305)	(0.181)	(0.358)	(0.335)	(0.194)	(0.156)
Fulltime (m)	2.176***	2.442***	1.996***	2.508***	2.267***	1.144***	2.510***	3.354***	1.613***	2.165***
	(0.073)	(0.105)	(0.115)	(0.109)	(0.078)	(0.056)	(0.149)	(0.136)	(0.082)	(0.059)
$dU/dC < 0$	0.00	0.00	0.03	0.04	0.00	0.00	0.05	0.01	0.01	0.00
λ	0.10	0.10	1.10	1.10	0.10	0.10	4.60	1.10	0.10	0.10
N	4667	2913	2408	2335	4651	6727	1285	2260	4178	8788

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Single Men – Continued

	FI (pooled)	FR (pooled)	HU (pooled)	IE (pooled)	IT (pooled)	LT (pooled)	LU (pooled)	LV (pooled)	MT (pooled)	NL (pooled)
Cx										
Age_m	-0.000	0.001***	0.000***	0.001	0.002***	0.002*	0.000	0.002*	0.002***	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
Age_m^2	0.000	-0.001***	-0.000***	-0.001*	-0.002***	-0.003*	-0.000	-0.003**	-0.002***	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
Semi-Flexible	0.003***	-0.001	-0.000***	0.000	-0.003***	-0.008*	-0.004***	-0.002	-0.005***	0.001
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)
Constant	-0.007	-0.009	-0.000	0.007	-0.027***	-0.067**	-0.002	-0.029	-0.025**	-0.026***
	(0.004)	(0.005)	(0.000)	(0.006)	(0.005)	(0.024)	(0.005)	(0.017)	(0.010)	(0.008)
CxC										
Constant	0.000***	0.000	-0.000***	-0.000***	-0.000***	0.000***	0.000***	0.000**	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1										
Constant	0.000***	0.000	0.000***	-0.000***	0.000*	0.001***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x										
Age_m	-0.005**	0.008***	0.006**	0.007*	0.019***	0.007*	0.001	0.007**	0.005*	0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.004)
Age_m^2	0.009***	-0.010***	-0.008***	-0.008*	-0.022***	-0.011**	-0.001	-0.011***	-0.007**	-0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.004)
Semi-Flexible	0.005	-0.017***	-0.044***	-0.018*	-0.042***	-0.053***	-0.067***	-0.027***	-0.065***	-0.021*
	(0.006)	(0.005)	(0.004)	(0.008)	(0.004)	(0.009)	(0.007)	(0.006)	(0.006)	(0.009)
Constant	0.280***	0.136***	-0.004	0.223***	0.177***	-0.075	0.532***	-0.022	0.391***	-0.083
	(0.038)	(0.036)	(0.040)	(0.065)	(0.046)	(0.073)	(0.054)	(0.050)	(0.051)	(0.079)
L1xL1										
Constant	-0.005***	-0.004***	-0.002***	-0.004***	-0.008***	-0.003***	-0.009***	-0.003***	-0.008***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND										
$H > 0$	-15.668***	-10.112***	-9.382***	-12.141***	-18.815***	-15.680***	-23.533***	-13.899***	-23.967***	-13.409***
	(0.369)	(0.346)	(0.360)	(0.545)	(0.272)	(0.654)	(0.880)	(0.508)	(0.793)	(0.403)
Parttime (m)	5.590***	3.884***	4.117***	4.186***	5.032***	6.425***	7.645***	5.669***	7.384***	6.128***
	(0.154)	(0.153)	(0.165)	(0.240)	(0.113)	(0.285)	(0.359)	(0.226)	(0.341)	(0.169)
Fulltime (m)	2.736***	2.238***	2.585***	2.039***	1.972***	3.590***	2.629***	3.280***	3.009***	4.196***
	(0.073)	(0.074)	(0.085)	(0.127)	(0.045)	(0.152)	(0.101)	(0.122)	(0.094)	(0.126)
$dU/dC < 0$	0.06	0.00	0.00	0.00	0.01	0.05	0.00	0.03	0.02	0.03
λ	0.10	0.10	0.10	0.10	0.10	0.60	0.10	0.10	0.10	1.60
N	6582	5080	4674	2281	14776	2330	3011	3262	3986	5164

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Single Men – Continued

	PL (pooled)	PT (pooled)	RO (pooled)	SE (pooled)	SI (pooled)	SK (pooled)	UK (pooled)
Cx							
Age_m	0.001***	-0.001	0.002***	0.000	0.002***	0.003	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)
Age^2_m	-0.001***	0.001	-0.002***	-0.000	-0.002***	-0.004*	0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.000)
Semi-Flexible	-0.001**	-0.007***	-0.001	-0.000	-0.007***	-0.017***	-0.000
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.004)	(0.000)
Constant	-0.005	0.006	-0.041***	-0.001	-0.029**	-0.084*	0.005
	(0.003)	(0.009)	(0.012)	(0.001)	(0.009)	(0.033)	(0.003)
CxC							
Constant	-0.000***	0.000	0.000	0.000	0.000**	0.000***	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1							
Constant	0.000***	0.000***	0.000***	0.000*	0.000***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x							
Age_m	0.010***	-0.004*	0.006*	0.006	0.006**	0.007	-0.003***
	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.001)
Age^2_m	-0.014***	0.005*	-0.006*	-0.007	-0.007**	-0.010*	0.004***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)	(0.001)
Semi-Flexible	-0.034***	-0.053***	-0.025***	-0.016	-0.059***	-0.070***	-0.023***
	(0.004)	(0.005)	(0.006)	(0.011)	(0.005)	(0.009)	(0.003)
Constant	0.196***	0.324***	0.480***	0.078	0.071	0.393***	0.473***
	(0.031)	(0.042)	(0.054)	(0.071)	(0.050)	(0.082)	(0.020)
L1xL1							
Constant	-0.005***	-0.005***	-0.011***	-0.005***	-0.004***	-0.010***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
IND							
$H > 0$	-14.419***	-16.095***	-30.058***	-22.915***	-15.753***	-27.911***	-19.035***
	(0.370)	(0.645)	(1.027)	(0.856)	(0.483)	(1.186)	(0.333)
Parttime (m)	4.002***	4.868***	8.547***	11.145***	6.126***	8.466***	5.783***
	(0.160)	(0.278)	(0.446)	(0.358)	(0.204)	(0.491)	(0.138)
Fulltime (m)	1.640***	2.294***	2.998***	5.711***	3.009***	2.661***	2.089***
	(0.057)	(0.109)	(0.099)	(0.232)	(0.106)	(0.122)	(0.049)
$dU/dC < 0$	0.01	0.05	0.00	0.00	0.00	0.06	0.02
λ	0.10	1.10	0.10	0.10	0.10	0.10	2.10
N	7510	2763	4348	2766	4695	2684	12404

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Table B.7.: Labor Supply Estimation: Couples

	AT (pooled)	BE (pooled)	BG (pooled)	CY (pooled)	CZ (pooled)	DE (pooled)	DK (pooled)
Cx							
Age_m	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.000*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Age_m^2	0.000	-0.000	0.000	0.000	-0.000	0.000	-0.000*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Age_f	0.000	0.000	0.001	-0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age_f^2	-0.000	-0.000	-0.001*	0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Elderly	0.002	0.005	0.021***	0.001	0.001***	0.006***	0.000
	(0.001)	(0.003)	(0.002)	(0.001)	(0.000)	(0.002)	(0.000)
Constant	0.005	0.038***	-0.002	0.018***	-0.000	0.018***	-0.001
	(0.006)	(0.007)	(0.014)	(0.005)	(0.001)	(0.004)	(0.001)
CxC							
Constant	0.000	-0.000***	0.000*	-0.000***	-0.000	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1							
Constant	0.000	-0.000***	0.000**	0.000	0.000	-0.000***	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL2							
Constant	0.000*	-0.000***	0.000***	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x							
Age_f	0.001	0.000	-0.003	-0.003	0.003	0.005***	-0.006
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)
Age_f^2	0.001	0.003	0.002	0.003	-0.003	-0.002	0.008*
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)
Elderly	0.172***	0.111***	0.128***	0.098***	0.139***	0.126***	0.096**
	(0.017)	(0.025)	(0.005)	(0.010)	(0.011)	(0.014)	(0.035)
Constant	0.192***	0.489***	0.555***	0.323***	0.509***	0.123***	0.300***
	(0.052)	(0.055)	(0.042)	(0.046)	(0.055)	(0.028)	(0.077)
L1xL1							
Constant	-0.003***	-0.004***	-0.008***	-0.004***	-0.009***	-0.002***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2x							
Age_m	-0.002	0.004	-0.001	-0.004	0.004	0.003*	0.001
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)	(0.004)
Age_m^2	0.002	-0.001	0.000	0.004	-0.005	-0.002	-0.000
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.004)
Elderly	0.048***	0.101***	0.104***	0.053***	0.143***	0.071***	0.127***
	(0.014)	(0.025)	(0.006)	(0.011)	(0.013)	(0.014)	(0.037)
Constant	0.582***	0.667***	0.552***	0.447***	0.632***	0.568***	0.593***
	(0.062)	(0.065)	(0.049)	(0.055)	(0.068)	(0.034)	(0.086)
L2xL2							
Constant	-0.009***	-0.008***	-0.009***	-0.006***	-0.011***	-0.009***	-0.010***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1xL2							
Constant	0.000	-0.001**	0.000	0.000***	0.001***	0.000**	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND							
$H > 0$	-21.432***	-16.650***	-22.514***	-15.258***	-26.343***	-19.109***	-21.802***
	(0.580)	(0.492)	(0.603)	(0.487)	(0.739)	(0.412)	(0.713)
$H > 0$	-4.236***	-6.088***	-20.414***	-10.982***	-20.989***	-2.179***	-6.140***
	(0.219)	(0.259)	(0.548)	(0.367)	(0.459)	(0.136)	(0.398)
Parttime (m)	6.470***	5.007***	7.221***	4.692***	7.650***	5.062***	6.629***
	(0.243)	(0.210)	(0.248)	(0.215)	(0.317)	(0.172)	(0.299)
Parttime (f)	2.871***	2.764***	6.572***	4.421***	6.829***	1.731***	1.913***
	(0.134)	(0.137)	(0.222)	(0.157)	(0.180)	(0.097)	(0.151)
Fulltime (m)	2.352***	2.226***	2.681***	2.378***	2.460***	1.208***	2.386***
	(0.072)	(0.075)	(0.083)	(0.076)	(0.070)	(0.048)	(0.086)
Fulltime (f)	1.968***	1.813***	2.768***	3.038***	2.959***	1.291***	2.097***
	(0.106)	(0.105)	(0.097)	(0.116)	(0.087)	(0.073)	(0.115)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.00	0.00	0.01	0.01	0.00	0.00	0.00
λ	0.10	0.10	0.60	0.10	0.10	0.10	0.10
N	4876	4358	4833	4243	6296	8992	3849

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Couples – Continued

	EE (pooled)	EL (pooled)	ES (pooled)	FI (pooled)	FR (pooled)	HU (pooled)	IE (pooled)
Cx							
Age_m	0.001	-0.000*	-0.000	-0.000	-0.000*	-0.000	-0.000**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age_m^2	-0.001	0.000	0.000	0.000	0.000	-0.000	0.000*
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age_f	0.000	0.000	0.000	0.000	0.000**	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age_f^2	-0.001	-0.000	-0.000	-0.000	-0.000**	-0.000	-0.000*
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Elderly	0.034***	0.005**	0.004***	-0.007***	0.008***	0.000***	0.000
	(0.004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.000)	(0.002)
Constant	0.016	-0.014*	0.018***	0.008*	0.013***	0.000	0.012*
	(0.018)	(0.007)	(0.004)	(0.004)	(0.004)	(0.000)	(0.005)
CxC							
Constant	-0.000	0.000***	-0.000***	-0.000	-0.000**	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1							
Constant	0.000	0.000***	-0.000**	0.000*	-0.000	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL2							
Constant	-0.000	0.000***	-0.000*	0.000	-0.000***	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x							
Age_f	-0.003	-0.004	-0.001	-0.006***	-0.004**	0.000	-0.005
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
Age_f^2	0.002	0.004	0.002	0.008***	0.006***	-0.001	0.008*
	(0.002)	(0.003)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Elderly	0.171***	0.109***	0.109***	0.013	0.110***	0.121***	0.133***
	(0.010)	(0.013)	(0.007)	(0.018)	(0.015)	(0.006)	(0.032)
Constant	0.496***	0.157**	0.161***	0.407***	0.297***	0.163***	0.214**
	(0.057)	(0.055)	(0.027)	(0.038)	(0.031)	(0.038)	(0.070)
L1xL1							
Constant	-0.006***	-0.003***	-0.002***	-0.005***	-0.003***	-0.003***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2x							
Age_m	0.003	-0.005*	-0.002	-0.003	-0.001	-0.002	-0.002
	(0.003)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)
Age_m^2	-0.006	0.006*	0.004*	0.005*	0.003	0.001	0.002
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Elderly	0.174***	0.060***	0.072***	-0.023	0.139***	0.039***	0.026
	(0.015)	(0.012)	(0.007)	(0.020)	(0.016)	(0.006)	(0.028)
Constant	0.546***	0.174**	0.502***	0.525***	0.622***	0.179***	0.296***
	(0.078)	(0.056)	(0.035)	(0.044)	(0.037)	(0.040)	(0.070)
L2xL2							
Constant	-0.009***	-0.005***	-0.007***	-0.008***	-0.008***	-0.003***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1xL2							
Constant	-0.000	0.002***	0.000***	0.001***	0.000	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND							
$H > 0$	-22.964***	-14.087***	-17.030***	-20.251***	-16.121***	-12.121***	-13.978***
	(0.686)	(0.462)	(0.293)	(0.376)	(0.346)	(0.365)	(0.571)
$H > 0$	-17.237***	-10.652***	-8.183***	-13.449***	-5.691***	-10.472***	-5.906***
	(0.500)	(0.361)	(0.160)	(0.275)	(0.182)	(0.302)	(0.302)
Parttime (m)	7.978***	4.136***	5.220***	6.869***	5.001***	5.167***	5.076***
	(0.284)	(0.192)	(0.124)	(0.156)	(0.145)	(0.159)	(0.241)
Parttime (f)	6.661***	4.175***	4.322***	5.482***	2.991***	4.798***	4.008***
	(0.203)	(0.173)	(0.097)	(0.110)	(0.094)	(0.140)	(0.222)
Fulltime (m)	3.254***	1.651***	2.217***	2.974***	2.057***	2.973***	2.269***
	(0.094)	(0.083)	(0.048)	(0.058)	(0.049)	(0.073)	(0.119)
Fulltime (f)	3.489***	2.312***	3.105***	3.387***	2.402***	3.125***	2.745***
	(0.118)	(0.120)	(0.075)	(0.080)	(0.069)	(0.086)	(0.178)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.00	0.05	0.00	0.00	0.00	0.00	0.00
λ	0.10	0.20	0.10	0.10	0.10	0.10	0.10
N	4113	3654	12090	9933	9309	6092	2281

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Couples – Continued

	IT (pooled)	LT (pooled)	LU (pooled)	LV (pooled)	MT (pooled)	NL (pooled)	PL (pooled)
Cx							
Age$_m$	-0.000	-0.000	-0.000	-0.001	0.001*	-0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age$_m^2$	-0.000	-0.000	0.000	0.001	-0.001**	0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Age$_f$	0.000	-0.000	0.000	0.001*	0.000	0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age$_f^2$	-0.000	-0.000	-0.000	-0.001**	-0.000	-0.000	-0.000*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Elderly	0.003***	0.034***	0.002*	0.015***	0.012***	-0.007*	0.005***
	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)	(0.003)	(0.000)
Constant	-0.006	-0.003	0.009*	0.024*	0.009	-0.008	0.004
	(0.004)	(0.017)	(0.004)	(0.012)	(0.011)	(0.006)	(0.002)
CxC							
Constant	0.000***	0.000***	0.000	-0.000	-0.000***	0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1							
Constant	0.000***	0.000***	0.000**	-0.000	-0.000**	0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL2							
Constant	0.000***	0.000***	0.000	-0.000	-0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x							
Age$_f$	0.001	-0.001	-0.003	-0.000	0.011***	-0.001	-0.003**
	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.003)	(0.001)
Age$_f^2$	-0.002	0.000	0.005	-0.001	-0.014***	0.005	0.003**
	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.001)
Elderly	0.123***	0.170***	0.092***	0.128***	0.232***	0.016	0.129***
	(0.008)	(0.009)	(0.015)	(0.006)	(0.026)	(0.040)	(0.005)
Constant	0.237***	0.253***	0.283***	0.283***	0.162*	0.382***	0.470***
	(0.038)	(0.054)	(0.050)	(0.039)	(0.076)	(0.062)	(0.026)
L1xL1							
Constant	-0.004***	-0.006***	-0.003***	-0.005***	-0.004***	-0.005***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2x							
Age$_m$	-0.002	-0.002	-0.002	0.004*	0.007*	-0.011***	0.001
	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.001)
Age$_m^2$	0.002	0.000	0.003	-0.005**	-0.008*	0.014***	-0.001
	(0.002)	(0.003)	(0.003)	(0.002)	(0.004)	(0.003)	(0.001)
Elderly	0.086***	0.125***	0.097***	0.072***	0.149***	0.066	0.097***
	(0.008)	(0.010)	(0.013)	(0.007)	(0.023)	(0.042)	(0.005)
Constant	0.554***	0.382***	0.778***	0.274***	0.511***	0.154*	0.437***
	(0.043)	(0.062)	(0.060)	(0.043)	(0.081)	(0.069)	(0.029)
L2xL2							
Constant	-0.009***	-0.007***	-0.011***	-0.006***	-0.009***	-0.004***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1xL2							
Constant	0.001***	0.001***	0.000	0.000	-0.000	0.002***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND							
$H > 0$	-20.058***	-21.892***	-25.212***	-18.343***	-21.164***	-13.116***	-18.681***
	(0.325)	(0.561)	(0.787)	(0.511)	(0.850)	(0.353)	(0.346)
$H > 0$	-8.810***	-18.899***	-7.253***	-15.759***	-6.772***	-3.782***	-16.194***
	(0.182)	(0.496)	(0.267)	(0.444)	(0.374)	(0.203)	(0.286)
Parttime (m)	5.675***	8.325***	8.101***	6.789***	6.291***	5.574***	5.146***
	(0.133)	(0.229)	(0.318)	(0.214)	(0.380)	(0.130)	(0.150)
Parttime (f)	3.668***	7.995***	3.769***	6.683***	3.216***	2.630***	5.496***
	(0.090)	(0.205)	(0.150)	(0.191)	(0.188)	(0.162)	(0.115)
Fulltime (m)	1.984***	3.786***	2.463***	3.242***	2.772***	4.051***	2.010***
	(0.049)	(0.101)	(0.089)	(0.090)	(0.109)	(0.100)	(0.046)
Fulltime (f)	2.325***	4.186***	2.030***	3.696***	2.383***	1.690***	2.563***
	(0.072)	(0.124)	(0.110)	(0.115)	(0.148)	(0.149)	(0.063)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.00	0.02	0.00	0.00	0.00	0.00	0.00
λ	0.10	0.10	0.10	0.10	0.10	0.10	0.10
N	11636	5061	3924	4756	2428	9315	11204

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

Labor Supply Estimation: Couples – Continued

	PT (pooled)	RO (pooled)	SE (pooled)	SI (pooled)	SK (pooled)	UK (pooled)
Cx						
Age_m	-0.000	0.001*	-0.000	-0.000	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Age_m^2	0.000	-0.001*	0.000	-0.000	-0.000	0.000*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Age_f	0.001***	-0.000	0.000	0.001**	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Age_f^2	-0.001***	0.000	0.000	-0.001***	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Elderly	0.002	0.017***	0.001	0.006***	0.004	-0.002
	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)
Constant	0.012	-0.012	0.000	-0.016*	0.024	0.007***
	(0.009)	(0.012)	(0.000)	(0.007)	(0.020)	(0.002)
CxC						
Constant	-0.000***	-0.000***	0.000	0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL1						
Constant	-0.000*	-0.000***	0.000	0.000***	0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CxL2						
Constant	-0.000**	0.000***	0.000***	0.000***	0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1x						
Age_f	0.002	0.002	-0.004	-0.010***	-0.003	-0.004***
	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)	(0.001)
Age_f^2	-0.001	-0.003	0.007*	0.011***	0.002	0.006***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.001)
Elderly	0.087***	0.179***	0.239*	0.125***	0.076***	0.079***
	(0.007)	(0.009)	(0.103)	(0.005)	(0.007)	(0.009)
Constant	0.318***	0.828***	0.257***	0.638***	0.689***	0.205***
	(0.035)	(0.062)	(0.062)	(0.038)	(0.054)	(0.018)
L1xL1						
Constant	-0.005***	-0.014***	-0.006***	-0.009***	-0.010***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L2x						
Age_m	0.002	0.007*	-0.003	-0.005**	-0.001	-0.003***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)
Age_m^2	-0.001	-0.010**	0.004	0.006**	-0.001	0.003***
	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	(0.001)
Elderly	0.060***	0.113***	0.163	0.077***	0.029***	0.020*
	(0.007)	(0.011)	(0.105)	(0.005)	(0.008)	(0.009)
Constant	0.440***	0.565***	0.274***	0.522***	0.664***	0.567***
	(0.038)	(0.071)	(0.064)	(0.041)	(0.058)	(0.020)
L2xL2						
Constant	-0.007***	-0.013***	-0.009***	-0.009***	-0.011***	-0.009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1xL2						
Constant	-0.000	0.000**	0.003***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IND						
$H > 0$	-19.656***	-34.912***	-30.776***	-24.659***	-28.026***	-22.545***
	(0.535)	(1.238)	(0.807)	(0.399)	(0.724)	(0.295)
$H > 0$	-14.938***	-35.071***	-24.424***	-23.445***	-25.377***	-7.781***
	(0.388)	(1.176)	(0.619)	(0.373)	(0.569)	(0.115)
Parttime (m)	5.542***	9.684***	14.063***	8.505***	7.915***	6.354***
	(0.239)	(0.559)	(0.320)	(0.162)	(0.312)	(0.124)
Parttime (f)	5.351***	10.273***	13.545***	8.590***	8.088***	4.202***
	(0.164)	(0.506)	(0.279)	(0.146)	(0.222)	(0.074)
Fulltime (m)	2.466***	3.400***	6.041***	3.274***	2.695***	2.258***
	(0.071)	(0.107)	(0.159)	(0.057)	(0.075)	(0.038)
Fulltime (f)	2.978***	3.650***	6.516***	3.600***	3.423***	2.842***
	(0.092)	(0.115)	(0.227)	(0.071)	(0.103)	(0.059)
Kids dummies	Yes	Yes	Yes	Yes	Yes	Yes
$dU/dC < 0$	0.00	0.02	0.00	0.00	0.00	0.02
λ	0.10	0.10	0.10	0.10	0.10	0.10
N	5392	4893	6882	13185	6363	19699

Notes: Stars denote significance levels at 5%, 1% and 0.1%. *Source*: Own calculations based on EUROMOD and EU-SILC.

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3. Dynamic Scoring of Tax Reforms in the European Union[1]

3.1. Introduction

Assessing the revenue, behavioral and macroeconomic effects of tax reform proposals before their introduction provides important information to feed the political and public debate. The interaction between tax reforms and the induced changes in the economy are multi-faceted. Hence, it is necessary to capture not only the reaction of economic agents to the tax reforms (in particular labor adjustment effects), but also the overall economic effect, including on factor and product markets. An evaluation of tax reforms that accounts for individual behavioral effects and general equilibrium macroeconomic feedback effects is known as dynamic scoring.[2] In the U.S., dynamic scoring analyses are now well established and legally required before significant changes in tax legislation are implemented.[3]

In contrast to the U.S., dynamic scoring has not been applied in the fiscal governance framework in the European Union (EU) yet. However, such analysis would allow an in-depth evaluation of discretionary tax measures and a better assessment of the true fiscal policy stance, which remain important issues in the EU (Buti and Van den Noord, 2004). Moreover, in a policy context where the European Commission analyses the fiscal and structural reform policies of every Member State—providing recommendations, and

[1]This paper is joint work and published as Barrios, Dolls, Maftei, Peichl, Riscado, Varga, and Wittneben (2019)

[2]Dynamic scoring is distinct from static scoring, which focuses on the “morning-after” effect of a policy reform and does not account for behavioral responses and macroeconomic feedback effects. See Adam and Bozio (2009) for a comprehensive assessment of the dynamic scoring exercise.

[3]In the U.S., dynamic scoring analyses are conducted by the Joint Committee on Taxation (JCT) and the Congressional Budget Office (CBO). The JCT has been responsible for a macroeconomic impact analysis of changes in tax law since 2003. In addition, the CBO has incorporated these macroeconomic feedback effects into their estimates of fiscal effects if revenue effects exceeded $5 billion in any fiscal year. Since 2015, the JCT and the CBO are obliged to provide precise estimates for output and revenue feedback effects of major tax and mandatory spending changes (for more details, see Altshuler et al., 2005; Auerbach, 2005; Auerbach and Grinberg, 2017; Furman, 2006; Gravelle, 2014, 2015; Holtz-Eakin, 2015).

monitoring their implementation according to an annual round of policy dialogue (the so-called European Semester)—the analysis of how fiscal and structural reforms can affect national budgets as well as Member States' economic performance is required.[4] Accounting for macroeconomic feedback effects of tax reforms is also crucial for the determination of the cyclically adjusted fiscal balance, which plays a key role in the European fiscal framework (see in particular Larch and Turrini, 2010).

In this paper, we develop the first dynamic scoring framework for modelling and analyzing tax and benefit reforms for all EU countries. A key feature of our dynamic scoring approach is to combine EUROMOD, the microsimulation model for all European Union Member States, with QUEST, the European Commission's dynamic stochastic general equilibrium (DSGE) model used for the analysis of structural reforms (including fiscal ones).[5] By doing so, we are able to precisely model actual tax reforms since EUROMOD contains all relevant rules of the tax-benefit systems in the EU Member States and allows for the simulation of direct taxes, social insurance contributions and benefits according to actual legislation and hypothetical reform scenarios. This is usually not possible using aggregated macroeconomic models alone, that only differentiate between capital and labor taxes (see Leeper and Yang, 2008; Mankiw and Weinzierl, 2006; Strulik and Trimborn, 2012; Trabandt and Uhlig, 2011).

On the other hand, microsimulation models do not take into account agents' reactions to policy changes, and hence ignore how tax reforms endogenously affect prices and quantities as well as monetary and fiscal variables in the economy that can lead to non-negligible second-round effects on tax-revenues. By linking QUEST with EUROMOD, these effects are also included in our analysis. In order to do so, we follow Bargain et al. (2014) and estimate country specific labor supply elasticities using a discrete choice labor supply model based on the EUROMOD micro-data and feed them into the QUEST model.

We illustrate our dynamic scoring approach with an analysis of two hypothetical reforms of the Belgian social insurance system: a reduction of the social insurance contributions paid by employees and employers, respectively.[6] We provide various robustness checks

[4] For example, recently the European Commission has also started to collect data on estimates of the impact of discretionary tax measures relying on the Member States' own assessment and providing information at a more disaggregated level (see in particular Barrios and Fargnoli, 2010).

[5] See Sutherland (2001) and Sutherland and Figari (2013) for a description of the EUROMOD microsimulation model and Ratto et al. (2009) for details on the QUEST III model. Decoster et al. (2010) simulate a tax shift between labor and consumption taxes using EUROMOD. In contrast to our paper, their analysis abstracts from labor supply responses and general equilibrium effects.

[6] We also examine reform proposals made for Italy's and Poland's tax system (see Appendix A). All reform scenarios can be precisely simulated in EUROMOD, and are straightforward examples of reforms affecting personal income taxes or social insurance contributions.

in order to assess the sensitivity of the macroeconomic effects of the tax reform to the assumptions of the QUEST model. In addition to the analysis of the macroeconomic and fiscal effects of these tax reforms, we provide insights into the distributional effects of the reform scenarios under consideration, which is novel to the previous dynamic scoring literature.[7]

Our results indicate that accounting for labor supply responses and the macroeconomic feedback to tax policy changes is essential for a comprehensive assessment of the fiscal and distributional effects of tax reforms. We find only weak self-financing effects for tax reforms lowering the employees' tax burden. After three (five) years, the self-financing effect amounts to 6 percent (13 percent), measured as the percentage change of labor tax revenues upon the tax shock. The reform generates responses of wages and employment of opposite sign, with an expansion of labor supply leading to higher employment, but lower wages. These counteracting effects explain why first-round tax revenue effects derived from the microsimulation model and second-round effects reflecting behavioral responses and the macroeconomic trajectories derived from the macroeconomic model QUEST differ only slightly. In contrast, we find much larger self-financing effects amounting to roughly 49 percent (50 percent) after three (five) years resulting from cuts in employers' social insurance contributions. In this case, both wages and employment evolve positively because of the expansionary labor demand effect generated by the tax cut. In terms of distributional implications, we show that both reductions in social insurance contributions have regressive effects with increasing gains along the income distribution.

The rest of the paper is organized as follows. The second section presents our modelling choices and describes in detail the models used in the dynamic scoring exercise. The third section illustrates our approach for hypothetical tax reforms in Belgium. The fourth section concludes.

3.2. Modelling Second-round Effects of Tax Reforms

In this section, we first describe the different models used followed by an overview of the methodological steps of the dynamic scoring analysis.

[7]Note that in a different literature microsimulation models are combined with Computable General Equilibrium (CGE) models (see Bourguignon and Bussolo, 2013; Cockburn et al., 2014; Peichl, 2009, 2016). While many of these micro-macro linkages are static, there are some approaches that introduce dynamics through projections into the model. However, these models don't feature labor market dynamics from optimizing firms as in our analysis using QUEST.

3.2.1. The Microsimulation Model EUROMOD

EUROMOD is a tax-benefit microsimulation model covering all 28 member states of the European Union. The model is a static tax and benefit calculator that makes use of representative micro-data from the EU Statistics on Income and Living Conditions (EU-SILC) survey to simulate individual tax liabilities and social benefit entitlements according to the rules in place in each member state.[8] Starting from gross incomes contained in the micro-data, EUROMOD simulates most of the (direct) tax liabilities and (non-contributory) benefit entitlements, and calculates household disposable incomes.[9] The model is unique in its area as it integrates taxes, social contributions and benefits in a consistent framework, thus accounting for interactions between the tax and benefits systems, which—in the European case—can have a non-negligible impact in terms of tax revenues, disposable income distribution and also in terms of work incentives (see in particular Barrios et al., 2018). However, EUROMOD is static and only delivers the first-round effects of the simulations. It does not take into account the behavioral response of individuals to a given policy change. General equilibrium macroeconomic feedback effects are also not addressed with this model.

EUROMOD uses the latest available EU-SILC data. However, since the frequency of the releases of the survey data does not coincide with each of the fiscal years included in the model, whenever the policy year does not match the one of the dataset, EUROMOD uses index variables to inflate or deflate monetary values to the year of the simulated tax-benefit system. These index variables are called uprating factors and are usually taken from Eurostat (the European statistics agency) or national statistical offices.[10] In the context of this analysis, uprating factors will be used for including general equilibrium effects in EUROMOD.

[8] We use the latest available version G3.0+ of EUROMOD together with the datasets based on the 2012 version of EU-SILC. For the simulation of the tax reforms, we choose 2013 tax-benefit rules as the baseline. This is the most recent policy year that can be simulated with EUROMOD at the time of writing this paper. Uprating factors are used to inflate the non-simulated income components to 2013. The micro-data include information on personal and household characteristics, several types of income (e.g., market income, pensions or social transfers), certain expenditures (e.g., housing costs or life insurance payments), and other variables related to living conditions. The validity of the simulated aggregates is ensured by comparison with the corresponding macroeconomic estimates provided by national tax authorities or by statistical institutes. Validation tables are offered in the EUROMOD country reports for the EU28 Member States, which can be found at `https://www.euromod.ac.uk/using-euromod/country-reports`.

[9] Note that some contributory benefits (e.g., pensions as well as unemployment or disability benefits) are not simulated but taken directly from the EU-SILC data, given the lack of individual contribution histories that would be needed to simulate them.

[10] Examples of uprating factors are consumer price indices and evolution of earnings and statutory adjustment rules for certain benefits.

3.2.2. The Labor Supply Discrete Choice Model

In order to account for behavioral responses at the micro level, we estimate a labor supply model. We follow standard practice and in particular Bargain et al. (2014) to estimate a random utility discrete choice model.[11] The random utility framework (McFadden, 1974) is based on the assumption that households maximize utility and thereby face the standard consumption-leisure trade-off. In this setting, agents face a discrete set of alternatives in terms of working hours. Individuals can choose to work zero hours, part-time (20 hours), full-time (40 hours) or over-time (60 hours) so that the choice covers both the extensive and intensive margin. The labor supply discrete choice model provides us with parameters that are fed into the macro model (among these the elasticities of labor supply).

Econometrically, our methodology entails the specification and estimation of consumption-leisure preferences, and the evaluation of utility at each discrete alternative.[12] Utility consists of a deterministic part, which is a function of observable variables, and an error term, which can reflect optimization errors of the household, measurement errors concerning the explanatory variables, or unobserved preference characteristics. For the deterministic part, we specify a utility function that depends on both household characteristics (such as age, number and age of children, allowing for heterogeneity in preferences) and characteristics of the specific category (leisure time, disposable income as well as fixed costs of taking up work). Household characteristics also influence how gross income translates into disposable income as effective tax rates vary with household characteristics (such as marital status, age, family composition).

For identification, we exploit the resulting variation created by nonlinearities and discontinuities inherent in the tax-benefit system and how they reflect on households' and individuals' consumption.[13] Although we include some of the household characteristics in the estimated utility functions, tax-benefit rules condition on a richer variety of household characteristics (for example, detailed age of children, regional information or home-ownership status). Hence, the data provide variation in disposable income (as a

[11]Discrete choice models have their theoretical roots in the Random Utility Model of McFadden (1974). They have become increasingly popular in the labor supply literature (see Aaberge et al., 1995; Dagvisk, 1994; Hoynes, 1996; Van Soest, 1995, for early contributions).

[12]In contrast to the classical labor supply model where households choose from a continuous set of working hours (Hausman, 1985), it is not necessary to impose tangency conditions, and in principle the model is very general. In practice, a functional form for the utility function has to be explicitly specified. However, the choice of functional form has no major influence on the estimated elasticities (see Löffler et al., 2014).

[13]This is the usual source of variation for models estimated on cross-sectional data that cannot rely on variation over time.

proxy of consumption) that allows identifying the parameters of the econometric model.

The disposable income is calculated for each discrete hour category and each household by aggregating all sources of household income, adding benefits (family and social transfers), and subtracting direct taxes (on labor and capital income) and social insurance contributions using EUROMOD.[14] Appendix B provides detailed information on the discrete choice model and its underlying assumptions.

3.2.3. The Macroeconomic DSGE Model QUEST III

The macroeconomic model used in this analysis is an extension of the European Commission's New-Keynesian model, QUEST (to be precise, version QUEST III, see Ratto et al., 2009), to include workers with different skill levels. The QUEST model is the standard model used by the European Commission to analyze the impact of fiscal scenarios and structural reforms in the EU Member States (see, for instance, in 't Veld, 2013; Varga and in 't Veld, 2014; Vogel, 2012). As a fully forward-looking DSGE model, QUEST can capture the behavioral responses of major macroeconomic variables in an open economy context, going beyond the direct, static impact of specific tax reforms measured by EUROMOD. The labor market modelled in QUEST is strongly based on microeconomic theory and sufficiently general to adapt to the different labor market institutions of the EU countries.

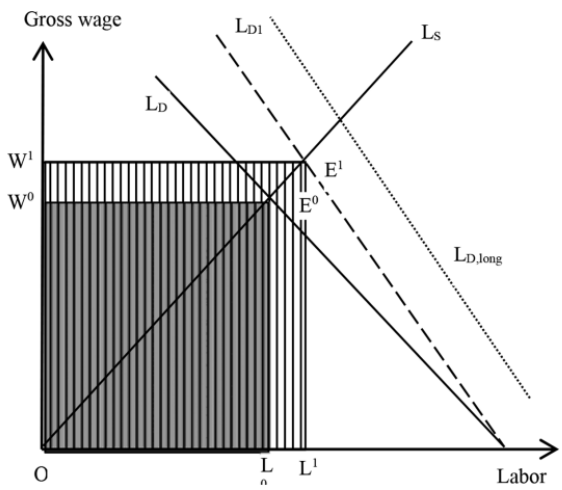
More specifically, the model-version used for this exercise is a three-region open-economy model, calibrated for the country of interest (Belgium), the (rest of) euro area and the rest of the world. For each region, the model economy is populated by households and final goods producing firms. There is a monetary and a fiscal authority, both following rule-based stabilization policies. The domestic and foreign firms produce a continuum of differentiated goods under monopolistic competition. In order to measure the distributional consequences of policies we introduce three skill groups—high, medium and low—into the model earning different wages.[15] Appendix C explains in detail the

[14] In practical terms, the link between EUROMOD and the labor supply model is implemented according to the following methodological steps. First, we estimate the hourly wage rate using a Heckman selection model. Next, we calculate gross earnings for each hypothetical hours choice. For instance, for a single (couple) household, we obtain four (16) different gross labor incomes (describing all possible combinations of hours that can be chosen by the two partners). The key assumption here is that the predicted hourly wage rate does not depend on the number of hours supplied in the labor market. This is a standard assumption in discrete choice labor supply models, Aaberge et al. (see 2009); Bargain et al. (see 2014); Blundell et al. (see 2000); Creedy and G. Kalb (see 2005); Van Soest (see 1995). Allowing wages to vary across choices would lead to complications when estimating the likelihood function, which are beyond the scope of this paper (see the discussion in Löffler et al., 2014).

[15] By using the ISCED education classification, we define the share of population with up to lower secondary education (ISCED 0-2) as low-skilled, with up to upper secondary, non-tertiary education

main blocks of our macro model: households, firms, policies and trade.

In our dynamic scoring exercise, one of the links between EUROMOD and QUEST is the labor market. In the following, we describe the workings and main driving forces of this market in QUEST. Although the general equilibrium effects influence the numerical results—since output, consumption, capital utilization and prices are fully endogenous in the model—the partial equilibrium analysis of Figures 3.1 and 3.2 can illustrate the basic wage setting mechanism in the QUEST model. These figures also highlight the role played by tax incidence after the different policy shocks are introduced in QUEST (third section).



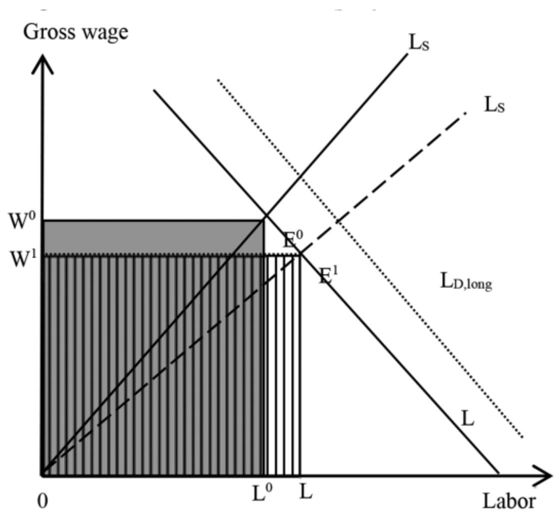
Note: The rectangle of $OL^0E^0W^0$ is the pre-reform tax base while $OL^1E^1W^1$ is the new tax base after the corresponding tax cut. Illustration is based on Borjas (2016).

Figure 3.1.: Employer Reform

In the figures, L_S denotes labor supply and L_D is labor demand.[16] Let us consider two reforms to illustrate the wage setting mechanism in the labor market. The first reduces the tax burden of employers (Figure 3.1), the second the tax burden of employees (Figure 3.2). When employee-paid labor taxes decrease (Figure 3.2), workers are willing to offer more labor services at all levels of the gross wage, and L_S rotates down to the right to L_{S1}. In this case, the tax-cut has two opposing effects on the tax-base: in the new equilibrium, gross wages are lower and firms are willing to hire more labor. The tax-base in Figure 3.2 transforms from the shaded $OL^0E^0W^0$ rectangle to the $OL^1E^1W^1$ rectangle with stripes. Due to these two opposing effects, the tax-base may not even

(ISCED 3-4) as medium skilled and the rest of the population as high-skilled.

[16]Equations (E.1.17) and E.1.26 in Appendix E, respectively. For simplicity, we assume that all other variables are constant, except real gross wages and labor, and there are no adjustment costs.



Note: The rectangle of $OL^0E^0W^0$ is the pre-reform tax base while $OL^1E^1W^1$ is the new tax base after the corresponding tax cut. Illustration is based on Borjas (2016).

Figure 3.2.: Employee Reform

change significantly in the short-run and scoring exercises with or without endogenous wage and labor response might give similar results in the short-run.

When employer-paid labor taxes decrease (Figure 3.1), firms are willing to hire more labor services at all levels of the gross wage and L_D rotates up to L_{D1}. In the new equilibrium gross wages are higher and firms are willing to hire more labor at the new wage rate. As both wages and employment rise, the tax-cut unambiguously increases the tax-base (from the shaded $OL^0E^0W^0$ rectangle to the $OL^1E^1W^1$ rectangle with stripes). Notice that this effect would be completely missed in a simple static scoring framework where wages and employment are kept exogenous.

In the long-run, the capital stock will gradually increase to its new steady-state level, which will lead to higher labor demand (e.g. $L_{D\text{-long}}$ in Figure 3.1 and 3.2), higher wages and a larger tax-base. Consequently, along the transition path, the difference between the static and dynamic scoring revenue estimates will increase.[17]

3.2.4. Methodological Framework

We combine the three models described in the previous sections as shown in Figure 3.3. The first step of our analysis consists in running EUROMOD for the actual tax-benefit

[17] It is important to stress that the Invariance of Incidence Proposition (IIP) does hold in the model over the medium to long-run: a shift of taxation from employers to employees, which leaves overall labor tax revenues constant, or only changes the composition of the tax-wedge but not its size, does not affect employment and GDP (Goerke, 2000).

system and the reform scenario for the year of interest, using the household micro-data for Belgium. This step provides us with the change in the effective tax burden on labor income for employees and employers, i.e. an aggregate indicator of the change in the tax burden resulting from the tax reform implemented in the microsimulation set-up. This tax burden is calculated as the ratio of taxes and social insurance contributions on labor income to the total compensation of employees and payroll taxes (see European Commission, 2013).

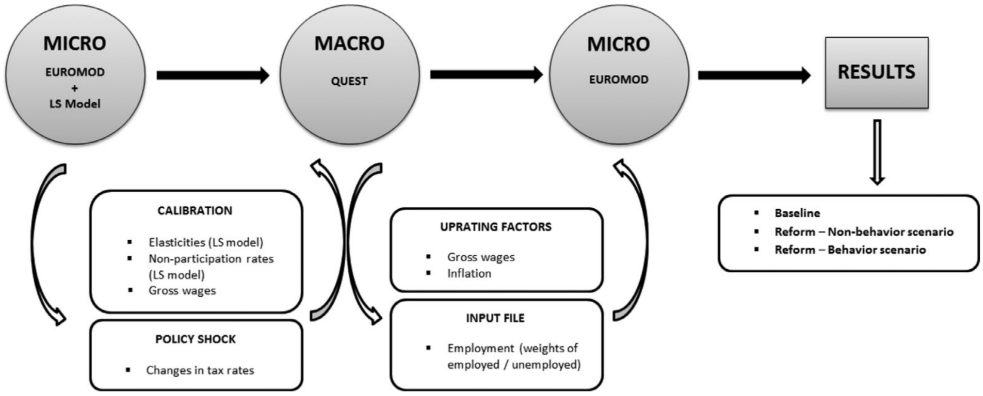


Figure 3.3.: Methodological Steps

Next, we estimate the discrete choice labor supply model. From this we obtain estimates for parameters such as the non-participation rate, i.e. the expected number of individuals offering zero labor hours, and the labor supply elasticities, i.e. the percentage change in labor supply, given a one percentage change in gross wages.

After having estimated the labor supply model, the change in the tax burden resulting from the tax reform is introduced in QUEST as policy shocks and labor market parameters such as the level of gross wages (obtained from the household micro-data), the non-participation rates and labor supply elasticities (obtained from the discrete choice labor supply model)—each obtained for three skill levels—feed into the calibration of QUEST.[18]

[18]QUEST is calibrated so that the model matches the observed empirical data from Eurostat in terms of labor productivity, investment, consumption to GDP ratios, the wage share, the employment rate, a given set of structural indicators describing market frictions in goods and labor markets, tax wedges and skill endowments. Most of the variables and parameters are taken from available statistical or empirical sources from the literature. Supplementary data associated with the calibration of the QUEST III model can be found in the online version of Ratto et al. (2009) at `http://publications.jrc.ec.europa.eu/repository/handle/JRC46465`. In this paper, we focus only on the calibration of selected parameters, which are directly related to the labor market. The remaining parameters are pinned down by the mathematical relationships of the model equilibrium conditions, i.e. all agents are maximizing their utility given their budget constraints, and the feasibility conditions of the economy are met.

By calibrating the main labor market parameters in QUEST with the micro-econometric estimates obtained from the labor supply model, we ensure consistency between the labor markets in QUEST and the discrete choice model.[19]

The second step of our analysis consists in running QUEST in order to obtain the three-year macroeconomic trajectories for the endogenous variables of the model. We are mainly interested in the trajectories for the price level, employment and gross wages, since these variables are fed back into the EUROMOD model.

In the third step, we analyze the fiscal and distributional effects of the tax reforms by feeding the macroeconomic trajectories obtained in the second step into EUROMOD. This is done by uprating prices and wages for the three-year period after the reform.[20] In addition, we simulate the employment trajectory by adjusting the sample weights in our household micro-data.

3.3. Illustration: Hypothetical Social Insurance Contributions Cuts in Belgium

In this section, we focus on two hypothetical tax reforms in Belgium. The first reform reduces the social insurance contributions (SIC) paid by employees, the second those paid by employers. In both scenarios, the total statutory tax rate of the social insurance contributions paid by employees and employers is cut by approximately 30 percent, i.e. the tax cuts granted to employees and employers in these scenarios have a comparable magnitude. More precisely, we implement the 30 percent tax rate cut by simulating: (1) a reduction of the social insurance contributions rate paid by employees from 13.07 percent to 9.07 percent (by cutting the rate for public pensions by 3 percentage points and the one for public health insurance by 1 percentage point); (2) a reduction of the standard social insurance contributions[21] rate paid by employers from 25.36 percent to 17.75 percent (by cutting the rate for public pensions by 5 percentage points and the one for public health insurance by 2.6 percentage points).

[19] Appendix D provides information on the aggregation issues that arise from linking the two models. It compares the worker's optimization problem and derives the labor supply elasticities in both models. It is shown that the labor supply elasticity estimated from the discrete choice model can be consistently used to calibrate the parameter guiding this elasticity in QUEST.

[20] Recall that EUROMOD inflates or deflates monetary variables using uprating factors whenever the year of the simulated tax-benefit system does not coincide with the reference year of the survey data.

[21] These standard social insurance contributions include contributions for pensions, healthcare, disabilities, unemployment, family allowances, accidents at work (standard and special), work-related illness (standard and asbestos fund), educational leave, integration and guidance programs for youth, daycare provision and (re)employment of vulnerable groups. As of 2016, the referred contributions have been substituted by the "global social insurance contribution".

Note that these two specific reforms are just illustrative and have neither been proposed nor implemented in the policy process. However, in the policy debate in Belgium and many other EU countries in the aftermath of the Great Recession and the Euro crisis, fiscal shifts away from labor taxation were heavily discussed (see Mathé, Nicodeme & Rua, 2015 for an overview) and the two reform proposals are meant to be illustrative of such potential reforms. They are insofar comparable as the two reforms imply the same percentage rebate in the social insurance contribution rates. In both cases, the contribution rates for public pensions and public health insurance are reduced. In the third section, we consider sensitivity checks, including a scenario where the reduction in labor tax revenues obtained with the reform of employers' contributions is applied to employees' contributions.

3.3.1. First Step: Policy Shocks and Labor Market Characterization

As explained in the previous section, the micro-macro interaction involves calculating the change in the effective labor tax burden for each reform using EUROMOD, and introducing it in QUEST as a policy shock. Furthermore, it involves calibrating QUEST labor supply elasticity parameters and the expected voluntary unemployment rate using the estimates of the discrete choice model described before.

3.3.1.1. Policy Shocks

For the calculation of the policy shock, we simulate each reform in EUROMOD and compute the pre- and post-reform effective tax rates on labor income. We follow European Commission (2013) and define the average effective tax rate on labor as the ratio between total taxes paid on labor income over total compensation.[22] For each reform, the average effective tax rate on labor income is computed for employees and employers, and for three skill groups, respectively. The next step is to establish the correspondence between these average effective tax rates computed using EUROMOD with the statutory tax rates on labor income in QUEST, levied on workers and firms. These statutory rates are defined

[22] More formally, the average effective tax rate on labor is defined as the ratio $\frac{\sum_i w_i * \mathrm{PIT}_i + \mathrm{SIC}_{\mathrm{EE}} + \mathrm{SIC}_{\mathrm{ER}}}{Gross\ Wages + \mathrm{SIC}_{\mathrm{ER}}}$, where PIT_i is the personal income tax liability of individual i, and $\mathrm{SIC}_{\mathrm{EE}}$ and $\mathrm{SIC}_{\mathrm{ER}}$ are the social insurance contributions paid by employees and employers, respectively. w_i is the ratio of wages relative to the total taxable income of taxpayer i, and is defined as $w_i = \frac{\text{Gross wages}_i}{\text{Total Taxable Income}_i}$. Note that this ratio does not change after the reform, because it is calculated only from the microsimulation set-up and does not include behavioral effects. We can further derive the average effective tax rates for employees and employers as $\frac{\sum_i .w_i * \mathrm{PIT}_i + \mathrm{SIC}_{\mathrm{EE}}}{Gross\ Wages + \mathrm{SIC}_{\mathrm{ER}}}$ and $\frac{SIC_{\mathrm{ER}}}{Gross\ Wages + \mathrm{SIC}_{\mathrm{ER}}}$, respectively.

in terms of gross wages and can be obtained with a simple algebraic relationship.[23] The difference between the pre- and post-reform statutory rates will be introduced as the policy shock in QUEST. Importantly, at this stage these changes are the morning-after effects and do not include any behavioral responses, neither from workers nor from firms. Table 3.1 shows statutory tax rates for the baseline and the two reform scenarios as well as the policy shocks, which are introduced in QUEST.

Table 3.1.: Tax Rates and Policy Shocks for the Belgium Reforms.

	30% Reduction of the SICee tax rate			30% Reduction of the SICer tax rate		
	High	Medium	Low	High	Medium	Low
QUEST statutory tax rates on labor income paid by employees						
Baseline (percentage)	33.5	28.8	27.1	33.5	28.8	27.1
Reform (percentage)	31.1	26.3	24.5	33.5	28.8	27.1
Shocks (percentage points)	−2.4	−2.5	−2.6	0.0	0.0	0.0
QUEST statutory tax rates on labor income paid by employers						
Baseline (percentage)	20.3	25.9	26.9	20.3	25.9	26.9
Reform (percentage)	20.3	25.9	26.9	16.6	20.7	21.4
Shocks (percentage points)	0.0	0.0	0. 0	−3.7	−5.2	−5.5

Table 3.1 shows that both reforms reduce the tax rates and that the size of the policy shock is larger in case of the reduction of employers' contributions, ranging from -3.7 percentage points for high-skilled to -5.5 percentage points for low-skilled workers.

3.3.1.2. Labor Supply Elasticities and Non-participation Rates

In the next step of the analysis, labor supply elasticities and non-participation rates by skill level are estimated using the discrete labor supply model described in the second

[23] Let $t_{w,s}$ and $t_{er,s}$ be the tax rates levied on employees and employers for skill group s, respectively. In QUEST, the tax burden of workers and firms is defined, respectively, as $t_{w,s} * Gross\ Wages$ and $t_{er,s} * Gross\ Wages$ (see also Appendix D for a description of the tax incidence mechanism in QUEST). Then, statutory tax rates in QUEST and average effective tax rates in EUROMOD are related as follows: let $t_{w,s,EUROMOD}$ and $t_{er,s,\ EUROMOD}$ be the average effective tax rates of employees and employers for skill group s derived from EUROMOD, then:

$$t_{w,s} * Gross\ Wages = \left(\sum_i w_i * \mathrm{PIT}_i + \mathrm{SIC}_{\mathrm{EE}}\right) = t_{w,s,EUROMOD} * (Gross\ Wages) + \mathrm{SIC}_{\mathrm{ER}})$$

and,

$$t_{er,s} * Gross\ Wages = \mathrm{SIC}_{\mathrm{ER}} = t_{er,s,\ EUROMOD}\ * (Gross\ Wages + \mathrm{SIC}_{\mathrm{ER}})$$

It follows that, $t_{er,s} = \frac{t_{er,s,\ EUROMOD}}{1-t_{er,s,\ EUROMOD}}$ and $t_{w,s} = \frac{t_{w,s,EUROMOD}}{1-t_{er,s,\ EUROMOD}}$. These are the rates presented in Table 3.1.

section. The estimation is based on the EU-SILC micro-data. Results are shown in Table 3.2. In line with the literature, we find that labor-supply elasticities as well as non-participation rates are highest for the low-skilled (see e.g. Bargain et al., 2014). Labor supply elasticities are used to calibrate the Frisch elasticity in QUEST.[24] The expected number of voluntary unemployed is based on the estimated probability of supplying zero hours in the labor market.[25]

Table 3.2.: Calibration of Labor Supply Elasticity Parameter and Non-participation Rates in QUEST, by Skill Level.

	High	Medium	Low
Labor supply elasticities	0.357	0.395	0.716
Non-participation rates	0.057	0.107	0.246

3.3.2. Second Step: The Macroeconomic Impact

We have calibrated QUEST for the Belgian economy, the rest of the euro area and the rest of the world. As explained in the previous section, the parameters representing the Frisch elasticity and the non-participation rate are based on the elasticities and predicted labor supply responses obtained from the discrete choice microeconometric model.

Moreover, the changes in the average effective tax rates on labor paid by employees and employers are introduced in QUEST through the statutory tax rates. Importantly, we temporarily set off the debt-stabilization rule[26] for the first fifteen years in order to analyze the direct budgetary effect of the reforms, thereby generating a government budget deficit in that period relative to the baseline. Note that different ways to tackle the government deficit generated by the reforms may have different second-round effects and that our results have to be interpreted in the light of this simplifying assumption.[27]

[24]Explained in detail in Appendix F, equations (F.2.1) to (F.2.19).

[25]See equation F.1.28 derived in Appendix F.

[26]See equation E.1.33 in Appendix E.

[27]We assume that after 15 years, our simulated tax-reforms are reversed and the pre-reform level of government debt is gradually restored through labor taxation (see Appendix G.). Alternatively, the QUEST model offers a wide range of closure rules, which could be based on the revenue or expenditure items of the government's budget constraint. Exploring the long-run implications of these various alternative fiscal closure rules goes beyond the scope of the paper.

3.3.2.1. Impulse Responses and Tax Incidence

The introduction of the shocks for each of the reforms in QUEST generates impulse responses for the endogenous variables of the model. Impulse responses show how these variables react to the changes in the tax rates and, at the same time, how they evolve together with the other endogenous variables. Impulse responses are informative as they shed light on the dynamics of the model: we can observe from the trajectories of the endogenous variables how these variables evolve simultaneously over time towards the new equilibrium. The impulse response functions generated by the policy shocks for the main labor market variables—net real wages,[28] total compensation of employees,[29] gross real wages, and employment—are presented in Appendix E (graphs G.1 to G.8).

Graphs G.1 to G.4 show the impulse response functions for the reform of employees' contributions. In line with the simplified partial equilibrium analysis of Figure 3.2 (see second section), we observe a decrease (an increase) in gross wages (employment) as shown in Graph G.3 (Graph G.4). This is due to the fact that employees are willing to work more at higher net-real wage due to the cut in contributions (Graph G.1). The total compensation of employees (Graph G.2) falls for all skill groups, but in a smoother way, because the tax rate paid by employers remains constant in our simulations and the changes only stem from the smooth decrease (increase) in gross wages (employment).

Graphs G.5 to G.8 show the impulse response functions for the reform of employers' contributions. As shown in the partial equilibrium analysis of Figure 3.1, firms are willing to offer higher gross wages to their employees due to the reduced tax burden. Employment increases over the simulation period (Graph G.8) as well as gross (and net) wages (Graphs G.5 and G.7). The total compensation of employees (Graph G.6.) immediately drops for all skill groups after the tax cut is introduced, and then smoothly recovers over the period of analysis due to the increase in gross wages along the transition path.

These results are also consistent with the partial equilibrium analysis of tax incidence.[30]

3.3.2.2. Sensitivity Analysis

We have performed a sensitivity analysis showing to what extent our results depend on the type of shocks and on the selected QUEST parameters and variables. More precisely,

[28]Net real wages are defined as gross wages minus taxes paid by employees, as in expression (F.3.1) in Appendix D.

[29]Recall that total compensation of employees is defined as the sum of gross wages plus taxes paid by employers on labor income, as in expression (F.3.2) in Appendix D.

[30]Described analytically in Appendix D.

we compare the following three alternative scenarios with the reform of the employers' contributions:

1. *SIC-Employee (ee) equivalent dynamic scoring:* We replicate the policy shocks of the employers' contributions reform as an equivalent reform on the employees' contributions, leaving unchanged the baseline social insurance contributions rate paid by employers. This means that under static scoring and without accounting for any behavioral effect, the reduction in labor tax revenues resulting from this reform equals the reduction resulting from the previous reform of employers' contributions;

2. *Low elasticity dynamic scoring:* We consider a new baseline with half of the Frisch elasticities of the original estimates for each skill group, and apply the policy shocks derived from the employers' contributions reform;

3. *Low nominal frictions dynamic scoring:* We start from a new baseline with half of the nominal wage and price adjustment costs and apply the policy shocks derived from the employers' contributions reform.

Figures 3.4 to 3.6 below show the impulse responses for selected variables—labor tax revenues, total gross wages and total employment—obtained for each of the three scenarios described above and for the baseline reform of employers' contributions (denoted by *SIC-er reform dynamic scoring*). Besides these four scenarios, Figures 3.4 to 3.6 also plot the static scoring scenario, which only reflects the mechanical cut of the employers' and the equivalent cut of employees' social insurance contributions without any endogenous wage and employment response, i.e. neither workers nor firms are allowed to re-optimize (denoted by *SIC reform static scoring*).

Figure 3.4 shows that, as expected, labor tax revenues decrease after the policy shock in all scenarios upon impact. While in the *SIC reform static scoring* case this impact remains the same in the subsequent periods as agents do not re-optimize, the decrease in the labor tax revenues shrinks over the three-year period in all dynamic scoring scenarios. More precisely, we observe that the decrease in tax revenues almost halves over the period of analysis when the employers' social insurance contributions are cut, revealing that these reforms are to some extent self-financing. The self-financing effect is substantially smaller in the scenario where the tax cut is applied to employees' contributions. In this last scenario, the percent deviation from the steady-state scenario (baseline in QUEST) goes from -8.0 percent at the beginning of the period to around -7.5 percent after three years.

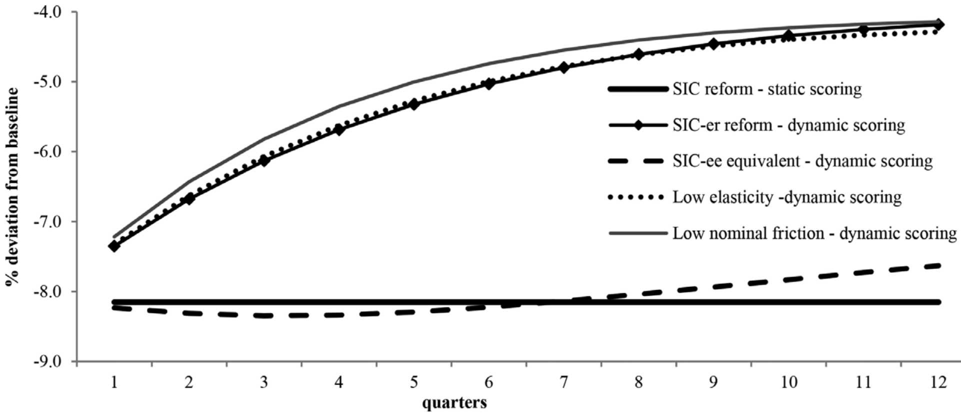


Figure 3.4.: Labor Tax Revenues Impulse Responses

These differences in self-financing effects can be explained by the trajectories of wages and employment: from Figures 5 and 6, we observe that both wages and employment have increasing trajectories when the tax cut affects firms. This result is robust with respect to the labor supply elasticity and the wage and price adjustment costs: the impulse responses obtained for the *Low elasticity* and the *Lower nominal frictions* scenarios closely follow the ones for the employers' social insurance contribution reform. Figure 3.4 also shows that in the *SIC-ee equivalent* scenario—where exactly the same tax cuts assigned before to employers are now granted to employees—labor tax revenues decrease and only slightly recover over the period of analysis. This result can be explained by the wage and employment trajectories shown in Figures 3.5 and 3.6: when the tax cut affects employees only, wage and employment effects cancel each other out. Consequently, we obtain only modest self-financing effects that are close to the static, no-behavior situation. This result is in line with the trajectories obtained for wages and employment for the reform of employee's social insurance contributions (see Table 3.3 below).

3.3.2.3. Feedback Effects

Following the standard practice in dynamic scoring exercises, we can also quantify the behavioral feedback effects of the reforms. Table 3.3 shows the revenue feedback effect for both tax reform scenarios, which is defined as the percentage difference of the revenue effect produced by the macroeconomic model relative to the static revenue estimate (see Joint Committee on Taxation, 2005). This measure allows us to quantify to which extent the reforms are self-financing through economic growth and price changes. We

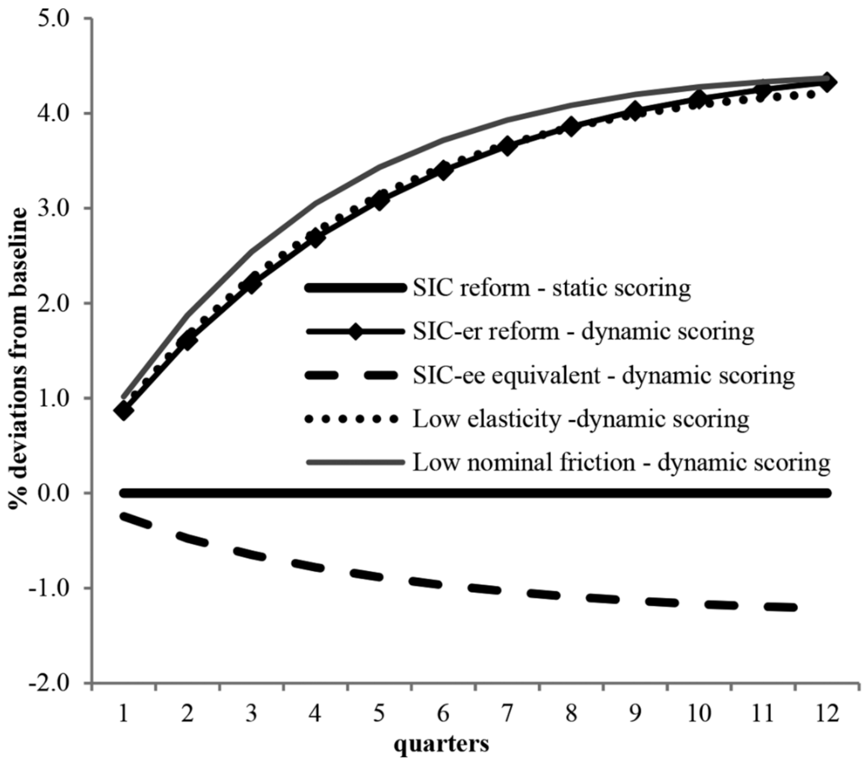


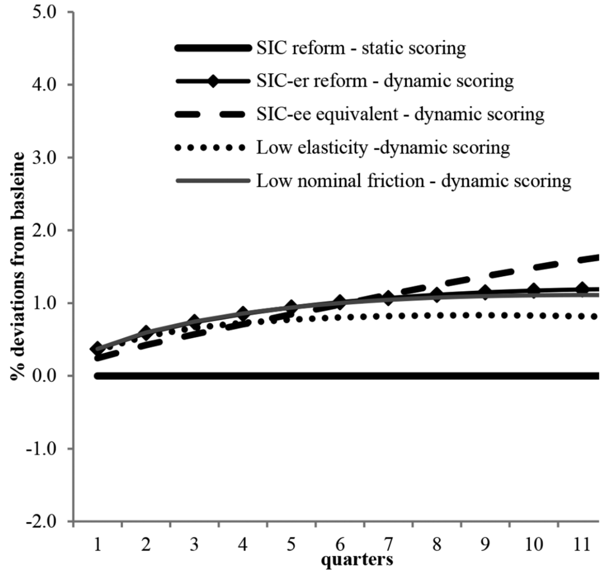
Figure 3.5.: Total Gross Wages Impulse Responses

also decompose the revenue feedback effect into the endogenous feedback contribution from wages and employment, respectively.

The reform implemented on the workers' side generates lower feedback effects compared to the reduction of firms' tax burden. By the end of the three-year period, the combined effect of wages and employment accounts for self-financing of about 6.4 percent of the reduction in total labor tax revenues in case of the reform of employees' social insurance contributions.[31] The self-financing effect amounts to almost 50 percent in case of the employers' social insurance contribution reform.

In line with the theoretical predictions (see second section, Figures 3.1 and 3.2), Table 3.3 illustrates that our result is due to the different behavioral effects of wages in the two scenarios: decreasing the firms' tax burden (Figure 3.1) induces an upward pressure on wages and increases the tax-base. The corresponding self-financing rate amounts to

[31]Note that we find similar self-financing effects for the Italian and Polish reforms presented in Appendix A, which have the same counteracting effects on wages and employment as the Belgian reform of employees' social insurance contributions.



Source: QUEST simulations.

Figure 3.6.: Total Employment Impulse Responses

37.8 percent after five years. On the other hand, cutting the tax burden on employees (Figure 3.2) has the opposite effect on the tax-base due to the downward pressure on wages. The corresponding self-financing rate is 10 percentage points smaller compared to the static estimate. Notice that the feedback effect from employment is positive in both cases: higher employment increases the tax-base. After five years, the corresponding self-financing rates amount to 23 (12.5) percentage points in the case of the employee (employer) tax-cut.

The magnitude of these feedback effects is close to the dynamic scoring results of Mankiw and Weinzierl (2006). These authors find that in a standard neoclassical model, up to half of a capital tax cut can be self-financing. However, they obtain substantially lower feedback effect from a labor tax cut, ranging from 0 percent to 17 percent depending on the labor supply elasticity.[32] Other dynamic scoring studies including Joint Committee on Taxation (2005) and Trabandt and Uhlig (2011) report similar patterns for labor and capital tax reform scenarios. Note, however, that our simulated reform of employer social insurance contributions is distinctly different from the capital income tax cuts considered by Mankiw and Weinzierl (2006) and others. Therefore, our results are not

[32]In general, they find that independent of how labor supply is calibrated, “if capital and labor tax rates start off at the same level, cuts in capital taxes have greater feedback effects in the steady state than cuts in labor taxes” (Mankiw and Weinzierl, 2006, p. 1416).

Table 3.3.: Decomposing the Revenue Feedback Effects of Tax Reform Scenarios in Belgium (Percentage Changes Relative to Static Estimates Based on QUEST Simulations).

	3 years	5 years
Employee tax-cut	6.4	12.9
Effect from employment	18.3	23.0
Effect from wages	−11.9	−10.1
Employer tax-cut	48.7	50.3
Effect from employment	13.2	12.5
Effect from wages	35.4	37.8

Note that a positive percentage change indicates that the estimated revenue loss is smaller when the macroeconomic feedback effects are taken into account while a negative percentage change indicates a higher revenue loss compared to the static estimate.

directly comparable for the following two reasons. First and most importantly, the large feedback effect in Mankiw and Weinzierl (2006) is driven by the response of capital accumulation to the capital income tax cut. By contrast, we consider cuts in social insurance contributions that have no primary impact on capital accumulation. Second, Mankiw and Weinzierl (2006) focus on steady state results, while our feedback effects are limited to a five-year adjustment period.[33]

3.3.2.4. Macroeconomic Trajectories

The final annualized macroeconomic impact on the variables of interest, following the policy shocks, is summarized in Table 3.4 below. The table shows the annualized percentage deviations of prices, employment, gross wages and labor tax revenues from the steady-state, which are caused by the policy shocks.[34] The main difference between

[33]The steady state results depend on the budgetary rule, which ensures that government debt is sustainable in the long-run. Mankiw and Weinzierl (2006) assume that lump-sum transfers (or taxes) adjust in response to the changes in tax rates, which offers a budget-neutral way to analyze the feedback effect without influencing the behavior of economic agents. Although the same assumption could be introduced in the QUEST model, the genuine concept of lump-sum transfers cannot be easily reconciled with EUROMOD. Therefore, we opt for switching off the fiscal rule in the short to medium-run leading to a temporary increase in debt and do not impose additional taxes, which could influence agents' behavior in the model. In the long-run, we use labor taxes to restore debt-sustainability, which reverses both tax-reforms.

[34]The trajectories are the annualized version of quarterly impulse responses, i.e. changes in selected endogenous variables of QUEST, given the policy shocks. Table 3.4 shows those QUEST variables, which are relevant for feeding the policy response back into EUROMOD. Tables G.1 and G.2 in Appendix G present the simulation results for other variables such as GDP and consumption for more years towards the long-run steady state.

the two reforms consists in the sign of the trajectories for wages: while the cut in the social insurance contributions paid by workers generates downward trajectories for wages for all skill-groups, the reduction in the employers' contributions generates upward ones. This has a direct impact on the trajectories of total labor tax revenues, i.e. the sum of taxes on labor income and social insurance contributions paid by both employees and employers in each of the reforms. We observe that the recovery of tax revenues is modest in the case of the employees' contributions rebate, with a tax revenue loss in $T+3$ just slightly below the initial drop in $T+1$. Although employment increases, wages decrease throughout the three-year period. These counterbalancing effects cause labor tax revenues to remain relatively constant (there are more workers paying taxes, but overall gross wages are lower). This is not the case if the tax cut is applied to employers' contributions. This policy shock generates an increase in both employment and wages, which pushes total labor tax revenues up (there are more workers and overall gross wages are higher) and creates a strong self-financing effect.

Table 3.4.: Macro impact of the tax reforms on the variables of interest, based on QUEST simulations (annualized percentage deviation from baseline).

	30% Reduction on the SICee tax rate			30% Reduction on the SICer tax rate		
	T+1	T+2	T+3	T+1	T+2	T+3
Price level	−0.043	−0.101	−0.128	−0.096	−0.161	−0.154
Employment						
Low skilled	0.171	0.444	0.739	0.825	1.338	1.445
Medium skilled	0.233	0.556	0.847	0.790	1.292	1.443
High skilled	0.278	0.614	0.874	0.449	0.720	0.868
Gross real wage						
Low skilled	−0.225	−0.437	−0.527	1.379	2.867	3.576
Medium skilled	−0.334	−0.566	−0.619	1.336	2.749	3.370
High skilled	−0.397	−0.628	−0.627	1.143	2.282	2.732
Total labor tax revenue	−8.307	−8.173	−7.781	−6.461	−4.941	−4.309

Compared to the employer's reform, the counteracting behavioral effects generated in the context of the employees' reform will result in smaller differences between the no behavior and behavior scenarios considered in the last step of our analysis, which is presented in the next section.

3.3.3. Third Step: Microsimulation Results

In the third step of our dynamic scoring exercise, we input the impulse responses for employment, gross real wages and consumer price index generated by QUEST back into the microsimulation model EUROMOD in order to assess the medium-term projections in tax revenues, social insurance contributions, and the distribution of disposable incomes. In addition, we simulate a second scenario in which the second-round effects, i.e. the macroeconomic feedback and behavioral response to the tax change, are disregarded.

We analyze both scenarios over the period t_1 to t_3 and compare the medium-term projections against the baseline. More precisely, we apply the tax system of the baseline policy year t_0 to the subsequent three years, and assess the fiscal and distributional effects of the tax reforms. We account for the second-round effects by amending the uprating factors and the weights in the household micro-data according to the macroeconomic feedback provided by the QUEST model (Table 3.4) for prices and wages.[35] The trajectory of employment is fed into the micro-data directly through adjustment of the sample weights.

The exact procedure is as follows. First, we incorporate the macro impact of the tax reforms by creating micro-datasets for each year of analysis (t_1, t_2, t_3). For each skill group, the weights of the employed are increased according to the corresponding impulse response, while the weights of the unemployed are scaled down keeping the total population constant. In this way, the employment effect estimated in QUEST is implemented as an extensive margin effect in the household micro-data. Second, the impulse response for the consumer price index is integrated in EUROMOD as a correction of the correspondent uprating factor. Finally, for gross wages we apply the same approach as for the consumer price index, with the only exception of having uprating factors for each skill category.

We subsequently run the microsimulation model to quantify the overall budgetary and distributional effects of the two reforms in the scenarios including/excluding second-round effects. These results are presented in detail in Figures 3.7 to 3.10. Figures 3.7 and 3.8 present the impact on the two affected subcomponents of employee and employer social insurance contributions—pension and health insurance contributions—while Figures 3.9 to 3.10 show the impact on broader categories of tax revenues (i.e. government revenue from personal income taxes and social insurance contributions) as well as the impact on household disposable income by income decile.

Figure 3.7 shows that employee social insurance contributions decrease both in the presence and in the absence of second-round effects. In t_1 and t_2, the drop is larger in the scenario accounting for second-round effects since the new equilibrium in the labor

[35]The input data files used here are based on EU-SILC 2012 survey data and hence do not correspond with the baseline year 2013 for the simulation of the tax reforms in EUROMOD. Therefore, the uprating factors allow for time consistency between the monetary variables of the survey and the tax system under analysis.

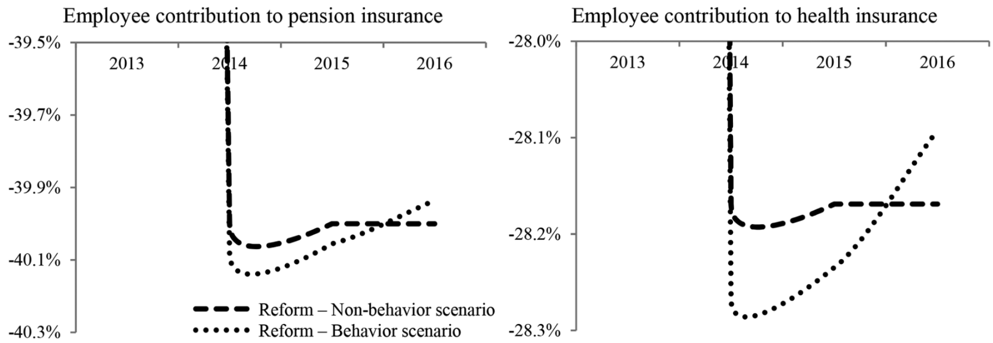


Figure 3.7.: Employee Contributions Impact in EUROMOD Incorporating Macro Feedback on Prices, Wages and Employment

market implies lower gross wages, and consequently lower social insurance contributions. However, we find that the positive employment effect counterbalances the negative wage effect leading to a lower tax revenue loss in t_3. Pension insurance contributions decrease by around 40 percent, while health contributions decrease by 28 percent.

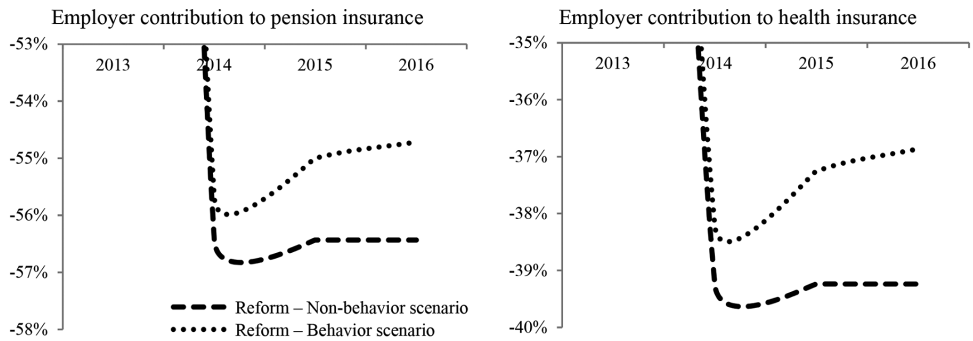


Figure 3.8.: Employer Contributions Impact in EUROMOD Incorporating Macro Feedback on Prices, Wages and Employment

Figure 3.8 shows that employer social insurance contributions decline at different rates, depending on the affected tax category. In the scenario ignoring behavioral responses, the loss in health (pension) insurance contributions amounts to roughly 40 percent (57 percent) in year t_1. In the scenario accounting for second-round effects, the revenue losses in t_1 are marginally smaller (almost 1 percentage point). The gap gradually widens over the period of analysis and reaches 2 percentage points in year t_3. This is due to the labor demand expansion that pushes wages and employment up.

Figures 3.9 and 3.10 show the impact of the two tax reforms on broader tax categories (total net tax revenues[36], personal income taxes and total social insurance contributions). Figure 3.9 shows that the reduction in social insurance contributions paid by employees leads to a fall in total net government revenues of almost 3.8 percent in t_3 in both scenarios. This drop is the result of two direct morning-after effects that evolve in opposite directions: on the one hand, decreasing employees' social insurance contributions, and, on the other, increasing revenues from personal income taxation (as the taxable income, which is net of social contributions, broadens).

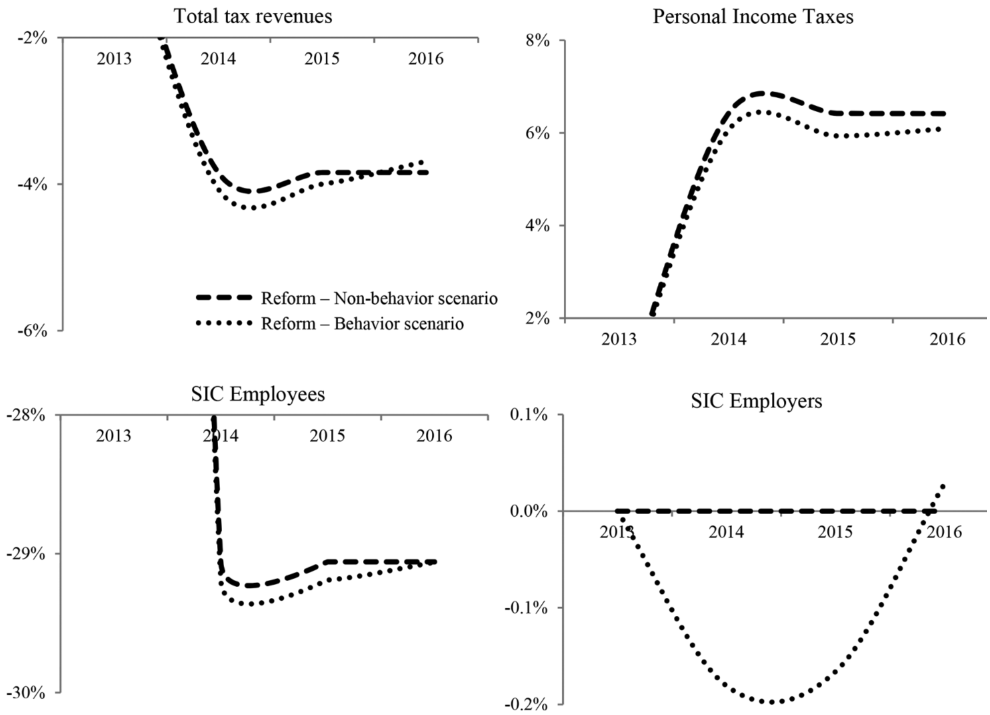


Figure 3.9.: Impact of the Employee SIC Reform on Aggregate Tax Revenues

The evolution of total net tax revenues differs only slightly when we consider second-round effects: in the first two years following the reform, total net tax revenues are lower compared to the no-behavior scenario, but this reverses in year t_3. The reason is that the effect of lower gross wages pushing total tax revenues down dominates in t_1 and t_2, while the positive employment effect outweighs the negative wage effect in year t_3. The positive employment effect also reduces unemployment benefit expenditures, which contributes to the stronger increase in total net government revenues in the scenario including behavioral reactions. As regards the social insurance contributions paid by

[36]By total net tax revenues we refer to the government revenues derived from simulated taxes and social insurance contributions net of means-tested and non means-tested benefits (excluding pensions).

employers, we observe that they shrink in the first year, but start to recover afterwards, slightly exceeding the baseline level by the end of the analyzed period. This can be explained by the simultaneous decrease in gross wages (and correspondent decrease in contributions paid) and the increase in employment with the latter effect being stronger at the end of the simulation period.

Figure 3.10 illustrates that the reduction in social insurance contributions paid by employers leads to an immediate revenue loss in t_1 amounting to 9.8 percent in the non-behavior scenario. When we account for the macro feedback on prices, wages and employment, we find that the revenue loss is smaller (7.2 percent) and shrinks to 3.9 percent by year t_3, i.e. a reduction of roughly 60 percent (from 7.2 to 2.9 billion euros). This is due to the positive effect on wages and employment, raising the revenues from personal income taxes (employees' social insurance contribution) by 5.2 percent (4.3 percent) in t_3. In contrast to the previous reform, the positive employment effect is now amplified by a positive wage effect (wage growth is up to 3.5 percent for the low-skilled in t_3). In addition, non-means tested benefits decline by 2.3 percent due to the decrease in unemployment.

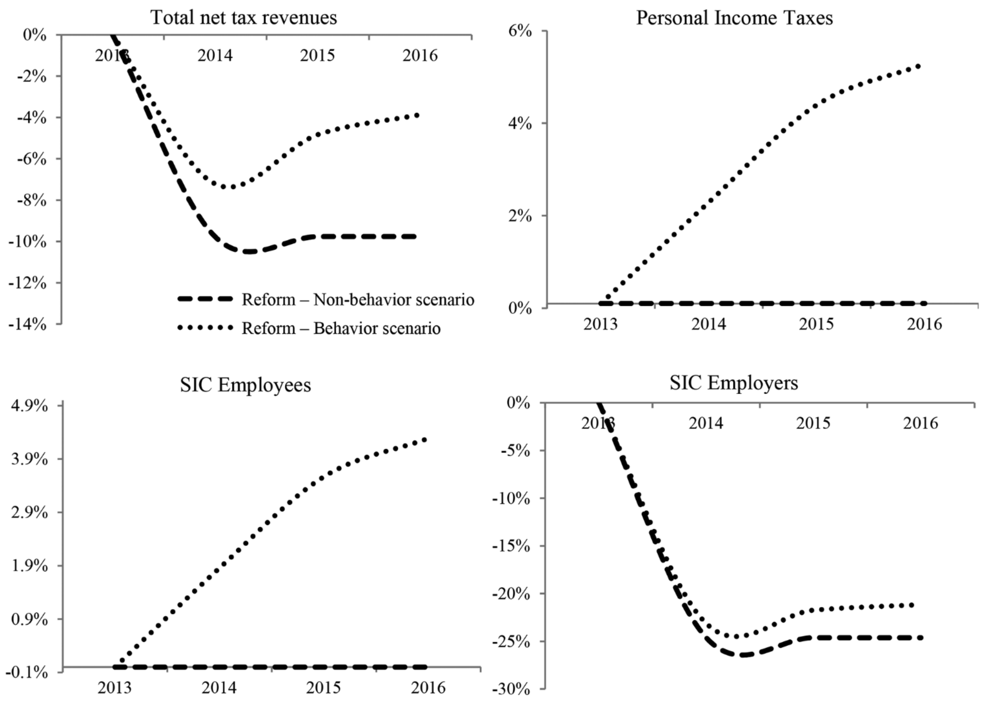


Figure 3.10.: Impact of the Employer SIC Reform on Aggregate Tax Revenues

Tables 3.5 and 3.6 present the effect of the reforms on equivalized disposable income across income deciles, in the no-behavior and behavior scenarios (compared with the baseline or no reform scenario).

Table 3.5.: Impact of the employee SIC reform on disposable income, by income decile (percentage deviation from baseline).

	Tax policy change, no behavior scenario			Tax policy change, behavior scenario		
Decile	2014	2015	2016	2014	2015	2016
1	0.26	0.26	0.26	0.03	−0.24	−0.44
2	0.71	0.71	0.70	0.63	0.58	0.54
3	0.75	0.75	0.75	0.70	0.67	0.70
4	1.12	1.12	1.13	1.09	1.09	1.14
5	1.57	1.57	1.55	1.49	1.47	1.51
6	1.83	1.85	1.86	1.74	1.74	1.79
7	1.94	1.94	1.93	1.85	1.82	1.88
8	2.24	2.24	2.24	2.11	2.07	2.12
9	2.42	2.41	2.41	2.27	2.22	2.26
10	2.51	2.48	2.48	2.35	2.25	2.28

Table 3.6.: Impact of the employer SIC reform on disposable income, by income decile (percentage deviation from baseline).

	Tax policy change, no behavior scenario			Tax policy change, behavior scenario		
Decile	2014	2015	2016	2014	2015	2016
1	0.00	0.00	0.00	−0.21	−0.38	−0.40
2	0.00	0.00	0.00	0.25	0.45	0.55
3	0.00	0.00	0.00	0.33	0.57	0.73
4	0.00	0.00	0.00	0.52	1.00	1.21
5	0.00	0.00	0.00	0.60	1.13	1.37
6	0.00	0.00	0.00	0.70	1.37	1.64
7	0.00	0.00	0.00	0.70	1.37	1.65
8	0.00	0.00	0.00	0.77	1.50	1.81
9	0.00	0.00	0.00	0.78	1.52	1.83
10	0.00	0.00	0.00	0.78	1.52	1.82

From Table 3.5, we observe that only the first decile is worse off at the end of the simulation period in the scenario including behavioral reactions, with the negative wage effect offsetting the positive morning-after effect of the employees' contributions cut. This can be explained by a phasing out of benefit entitlements caused by the increase in disposable income. Overall, the reform has a regressive effect with lower deciles benefiting less than the top of the distribution. The increase in disposable income for the bottom (top) three deciles is smaller (larger) than 1 percent (2 percent) by year t_3.

Table 3.6 shows that the reform of employers' social insurance contributions raises household disposable income only in the behavior scenario, with the exception of the first decile. As expected, the reform has no direct first-order distributive effects, because it reduces contributions paid by employers and leaves households' disposable income unaffected in the static scenario. However, when we include behavioral effects, disposable income increases, as the labor demand expansion leads to both higher wages and higher employment. Nevertheless, this expansion has a regressive impact on the disposable income distribution, with largest gains for the top deciles. In spite of improving labor market conditions, the first decile still faces a loss in disposable income due to lower benefit payments following the wage and employment increase.

3.4. Conclusion

Dynamic scoring analyses comprise the use of different models that allow quantifying revenue, behavior and macroeconomic effects of policy reforms. In this paper, we propose a dynamic scoring framework to analyze the impact of tax reforms in EU Member States, taking into account individual behavioral effects and macroeconomic (general equilibrium) feedback effects. For this purpose, we have combined a microsimulation model, augmented with a microeconometric discrete choice labor supply model, with a New-Keynesian DSGE model. We establish a coherent link between the micro and macro models, in particular in terms of aggregation, by calibrating the macro-model with parameters derived from the micro-data and by ensuring that labor supply elasticities are consistent in both models. In order to illustrate our methodology, we have quantified the fiscal and distributional effects of hypothetical tax cuts in Belgium implemented as reductions in social insurance contribution rates paid by employees and employers.

Our results indicate that accounting for behavioral responses and macroeconomic feedback effects is essential for a comprehensive evaluation of tax reforms. We find a substantial self-financing effect of a reduction of the employers' social insurance contribution rate in Belgium of roughly 50 percent. The self-financing effect is smaller in case of a comparable reduction in employees' social insurance contributions rate amounting to 13 percent. The larger effect for the social insurance reform affecting employers rather than employees can be explained by the fact that the former increases both wages and employment, while the latter leads to higher employment, but lower wages in the short-run. In addition to the self-financing effects, we pay special attention to the distributional implications of the reforms. We show that both reforms have regressive effects.

Besides allowing for a very accurate and detailed implementation of real-life tax reforms, our approach combines the analyses of first-order fiscal and distributional effects of tax reforms using microsimulation methods and of second-order general equilibrium effects derived from a DSGE model. This opens up venues for future research and policy analysis in the European Union context. Our analysis could be extended to account for other types of behavioral adjustments to tax policy reforms, in particular consumption or saving responses. Ongoing extensions of the EUROMOD model broadening the coverage of EUROMOD to include consumption taxes (see Decoster et al., 2014) could be used for this purpose. For instance, tax shifting between labor and consumption taxes aims at reducing the distortionary effect of labor taxation, but is also likely to have an impact on consumption and equity (Decoster et al., 2010; Mathé et al., 2015). Future work could also analyze more sizeable tax reforms combined with structural reforms in order to investigate possible complementarities between these different policy instruments.

C. Extensions: Evaluating Tax Reforms in Italy and Poland

We use the methodology illustrated in the previous sections to evaluate two additional reforms: an already implemented refundable tax credit for workers in Italy and an announced, but not legislated, increase in the universal tax credit in Poland.

More specifically, the Italian reform consists in the introduction of a refundable in-work tax credit for low income earners. It was implemented in May 2014 and has been made permanent as of 2015[1], resulting in a tax credit of EUR 960 per year. The maximum amount (i.e. EUR 80 euro per month) is given to employees with a taxable income below EUR 24.000 per year. Above this threshold, the tax credit is linearly decreasing up to a maximum taxable income of EUR 26.000. In order to be eligible for the bonus, the employees must earn at least 8.000 euro per year (below the limit, employees do not pay income tax).

The proposed Polish reform consists in an increase in the income exempt from the personal income tax from PLN 3,090 to PLN 8,000. The reform was planned to be introduced by the recently appointed government on 1st January 2017 (though there has been no official draft legislation). The increase in the tax-free amount implies that the amount of the universal tax credit rises from PLN 556 up to PLN 1,440, due to the fact that the tax base free of taxation is derived by dividing the universal tax credit[2] to the tax rate of the first tax bracket (18 percent).

A priori, both reforms increase incentives to participate in the labor market.[3] The labor supply elasticities and the non-participation rates computed for the calibration of QUEST for each of the countries of interest are shown in Table C.1.

The correspondent policy shocks to be introduced in the QUEST model are presented in Table C.2 below. As expected, the two reforms reduce tax rates paid by employees on

[1] With the Stability Law for 2015 (n.190 of 2014).

[2] The value of the universal tax credit in Poland is defined in The Natural Persons' Income Tax Act (PLN 556 per year).

[3] As for the Belgium reform, we use version G3.0 of the EUROMOD microsimulation model, together with the datasets based on the 2012 release of EU-SILC for Italy and Poland. Moreover, the described reforms are implemented in the 2013 tax-benefit systems of the two countries, as in the Belgian case.

Table C.1.: Calibration of labor supply elasticity parameters and non-participation rates in QUEST, by skill level.

	Labor supply elasticities			Parameter κ			Nonparticipation rates		
Countries	High	Medium	Low	High	Medium	Low	High	Medium	Low
Italy	0.199	0.201	0.301	0.896	1.497	2.485	0.079	0.132	0.290
Poland	0.311	0.271	0.598	0.515	1.776	1.173	0.102	0.214	0.270

labor income. Low-skilled workers benefit relatively more from the tax cuts, especially in the case of Italy, where the reform has a stronger progressive nature.

Table C.2.: Effective tax rates, statutory tax rates and policy shocks for the Italian and Polish reforms.

	Introduction in-work tax credit in Italy			Increase in universal tax credit in Poland		
	High	Medium	Low	High	Medium	Low
Tax rates on labor income paid by employees (QUEST)						
Baseline (percentage)	31.0	26.3	23.4	20.1	18.7	19.0
Reform (percentage)	29.5	23.5	19.9	18.1	16.3	16.5
Shocks (percentage points)	−1.5	−2.8	−3.5	−2.0	−2.4	−2.5
Tax rates on labor income paid by employers (QUEST)						
Baseline (percentage)	33.3	33.4	34.0	20.6	20.7	20.7
Reform (percentage)	33.3	33.4	34.0	20.6	20.7	20.7
Shocks (percentage points)	0.0	0.0	0.0	0.0	0.0	0.0

When introducing the shocks in QUEST, we obtain the three-year trajectories for the price level, employment and gross wages as shown in Table C.3. These are then fed back into the household micro-data.

Similarly to the Belgian cut in employees' social insurance contributions, the tax cuts implemented in the personal income tax systems of Italy and Poland generate negative trajectories for wages, while employment increases over the period for all three skill levels. The wage and employment trajectories determine the evolution of labor tax revenues throughout the period and hence the magnitude of the feedback effect. Over a five-year period, we obtain a total revenue feedback effect of 9 (8) percent in the Italian (Polish) case, as shown in Table C.4 below. Our results are in line with estimates presented in other studies (see e.g. Gravelle (2014) who finds income tax feedback effects ranging between 3.3 to 10.5 percent for reasonable values of labor supply and capital stock elasticities). The decomposition of the revenue feedback effects illustrates the positive (negative) feedback effect of job creation (wages) on the tax-base (see Table C.4 below).

Table C.3.: Macro impact of the tax reforms on the variables of interest based on QUEST simulations in Italy and Poland (annualized percentage deviation from baseline)

	Introduction in-work tax credit in Italy			Increase in universal tax credit in Poland		
	T+1	T+2	T+3	T+1	T+2	T+3
Price level	−0.027	−0.127	−0.177	−0.087	−0.233	−0.350
Employment						
Low skilled	0.257	0.424	0.539	0.201	0.444	0.626
Medium skilled	0.352	0.555	0.657	0.244	0.503	0.659
High skilled	0.271	0.336	0.387	0.285	0.538	0.664
Gross real wage						
Low skilled	−0.175	−0.274	−0.272	−0.166	−0.316	−0.358
Medium skilled	−0.289	−0.386	−0.351	−0.251	−0.389	−0.384
High skilled	−0.161	−0.179	−0.137	−0.274	−0.392	−0.360

Table C.4.: Decomposing the revenue feedback effects of tax reform in Italy and Poland (percent changes relative to static estimates).

	3 years	5 years
Employee tax-cut (Italy)	6.9	9.1
Effect from employment	12.4	13.3
Effect from wages	−5.5	−4.2
Employee tax-cut (Poland)	5.6	7.8
Effect from employment	11.6	12.8
Effect from wages	−6.0	−5.0

Note: Positive percentage change indicates that the estimated revenue loss is less when the macroeconomic effects are taken into account while negative percentage change indicates higher revenue loss compared to the static estimate.

Figures C.1 and C.2 show budgetary effects for the particular components of the personal income tax system affected by the reforms.[4]

From Figure C.1, we observe that the change in expenditures for the Italian in-work refundable tax credit is higher in the scenario including second-round effects. This results from the increase in employment after the reform due to the positive reaction of labor supply.[5] More people take advantage of the tax credit and expenditures increase when

[4]Note that the numbers related with the Italian in-work tax credit are presented in absolute terms because in the baseline pre-reform scenario this tax credit did not exist as a component of the personal income tax system.

[5]Notice that the positive macroeconomic trajectories for employment derived from QUEST are introduced in EUROMOD as changes in the weights of employed and unemployed in the micro-data used in the microsimulation model.

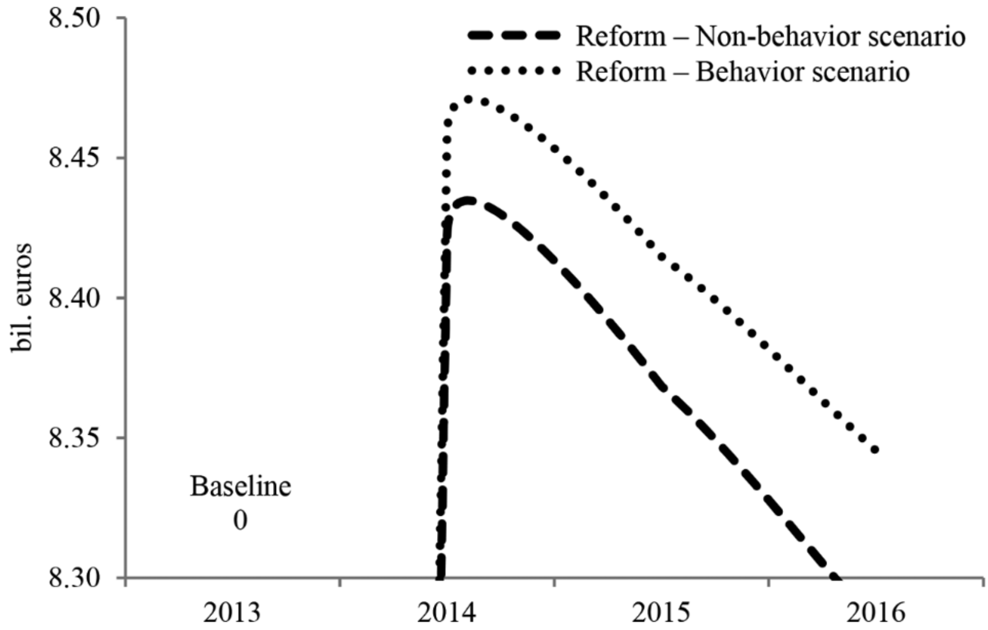


Figure C.1.: In-Work Refundable Tax Credit Impact in EUROMOD Incorporating Macro Feedback on Prices, Wages and Employment in Italy

behavioral adjustments are taken into account. Figure A.2 indicates that in the Polish case the positive labor supply effect does not change the direct costs of the universal tax credit.

Figures C.3 and C.4 present the impact of the Italian and Polish reforms on the aggregated tax revenues. These figures suggest modest self-financing effects of the reforms, i.e. total tax revenues recover faster in the scenario including behavioral reactions, driven by higher revenues from personal income taxes and social insurance contributions.

The redistributive effects of the Italian and Polish reforms are shown below. Table C.5 suggests that taxpayers in the 2nd to 6th decile benefit most from the introduction of the in-work tax credit. In Poland, the effect is more progressive with taxpayers in the bottom half of the distribution benefiting most as shown in Table C.6.

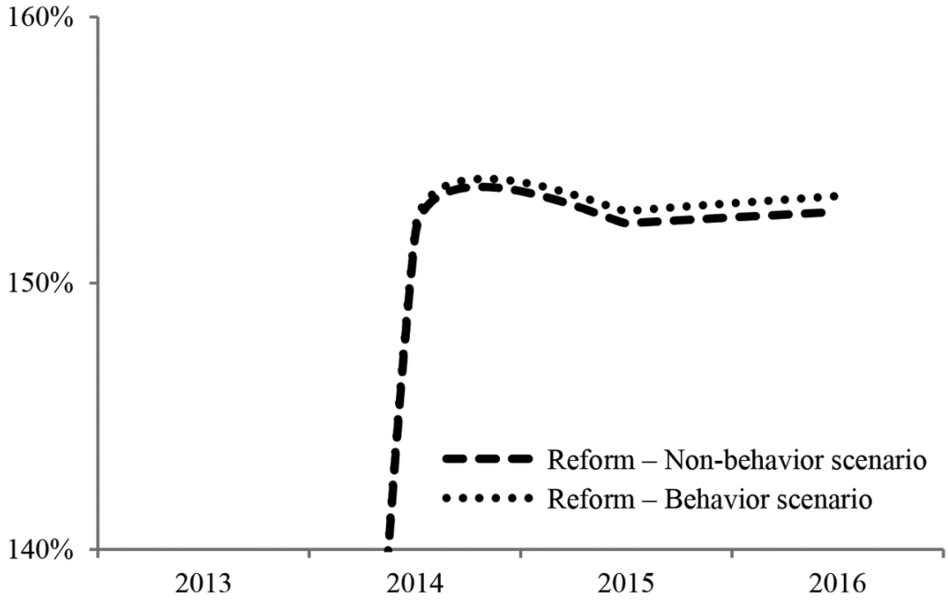


Figure C.2.: Universal Tax Credit Impact in EUROMOD Incorporating Macro Feedback on Prices, Wages and Employment in Poland

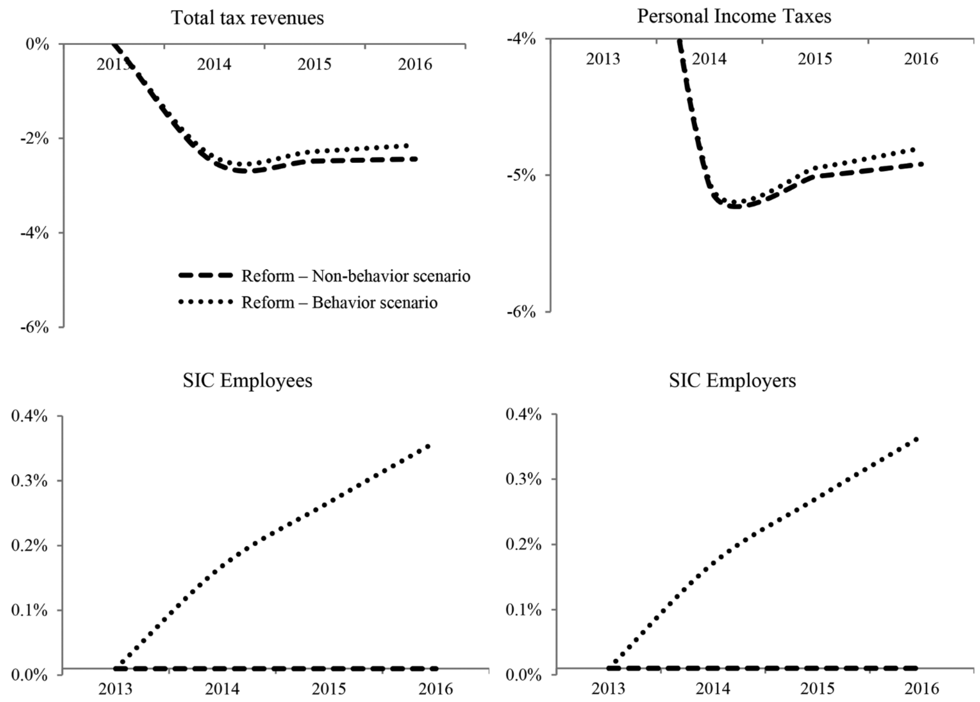


Figure C.3.: Impact of the Refundable Tax Credit Reform on Aggregate Tax Revenues in Italy

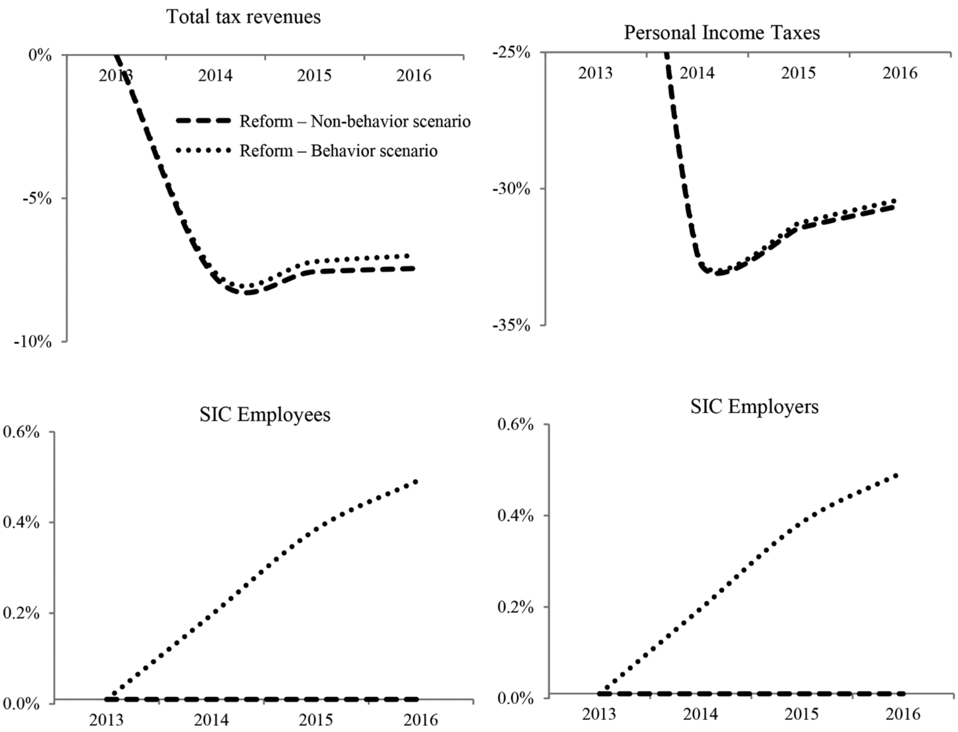


Figure C.4.: Impact of the Universal Tax Credit Reform on Aggregate Tax Revenues in Poland

Table C.5.: Impact of the refundable tax credit reform on disposable income in Italy, by income decile (percentage deviation from baseline).

	Tax policy change, no behavior reaction			Tax policy change, including behavior reaction		
Decile	2014	2015	2016	2014	2015	2016
1	1.38	1.34	1.34	1.42	1.41	1.46
2	1.65	1.65	1.61	1.69	1.73	1.72
3	1.73	1.71	1.69	1.78	1.79	1.80
4	1.63	1.62	1.59	1.68	1.67	1.69
5	1.53	1.52	1.51	1.55	1.58	1.58
6	1.73	1.71	1.68	1.75	1.76	1.76
7	1.54	1.52	1.50	1.56	1.55	1.56
8	1.15	1.14	1.11	1.16	1.16	1.15
9	0.82	0.81	0.80	0.81	0.80	0.81
10	0.25	0.24	0.24	0.19	0.15	0.14

Table C.6.: Impact of the universal tax credit reform on disposable income in Poland, by income decile (percentage deviation from baseline).

	Tax policy change, no behavior reaction			Tax policy change, including behavior reaction		
Decile	2014	2015	2016	2014	2015	2016
1	4.62	4.62	4.40	4.74	4.84	4.71
2	4.92	4.88	4.64	5.03	5.09	4.93
3	4.67	4.67	4.53	4.75	4.83	4.75
4	4.68	4.59	4.51	4.78	4.78	4.76
5	4.51	4.44	4.33	4.58	4.61	4.55
6	4.08	3.99	3.90	4.15	4.13	4.06
7	3.80	3.74	3.62	3.86	3.86	3.78
8	3.34	3.26	3.21	3.40	3.38	3.36
9	2.73	2.66	2.61	2.80	2.79	2.76
10	1.70	1.65	1.63	1.74	1.74	1.74

D. The Discrete Choice Labor Supply Model

We follow standard literature and especially Bargain et al. (2014) in setting up the labor supply model by choosing a flexible discrete choice household labor supply model.[1] In our baseline, we specify consumption-leisure preferences using a quadratic utility function with fixed costs.[2] The deterministic part of utility of a couple i at each discrete choice $j = 1, ..., J$ can be written as:

$$U_{\text{ij}} = \alpha_{\text{ci}} C_{\text{ij}} + \alpha_{\text{cc}} C_{\text{ij}}^2 + \alpha_{h_f i} H_{\text{ij}}^f + \alpha_{h_m i} H_{\text{ij}}^m + \alpha_{h_{\text{ff}}} (H_{\text{ij}}^f)^2 + \alpha_{h_{\text{mm}}} (H_{\text{ij}}^m)^2 \tag{D.0.1}$$

$$+ \alpha_{ch_f} C_{\text{ij}} H_{\text{ij}}^f + \alpha_{ch_m} C_{\text{ij}} H_{\text{ij}}^m + \alpha_{h_m h_f} H_{\text{ij}}^f H_{\text{ij}}^m - \eta_j^f \cdot 1(H_{\text{ij}}^f > 0) - \eta_j^m \cdot 1(H_{\text{ij}}^m > 0) \tag{D.0.2}$$

with household consumption C_{ij} and spouses' work hours H_{ij}^f and H_{ij}^m. The J choices for a couple correspond to all combinations of the spouses' discrete hours (for singles, the model above is simplified to only one hour term H_{ij}, and J is simply the number of discrete hour choices for this person). Coefficients on consumption and work hours are specified as:

$$\alpha_{\text{ci}} = \alpha_c^0 + Z_i^c \alpha_c + u_i \tag{D.0.3}$$

$$\alpha_{h_f i} = \alpha_{h_f}^0 + Z_i^f \alpha_{h_f} \tag{D.0.4}$$

$$\alpha_{h_m i} = \alpha_{h_m}^0 + Z_i^m \alpha_{h_m}, \tag{D.0.5}$$

i.e. they vary linearly with observable taste-shifters Z_i (including polynomial form of age, presence of children or dependent elderly persons and dummies for education). The

[1]This model has been used in well-known contributions for Europe, like Van Soest (1995); Aaberge et al. (1995); Blundell et al. (2000) or the U.S., like Hoynes (1996); Keane and Moffitt (1998).

[2]Other common specifications include Box-Cox or translog utility. However, the choice of the functional form is not a significant driver of labor supply elasticities (Löffler et al., 2014).

term α_{ci} can incorporate unobserved heterogeneity, in the form of a normally-distributed error term u_i, for the model to allow random taste variation and unrestricted substitution patterns between alternatives.[3] We include fixed costs of work into the model that help explain that there are very few observations with a small positive number of hours worked. These costs, denoted by η_j^k for $k = f, m$, are non-zero for positive hours choices.[4] In general, the approach is flexible and allows imposing few constraints.[5] One restriction sometimes taken in the literature is to require the utility function to be monotonically increasing in consumption, as this can be seen as a minimum consistency requirement of the econometric model with economic theory. When the fraction of observations with an implied negative marginal utility of consumption is more than 5 percent we impose positive marginal utility as a constraint in the likelihood function.[6] For each labor supply choice j, disposable income is calculated as a function

$$C_{\text{ij}} = d(w_i^f H_{\text{ij}}^f, w_i^m H_{\text{ij}}^m,\, y_i, X_i) \tag{D.0.6}$$

of female and male earnings, $w_i^f H_{\text{ij}}^f, w_i^m H_{\text{ij}}^m$, non-labor income y_i and household characteristics X_i. We denote disposable income by C to stress its equivalence with consumption. In this static setting, we do not model a savings decision of the household. The elasticities we estimate are hence Marshallian elasticities.[7] We argue below that this elasticity concept is appropriate to use for calibration of the elasticity in the macroeconomic model. We simulate the tax-benefit function d in (D.3) using the tax-benefit calculator EUROMOD. Disposable income needs to be calculated at the discrete set of choices, that is, only certain points on the budget curve have to be evaluated. We obtain wage rates for individuals by dividing earnings by working hours in the choice category.[8] As our sample includes individuals that are not observed to be working, we estimate a Heckman

[3]By unrestricted substitution patterns we mean that the model does not impose the "Independence from Irrelevant Alternatives" assumption that is implicit in the conditional or multinomial logit model. Formally, this makes the model a mixed logit model, which can be estimated using maximum simulated likelihood (Train, 2009). Moreover, Haan (2006) shows that the IIA assumption typically does not matter for deriving labor supply elasticities in discrete choice models.

[4]Introducing fixed costs of work (estimated as model parameters as in Bargain et al., 2014; Callan et al., 2009; Blundell et al., 2000, improves the fit of the model).

[5]See Bargain et al. (2014); Van Soest (1995).

[6]We choose the lowest multiplier that ensures at least 95 percent of the observations with positive marginal utility of consumption through an iterative procedure. To speed up estimation, we refrain from estimating the model with unobserved heterogeneity in these cases, that is, we do not include an error term in the coefficientα_{ci}.

[7]Hicksian elasticities can be obtained by additionally estimating income elasticities and using the Slutsky decomposition.

[8]We use hours normalized through rounding to the nearest hours category instead of actual hours to reduce division bias, as in Bargain et al. (2014).

selection model for wages and use predicted wages for all observations[9]. We assume that the hourly wage rate does not depend on the number of hours supplied in the labor market. As the model is stochastic in nature, the full specification of the labor supply model is obtained after including i.i.d. error terms ϵ_{ij} for each choice $j = 1, ..., J$. That is, total utility at each alternative is

$$V_{\mathrm{ij}} = U_{\mathrm{ij}} + \epsilon_{\mathrm{ij}}, \tag{D.0.7}$$

with the observable part of utility U_{ij} being defined as above in (D.0.1). The error terms can represent measurement errors or optimization errors of the household. Under the assumption that errors follow an extreme value type I (EV-I) distribution, the (conditional) probability for each household i of choosing a given alternative j has the explicit analytical solution below:[10]

$$p_{\mathrm{ij}} = \frac{e^{U_{\mathrm{ij}}}}{\sum_{k=1}^{J} e^{U_{\mathrm{ik}}}}. \tag{D.0.8}$$

D.1. Labor Supply Effects from the Augmented Microsimulation Model

We report labor supply responses to the three reforms evaluated. In Table D.1. We present the labor supply responses to the employees' social insurance reform in Belgium in terms of aggregate weekly full time equivalent jobs[11], separately for the intensive and extensive margin.[12] The predictions for the baseline and the employees' social insurance contribution reform are based on the estimated labor supply model described above.[13] We find particular large effects on the extensive margin. This is in line with the literature and also confirmed by our findings of larger extensive than intensive margin elasticities.[14] Recall that we have considered two reforms in the Belgian case: a decrease in social insurance contributions on the employee and the employer side. The labor

[9]Using predicted wages for all observations further reduces selection bias (see Bargain, Orsini & Peichl, 2014). It is common practice to first estimate wage rates and then use them in a labor supply estimation, (see Creedy & Kalb, 2005; Creedy & Kalb, 2006; Löffler, Peichl, & Siegloch, 2014).

[10]See McFadden (1974); Creedy and G. Kalb (2005).

[11]We calculate full time equivalents by dividing aggregate expected weekly working hours by 40.

[12]The intensive margin is the hours effect on those observed to be working, while the extensive effect is the change in hours for those observed to be not working (see Bargain et al., 2014). The total effect is the average of intensive and extensive margin effects, weighted by their respective share of the population.

[13]We only report results on aggregate hours. Additional detailed regression results of the discrete choice model are available on request.

[14]See Chetty et al. (2012); Chetty (2012).

supply effects reported in Table D.1 for Belgium are only the effects from the decrease in the social insurance contributions paid by the employee, as the decrease on the employer contributions does not affect household disposable incomes in the microeconometric setup.[15] The reform leads to an increase in aggregate labor supply of 1.24 percent.

Table D.1.: Employment effects from the Belgian employees reform (change in full time equivalents).

	Total	Intensive	Extensive
Baseline	2,920,764	2,735,788	184,976
Reform	2,957,053	2,768,090	188,963
% Change	1.24	1.18	2.16

In the same way, Table D.2 below shows results from the discrete choice labor supply model on aggregate working hours for the Italian and Polish reforms. The in-work tax credit in Italy increases hours at the extensive margin, as it makes working more attractive relative to not working. However, for those already in work, the tax credit has an income effect on consumption and leisure, so that it reduces working hours. The latter effect is larger, so that the overall change in aggregate hours is negative. For Poland, we find a positive effect on intensive and extensive margin hours because of the nature of the reform. Again, the increase in participation is larger, as the extensive margin is in general more sensitive to changes in incentives. Overall, we find that total labor supply increases by 1 percent in Poland.

Table D.2.: Employment effects from the reforms in Italy and Poland (change in full time equivalents).

	Total	Intensive	Extensive
Introduction in-work tax credit in Italy			
Baseline	10,607,323	9,879,253	728,070
Reform	10,570,537	9,841,150	729,387
% Change	−0.35	−0.39	0.18
Increase in universal tax credit in Poland			
Baseline	7,124,988	6,520,299	604,689
Reform	7,205,513	6,589,168	616,344
% Change	1.13	1.06	1.93

[15] In principle, second-round effects can occur if the decrease in employer SIC is not fully born by employers, but passed on to the workers. In our modelling framework, second-round effects are considered in QUEST.

D.2. Additional Selected Results

Tables D.3 to D.5 present the estimated parameters of equation (D.0.1) for the three countries analyzed, for different sample groups: couples, single women and single man.

Table D.3.: Labor Supply Estimation: Couples

	BE choice	IT choice	PL choice
Cx			
age_m	-0.000209 (-0.57)	-0.0000234 (-0.09)	-0.00168* (-2.29)
age2_m	0.000138 (0.33)	-0.0000835 (-0.28)	0.00195* (2.28)
age_f	0.000488 (1.43)	0.0000618 (0.21)	0.000483 (0.81)
age2_f	-0.000545 (-1.32)	-0.000224 (-0.68)	-0.000688 (-0.97)
pchild	0.000597 (1.06)	0.000312 (0.85)	-0.000167 (-0.17)
pold	0.00459 (0.73)	-0.000184 (-0.08)	-0.00185 (-0.40)
ed_ter_m	0.00125 (1.80)	0.000927* (1.96)	0.0128*** (11.42)
ed_ter_f	0.00130 (1.77)	0.00157** (3.17)	0.00567*** (4.61)
ed_up_m	0.00107 (1.94)	0.000545 (1.88)	0.0167*** (16.35)
ed_up_f	0.000664 (1.11)	0.00129*** (4.04)	0.00773*** (7.00)
_cons	0.0150 (1.11)	0.00869 (1.00)	0.0363 (1.96)
CxC			
_cons	-0.00000289 (-1.24)	-3.30e-08 (-0.05)	-0.0000114 (-1.08)
CxL1			
_cons	-0.0000253 (-0.54)	-0.00000659 (-0.49)	-0.0000463 (-0.72)
CxL2			

Table D.3 – *Continued from last page*

	BE choice	IT choice	PL choice
_cons	-0.0000173	0.000000272	0.0000490
	(-0.32)	(0.03)	(0.64)
L1x			
age_f	-0.000650	0.00642	-0.00561**
	(-0.16)	(1.85)	(-2.60)
age2_f	0.00333	-0.0108**	0.00667*
	(0.65)	(-2.64)	(2.53)
pchild02	0.0223**	0.0103*	0.00776
	(3.16)	(2.04)	(1.71)
pchild36	0.0171**	-0.00150	0.00860*
	(2.74)	(-0.35)	(2.26)
pchild712	0.0143*	0.00727	0.00439
	(2.32)	(1.96)	(1.27)
pchild1317	0.00785	0.00129	0.00370
	(1.19)	(0.32)	(1.04)
pold	0.174*	0.107***	0.104***
	(2.43)	(4.09)	(7.04)
_cons	0.427***	0.412***	0.507***
	(3.86)	(5.33)	(10.06)
L1xL1			
_cons	-0.00349***	-0.00406***	-0.00308***
	(-12.34)	(-25.41)	(-23.09)
L2x			
age_m	0.00293	-0.00323	-0.00191
	(0.62)	(-0.97)	(-0.70)
age2_m	-0.00219	0.00192	0.00235
	(-0.39)	(0.51)	(0.73)
pchild02	0.00641	-0.00470	-0.00350
	(0.78)	(-0.78)	(-0.72)
pchild36	0.0104	0.00305	-0.00829*
	(1.44)	(0.60)	(-2.02)
pchild712	0.00610	0.000826	-0.00307
	(0.84)	(0.19)	(-0.86)
pchild1317	-0.00839	0.00182	-0.00517
	(-1.08)	(0.39)	(-1.44)

Table D.3 – *Continued from last page*

	BE choice	IT choice	PL choice
pold	0.149	0.0609**	0.0382*
	(1.87)	(2.74)	(2.34)
_cons	0.287*	0.445***	0.297***
	(2.26)	(6.10)	(4.75)
L2xL2			
_cons	-0.00279***	-0.00311***	-0.00206***
	(-8.18)	(-33.58)	(-13.20)
L1xL2			
_cons	0.000690	0.0000994	-0.000181
	(1.23)	(0.60)	(-0.71)
IND			
d_parttime_m	-2.460***	-2.748***	-1.786***
	(-16.68)	(-28.31)	(-23.88)
d_parttime_f	-0.955***	-1.697***	-2.063***
	(-10.68)	(-23.54)	(-29.55)
N	21664	46288	45984

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table D.4.: Labor Supply Estimation: Single women

	BE choice	IT choice	PL choice
Cx			
age_f	-0.000798	-0.000702	-0.00346
	(-0.84)	(-0.55)	(-1.40)
age2_f	0.00107	0.000710	0.00409
	(0.95)	(0.50)	(1.42)
nchild	-0.00201	-0.00158	-0.00273
	(-1.79)	(-1.32)	(-1.18)
nold	-0.00448**	-0.00647***	-0.0182***
	(-3.18)	(-9.56)	(-5.59)
_cons	0.0143	0.0330	0.0675
	(0.70)	(1.18)	(1.28)
CxC			
_cons	0.00000290	-0.000000821	0.0000481*
	(1.17)	(-1.46)	(2.37)

Table D.4 – *Continued from last page*

	BE choice	IT choice	PL choice
CxL1			
_cons	0.0000758	-0.0000133	0.000411***
	(1.39)	(-1.40)	(3.31)
L1x			
age_f	-0.00989	-0.00423	-0.00815
	(-1.29)	(-0.35)	(-1.28)
age2_f	0.0134	0.00286	0.00907
	(1.41)	(0.21)	(1.20)
nchild	-0.0157	-0.0206	-0.00924
	(-1.52)	(-1.71)	(-1.39)
pold	-0.00893	-0.00326	-0.0151
	(-0.61)	(-0.42)	(-1.50)
ed_ter_f	-0.0420***	-0.0154*	-0.0558***
	(-4.57)	(-1.96)	(-5.77)
ed_up_f	-0.0209***	-0.0232***	-0.0706***
	(-3.41)	(-5.23)	(-9.83)
_cons	0.487**	0.641*	0.466***
	(3.03)	(2.45)	(3.54)
L1xL1			
_cons	-0.00257***	-0.00338***	-0.00192***
	(-7.32)	(-24.85)	(-8.51)
IND			
d_parttime_f	-1.213***	-2.253***	-2.157***
	(-10.85)	(-26.09)	(-19.27)
N	3036	8028	4776

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table D.5.: Labor Supply Estimation: Single men

	BE choice	IT choice	PL choice
Cx			
age_m	-0.000332	0.0000636	-0.00544*
	(-0.36)	(0.07)	(-2.24)
age2_m	0.000493	-0.000399	0.00715*
	(0.46)	(-0.38)	(2.52)

Table D.5 – *Continued from last page*

	BE choice	IT choice	PL choice
nchild	-0.000292	0.00273**	0.00471**
	(-0.54)	(2.71)	(2.64)
nold	-0.00419***	-0.00729***	-0.0139***
	(-3.49)	(-11.83)	(-6.58)
_cons	-0.00135	0.0196	0.113*
	(-0.07)	(0.96)	(2.07)
CxC			
_cons	0.00000297	-0.000000174	0.0000101
	(0.91)	(-0.12)	(0.44)
CxL1			
_cons	0.000212 **	-0.00000340	0.000294
	(3.02)	(-0.14)	(1.85)
L1x			
age_m	-0.00272	0.00600	-0.0113
	(-0.36)	(0.85)	(-1.67)
age2_m	0.00483	-0.00869	0.0154
	(0.53)	(-1.05)	(1.93)
pchild	-0.0395 **	0.0279*	0.00299
	(-3.13)	(2.04)	(0.30)
pold	-0.0520***	-0.0199 **	-0.0338***
	(-3.42)	(-2.88)	(-4.05)
ed_ter_m	-0.0291 **	-0.0131	-0.0590***
	(-2.77)	(-1.41)	(-5.30)
ed_up_m	-0.0268***	-0.00260	-0.0662***
	(-4.09)	(-0.56)	(-6.22)
_cons	0.0597	0.279	0.403**
	(0.38)	(1.90)	(2.78)
L1xL1			
_cons	-0.000403	-0.00255***	-0.00102***
	(-0.98)	(-17.53)	(-3.34)
IND			
d_parttime_m	-2.760***	-2.645***	-1.704***
	(-12.85)	(-23.83)	(-13.29)
N	2212	6616	3260

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

E. The QUEST Model

E.1. Model

The household sector consists of a continuum of households $h[0, 1]$. A share $(1-\epsilon)$ of these households is not liquidity constrained and indexed by $i \in [0, 1-\epsilon]$. They have access to financial markets where they can buy and sell domestic assets (government bonds), accumulate physical capital, which they rent out to the final goods sector. The remaining share ϵ of households is liquidity constrained and indexed by $k \in [1-\epsilon, 1]$. These households cannot trade in financial and physical assets and consume their disposable income each period. We identify the liquidity constrained households as low-skilled and the non-liquidity constrained households as medium- and high-skilled. For each skill group we assume that households (liquidity and non-liquidity constrained) supply differentiated labor services to unions, which act as wage setters in monopolistically competitive labor markets. The unions pool wage income and distribute it in equal proportions among their members. Nominal rigidity in wage setting is introduced by assuming that the households face adjustment costs for changing wages. Non-liquidity constrained households maximize an intertemporal utility function in consumption and leisure subject to a budget constraint. These households make decisions about consumption ($C_{i,t}$), and labor supply ($L_{i,z,t}$), the purchases of investment good ($J_{i,t}$) and government bonds ($B_{i,t}$), the renting of physical capital stock ($K_{i,t}$), and receive wage income ($W_{s,t}$), unemployment benefits ($b W_{s,t}$), transfer income from the government ($TR_{i,t}$), and interest income on bonds and capital ($i_t,$). Hence, non-liquidity constrained households face the following Lagrangian

$$\max_{\left\{\substack{C_{i,t},L_{i,s,t},B_{i,t},\\ J_{i,t},K_{i,t}}\right\}_{t=0}^{\infty}} V_{i,0} = E_0 \sum_{t=0}^{\infty} \beta^t \left(U(C_{i,t}) + \sum_z V(1 - L_{i,z,t}) \right) \tag{E.1.1}$$

$$- E_0 \sum_{t=0}^{\infty} \lambda_{i,t} \frac{\beta^t}{P_t}((1 + t_{C,t})P_{C,t}C_{i,t} \tag{E.1.2}$$

$$+ B_{i,t} + P_{I,t}(J_{i,t} + \Gamma^j(J_{i,t})) - (1 + i_{t-1}B_{i,t-1}) \tag{E.1.3}$$

$$- \sum_z (1 - t_{w,z,t})W_{z,t}L_{i,z,t} - bW_{z,t}(1 - NPART_{i,z,t} - L_{i,z,t}) \tag{E.1.4}$$

$$- (1 - t_k)(i_{K,t-1} - rp_K)P_{I,t-1}K_{i,t-1} - tK\delta_K P_{I,t-1}K_{i,t-1} \tag{E.1.5}$$

$$- TR_{i,t} - PR_{fin,i,t}) \tag{E.1.6}$$

$$E_0 \sum_{t=0}^{\infty} \lambda_{i,t}\xi_{i,t}\beta^t(K_{i,t} - J_{i,t} - (1 - \delta_K)K_{i,t-1}) \tag{E.1.7}$$

where z is the index for the corresponding medium (M) and high-skilled (H) labor type respectively ($z \in \{M, H\}$). The budget constraints are written in real terms with the price for consumption and investment ($P_{C,t}, P_{I,t}$) and wages ($W_{z,t}$) divided by GDP deflator (P_t). All firms of the economy are owned by non-liquidity constrained households who share the total profit of the final good sector firms, $PR_{fin,i,t}$. As shown by the budget constraints, all households pay consumption taxes ($t_{C,t}$), wage income taxes ($t_{W,z,t}$) and capital income taxes (t_K) less depreciation allowances ($t_K\delta_K$) after their earnings on physical capital. When investing into tangible capital the household requires premium in order to cover the increased risk on the return related to these assets. The utility function is additively separable in consumption ($C_{i,t}$) and leisure (1-$L_{i,z,t}$). We assume log-utility for consumption and allow for habit persistence in consumption (with parameter habc) as follows:

$$U(C_{i,t}) = (1 - habc)\log(C_{i,t-habcC_{t-1}}) \tag{E.1.8}$$

We assume CES preferences with common elasticity but a skill specific weight (ω_s) on leisure. This is necessary in order to capture differences in employment levels across skill groups. Thus preferences for leisure are given by:

$$V(1 - L_{i,s,t}) = \frac{\omega_s}{1 - \kappa}(1 - L_{i,s,t})^{1-\kappa}, \quad s \in \{L, M, H\} \tag{E.1.9}$$

with $\kappa > 0$. The investment decisions with respect to real capital are subject to convex adjustment costs, which are given by:

$$\Gamma_J(J_{i,t}) = \frac{\gamma_K (J_{i,t})^2}{2K_{i,t-1}} + \frac{\gamma_I}{2}(\Delta J_{i,t})^2. \tag{E.1.10}$$

where γ_K and γ_I are parameters.

The first order conditions of the household with respect to consumption, financial and real assets are given by the following equations:

$$\frac{\partial V_0}{\partial C_{i,t}} : \quad U_{C,i,t} - \lambda_{i,t}(1 + t_{C,t})\frac{P_{C,t}}{P_t} = 0 \tag{E.1.11}$$

$$\frac{\partial V_0}{\partial B_{i,t}} : \quad -\lambda_{i,t} + E_t\left(\lambda_{i,t+1}\beta(1+i_t)\frac{P_t}{P_{t+1}}\right) = 0 \tag{E.1.12}$$

$$\frac{\partial V_0}{\partial K_{i,t}} : \quad E_t\left(\lambda_{i,t+1}\frac{\beta P_I, t}{P_{t+1}}((1-t_K)(i_{K,t} - rp_K) + t_K\delta_K)\right) \tag{E.1.13}$$

$$-\lambda_{i,t}\xi_{i,t} + E_t(\lambda_{i,t+1}\xi_{i,t+1}\beta(1-\delta_K)) = 0 \tag{E.1.14}$$

$$\begin{aligned} \frac{\partial V_0}{\partial J_{i,t}} : \quad & -\left(1 + \gamma_k\left(\frac{J_{i,t}}{K_{i,t+1}}\right) + \gamma_I \Delta J_{i,t}\right) \\ & + E_t\left(\frac{1}{1+i_t}\frac{P_{I,t+1}}{P_{I,t}}\gamma_I \Delta J_{i,t+1}\right) \\ & + \xi_{i,t}\frac{P_t}{P_{i,t}} = 0 \end{aligned} \tag{E.1.15}$$

Liquidity constrained households do not optimize but simply consume their current income at each date. Real consumption of these households is thus determined by the net wage income plus benefits and net transfers, as follows:

$$(1+t_{C,t})P_{c,t}C_{L,t} = (1-t-w,L,t)W_{L,t}L_{L,t} + bW_{L,t}(1 - NPART_{L,t} - L_{L,t}) + TR_{L,t} \tag{E.1.16}$$

Within each skill group a variety of labor services are supplied, which are imperfect substitutes to each other. Thus, trade unions can charge a wage mark-up $(1/\nu_{\mathrm{s},\,\mathrm{t}})$ over the reservation wage[1]. The reservation wage is given as the marginal utility of leisure

[1] The mark-up depends on the intra-temporal elasticity of substitution between differentiated labor services within each skill groups (σ_{s}) and fluctuations in the mark-up arise because of wage adjustment costs and the fact that a fraction (1-*sfw*) of workers is indexing the growth rate of wagesto wage

divided by the corresponding marginal utility of consumption. The relevant net real wage to which the mark up adjusted reservation wage is equated is the gross wage adjusted for labor taxes, consumption taxes and unemployment benefits, which act as a subsidy to leisure. Thus, the wage equation is given as,[2]

$$\frac{V_{1-L,h,s,t}}{U_{C,h,s,t}}\frac{1}{\eta_{s,t}} = \frac{W_{s,t}(1-t_{w,s,t}-b)}{P_{c,t}(1+t_{C,t})} \qquad \text{for } s \in \{L, M, H\}, \tag{E.1.17}$$

where b is the benefit replacement rate. The aggregate of any household specific variable $X_{h,t}$ in per capita terms is given by

$$X_t = \int_0^1 X_{h,t}dh = (1-\varepsilon)X_{i,t} + \varepsilon X_{k,t}. \tag{E.1.18}$$

Hence, aggregate consumption and employment are given by

$$C_t = (1-\varepsilon)C_{i,t} + \varepsilon C_{k,t} \tag{E.1.19}$$

and

$$L_t = (1-\varepsilon)L_{i,t} + \varepsilon L_{k,t} \tag{E.1.20}$$

We assume that final goods producers work under monopolistic competition setting and each firm produces a variety of the domestic good, which is an imperfect substitute for varieties produced by other firms. Final output of firm j ($Y_{j,t}$) is produced using capital and a labor aggregate (l_j, t) in a Cobb-Douglas technology, subject to a fixed cost FC_j, as follows:

$$Y_{j,t} = (L_{j,t} - FC_{j,L})^{\alpha}(u_{j,t}K_{j,t})^{1-\alpha} - FC_{j,Y} \tag{E.1.21}$$

with

---

inflation in the previous period .

[2]In order to find the wage equation, consider the problem of representative household i, of a subgroup s of the population given by (E.1.1). Then, the first order conditions with respect to labor $(L_{i,\ z,t})$ is the following:

$\frac{\partial V_0}{\partial L_{i,z,t}} = 0 \Leftrightarrow V^{'}\left(1-L_{i,z,t}\right) = \frac{\lambda_{i,t}}{P_t}\left(1-t_{W,z,t}-b\right)W_{z,t}$

We can now combine the above condition with the first order condition with respect to consumption to obtain the intra-temporal condition on the optimal household choices on consumption and labor:

$\frac{V'\left(1-L_{i,z,t}\right)}{U'\left(C_{i,t}\right)} = \frac{\left(1-t_{W,z,t}-b\right)W_{z,t}}{P_{c,t}\left(1+t_{c,t}\right)}$

We can recognize in the above condition equation (E.1.17), which determines the equilibrium wage. In fact, and as mentioned before, since within each sub-group s the labor services supplied are imperfect substitutes of each other, the trade unions can charge a wage mark-up $(\frac{1}{\eta_{s,t}})$ over the reservation wage, which is given by the ratio of the marginal utilities of leisure and consumption, i.e. the left-hand side of the above equation.

$$L_{j,t} = \left(\Lambda_L^{\frac{1}{\mu}} (\chi_L L_{j,L,t})^{\frac{(\mu-1)}{\mu}} + \Lambda_M^{\frac{1}{\mu}} (\chi_M L_{j,M,t})^{\frac{(\mu-1)}{\mu}} + \Lambda_H^{\frac{1}{\mu}} (\chi_H L_{j,H,t})^{\frac{(\mu-1)}{\mu}} \right)^{\frac{(\mu-1)}{\mu}}, \quad \text{(E.1.22)}$$

where L_L, L_M, and L_H denote the employment of low, medium and high-skilled by firm j respectively. Parameter Λ_s is the corresponding share parameter, χ_s is the efficiency unit, and μ is the elasticity of substitution between different labor types. The term FC_L represents overhead labor and u_t is the measure of capacity utilization. The objective of the firm is to maximize the present discounted value of profits:

$$PR_{j,t} = P_{j,t} Y_{j,t} - \sum_s (1 + t_{er,s,t}) W_{j,s,t} L_{j,s,t} - i_t^K P_{j,I,t} K_{j,t} \quad \text{(E.1.23)}$$

$$- \Big(\Gamma^p(P_{j,t}) + \Gamma^L(L_{j,L,t}, L_{j,M,t}, L_{j,H,t}) + \Gamma^u(u_{j,t}) \Big) \quad \text{(E.1.24)}$$

where i^K denotes the rental rate of capital and $t_{er,s,t}$ stands for the tax rate on labor levied on the employers. Following Ratto et al. (2009), we assume that firms face technological constraints, which restrict their price setting, employment and capacity utilization decisions. These constraints are captured by the corresponding adjustment costs . It can be shown that in a symmetric equilibrium, when $P_{j,t} = P_t, \forall j$, firms charge a mark-up over the marginal cost of production (MC):

$$P_{j,t} = \frac{1}{\eta_{j,t}} MC_{j,t} \quad \text{(E.1.25)}$$

where $\eta_{j,t}$ is the inverse price mark-up factor, which is defined as a function of the elasticity of substitution (σ^d), changes in inflation (π) and the mark-up shock (ε_{mkp})[3]. Skill-specific labor demand can be obtained from the first order condition with respect to labor:

$$P_{j,t} \frac{\partial Y_{j,t}}{\partial L_{j,s,t}} \eta_{j,t} = (1 + t_{er,s,t}) W_{s,t} + \frac{\partial \Gamma^L(L_{j,L,t}, L_{j,M,t}, L_{j,H,t})}{\partial L_{j,s,t}}, \quad \text{(E.1.26)}$$

$s \in \{L, M, H\}$, where the marginal product of labor, the corresponding adjustment costs and the gross mark-up factor will jointly determine the optimally chosen level of low-, medium- and high-skilled employment level. Similarly, the demand for capital is

[3] We follow Ratto et al. (2009) and allow for additional backward looking elements by assuming that a fraction (1-*sfp*) of firms index price increases to inflation in *t*-1,, where is the corresponding adjustment cost parameter.

constrained by the corresponding first order condition:

$$(1-\alpha)P_{j,t}\frac{\partial Y_{j,t}}{\partial K_{j,t}}\eta_{j,t} = i_{K,t}P_{j,I,t} \tag{E.1.27}$$

where is the price of investment goods while is the rental rate of capital. Finally, the first order condition for capacity utilization is:

$$(1-\alpha)P_{j,t}\frac{\partial Y_{j,t}}{\partial K_{j,t}ucap_{j,t}}\eta_{j,t} = i_{K,t}P_{j,I,t} \tag{E.1.28}$$

In this model we have a fiscal authority, which manages a public budget. On the expenditure side we distinguish between government consumption (G_t), government investment (IG_t), government transfers (TR_t) and unemployment benefits (BEN_t), where

$$BEN_t = \sum_s bW_{s,t}(1 - NPART_{s,t} - L_{s,t}), \quad s \in \{L, M, H\}. \tag{E.1.29}$$

Government revenues are made up of taxes on consumption as well as capital and labor income:

$$R_t^G = t_{c,t}P_{C,t}C_{i,t} + \sum_s (t_{w,s,t} + t_{er,s,t})W_{s,t}L_{s,t} + t_K i_{K,t-1}P_{I,t-1}, K_{I,t-1} \tag{E.1.30}$$

$$- t_K\delta_K P_{I,t-1}K_{i,t-1} \tag{E.1.31}$$

Government debt (B_t) evolves according to

$$B_t = (1+i_t)B_{t-1} + G_t + IG_t + TR_t + BEN_t - R_t^G \tag{E.1.32}$$

The labor tax ($t_{w,t}$) is used for controlling the debt to GDP ratio, according to the following rule:

$$\Delta t_{w,t} = \tau_B\left(\frac{B_{t-1}}{Y_{t-1}} - b^T\right) + \tau_{DEF}\Delta\left(\frac{B_t}{Y_t}\right) \tag{E.1.33}$$

where captures the sensitivity with respect to deviations from , the government debt target, and controls the sensitivity of the tax-rule with respect to changes in the debt to output ratio. Note that this budget balanced rule is turned off when simulating the tax reforms considered in this paper.

Monetary policy is modelled via the following Taylor rule, which allows for some smoothness of the interest rate response (i_t) to the inflation and output gap:

$$i_t = \gamma_{ilag} i_{t-1} (1 - \gamma_{ilag})(r_{EQ} + \pi_{TAR} + \gamma_{inf}(\pi_{C,t} - \pi_{TAR}) + \gamma_{ygap}\hat{y}_t). \tag{E.1.34}$$

The central bank has a constant inflation target and it adjusts interest rates whenever actual consumer price inflation deviates from the target and it also responds to the output gap via the corresponding $gamma_{\text{inf}}$ and $gamma_{ygap}$ coefficients. There is also some inertia in nominal interest rate setting over the equilibrium real interest rate determined by $gamma_{ilag}$. Output gap is defined as deviation of capital and labor utilization from their long run trends. Note that in our multi-country setting, members of the euro area do not have independent monetary policy. In this way, we assume that the European Central Bank sets interest rate by taking into account the euro area wide aggregate inflation and output gap changes in its Taylor-rule.

Finally, concerning the trading sector in order to facilitate aggregation, we assume that households, the government and the final goods sector have identical preferences across goods used for private consumption, investment and public expenditure. Let be the demand of households, investors or the government as defined in the previous section. Then their preferences are given by the following utility function:

$$Z_t = \left((1-\rho)^{1/\sigma_{im}} Z_{d,t}^{(\sigma_{im}-1)/\sigma_{im}} + \rho^{1/\sigma_{im}} Z_{f,t}^{(\sigma_{im}-1)/\sigma_{im}} \right)^{\sigma_{im}/(\sigma_{im}-1)} \tag{E.1.35}$$

where ρ is the share parameter and σ_{im} is the elasticity of substitution between domestic ($Z_{d,t}$) and foreign produced goods ($Z_{f,t}$).

E.2. Calibration

The following table gives an overview of the major structural parameters for our countries of interest.

Table E.1.: Calibration of main structural parameters in the QUEST model.

Variable/Parameter	Belgium	Italy	Poland	Source
Elasticities				
Frisch elasticity of labor supply by skills				
Low ($(1\text{-}L_L)/(\kappa_L L_L)$)	0.72	0.30	0.60	author's estimation
Medium ($(1\text{-}L_M)/(\kappa_M L_M)$)	0.40	0.20	0.27	author's estimation
High ($(1\text{-}L_H)/(\kappa_H L_H)$)	0.36	0.20	0.20	author's estimation
Elasticity of substitution between capital and labor (Cobb-Douglas)	1	1	1	Ratto, Roeger & in 't Veld (2009)
Output elasticity of labor (α)	0.6	0.6	0.6	Ratto, Roeger & in 't Veld (2009)
Elasticity of substitution between skills (μ)	1.4	1.4	1.4	Katz & Murphy (1992)
Share parameters				
High-skilled share (Λ_H)	0.41	0.16	0.24	EUROMOD
Medium-skilled share (Λ_M)	0.36	0.43	0.61	EUROMOD
Low-skilled share (Λ_L)	0.23	0.41	0.15	EUROMOD
Friction parameters				
Final goods mark-up ($1/\eta$-1)	0.14	0.13	0.16	Canton & Thum-Thysen (2015)
Wage mark-up ($1/\eta_s$-1)	0.20	0.20	0.20	Varga & in 't Veld (2014)
Liquidity constrained share (ε)	0.23	0.41	0.15	EUROMOD
Habit persistence (*hab*)	0.70	0.70	0.70	Varga & in 't Veld (2014)

F. Labor Market Modelling: Labor Supply Function, Labor Supply Elasticities and Tax Incidence

F.1. Labor Supply Function

The labor market plays the key role in linking the micro and macro models in our analysis. Here we follow the analysis of Magnani and Mercenier (2009),[1] which to some extent can be seen as a simplified version of linking the micro and macro models we use in our dynamic scoring analysis, in order to ensure consistency between our discrete choice labor supply model and the labor supply modelling in QUEST. Our aim is to compare the optimal labor supply produced in the micro and macroeconomic settings, in terms of how the decision is modelled. We also derive the labor supply elasticities for both the micro and macro models. Finally, we describe in detail how tax incidence works in the labor market modelled in QUEST.

Let us focus first on the modelling of the labor supply side of the labor market from the microeconomic perspective. We assume that each individual i faces alternatives of working 0, 20, 40 or 60 hours per week such that her preferences can be described by the following stochastic utility function:

$$V_{\mathrm{ij}} = U_{\mathrm{ij}}(C_{\mathrm{ij}}, H_{\mathrm{ij}}, .) + \epsilon_{\mathrm{ij}} \tag{F.1.1}$$

[1] These authors describe an exact aggregation of the results of a discrete choice model and a representative agent macroeconomic model, with constant elasticity of substitution/transformation utility function. They show that in order to ensure consistency between the micro and macro models , whereby both models can be characterized by similar equilibrium/optimality conditions, the calibration of the macro model labor parameters (labor elasticities and labor shares, fundamentally) must be tied to the statistical parameters of the probability distribution of the micro-data. In Magnani and Mercenier (2009), like in our case, the labor market decisions at the micro level are modelled as a discrete-choice model, where choice probabilities are derived from a multinomial-logit distribution. They show that the micro and macro optimality conditions are identical if the “deep” parameter of the macroeconomic model—elasticity of substitution in the utility function—coincides with the dispersion parameter of the multinomial logit population from the discrete choice model, and the shares of time spent in leisure activities are matched to measures of the disutility of working (wage).

where ϵ_{ij} is an independent and identically distributed error term for the each of the choice *j*, and follows an extreme value type I (EV-I) distribution. Then we can define the probability of i choosing alternative $j \in \{0, 20, 40, 60\}$ as follows:

$$\begin{aligned}
\text{Prob}_{\text{ij}} &= prob\left[V_{\text{ij}} \geq V_{\text{ik}},\ \forall k \in \{0, 20, 40, 60\}\,,\ k \neq j\right] && \text{(F.1.2)}\\
&= prob\left[U_{\text{ij}}\left(C_{\text{ij}}, H_{\text{ij}}, .\right) + \epsilon_{\text{ij}} \geq U_{\text{ik}}\left(C_{\text{ik}}, H_{\text{ik}}, .\right) + \epsilon_{\text{ik}},\ \forall k \in \{0, 20, 40, 60\}\,,\ k \neq j\right] && \text{(F.1.3)}\\
&= prob\left[U_{\text{ij}}\left(C_{\text{ij}}, H_{\text{ij}}, .\right) - U_{\text{ik}}\left(C_{\text{ik}}, H_{\text{ik}}, .\right) \geq \epsilon_{\text{ik}} - \epsilon_{\text{ij}},\ \forall k \in \{0, 20, 40, 60\}\,,\ k \neq j\right] && \text{(F.1.4)}\\
&= prob\left[\epsilon_{\text{ik}} - \epsilon_{\text{ij}} \leq U_{\text{ij}}\left(C_{\text{ij}}, H_{\text{ij}}, .\right) - U_{\text{ik}}\left(C_{\text{ik}}, H_{\text{ik}}, .\right),\ \forall k \in \{0, 20, 40, 60\}\,,\ k \neq j\right] && \text{(F.1.5)}\\
&= F(\epsilon_{\text{ik}} - \epsilon_{\text{ij}}) && \text{(F.1.6)}
\end{aligned}$$

Since we have assumed that $\epsilon_{\text{ij}} \sim EV - I$, then we can write the generalized extreme value distribution function as follows:

$$F\left(\epsilon_{i0}, \epsilon_{i20}, \epsilon_{i40}, \epsilon_{i60}\right) = exp\left[-H\left(e^{-\epsilon_{i0}}, e^{-\epsilon_{i20}}, e^{-\epsilon_{i40}}, e^{-\epsilon_{i60}}\right)\right] \tag{F.1.7}$$

Function H satisfies all the necessary conditions to ensure that F is a cumulative distribution function. Following Magnani and Mercenier (2009), we assume that the following functional form for H^f is:

$$H^f\left(\epsilon_{i0}, \epsilon_{i20}, \epsilon_{i40}, \epsilon_{i60}\right) = \sum_{s \in \{0,20,40,60\}} \epsilon_{\text{is}}^{\frac{1}{\mu}} \tag{F.1.8}$$

Given the functional form of *H*, then the cumulative distribution F is equal to the product of double exponential distributions that characterize the behavior of V_{ij} for each alternative of working hours such that:

$$H^f\left(e^{-\epsilon_{i0}}, e^{-\epsilon_{i20}}, e^{-\epsilon_{i40}}, e^{-\epsilon_{i60}}\right) = \sum_{s \in \{0,20,40,60\}} \left(e^{-\epsilon_{\text{is}}}\right)^{\frac{1}{\mu}} = \sum_{s \in \{0,20,40,60\}} e^{-\left(\frac{\epsilon_{\text{is}}}{\mu}\right)} \tag{F.1.9}$$

and F assumes the following form:

$$F\left(\epsilon_{i0}, \epsilon_{i20}, \epsilon_{i40}, \epsilon_{i60}\right) = exp\left[-\sum_{s\in\{0,20,40,60\}} e^{-\left(\frac{\epsilon_{\text{is}}}{\mu}\right)}\right] = \prod_{s\in\{0,20,40,60\}} \exp\left[-e^{-\left(\frac{\epsilon_{\text{is}}}{\mu}\right)}\right] \tag{F.1.10}$$

Then, according to McFadden theorem, the probability of i choosing alternative j is given by:

$$\text{Prob}_{\text{ij}} = \mu\frac{\partial lnH\left(e^{U_{i0}}, e^{U_{i20}}, e^{U_{i40}}, e^{U_{i60}}\right)}{\partial U_{\text{ij}}} \tag{F.1.11}$$

where μ is the dispersion parameter of the extreme value distribution. The probability we are looking for can be obtained by substituting (F.1.9) into (F.1.11) to obtain:

$$\text{Prob}_{\text{ij}} = \frac{e^{\frac{U_{\text{ij}}}{\mu}}}{\sum_{s\in\{0,20,40,60\}} e^{\frac{U_{\text{is}}}{\mu}}} \tag{F.1.12}$$

which, when $\mu = 1$, is equivalent to :

$$\text{Prob}_{\text{ij}} = \frac{e^{U_{\text{ij}}}}{\sum_{s\in\{0,20,40,60\}} e^{U_{\text{is}}}}. \tag{F.1.13}$$

Then, the expected number of hours supplied by individual i will be given by:

$$L_i = \sum_{j\in\{0,20,40,60\}} P_{\text{ij}} * j = \sum_{j\in\{0,20,40,60\}} \left(\frac{e^{U_{\text{ij}}}}{\sum_{s\in\{0,20,40,60\}} e^{U_{\text{is}}}}\right) * j = \frac{\sum_{j\in\{0,20,40,60\}} j * e^{U_{\text{ij}}}}{\sum_{s\in\{0,20,40,60\}} e^{U_{\text{is}}}} \tag{F.1.14}$$

Consider now that a given individual i belongs to a particular sub-population group that share the same socio-economic characteristics, and that there are N statistically identical and independent individuals in this sub-population group. Then, within this group, the expected number of hours supplied will be given by:

$$L = \sum_{i=1}^{N} L_i = \sum_{i}^{N} \left[\frac{\sum_{j\in\{0,20,40,60\}} j * e^{U_{\text{ij}}}}{\sum_{s\in\{0,20,40,60\}} e^{U_{\text{is}}}}\right] \tag{F.1.15}$$

Note that equation (F.1.15) is a simplified analytical expression of the labor supply function for a group of individuals sharing the same socio-economic characteristics. We can also compute the expected number of individuals in this population subgroup that will choose any of the working hours' alternatives. For instance, the expected number of individuals supplying zero hours, i.e. individuals deciding not to participate in the labor market, is equal to:

$$L_{j=0} = \text{Prob}_{i0} * N = \left(\frac{e^{U_{i0}}}{\sum_{s \in \{0,20,40,60\}} e^{U_{\text{is}}}} \right) * N \tag{F.1.16}$$

Similarly, the expected number of working individuals, i.e. individuals supplying non-zero working hours, is equal to:

$$L_{j \neq 0} = (1 - Prob_{i0}) * N = \left(1 - \frac{e^{U_{i0}}}{\sum_{s \in \{0,20,40,60\}} e^{U_{\text{is}}}} \right) * N = N - L_{j=0} \tag{F.1.17}$$

In more general terms, the expected number of individuals choosing any alternative j of the setting of alternatives is equal to:

$$L_j = \text{Prob}_{\text{ij}} * N = \left(\frac{e^{U_{\text{ij}}}}{\sum_{s \in \{0,20,40,60\}} e^{U_{\text{is}}}} \right) * N \tag{F.1.18}$$

We turn now to the macroeconomic setting. In QUEST the labor market is populated by workers, and firms. The QUEST model therefore takes into account both the supply and demand of labor. Focusing only on the partial equilibrium, this translates into a system of equations that allows finding the equilibrium wage and working hours. In this way, and abstracting from other general equilibrium effects, the referred system is presented below:[2]

$$\frac{V_{1-L,h,s,t}}{U_{C,h,s,t}} \frac{1}{\eta_{s,t}} = \frac{W_{s,t}(1 - t_{w,s,t} - b)}{P_{C,t}(1 + t_{C,t})} \tag{F.1.19}$$

$$P_{j,t} \frac{\partial Y_{j,t}}{\partial L_{j,s,t}} \eta_{j,t} = (1 + t_{er,s,t}) W_{s,t} + \frac{\Gamma^L(L_{j,L,t}, L_{j,M,t}, L_{j,H,t})}{\partial L^j_{j,s,t}}, \qquad \text{for} s \in \{H, M, L\} \tag{F.1.20}$$

where the first equation of the system[3] results from the combination between the first order conditions with respect to consumption and labor—the inter-temporal and the intra-temporal optimality conditions, respectively—resulting from the household problem,

[2]Note that QUEST is characterized by the system of all the equilibrium conditions of economic agents, laws of motion of state endogenous variables and shocks, and feasibility conditions, and as such the solution of the model implies solving this system, and having all the (approximated) conditions met simultaneously in the steady state.

[3]This corresponds to equation (E.1.17) in Appendix E.

and the second equation of the system results from maximizing firms profits with respect to labor.[4] From the system in (F.1.19), we obtain the partial equilibrium pair of hours worked and wage rate $\left(L^*_{s,t}, W^*_{s,t}\right)$, $s \in \{H, M, L\}$. Notice that the decisions modelled in the supply side of the labor market have similar aspects in both micro and macro settings: both consider maximization of individual/household utilities, which depend on consumption and leisure. However, in the macro setting, the number of hours worked in equilibrium is derived from intersecting labor supply and labor demand functions, i.e. QUEST take into account the demand of labor. This demand effect, which is basically constrained by the labor demand elasticity to wages, is not considered in the micro framework but rather taken as given by the macro-economic conditions described by the DSGE model.[5] Considering the following functional form of the household utility function in QUEST, given by expressions (F.1.21) and (F.1.22) below [6], for skill group $s \in \{H, M, L\}$,

$$V_{1-L,h,s,t} = \frac{\omega_s}{(1 - L_{i,s,t})^{\kappa}}, \ s \in \{H, M, L\} \tag{F.1.21}$$

and,

$$U_{C,h,s,t} = \frac{1 - \mathrm{habc}}{C_{i,t} - habcC_{t-1}}, s \in \{H, M, L\} \tag{F.1.22}$$

and substituting them in the inter-temporal condition of the system in (F.1.19), we obtain the expression for the labor supply function in QUEST:

$$L_{i,s,t} = 1 - \left[\frac{\omega_s}{\eta_{s,t}\,(1 - \mathrm{habc})} \frac{P_{c,t}\,(1 + t_{c,t})\,(C_{i,t} - habcC_{t-1})}{W_{s,t}\,(1 - t_{W,s,t} - b)}\right]^{\frac{1}{\kappa}} \tag{F.1.23}$$

$$\Leftrightarrow L_{i,s,t} = 1 - \left[\frac{\omega_s}{\eta_{s,t}} \frac{1}{W_{s,t}\,(1 - t_{W,s,t} - b)} \frac{P_{c,t}\,(1 + t_{c,t})}{U_{C,h,s,t}}\right]^{\frac{1}{\kappa}} \tag{F.1.24}$$

If we now consider that there are N identical households on the skill group $s \in \{H, M, L\}$ we can rewrite (F.1.23) as follows:

[4] This corresponds to equation (E.1.26) in Appendix E.

[5] Notice that not considering labor demand in the micro model can be problematic in what concerns the coherence between the micro and macro settings. It may be difficult to obtain convergence on the main economic aggregates between the two models.

[6] These correspond to expressions (E.1.8) and (E.1.9) in Appendix E.

$$(L_{s,t} = N\left(1 - \left[\frac{\omega_s}{\eta_{s,t}} \frac{1}{W_{s,t}\left(1 - t_{W,s,t} - b\right)} \frac{P_{c,t}\left(1 + t_{c,t}\right)}{U_{C,h,s,t}}\right]^{\frac{1}{\kappa}}\right) \tag{F.1.25}$$

Expression (F.1.25) can be compared with expression (F.1.17), the expected number of individuals that was derived in our simplified discrete choice setting. First of all, notice that both expressions are optimality conditions derived from a utility maximization problem, conditional on how much the household wants to consume. To see this better, we can write expression (F.1.25) in the following terms:

$$(L_{s,t} = N\left(1 - g\left(X_t; T_t; \Omega\right)\right) \tag{F.1.26}$$

where *g(.)* is a function of a vector of aggregated endogenous variables, X_t, a vector of policy exogenous variables, T_t, and a vector of parameters, Ω, , with

$$X_t = \left(C_{i,t}, W_{s,t}, P_{c,t}; \eta_{s,t}\right);\ T_t = \ \left(t_{W,s,t}, t_{c,t}, b\right);\ \Omega = \left(\kappa, \omega_s, habc\right).$$

In a similar way, we can rewrite (F.1.17) as follows:

$$(L_{j\neq 0} = N\left(1 - F\left(U_{\text{ij}}; \Theta\right)\right) \tag{F.1.27}$$

where *F(.)* is the distribution function depending on the arguments of the deterministic utility function $U_{\text{ij}} = (C_{\text{ij}}, H_{\text{ij}},\ Z_{\text{ij}})$ and on a set of parameters Θ. However, while expression (F.1.25) denotes the optimal amount of labor services supplied, in terms of total number of hours, for any level of the net adjusted wage (the intensive margin), expression (F.1.17) denotes the expected number of individuals working in the economy (the extensive margin). Furthermore, notice that, in QUEST, unemployment is obtained endogenously and is equal to:

$$UNEMPL = 1 - \text{NPART}_{L,t} - L_{L,t} \tag{F.1.28}$$

where *NPART* is the non-participation rate. In QUEST households only decide on the amount of hours supplied in the labor market, but they do not choose between unemployment and non-participation, explicitly. The non-participation rate is calibrated as the proportion of inactive people in the total population. The non-participation rate (*NPART*) must therefore be seen as an exogenous policy variable characterizing the generosity of the benefit system. However, in our discrete choice model the choice of non-participation, or being unemployed voluntarily, is one of the possible alternatives of individual *i*. The choice of participating in the labor market is nested together with the decision on supplying different number of hours (which can be seen as the different working modalities). We reconcile the two models on this issue by calibrating in QUEST the non-participation rate according to the expected number of individuals that choose to be out of the labor market, i.e. equation (F.1.16) in the discrete choice model.

F.2. Labor Supply Elasticities

In our dynamic scoring exercise, labor supply elasticities are crucial to understand the effects of a particular tax reforms on the households' disposable income, in particular, and on the economy as a whole. More specifically, the labor supply elasticity is a good measure of the work effort incentives, and, in this way, crucial to understand the effects of the tax reforms implemented on the workers behavior. Moreover, the analysis of the elasticities in both models is important to see whether we can calibrate QUEST with the elasticities obtained from our microeconometric model, so that a greater consistency can be achieved in linking the two models. In what follows we derive analytically the labor supply elasticities in the micro and macro settings, and see how these relate to each other. Recall that in what concerns QUEST, the parameter that we are interested in calibrating is the parameter κ.[7] This parameter relates the Frisch elasticity to the inter-temporal elasticity of substitution, as we will see in what follows.

In QUEST, the Frisch elasticity is defined as the elasticity of the labor supply, as defined in equation (F.1.25), with respect to the wage, maintaining the marginal utility of consumption constant. In this way, we can define the Frisch elasticity as follows:

$$\varepsilon^F_{L,W} = \frac{\frac{\partial L_{s,t}}{L_{s,t}}}{\frac{\partial W_{s,t}}{W_{s,t}}} <=> \varepsilon^F_{L,W} = \frac{1}{\kappa}\left(\frac{N - L_{s,t}}{L_{s,t}}\right) \tag{F.2.1}$$

The elasticity in (F.2.1) suggests a positive relationship between wages and labor supply, depending on the level of labor hours supplied. This implies that the Frisch elasticity might differ (and, in fact, it will) for the three skill groups considered in QUEST. In this way, we expect that some groups will be more reactive to changes in the wage level than others. Besides the Frisch elasticity, another important result in macroeconomic models such as QUEST is how labor supply evolves over time, given temporary changes in the wages path. This is known as the inter-temporal elasticity of substitution, ε^{IES}. In this way, this elasticity measures the relation between the changes in the ratio of labor supplied tomorrow and today, and the ratio of wages paid tomorrow and today. In order to derive this elasticity, we need to find the inter-temporal labor supply function,

[7] See the functional form given in expression (E.1.9) in Appendix E.

where we can relate the path of labor supply with the path of wages. For that consider the QUEST model described in Appendix D. Consider also the labor supply function in equation (F.1.25) of this appendix section. In order to derive the inter-temporal labor supply function, one needs to combine the intra-temporal optimality condition with the inter-temporal one (the Euler equation). Let us consider first the intra-temporal optimality condition given by equation (E.1.17) and write it one period ahead, as follows:

$$\frac{V_{1-L,h,s,t+1}}{U_{C,h,s,t+1}}\frac{1}{\eta_{s,t+1}} = \frac{W_{s,t+1}\left(1-t_{W,s,t+1}-b\right)}{P_{c,t+1}\left(1+t_{c,t+1}\right)} \tag{F.2.2}$$

From this condition we can obtain the labor supply function of the N households in group s, one period ahead:

$$L_{s,t+1} = N\left(1-\left[\frac{\omega_s}{\eta_{s,t+1}}\frac{1}{W_{s,t+1}\left(1-t_{W,s,t+1}-b\right)}\frac{P_{c,t}\left(1+t_{c,t+1}\right)}{U_{C,h,s,t+1}}\right]^{\frac{1}{\kappa}}\right) \tag{F.2.3}$$

We can now substitute in (F.2.3) the marginal utility of consumption $U_{C,h,s,t+1}$ by its expression one period ahead, given the functional form in expression (E.1.8)):

$$L_{s,t+1} = N\left(1-\left[\frac{\omega_s}{\eta_{s,t+1}}\frac{1}{W_{s,t+1}\left(1-t_{W,s,t+1}-b\right)}\frac{P_{c,t}\left(1+t_{c,t+1}\right)}{1-\text{habc}}\left(C_{i,t+1}-\text{habc}C_t\right)\right]^{\frac{1}{\kappa}}\right) \tag{F.2.4}$$

At this point, we need to consider also the intertemporal optimality condition of the household problem—the Euler equation. This condition is obtained by combining the first order conditions with respect to consumption and bonds of the household problem, i.e. equations (E.1.11) and (E.1.12) in Appendix D respectively, and it explains the path of consumption over time. From these two conditions, we obtain an expression for the Lagrangian multiplier, $\lambda_{i,t}$:

$$\lambda_{i,t} = \frac{P_t}{P_{c,t}}\frac{U_{c,i,t}}{1+t_{c,t}} \tag{F.2.5}$$

And writing (F.2.5) one period ahead, we get:

$$\lambda_{i,t+1} = \frac{P_{t+1}}{P_{c,t+1}}\frac{U_{c,i,t+1}}{1+t_{c,t+1}} \tag{F.2.6}$$

Now that we have the expressions of the Lagrangian multiplier, at t and $t+1$, we can substitute them in the first order condition with respect to bonds to obtain the Euler equation:

$$\frac{U_{c,i,t}}{P_{c,t}\left(1+t_{c,t}\right)}\frac{1}{\beta\left(1+i_t\right)}=E_t\left[\frac{U_{c,i,t+1}}{P_{c,t+1}\left(1+t_{c,t+1}\right)}\right] \tag{F.2.7}$$

where we can explicitly include the expressions of the marginal utility of consumption at t and *t+1*. Then, the Euler equation can be re-written as follows:

$$E_t\left[P_{c,t+1}\left(1+t_{c,t+1}\right)\left(C_{i,t+1}-\mathrm{habc}C_t\right)\right]=\beta\left(1+i_t\right)P_{c,t}\left(1+t_{c,t}\right)\left(C_{i,t}-\mathrm{habc}C_{t-1}\right) \tag{F.2.8}$$

The next step is to include the Euler equation derived in equation (F.2.8) in the labor supply function, equation (F.2.4) to obtain a relation between the labor supplied tomorrow and consumption today, as follows:

$$L_{s,t+1}=N\left(1-\left[\frac{\omega_s}{\eta_{s,t+1}}\frac{1}{W_{s,t+1}\left(1-t_{W,s,t+1}-b\right)}\frac{\beta\left(1+i_t\right)P_{c,t}\left(1+t_{c,t}\right)\left(C_{i,t}-\mathrm{habc}C_{t-1}\right)}{1-\mathrm{habc}}\right]^{\frac{1}{\kappa}}\right) \tag{F.2.9}$$

Recurring again to the intra-temporal optimality condition, and substituting the marginal utilities of leisure and consumption, we find that:

$$P_{c,t}\left(1+t_{c,t}\right)\left(C_{i,t}-\mathrm{habc}C_{t-1}\right)=\frac{\eta_{s,t}\left(1-\mathrm{habc}\right)}{\omega_s}W_{s,t}\left(1-t_{W,s,t}-b\right)\left(1-L_{i,s,t}\right)^{\kappa} \tag{F.2.10}$$

Substituting the previous result in the labor supply equation given by (F.2.9), we will obtain finally an expression which includes $L_{s,t+1}$, $L_{i,s,t}$, $W_{s,t+1}$and $W_{s,t}$, shown below.

$$L_{s,t+1}=N\left(1-\left[\frac{\eta_{s,t}}{\eta_{s,t+1}}\frac{W_{s,t}\left(1-t_{W,s,t}-b\right)}{W_{s,t+1}\left(1-t_{W,s,t+1}-b\right)}\beta\left(1+i_t\right)\left(1-L_{i,s,t}\right)^{\kappa}\right]^{\frac{1}{\kappa}}\right) \tag{F.2.11}$$

After some algebraic computations we can derive the following expression, which relates the path of leisure hours (and labor supply) with the path of wages, as follows:

$$\frac{1-L_{i,s,t+1}}{1-L_{i,s,t}}=\left[\beta\left(1+i_t\right)\frac{\eta_{s,t}}{\eta_{s,t+1}}\frac{1-t_{W,s,t}-b}{1-t_{W,s,t+1}-b}\right]^{\frac{1}{\kappa}}\left(\frac{W_{s,t+1}}{W_{s,t}}\right)^{-\frac{1}{\kappa}} \tag{F.2.12}$$

Similarly to the Euler equation, equation (F.2.12) represents the inter-temporal optimality condition for leisure (labor). We can now denote $\frac{1-L_{i,s,t+1}}{1-L_{i,s,t}} = (\widehat{1-L_{i,s}})$ and $\frac{W_{s,t+1}}{W_{s,t}} = \widehat{W_s}$ and rewrite equation (F.2.12) as follows:

$$(\widehat{1-L_{i,s}}) = \left[\beta\,(1+i_t)\,\frac{\eta_{s,t}}{\eta_{s,t+1}}\frac{1-t_{W,s,t}-b}{1-t_{W,s,t+1}-b}\right]^{\frac{1}{\kappa}}\left(\widehat{W_s}\right)^{-\frac{1}{\kappa}} \tag{F.2.13}$$

We can now compute the elasticity of inter-temporal substitution for leisure since the results are very easily extrapolated in terms of labor supply. We apply logarithms to equation (F.2.13) and then compute the derivative of the $\ln(\widehat{1-L_{i,s}})$ with respect to $\ln\left(\widehat{W}\right)_s$. In this way, we obtain the following expression:

$$\ln(\widehat{1-L_{i,s}}) = \frac{1}{\kappa}\ln\left[\beta\,(1+i_t)\,\frac{\eta_{s,t}}{\eta_{s,t+1}}\frac{1-t_{W,s,t}-b}{1-t_{W,s,t+1}-b}\right] - \frac{1}{k}\ln\left(\widehat{W_{s,t}}\right) \tag{F.2.14}$$

and

$$\frac{\mathrm{dln}(\widehat{1-L_{i,s}})}{\mathrm{dln}\left(\widehat{W_{s,t}}\right)} = -\frac{1}{k} <=> \frac{\frac{d(\widehat{1-L_{i,s}})}{(\widehat{1-L_{i,s}})}}{\frac{d\left(\widehat{W_{s,t}}\right)}{\left(\widehat{W_{s,t}}\right)}} = -\frac{1}{k} <=> \varepsilon^{\mathrm{IES}}_{1-L_{i,s}} = -\frac{1}{k} \tag{F.2.15}$$

As we can observe from expression (F.2.15), parameter k guides the elasticity of inter-temporal substitution, and the smaller this parameter is, the higher (in absolute terms) is this elasticity, and the more willing is the household to change the path of leisure (or labor), given temporary changes in wages. Moreover, we can see clearly that the relation between the Frisch elasticity and the inter-temporal elasticity of substitution depends on the parameter k. In this way, we can establish the following relation between the two elasticities:

$$\varepsilon^{F}_{L,W} = -\varepsilon^{\mathrm{IES}}_{1-L_{i,s}}\left(\frac{N-L_{s,t}}{L_{s,t}}\right) \tag{F.2.16}$$

In the nonlinear discrete choice econometric model, labor supply elasticities cannot be derived analytically. However, using the estimated structural utility function, we can calculate choice probabilities for varying incomes. Wage elasticities are calculated after simulating a marginal increase in the wage rate and predicting the probability distribution over the choice categories for the increased wage rate. The wage elasticity is defined as the change in expected working hours (that is, the probability-weighted average of working hours) with respect to the change in the wage rate. Similarly, we calculate expected incomes, benefits, and tax payments before and after the simulated income change. In this way, using the estimated structural utility function, we predict the probability distribution over the hour's categories that emerge after simulating a marginal increase in the wage rates. As the estimated utility function depends on the net income, the predicted probability distribution will change after the simulated income change. Recall from equation (F.1.14) the expected hours supplied by household i. Denote by $\widetilde{U}_{\text{ij}}$ the predicted utility of the household from working j hours at the marginally increased wage rate. Then expected hours for the new wage can be calculated in the same way:

$$\widetilde{L_i} = \frac{\sum_{j \in \{0,20,40,60\}} j * e^{\widetilde{U}_{\text{ij}}}}{\sum_{s \in \{0,20,40,60\}} e^{\widetilde{U}_{\text{is}}}} = \sum_{j \in \{0,20,40,60\}} \widetilde{\text{Prob}}_{\text{ij}} * j. \tag{F.2.17}$$

The labor supply elasticity can be calculated as the change in predicted hours with respect to the marginal change in the wage rate:

$$\varepsilon_{L_i,w} = \frac{\frac{\partial L_i}{L_i}}{\frac{\partial w_i}{w_i}} = \frac{\frac{\left(\widetilde{L}_i - L_i\right)}{L_i}}{\frac{\left(\widetilde{w}_i - w_i\right)}{w_i}} \tag{F.2.18}$$

The econometric framework from which the elasticity is calculated is static in nature. We rely on cross sectional data and do not observe households at multiple points in time. Moreover, the econometric model does not encompass saving decisions. The elasticities we estimate are uncompensated (Marshallian) elasticities. The Marshallian elasticity is related by the Slutsky equation to the compensated (Hicksian) income elasticity. In studies focusing on the deadweight loss of taxation or steady state responses to tax changes, the Hicksian elasticity is the crucial parameter. However, these studies usually assume that tax revenue is redistributed as a lump sum payment to households, shutting off the income effect. As we do not make this assumption, tax changes have income effects, and the Marshallian elasticity is the appropriate parameter to use. In principle, we could obtain the Hicksian elasticity as the residual of the Marshallian elasticity (the one we estimate) and the income effect (which we could calculate by simulating a marginal increase in non-labor income) but since we focus on a situation with income effects, we refrain from doing so.[8]

Comparing the elasticities defined both in the micro and in macroeconomic settings, we conclude that, in fact, the elasticity defined in (F.2.18) is the micro-equivalent to the

[8]Note that Bargain et al. (2014) estimate uncompensated, income and compensated elasticities using EUROMOD. They find that income effects are almost zero and hence the difference between compensated and uncompensated elasticities is small.

elasticity derived in (F.2.1), i.e. the Frisch elasticity, in the macro setting. This is a very important result, because we can greatly improve the consistency between the two models by calibrating the Frisch elasticity with the labor supply elasticities estimated from the discrete choice model. In this way, parameter κ in QUEST can be obtained from the following expression:

$$\kappa = \frac{1}{\varepsilon^F_{L,W}} \frac{N - L_{s,t}}{L_{s,t}} \tag{F.2.19}$$

where $\varepsilon^F_{L,W} = \varepsilon_{L_i,w}$.

F.3. Tax Incidence in QUEST

For our exercise is very important to assess how the tax incidence mechanism works in the labor market defined in the QUEST model. In this way, following Fullerton and Metcalf (2002) analysis of tax incidence and considering the labor market of the QUEST model, workers face the statutory burden of paying the fraction t_w of the gross wage, receiving the net wage defined as follows (for simplicity we abstract here from time and skill type indices):

$$NW = (1 - t_w)\, W \tag{F.3.1}$$

The firms pay gross wages and social insurance contributions, i.e. a total compensation of employees defined by:

$$TC = (1 + t_{\text{er}})\, W \tag{F.3.2}$$

where W is the gross wage, facing, in this way, the statutory tax rate of t_{er}. However, the economic incidence of these taxes may be different from their legal incidence, and this will basically depend on the labor supply and demand elasticities with respect to wages. Let us define labor supply elasticity with respect to net wage as follows:

$$\varepsilon_{\text{LS}} = \frac{\frac{dL_s}{L_s}}{\frac{\text{dNW}}{\text{NW}}} = \frac{\frac{dL_s}{L_s}}{\frac{d[(1-t_w)W]}{[(1-t_w)W]}} \cong \frac{\widehat{L_s}}{\widehat{W} - \widehat{t_w}}, \tag{F.3.3}$$

where the symbol $\hat{}$ represents percent changes. The changes in labor supply will depend on the changes on gross wages, taxes and on the elasticity parameter as follows:

$$\widehat{L_s} = \left(\widehat{W} - \widehat{t_w}\right) \varepsilon_{\text{LS}} \tag{F.3.4}$$

In the same way, we can define labor demand elasticity with respect to the total compensation of employees as follows:

$$\varepsilon_{\mathrm{LD}} = \frac{\frac{dL_d}{L_d}}{\frac{\mathrm{dTC}}{\mathrm{TC}}} = \frac{\frac{dL_d}{L_d}}{\frac{d[(1+t_{\mathrm{er}})W]}{[(1+t_{\mathrm{er}})W]}} \cong \frac{\widehat{L_d}}{\widehat{W} + \widehat{t_{\mathrm{er}}}} \tag{F.3.5}$$

and the changes in labor demand will depend equally on gross wages, taxes and on the elasticity parameter as follows:

$$\widehat{L_d} = \left(\widehat{W} + \widehat{t_w}\right) \varepsilon_{\mathrm{LD}} \tag{F.3.6}$$

Tax changes will lead to a new equilibrium in the labor market, which implies that:

$$\widehat{L_s} = \widehat{L_d}. \tag{F.3.7}$$

Substituting (F.3.4) and (F.3.6) into (F.3.7), we find that, in order to reach the new equilibrium, changes in gross wages will be given by the following expression:

$$\widehat{W} = \frac{\varepsilon_{\mathrm{LS}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}} \widehat{t_W} + \frac{\varepsilon_{\mathrm{LD}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}} \widehat{t_{\mathrm{er}}}. \tag{F.3.8}$$

Since in QUEST, $0 < \varepsilon_{\mathrm{LS}} < \infty$ and $\epsilon_{\mathrm{LD}} < 0$, the final change in the equilibrium wage will depend on the relative magnitude of the elasticities and the signs and magnitude of the fiscal policy shocks, i.e., the relative changes in t_W and t_{er}. In the same way, we can also find the changes in the net wages and total compensation of employees, given the changes in the tax rates for employees and employers. Consider the definition of net wages in (F.2.19). Applying logarithms and differentiating, we obtain:

$$\widehat{\mathrm{NW}} = \widehat{W} - \widehat{t_w}. \tag{F.3.9}$$

Substituting (F.3.8) in (F.3.9), we obtain that:

$$\widehat{\mathrm{NW}} = \frac{\varepsilon_{\mathrm{LD}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}} \left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) \tag{F.3.10}$$

The ratio $\frac{\varepsilon_{\mathrm{LD}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}}$ is negative. This means that there is an inverse relationship between the change in total taxes on labor and net wages. The same algebraic reasoning can be done in order to find the change in the total compensation of employees. Consider in this case the definition of the total compensation in (F.3.2). Applying logarithms and differentiating, we obtain:

$$\widehat{\mathrm{TC}} = \widehat{W} + \widehat{t_{\mathrm{er}}}. \tag{F.3.11}$$

Substituting (F.3.8) in (F.3.11), we obtain that:

$$\widehat{\mathrm{TC}} = \frac{\varepsilon_{\mathrm{LS}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}} \left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) \tag{F.3.12}$$

The ratio $\frac{\varepsilon_{\mathrm{LS}}}{\varepsilon_{\mathrm{LS}} - \varepsilon_{\mathrm{LD}}}$ is positive. This means that there is a direct relationship between the change in total taxes on labor and the total compensation. As we can conclude, tax incidence in QUEST, i.e. the sharing of the tax burden between workers and firms, will depend on the sign and magnitude of the elasticities of supply and demand.

In case of the Belgian reforms, when cutting employee paid contributions, the responses of net wages and of the total compensation of employees to an increase in labor tax are negative and positive, respectively, and are constrained by the elasticity of labor supply ($\varepsilon_{L,s} > 0$) and labor demand ($\varepsilon_{L,d} < 0$). Our shocks imply that $\widehat{t_w} < 0$ and $\widehat{t_{\mathrm{er}}} = 0$, then from equation (F.3.8) gross wages should go down, i.e. $\widehat{W}$<0. In the same way, and now from equation (F.3.10), we should expect the net wages to rise in the new equilibrium. Note that $\left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) < 0$, and, according to equation (F.3.10), there is an inverse relationship between the change in total taxes on labor income and net wages. This is also confirmed by the impulse response functions of the net wages (graph G.1. Finally, in what concerns the total compensation of employees paid by the firms, and according to equation (F.3.12), we should expect it to decrease. Equation (F.3.12) implies a positive relationship between the change in total taxes on labor income and the total compensation. In our case, $\left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) < 0$. So, the total compensation of employees will decrease in the new equilibrium. Again this is shown in the impulse response functions of the total compensation of employees, in graph G.2.

A similar analysis can be done in case of cutting employer paid contributions. Again drawing from our tax incidence analysis and since our shocks imply that $\widehat{t_w} = 0$ and $\widehat{t_{\mathrm{er}}} < 0$, from equation (F.3.8) gross wages should go up, i.e. $\widehat{W}$<0. In the same way, and now from equation (F.3.10), we should expect the net wages to rise in the new equilibrium, $\left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) < 0$, and, according to equation (F.3.10) there is an inverse relationship between the change in total taxes on labor income and net wages. This is also confirmed by the impulse response functions of the net wages (graph G.3). Finally, in what concerns the total compensation of employees paid by the firms, and according to equation (F.3.12), we should expect it to decrease. Since $\left(\widehat{t_w} + \widehat{t_{\mathrm{er}}}\right) < 0$, the total compensation of employees will decrease in the new equilibrium. Again this is shown in the impulse response functions of the total compensation of employees, in graph G.6.

G. QUEST Impulse Responses

G.1. Reform on Employees' Contributions

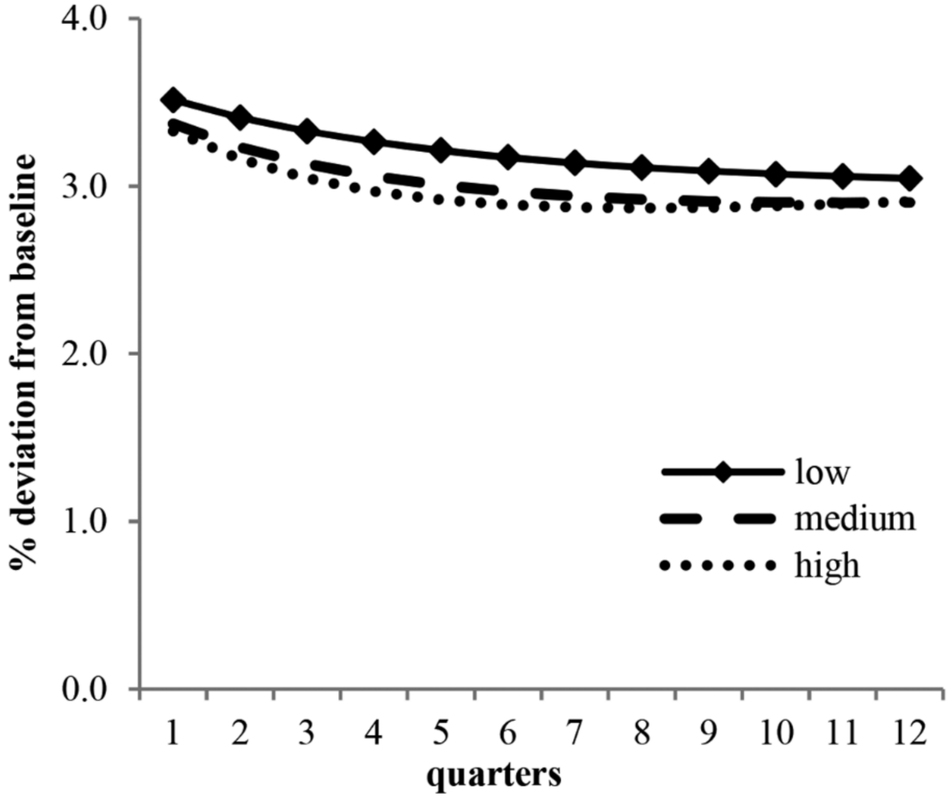


Figure G.1.: Net Real Wage of Employees by Skill Level

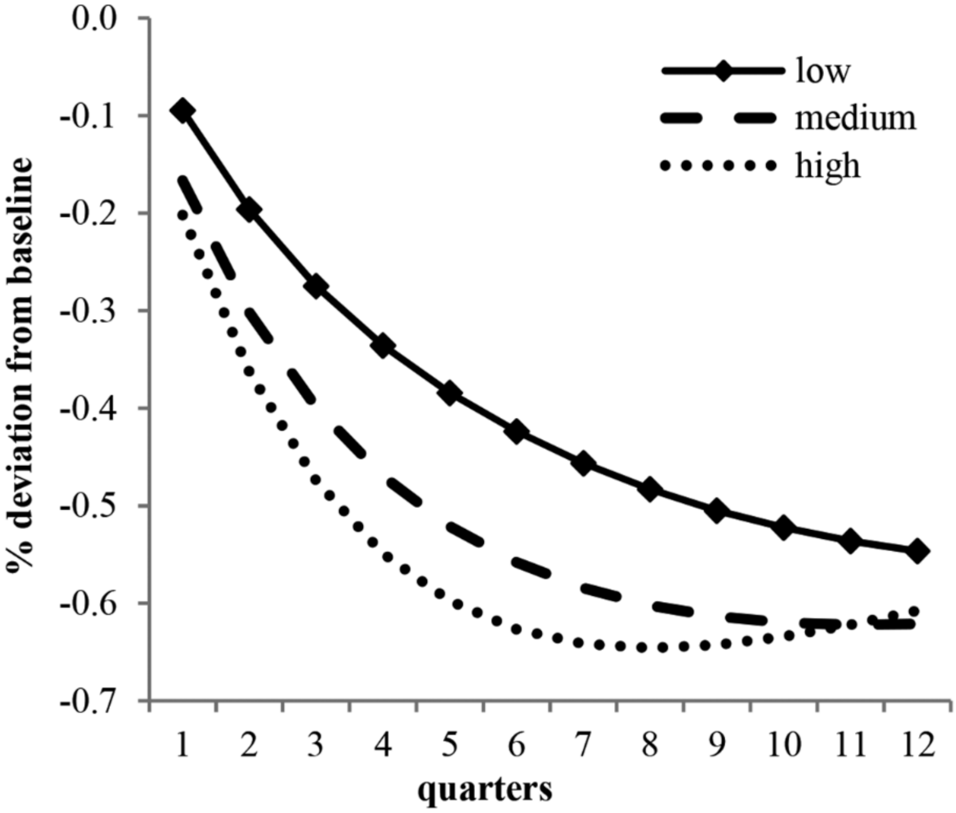


Figure G.2.: Total Compensation of Employees by Skill Level

G.2. Reform on Employers' Contributions

G.3. Transition Path Towards the New Steady State

The tax reforms were only implemented temporarily by setting off the debt-stabilization rule (equation (E.1.33).) for 15 years. After 15 years the reforms are reversed and employee paid labor taxes are used to raise additional tax revenues in order restore the pre-reform debt to GDP ratio. Tables G.1 and G.2 below show the macroeconomic impact of the reforms on selected variables over several years towards the re-established pre-reform steady state. The reforms generate positive GDP effects in both cases up to the first 10 years but these output gains gradually diminish as the financially unconstrained households increase precautionary savings while preparing for the forthcoming labor tax hike. After 20 years, i.e. five years after the debt-stabilization rule is restored, GDP is falling below the baseline as the government has to decrease the debt by raising

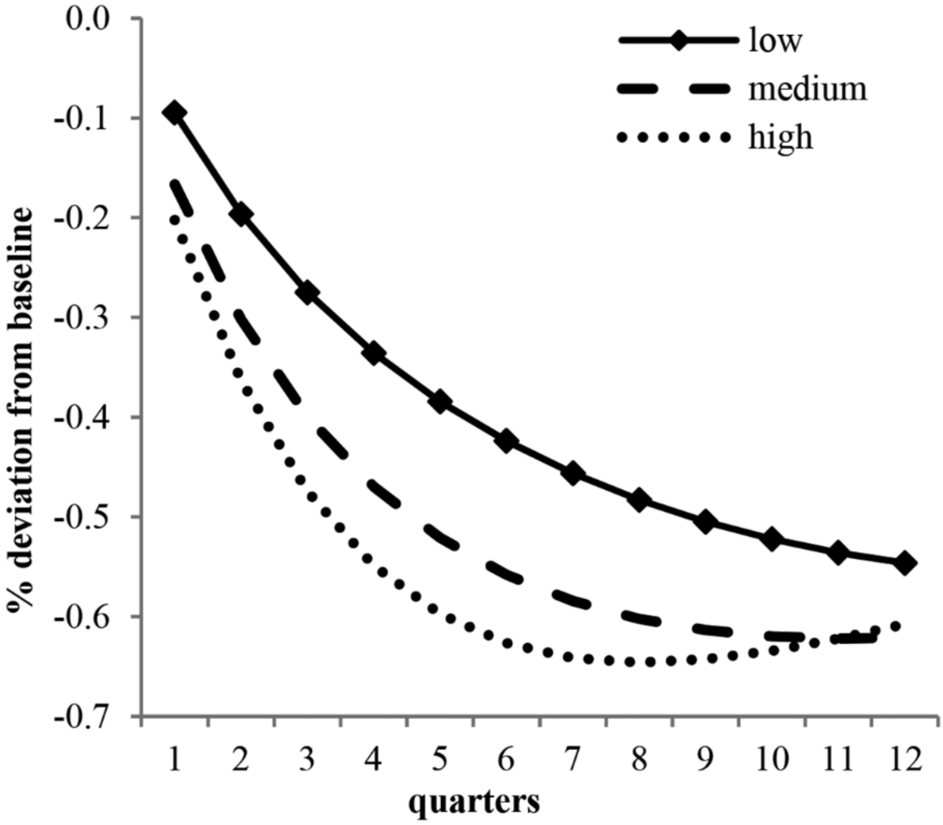


Figure G.3.: Gross Real Wage by Skill Level

taxes. Note that the speed of adjustment towards the pre-reform steady state can be controlled by the and parameters in the debt-stabilization rule: higher values imply stronger reaction from the government with larger tax hikes in order to reduce the debt. Note that as the SICer reform implies a larger reduction in labor tax-revenues, the corresponding debt-consolidation also requires a larger tax-hike with even stronger negative GDP effects compared to the SICee reform. As Belgium is part of the euro area without independent monetary policy, the change in interest rates is negligible. In the long-run the economy returns to its pre-reform steady state, therefore, the variables' deviation from the baseline is nihil. As noted before, the QUEST model offers a wide range of fiscal rules to stabilize the debt over the long-run. Exploring the long-run implications of these various alternative rules goes beyond the scope of the paper. Since we focus only on the short-run implications of the reforms and their direct feedback effects on the tax-revenues, by switching off the debt-rule for a relatively long period we

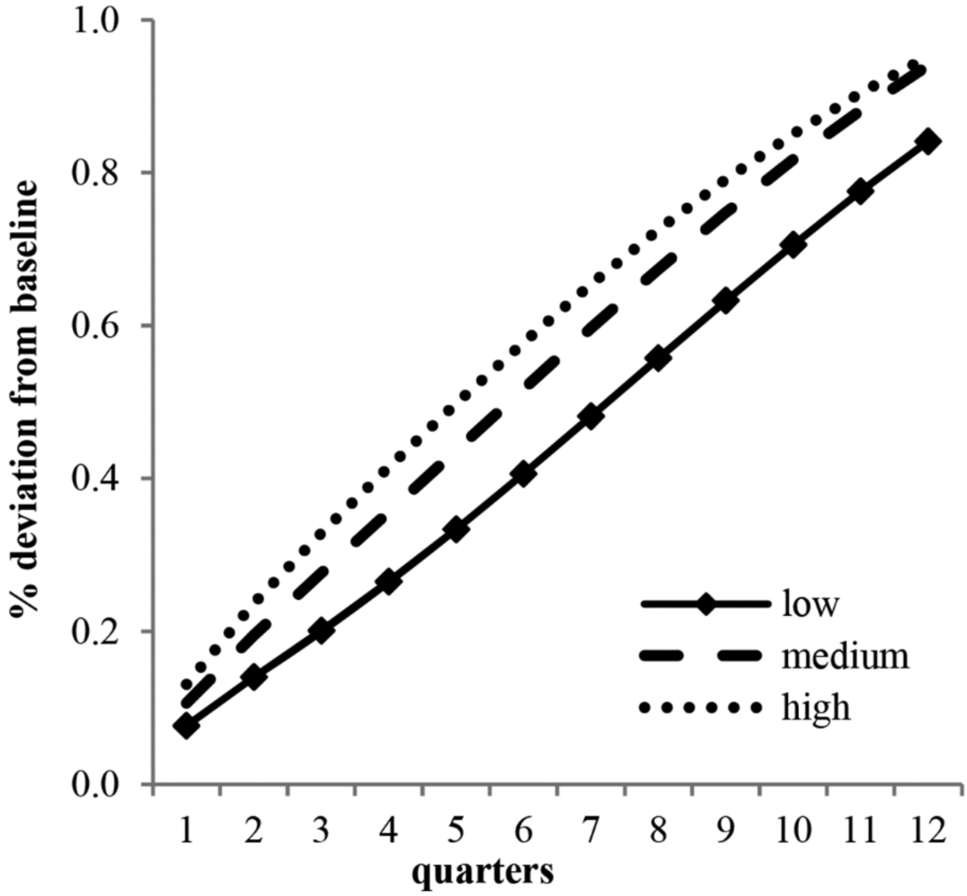


Figure G.4.: Employment by Skill Level

can ensure that the short-run behavior of economic agents is not strongly influenced by the debt-stabilization rule.

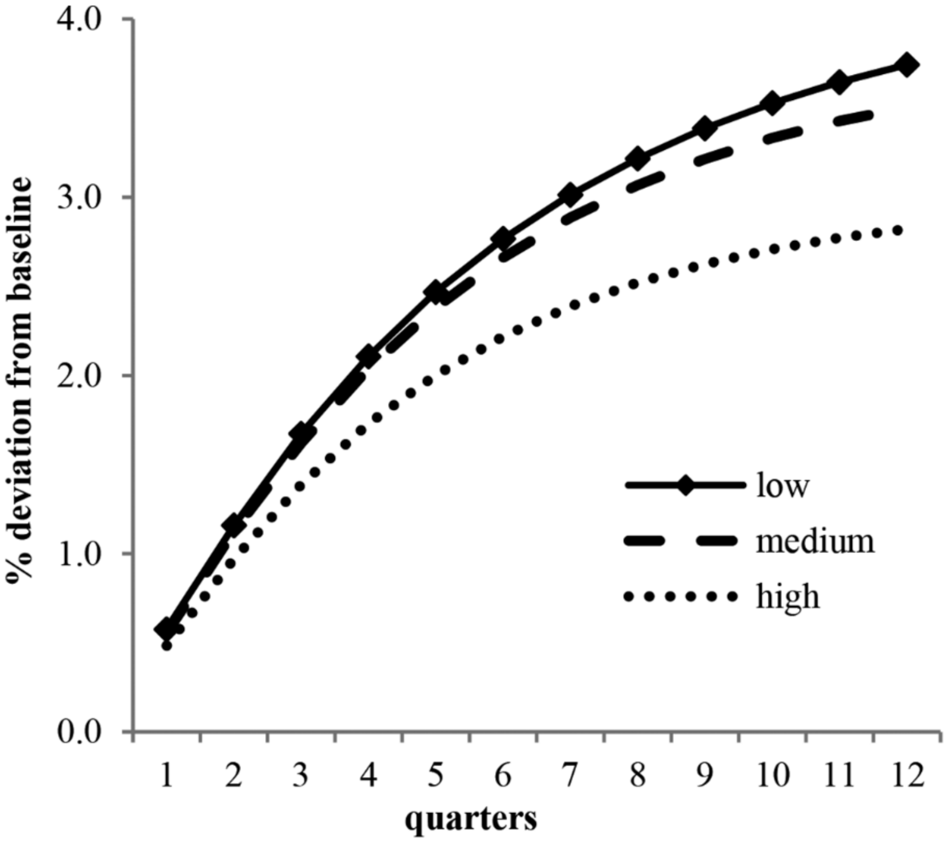


Figure G.5.: Net Real Wage of Employees

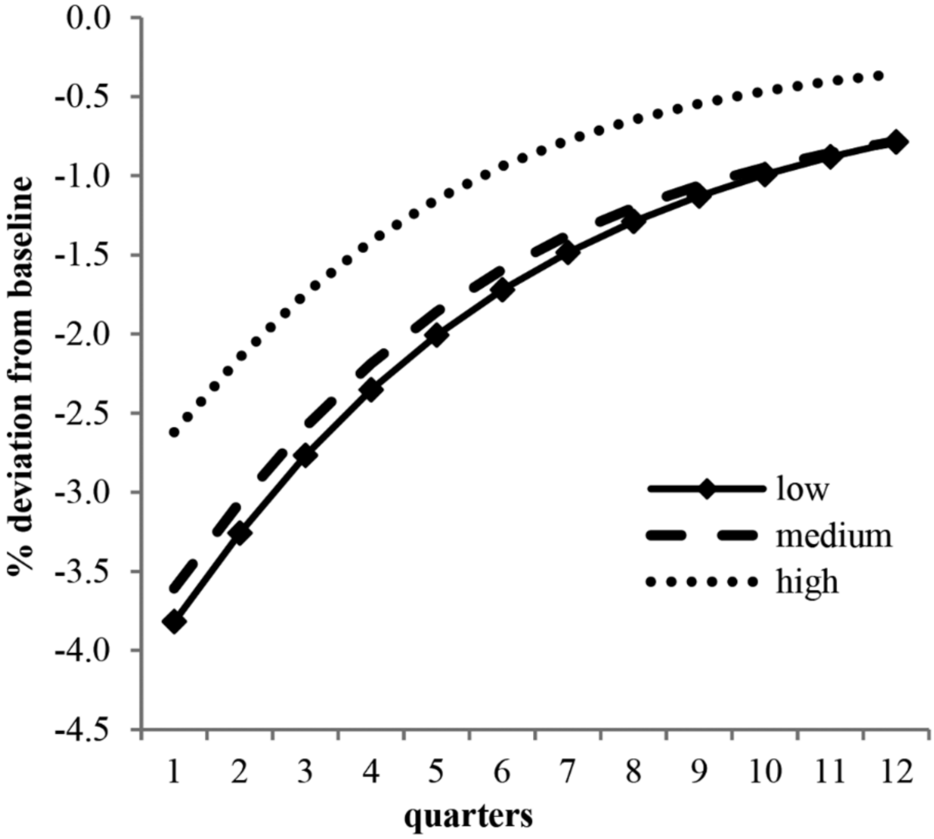


Figure G.6.: Total Compensation of Employees

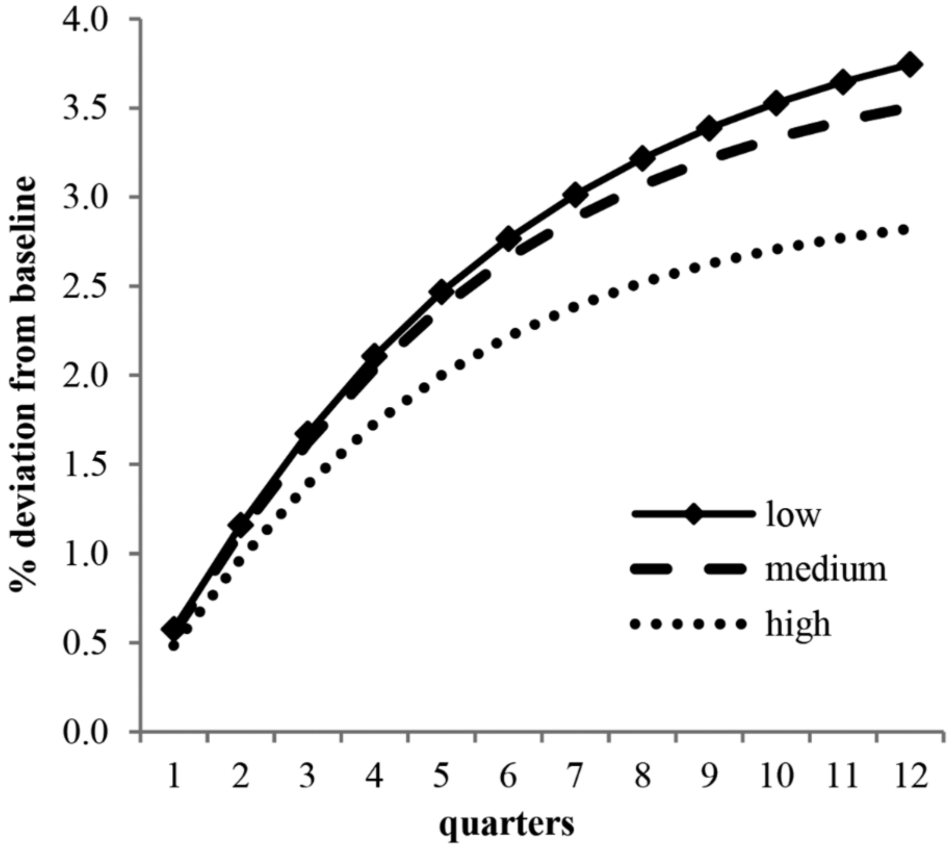


Figure G.7.: Gross Real Wage

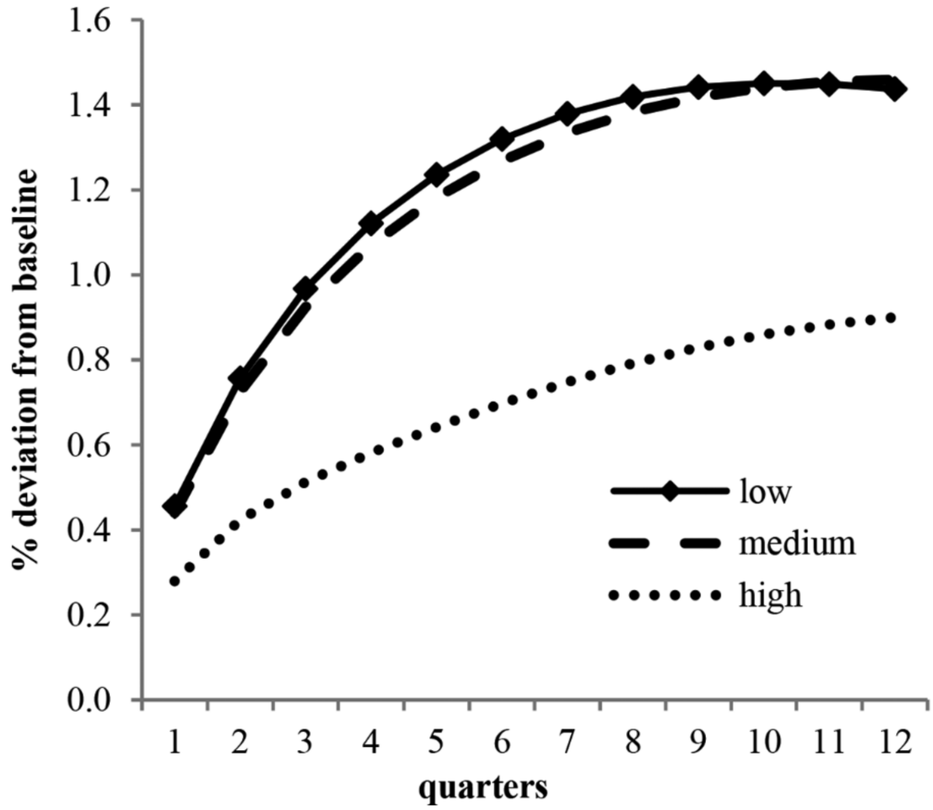


Figure G.8.: Employment

Table G.1.: Macroeconomic impact of the 30% reduction on the SICee tax rate (percentage deviation from baseline).

	Years								
	1	2	3	4	5	10	15	20	Long-run
GDP	0.14	0.32	0.51	0.66	0.76	0.84	0.24	−2.07	0.00
Price level	−0.04	−0.10	−0.13	−0.14	−0.14	−0.16	−0.03	0.31	0.00
Employment									
Low skilled	0.17	0.45	0.74	0.98	1.14	1.17	0.23	−2.02	0.00
Medium skilled	0.23	0.56	0.85	1.06	1.19	1.24	0.24	−2.63	0.00
High skilled	0.28	0.61	0.87	1.04	1.13	1.16	0.01	−4.08	0.00
Gross real wage									
Low skilled	−0.23	−0.44	−0.53	−0.56	−0.56	−0.48	−0.22	0.85	0.00
Medium skilled	−0.33	−0.56	−0.62	−0.61	−0.58	−0.52	−0.32	1.31	0.00
High skilled	−0.40	−0.63	−0.62	−0.57	−0.51	−0.45	−0.23	2.39	0.00
Total labor tax revenue	−4.61	−4.53	−4.29	−4.08	−3.94	−3.84	−4.66	10.21	0.00
Consumption	0.21	0.21	0.24	0.27	0.29	0.32	0.30	−0.63	0.00
Savings	3.41	2.83	2.86	3.20	3.65	5.89	11.66	−0.05	0.00
Interest rates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Debt (% GDP)	0.72	2.03	3.03	3.88	4.70	9.62	15.87	12.53	0.00

Source: QUEST III simulations.

Table G.2.: Macroeconomic impact of the 30% reduction on the SICer tax rate (percentage deviation from baseline).

	Years								
	1	2	3	4	5	10	15	20	Long-run
GDP	0.25	0.55	0.72	0.77	0.77	0.70	−0.10	−3.55	0.00
Price level	−0.10	−0.16	−0.15	−0.14	−0.13	−0.16	0.03	0.57	0.00
Employment									
Low skilled	0.83	1.34	1.45	1.38	1.26	0.81	−0.48	−3.74	0.00
Medium skilled	0.79	1.29	1.44	1.44	1.38	1.16	−0.13	−4.24	0.00
High skilled	0.45	0.72	0.87	0.91	0.90	0.78	−0.79	−7.06	0.00
Gross real wage									
Low skilled	1.38	2.87	3.58	3.92	4.09	4.26	4.64	6.20	0.00
Medium skilled	1.34	2.75	3.37	3.63	3.74	3.78	4.01	6.34	0.00
High skilled	1.14	2.29	2.74	2.90	2.96	2.94	3.24	7.46	0.00
Total labor tax revenue	−6.46	−4.94	−4.31	−4.09	−4.05	−4.21	−5.32	13.92	0.00
Consumption	0.10	0.26	0.34	0.37	0.38	0.37	0.34	−0.95	0.00
Savings	3.15	2.45	3.16	4.05	4.79	7.43	15.27	2.24	0.00
Interest rates	−0.01	−0.01	−0.01	0.00	0.00	−0.01	0.00	0.02	0.00
Debt (% GDP)	0.86	2.12	2.90	3.69	4.64	11.12	19.24	15.95	0.00

Source: QUEST III simulations.

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4. Automatic Stabilizers in Monetary and Fiscal Unions

4.1. Introduction

Automatic stabilizers are elements of fiscal policy that have the potential to smooth the business cycle by automatically adjusting government spending and revenue. While "very little work has been done on automatic stabilization [...] in the last 20 years" (Blanchard, 2006), fiscal stabilization policies in general and automatic stabilizers in particular have seen an increased focus from researchers, especially since the 2007–2008 financial crisis and the following recession.[1]

Many economists now agree that automatic stabilizers are an important part of macroeconomic policy, and understanding their workings and optimal design is of considerable interest to researchers, institutions and policy makers alike.[2] This is partly driven by the recent experience that monetary policy alone may not be enough to stabilize the economy, especially after large and adverse shocks that constrain monetary policy.[3] In turn, the recent literature also shows that fiscal stabilization is particularly powerful when monetary policy is constrained. Automatic stabilizers, in particular, mitigate the losses in aggregate output and consumption significantly more during episodes of a zero lower bound (McKay and Reis, 2016). The reason is that monetary policy generally does a good job of stabilizing the economy, but is unable to do so (using conventional measures) if interest rates are effectively zero. Tax and transfer systems serve an important role under these circumstances, providing insurance against income fluctuations over the business cycle.

This paper contributes to the literature by developing a framework to quantify how automatic stabilizers in Europe influence the business cycle. To this end, I develop a multi-country New Keynesian model with heterogeneous agents and incomplete markets

[1] See Dolls et al. (2012); McKay and Reis (2016, 2017); Kekre (2017); Dolls et al. (2019b).

[2] These include for example Auerbach (2009); Dolls et al. (2012, 2015); McKay and Reis (2016, 2017), Fedelino et al. (2005); Spilimbergo et al. (2008); Darby and Melitz (2008).

[3] Corsetti et al. (2016).

calibrated to the euro area, in which countries are linked through trade and hit by country-specific shocks. Each country is populated with heterogeneous households and has its own tax and transfer system, but is bound by the union-wide monetary policy. I analyze how trade linkages between European countries affect business cycle stabilization. Using the model, I propose experiments by shutting off automatic stabilizers to gauge their effect on the business cycles in the EU by measuring aggregate volatility with and without automatic stabilizers. On the methodological side, this paper is, to the best of my knowledge, the first multi-country heterogeneous agents New Keynesian model calibrated to the euro area.

This paper is placed in a recent literature of heterogeneous agent models with incomplete markets in the presence of aggregate shocks.[4] The model incorporates international trade in this framework to account for demand spillover.[5] Modeling both aggregate and individual-level fluctuations is necessary, as they allow to study the social insurance and redistribution effects of tax and transfer systems, which are particularly powerful channels of stabilization. This setup gives rise to an equilibrium distribution of wealth across households. The model is solved using the method of Reiter (2009), first deriving household policy functions that are non-linear in idiosyncratic risk, approximating the wealth distribution by a histogram, and then linearizing the model in aggregate variables to solve for aggregate fluctuations.

What makes automatic stabilizers in Europe particularly interesting to study?

For one, in the European currency area, the effectiveness of nominal adjustments is limited, putting fiscal stabilizers into focus. Countries in monetary unions incur two inherent constraints on nominal adjustment to shocks. First, monetary policy cannot condition on country specific shocks but has to resort to a "one-size-fits-all" policy. Second, countries in the union also give up the stabilizing potential of flexible exchange rates.[6] This situation resembles the case of a constrained monetary policy through a zero lower bound outlined above. The recent research on fiscal policy in monetary unions indicates that membership in a currency union substantially enhances fiscal stimulus.[7]

[4]See Krusell and Smith (1998); Gornemann et al. (2016); McKay and Reis (2016); Kaplan et al. (2018); Bayer et al. (2019).

[5]See House et al. (2017) and Dupor et al. (2018).

[6]This holds not only for the 19 states of the Euro Area (EA), but also for the rest of the EU states, who have agreed to adopt the euro in the future and hence have to keep their exchange rates within a narrow fluctuation band. In particular, the EU's Exchange Rate Mechanism (ERM II) is voluntary, but must be followed for at least two years before a country can adopt the euro. Currently, only Denmark is a member of the ERM II. Bulgaria has been pegging their currency to the *Deutsche Mark*, and subsequently to the euro. The Czech Republic, Croatia, Hungary, Poland, Romania and Sweden have free-floating currencies (Convergence Report 2014).

[7]E.g. Erceg and Lindé (2013); Ilzetzki et al. (2013); Nakamura and Steinsson (2014); Suárez Serrato

Therefore, in a monetary union, automatic stabilizers are of particular importance to insure against country specific shocks.

Moreover, high trade linkages between European countries introduce cross-country spillover effects from demand stabilization. In other words, automatic stabilizers in one country have a stabilizing effect in others.[8] In my model, in each country, firms produce an intermediate good from domestic capital and labor. The inter-regional spillovers then enter the model through trade in the intermediate good. This way, international trade is a new stabilization channel in my model.[9] Another finding in the public finance literature is that richer countries tend to have a larger government size (and thus higher automatic stabilizers, see Dolls et al., 2012). If these are the countries that also rely more on trade openness, this indicates that improving automatic stabilizers in Southern and Eastern European countries could benefit the rest of Europe, because the 'core' relies more on stabilization of foreign demand.

The third reason to focus on the case of Europe are the variations in wealth distributions between countries. They lead to heterogeneity in stabilization from redistribution and social insurance, with a scope for possible benefits of union-wide automatic stabilizers. For instance, a proposal that is currently discussed is an EU unemployment insurance scheme, which would redistribute at a supra-national level towards the unemployed.[10] The gains for output stabilization are potentially large, because redistributing towards households who have a high propensity to consume has a particularly high stabilizing effect.[11]

The different wealth distributions in Europe are to a large extent determined by economic conditions and institutions, such as taxes and transfers and the social insurance

and Wingender (2016); Farhi and Werning (2017); Dupor et al. (2018).

[8]For instance, after the car scrappage scheme enacted in Germany after the 2008 recession, Fiat and Renault were major benefactors of the reform, with German car buyers opting for smaller cars manufactured in Italy and France instead of German luxury cars from BMW or Mercedes. See "Cash for Clunkers Car-Scrapping Plans – Germany's Lessons", published on Spiegel Online, `http://www.spiegel.de/international/business/cash-for-clunkers-car-scrapping-plans-germany-s-lessons-a-623362.html`, retrieved 2019-01-17. Although being an example of discretionary stimulus and not an automatic stabilizer, it still illustrates the possible spillover mechanism.

[9]Through this spillover effect, more open economies benefit more from stabilization of foreign demand. In turn, this also means that very open economies have a lower effectiveness of output stabilization through domestic demand. My paper provides a framework which allows to translate closed-economy automatic stabilizers into open-economy stabilizers, similar in spirit to the open-economy fiscal multiplier in Nakamura and Steinsson (2014) and Dupor et al. (2018).

[10]For example, EU unemployment insurance systems are discussed in Jung et al. (2017); Ábrahám et al. (2018); Dolls et al. (2018); Enders and Vespermann (2018).

[11]McKay and Reis (2016). See also Oh and Reis (2012) for the gains of redistributing towards high MPC households.

system.[12] This heterogeneity in social insurance and tax policies is another reason why it is worthwhile to take a closer look at how automatic stabilizers affect the EU business cycle.

This paper develops a heterogeneous agents model that can reflect international differences in wealth distributions to account for these important channels. It provides an interesting framework, because it allows to study the interactions of distributional questions, fiscal policy and the business cycle in the EU. Introducing household heterogeneity increases the stabilizing role of fiscal policy because it enables redistribution and social insurance channels to play a role. That is why it is important to analyze the questions asked in this paper through the lens of a heterogeneous agent model with differences in wealth.

This paper is still work in progress. It is structured as follows. Section 4.2 provides a brief overview over the literature. Section 4.3 presents the main automatic stabilizers in the EU that are reflected in the model, which is presented in section 4.4. Section 4.5 has details on the intended quantitative exercise and the calibration. Section 4.6 presents a brief discussion and outlook for future work.

4.2. Literature

The main feature and advantage of automatic stabilizers is that they work automatically, without discretionary action of the government.[13] This makes them difficult for researchers to measure, because they are inherently endogenous to the business cycle. While fiscal stimulus or monetary policy are also aimed at stabilizing the economy, they are not *automatic* stabilizers, because they require discretionary action. For researchers trying to single out automatic stabilizers, discretionary policy changes pose another problem because they act as additional confounders in empirical studies.[14]

The recent empirical literature on automatic stabilizers solves this problem by analyzing fiscal stabilization capacities using household micro-data and tax policy simulations (Auerbach and Feenberg, 2000; Auerbach, 2009; Dolls et al., 2012, 2019b,a).[15] These papers use the "normalized tax change", that is, the ratio of the change in the disposable

[12] For instance, Pham-Dao (2018) analyzes wealth inequality in the euro area and finds that it is influenced by the differences in pension systems.

[13] See Solow (2004), cf. McKay and Reis (2012).

[14] For example, macro-econometric approaches (e.g. Fatás and Mihov, 2001) rely on correlations of aggregate variables.

[15] In this literature, the automatic stabilization property of the tax and transfer system is called its "built-in flexibility" (see Musgrave and Miller, 1948; Pechman, 1973) or "normalized tax change" (Auerbach and Feenberg, 2000).

income to a change in market income, as a metric for automatic stabilization.

The micro data and the tax models used in these papers allow for a detailed and fine-grained representation of household incomes, taxes and transfers, but a shortcoming of this methodology is that it does not allow to solve for dynamics and the volatility of aggregate variables over the business cycle.

McKay and Reis (2016) analyze the effect of automatic stabilizers on business cycle volatility in the US. To this extent, they develop a New Keynesian model with incomplete markets and aggregate shocks, that features the main automatic stabilizers, calibrated to the US business cycle. They find that the quantitatively most important channels through which automatic stabilizers influence the business cycle are redistribution and social insurance. Besides that, automatic stabilizers are more effective when monetary policy is constrained (through the zero lower bound). In a follow-up paper, McKay and Reis (2017) solve for the optimal automatic stabilizers (unemployment insurance and tax progressivity), taking into account aggregate volatility and the state of the labor market.[16]

House et al. (2017) analyze the effects of austerity in Europe after the crisis using a New Keynesian model with international trade, calibrated to the EU. I build on their model to introduce international trade and spillovers into my model.[17]

Another related strand of literature estimates fiscal multipliers in open economy settings and cross-border spillovers from fiscal shocks. Nakamura and Steinsson (2014) estimate open economy multipliers from military spending data for the US and propose a two-region New Keynesian model to translate the classic (closed-economy) fiscal multiplier into an 'open-economy relative multiplier'. Similarly, Dupor et al. (2018) estimate consumption multipliers from the American Recovery and Reinvestment Act (ARRA) and develop a two-region heterogeneous agents New Keynesian model for the US. Their model highlights trade linkages as a transmission mechanism of fiscal policy.[18]

Another strand of literature studies fiscal policy in monetary unions, with a focus on the EU and EMU. Blanchard et al. (2016) argue that periphery countries benefit from expansionary fiscal stimulus when monetary policy is at the zero lower bound. Their model is a two-country representative agent model with perfect insurance. With heterogeneous agents and imperfect insurance, as in this paper, the stabilization gains

[16]Similarly, Kekre (2017) develops a theoretical model of macroeconomic stabilization through unemployment insurance, but treats it as discretionary policy.

[17]Trabandt and Uhlig (2011) also calibrate a DSGE model to several European countries to study questions of taxation.

[18]Recently, Auerbach et al. (2019) use local defense spending data to estimate local fiscal multipliers, accounting for spillovers across regions and industries.

are potentially even larger (see McKay and Reis, 2016). Blagrave et al. (2018) find that spillovers are larger at the effective lower bound. Hettig and Müller (2018) argue that fiscal policy should be coordinated in a currency union when monetary policy is constrained by the zero lower bound. Similarly, Corsetti et al. (2010) find that coordinated stimulus is important, but depends crucially on how spending is financed. Galí and Monacelli (2008) analyze optimal monetary and fiscal policy in monetary unions and show that a role for national stabilization of the "local" governments is warranted when the union level monetary authority takes care of aggregate inflation. Dmitriev and Hoddenbagh (2019) analyze optimal transfers in fiscal unions, also in the context of constrained monetary policy.

Also related is the growing literature studying monetary or fiscal policy in incomplete markets models (e.g. Oh and Reis, 2012; McKay et al., 2016; Gornemann et al., 2016; Auclert, 2017; Bhandari et al., 2017; Auclert et al., 2018; Kaplan et al., 2018; Bayer et al., 2019). More broadly, my paper is also related to the study of international business cycles (Heathcote and Perri, 2002) and optimal monetary and fiscal policy in open economies (Schmitt-Grohé and Uribe, 2004, 2006).

4.3. Automatic Stabilizers in the EU and EA

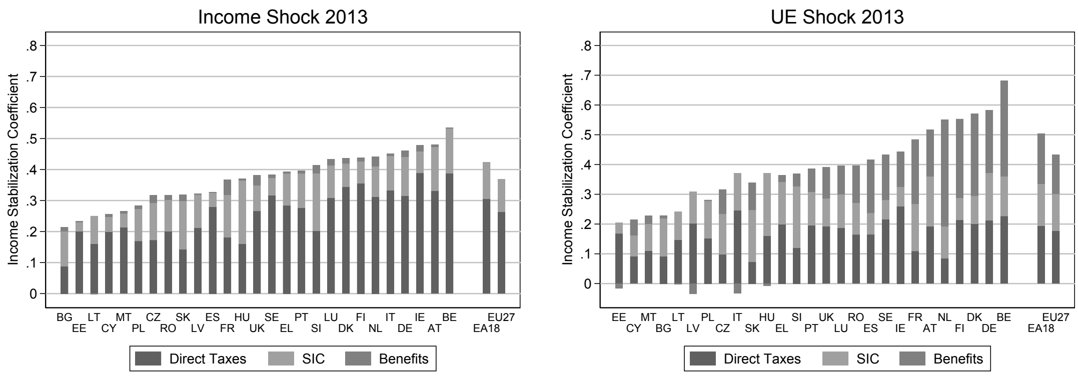


Figure 4.1.: Normalized Tax Change of the Tax Systems in the EU

Note: Measured as the change in taxes, social insurance contributions and benefits, respectively, relative to a change in gross income. The left panel depicts a simulated proportional drop in gross income and the right panel depicts a simulated five percent increase in the unemployment rate. *Source:* Dolls et al. (2019b), based on calculations using EUROMOD.

This section provides a brief description of automatic stabilizers with a particular focus on the EU and then describes the channels through which they work. Figure 4.1 gives an overview of automatic stabilizers in the EU, measured by the normalized tax change. In recent studies, Dolls et al. (2012) and Dolls et al. (2019b) have analyzed the presence of automatic stabilizers in the EU, building on the method pursued for the US by Auerbach and Feenberg (2000) of the "normalized tax change". The normalized tax change shows how changes in tax revenue, social insurance contributions and benefit expenditures with respect to a change in gross income determine the change in disposable income.

While most Western European countries in the core have rather high automatic stabilizers, Southern and Eastern European countries often have lower stabilizers. To date, there is no study analyzing how this affects the aggregate volatility over the business cycle of the whole union and its member states.

Comparing automatic stabilizers in the EU and the US, Dolls et al. (2012) find that the cyclical reaction of government budget to the business cycle is stronger in the euro area than in the US.[19] The difference is particularly large when the recession goes along with a large increase in unemployment, because the benefit system is typically more generous in the EU and the EA. The right panel of Figure 4.1 shows the normalized tax change after a simulated increase in the unemployment rate, revealing an overall larger stabilization for EU and EA (compared to the income shock) as well as a larger heterogeneity across European countries. Also, it shows that in this case, unemployment insurance plays a larger role as a stabilizer than after the income income shock.

4.3.1. Channels and Main Stabilizers

The literature suggests four channels through which the stabilizing power of taxes and transfers can work: (i) the disposable income channel, (ii) the marginal incentives channel, (iii) the redistribution channel and (iv) the social insurance channel (McKay and Reis, 2016).

The disposable income channel works through a mechanical effect of the tax system to absorb fluctuations in gross income, which stabilizes aggregate demand through the stabilizing effect on disposable income.[20] This means that, with taxes and transfers, disposable income will fluctuate less than gross income. This will stabilize aggregate demand and, assuming output is demand-determined, will stabilize output as well.

The marginal incentives channel works through the change in the marginal tax rate when a household is subject to an income shock: In a progressive tax system this will

[19] See also Dolls et al. (2015) for a recent political report on automatic stabilizers in the EU with similar results.

[20] This is the main channel in Pechman (1973); Auerbach and Feenberg (2000); Dolls et al. (2012).

lead to an increase in work incentives, which increases labor supply (Dolls et al., 2019a).

The redistribution channel takes into account that receivers of transfers may have higher propensities to spend out of their income, which then also leads to an increase in aggregate demand.

Through the social insurance channel, automatic stabilizers influence household income risk. In particular, they may reduce the need for precautionary savings, which increases welfare from increased consumption, but reduced precautionary savings may also lead to an increased likelihood that household will be liquidity constrained after a shock. The downside of reduced precautionary savings is that households are then less likely to be able to smooth their consumption demand after a series of "bad" shocks.

McKay and Reis (2016) include the personal income tax, transfers (unemployment benefits and safety-net payments like "food stamps", family assistance etc.), a group of proportional taxes consisting of the corporate income taxes, property taxes, and sales and excise taxes, and the budget deficit in their analysis. In their quantitative analysis, they find the effect of the group of proportional taxes to be small for business cycle volatility.

In this paper, I focus on the most important stabilizers on the household sides, most notably consumption taxes, the progressive income tax and transfers, to keep the model tractable. Hence, I omit the property tax (the tax on capital) and the corporate income tax. One reason is that my model is more complex by introducing trade, so any simplification is welcome to keep the model tractable. Second, the New Keynesian model in McKay and Reis (2016) generates the wrong sign of the covariance of the revenue from the corporate income tax with detrended GDP when comparing the model to the data, effectively working as a destabilizer in the model. For the property tax on capital, the same is true, but the correlation is much smaller and its share is less than a third of the revenue coming from proportional taxes. Hence, I will mainly focus on the personal income tax, transfers (namely unemployment benefits and social assistance), and the sales tax.

Personal income tax. First, the personal income tax works as an automatic stabilizer, because tax revenue falls when incomes go down. This effect is larger when income taxes are progressive, but a stabilizing effect on disposable incomes is also present with a proportional tax. For instance, consider a household that has to pay a proportional tax of 30 percent and faces a decline in gross income of 100 euro. Then 30 percent of the shock would be absorbed by the proportional tax, leaving a decline of 70 euro of disposable income.

When the income tax is progressive, there is an additional marginal incentives effect on labor supply, coming from the change in the marginal tax rate.[21] Furthermore, tax systems redistribute income, which can be stabilizing if the receivers have higher marginal propensities to consume than the spenders (see also Oh and Reis, 2012). Additionally to income taxes, most countries levy social insurance contributions (or payroll taxes), which work similarly as personal income taxes.

A progressive personal income tax appeals to all four channels mentioned at the beginning of this section: It stabilizes disposable incomes 'mechanically', it changes marginal incentives, it redistributes and it provides insurance against 'bad' states of the world. Hence, as it works through all four channels above, it is an important stabilizer that is included in my model.

It is also important to include the progressive tax rate in the welfare considerations, because, in spite of serving as an automatic stabilizer, it also provides a disincentive to work, which means that there is a trade-off between stabilization and discouraging work.

The heterogeneity in tax systems in Europe also warrants a careful analysis of the income tax. For instance, in related work that focuses on the marginal rates in European tax systems (Dolls et al., 2019a), we see a large heterogeneity in the progressivity of tax systems. Some countries in Eastern Europe have flat rates, while other countries like Belgium, Denmark or Germany have very progressive systems.

Transfers. On the spending side, transfers such as unemployment benefits have the potential to stabilize the economy, especially so when unemployment rises during a recession.[22] In fact, McKay and Reis (2016) find that transfers are even more important quantitatively than the income tax as an automatic stabilizer in the US, because they work through the stronger redistribution and social insurance channels. In Europe, unemployment benefits makes up an even larger share of GDP than in the US for almost all countries except the UK (OECD, 2017)[23]. Hence, transfers are also included in my model.

Sales tax. As a proportional tax, I include value added taxes in the model. In the US, they are the largest proportional tax, compared to the property and the corporate income tax. In Europe, value added taxes are larger than sales taxes in the US, so a

[21] This effect is studied in Dolls et al. (2019a) in a micro setting with labor supply.

[22] In the US, additional safety-net programs like food stamps to the very needy play a role, but they are not prominent in Europe, which typically has more generous unemployment insurance and social assistance.

[23] These data are from 2017. As unemployment benefits rise with the number of unemployed, they can vary over time.

larger effect is expected. However, because the proportional tax rates do not change with respect to the business cycle, their overall effect is limited.

4.3.2. Measuring the Stabilizing Effect on the Business Cycle

Following Smyth (1966) and McKay and Reis (2016), I measure the macroeconomic stabilization effect as

$$\mathbf{S} = \frac{V'}{V} - 1, \tag{4.3.1}$$

where V is the ergodic variance of macroeconomic variables (output, consumption) in the calibrated model ("baseline") and V' is the ergodic variance under a counterfactual. This measure differs from the normalized tax change. While the normalized tax change measures the presence and size of automatic stabilizers in a static setting, it is not a measure of business cycle volatility. Equation (4.3.1) is the percentage reduction in the variance of aggregate variables, so that it measures how automatic stabilizers reduce aggregate fluctuations.

The model experiments are the following. For simplicity, I will consider first a stylized experiment of a monetary union with only two countries that are linked through trade. The counterfactual experiment to assess the importance of automatic stabilizers is to switch off the stabilizers in one country and calculate the variance of aggregate variables in the second country. I also analyze how these values change when I allow for country specific monetary policy.

The counterfactuals are (i) some or all stabilizers switched off, (ii) country-specific monetary policy (including flexible exchange rate regime), (iii) no trade spillovers. In model experiment (iv), I plan to analyze elements of a centralized budget. These could mean, for example, a centralized unemployment insurance or other forms of transfers between countries.[24]

4.4. Model

In this section, I describe the quantitative model. It combines an incomplete markets, heterogeneous agents model[25], with an open economy framework[26].

[24] It should be noted that my analysis abstracts from moral hazard considerations at the regional government level at this point. Instead, as a first step, I focus on the positive aspects on the business cycle.

[25] McKay and Reis (2016)

[26] House et al. (2017) and Dupor et al. (2018)

4.4.1. Model Features

I develop a multi-country New Keynesian model with heterogeneous agents and incomplete markets. As the focus of this paper is the impact of automatic stabilizers on EMU countries' business cycle volatility, I implement a business cycle model similar to McKay and Reis (2016). To capture the redistribution and social insurance properties of automatic stabilizers, the model features heterogeneous agents and incomplete markets. The model also incorporates nominal rigidities to allow for stabilization through aggregate demand. To model regional spillovers and trade linkages, the model has an open economy setting similar to House et al. (2017) and Dupor et al. (2018). Table 4.1 summarizes the main ingredients of the model.

Table 4.1.: Model features and relation to the literature

	McKay and Reis (2016)	House et al. (2017)	Dupor et al. (2018)
Nominal Rigidities	✓	✓	✓
Open Economy/Multi region		✓	✓
Incomplete markets	✓		✓
Aggregate shocks	✓		
Automatic Stabilizers	✓		
EU calibration		✓	

4.4.2. Description of the Economy

I consider a model with a finite number N of countries, indexed by n. The model is written down generally, so it could be calibrated as in House et al. (2017) to 30 countries (EU28, the US and 'Rest of World'). The main quantitative exercise shall, however, be first carried out in a stylized model with two countries, indexed by n.[27]

The household-side of the model is close to McKay and Reis (2016) and Dupor et al. (2018). Each country is populated by a fully insured and patient agent alongside a continuum of impatient agents, who are subject to idiosyncratic uninsurable income risk who make consumption, labor hours and savings decision. Impatient households do not have state contingent assets available so they cannot insure against idiosyncratic labor income risk (Bewley, 1986; Huggett, 1993; Aiyagari, 1994), but they can build up precautionary savings using a government bond.

Each region has its own stock of capital, wage w_n and rate of inflation π_n. Region-specific capital and labor cannot be traded across countries. They are used in the production of intermediate varieties by monopolistic sub-intermediary firms that face

[27] This is a slight abuse of notation, as n also stands for labor supply of households.

nominal rigidities. The varieties are combined into a country-specific intermediate good and regions trade in this intermediate good. This tradable good is used in domestic and foreign production of the final good. The final good is consumed or used for investment and government purchases.

There is a government in each region that levies a progressive income tax on households. It buys final goods from its respective region. Taxation and spending happen at a regional level. Households can save in government bonds. The interest rate is the same in all regions that belong to the currency union.

4.4.3. Households

A household in country n consumes the final good produced in their region.[28] They supply labor and receive a real wage w_n. While the impatient households are subject to shocks to their skill level s, changing their effective labor supply, and their employment status e, the patient household has a fixed skill level $\bar{s}$ and effective labor supply $\bar{s}n$. The implicit assumption is that the patient household can insure all idiosyncratic risk. The patient household can be thought of as a representative agent, while the impatient households are heterogeneous.

Patient Households. The patient household has a utility function

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{c_{n,t}^{1-\sigma}}{1-\sigma} - \psi_1 \frac{n_{n,t}^{1+\psi_2}}{1+\psi_2} \right) \right]$$

The representative patient household has access to insurance markets and can insure all idiosyncratic risk. β denotes the discount factor, σ is risk aversion (which is set to $\sigma = 1$, leading to log-utility in consumption), ψ_1 is utility cost of labor and ψ_2 controls the Frisch elasticity of labor supply.

Patient households can save using risk-free nominal bonds and invest in capital and they receive a share of the intermediate firms' profits.[29] Her budget constraint is

$$P_{n,t} c_{n,t} + (b_{n,t+1} - b_{n,t}) = P_{n,t} \left(x_{n,t} - \bar{\tau}_n^x(x_{n,t}) + T_{n,t}^p \right),$$

which consists of consumption expenditures and net bond purchases on the left and real

[28] The presentation and modeling follows McKay and Reis (2016) and Dupor et al. (2018).

[29] Dupor et al. (2018) make a similar assumption, which is that dividends are non-uniformly distributed across the skill distribution to avoid unrealistic distribution of firm profits towards the low end of the skill distribution. The assumption here is similar by assuming that the dividends distribution is "degenerate" in the sense that all profits are distributed to the fully insured agents.

pre-tax income $x_{n,t}$ minus taxes $\bar{\tau}^x_{n,t}(x_{n,t})$ on the right. $P_{n,t}$ is the price of the final good in country n. $T^p_{n,t}$ is set to zero in the baseline but is used in counterfactuals to make up for lost revenue as a lump-sum tax.

The real income of the patient household is equal to

$$x_{n,t} = \frac{I_{n,t-1}}{P_{n,t}} b_{n,t} + d_{n,t} + w_{n,t}\bar{s}_n n_t, \tag{4.4.1}$$

which includes real interest payments on the government bond, dividends from owning firms $d_{n,t}$, and labor income.

The personal income tax system in country n is defined as

$$\bar{\tau}^x_n(x) = \int_0^x \tau^x_n(x')\mathrm{d}x', \tag{4.4.2}$$

where τ^x_n is the marginal tax rate.

The region-specific inflation rate $\pi_{n,t+1}$ is defined as the change in the price of the final good in region n:

$$\pi_{n,t+1} = \frac{P_{n,t+1}}{P_{n,t}} - 1$$

The first order conditions of maximization problem for the patient household are given in the appendix in section H.1.

Impatient Households. In each country, there are ν impatient households, indexed by $h \in [0, \nu]$. In the baseline calibration, $\nu = 4$, so that there are four impatient households per patient household. They can be thought of as the lower four quintiles in the distribution. By assuming $\hat{\beta} < \beta$, they are less patient than the representative household. Like the patient households, the impatient households also choose consumption, working hours and bond holdings to maximize their utility, but they neither own capital nor receive dividends from the firm.

Formally, they maximize

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \hat{\beta}^t \left(\frac{c_{n,t}(h)^{1-\sigma}}{1-\sigma} - \psi_1 \frac{n_{n,t}(h)^{1+\psi_2}}{1+\psi_2} \right) \right],$$

where $\hat{\beta}$ is the discount factor, σ denotes the degree of risk aversion, ψ_1 represents disutility of work and ψ_2 controls the Frisch elasticity of labor supply.

The budget constraint is

$$P_{n,t}c_{n,t}(h) + (b_{n,t+1}(h) - b_{n,t}(h)) = P_{n,t}\left(x_{n,t}(h) - \bar{\tau}^x_n\left(x_{n,t}(h)\right) + T^s_{n,t}(h) \right).$$

These households further face a borrowing constraint $b_{t+1}(h) \geq 0$.

Impatient households face uninsurable idiosyncratic risk on their employment status $e_{n,t}(h)$ as well as on their skill $s_{n,t}(h)$. When the household is employed, she can choose her working hours and receive her labor income $w_{n,t}s_{n,t}(h)n_t(h)$. When the household is unemployed, she receives only unemployment benefits (her labor income is zero). The third state, called 'needy', is a state of long-term unemployment, during which the household receives social assistance. The real income of impatient households consists of stochastic labor income

$$x_{n,t}(h) = \begin{cases} \frac{I_{n,t-1}}{P_{n,t}} b_{n,t} + w_{n,t}s_{n,t}(h)n_t(h) & \text{if employed;} \\ \frac{I_{n,t-1}}{P_{n,t}} b_{n,t} + T^u_{n,t}(h) & \text{if unemployed;} \\ \frac{I_{n,t-1}}{P_{n,t}} b_{n,t} & \text{if needy.} \end{cases} \tag{4.4.3}$$

The unemployment benefit is modeled as

$$T^u_{n,t}(h) = \bar{T}^u_n \min \left\{ s_{n,t}(h), s^u_n \right\}. \tag{4.4.4}$$

T^u_n can be thought of as a replacement rate out of previous income, here captured by the current skill level $s_{n,t}(h)$. Overall benefits are capped at a maximum value $\bar{T}^u_n s^u_n$.

The idiosyncratic state variables are real bond holdings $\tilde{b}$, the skill level s and the employment status e. Letting $\mathbf{s}$ denote the set of all values of $s(h)$ and $\mathcal{S}$ the collection of aggregate states, the problem can be expressed recursively as[30]

$$V(\tilde{b}, e, s, \mathcal{S}) = \max_{c,n} \left\{ \frac{c_n(h)^{1-\sigma}}{1-\sigma} - \psi_1 \frac{n_n(h)^{1+\psi_2}}{1+\psi_2} + \hat{\beta}\mathbb{E}V\left(\tilde{b}', e', s', \mathcal{S}'\right) \right\}$$

subject to

$$(1+\tau^c_n)c_n + \tilde{b}'_n \pi'_n - \tilde{b} = x_n(h) + T^s_n(h) \tag{4.4.5}$$

$$x(h) = (1 + I(\mathcal{S}_{-1}))\,\tilde{b}_n + \mathbb{1}_{\text{employed}} \cdot w_n(\mathcal{S})s_n(h)n_n + T^u_n(h) \tag{4.4.6}$$

where $\mathbb{1}_{\text{employed}}$ is one if the individual state is 'employed' and zero otherwise. The transition matrix of moving between skill states and employment states (Γ and Π respectively, where $\Gamma_{ss'}$ denotes the probability of moving from state s to s' and $\Pi_{ee'}$ the probability of moving from emplyoment state e to e') are given in the appendix. The expectations operator in the Bellman equation of the impatient household reflects

[30] The time subscript can be dropped as usual with infinite horizon optimization problems and the prime indicates next-period variables. See also McKay and Reis (2014).

uncertainty in both aggregate and idiosyncratic variables.[31]

4.4.4. Firms

There are three 'layers' of firms that produce intermediate and final goods in two stages.[32] These layers introduce the following model features. The sub-intermediary firm introduces price stickiness into the model. The second-stage intermediary assembles a country specific tradable good. Through this, the international spillovers enter the model. The final goods producer assembles a country specific domestic final good.

Final Goods Producers. There is a single final good in every country n. Each is produced by a final good firm that packs tradable intermediate goods by the various countries into the non-tradable final good according to a (country-specific) CES function. Each final good is sold at price $P_{n,t}$ within each country.

The firm in country n solves the problem

$$\max_{y^m_{n,t}} \left\{ P_{n,t} Y_{n,t} - \sum_{m=1}^{N} \frac{\mathcal{E}_{m,t}}{\mathcal{E}_{n,t}} p_{m,t} y^m_{n,t} \right\} \tag{4.4.7}$$

subject to the production technology of country n,

$$Y_{n,t} = \left(\sum_{m=1}^{N} (\omega^m_n)^{\frac{1}{\mu_y}} y^{m\,\frac{\mu_y - 1}{\mu_y}}_{n,t} \right)^{\frac{\mu_y}{\mu_y - 1}}. \tag{4.4.8}$$

For countries in the monetary union, nominal exchange rates $\mathcal{E}_{n,t}$ are equal to 1 so that exchange rate terms drop out. In the production function, $y^m_{n,t}$ denotes the amount of country-m intermediate good used in production by country n at time t. The parameter ω^m_n reflects the preference of the country-n final good firm for input coming from country m. I assume $\omega^m_n \geq 0$ and $\sum_{m=1}^{N} \omega^m_n = 1$ for each n. In general, this specification allows a country-specific input mix that can be calibrated to match bilateral import shares (House et al., 2017). In the simplified two country model, $\omega^n_n = 0.71$ is the home bias (fraction of domestic goods used in production) and $\omega^m_n = 1 - \omega^n_n = 0.29$. Parameter μ_y governs the degree of substitutability between the intermediate goods.

[31] McKay and Reis (2016).

[32] The modeling and presentation in this section follows House et al. (2017), Dupor et al. (2018) and McKay and Reis (2016).

The optimization results in iso-elastic demand functions

$$y_{n,t}^m = Y_{n,t}\omega_n^m \left[\frac{\mathcal{E}_{m,t}}{\mathcal{E}_{n,t}}\frac{p_{m,t}}{P_{n,t}}\right]^{-\mu_y}$$

and a nominal price aggregate of the final good of

$$P_{n,t} = \left(\sum_{m=1}^{N} \omega_n^m \left[\frac{\mathcal{E}_{m,t}}{\mathcal{E}_{n,t}} p_{m,t}\right]^{1-\mu_y}\right)^{\frac{1}{1-\mu_y}}.$$

I now turn to the production of the intermediate good, which happens in two stages.

First stage: domestic varieties. In each region, a continuum of varieties indexed by j is produced from domestic capital and labor. Neither capital nor labor can be moved across regions. The production happens using a Cobb-Douglas technology

$$q_{n,t}(j) = z_{n,t}\left(k_{n,t}(j)\right)^{\alpha}\left(l_{n,t}(j)\right)^{1-\alpha}. \tag{4.4.9}$$

The sub-intermediate firms are monopolistically competitive and take into account the demand they face. Because of nominal rigidities as in Calvo (1983), they can adjust their price $\varphi_{n,t}(j)$ only infrequently. The probability that a firm can adjust its price is θ and its optimal reset price is denoted $\varphi_{n,t}^*(j)$. The firms are owned by the patient household in each country, so their stochastic discount factor is used in the optimization.

A firm j that sets its price at date t maximizes the discounted sum of dividends

$$\max_{\varphi_{t,n}^*,\{k_s(j),l_s(j)\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t}\left[\left(\frac{\varphi_{t,n}^*}{P_{n,s}}\right) q_{n,s}(j) - w_{n,s}l_{n,s}(j) - (r_{n,s}+\delta)k_{n,s}(j)\right] \tag{4.4.10}$$

subject to the production function (4.4.9) and the demand it faces:

$$q_{n,s}(j) = Q_{n,s}\left(\frac{\varphi_{n,t}(j)}{p_{n,s}}\right)^{-\mu_q} \tag{4.4.11}$$

or (with the production function substituted in):

$$Q_{n,s}\left(\frac{\varphi_{n,t}(j)}{p_{n,s}}\right)^{-\mu_q} = z_{n,t}\left[k_{n,t}(j)\right]^{\alpha}\left[l_{n,t}(j)\right]^{1-\alpha}. \tag{4.4.12}$$

The labor market clearing condition is

$$l_{n,t} = \int_0^1 l_{n,t}(j)\mathrm{d}j = \int_0^1 s_{n,t}(h)n_{n,t}(h)\mathrm{d}h + \bar{s}n_t \tag{4.4.13}$$

Assuming time-constant markups μ_q, the latter of the FOCs can be rearranged to yield

$$\frac{\varphi^*_{n,t}}{P_t} = -\frac{\mu_q}{1-\mu_q} \cdot \frac{\mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t}\mathcal{M}_s \left(\frac{P_t}{P_s}\right)^{-\mu_q-1} \frac{Q_{n,s}}{P_s}}{\mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t} \left(\frac{P_t}{P_s}\right)^{-\mu_q} \frac{Q_{n,s}}{P_s}} \tag{4.4.14}$$

$$p_{n,t} = \left[(1-\theta)p_{n,t-1}^{1-\mu_q} + \theta {\varphi^*_{n,t}}^{1-\mu_q}\right]^{\frac{1}{1-\mu_q}} \tag{4.4.15}$$

Second stage: intermediate goods. The second stage firm combines the domestic varieties in country n to produce the tradable intermediate good according to the CES production function

$$Q_{n,t} = \left[\int_0^1 q_{n,t}(j)^{\frac{\mu_q-1}{\mu_q}}\mathrm{d}j\right]^{\frac{\mu_q}{\mu_q-1}}, \tag{4.4.16}$$

where $q_{n,t}(j)$ is the input of the j-th variety in country n at time t.

These firms maximize their profits

$$\max_{q_{n,t}(j)} \mathbb{E}_0 \left\{p_{n,t}Q_{n,t} - \int_0^1 \varphi_{n,t}(j)q_{n,t}(j)\mathrm{d}j\right\} \tag{4.4.17}$$

subject to the production function above. They pay a price of $\phi_{n,t}(j)$ for its input variety j and take as given the intermediate goods price $p_{n,t}$.

The optimization yields the first order condition

$$q_{n,t}(j) = Q_{n,t}\left(\frac{\varphi_{n,t}(j)}{p_{n,t}}\right)^{-\mu_q}. \tag{4.4.18}$$

The price can be summarized as

$$p_{n,t} = \left[\int_0^1 \varphi_{n,t}(j)^{1-\mu_q}\mathrm{d}j\right]^{\frac{1}{1-\mu_q}}. \tag{4.4.19}$$

4.4.5. A Two-Country Example

The household problems remain as before, with a patient agent and a continuum of impatient agents in each country. There are two countries, "core" (H) and "periphery" (F).

Domestic varieties and intermediate goods Production of variety j in each country is

$$q_{H,t}(j) = z_{H,t} \left(\frac{k_{H,t}}{l_{H,t}} \right)^{\alpha} l_{H,t}(j) \tag{4.4.20}$$

$$q_{F,t}(j) = z_{F,t} \left(\frac{k_{F,t}}{l_{F,t}} \right)^{\alpha} l_{F,t}(j) \tag{4.4.21}$$

After integrating over varieties, intermediate good production is

$$S_{H,t} \cdot Q_{H,t} = z_{H,t} \left(\frac{k_{H,t}}{l_{H,t}} \right)^{\alpha} l_{H,t} \tag{4.4.22}$$

$$S_{F,t} \cdot Q_{F,t} = z_{F,t} \left(\frac{k_{F,t}}{l_{F,t}} \right)^{\alpha} l_{F,t} \tag{4.4.23}$$

Final goods The final goods firms maximize their profits

$$\max_{y^F_{H,t}, y^H_{H,t}} \left\{ P_{H,t} Y_{H,t} - p_{H,t} y^H_{H,t} - p_{F,t} y^F_{H,t} \right\} \tag{4.4.24}$$

$$\max_{y^H_{F,t}, y^F_{F,t}} \left\{ P_{F,t} Y_{F,t} - p_{H,t} y^H_{F,t} - p_{F,t} y^F_{F,t} \right\} \tag{4.4.25}$$

subject to

$$Y_{H,t} = \left((\omega^H_H)^{\frac{1}{\mu_y}} {y^H_{H,t}}^{\frac{\mu_y - 1}{\mu_y}} + (\omega^F_H)^{\frac{1}{\mu_y}} {y^F_{H,t}}^{\frac{\mu_y - 1}{\mu_y}} \right)^{\frac{\mu_y}{\mu_y - 1}} \tag{4.4.26}$$

$$Y_{F,t} = \left((\omega^H_F)^{\frac{1}{\mu_y}} {y^H_{F,t}}^{\frac{\mu_y - 1}{\mu_y}} + (\omega^F_F)^{\frac{1}{\mu_y}} {y^F_{F,t}}^{\frac{\mu_y - 1}{\mu_y}} \right)^{\frac{\mu_y}{\mu_y - 1}} \tag{4.4.27}$$

The resulting demand functions read

$$y^H_{H,t} = Y_{H,t} \omega^H_H \left[\frac{p_{H,t}}{P_{H,t}} \right]^{-\mu_y}, \qquad y^F_{H,t} = Y_{H,t} \omega^F_H \left[\frac{p_{F,t}}{P_{H,t}} \right]^{-\mu_y}$$

$$y^H_{F,t} = Y_{F,t} \omega^H_F \left[\frac{p_{H,t}}{P_{F,t}} \right]^{-\mu_y}, \qquad y^F_{F,t} = Y_{F,t} \omega^F_F \left[\frac{p_{F,t}}{P_{F,t}} \right]^{-\mu_y}$$

and the nominal prices of the final goods are

$$
\begin{aligned}
P_{H,t} &= \left(\omega_H^H \left(p_{H,t}\right)^{1-\mu_y} + \omega_H^F \left(p_{F,t}\right)^{1-\mu_y}\right)^{\frac{1}{1-\mu_y}} \\
P_{F,t} &= \left(\omega_F^H \left(p_{H,t}\right)^{1-\mu_y} + \omega_F^F \left(p_{F,t}\right)^{1-\mu_y}\right)^{\frac{1}{1-\mu_y}} .
\end{aligned}
$$

4.4.6. Government Budget

The government budget constraint in each country is

$$
\begin{aligned}
P_{n,t}\Bigg(& \tau_n^c \left(\int_0^\nu c_{n,t}(h)\mathrm{d}h + c_{n,t}\right) + \int_0^\nu \bar{\tau}_{n,t}^x \left(x_{n,t}(h)\right)\mathrm{d}h + \bar{\tau}_n^x(x_{n,t}) \\
& - \int_0^\nu \left[T_{n,t}^u(h) + T_{n,t}^s(h)\right]\mathrm{d}h\Bigg) \\
&= P_{n,t}g_{n,t} + I_{t-1}B_{n,t} + (B_{n,t} - B_{n,t+1}) + P_{n,t}T_{n,t}^p. \qquad (4.4.28)
\end{aligned}
$$

The government budget constraint reflects the simplifications made regarding some automatic stabilizers. Notably, revenue from property and corporate income taxes are dropped. Hence, the government raises revenue from consumption taxes and the personal income tax (first line). In the second line are transfers (unemployment benefits and social assistance). On the right-hand side, $P_{n,t}g_{n,t}$ denotes nominal government purchases, $B_{n,t}$ denotes government bonds and interest payments are $I_{n,t-1}B_t$.

Aggregate bonds $B_{n,t}$ consist of bond holdings by the patient and impatient households:

$$
B_{n,t} = \int_0^\nu b_{n,t}(h)\mathrm{d}h + b_{n,t} \qquad (4.4.29)
$$

As in McKay and Reis (2016), government purchases adjust according to the deviation of government deficit from steady state value according to

$$
\ln(G_{n,t}) = \ln(\bar{G}_n) - \gamma^G \ln\left(\frac{B_{n,t}/P_{n,t}}{\bar{B}_n}\right), \qquad (4.4.30)
$$

$$
T_{n,t}^p = \bar{T}^p + \gamma^T \ln\left(\frac{B_{n,t}/P_{n,t}}{\bar{B}_n}\right). \qquad (4.4.31)
$$

The parameters γ^G and γ^T control the speed at which deficits return to their steady state value. When they are large, the level of government debt is adjusted immediately, when they are close to zero, adjustment takes arbitrarily long (McKay and Reis, 2016).

4.4.7. Monetary Authority

Monetary policy is assumed to follow a simplified version of the Taylor rule

$$I_t = \bar{I} + \phi \Delta \log \left(\bar{P}_t^{EA} \right) - \varepsilon_t, \tag{4.4.32}$$

where the interest rate depends on a weighted average of the country-specific inflation rates $\bar{P}^{EA}$. The counterfactual Taylor rule in the case of independent monetary policy that conditions on country-specific inflation is $I_{n,t} = \bar{I}_n + \phi \Delta \log (P_{n,t}) - \varepsilon_{n,t}$. The Taylor rule does not condition on the output gap to focus on the role of automatic stabilizers. An "inferior monetary policy rule" like this emphasizes the role of fiscal policy (McKay and Reis, 2016, p. 154).

4.5. Quantitative Analysis

4.5.1. Calibration

Table 4.2 summarizes the calibration parameters of the model. The discount factors of patient and impatient households (β and $\hat{\beta}$, respectively) are chosen based on McKay and Reis (2016) for comparability, but can later be calibrated to match the differing wealth shares of the top twenty percent, in each country.

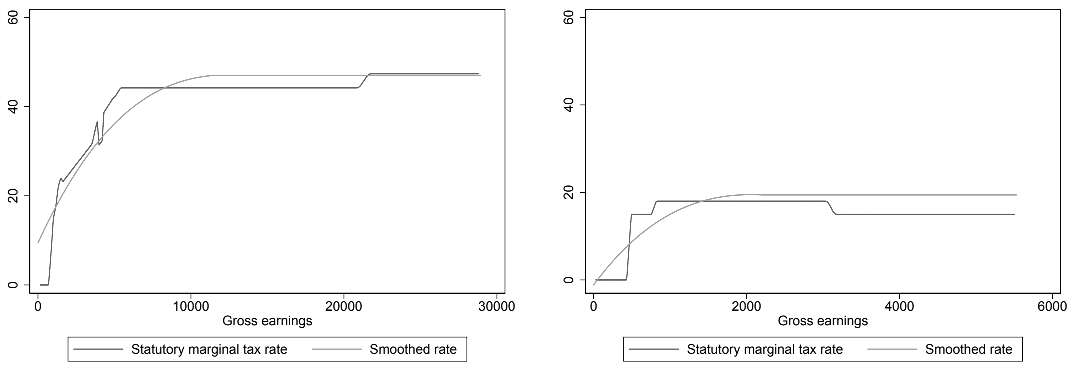
The disutility of labor ψ_1 is set to 1 based on Martin and Philippon (2017), to start with the simplest possible specification. The intertemporal labor supply parameter ψ_2 is set to 2, yielding a Frisch elasticity of 0.5 as in Chetty (2012). An interesting robustness check would be to allow the Frisch elasticities to differ by country. They could be calibrated using empirical estimates from Dolls et al. (2019a), in an exercise similar to Barrios et al. (2019), to take into account cross-country differences in labor supply elasticities.

The coefficient of risk aversion σ is set to 1 (i.e., log-utility, see McKay and Reis, 2016; House et al., 2017). Idiosyncratic shock processes of productivity and employment status are calibrated based on McKay and Reis (2016) and documented in the appendix (section H.2).

The trade preference weight of the tradable good is calibrated to match data on trade in the EMU. From House et al. (2017), I calculate an average home bias of 0.71 for the "core" EU.[33] In a multi-country setting, I use the country specific import share. The elasticity of substitution between tradables μ_y is set to 0.5 as in House et al. (2017). The other production parameters are set to standard values from Trabandt and Uhlig (2011)

[33] Core countries consist of Austria, Belgium, Germany, France, Netherlands, Finland.

and House et al. (2017).



(a) DE

(b) LT

Figure 4.2.: Marginal Tax Rates: Germany and Lithuania

Notes: Marginal income tax rates on the y-axis, gross monthly earnings on the x-axis. Smoothed rates are the fitted values from regressing statutory marginal tax rates on a cubic function of income, combined with a linear spline above a threshold. *Source:* Own calculations based on EUROMOD.

Marginal tax rates. To estimate the progressivity of the tax systems of EMU countries, I make use of the European tax model EUROMOD. EUROMOD is a European tax and benefit calculator similar to TAXSIM for the US (Sutherland and Figari, 2013). I use it to calculate the marginal tax rates for a representative single-earner along the income distribution.

Figure 4.2 shows the exemplary cases of the German tax system in the left panel and Lithuania on the right. The statutory rate is calculated using EUROMOD, and then approximated by the cubic spline. The graph shows the differences in the tax systems, Germany having a progressive system with a relatively high rate, while the Lithuanian system is almost flat and regressive at the top.

Figure J.1 in appendix section J shows statutory and smoothed marginal tax rates for all Euro area countries. The smoothing is done to facilitate numerical application of the tax function.[34]

[34] Bick et al. (2018) provide tax functions to be used with Matlab, but provide only a small sample of countries.

Table 4.2.: Calibration

Parameter	Symbol	Value	Source or Target
Preferences			
Discount factor (patient)	β	0.989	McKay and Reis (2016)
Labor supply (disutility)	ψ_1	1	Martin and Philippon (2017)
Labor supply (Frisch elasticity)	ψ_2	2	Frisch elasticity = 0.5 (Chetty, 2012)
Risk aversion	σ	1	Log-utility
Income and Wealth Heterogeneity			
Discount factor (impatient)	$\widehat{\beta}$	0.979	McKay and Reis (2016)
Impatient HH per patient HH	ν	4	
Skill level of patient HH	$\bar{s}$	3.72	McKay and Reis (2016)
Technology			
Capital share	α	0.38	Trabandt and Uhlig (2011), House et al. (2017)
Depreciation rate	δ	0.028	House et al. (2017)
Calvo price stickiness	θ	0.2	House et al. (2017)
Investment adjustment cost	ζ	2.48	House et al. (2017)
Substitution of varieties	μ_q	10	House et al. (2017)
Trade and Country Size			
Trade preference weights	ω_n^n	0.71	Home bias (House et al., 2017)
Trade demand elasticity	μ_y	0.5	House et al. (2017)
Tax Rates			
Labor income tax	τ^x		Country-specific
Consumption tax	τ^c		Country-specific
Transfers	$T_{n,t}^u, T_{n,t}^s$		Country-specific
Government			
Taylor Rule (output gap)		0	McKay and Reis (2016)
Taylor Rule (inflation)	ϕ	1.5	House et al. (2017)

4.5.2. Numerical Solution

The model is solved using the method from Reiter (2009) to keep track of wealth distributions (see below). To keep the numerical analysis tractable, I use an algorithm similar to the "precomputation" approach in Maliar et al. (2011). The idea is to construct policy functions for labor and savings based on a household problem with idiosyncratic risk, outside of the main iteration loop over the countries. The policy functions are then recycled and interpolated in the country loop.

First, I calculate the non-stochastic steady state with zero inflation and real and nominal exchange rates equal to one. The trade flows are determined by the preference weights ω and relative country sizes. Second, I solve backwards from this steady state to obtain an initial guess of household policy functions using the endogenous grid method. Third, the guess for the policy functions is used to solve the Euler equation using Broyden's method. This involves, for each household type, interpolating savings and labor supply functions using splines. Having end-of-period assets and current-period assets, one can solve for current consumption and expected marginal utility. The solution gives new household policy rules. Fourth, using the algorithm by Reiter (2009), I compute the transition matrix to get the distribution of wealth. Fifth, I solve for the steady state, given household policy rules and the distribution of wealth.

The aggregate equations are linearized in aggregate states to simulate time series of aggregate incomes, consumption and investment.

Keeping track of the wealth distribution and solving the model. A challenge in incomplete markets models with aggregate and idiosyncratic risk is the question of how to keep track of the wealth distributions. When there are aggregate and idiosyncratic fluctuations, the (infinitely dimensional) wealth distribution becomes a state variable in the model. This problem is solved in McKay and Reis (2016) using the algorithm developed in Reiter (2009). The seminal paper to solve this problem is Krusell and Smith (1998), which summarizes the wealth distribution with just a few of its moments. A more recent solution algorithm is Reiter (2009), which is also used in McKay and Reis (2016). The advantage of this solution method is that it is able to handle models with a rich structure well. The algorithm works through discretization of both the wealth distribution (by a histogram) as well as the household decision problem (by a spline). In this way, the problem is converted into a finite-dimensional one, and can be solved with conventional algorithms (e.g. backward induction). The household problem is non-linear (so it can reflect risk and precautionary savings at the individual level). In the next step, the algorithm uses automatic differentiation to linearize the model in aggregate variables and then calculates aggregate dynamics using a standard solver for rational expectations models (e.g. Sims, 2002).[35]

4.6. Discussion and Outlook

This paper presents a framework for studying the effect of automatic stabilizers on the EU business cycle. A new feature of the model is its open economy setting, in which the heterogeneous agent New Keynesian model is embedded, allowing for positive spillovers of stabilization between the closely connected countries in the Euro area. The effect of automatic stabilizers on the EU business cycle can be quantified in a model experiment, in which I shut off all or some of the automatic stabilization channels. In another model experiment, I intend to shut off trade to gauge the spillover of automatic stabilizers between countries in the EU.

While the numerical solution is not yet implemented, I conjecture that the business cycle volatilities differ in these scenarios, pointing to the relevance of automatic stabilizers, and the importance of studying them in the setting of a closely integrated monetary union.

Within the setting of this model, several important questions can be answered in the future. One example is the debate regarding the EMU moving closer to a fiscal union.[36] One hypothetical reform looks at a unified unemployment insurance in the EU. This could be evaluated by recalibrating the relevant parameters in the model.

Another hypothetical reform is a unified tax system in the EMU. The model could be extended to substitute the national governments with a single government for the whole monetary union.

[35] See also a recent paper by Pröhl (2018) for an overview of solution algorithms and a new approach for heterogeneous agent models with aggregate risk using methods from the engineering literature.

[36] For instance, in 2015, the “Five Presidents’ Report” (Juncker et al., 2015) has identified steps for deepening the EMU. Since then, a convergence concept for a euro area budgetary capacity and concepts toward a fiscal union have been discussed (European Commission, 2017).

H. Household Equations

H.1. Patient Household's First Order Conditions.

The first order conditions of this problem are

$$\begin{aligned}
\beta^t c_{n,t}^{-\sigma} &= m_{n,t} \\
\beta^t \psi_1 n_{n,t}^{\psi_2} &= m_{n,t}(1-\tau_{n,t}) w_{n,t} \bar{s}_n \\
m_{n,t} &= \mathbb{E}_t \left[m_{n,t+1} \frac{1+i_{n,t}}{\pi_{n,t+1}^{\text{CPI}}} \right] \\
m_{n,t} \left(1 + \zeta \frac{\Delta k_{n,t+1}}{k_{n,t}} \right) &= \mathbb{E}_t \left[\left(1 + r_{n,t+1} + \zeta \left(\frac{\Delta k_{n,t+2}}{k_{n,t+1}} \right) \frac{k_{n,t+2}}{k_{n,t+1}} - \frac{\zeta}{2} \left(\frac{k_{n,t+2}}{k_{n,t+1}} \right)^2 \right) c_{n,t+1}^{-\sigma} \right]
\end{aligned}$$

These can be rearranged to yield

$$\begin{aligned}
\psi_1 n_{n,t}^{\psi_2} &= c_{n,t}^{-\sigma}(1-\tau_{n,t}) w_{n,t} \bar{s} \\
c_{n,t}^{-\sigma} &= \beta \mathbb{E}_t \left[\frac{1+i_{n,t}}{c_{n,t}^{\sigma} \pi_{n,t}^{\text{CPI}}} \right] \\
c_{n,t}^{-\sigma} \left(1 + \zeta \frac{\Delta k_{n,t+1}}{k_{n,t}} \right) &= \beta \mathbb{E}_t \left[\left(1 + r_{n,t+1} + \zeta \frac{\Delta k_{n,t+2}}{k_{n,t+1}} \frac{k_{n,t+2}}{k_{n,t+1}} - \frac{\zeta}{2} \left(\frac{\Delta k_{n,t+2}}{k_{n,t+1}} \right)^2 \right) c_{n,t+1}^{-\sigma} \right]
\end{aligned}$$

H.2. Idiosyncratic Shock Processes

The Markov processes for skill and employment are calibrated as in McKay and Reis (2016):

$$\Gamma = \begin{pmatrix} 0.985 & 0.015 & 0 \\ 0.015 & 0.970 & 0.015 \\ 0 & 0.015 & 0.985 \end{pmatrix} \tag{H.2.1}$$

The diagonal elements are the probability of remaining in the same skill group, the off-diagonal elements are the transition probabilities from one state to another.

The employment status transition matrix is calibrated as in McKay and Reis (2016):

$$\Pi = \begin{pmatrix} E \to E & E \to U & E \to N \\ U \to E & U \to U & U \to N \\ N \to E & N \to U & N \to N \end{pmatrix} = \begin{pmatrix} 0.97 & 0.03 & 0 \\ 0.54 & 0.20 & 0.26 \\ 0.09 & 0 & 0.91 \end{pmatrix} \tag{H.2.2}$$

The ‘E’ denotes employed, ‘U’ denotes unemployed and ‘N’ stands for needy (long-term unemployed). In the transition matrix, for example $E \to U$ denotes the probability of an individual currently employed becoming unemployed, and so on. Once a person is long-term unemployed (‘needy’), they cannot go back to ‘unemployed’ (zero probability) and they have a lower probability than the unemployed of regaining employment. Similarly, an ‘employed’ agent does not transition into ‘long-term unemployment’ immediately.

I. Firm equations

I.1. Capital

The capital is owned by the patient household in each country, taking $r_{n,t}$ as given. The market clearing condition for capital is

$$k_{n,t} = \int_0^1 k_{n,t}(j)\mathrm{d}j. \tag{I.1.1}$$

The sequence of capital $\{k_{t+1}, k_{t+2}, \dots\}$ is chosen so as to maximize

$$\mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s} \left[(1 + r_{n,s})k_{n,s} - k_{n,s+1} - \frac{\zeta}{2} \left(\frac{\Delta k_{n,s+1}}{k_{n,s}} \right)^2 k_{n,s} \right], \tag{I.1.2}$$

leading to the first order condition

$$\left(1 + \zeta \frac{\Delta k_{n,t+1}}{k_{n,t}}\right) = \mathbb{E}_t \left[\Lambda_{n,t,t+1} \left(1 + r_{n,t+1} + \zeta \frac{\Delta k_{n,t+2}}{k_{n,t+1}} \frac{k_{n,t+2}}{k_{n,t+1}} - \frac{\zeta}{2} \left(\frac{\Delta k_{n,t+2}}{k_{n,t+1}} \right)^2 \right) \right] \tag{I.1.3}$$

The dividends from capital are distributed together with the variety-producing firms' profits to the patient households:

$$d_{n,t} = \int_0^1 d^i_{n,t}(j)\mathrm{d}j + d^k_{n,t} \tag{I.1.4}$$

I.2. Firms' Reset Price

$\Lambda_{t,s} = \beta^s (c_s/c_t)^{-\sigma}$ denotes the stochastic discount factor between periods t and s.

Letting $\mathcal{M}$ denote the Lagrange multiplier on the constraint, the first order conditions

Table I.1.: Pricing notation

Name	Symbol
Reset price of sub-intermed firm j in country n at time t	$\varphi_{n,t}(j)$
Optimal reset price	$\varphi^*_{n,t}(j)$
Competitive price of tradable intermediate (weighted avg of sub-intermed)	$p_{n,t}$
Price of final good in country n in period t	$P_{n,t}$

for capital and labor are

$$-(r_{n,s}+\delta)+\mathcal{M}_s\alpha z_{n,s}k_{n,s}(j)^{\alpha-1}l_{n,s}(j)^{1-\alpha}=0 \tag{I.2.1}$$

$$-w_{n,s}+\mathcal{M}_s(1-\alpha)z_{n,s}k_{n,s}(j)^{\alpha}l_{n,s}(j)^{-\alpha}=0 \tag{I.2.2}$$

Dividing the first two FOCs shows that the first stage intermediary firms have the same capital-labor ratio:

$$\frac{w_{n,s}}{r_{n,s}+\delta}=\frac{1-\alpha}{\alpha}\frac{k_{n,s}(j)}{l_{n,s}(j)} \tag{I.2.3}$$

The production of variety j is then

$$q_{n,t}(j)=z_{n,t}k_{n,t}(j)^{\alpha}l_{n,t}(j)^{1-\alpha} \tag{I.2.4}$$

$$=z_{n,t}\left(\frac{k_{n,t}(j)}{l_{n,t}(j)}\right)^{\alpha}l_{n,t}(j) \tag{I.2.5}$$

$$=z_{n,t}\left(\frac{k_{n,t}}{l_{n,t}}\right)^{\alpha}l_{n,t}(j) \tag{I.2.6}$$

And by substituting in production and then integrating over varieties:

$$\left(\frac{\varphi^*_{n,t}(j)}{p_t}\right)^{-\mu_g}Q_{n,t}=z_{n,t}\left(\frac{k_{n,t}}{l_{n,t}}\right)^{\alpha}l_{n,t}(j) \tag{I.2.7}$$

$$\Leftrightarrow \underbrace{\int_0^1\left(\frac{\varphi^*_{n,t}(j)}{p_t}\right)^{-\mu_g}\mathrm{d}j}_{S_{n,t}}\,Q_{n,t}=z_{n,t}\left(\frac{k_{n,t}}{l_{n,t}}\right)^{\alpha}\underbrace{\int_0^1 l_{n,t}(j)\mathrm{d}j}_{l_{n,t}} \tag{I.2.8}$$

$$\Leftrightarrow S_{n,t}\cdot Q_{n,t}=z_{n,t}\left(\frac{k_{n,t}}{l_{n,t}}\right)^{\alpha}l_{n,t}, \tag{I.2.9}$$

where $S_{n,t}$ reflects the efficiency loss due to price dispersion.

The condition for the optimal reset price is

$$\mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t} \left[(1-\mu_q) \left(\frac{\varphi^*_{n,t}}{P_s} \right)^{-\mu_q} \frac{Q_{n,s}}{P_s} - \mathcal{M}_s(-\mu_q) \left(\frac{\varphi^*_{n,t}}{P_s} \right)^{\mu_q-1} \frac{Q_{n,t}}{P_s} \right] = 0 \tag{I.2.10}$$

Equation (4.4.14) can be split in two recursively defined expressions:[1]

$$\begin{aligned}
\bar{p}^A_t &= \mathbb{E}_t \sum_{s=t}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t} \mathcal{M}_s \left(\frac{P_t}{P_s} \right)^{-\mu_q-1} \frac{Q_{n,s}}{P_s} \\
&= \mathcal{M}_t \frac{Q_{n,t}}{P_t} + \mathbb{E}_t \sum_{t+1}^{\infty} \Lambda_{t,s}(1-\theta)^{s-t} \mathcal{M}_s \left(\frac{P_t}{P_s} \right)^{-\mu_q-1} \frac{Q_{n,s}}{P_s} \\
&= \mathcal{M}_t \frac{Q_{n,t}}{P_t} + \mathbb{E}_{t+1} \Lambda_{t,t+1}(1-\theta) \left(\frac{P_t}{P_{t+1}} \right)^{-\mu_q-1} \sum_{s=t+1}^{\infty} \Lambda_{t+1,s}(1-\theta)^{s-t-1} \mathcal{M}_s \left(\frac{P_{t+1}}{P_s} \right)^{-\mu_q-1} \frac{Q_n, s}{P_s} \\
&= \mathcal{M}_t \frac{Q_{n,t}}{P_t} + \mathbb{E}_{t+1} \Lambda_{t,t+1}(1-\theta) \pi^{\mu_q+1} \bar{p}^A_{t+1}
\end{aligned}$$

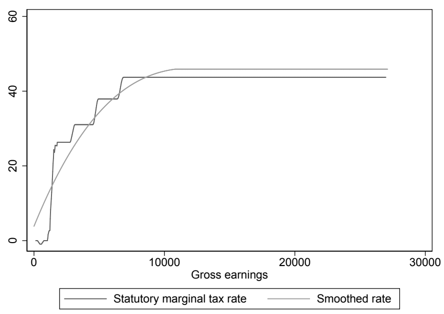
and

$$\bar{p}^B_t = \frac{Q_{n,t}}{P_t} + \mathbb{E}_{t+1} \Lambda_{t,t+1}(1-\theta) \pi^{\mu_q+1} \bar{p}^B_{t+1}.$$

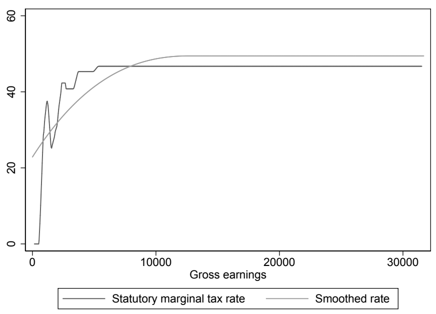
The nominal price of the tradable intermediate good is sticky (because first-stage intermediate producers adjust their prices only infrequently) and evolves according to

[1] See Schmitt-Grohé and Uribe (2006); McKay and Reis (2016).

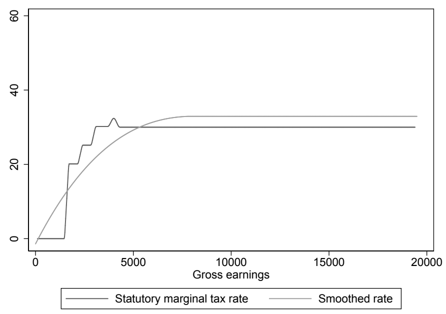
J. Marginal Income Tax Rates



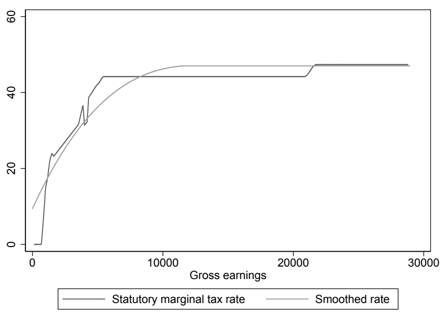
(a) AT 2010



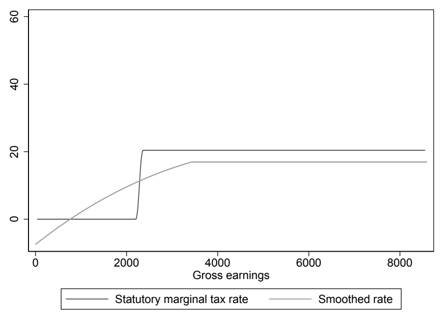
(b) BE 2010



(c) CY 2010

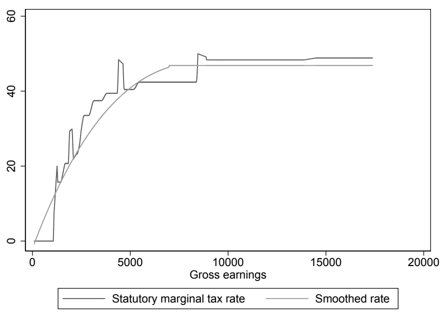


(d) DE 2010

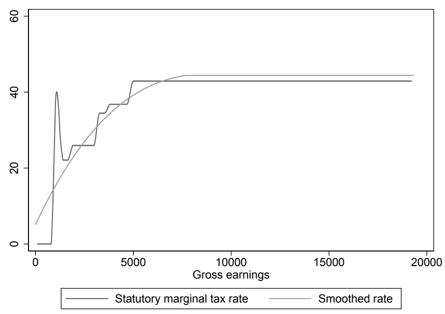


(e) EE 2010

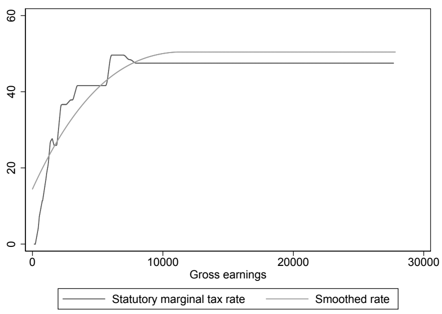
Figure J.1.: Marginal Tax Rates



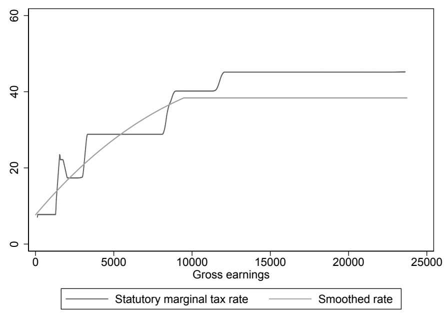
(f) EL 2010



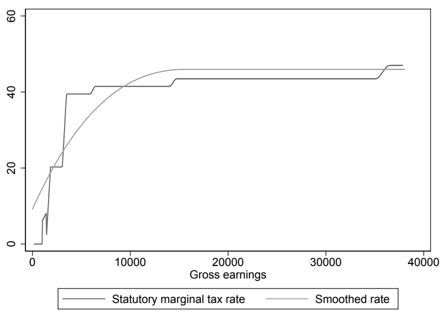
(g) ES 2010



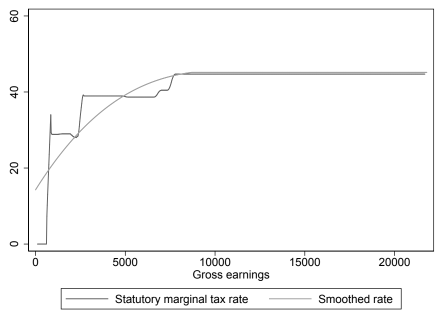
(h) FI 2010



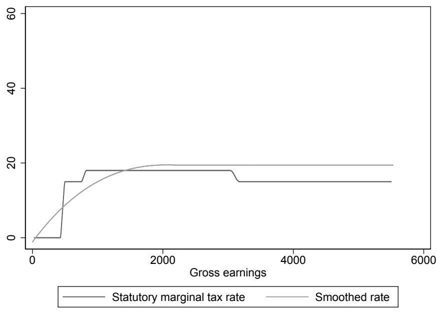
(i) FR 2010



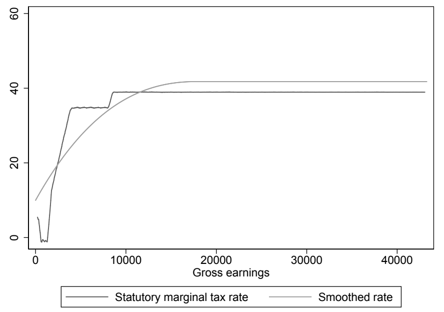
(j) IE 2010



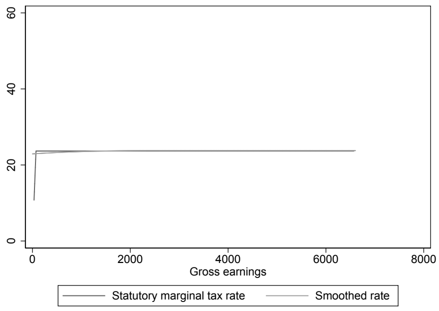
(k) IT 2010



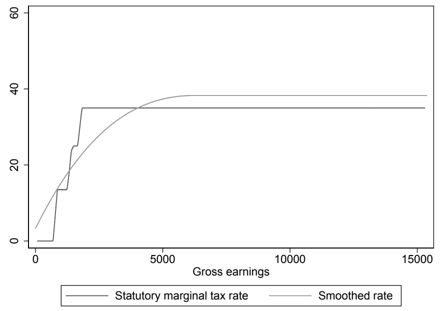
(l) LT 2010



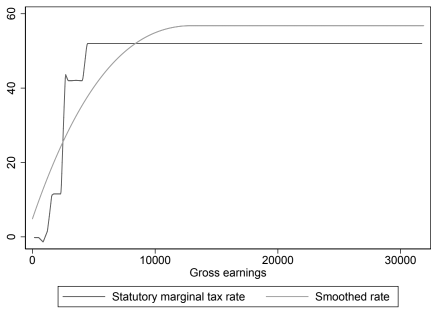
(m) LU 2010



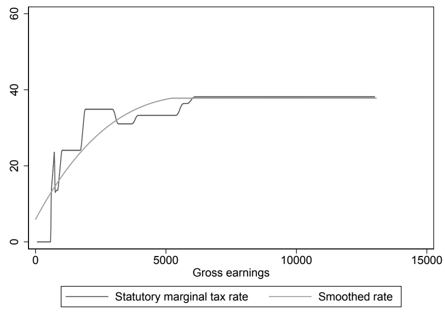
(n) LV 2010



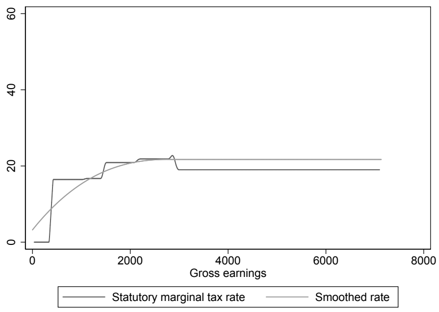
(o) MT 2010



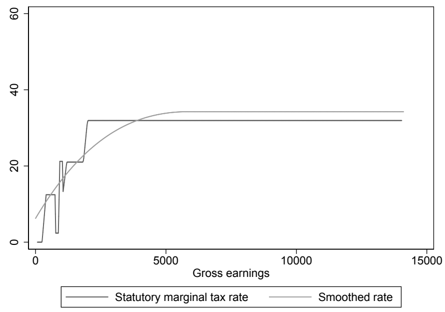
(p) NL 2010



(q) PT 2010



(r) SK 2010



(s) SI 2010

K. Model

K.1. Aggregate Shocks

Aggregate shocks follow the following law of motion:

$$\boldsymbol{z}_t = \boldsymbol{A}\boldsymbol{z}_{t-1} + \boldsymbol{\varepsilon}_t, \tag{K.1.1}$$

where $\boldsymbol{A}$ is an $n \times n$-matrix and $\boldsymbol{\varepsilon}$ are $n \times 1$ random disturbances that are distributed as $\boldsymbol{\varepsilon}_t \sim \mathcal{N}(0, \boldsymbol{\Sigma})$ and $\boldsymbol{\Sigma}$ is the variance-covariance matrix of country-specific shocks.

K.2. Equilibrium

In equilibrium, households behave optimally and firms maximize their profits, for countries $n = 1, 2$. The equilibrium consists of the following equations.

- Household Euler conditions
- Labor market clearing condition for each country n
- Capital rental market clearing condition for each country n
- Final good production in country n
- Intermediate good production in country n
- Domestic demand for intermediate good
- Price of the final good in each country n
- Price of the intermediate good in each country n
- Market clearing for the final good (domestic, in each n)
- Market clearing for intermediate goods (tradable)
- GDP for each country

- Taylor rule for monetary authority (4.4.32)
- Bonds in zero net supply (4.4.29)
- Government budget and purchases follow (4.4.28), (4.4.30), (4.4.31)

Final goods Final goods must equal consumption plus investment plus government purchases. Investment is defined implicitly through $k_{t+1} = k_t - \delta k_t + X_t \Rightarrow X_t = k_{t+1} - (1-\delta)k_t$

$$Y_{n,t} = C_{n,t} + X_{n,t} + g_{n,t} \tag{K.2.1}$$

Intermediate goods

$$Q_{n,t} = \left(\sum_{j=1}^{N} y_{j,t}^{n}\right) \tag{K.2.2}$$

Nominal net exports

$$NX_{n,t} = p_{n,t}Q_{n,t} - \sum_{j=1}^{N} \frac{\mathcal{E}_{j,t}}{\mathcal{E}_{n,t}} p_{j,t} y_{n,t}^{j} = p_{n,t}Q_{n,t} - P_{n,t}Y_{n,t} \tag{K.2.3}$$

Nominal GDP

$$NGDP_{n,t} = p_{n,t}Q_{n,t} = NX_{n,t} + P_{n,t}\left(C_{n,t} + X_{n,t} + G_{n,t}\right) \tag{K.2.4}$$

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