Piecemeal modelling of the effects of joint direct and indirect tax reforms

Bart Capéau*,†, André Decoster*,‡, and Stijn Van Houtven*,§

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Abstract

This paper offers a framework to establish a micro–based evaluation of a joint reform in personal income taxes, and/or social security contributions and indirect taxes. One often lacks an encompassing model for both the labour supply decisions in real world tax and benefit contexts and the allocation of disposable income to commodities. In this paper we elicit the assumptions which allow us to combine different submodels, such that an assessment of a joint reform becomes possible in a consistent conceptual framework. We characterise households' labour supply decisions by a random utility random opportunity (RURO) model of job choice. We apply this framework to a Belgian tax reform which shifts the burden away from labour taxes to indirect taxation. We find substantial empirical evidence that, both from a distributional and from a budgetary perspective, it is important to account for the impact of indirect taxes on the labour supply decision of households when assessing this kind of joint tax reform. The cost recovery effects of the tax shift are negative. This is, among other things, explained by a more encompassing income effect in our job choice model, than is found in the more classic discrete choice model of labour supply.

Keywords: job choice, joint direct and indirect tax reform, microsimulation

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*Department of Economics, KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium.

†ECARES, ULB, Avenue Franklin Roosevelt 50, 1050 Bruxelles, Belgium.

‡Corresponding author: andre.decoster@kuleuven.be

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1 Introduction

In this paper we offer a framework that allows us to make a micro–based budgetary and distributional evaluation of a joint reform in both the personal tax and benefit system and the indirect tax system. Such joint tax reforms are initiated by governments worldwide in an attempt to shift part of the tax burden from labour to consumption, which is considered to be less detrimental to economic growth (see Myles, 2009a,b, and c for a review). However, there is not so much literature on micro–based empirical policy evaluations of these kinds of joint reforms.[1] Exceptions are Bach et al. (2006), Capéau et al. (2009), Pestel and Sommer (2017), and Savage (2017). From these studies, it can be inferred that such reforms may have substantial distributional effects. These papers, however, all proceed without an encompassing model for the labour market participation decision and the allocation of disposable income to commodities, which, at first sight, would seem a necessary tool for a consistent analysis of these distributional effects.

The reason for this gap is that such an encompassing model which at the same time sufficiently keeps track of the existing intricacies of the direct and indirect tax–benefit system, often becomes theoretically intractable, let alone useful for empirical implementation. And even if such a model did exist, few available datasets would allow for the estimation of such a model, as detailed information is required on households' gross incomes, their labour market participation, and their expenditures. Therefore, the papers cited above make use of existing disconnected microsimulation models of direct taxes and benefits on the one hand, and of indirect taxes on the other. The former are often connected with a behavioural model of labour supply, the latter with a demand system that allocates expenditures. The cited papers then glue these model pieces together in a rather ad hoc fashion, to arrive at an evaluation toolbox for the joint tax reform.

What the present paper offers is a framework that allows one to underpin how these model pieces can be fit one into another in a consistent way. Thereto, we rely on a two–stage budgeting approach.[2] The first stage models the labour supply decision, which determines households' disposable income. The second stage models the allocation of this disposable income to commodities and saving. It is known that such a two–stage budgeting approach requires the assumption of weak separability between leisure and consumption goods (Gorman 1971). One of our main contributions is to exploit the fact that such a two–stage approach still entails the necessity of including commodity prices in the first stage decision.

Building on Bach et al. (2006), Capéau et al. (2009), and Pestel and Sommer (2017),

[1] On the contrary, numerous macroeconomic evaluation tools have been developed, all investigating primarily employment and growth effects of such a shift. See for example Altig et al. (2001) for the US, Dahlby (2003) for Canada, Böhringer, Boeters and Feil (2005) for Germany, European Commission services (2006) for 15 EU member states, NBB (2017) for Belgium, and de Castro Fernàndez Perelle and Priffis (2018) for France.

[2] Similar ideas have been used to develop empirically tractable models of labour supply and commodity demand over the life cycle, by separating the within period allocation of the budget over different goods from the allocation of life time income over the different periods (See e.g. Browning, Deaton and Irish 1985; Blundell and Walker 1986; and Blundell, Browning and Meghir 1994).

we formalize the implementation of a joint tax reform in a microsimulation model with both labour supply reactions, and commodity demand reactions. Our framework allows us to assess the labour supply effect stemming from solely the change in consumer prices as a consequence of an indirect tax reform. Similarly to Bach et al. (2006), Capéau et al. (2009), and Pestel and Sommer (2017) the change in consumer prices is taken into account in the labour supply decision by estimating and simulating the model with a *real* disposable income concept. However, whereas the deflation of income in those cited papers was chosen somewhat arbitrarily, we provide a theoretical underpinning of a household-specific deflator of disposable income. Instead of subtracting indirect taxes from expenditures in the estimation of their labour supply model, we argue that the inclusion of commodity prices in the first stage of the decision process with such household-specific price index is sufficient to assess budgetary effects of, behavioural reactions to, and distributional implications of a joint tax reform.

As far as the first stage is concerned, we use a random utility random opportunity (RURO) discrete choice model of job choice (see e.g. Aaberge and Colombino 2014, Dagsvik et al. 2014).[3] Contrary to classical discrete choice models of labour supply (e.g. Van Soest 1995), this model considers a job to consist of a package of attributes: the labour time regime, the wage paid, and other pecuniary and non–pecuniary attributes. As such, offered wages become an aspect of the elements in the choice set. This allows us to capture a number of behavioural reactions which have hitherto received little attention in the literature on tax reforms. For example, in our framework, jobs with lower gross wages may become more attractive after a reform in the tax–benefit schedule. As will be shown in the empirical application, this might have important second order effects on the taxable base, and hence on government revenues.

We deliberately kept the modelling of the second step simple. We impute income shares for each commodity group, and then assume Cobb–Douglas preferences characterised by these estimated shares. Due to the imputation method used, the income shares are dependent on labour market participation of household members. Given the Cobb–Douglas assumption together with the two–stage budgeting approach, we then treat the estimated budget shares as parameters, and keep them fixed throughout our simulations. The constant shares assumption could be relaxed and/or replaced by more complex demand models, but the added value of doing so will depend on the specificity of the change in indirect taxation in the joint tax reform to be evaluated. Indeed, despite its restrictive character, this specification allows us to capture the real income effect of an indirect tax reform on the labour supply decision in a convenient fashion, and this might well be quantitatively the most important impact.

To illustrate the framework proposed in this paper, we perform policy simulations that are inspired by a tax shift proposed in Belgium in 2023. The reform's principal aim is to lower tax on labour incomes through a higher tax-free amount in the personal income tax, and it is partly financed by increases in VAT (value added tax) rates. We simulate a revenue neutral reform in which the increase of VAT rates covers the financing necessary for the proposed increase in the

[3] Only part of the active population is modelled. The model is thought not to be suitable to capture labour supply decisions of the self–employed or interactions between members of households with complex structures.

tax-free amount.

We limit our analysis in the empirical illustration to the budgetary and employment effects of the simulated reform and their distribution across households. We refrain from performing a proper normative analysis. To analyse the budgetary effect of the joint reform, we advance a decomposition into first and second order components. The former measures the impact of the reform on government revenues when there is no change in individual behaviour. That is, individuals are not allowed to adapt their bundle of commodities nor their job choice. The second order component, by contrast, collects the change in revenues that can only be ascribed to changes in individual behaviour. To be able to assess the added value of our framework, we further decompose the second order effect in the impact of changes in commodity demand, of changes in labour supply due to the change in *nominal* disposable income, and changes in labour supply due to the change in consumer prices.

The paper is organised as follows. In Section 2, we present the piecemeal modelling framework. First, we present in Section 2.1 the main components and explain how these components are linked through two–stage budgeting. Second, Section 2.2 introduces our implementation of the job offer model. Third, Section 2.3 explains how to measure budgetary effects and how to decompose them into first and second order effects. In Section 3 we illustrate the presented framework with an empirical application. First we discuss our empirical modelling strategy in Section 3.1, whereafter we present the simulation results in Section 3.2. Section 4 concludes the paper. The appendices contain more detailed information on the construction of the subsample on which the RURO model operates (Appendix A.1), on the estimated parameters of the RURO model, the simulated labour supply elasticities and the model fit (Appendix A.2), on the procedure we used to simulate with the RURO model (Appendix A.3), and on additional simulation results (Appendix A.4).

2 The piecemeal modelling framework

In this section we introduce the piecemeal modelling framework to evaluate the labour supply effects of a joint direct and indirect tax reform. We present the link between consumer prices and the job choice in a general fashion by means of a two–stage budgeting approach in Section 2.1. Section 2.2 presents the discrete job choice model (RURO), and Section 2.3 explains how we can disentangle the different effects of the joint tax reform with our framework.

2.1 Two–stage budgeting approach

In its most general form, a (static) consumer decision model jointly treats the labour supply decision and the allocation of disposable income to commodities and saving. Formally, let h represent labour time, $\mathbf{x}$ an n-vector of commodities, and $\mathbf{q}$ the associated vector of strictly positive consumer prices, and suppose that $\Omega(\cdot)$ denotes a utility function representing preferences over commodities and labour time.[4] Then, the integrated decision model for labour market participation and consumption is represented by the program

$$\begin{aligned} &\max_{\mathbf{x},h}\ \Omega(\mathbf{x},h) \\ \text{s.t.}\ &\mathbf{q}'\mathbf{x} \leq f(w,h;M,\mathbf{z}) \\ &\mathbf{x} \geq 0 \\ &0 \leq h \leq T, \end{aligned} \tag{1}$$

in which $f(\cdot)$ embodies the tax–transfer system, and T denotes total time endowment. Disposable income $y = f(w,h;M,\mathbf{z})$, is a function of gross wages w, labour time h, unearned gross income M, and a vector of individual and/or household characteristics $\mathbf{z}$.

Such models of joint determination have been formulated and successfully empirically implemented in the literature (see e.g. Blundell and Walker 1982, 1986, Browning, Deaton and Irish 1985, Browning and Meghir 1991). These contributions, however, refrain from modelling the complexity of tax–transfer systems by assuming that labour income is simply the product of labour time and net wages. This renders these models less suitable for a more detailed assessment of the impact of the tax–benefit system on consumers' behaviour. However, introducing a more detailed description of the tax–benefit system poses a lot of intricate problems, as most existing tax–benefit systems cause the budget set $\left\{\mathbf{x} \in \mathbb{R}^n_+ \mid \mathbf{q}'\mathbf{x} \leq f(w,h;M,\mathbf{z})\right\}$ to be non–convex, combined with kinks and jumps in $f(\cdot)$ (see e.g. Hausman 1981, 1985a,b). Such highly non–linear tax schemes often cause the optimisation program in (1) to be analytically and numerically intractable.

Many of these issues have been resolved by the introduction of discrete choice modelling into the empirical labour supply literature (popularised by Van Soest 1995; for overviews, see Aaberge and Colombino 2014, Blundell and MaCurdy 1999, Creedy and Kalb 2005, Blundell, MaCurdy and Meghir 2007, Keane 2011, Keane, Todd and Wolpin 2011). In this approach, the budget constraint $f(\cdot)$ is discretised along the hours margin, yielding a finite number of alternatives from which individuals select the option that delivers the highest utility. In combination with a detailed micro–simulation model, tax–transfer systems of virtually any complexity can be analysed in this framework.

However, the price to be paid for this increased realism on the side of labour supply modelling, is that one reverts to a simple trade–off between disposable income and leisure, irrespective of the allocation of the former to different consumer goods. This independence between the labour supply decision on the one hand and the allocation of the income generated by it on the other, is only warranted if one assumes weak separability between consumer goods and leisure in the preference structure (Gorman 1971). Unfortunately, this assumption was subject to much criticism when it comes to empirical applications (see e.g. Blundell and Walker 1982, Browning and Meghir 1991). Estimates of commodity demand functions can be severely biased

[4] Throughout the paper, we denote vectors by boldface, and the i-th element of a vector $\mathbf{v}$ by v_i.

when the erroneous assumption of separability between budget allocation and choice of leisure time is maintained.

So it seems as if one faces a trade–off: either using a labour supply model in which real world tax–benefit systems are integrated, but without indirect taxes and detailed consumption decisions integrated in the analysis; or modelling consumption decisions in great detail, but without the possibility to link this with a sufficiently realistic behavioural labour supply model. On top of this, even if a tractable general model for labour supply and the allocation of disposable income to commodities would be available, few datasets contain the information necessary to estimate such a model, as information on both gross labour income and disaggregated expenditures is generally not available.

In the absence of both a suitable encompassing model and the data to estimate such a model, we therefore propose a *piecemeal modelling* strategy to assess the impact of a joint tax reform at the micro–level. Given the limitations outlined above, our methodology proposes a consistent integration of different submodels, which are allowed to interact to the maximal extent. This interaction takes two forms. First, as will be explained in Section 3.1, we rely on parametric Engel curves, estimated on a detailed budget survey, to impute expenditures into an income survey. To attenuate the impact of the assumption of separability between budget allocation and labour supply, we included labour market status variables as covariates in the estimation of the Engel curves. Second, we advance a two–stage budgeting approach in which we allow (changes in) relative consumer prices to impact the labour supply decision as follows.

Under the assumption of weak separability, we can rewrite the overall utility function $\Omega(\mathbf{x}, h)$ in expression (1) as

$$\Omega(\mathbf{x}, h) = H(u(\mathbf{x}), h), \tag{2}$$

where $u(\mathbf{x})$ denotes a subutility function over consumption goods.

The second stage of the two–stage budgeting approach consists in the allocation of the budget $y \equiv f(w^*, h^*; M, \mathbf{z})$ determined by the chosen job (w^*, h^*) to the set of commodities $\mathbf{x}$.[5] In the next section (Section 2.2) we explain our job choice model in more detail. The solution of this second stage is summarised by the indirect utility function $v(\mathbf{q}, y) \equiv u(\boldsymbol{\xi}(\mathbf{q}, y))$, in which $\boldsymbol{\xi}(\mathbf{q}, y)$ stands for the vector of Marshallian demand functions.

Replacing $u(\mathbf{x})$ in Equation (2) with this indirect utility function yields a representation of preferences in the income–labour time space:

$$V(y, h) = H(v(\mathbf{q}, y), h), \tag{3}$$

which is maximised through choices of y and h under the budget constraint $y \leq f(w, h; M, \mathbf{z})$. This first stage choice is described by the job choice model of the next section.

Notice that with this notation, the functional form of $V(y, h)$ incorporates the dependency on commodity prices. While this impact of prices of goods in the second stage on the first stage

[5] As we work with a static model, the set of commodities also includes saving.

decision is well established in the theoretical literature, it seems to have been largely overlooked in empirical applications. In as far as there is interindividual heterogeneity in preferences over commodities, omitting these variables, as is usually done in discrete choice models of labour supply, can bias results, even if all individuals faced the same commodity prices, $\mathbf{q}$. It is by rendering this dependency explicit, that it becomes clear that even in a labour supply model resulting from weakly separable preferences over leisure and commodities, relative commodity prices have an effect on labour supply.[6] It is this dependency that we will fully exploit in order to investigate the effects of a joint tax reform.

In particular, we assume that $u(\cdot)$ belongs to the class of Cobb–Douglas utility functions, $u(\mathbf{x}) = \prod_{i=1}^{n} x_i^{\omega_i}$, in which the parameters ω_i can be interpreted as the budget share of commodity i.[7] The indirect utility function for this class of preferences reads as $v(\mathbf{q}, y) = \frac{y}{Q(\mathbf{q})}$, with $Q(\mathbf{q}) = \prod_{i=1}^{n} q_i^{\omega_i}$, in which $Q(\mathbf{q})$ is known as a Divisia price index, which is household specific through the budget shares $\boldsymbol{\omega}$. Plugging this indirect utility in the overall utility function (2), we obtain

$$\begin{aligned} \tilde{V}(\mathbf{q}, y, h) &= H\left(\frac{y}{Q(\mathbf{q})}, h\right) \\ &\equiv H(c, h), \end{aligned} \tag{4}$$

in which $c = y/Q(\mathbf{q})$ is a measure for consumption in real terms.[8] This clearly shows that the job choice model of the next section should thus be estimated using deflated disposable income, and since the deflator is household specific, this is more than just a normalisation issue. Furthermore, this specification also allows us to feed the impact of indirect tax reforms — that is, changes in consumer prices $\mathbf{q}$ — back into the job choice decision.

2.2 Job choice model

To model the first–stage labour supply decision, we employ a random utility random opportunity (RURO) framework (see Aaberge, Dagsvik and Strøm 1995, Aaberge, Colombino and Strøm 1999, and Dagsvik and Strøm 2006; for surveys, see Aaberge and Colombino 2014, and Dagsvik et al. 2014). The RURO model differs from the standard discrete choice multinomial logit model for labour supply (McFadden 1973, Van Soest 1995) in two ways. First, in contrast to the standard model, an individual chooses a job rather than optimal working hours. A job consists of a wage offer, w, a labour time regime, h, and a number of other pecuniary and non–pecuniary attributes (e.g. fringe benefits, challenge, prestige, ...). Second, the RURO model introduces demand–side restrictions in a structural fashion. Job availability is modelled in

[6]It is known from demand theory that the compensated commodity price effects on labour supply are proportional to an income effect when preferences are weakly separable over leisure and consumption (Barten and Böhm, 1986).

[7]We consider saving as one of the commodities. Therefore, the budget shares are in fact income shares. Since we utilise a static framework, we do not consider the welfare implications of changes in savings.

[8]We make the dependency of preferences in the income–labour time space on commodity prices $\mathbf{q}$ explicit by including it as an argument. Hence the notation $\tilde{V}(\cdot)$ instead of $V(\cdot)$.

RURO by an individual specific stochastic process governing the probability that jobs with a specific wage and labour time regime are offered to that individual. The availability of certain jobs may not only depend on an individual's personal characteristics and capabilities, but also on the demand side of the labour market and on macroeconomic fluctuations. A similar reasoning holds for non–market alternatives: their availability depends on certain abilities an individual might possess and on the availability of the infrastructure and institutions that facilitate particular leisure activities. Consequently, the relative availability of job offers versus non–market alternatives in a RURO model may depend both on personal characteristics and macroeconomic circumstances.

From the previous section, it turns out that the labour supply model should be specified in real terms, i.e. deflating disposable incomes obtained from a particular job choice, by an individual specific Divisia price index.

Formally, let $\mathcal{B}$ denote the set of all market and non–market alternatives available to an individual. From the econometrist's point of view, the probability that an individual prefers alternative (w_k, h_k) over all other alternatives in this set can then be expressed as follows:

$$P(w_k, h_k \mid \mathcal{B}) = \frac{\exp\left[H\left(f(w_k, h_k; M, \mathbf{z})/Q(\mathbf{q}), h_k\right)\right]\varphi(w_k, h_k)}{\int_{(w,h)\in\mathcal{B}} \exp\left[H\left(f(w, h; M, \mathbf{z})/Q(\mathbf{q}), h\right)\right]\varphi(w, h)\ \mathrm{d}w\ \mathrm{d}h}. \tag{5}$$

Note that this equation constitutes a weighted version of the likelihood contribution in the standard multinomial logit framework, where the probability to choose an alternative k only depends on its relative attractiveness as embodied by the utility function $H(\cdot)$. In the RURO model each alternative is in addition weighted by a measure $\varphi(w, h)$ that captures the likelihood that an alternative (with specific wage w and labour time regime h) will be available in the individual–specific choice set. If all alternatives are equally available and the wages do not vary over jobs, the weights cancel out and expression (5) would reduce to the standard multinomial logit formula. For more details on the assumptions that underpin our implementation of the RURO model, we refer to Capéau and Decoster (2016) and Capéau, Decoster and Dekkers (2016).

In our modelling strategy, we represent individuals' opportunities and preferences by the following functional forms.

- Opportunities

$$\frac{\varphi(w, h)}{\varphi(0, 0)} = \begin{cases} g_1(w)g_2(h)\theta, & \text{if } w, h > 0, \\ 1, & \text{if } w, h = 0, \end{cases} \tag{6}$$

  where the distribution of offered wages, $g_1(w)$, is lognormal with a sex, education, and experience specific location parameter and a sex specific scale parameter. Offered hours follow a sex specific piecewise uniform distribution, $g_2(h)$, with peaks at half–time, three quarters and full–time working hours; and θ is a measure for the relative intensity of job offers versus the availability of non–market alternatives, dependent on sex, education, region and a type specific unemployment rate. We consider the latter to be a proxy for the macroeconomic impact on individual job offer availability. The measure θ is positively valued and can be converted into a probability measure:

$$\pi_1 = \frac{\theta}{1+\theta}, \tag{7}$$

in which π_1 can be interpreted as the number of job opportunities relative to the total number of market and non–market opportunities for an individual. Dagsvik and Jia (2016) show how the separability between the role of w and h in the specification of the opportunities introduced in Equation (6) is necessary for a partial nonparametric identification of the model.[9]

- <u>Preferences</u>
  $H(c,h)$ is a gender specific Box–Cox utility function with marginal rates of substitution dependent on age, education, region and the number of children (these variables are denoted by the vector $\mathbf{r}$):

$$H(c,h) = \beta_c \frac{c^{\alpha_c}-1}{\alpha_c} + \boldsymbol{\beta}_l' \mathbf{r} \left(\frac{\left(\frac{T-h}{T}\right)^{\alpha_l} - 1}{\alpha_l} \right). \tag{8}$$

  For couples, an interaction term between spouses' leisure is added:

$$\begin{aligned} H_2(c,h_f,h_m) \;=\; & \beta_c \frac{c^{\alpha_c}-1}{\alpha_c} + \boldsymbol{\beta}_{lf}' \mathbf{r}_f \left(\frac{\left(\frac{T-h_f}{T}\right)^{\alpha_{lf}} - 1}{\alpha_{lf}} \right) + \boldsymbol{\beta}_{lm}' \mathbf{r}_m \left(\frac{\left(\frac{T-h_m}{T}\right)^{\alpha_{lm}} - 1}{\alpha_{lm}} \right) \\ & + \beta_{l_f l_m} \left(\frac{\left(\frac{T-h_f}{T}\right)^{\alpha_{lf}} - 1}{\alpha_{lf}} \right) \cdot \left(\frac{\left(\frac{T-h_m}{T}\right)^{\alpha_{lm}} - 1}{\alpha_{lm}} \right). \end{aligned} \tag{9}$$

The use of the RURO model to simulate the impact of policy changes widens the scope of the analysis, not readily available in the standard Random Utility Model (RUM) framework. The job choice model, in which unobserved characteristics of the job are present in the structural specification, allows us to capture behavioural reactions that cannot be simulated within the standard framework. In the RURO model e.g., jobs with lower wages but with more attractive unobserved non–pecuniary characteristics might become more attractive after a reform in the tax–benefit schedule which lowers personal income taxes.

2.3 Measuring the effects of a joint tax reform

We decompose the budgetary effects of tax reforms into a first and second order component. The former measures the impact of the tax reform on government revenues when there is no change in individual behaviour. That is, individuals are allowed to change neither their bundle of commodities nor their job choice. The second order component, by contrast, only collects the

[9] See Capéau, Decoster and Dekkers (2016), who summarise the main identification results in the literature (Aaberge, Colombino, and Strøm 1999, and Dagsvik and Strøm 2004).

change in revenues that can be ascribed to changes in individual behaviour. This behavioural component consists of three elements: a change of consumed quantities, a change of labour supply due to changes in the nominal net wage, and a change in labour supply due to changes in consumer prices. Throughout, we indicate pre–reform variables by a subscript 0, while post–reform variables are subscripted by 1. Recall that we denote the chosen job by (w^*, h^*), where the asterisk denotes optimising behaviour. Variables that are influenced by the job choice, such as income, quantities and expenditures, will also be denoted with such asterisk in the case they correspond to the optimal choice, both in the baseline and after the reform, denoted by respectively subscript 0 and 1.[10]

Revenues from indirect taxation We denote expenditures on good i in pre– and post–reform situation by $e^*_{j,i}$, where subscript $j = 0, 1$ refers to pre- and post-reform respectively. These expenditures are measured at consumer prices $\mathbf{q}$, inclusive of all indirect taxes. As we assume general equilibrium effects on producer prices $\mathbf{p}$ to be absent, these can be treated as fixed. Therefore, consumed quantities $\mathbf{x}^*$ can be measured in terms of these prices. That is, consumption of good i in situation j, $x^*_{j,i}$, is measured by the value in euro's, when valued at producer price p_i (independent of j). Indirect taxes on good i in situation j then equal:

$$IT_{j,i} = e^*_{j,i} - x^*_{j,i}, \qquad j = 0, 1,\ i = 1, \ldots, n. \tag{10}$$

Thus, indirect taxes $\mathbf{t}_j$ $(j = 0, 1)$ can easily be defined as *ad valorem* rates[11]:

$$t_{j,i} = \frac{e^*_{j,i} - x^*_{j,i}}{x^*_{j,i}} \qquad j = 0, 1,\ i = 1, \ldots, n. \tag{11}$$

Pre– and post–reform government indirect tax revenues can be calculated as

$$IT_j = \mathbf{t}'_j \mathbf{x}^*_j, \qquad j = 0, 1. \tag{12}$$

We obtain the pre–reform quantity of a particular good i, $x^*_{0,i}$, from data on consumer expenditures (expressed in terms of consumer prices), by dividing this amount by $1 + t_{0,i}$. To recover post–reform quantities, we first simulate the new expenditures. Using the Cobb–Douglas assumption, these amount to

$$e^*_{1,i} = \omega_i y^*_1, \qquad i = 1, \ldots, n, \tag{13}$$

where y^*_1 is the disposable income stemming from the post–reform job choice (w^*_1, h^*_1), and ω_i is the budget share, which is a parameter in the Cobb–Douglas case, and therefore kept constant

[10] Optimal choice in the spending decision is determined by the assumption of constant income shares.
[11] An *ad valorem* tax is a tax which is expressed in terms of the final consumer price q.

when simulating the reform. Post–reform quantities are then easily obtained as:[12]

$$x^*_{1,i} = \frac{e^*_{1,i}}{1+t_{1,i}}. \tag{14}$$

The indirect tax rate $\mathbf{t}$ includes all taxes which cause a wedge between producer and consumer prices: value added taxes, excises, and *ad valorem* taxes. The change in revenue from indirect taxes, $IT_1 - IT_0$, can then be decomposed into a first and second order effect as follows:

$$IT_1 - IT_0 = \underbrace{\mathbf{x}^{*\prime}_0 \left(\mathbf{t}_1 - \mathbf{t}_0\right)}_{\text{first order effect}} + \underbrace{\mathbf{t}'_1(\mathbf{x}^*_1 - \mathbf{x}^*_0)}_{\text{second order effect}} . \tag{15}$$

In this equation, the first order effect measures the change in government tax revenue that would arise if individuals could not alter their consumption bundle during a reform. The residual part embodies the second order effect and captures the change in revenue that is due to individuals' altered consumption behaviour — even with constant budget shares, quantities do change — and job choice. We decompose the second order effect on indirect taxation paid further in three parts.

First we define the quantities following from applying the constant budget share assumption on the disposable income after the first order effect in the direct taxation, but before any labour supply adjustment, $\mathbf{x}_1$, as :

$$x_{1,i} = \frac{e_{1,i}}{1+t_{1,i}} = \frac{\omega_i y_1}{1+t_{1,i}} = \frac{\omega_i f_1\left(w^*_0, h^*_0; M, \mathbf{z}\right)}{1+t_{1,i}}. \tag{16}$$

In this equation $f_1(\cdot)$ embodies the post–reform schedules for personal income taxes, social security contributions paid by the employee, and benefits received, as it did in Section 2.1. That is, this function maps gross labour income into disposable income, taking into account other income M, and characteristics $\mathbf{z}$. The change in quantities, $\mathbf{x}_1 - \mathbf{x}^*_0$, solely comes from changes in this tax function. Second, we let individuals change their optimal job choice as a reaction to the change in the direct tax function, $f_1(\cdot)$, but not yet to any change to consumer prices, which enters the utility through the price index, $Q\left(\mathbf{q}\right)$. We denote the variables affected by this choice in this intermediate stage with a tilde. We can construct new quantities, $\tilde{\mathbf{x}}_1$, based on this intermediate stage. We have:

$$\tilde{x}_{1,i} = \frac{\omega_i f_1\left(\tilde{w}_1, \tilde{h}_1; M, \mathbf{z}\right)}{1+t_{1,i}}, \tag{17}$$

Finally, after individuals have chosen their new optimal job choice, accounting for the joint tax reform, including the change in consumer prices, we have the optimal bundle $\mathbf{x}^*_1$, as introduced before. We can now further decompose the second order effect in the impact of changes in

[12]In practice, one can calculate $T_j, j = 0, 1$, immediately from $e^*_{j,i}, i = 1, \ldots, n; j = 0, 1$ as follows: $T_j = \sum_{i=1}^{n} \frac{t_{j,i} e^*_{j,i}}{1+t_{j,i}}, j = 0, 1$.

consumer demand, in labour supply due to the change in nominal earnings (LS1), and in labour supply due to the change in prices (LS2):

$$IT_1 - IT_0 = \underbrace{\mathbf{x}_0^{*\prime}(\mathbf{t}_1 - \mathbf{t}_0)}_{\text{first order effect}} + \underbrace{\mathbf{t}_1'(\mathbf{x}_1 - \mathbf{x}_0^*)}_{\text{commodity demand}} + \underbrace{\mathbf{t}_1'(\tilde{\mathbf{x}}_1 - \mathbf{x}_1)}_{\text{LS1}} + \underbrace{\mathbf{t}_1'(\mathbf{x}_1^* - \tilde{\mathbf{x}}_1)}_{\text{LS2}}. \tag{18}$$

Revenues from direct taxes and social security contributions We define government revenues from personal income taxes and social security contributions as the difference between employer labour costs g and employee disposable income y:

$$DT_j = g_j - y_j, \quad j = 0, 1. \tag{19}$$

This definition of direct tax revenues is broader than revenue from personal income taxes. It also consists of social security contributions, paid by both employee and employer, and it is net of benefits paid. Employers' labour cost can be written as

$$g_j = (1 + \sigma_{j,er})\, w_j^* h_j^*, \quad j = 0, 1, \tag{20}$$

in which $\sigma_{j,er}$ denotes the rate of employers' social security contributions, expressed in terms of gross earnings.[13] The latter are inclusive of employee's social security contributions. The change in direct tax revenues can then also be decomposed into a first and second order effect:

$$\begin{aligned} DT_1 - DT_0 = & \underbrace{(\sigma_{1,er} - \sigma_{0,er})(w_0^* h_0^*) - (f_1(w_0^*, h_0^*; M, \mathbf{z}) - f_0(w_0^*, h_0^*; M, \mathbf{z}))}_{\text{first order effect}} \\ & + \underbrace{(1 + \sigma_{1,er})(w_1^* h_1^* - w_0^* h_0^*) + (f_1(w_0^*, h_0^*; M, \mathbf{z}) - f_1(w_1^*, h_1^*; M, \mathbf{z}))}_{\text{second order effect}}. \end{aligned} \tag{21}$$

In this equation $f_0(\cdot)$ and $f_1(\cdot)$ embody respectively the pre– and post–reform schedules for personal income taxes, social security contributions paid by the employee, and benefits received. As before, the first order effect assumes there is no change in individuals' behaviour. That is, the post–reform job choice is identical to the pre–reform (w_0^*, h_0^*), simulated in the baseline. The second order effect can again be decomposed in two parts, drawing on the intermediate job choice, $(\tilde{w}_1, \tilde{h}_1)$, which we have defined before. This job choice is based on a reaction of households to solely changes in the tax function $f_1(\cdot)$, and not to any change in consumer prices, and thus in $Q(\mathbf{q})$. The overall change in direct tax revenues can then be decomposed in the first order effect, the behavioral effect following changes in the net wage, as a consequence of the direct tax reform (LS1), and the behavioral effect following changes in the consumer prices,

[13] In the empirical illustration we do not simulate any changes in employers' social security contributions, and thus $\sigma_0 = \sigma_1$

as a consequence of the indirect tax reform (LS2):

$$\begin{aligned}
DT_1 - DT_0 = & \underbrace{\left(\sigma_{1,er} - \sigma_{0,er}\right)\left(w_0^* h_0^*\right) - \left(f_1\left(w_0^*, h_0^*; M, \mathbf{z}\right) - f_0\left(w_0^*, h_0^*; M, \mathbf{z}\right)\right)}_{\text{first order effect}} \\
& + \underbrace{\left(1 + \sigma_{1,er}\right)\left(\tilde{w}_1 \tilde{h}_1 - w_0^* h_0^*\right) + \left(f_1\left(w_0^*, h_0^*; M, \mathbf{z}\right) - f_1\left(\tilde{w}_1, \tilde{h}_1; M, \mathbf{z}\right)\right)}_{\text{LS1}}. \\
& + \underbrace{\left(1 + \sigma_{1,er}\right)\left(w_1^* h_1^* - \tilde{w}_1 \tilde{h}_1\right) + \left(f_1\left(\tilde{w}_1, \tilde{h}_1; M, \mathbf{z}\right) - f_1\left(w_1^*, h_1^*; M, \mathbf{z}\right)\right)}_{\text{LS2}}.
\end{aligned} \tag{22}$$

Distributional effects To assess the reform's distributional impact we subtract indirect taxes paid from disposable income. This concept acts as a measure for households' real income and thus purchasing power.[14] In the cases where we assume constant quantities (the first order effect), it is a lower bound for a measure of welfare change based on the compensating variation (see Capéau et al. 2018).

3 Empirical illustration

The framework proposed in Section 2 is illustrated by applying it to joint tax reform scenario in Belgium. First, we discuss the data we use for the application, and explain the implemented joint tax reform in the simulations (Section 3.1). Thereafter, we present the results (Section 3.2), focusing first on the budgetary and employment effects (Section 3.2.1), and then on the distributional impact of both the first and second order effects (Section 3.2.2).

3.1 Data and simulated reforms

We implement our approach on Belgian data. We argued that the income variable in the RURO job choice model needs to be specified in real terms. To arrive at this variable we used the tax benefit microsimulation model EUROMOD (Sutherland and Figari, 2013).[15]

EUROMOD runs on the Statistics on Income and Living Conditions (SILC) survey, which is a micro–level dataset that contains detailed information on income, poverty, social exclusion and other living conditions. For Belgium, the survey's reference population includes all private households and their current members residing in the country. Individuals living in collective households, such as hospitals, youth institutions, and old peoples homes are excluded from the reference population. All of our calculations in the simulation stage are performed on the Belgian SILC 2019, which contains 15,409 individuals who live in 6,762 households. The RURO

[14]Note that this is another concept of real income than the real measure for consumption, c, which we defined in Section 2.1.

[15]EUROMOD covers the personal income tax code of 27 EU countries for several policy years, and allows us to simulate tax reforms. Recently an Indirect Tax Tool has been added (see Akoğuz et al. 2020; De Agostini et al. 2017). A more detailed version, based on the more detailed HBS of Statbel was developed and used in this paper (see Capéau et al. 2022).

model was estimated on pooled SILC's of 2015, 2017 and 2019.[16]

SILC does not contain data on expenditures, which is required to calculate indirect taxes paid by the households and to construct the household specific Divisia price indices, needed to estimate the RURO model. We impute consumption income shares in SILC, based on a statistical match between SILC and the Household Budget Survey (HBS). We link SILC waves 2015, 2017 and 2019 with respectively HBS waves 2014, 2016 and 2018. The statistical match is based on predictive mean matching methodology, and is discussed in detail in Akoğuz et al. 2020. The imputation of budget shares is now standardised and implemented in EUROMOD as part of the Indirect Tax Tool.[17]

The RURO model was estimated on a subsample of the SILC data of waves 2015, 2017 and 2019, that only contains those households in which the reference person and their partner, if any, are available for the labour market. The online Appendix A.1 contains more details on the composition of this subsample. In Section 2.2 we presented our functional forms. Appendix A.2 presents the estimated model parameters, the simulated aggregate wage elasticities of labour supply, and the model fit.[18] The elasticities of our model are low, and in this sense broadly in line with the abundant micro–econometric estimates for other countries (see Bargain, Orsini and Peichl 2014 and Mastrogiacomo et al. 2017 for recent overviews for several European countries and the US). First, the total own wage elasticity of 0.19 for single females and 0.23 for single males is mainly determined by the participation elasticities. The total own wage elasticity of 0.13 for females in couples and 0.11 for males in couples is mainly determined by the intensive margin elasticities (see Table A.4). Second and contrary to the cited literature, the elasticities are not declining with the level of the gross wage rate (see Table A.5 and Table A.6). Third, in couples we find substantial negative cross wage elasticities (-0.10 for females and -0.09 for males), which are driven by reactions at both the intensive and extensive margin.

After estimating the model parts, we use the model to simulate the effects of a tax reform inspired by a tax shift proposal in Belgium.[19] The tax reform constitutes primarily of an increase of the tax-free amount in the personal income tax, financed by an increase of the VAT rates. We bring all reduced rates (resp. 6 and 12 percent) to the standard rate of 21 percent. The revenues from the reform in indirect taxation determine the increase in the tax-free amount. However, we know that our model captures only half of all indirect taxes paid in the baseline. This can partly be explained by the under–reporting of alcohol and tobacco consumption, but is mainly due to our inability to observe VAT and excise–payments from transactions between firms. As a result, we define the revenue gap to be financed *within* the model, using the rate of partial

[16] See Appendix A.1 for more information on the subsample on which the RURO model is estimated, and which is used for the simulation of the labour supply responses.

[17] For our empirical illustration we use an update of the methodology, utilizing the more detailed version of the Household Budget Survey from Statbel for more recent years. The update of the statistical match between the SILC and HBS for several years is described in Capéau et al. 2022.

[18] In our job choice model individuals are not characterised by one specific wage, rather by the distribution of wage offers determining the choice set from which they make their preferred choice. Therefore we obtain elasticities by shifting the whole distribution of wage offers to the right, increasing the first moment of the individual specific wage distribution by 10%.

[19] The broad tax reform was proposed by the Minister of Finance in March of 2023.

coverage in the baseline to determine the additional VAT–revenues to be collected. Moreover, the goal of the reform in direct taxation is to increase the net gain of working. Therefore, the increase in the tax-free amount is neutralised in a later stage of the personal income tax calculation for those receiving replacement incomes, proportional to the share of replacement income in taxable income. As a result, the tax-free amount increases from €9,050 to €14,955 (euros of 2019).

The (household specific) imputed income shares serve as parameters of the Cobb–Douglas preferences in our two–stage budgeting approach. They can thus be used to simulate the effects of indirect tax reforms on expenditures, indirect taxes paid, and the Divisia price indices. The weak separability assumption we exploit in the simulation stage implies that we do not allow the budget shares to change when labour market status alters as a consequence of a tax reform.

Next, using the new Divisia indices following from the indirect tax reform, and the possibility to simulate direct tax reforms with EUROMOD, the impact of a reform on households' labour supply decisions can be simulated by our estimated RURO model. The simulation procedure is explained more in detail in Appendix A.3. Note that households who do not belong to the subsample on which RURO was estimated, can alter their behaviour only through the expenditures margin in our simulations.

3.2 Results

3.2.1 Budgetary and employment effects

As discussed in Section 2.3, we decompose the total budgetary effect of a tax shift into two distinct parts: a *first order effect* (or 'impact' effect) and a *second order effect*. The former measures the effect when households could not alter their consumption bundle and their labour supply with respect to the baseline scenario. The latter, by contrast, exclusively captures the impact of these behavioural responses, and is further decomposed in a commodity demand effect, the labour supply effect of the change in net wage, and the labour supply effect of the change in consumer prices. Changes in labour supply are predicted by the RURO model and we assume that households alter their consumption according to the constant income shares assumption, i.e. assuming Cobb–Douglas preferences. Note that employment effects are by definition always second order effects. Unless otherwise stated, results are grossed up at population level by means of statistical weights.

Table 1 displays the absolute changes of the joint tax reform with respect to the simulated baseline. The first four rows show the employment effect, the effect on household disposable income, both including and net of indirect taxes, and the effect on government revenue. The impact effect of the simulated reform is a loss in personal income tax revenue of €10.7bn, a considerable bill for the treasury coffers.[20] The personal income tax reductions are immediately reflected in an increase in disposable income of households: it increases with €181 per month

[20]Nominal GDP in 2019 was €478.6bn, which leads to an estimated first round cost in the form of lower personal income taxes of 2.24% of GDP.

per household.

The increase in VAT rates leads to additional revenues of €5.6bn, pushing down the initial cost from €10.7bn to €5.1bn.[21] This is also revealed in the third line in which we show the impact on disposable income minus indirect taxes paid at the household level. The impact effect goes down from €181 to €87 per month per household, implying an additional indirect tax bill of €94 per month.

Table 1: Employment and revenue effects of the simulated reform

	baseline	1st order	2nd order			total
			demand	LS1	LS2	
	(1)	(2)	(3)	(4)	(5)	(6)
FTEs (1000 units)	5,771			+1.24	-0.55	+0.69
disp. inc. (€/month/hh.)	3,374	+181		-2	-1	+178
disp. inc. - ind. tax (€/month/hh.)	3,046	+87	-5	-2	-1	+79
net gov.rev. (mio €)	61,007	-5,130	+278	-122	-42	-5,017
employer SSC (mio €)	46,173			-16	-9	-24
employee SSC (mio €)	22,281			-33	-18	-51
pers. inc. tax (mio €)	54,325	-10,714		-62	-20	-10,797
benefits (mio €)	81,168	-8		-8	+8	-8
ind. tax (mio €)	19,396	+5,575	+278	-4	-4	+5,846

a. The second order effect is split in an effect due to changes in commodity demand (column (3)), the effect of labour supply changes due to the change in the net earnings, i.e. the reduction in labour income taxes (column (4): LS1) and the effect of labour supply changes due to higher consumer prices, i.e. due to the VAT reform (column (5): LS2).
b. All effects are with respect to the baseline in the first column of the table. Baseline levels are obtained by simulating the pre–reform scenario.
c. Monthly disposable income is not equivalised.
d. The baseline, the first order effect and the commodity demand effect, are based on the entire SILC population. Both labour supply effects can only be modelled for the population taken up in the RURO model, the level effect represents thus only the impact within the RURO subpopulation.

The first line of Table 1 shows the additional employment, expressed in full time equivalents (FTEs), triggered by the tax reform.[22] The rise in net earnings triggered by the reform induces an additional employment of 1,240 FTEs. Not unexpectedly, the diminution of the increase in disposable income net of indirect taxes comes with an erosion of the employment effect: due to the VAT increase almost one half of the newly created FTEs are lost, and additional employment due to the joint reform falls back to 690 FTEs.

The cost recovery effect of this additional employment is however negative. This cost recovery is the net effect of a decrease in benefits to be paid due to more employment, an increase in social security contributions paid by the employer and by the employee, and an increase in the personal income tax, as a result of increased labour supply, and finally, an increase in indirect tax payments following the increase in disposable income, and thus higher consumption. Surprisingly, the additional employment of 1,240 FTEs, due to the change in net earnings,

[21] In % of GDP the first order increase in VAT revenue amounts to 1.16%, and the net first order revenue impact is 1.17% of GDP. Without additional incidence assumptions, our household model is unable to pick up the additional revenue from VAT paid by the production sector.

[22] The behavioural model simulates labour supply in hours per week. To transform the additional labour supply into FTEs, we divide by the standard of 38 hours per week.

is not translated into an increase of the taxable base of social security contributions and the personal income tax (column (4)). Contrary to the expectation, revenues from social security contributions drop with €49 million (16 million paid by the employer and 33 million paid by the employee), and personal income tax revenues decrease with €62 million. Later in this section, we will show that the negative impact on revenues of the labour supply reaction to higher net earnings can be attributed to a negative income effect. The income of new entrants is rather moderate, so they generate few additional tax revenues. At the same time, the tax reform allows persons already working to work less and to afford jobs with somewhat lower gross wages. Since the tax schedule is progressive, this effect excavates possible cost recovery effects, especially when individuals higher up in the income distribution are lowering their labour supply or are choosing jobs with lower wage. Contrary to what is often raised in the public debate, viz. that a bill of €10,7bn. in the personal income tax will finance itself through cost recovery, the final bill exceeds the initial one.

As expected, the impact of the increase in VAT rates (column (5)) leads to an additional deterioration of revenues from social security contributions and personal income tax, but to a lesser extent than the initial labour supply reaction to the reduction of personal income taxes.

The only positive element for cost recovery is the impact of higher indirect tax revenues due to a higher disposable income after the personal income tax reform (column (3)). In a first stage, without any labour supply reactions, the demand adjustment results in €278 million additional revenues. The labour supply reactions, which in general lower disposable income to be spent, deteriorate this effect slightly with €8 million (€4 million in both columns (4) and (5)). Only because of this demand reaction, the final bill of €5.017 billion is slightly lower than the initial bill of €5.13 billion.

Summing up these aggregate results, we conclude that the actual tax shift does indeed create additional employment, but that the numbers are very small overall. And due to the reaction on the intensive margin, both in hours and in wages, the cost recovery effects are negative. Moreover, revenue neutrality obtained by higher VAT rates, erodes the employment effect, and thus exacerbates the negative cost recovery effects. The final bill, after second order effects, is slightly lower than the initial bill, only due to the additional VAT paid after the increase in disposable income. To deepen our understanding of these aggregate effects, we first look at the employment effects in more detail.

Heterogeneity in labour market effects. In Tables 2 to 4 we summarise the labour market effects of the simulated reform. The tables presents effects of the reform on job choice for the population of individuals included for analysis in our job choice model (Section 2.2), across quintiles of the gross wage. Table 2 shows the labour market effects due to the change in the net wage as a consequence of the reform in the personal income tax system. Table 3 shows the additional labour market effects due to the higher consumer prices, which follows from the indirect tax reform. Finally, Table 4 summarises the total labour market effects of the joint reform. To order the individuals, we use the gross wage rate observed in the job choice of the baseline for those individuals who work in the baseline. For the non–participating individuals we impute a gross wage based on their observable characteristics and the wage equation used in the EUROMOD framework. Columns (1) to (4) describe effects for the whole RURO population, both on the extensive (working or not, labelled here as 'participation') and on the intensive (number of hours worked per week) margin. Gross wage being a characteristic of the job, changes in job choice may also trigger an additional effect on earnings, which are the product of gross wage and hours worked. This is presented in the right part of Table 2, 3 and 4 (columns (5) to (10)). In that part of the tables we limit ourselves to the population being employed in the baseline. The reason is that wages of non–working individuals are not observed. Hence we cannot calculate the percentage change in wages and earnings for these individuals.[23]

Table 2: Labour market effects due to changes in the net wage across quintiles of gross wages

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	h/wk	%	h/wk	%	€/h	%	€/mo	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	90.08	-0.04	33	-0.02	36	-0.02	14	-0.12	2,163	-0.09
Q2	88.04	0.03	34	0.06	38	0.01	18	-0.08	2,982	-0.07
Q3	90.57	0.05	34	0.05	37	-0.03	22	-0.11	3,505	-0.12
Q4	93.48	0.08	35	0.06	38	-0.05	26	-0.23	4,311	-0.26
Q5	96.34	0.16	36	0.19	38	-0.03	40	-0.22	6,486	-0.24
all	91.70	0.06	34	0.07	37	-0.02	24	-0.17	3,931	-0.18

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row.
b. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation in the EUROMOD framework. We keep the allocation of individuals across quintiles fixed.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *direct* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *direct* tax reform relative to the baseline values. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.

Column (2) of Table 2 shows that the increase in employment of 690 FTE's, discussed in Section 3.2.1, mainly results from an increase in participation of individuals characterised by a high gross wage. The increase of participation is most outspoken in the top quintile of the gross wage distribution (an increase of 0.11 percentage points from a baseline level of 96.34 percent). There is a negative impact on participation in the first quintile of observed wages, and only small effects in the second and third wage quintiles. This negative income effect also pops up in column (4) where we find that for the bottom quintile of the gross wage distribution, the

[23] It is true that we have imputed a wage for these non–working individuals to assign them a place in the quintile ordering based on gross wages, but we choose to limit the use of this imputation for that purpose only.

Table 3: Labour market effects due to changes in prices across quintiles of gross wages

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	h/wk	%	h/wk	%	€/h	%	€/mo	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	90.08	-0.05	33	-0.05	36	-0.05	14	-0.09	2,163	-0.07
Q2	88.04	-0.02	34	-0.02	38	-0.02	18	-0.04	2,982	-0.03
Q3	90.57	-0.01	34	-0.02	37	-0.02	22	-0.06	3,505	-0.06
Q4	93.48	-0.02	35	-0.03	38	-0.01	26	-0.07	4,311	-0.08
Q5	96.34	-0.04	36	-0.04	38	-0.02	40	-0.10	6,486	-0.10
all	91.70	-0.03	34	-0.03	37	-0.02	24	-0.08	3,931	-0.08

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row.
b. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation in the EUROMOD framework. We keep the allocation of individuals across quintiles fixed.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *indirect* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *indirect* tax reform relative to the baseline values. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.

Table 4: Total labour market effects across quintiles of gross wages

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	h/wk	%	h/wk	%	€/h	%	€/mo	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	90.08	-0.09	33	-0.06	36	-0.05	14	-0.20	2,163	-0.16
Q2	88.04	0.01	34	0.04	38	-0.02	18	-0.12	2,982	-0.10
Q3	90.57	0.04	34	0.03	37	-0.02	22	-0.17	3,505	-0.18
Q4	93.48	0.06	35	0.03	38	-0.01	26	-0.30	4,311	-0.35
Q5	96.34	0.11	36	0.15	38	-0.02	40	-0.33	6,486	-0.34
all	91.70	0.03	34	0.04	37	-0.02	24	-0.25	3,931	-0.26

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row.
b. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation in the EUROMOD framework. We keep the allocation of individuals across quintiles fixed.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *joint* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *joint* tax reform relative to the baseline values. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.

average number of hours worked decreases. Overall, the average number of hours worked per week increases with 0.06 percent due to the increase in net earnings.

The negative income effect of a significant increase in disposable income following a tax reduction does not come as a surprise. It has been documented frequently in other assessments of tax reforms based on modelling behaviour with a standard discrete choice approach (e.g. Blundell et al. 2000). However, the RURO model is uniquely equipped to unveil a potentially more important, additional, 'income effect'. It shows up in column (8) as a considerable reduction in gross wages, itself the result of the switch by some individuals to the choice of a wage–hours package with lower gross wages than before the reform. On average, gross wages, following from the choice of jobs after the tax reform, are 0.17 percent lower than the gross wages of the jobs chosen in the baseline. This effect is mainly driven by the upper half of the gross wage distribution.[24] Combined with the decrease in labour supply this trickles down in a reduction of the taxable base of both social security contributions and personal income taxes: gross earnings decrease by 0.18 percent. Since this effect is predominantly found in the upper half of the distribution (earnings go down by 0.24 percent in the top quintile of gross wages, whereas they decrease by only 0.09 percent in the bottom quintile), this explains why the negative revenue effect in the progressive personal income tax is larger than the negative revenue effect in the proportional social security contributions.

The crux here is not whether we can produce the right amount of cost recovery. But the structural model of job choice unveils a mechanism which might at least partially explain the often disappointing revenue figures following tax reductions in the form of increases of household disposable incomes. Lowering of personal income taxes allows some individuals to afford a new job choice which comes with a lower gross wage, but with less hours to work and preferred unobserved characteristics (less stress, lower commuting time, etc.). Using a structural model which allows for this additional behavioural channel shows that a good empirical estimate of this additional 'income' effect is crucial to produce credible revenue predictions.

Table 3 shows the impact on labour supply due to the increase in VAT rates, and thus the decrease in real disposable income triggered by the increase in consumer prices. The decrease in additional FTEs due to joint tax reform as discussed in 3.2.1 is due to a reaction on both the extensive margin and the intensive margin across the wage distribution. This is the result of a positive income effect, real disposable income has dropped, and a negative substitution effect between leisure and labour. Indeed, the *real* gain of working is now lower. On all margins the income effect does not compensate the substitution effect. Participation (column (2)) drops with 0.03 percentage points, driven by changes across the entire gross wage distribution. Also total labour supply decreases across the entire wage distribution, amounting to a total decrease of 0.03 percent, relative to the baseline level of labour supply. Focusing on only those working in the baseline, we additionally find that the increase in VAT rates has a similar effect on the wages

[24] In Table A.9 in Appendix A.4 we also show the results for an ordering of the individuals based on their equivalised disposable income. The numbers evidently slightly differ, but the conclusions remain the same. Admittedly, the decrease in wages as represented here might be somewhat exaggerated, as the group who stops working due to the reform, is registered here as facing a 100% wage loss.

resulting from the job choice as the decrease of the personal income tax, albeit less outspoken. Overall, wages drop by 0.08 percent. The decrease of worked hours, and of gross wages, results in an additional deterioration of the taxable base of personal income tax and social security contributions, gross earnings.

Table 4 combines both labour supply reactions, and shows the overall reactions for the joint tax reform. Regarding the extensive margin, the initial effect of the increase in net earnings dominates the impact of the increased VAT rates. Participation increases with 0.03 percentage points due to the joint tax reform. The same is true for the overall hours, which increases with 0.04 percent. The impact of both the direct and indirect tax reform on wages has the same direction. The initial negative impact on wages, mainly driven by the top gross wage quintiles, is exacerbated by the indirect tax reform, leading to an overall drop in gross wages of 0.25 percent. The gross earnings decrease due to the joint reform with 0.26 percent.

3.2.2 Distributional analysis

A comprehensive distributional analysis should incorporate all three elements of the reform: (1) the change in disposable incomes, due to the higher tax-free amount in the personal income tax for individuals active on the labour market, (2) increases in indirect taxes to be paid, which are also to be borne by non–active persons, affected by a commodity demand adjustment, and finally (3) the changes in real disposable income and leisure time induced by changes in behaviour. As mentioned above, in this paper we abstract from the effect of changed leisure time on individual welfare.[25] The results are summarised in Table 5.

Contrary to the results in Tables 2, 3 and 4 above, where we only used the subpopulation modelled in the behavioural labour supply model, we now present results for the whole population. Each quintile of Table 5 contains 20 percent of the number of persons in the population (including children, pensioners, etc.). The position in the ordering is determined by equivalised disposable income of the household the person belongs to. In the top part of the table we show the effect on monthly household disposable income net of indirect taxes paid. The amounts in the top part of the table are *non–equivalised.* They should be read as the averages of household incomes or of indirect taxes paid by the household, where averages are taken over these households. The bottom part of Table 5 expresses the changes in percent of baseline *real* disposable income, i.e. disposable income net of indirect taxes paid.

The first observation to be inferred from Table 5 is the important impact of the financing through indirect taxes on the distributional assessment of the reform. Column (1) shows that the first order change in disposable income is broadly regressive. The first order effect increases up to the fourth quintile, both in euro and relative to baseline real income (bottom part of Table 5). Only the impact for the top quintile, although still larger in absolute amounts, is smaller than the impact of the fourth quintile relative to baseline real disposable income. The increase in indirect taxes is more proportional to baseline real disposable income. This again

[25] See Capéau et al. (2018) for an analysis that accounts for changes in welfare induced by changes in working hours.

Table 5: Distributional effects of the simulated reform

	1st order			2nd order			total
				demand	LS1	LS2	
	disp.inc. (1)	ind.tax (2)	real inc. (3)	real inc. (4)	real inc. (5)	real inc. (6)	real inc. (7)
				impact in euro			
Q1	21.8	63.0	-41.2	7.6	4.6	-1.2	-30.1
Q2	136.1	80.9	55.2	-4.7	-0.1	-0.6	49.8
Q3	222.9	102.5	120.4	-10.1	-0.6	-0.7	109.0
Q4	304.0	120.1	183.9	-15.6	-2.7	-1.0	164.6
Q5	350.2	131.7	218.5	-9.4	-9.6	-3.2	196.4
all	180.9	94.2	86.7	-4.7	-2.3	-1.4	78.3
				impact in percent of baseline real inc.			
Q1	0.99	2.87	-1.87	0.35	0.21	-0.05	-1.37
Q2	6.20	3.68	2.51	-0.22	-0.01	-0.03	2.27
Q3	7.02	3.23	3.79	-0.32	-0.02	-0.02	3.43
Q4	7.36	2.91	4.45	-0.38	-0.07	-0.02	3.99
Q5	5.89	2.22	3.68	-0.16	-0.16	-0.05	3.30
all	5.94	3.09	2.85	-0.15	-0.08	-0.04	2.57

a. Real income is equal to disposable income minus indirect taxes paid. The figures in column (3) are thus the differences between the figures in column (1) and in column (2).
b. The values in the top part of the table show averages of *non–equivalised* household incomes and indirect taxes, where the averages are calculated over the population of households. In columns (3) to (7) we subtract the change in indirect taxes paid at pre–reform quantities from the change in disposable income. The values in the bottom part of the table are these differences expressed in the average baseline real disposable income, i.e. the average of disposable income in the baseline minus indirect taxes paid in the baseline per quintile.
c. The second order effect is split in an effect due to changes in commodity demand (column (4)), the effect of labour supply changes due to the change in the net earnings, i.e. the reduction in labour income taxes (column (5): LS1) and the effect of labour supply changes due to higher consumer prices, i.e. due to the VAT reform (column (6): LS2).
d. All effects are with respect to the baseline simulation.
e.The quintiles are constructed by ranking all individuals on the basis of their household equivalised disposable income in the baseline. Each quintile contains 20% of the total population of individuals.

leads to a regressive pattern: with the exception of the bottom quintile, expressed in percent of baseline real income, the indirect tax hike declines across the income distribution. For the bottom quintile, the indirect tax increase turns an already modest impact of disposable income into a substantial loss of −1.9% (column (3)). Hence, the first order impact of the reform as a whole is unsurprisingly regressive: from the first to the fourth quintile, the impact change is increasing from a loss of −1.9 percent to a gain of 4.5 percent (in absolute amounts: from a loss of €41 per month to a gain of €120 per month). Since the gains decrease in relative terms for the top quintile (from 4.5 percent to 3.7 percent), one can at best bend the adjective 'regressive' into 'pro middle class' to describe this tax reform, but certainly not into 'pro poor'. The explanation for this 'pro middle class' distributional pattern of the impact effects lies in the character of this specific tax reform. First, the increase in the tax-free amount in the personal income tax is conditional on being at work. Second, in absolute terms the gain of an increase in the tax-free amount does not increase with income, leading to a gain which declines when expressed as percent of baseline (real) disposable income.

The second message from Table 5 is the impact of the behavioural changes on the distributional assessment. First, given the first order impact on disposable income and indirect taxes, the expenditure model with constant income shares makes households in the bottom quintile reduce expenditures. In the top four quintiles, households spend more, since the first order impact on disposable income is larger than the first order impact on indirect taxes paid. The effect on real income of this demand reaction is displayed in column (4) of Table 5 by tabulating the additional change in real income stemming from moving from constant quantities to constant income shares.[26] It shows that the impact of the reaction in commodity demand, counteracts the first order distributional picture. As in the previous sections, our framework also allows to disentangle the labour supply effect of the increase in net earnings (displayed in column (5) of Table 5) from the labour supply effect of the increase in consumer prices (displayed in column (6) of Table 5). Both have distinct, albeit small, impacts on the distributional picture. First, column (5) reveals that the increase of the tax-free amount corrects the regressive first order distributional picture further, at least in monetary terms. The reasons are that (1) in the lowest equivalised disposable income quintile households start working, or work more leading to additional disposable income, and (2) that households in the top part of the distribution will work less or will accept lower wages, leading to a decrease in disposable income.[27] Second, the labour supply effect due to the price change in column (6) is very different, with a decrease in disposable income for all quintiles. As discussed in 3.2.1, the increase in VAT rates leads to a decrease of labour supply across the gross wage distribution. Even though the second order effects slightly counteract the regressive nature of the joint tax reform, overall, the reform does lead to a regressive change in real disposable income, with the bottom quintile losing 1.4 percent of real disposable income (€30 per month), while the top three quintiles gain more than 3.3

[26] Real income is again defined as disposable income minus indirect taxes paid.

[27] This is in line with the discussion in 3.2.1. Note that the quintiles in Table 5 are based on equivalised disposable income, and not on gross wages as is the case in Tables 2, 3 and 4. In appendix A.4 we show the employment effects for quintiles of equivalised disposable income.

percent (resp. €109, €165 and €196 per month).

4 Conclusion

In this paper, we propose a *piecemeal modelling* strategy to establish a micro–based budgetary and distributional evaluation of a joint reform in the direct and indirect tax systems. Using a two–stage budgeting approach, we allow (changes in) commodity prices to interact with households' labour supply, and even more general, job choice decision. Assuming a Cobb-douglas subutility of consumption, we show that deflation of disposable income with the household specific Divisa price index bridges the commodity prices with the labour supply decision. We employ this approach to a random utility random opportunity (RURO) model of labour supply, which enables us to highlight an additional margin on the labour market, the accepted wage in the job choice.

We illustrate the framework with an empirical application to a proposed Belgian tax shift. An increase in the tax-free amount in the personal income tax for working individuals is financed by an increase of reduced VAT rates of six and twelve percent to the standard rate of twenty-one percent. We find substantial evidence that it is important to account for indirect taxes in the assessment of the distributional and budgetary evaluation of a joint tax reforms. Our results show that, despite an overall increase in labour supply, cost recovery effects from personal income taxes and employee and employer social security contributions are negative. This lack of cost recovery is partly explained by the negative employment effect at the intensive margin, due to the income effect after the personal income tax reform. Jobs with on average less working hours are chosen, a behavioural reaction which is in line with the literature. However, the second order erosion of government revenues is enhanced by an additional mechanism, unveiled by the use of the rich structural specification of the RURO-model. Indeed, the RURO model predicts that the personal income tax reform might induce some individuals to choose jobs with lower gross wages, especially at the top of the gross wage distribution. Since lower gross wages trickle down into a negative effect on the taxable base for both PIT and social security contributions, our job choice model might point to an important new explanation for the low cost recovery of this kind of reforms.

Our framework also allows us to disentangle the overall employment effects from those stemming from the indirect tax reform, namely from the impact of changed commodity prices. The negative cost recovery effects worsen considerably due to the impact of increasing VAT rates on labour supply. Higher consumption prices means that the net marginal gain of working decreases. As a result, part of the positive impact of the direct tax reform on participation is deteriorated, and more households choose to work less hours and accept a lower wage in their job choice. Our simulations indicate that a revenue neutral reform would destroy almost one half of the newly created FTEs, compared to the impact of solely the personal income tax reform, and the employment effect to the increased prices accounts for one fourth of the negative cost recovery effects of the overall tax reform.

Also the distributional picture of the simulated reform is affected by the behavioral changes we model in our framework. If we keep households' consumption bundle and labour supply fixed, our results show that the poorest gain the least from the reform. The gain in percentage of disposable income increases up to the fourth quintile. The bottom quintile incurs a loss. If we allow households to alter their behaviour the pictures slightly changes. The poorest decile now loses less due to more employment income. From the second to the fifth quintile the first order gain deteriorates after taking into account behavioral changes, with the largest impact in the top two quintiles. This is mainly due to change in commodity demand, and change in job choice which entails on average less hours and a smaller gross wage.

We argue that the piecemeal modelling framework is an attractive set-up for the evaluation of joint tax reforms. Even though it is well known that the job choice is based on the *real* return to hours worked, often in empirical applications, or policy evaluations, any change in indirect taxation is assumed to have no employment effect. The proposed framework is an alternative to a comprehensive model of the labour supply decision and the consumption allocation decision.

Nevertheless, the piecemeal modelling framework is built on some strong assumptions, and it does not take into account all feedback effects of a joint tax reform. First, the two-stage budgeting approach is based on the assumption of weak separability of utility between leisure and consumption. Second, our proposal to deflate disposable income in the labour supply decision with the Divisia price index, stems from the Cobb-Douglas functional form of subutility of consumption. We acknowledge this is a strong assumption, but only use it as a tractable way to focus on the issue of incorporating consumer price changes in the labour supply decision. We might of course introduce more involved demand systems to model the changes in the income shares following the change in income and in consumer prices. Yet, we conjecture that, given that we already modelled a large amount of household heterogeneity in the baseline spending patterns, the effect of additional changes in budget shares on the labour supply decision would be minor (compared to the current modelling strategy with constant budget shares). Anyhow, the piecemeal modelling framework allows to link such more intricate modelling of the consumption allocation with the labour supply decision. Especially in the case of evaluation of the labour supply effect of a very specific indirect tax reform, of which incidence is very unevenly spread in the population, or where non-standard commodity demand reactions are expected, for example related to the green transition, such an extension of the piecemeal modelling framework is advised. Finally, the framework only allows to evaluate the feedback effects of a joint tax reform that stem from the employment decision of households. There is no endogenous impact of the joint tax reform on labour demand, or on the wage formation, nor are there general equilibrium effects on commodity prices and wage rates. However, also in this case, the piecemeal modelling set-up is suitable to be extended with such general equilibrium effects. For example, exogenously determined labour demand reactions can be taken up by the RURO model, by shifting the distribution of opportunities of households. The proposed framework, which links commodity demand models with models of labour supply, certainly does not prevent the modelling of other important feedback effects of policy reform.

5 References

Aaberge, R., Colombino, U., and Strøm, S. (1999), Labor supply in Italy: an empirical analysis of joint household decisions, with taxes and quantity constraints, Journal of Applied Econometrics, Vol. 14(4), 403–422.

Aaberge, R. and Colombino, U. (2014), Labour supply models, in: C. O'Donoghue (ed.), Handbook of Microsimulation Modelling, Contributions to Economic Analysis, Volume 293, Emerald Group Publishing Limited: Bingley, 167–221.

Aaberge, R., Dagsvik, J., and Strøm, S. (1995), Labour supply responses and welfare effects of tax reforms, Scandinavian Journal of Economics, Vol. 97(4), 635–659.

Akoğuz, E.C., Capéau, B., Decoster, A., De Sadeleer, L., Güner, D., Manios, K., Paulus, A., Vanheukelom, T. (2020), A new indirect tax tool for EUROMOD. Final Report JRC Project no. JRC/SVQ/2018/B.2/0021/OC.

Altig, D., Auerbach, A.J., Koltikoff, L.J., Smetters, K.A., and Walliser J. (2001), Simulating fundamental tax reform in the United States, American Economic Review, Vol. 91(3), 574–595.

Bach, S., Haan, P., Hoffmeister O., and Steiner V. (2006), Increasing the value-added tax to refinance a reduction of social security contributions? A behavioral microsimulation analysis for Germany, mimeo, DIW: Berlin.

Bargain,O., Orsini, K. and Peichl, A. (2014), Comparing Labor Supply Elasticities in Europe and the United States, Journal of Human Resources, Vol. 49 (3), 723–838.

Barten, A.P. and Böhm, V. (1986), Consumer theory, in: K.J. Arrow and M.D. Intrilligator (eds.) Handbook of mathematical economics Volume II, North–Holland: Amsterdam, 381–421.

Blundell, R., Browning, M., and Meghir, C. (1994), Consumer demand and the life–cycle allocation of household expenditures, Review of Economic Studies, Vol.61(1), 57–80.

Blundell, R., Duncan, A., McCrae, J., and Meghir, C. (2000), The labour market impact of the working families' tax credit, Fiscal Studies, Vol. 21(1), 75–104.

Blundell, R. and MaCurdy, T. (1999), Labor supply: a review of alternative approaches, in: O. Ashenfelter and D. Card (eds.), Handbook of Labor Economics, Volume 3A, North-Holland Elsevier: Amsterdam, 1559–1695.

Blundell, R., MaCurdy, T., and Meghir, C. (2007), Labor supply models: Unobserved heterogeneity, nonparticipation and dynamics, in: J. Heckman, and E. Leamer (eds.), Handbook of Econometrics, Volume 6A, North–Holland Elsevier: Amsterdam, 4667–4775.

Blundell, R. and Walker, I. (1982), Modelling the joint determination of household labour supplies and commodity demands, The Economic Journal, Vol. 92 No.366, 351–364.

Blundell, R. and Walker, I. (1986), A life–cycle consistent empirical model of family labour supply using cross-section data, Review of Economic Studies, Vol. 53(4), 539–558.

Böhringer, C., Boeters S., and Feil, M. (2005), Taxation and unemployment: an applied general equilibrium approach, Economic Modelling, Vol. 22(1), 81–108.

Bourguignon, F., Fournier, M., and Gurgand, M. (2001), Fast development with a stable income distribution: Taiwan, 1979–94, Review of Income and Wealth, Vol. 47(2), 139–163.

Browning, M., Deaton, A., and Irish, M. (1985), A profitable approach to labor supply and commodity demands over the life–cycle, Econometrica, Vol. 53(3), 503–543.

Browning, M. and Meghir, C. (1991), The effects of male and female labor supply on commodity demands, Econometrica, Vol. 59(4), 925–951.

Capéau, B. and Decoster, A. (2016), Getting tired of work, or re–tiring in absence of decent job opportunities? Some insights from an estimated Random Utility/Random Opportunity model on Belgian data, EUROMOD working paper series, EM4/16.

Capéau, B., Decoster, A., and Dekkers, G. (2016), Estimating and Simulating with a Random Utility Random Opportunity Model of Job Choice Presentation and Application to Belgium, International Journal of Microsimulation, Vol. 9(2), 144–191.

Capéau, B., Decoster, A., De Swerdt, K., and Orsini, K. (2009), Welfare effects of alternative financing of social security. Some calculations for Belgium, in: A. Harding, P. Williamson, and A. Zaidi (eds.) New Frontiers in Microsimulation Analysis, Ashgate: Farnham, 437–470.

Capéau, B., Decoster, A., Maes, S., Vanheukelom, T. (2018), Piecemeal modelling of the effects of joint direct and indirect tax reforms, EUROMOD working paper series, EM14/18.

Capéau, B., Decoster, A., Vanderkelen, J., Van Houtven, S., Vanrespaille Q. (2022), Imputation of expenditures from HBS to SILC, BE-PARADIS Technical Report 1, www.beparadis.be

Creedy, J. and Kalb, G. (2005), Discrete hours labour supply modelling: Specification, estimation and simulation, Journal of Economic Surveys, Vol. 19(5), 697–734.

Dagsvik, J.K. and Jia, Z. (2016), Labor supply as a choice among latent jobs: unobserved heterogeneity and identification, Journal of Applied Econometrics, Vol. 31(3), 487–506.

Dagsvik, J.K., Jia, Z., Kornstad, T., and Thoresen, T.O. (2014), Theoretical and practical arguments for modeling labor supply as a choice among latent jobs, Journal of Economic Surveys, Vol. 28(1), 134–151.

Dagsvik, J.K. and Strøm, S. (2004), Sectoral labour supply, choice restrictions and functional form, Statistics Norway Research Department Discussion paper no. 388.

Dagsvik, J.K. and Strøm, S. (2006), Sectoral labour supply, choice restrictions and functional form, Journal of Applied Econometrics, Vol. 21(6), 803–826.

Dahlby, B. (2003), Restructuring the Canadian tax system by changing the mix of direct and indirect taxes, in: H. Grubel (ed.) Tax reform in Canada: Our path to greater prosperity, The Fraser Institute: Vancouver, 77–108.

De Agostini, P., Capéau, B., Decoster, A., Figari, F., Kneeshaw, J., Leventi, C., Manios, K., Paulus, A., Sutherland, H., Vanheukelom, T. (2017), EUROMOD extension to indirect taxation: final report, EUROMOD technical note series, EMTN/3.0.

de Castro Fernàndez, F., Perelle M. and Priffis R. (2018), The economic effects of a tax shift from direct to indirect taxation in France, European Economy Discussion Papers 077.

Duncan, A. and Weeks M. (2000), Transition estimators in discrete choice models, in L. Mitton, H. Sutherland, and M. Weeks (eds.) Microsimulation Modelling for Policy Analysis. Challenges and Innovations, Cambridge University Press: Cambridge, 292–308.

European Commission services (DG TAXUD) (2006), Macroeconomic effects of a shift from direct to indirect taxation: a simulation for 15 EU member states, paper presented at the 72nd meeting of the OECD Working Part No.2 on Tax Policy Analysis and Tax Statistics, Paris.

Gorman, W. M. (1971), Two stage budgeting, mimeo, London School of Economics. Printed in: C. Blackorby and A. Shorrocks (eds., 1995) Separability and Aggregation. The Collected Works of W. M. Gorman, Volume 1. Oxford University Press: Oxford, 22–29.

Hausman, J., (1981), Labor supply, in: H. Aaron and J. Pechman (eds.), How Taxes Affect Economic Behavior, Brookings Institution: Washington DC, 27–83.

Hausman, J., (1985a), The econometrics of nonlinear budget sets, Econometrica, Vol. 53(6), 1255–1282.

Hausman, J., (1985b), Taxes and labor supply, in: A. Auerbach and M. Feldstein (eds.), Handbook of Public Economics, Volume 1, North–Holland Elsevier: Amsterdam, 213–263.

Keane, M. (2011), Labor supply and taxes: A survey, Journal of Economic Literature, Vol.49(4), 961–1075.

Keane, M., Todd, P., and Wolpin, K. (2011), The structural estimation of behavioural models: Discrete choice dynamic programming methods and applications, O. Ashenfelter and D. Card (eds.), Handbook of Labor Economics, Volume 4A, North–Holland Elsevier: Amsterdam, 331–461.

Mastrogiacomo, M., Bosch, N., Gielen, M. and Jongen, E. (2017), Heterogeneity in Labour Supply Responses: Evidence from a Major Tax Reform, Oxford Bulletin of Economics and Statistics, Vol. 79(5), 769–796

McFadden, D. (1973), Conditional logit analysis of qualitative choice behavior, in: P. Zarembka (ed.), Frontiers in Econometrics, Academic Press: New York, 105–142.

Myles, G. (2009a), Economic growth and the role of taxation – Theory, OECD Economics Department Working Papers, No. 713, OECD Publishing, Paris.

Myles, G. (2009b), Economic growth and the role of taxation – Aggregate data, OECD Economics Department Working Papers, No. 714, OECD Publishing, Paris.

Myles, G. (2009c), Economic growth and the role of taxation – Disaggregate data, OECD Economics Department Working Papers, No. 715, OECD Publishing, Paris.

NBB (2017), Macro–economische en budgettaire impact van het door het kabinet van de Minister van Financiën gereviseerde taxshiftscenario en vergelijking met de oefening van november 2015, National Bank of Belgium, Note DS.17.07.320-NL.docx.

Pestel, N. and Sommer, E. (2017), Shifting Taxes from labor to consumption: more employment and more inequality, Review of Income and Wealth, Series 63(3), 542–563.

Savage, M. (2017), Integrated modelling of the impact of direct and indirect taxes using complementary datasets, The Economic and Social Review, Vol. 48(2), 171-205.

Sutherland, H. and Figari, F. (2013), EUROMOD: the European Union tax–benefit microsimulation model, International Journal of Microsimulation, Vol. 6(1), 4-26.

Van Soest, A. (1995), Structural models of family labor supply: a discrete choice approach, The Journal of Human Resources, Vol. 30(1), 63–88.

A Online appendix for "Piecemeal modelling of the effects of joint direct and indirect tax reforms"

A.1 Selection of the RURO model subsample

We estimate the labour supply model on a subsample of the Belgian Statistics on Income and Living Conditions (SILC) survey of 2015, 2017 and 2019. This RURO subsample contains all households in which the reference person and, in the case of couples, his or her partner are both available for the labour market. That is, we drop households in which at least one partner is younger than 18 or older than 64 years; at least one partner is an employer or self-employed; or at least one partner is disabled, retired, or studying. Households who declare additional live-in adult members that are also available for the labour market were equally removed, as were same-sex couples. The final subsample consists of 2,063 single females, 1,923 single males, and 2,301 couples. Table A.1 contains the unweighted descriptive statistics for each of these three groups. The model was estimated with real disposable income as explained in Section 2.2. To construct the Divisia price indices, we have imputed income shares from resp. the Household Budget Survey (HBS) 2014, 2016 and 2018 for each household in the SILC data. We utilize the EUROMOD indirect tax tool to disentangle expenditures in consumer prices and quantities for the 2019 data. We extrapolated the 2019 consumer prices to 2015 and 2017 using the detailed information on the evolution of the CPI and its components, published by Statbel. Using these price changes per detailed COICOP category and the imputed income shares, we can construct the Divisia price index, and thus real disposable income expressed in 2019 producer prices, for the input data in the estimation of our model. We use the most detailed level of COICOP categorization if possible, which varies over the different commodity groups.

The simulation of the job choices after the introduction of the joint tax reform is based on the estimated model, using only the SILC of 2019. The unweighted descriptive statistics are shown in Table A.2 The EUROMOD indirect tax tool provides the simulated household specific changes in the Divisia price indices due to the tax reform.

Table A.1: Descriptive statistics RURO subsample for estimation

Description	Singles		Couples	
	Female	Male	Female	Male
Age (years)	43.5	41.8	40.0	42.2
Dependent children (%)				
0 – 3 years	7.7	2.1	23.6	
4 – 6 years	7.6	2.4	18.5	
7 – 9 years	8.4	2.8	19.0	
Experience (years)	23.3	22.0	19.0	21.8
Education (%)				
Low	18.7	21.3	10.5	13.6
Middle	33.2	37.2	28.5	37.1
High	48.1	41.5	61.0	49.3
Residence (%)				
Brussels	23.3	24.3	13.3	
Flanders	43.2	44.8	58.7	
Wallonia	33.5	30.9	28.0	
Participation rate (%)	84.0	84.1	95.5	96.9
Hours worked (hours/week)				
Unconditional	29.3	32.9	31.8	39.1
Conditional on working	34.9	39.1	33.3	40.4
Hourly wage (euro)	21.6	22.8	21.2	23.5
Disposable income (euro/month)				
2015	1,987.8	2,000.3	1,862.0	2,473.1
2017	2,121.2	2,077.0	1,970.0	2,585.2
2019	2,362.1	2,437.0	2,366.4	3,182.8
Number of observations				
2015	638	589	1,136	
2017	651	606	1,096	
2019	774	728	569	

a. Figures represent unweighted means.

Table A.2: Descriptive statistics RURO subsample for simulation

Description	Singles		Couples	
	Female	Male	Female	Male
Age (years)	42.9	41.5	42.0	44.4
Dependent children (%)				
0 – 3 years	9.6	4.8	20.4	
4 – 6 years	9.4	4.3	20.2	
7 – 9 years	7.9	5.4	20.0	
Experience (years)	22.4	21.5	20.3	23.3
Education (%)				
Low	16.5	18.0	4.9	8.6
Middle	30.6	39.7	21.4	30.2
High	52.8	42.3	73.6	61.2
Residence (%)				
Brussels	21.2	22.1	13.0	
Flanders	44.4	44.6	60.1	
Wallonia	34.4	33.2	26.9	
Participation rate (%)	88.1	86.7	97.5	97.9
Hours worked (hours/week)				
Unconditional	31.2	34.2	33.8	40.3
Conditional on working	35.4	39.4	34.7	41.2
Hourly wage (euro)	22.8	24.5	24.1	28.0
Disposable income (euro/month)	2,362.1	2,437.0	2,366.4	3,182.8
Number of observations	774	728	569	

a. Figures represent unweighted means.

A.2 Parameters and elasticities RURO model

Parameter estimates This appendix contains the estimated parameters of the RURO model, which is discussed in Section 2.2 (see Table A.3).

Labour supply elasticities Tables A.4 and A.6 contain the counterparts for RURO models for the wage elasticities in a traditional labour supply model. In RURO models, wages are charateristics of job offers, implying that the labour supply reaction on a person's wage is an ill defined concept. Instead we calculate the effect on job choice and, consequently, hours chosen, of a small displacement of the wage offer distribution to the right (by increasing the estimated location parameters of the log normal wage offer distributions). Table A.4 contains the aggregated effects. Contrary to similar exercises with this model in the past, and to other empirical labour supply models, we obtain quite similar intensive margin elasticities for males and females.

Tables A.5 to A.6 contain the effects split out in quintiles of the observed wages in the baseline. For the individuals that do not work in the baseline, we impute a gross wage based on their observable characteristics and the wage equation used in the EUROMOD framework.

Table A.3: Parameters estimates RURO model

Description	Singles						Couples					
	Female			Male			Female			Male		
	E	S	T	E	S	T	E	S	T	E	S	T
Box-Cox utility function												
constant consumption	2.89	0.20	14.40	2.31	0.15	14.75	3.64	0.35	7.65	3.64	0.35	7.65
exponent consumption	0.35	0.08	3.26	0.43	0.06	6.31	0.48	0.06	1.40	0.48	0.06	1.40
exponent leisure	-7.43	0.59	-12.58	-8.59	1.05	-8.28	-10.53	0.77	9.91	-10.19	1.22	-13.90
interaction leisure	·	·	·	·	·	·	0.02	0.01	-20.07	0.02	0.01	-20.07
Leisure covariates												
constant	46.85	13.77	3.51	15.82	8.03	1.90	11.93	6.71	1.77	12.89	7.42	1.70
log(age)	-25.27	7.49	-3.47	-8.44	4.35	-1.87	-6.18	3.65	-1.68	-7.13	4.07	-1.72
$\log(\text{age})^2$	3.50	1.03	3.49	1.16	0.60	1.87	0.87	0.50	1.72	1.00	0.56	1.73
child 0-3	0.36	0.19	1.72	·	·	·	0.16	0.07	2.37	0.06	0.03	1.68
child 4-6	0.29	0.17	1.57	-0.03	0.12	-0.22	0.09	0.05	1.67	0.04	0.03	1.12
child 7-9	0.10	0.13	0.64	0.08	0.14	0.51	0.04	0.05	0.78	0.03	0.03	1.10
Brussels	0.11	0.11	1.06	0.12	0.07	1.62	-0.05	0.06	-0.79	0.15	0.07	1.91
Wallonia	0.42	0.13	3.19	0.13	0.08	1.72	0.11	0.06	1.74	0.01	0.02	0.43
low education	0.12	0.20	0.68	0.16	0.10	1.52	0.20	0.17	1.14	0.05	0.05	0.96
high education	-0.59	0.14	-4.48	-0.16	0.07	-2.17	-0.50	0.11	-4.23	0.02	0.02	0.85
Wage rate covariates												
constant	2.42	0.03	94.35	2.51	0.03	98.57	2.42	0.03	94.35	2.51	0.03	98.57
potential experience	2.43	0.21	11.76	2.16	0.22	10.12	2.43	0.21	11.76	2.16	0.22	10.12
potential experience^2	-3.49	0.46	-7.73	-2.56	0.47	-5.55	-3.49	0.46	-7.73	-2.56	0.47	-5.55
low education	-0.11	0.02	-5.68	-0.12	0.02	-6.33	-0.11	0.02	-5.68	-0.12	0.02	-6.33
high education	0.28	0.01	20.69	0.27	0.01	21.53	0.28	0.01	20.69	0.27	0.01	21.53
RMSE	0.29	0.00	77.95	0.29	0.00	77.51	0.29	0.00	77.95	0.29	0.00	77.51
year 2015	-0.11	0.01	-12.29	-0.11	0.01	-12.29	-0.11	0.01	-12.29	-0.11	0.01	-12.29
year 2017	-0.07	0.01	-7.80	-0.07	0.01	-7.80	-0.07	0.01	-7.80	-0.07	0.01	-7.80
Opportunities covariates												
constant	-2.82	0.19	-14.90	-3.74	0.19	-20.07	-2.82	0.19	-14.90	-3.74	0.19	-20.07
unemployment rate	0.84	1.64	0.52	1.17	1.46	0.77	0.84	1.64	0.52	1.17	1.46	0.77
Brussels	-1.39	0.17	-8.10	-1.01	0.17	-5.91	-1.39	0.17	-8.10	-1.01	0.17	-5.91
Wallonia	-0.91	0.16	-5.72	-0.61	0.16	-3.81	-0.91	0.16	-5.72	-0.61	0.16	-3.81
low education	-0.59	0.20	-2.91	-0.95	0.21	-4.56	-0.59	0.20	-2.91	-0.95	0.21	-4.56
high education	0.71	0.18	3.97	0.43	0.18	2.40	0.71	0.18	3.97	0.43	0.18	2.40
Hours peaks												
interval [18.5; 20.5]	1.52	0.08	17.80	0.57	0.15	3.71	1.52	0.08	17.80	0.57	0.15	3.71
interval [29.5; 30.5]	1.76	0.09	19.69	1.21	0.12	9.74	1.76	0.09	19.69	1.21	0.12	9.74
interval [37.5; 40.5]	2.12	0.05	39.16	2.59	0.05	49.50	2.12	0.05	39.16	2.59	0.05	49.50

a. E: Estimate S: Standard error T: *t*-value

Table A.4: Aggregate wage elasticities of labour supply

	Shift of the female wage distribution			Shift of the male wage distribution		
	Single	Couple		Single	Couple	
	Female	Female	Male	Male	Female	Male
elasticity: total	0.19	0.13	-0.09	0.23	-0.10	0.11
elasticity: intensive margin	0.04	0.10	-0.05	0.04	-0.06	0.07
part in (% pts)	1.40	0.30	0.00	1.70	0.10	0.50
part out (% pts)	0.00	0.00	0.50	0.00	0.50	0.00

a. These results are obtained by increasing the first moment of the distribution of offered wages by 10%.

Table A.5: Total elasticities by wage quintile

	Shift of the female wage distribution			Shift of the male wage distribution		
	Single	Couple		Single	Couple	
	Female	Female	Male	Male	Female	Male
Q1	0.14	0.17	-0.12	0.19	-0.15	0.07
Q2	0.23	0.14	-0.12	0.21	-0.14	0.11
Q3	0.21	0.15	-0.08	0.15	-0.09	0.18
Q4	0.16	0.12	-0.10	0.31	-0.04	0.09
Q5	0.20	0.10	-0.07	0.22	-0.07	0.11

a. These results are obtained by increasing the first moment of the distribution of offered wages by 10%.
b. Quintiles are based on observed wages in the baseline. Wages for non-working individuals are imputed based on observable characteristics.

Table A.6: Intensive margin elasticities by wage quintile

	Shift of the female wage distribution			Shift of the male wage distribution		
	Single	Couple		Single	Couple	
	Female	Female	Male	Male	Female	Male
Q1	0.06	0.15	-0.04	0.01	-0.07	0.03
Q2	0.02	0.10	-0.06	0.05	-0.08	0.07
Q3	0.03	0.10	-0.04	0.04	-0.07	0.08
Q4	0.05	0.10	-0.05	0.04	-0.03	0.06
Q5	0.05	0.07	-0.04	0.04	-0.05	0.08

a. These results are obtained by increasing the first moment of the distribution of offered wages by 10%.
b. Quintiles are based on observed wages in the baseline. Wages for non-working individuals are imputed based on observable characteristics.

A.2.1 Model fit

Figures 1 to 3 display the in–sample predictions for hours worked, wages, and consumption.[28] The fit of hours worked is rather good, except for singles whose full–time employment is underpredicted. The wage rates of single females are simulated more accurately than those of other groups, which are a slightly too low for single males and couples. The fit of consumption is acceptable, with small deviations around the modus of each distribution, and an underestimation of the density for single males.

[28] In contrast to our policy simulations, we do not calibrate households' baseline choices to assess the in–sample fit, as this procedure would always entail a perfect correspondence with the data (see also Section A.3).

Moreover, one might argue that simulating behavioural transitions — as we do in our policy simulations — is more robust to model misfit than these uncalibrated in–sample predictions (see Section A.3).

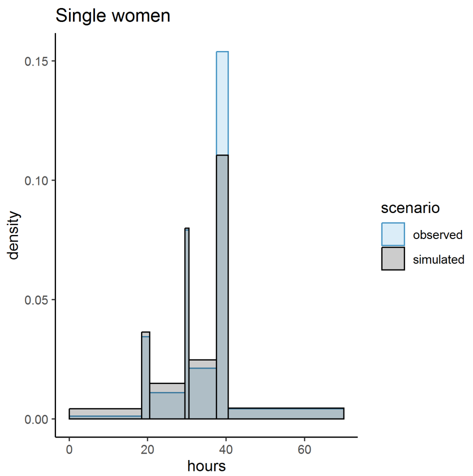
A.3 Simulation procedure

To simulate households' behavioural responses to a tax reform, we make use of the calibration procedure proposed by Duncan and Weeks (2000). This simulation method accounts for both the randomness in the unobserved term of the utility function and the transitional dependence on the observed baseline alternative. Intuitively, this dependence is implied by the modelling assumption that the unobserved terms are left unaltered by the tax reforms under consideration. The procedure is essentially a Monte Carlo approximation and consists of the following three steps:

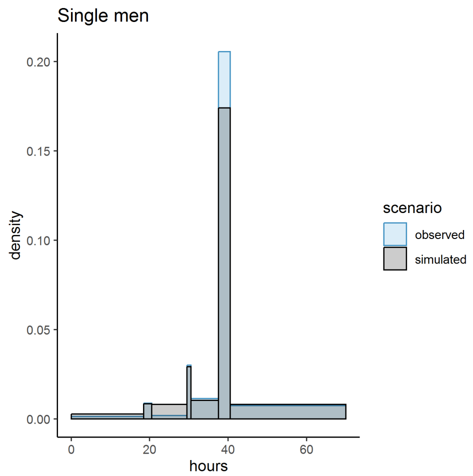
1. *Calibration*: We draw K distinct vectors of random terms from the Extreme Value Type I distribution, such that the observed alternative is optimal for each household. To avoid the heavy computational burden a brute force search would entail, we draw the random terms from conditional choice distributions, similar to Bourguignon, Fournier and Gurgand (2001).

2. *Calculation*: We calculate the effects of a tax reform for each vector of random terms. This yields K different statistics, S_k, of budgetary or distributional effects, as households may find different alternatives optimal after the reform, depending on the specific realisation of the random terms.

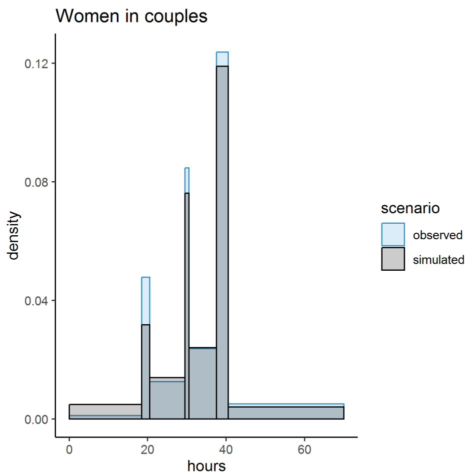
3. *Averaging*: We obtain a point estimate for each statistic of interest, S, by calculating the average across these K simulations: $S = \sum_{k=1}^{K} S_k/K$.



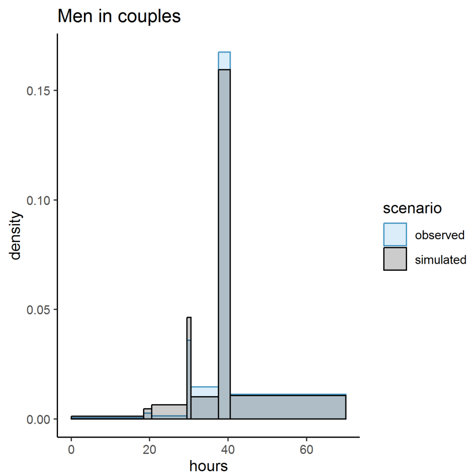
(a) Single females



(b) Single males

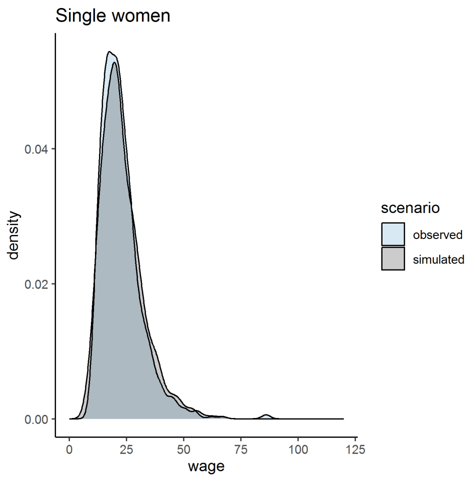


(c) Females in couples

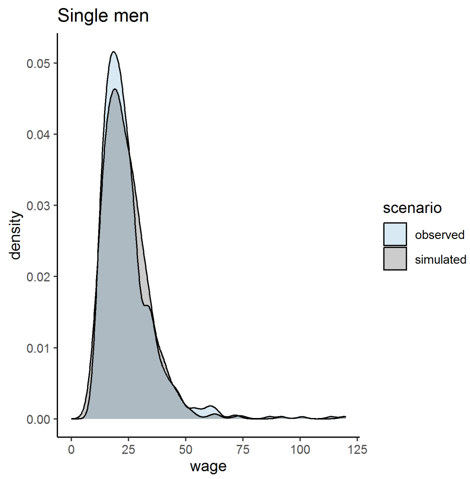


(d) Males in couples

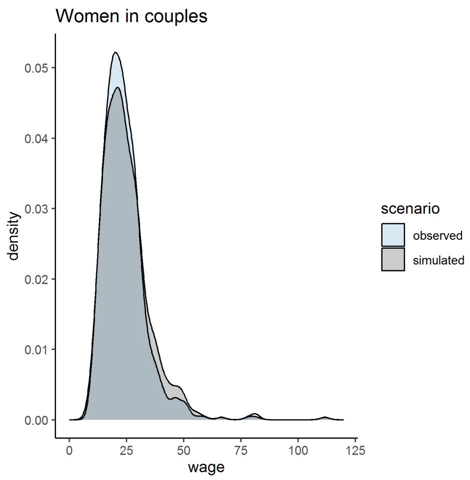
Figure 1: Fit of hours worked (hours/week)



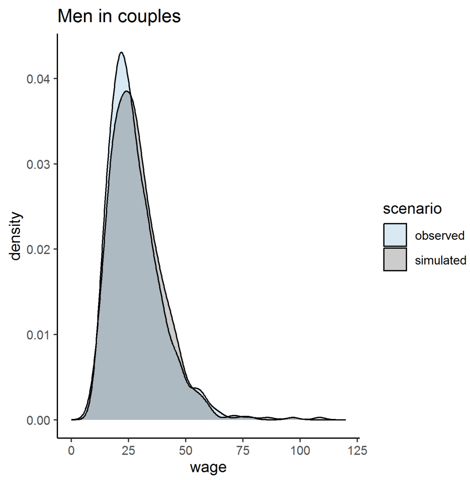
(a) Single females



(b) Single males

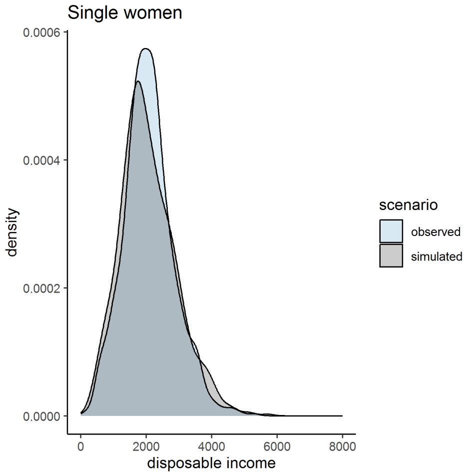


(c) Females in couples

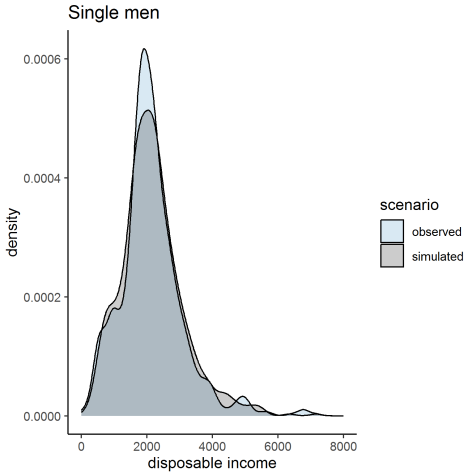


(d) Males in couples

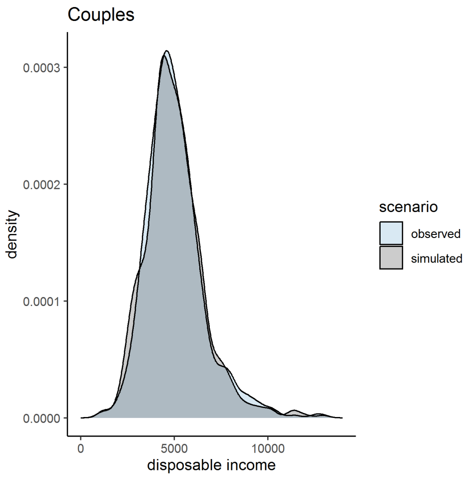
Figure 2: Fit of wage rates (euro/hour)



(a) Single females



(b) Single males



(c) Couples

Figure 3: Fit of consumption (log consumption)

A.4 Additional results

Tables A.7, A.8 and A.9 show the labour market effects of the simulated reform. The tables are based on the population of individuals included in the job choice model. They are the counterpart of resp. Table 2, 3, and 4. Whereas in those tables quintiles were based on observed wages, here the ordering of individuals is determined by equivalised disposable income of the household the person belongs to. The allocation to quintiles is based on the entire population (not only the RURO subpopulation), and quintiles thus correspond to the quintiles in Table 5.

Table A.7: Labour market effects due to changes in the net wage across quintiles of equivalised disposable income

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	hrs/wk	%	hrs/wk	%	€/hour	%	€/month	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	33.02	0.69	8	3.86	24	0.16	16	-0.19	1,589	0.02
Q2	93.29	-0.02	34	0.01	36	-0.02	18	-0.06	2,725	-0.05
Q3	98.29	0.01	36	0.05	37	0.04	21	-0.08	3,300	-0.06
Q4	99.67	0.00	37	0.00	37	0.00	24	-0.14	3,814	-0.14
Q5	100.00	-0.05	40	-0.10	40	-0.10	31	-0.27	5,447	-0.31
all	91.70	0.06	34	0.07	37	-0.02	24	-0.17	3,931	-0.18

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation of the RURO model.
b. For all columns we keep the allocation of individuals across quintiles fixed, i.e. the quintiles are always based on all individuals, both working and non–working in the baseline.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *direct* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *direct* tax reform relative to the baseline values. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.

Table A.8: Total labour market effects due to changes in prices across quintiles of equivalised disposable income

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	h/wk	%	h/wk	%	€/h	%	€/mo	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	33.02	-0.12	8	-0.55	24	-0.06	16	-0.19	1,589	-0.16
Q2	93.29	-0.02	34	-0.02	36	-0.03	18	-0.06	2,725	-0.05
Q3	98.29	-0.02	36	-0.02	37	-0.01	21	-0.05	3,300	-0.04
Q4	99.67	0.00	37	0.01	37	0.00	24	-0.06	3,814	-0.06
Q5	100.00	-0.03	40	-0.04	40	-0.04	31	-0.11	5,447	-0.11
all	91.70	-0.03	34	-0.03	37	-0.02	24	-0.08	3,931	-0.08

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row.
b. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation in the EUROMOD framework. We keep the allocation of individuals across quintiles fixed.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *indirect* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *indirect* tax reform relative to the baseline value. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.

Table A.9: Total labour market effects across quintiles of equivalised disposable income

	whole RURO subpopulation				RURO subpopulation working in baseline					
	participation		labour supply		labour supply		gross wage		earnings	
	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ	basel.	Δ
	%	% pts	h/wk	%	h/wk	%	€/h	%	€/mo	%
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Q1	33.02	0.58	8	3.31	24	0.11	16	-0.37	1589	-0.14
Q2	93.29	-0.04	34	-0.01	36	-0.05	18	-0.12	2725	-0.10
Q3	98.29	-0.01	36	0.03	37	0.02	21	-0.12	3300	-0.10
Q4	99.67	0.00	37	0.00	37	0.00	24	-0.20	3814	-0.20
Q5	100.00	-0.08	40	-0.14	40	-0.14	31	-0.38	5447	-0.42
all	91.70	0.03	34	0.04	37	-0.05	24	-0.25	3931	-0.26

a. The variables are calculated at the individual level for the two subpopulations mentioned in the top row.
b. Each individual is allocated to the quintile based on his or her gross wage (with an equal number of persons by quintile). The non–working individuals are assigned a gross wage based on the estimated wage equation in the EUROMOD framework. We keep the allocation of individuals across quintiles fixed.
c. 'Participation' in column (1) is calculated as the ratio of the number of persons working in the baseline to the total population of individuals included for analysis in the RURO model. The average number of hours worked per week in column (3) is also calculated for the whole RURO subpopulation, irrespective of whether the individual was working in the baseline or not. Columns (5), (7), and (9) are averages for the RURO subpopulation of individuals who are working in the baseline.
d. Column (2) shows the percentage points change of participation due to *joint* tax reform, while columns (4), (6), (8) and (10) show the percentage change due to the *joint* tax reform relative to the baseline values. Percentage change is calculated on the level of the quintile. We show the percentage change in averages, not the average of percentage change on the individual level.