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PROGRESSIVE CONSUMPTION TAX REFORMS

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Progressive consumption tax reforms

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Abstract

We study the effects of tax reforms in a heterogeneous agent overlapping generations life cycle model with idiosyncratic risk in capital and labour income and a rich tax system. The model replicates empirical joint distributions of income, wealth and tax payments well. In an economy with highly progressive income taxes, a revenue-neutral shift of the tax burden from income to consumption taxes increases saving and output, while also reducing inequality. It particularly benefits those with low wealth relative to income. It tends to harm retirees, who have high wealth relative to income. In contrast, an increase in the progressivity of income taxes also reduces inequality, but implies lower saving and output.

Nous étudions les effets de plusieurs réformes fiscales à l'aide d'un modèle de cycle de vie avec générations chevauchantes. Le modèle décrit des agents hétérogènes qui confrontent des risques idiosyncratiques pour leurs revenus du travail et du capital, dans un environnement avec un système fiscal progressif complexe. Le modèle réplique fidèlement les distributions empiriques conjointes du revenu, de la richesse et des paiements de taxes et d'impôts. Dans ce contexte, un déplacement du fardeau fiscal à effet neutre sur les revenus publics vers les taxes à la consommation augmente l'épargne et la production tout en réduisant les inégalités. Cette politique est avantageuse particulièrement pour les individus disposant d'un faible niveau de richesse par rapport à leur revenu, mais tend à nuire aux personnes retraitées en raison du niveau élevé de leur richesse par rapport à leurs revenus. En revanche, une hausse de la progressivité de l'impôt sur le revenu des particuliers réduit aussi les inégalités, mais génère une épargne et une production plus faible.

Keywords: Tax reforms, labor income, capital income, progressive tax system, consumption tax / Réformes fiscales, revenus du travail, revenus du capital, système fisca progressif, taxe à la consommation

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1 Introduction

Debates on tax reform are currently very active, with particular focus on the taxation of top income and wealth groups. This is the case across countries, to wit the latest US presidential election and recent policy changes, as well as debates in European countries like France and Germany, among others. In Canada, several provinces have recently raised top income tax rates (Smart 2019). In Québec, a commission of experts recently published a six-volume report with recommendations for tax reform (Godbout, Ades-Landy, Michaud, Milette, St-Maurice, Vidal, Villeneuve and Vincent 2015).

Inspired by these recent debates and proposals, this paper studies several revenue-neutral tax reforms. We particularly focus on a set of reforms that shift the tax burden from personal income taxes to consumption taxes. These are modelled as an increase in the sales tax rate, combined with reductions in income taxes that take a variety of forms. For comparison, we also study the effects of an increase in the progressivity of the personal income tax system, including an increase in the maximum effective marginal tax rate.

Proposals that recommend shifting the tax burden to consumption taxes have a long and distinguished history, see e.g. the Meade report in the UK (Meade 1978), Hall and Rabushka's (1983) flat tax, Bradford's (2013) X tax, as well as the recent report by Godbout et al. (2015). The motivation for these proposals typically is on efficiency grounds, since consumption taxes, unlike personal income taxes that hit capital income, do not discourage saving and capital accumulation. However, despite prominent endorsements of consumption taxes on grounds of both fairness and efficiency (Fisher and Fisher (1942), Kaldor (1955)), they are often thought to be regressive, since poorer households consume a larger fraction of their income (Huggett and Ventura 2000, Dynan, Skinner and Zeldes 2004). And indeed, early quantitative work suggested that the efficiency gains they induce come at a cost of increased inequality, at least for the case of transitions to fully flat tax systems (Ventura 1999, Altig, Auerbach, Koltikoff, Smetters and Walliser 2001, Nishiyama and Smetters 2005).[1] Yet, it is also known that consumption taxes have features of a capital levy (Auerbach and Kotlikoff 1987, Coleman 2000),[2] and can reduce inequality in economies with high levels of wealth inequality, as shown by Correia (2010) in a model economy with an exogenously given distribution of wealth.

It is clear from these conflicting results and arguments that an analysis of a shift towards consumption taxes has to be conducted in a framework with realistic levels of inequality, and with realistic *joint* distributions of

[1] Ventura (1999) analyzes a shift to a flat tax system with a constant marginal tax rate of 20% above an exemption. While this is a progressive system, it has a very low top marginal tax rate compare to typical progressive systems in place. Adopting it raises inequality. Nishiyama and Smetters (2005) similarly analyze a shift to a flat tax system. Adopting it reduces insurance so much as to reduce overall welfare. Conesa, Li and Li (2020) find that a complete switch from income to consumption taxes increases inequality and reduces welfare even if basic goods and other goods are taxed at different rates. Altig et al. (2001) analyze several reforms and find that flat tax reforms harm the poorest, whereas the "X tax", which has a progressive wage tax schedule, does not.

[2] Auerbach (1985) notes that in the presence of an inelastically supplied factor, an equal proportional tax on all commodities replicates a lump-sum tax. In a dynamic setting, the economy's initial capital stock is such an inelastically supplied factor (Auerbach and Kotlikoff 1987, Coleman 2000).

the relevant variables: namely wealth, income, and tax payments. Moreover, the framework needs to permit households to react to tax changes, since income and wealth are endogenous variables that are determined by household choices. This paper performs exactly this analysis, and takes the literature a step further by evaluating the effects of a shift toward consumption taxes in a model economy with rich heterogeneity and realistic, endogenous joint distributions of income, wealth, and tax payments.

We contrast the shift to consumption taxes with a reform that increases tax progressivity in a more conventional way: via higher progressivity of the income tax system. We model this as lower marginal tax rates at low income levels, and higher rates at high levels, including an increase in the top effective marginal rate. Such reforms have been studied in a variety of settings, like incomplete-markets economies with overlapping generations (Conesa and Krueger 2006), with dynastic households (Bakis, Kaymak and Poschke 2015), or with partial insurance and without capital (Heathcote, Storesletten and Violante 2014*a*). Other work focusses on optimal taxes at the top (Huggett and Badel 2014, Kindermann and Krueger 2014) or flat tax reforms (e.g. Erosa and Koreshkova (2007)). To our knowledge, our analysis is the first to consider variation in the progressivity of the entire personal income tax system, and not just the top marginal rate, in a setting that accurately replicates the very high levels of concentration of income and wealth and their joint distribution.

We study the two types of tax reform in a rich heterogeneous-agent life-cycle equilibrium model based on Kaymak, Leung and Poschke (2021). The model is geared to replicating the joint distribution of income and wealth, and the very high levels of concentration of these variables. It allows simulating how individual behaviour, distributions, and aggregate outcomes react to changes in the tax system. Model agents differ in age, wealth, wages, and returns to their investments. As a result, the model generates realistic joint distributions of income, wealth, and tax payments. This distributional realism is important for two reasons. An obvious and important advantage is that it allows studying not only aggregate, but also distributional implications of tax reforms. Beyond this, distributional features can affect aggregate implications of tax reforms and determine the nature of desirable reforms (Correia 2010, Davila, Hong, Krusell and Ríos-Rull 2012). Given the important role in our findings described below for inequality not only in income, but also in wealth, it is particularly important for the model economy to match the highly concentrated wealth distribution. The model economy generates a high concentration of wealth via a combination of three channels, namely high concentration of earnings, heterogeneity in investment returns, and bequests.[3]

The model economy also features a detailed tax and transfer system. There is a progressive tax on personal income, as well as taxes on corporate income and consumption. Working agents make contributions to a public pension system, and retirees receive benefits. In addition, all agents receive a flat transfer representing public

[3]See Kaymak, Leung and Poschke (2021) for details. These three channels have been proposed as dominant potential contributors to wealth inequality, see Castañeda, Díaz-Giménez and Ríos-Rull (2003), Benhabib, Bisin and Zhu (2011), Gabaix, Lasry, Lions and Moll (2016), Galor and Zeira (1993) and De Nardi (2004). See also Huggett (1996).

services.

We simulate the two tax reforms in a model economy calibrated to the Québec economy.[4] This economy features significant levels of inequality in labour earnings, income and wealth, with a level of income inequality close to those in continental European economies, but below those in the US, the UK, or Canada, and a level of wealth inequality comparable to that in Canada, but below that in the US.[5] The existing Québec tax and transfer system is progressive and features significant redistribution, with average effective income tax rates increasing from about 10% for the bottom half of the income distribution to almost 37% for the top 1%.[6] We think that the structural similarity of this economy to many others makes results from our analysis informative for other economies, too, in particular for those with similarly progressive income tax systems and levels of inequality.

The main finding of our analysis is that a shift of the tax burden from personal income to consumption taxes increases aggregate saving, labor supply, output and consumption.[7] Importantly, inequality of income and wealth declines. This stands in sharp contrast to the oft-voiced concern, cited above, that consumption taxes are regressive. Here, they are progressive, since they shift the tax burden towards households who hold a lot of wealth relative to income. As a result, the tax reform increases disposable income for all the age, income and wealth groups we consider, with the exception of the wealthiest 1%. Disposable income rises by more than the increase in consumption taxes (thus increasing potential consumption) for all working-age groups, with the exception of the top 1% of the distributions of income or wealth. It also rises by less than the tax increase for retirees, who have high wealth relative to income. Since the reform raises overall output and consumption, and also benefits the welfare-poor, it improves both equity and efficiency. It does, however, harm retirees, since they benefit little from lower income taxes.

We also show that consequences of the tax reform depend on how exactly income taxes are reduced. We consider several scenarios. Aggregate gains are largest when all marginal tax rates are cut proportionally – the least progressive scenario we consider. Inequality declines most, and welfare rises most, when marginal tax rates are reduced more for low incomes. (Reducing consumption tax revenue to fund a universal transfer does not clearly reduce inequality, and generates welfare losses.)

While the most favoured reform we model would only have the support of around half of the population alive (in addition to all future generations), we think that tweaked versions of it could receive stronger support. In particular, compensating retirees for their losses could make the reforms much more attractive. We briefly show that two reforms that do this do indeed receive larger support, but at a cost in terms of gains to the young

[4] Throughout, we also discuss results for similar reforms in a model economy calibrated to the Canadian economy.

[5] See Leung and Poschke (2021) for details and a comparative analysis of the sources of wealth inequality in these economies.

[6] Data source: Statistics Canada Table 11-10-0055-01 on high income tax filers. This top rate compares to a statutory top marginal tax rate of over 50%.

[7] The main scenario we analyze is an increase in the effective sales tax rate by half, from 10.2% to 15%. (From 9.3% to 13.7% for the Canadian calibration.) For comparison, the average statutory VAT or sales tax rate in the OECD in 2020 was 19.2% (OECD 2020). This is coupled with a reduction in marginal income tax rates for all households.

and future generations. Due to the complexity of this problem, which features several additional policy levers, we leave a more detailed analysis to future research.

More progressive income taxes also reduce inequality, but at a substantial cost in terms of aggregate output and consumption, due to reduced saving and labour supply. As a consequence, aggregate welfare declines.

Overall, the welfare effects of increased income tax progressivity are inferior to those of a shift towards consumption taxes.[8] While both reforms affect the distributions of income and wealth in similar ways, the latter improves economic efficiency, while the former reduces it. Another important difference between the two reforms is in the incidence of changes in the tax burden. In both cases, the progressivity of the overall tax burden increases. However, while more progressive income taxes raise the tax burden for high income earners, a shift to consumption taxes shifts the burden to people with high wealth to income ratios, and reduces the burden for those with high income relative to wealth. This encourages saving and work.

Note that our analysis focusses on long-run consequences of tax reforms. That is, it ignores transitional dynamics, for reasons of computational tractability. Since the shift of the tax burden to consumption taxes increases consumption not only at the post-reform stationary distribution, but also in partial equilibrium or when aggregating using the pre-reform distribution, it appears likely that the reform will also have favourable effects along the transition. We leave a full investigation of the transition to future research.

The paper is structured as follows. Section 2 presents the model. Section 3 presents the calibration of the model, and Section 4 compares its fit to the data. Section 5 presents the results of the two tax reforms. Section 6 concludes and discusses avenues for future research.

2 Model

For the analysis, we employ an overlapping generations life cycle model with idiosyncratic risk in capital and in labour income. Apart from institutional details, the model is very close to that used by Kaymak, Leung and Poschke (2021) in an analysis of the US economy, and the following description follows theirs closely. The model economy features heterogeneity in individual age, wealth, labour productivity, and investment returns, as well as a detailed tax and transfer system. The rich heterogeneity in the model implies that the model allows for heterogeneous reactions to tax reforms. As a result, changes in the tax system have both aggregate and distributional consequences.

[8] Naturally, the welfare effects of other interventions with redistributive effects, like changes in transfers, could be different.

2.1 Household problem

Model details are as follows. Each period, a continuum of agents enter the economy, with a potential life-span of J periods, subject to survival probabilities $s(j)$ for each age j. The fraction of age group j in the total population is denoted by μ_j, with $\mu_{j+1} = s(j)\mu_j$. Total population is normalized to one: $\sum_{j=1}^{J} \mu_j = 1$.

Agents work for the first $J(r)$ periods of their lives, after which they retire. Workers earn income on their labour and on their savings. A worker's labour endowment is given by $z\varepsilon_j$, where z is a stochastic component following a first-order Markov process $F_z(z'|z)$, and ε_j is a deterministic component that captures age-dependent movements in skills, such as work experience. With this endowment, a worker generates a labour income of $wz\varepsilon_j h$, where w is the market wage per skill unit, and $h \in [0, 1]$ is hours worked chosen by the worker. Income on savings is denoted by $r\kappa k$, where k denotes assets, r is a market rate of return determined in equilibrium, and κ is an idiosyncratic rate of return shifter that follows a Markov process defined by $F_\kappa(\kappa'|\kappa)$. Once retired, agents collect a pension, $b(z)$, and continue to earn income on their assets. Total income is denoted by y.

All income is subject to taxation. The tax system distinguishes between different sources of income and features pensions and other transfers. Disposable income after all taxes and transfers is denoted by y^d. Consumption is subject to sales tax at a rate τ_s. The government uses the tax revenue to finance an exogenously given level of expenditures, G, pension payments, and other transfers. The government's budget is balanced at all times. Details of the tax and transfer system are outlined in Section 3.1.

Agents value consumption, leisure and assets they leave for their offspring. The problem of an agent is to choose labour supply, consumption, savings and bequests to maximize the expected present value of lifetime utility. At each period j, agents are informed of their labour endowment for the period, $z\varepsilon_j$, and their rate of return on assets, κ, prior to taking their decisions. Future utility is discounted with a constant factor $\beta \in (0, 1)$. Formally, the Bellman equation for a worker's problem is

$$V(j, k, z, \kappa) = \max_{c,k' \geq 0, h \in [0,1]} \left\{ \frac{c^{1-\sigma_c}}{1-\sigma_c} - \theta \frac{h^{1+\sigma_l}}{1+\sigma_l} + \beta s(j) \mathbb{E}[V(j+1, k', z', \kappa')|z, \kappa] + (1 - s(j))\phi(k') \right\}$$

subject to

$$(1 + \tau_s)c + k' = y^d(zw\varepsilon_j h, r\kappa k) + k,$$

where $\phi(k) = \phi_1 \left[(k + \phi_2)^{1-\sigma_c} - 1\right]$ is the utility value of bequeathed assets. The expectation is taken over the future values of labour endowment, z' and the rate of return on assets, κ', given the processes F_z and F_κ. We assume that the two processes are independent of each other.

Since retirees do not work, the Bellman equation for a retiree's problem is given by

$$V(j,k,\kappa) = \max_{c,k' \geq 0} \left\{ \frac{c^{1-\sigma_c}}{1-\sigma_c} + \beta s(j) \mathbb{E}[V(j+1,k',\kappa')|\kappa] + (1-s(j))\phi(k') \right\}$$

subject to

$$(1+\tau_s)c + k' = y^d(b(z), r\kappa k) + k$$

The consumption goods are produced by a representative firm using aggregate capital K and total effective labour N. Output is given by a Cobb-Douglas production function: $Y = F(K,N) = \Psi K^{\alpha} N^{1-\alpha}$.

2.2 Equilibrium

We analyze a stationary competitive equilibrium of the model economy. In short, this is a situation in which households and firms behave optimally given prices and the information they have, markets clear, and aggregate variables, including distributions of income and wealth, do not change over time.

A detailed definition of equilibrium is as follows. Let $s = \{j,k,z,\kappa\} \in S$ be a generic state vector. The stationary equilibrium of the economy is given by a consumption function $c(s)$, a savings function $k'(s)$, labour supply $h(s)$, a value function $V(s)$, a wage rate $w(s)$ and a distribution of agents over the state space $\Gamma_j(s)$, such that

1. The functions $V(s)$, $c(s)$, $k'(s)$ and $h(s)$ solve the consumers' problems.

2. Firms maximize profits.

3. Factor markets clear:

$$\begin{aligned} K &= \int k'(j,k,z,\kappa) d\Gamma_{j<J_r}(j,k,z,\kappa) + \int k'(j,k,\kappa) d\Gamma_{j \geq J_r}(j,k,\kappa) \\ N &= \int z\varepsilon_j h(j,k,z,\kappa) d\Gamma_{j<J_r}(j,k,z,\kappa) \end{aligned}$$

4. The government's budget is balanced:

$$\begin{aligned} G + b(z) \int d\Gamma_{j \geq J_r}(j,k,\kappa) &= \tau_s \left[\int c(j,k,z,\kappa) d\Gamma_{j<J_r}(j,k,z,\kappa) + \int c(j,k,\kappa) d\Gamma_{j \geq J_r}(j,k,\kappa) \right] \\ &\quad + \int [y - y^d(zw\varepsilon_j h, r\kappa k)] d\Gamma_{j<J_r}(j,k,z,\kappa) + \int [y - y^d(b, r\kappa k)] d\Gamma_{j \geq J_r}(j,k,\kappa) \end{aligned}$$

5. $\Gamma_j(s)$ is consistent with the policy functions, and is stationary.

3 Calibration: Tax system, functional forms and parameters

We calibrate the model to the Québec economy and, for purposes of comparison, to the Canadian economy (including Québec). This requires choosing functional forms for the model objects described in the previous section, as well as parameters. This section describes our strategy for this. The next section describes the fit of the calibrated model as well as selected core parameter values.

Following the standard approach in quantitative economics, we first choose functional forms and parameter values that can be determined based on information outside the model. We then calibrate the remaining parameters so that, in equilibrium, the model economy is consistent with key relevant features of the Québec (Canadian) economy, in particular the tax and transfer system and the empirical joint distributions of earnings, wealth and income.

While this approach is standard, it is worth pointing out two particularities.[9] First, in the spirit of Castañeda, Díaz-Giménez and Ríos-Rull (2003), Kindermann and Krueger (2014) and Kaymak and Poschke (2016), we allow for the possibility that some households reach an extraordinarily high labour productivity level. This allows the model to match the highly skewed empirical distribution of income, and also generates strong concentration of wealth. Further, in the spirit of Benhabib Benhabib, Bisin and Luo (2015), we allow for investment rates of return to vary across households, with some households earning an extraordinarily high rate of return. The combination of these two features allows the model to closely approximate the empirical concentration of wealth.

The second particularity is empirical: we differ from earlier studies, with the exception of Kaymak et al. (2021) and Leung and Poschke (2021), in our explicit use of the joint distribution of income and wealth (as opposed to only the marginal distributions of income and wealth separately) in identifying model parameters. This is important in the analysis of taxes. The reason is that Kaymak et al. (2021) show that it is possible to match given marginal distributions with different parameterizations, which imply different roles for capital and labour income at the top of the distribution. As a result, these different parameterizations have different implications for the consequences of changes in different types of taxes. Information from the joint distribution of income and wealth allows us to correctly identify the importance of capital and labour income across the distribution of income, which is crucial for a plausible assessment of the effects of tax changes.

Our strategy in terms of data sources is to use recent data, while averaging over a substantial number of years to reduce the influence of cyclical fluctuations. To avoid the influence of the Great Recession and the Covid-19 recession, we typically use 2010 to 2017 averages.[10] In terms of taxes, this implies that the model does not exactly replicate the tax system of a single year (nor does it take into account future changes already in law), but is representative of a typical recent year. This is in line with our focus on long-run equilibria.

[9] These carry over from the similar approach in Kaymak et al. (2021).

[10] We mostly use data reported by Statistics Canada. Details and exceptions are noted in the following.

3.1 Tax and transfer system

Given the complexity of real-world tax systems, a tax system in a model can only be a simplification. Our strategy is to choose a system that is simple, but captures the two salient, relevant features of the tax and transfer systems in Québec and Canada: i) there are different types of taxes, on different types of income/economic activity, and ii) the personal income tax and pension systems are progressive. All tax rates used in the analysis are effective rates.

The model tax system thus consists of progressive personal income taxes levied on capital and labour earnings, corporate income taxes, and a sales tax. The model also features a pension system mimicking the Québec/Canada Pension Plan (CQPP). Tax receipts are used to support exogenous government expenditures, transfers to households, and pensions.

Total disposable income y^d is obtained after applying corporate and personal income taxes to taxable income, and adding lump-sum government transfers and the CQPP contribution credit:

$$y^d = \lambda \min\{y_b, y_f\}^{1-\tau} + (1-\tau_{\max}) \max\{0, y_f - y_b\} + (1-\tau_c) \max(r\kappa k - d_c, 0) + \text{CQPP tax credit} + Tr \tag{1}$$

Taxable income y_f consists of labour earnings net of pension contributions, non-corporate capital income, and pension income, if any. It is given by:

$$\begin{aligned} y_f &= zw\varepsilon_j h + \min\{r\kappa k, d_c\} - \text{CQPP contribution} && \forall j < J_r \text{ (working age)} \\ y_f &= b(z) + \min\{r\kappa k, d_c\} && \forall j \geq J_r \text{ (retirees)} \end{aligned}$$

We discuss each component in turn.

The first two terms in equation (1) represent our formulation of the income tax system, which can be approximated by a log-linear form for income levels outside the top of the income distribution, augmented by a flat rate for the top income tax bracket. In our setting, this way of modeling income taxes is advantageous, since the progressivity of the tax system is controlled by a single parameter, τ, and is therefore easy and transparent to change in simulations of potential tax reforms. Moreover, this modeling device fits the effective income tax system well (Bénabou 2002, Heathcote, Storesletten and Violante 2014*b*). The power parameter $0 \leq \tau \leq 1$ controls the degree of progressivity of the tax system, while λ adjusts to meet the government's budget requirement. $\tau = 0$ implies a proportional (or flat) tax system. When $\tau = 1$, all income is pooled, and redistributed equally among agents. For values of τ between zero and one, the tax system is progressive.[11]

[11] The average income tax rate is $1 - \lambda y^{-\tau}$, which increases in y if $\tau > 0$.

When disposable income is log-linear in pre-tax income, the marginal tax rate increases monotonically with income, converging to 100% at the limit. The second term in the maximum operator avoids this feature by imposing a cap on the top marginal tax rate, denoted by $\tau_{\max}$. y_b denotes the critical level of taxable income at which the top marginal tax rate is reached: $\lambda(1-\tau)y_b^{-\tau} = 1 - \tau_{\max}$. We set the top marginal tax rate to 40% in both calibrations. This rate delivers top effective average tax rates close to the data. It is below the statutory top marginal tax rate, indicating that our effective top rate captures deductions available in the tax system. To identify the progressivity of the income tax system, τ, we target the difference in average effective tax rates between the top 1% and the bottom 99%, which is 17.5 percentage points in Québec (17 in Canada).[12] The parameter λ is set so that the government budget constraint holds in the equilibrium of the model.

Workers make CQPP contributions of 10.8% of their labour earnings, up to the statutory cap. They receive a 15% tax credit on half of their CQPP contribution.[13] We model retirees' pension benefits as a function of their productivity state z at the time of retirement.[14] Concretely, we assume that for a worker retiring with productivity z, benefits are based on average incomes at ages 25-65 of workers with the same productivity state z. Benefits correspond to a quarter of this, up to a cap given by the YMPE.

Corporate taxes are modelled as a flat rate, τ_c, levied on a portion of capital income before households receive their income.[15] We set τ_c to 18.2% for Québec and 20.9% for Canada. This is the average effective marginal tax rate on corporate profits in 2017 as reported in the analysis of tax records by Bazel, Mintz and Thompson (2018). To reflect the fact that for most households, positive net worth takes the form of real estate and thus is not subject to corporate income taxes, we assume that corporate taxes only apply to capital income above a threshold d_c.We then choose d_c to match the data ratio of corporate income tax revenue to GDP, which is 3.5% in both Québec and Canada.[16]

Sales taxes are set to match tax revenue from taxes on products relative to aggregate consumption in the data. This implies effective rates of 10.2% for Québec and 9.3% for Canada. These effective rates are lower than combined headline goods and services tax (GST), harmonized sales tax (HST) and Québec sales tax (QST) rates due to exemptions and zero rates on some goods and services.

[12] Source: Statistics Canada Table 11-10-0055-01 on high income tax filers, 2010-17 average.

[13] The contribution rate is the 2018 combined worker and employer contribution rate. In the calibration for Canada, the figure is 9.9%. The 2018 cap was $52,400 for both the QPP and the CPP. Sources: `https://www.canada.ca/en/revenue-agency/services/tax/businesses/topics/payroll/payroll-deductions-contributions/canada-pension-plan-cpp/cpp-contribution-rates-maximums-exemptions.html`, [accessed Aug 2, 2021] and `https://www.revenuquebec.ca/en/press-room/tax-news/details/161100/2018-12-17/` [accessed Mar 25, 2021].

[14] In reality, benefits depend on earnings histories. Tracking earnings histories would introduce an additional state variable. This would have a punitive computational cost.

[15] Corporate income taxes reduce the tax base for personal income tax. Our setting assumes that the incidence of corporate income taxes is on all capital income. See Piketty and Saez (2007) for a discussion.

[16] Sources, including for the next two paragraphs: Statistics Canada Tables 36-10-0450-01, 36-10-0222-01, 36-10-0477-01 and 36-10-0104-01, 2010-17 average.

The government makes lump-sum transfers Tr to all households. In the data, these transfers represent 7.9% of GDP in the form of expenditure on health care (8.2% for Canada), and 8.9% in other forms (6.4% for Canada).

Finally, we need to set general government expenditure. In the model, we assume that there is a single government budget constraint that encompasses taxes, transfers, government expenditure, as well as the pension system, and that the government budget is balanced at all times. For this reason, we set government expenditure G to be the difference between total revenue (from personal and corporate income taxes, sales taxes, and pension contributions) and transfers (health, other, and pensions). This number corresponds to 7.9% of GDP for Québec and 6.6% for Canada.

3.2 Demographics

The model period is five years. Agents enter the economy at the age of 20, and the first model period ($j = 1$) corresponds to ages 20-24. Death is certain after age $J = 16$, which corresponds to ages 95-99. Retirement is mandatory at age 65 ($j_R = 10$). Following Halliday, He, Ning and Zhang (2015), we assume that the survival probability is a logistic function of age:

$$s(j) = \frac{1}{1 + \exp(\omega_0 + \omega_1 j + \omega_2 j^2)}$$

The parameters of the survival probability function are calibrated to match three moment conditions suggested by Halliday et al. (2015): the dependency ratio (population aged 65 and over divided by population aged 20-64), which is 41.7% in the data, the death rate weighted by age for 20 to 100 year olds (8.04%), and the ratio of the change in the survival probability between ages 65-69 and 75-79 to the change in survival probability between ages 55-59 and 65-69 (2.34 in the data). The resulting parameter estimates are reported in Table 2.

3.3 Preferences

Preferences are described by a discount rate, β, the elasticity of intertemporal substitution, σ_c, the inverse Frisch elasticity of labour supply, σ_l, the disutility of work θ and the parameters that govern utility from bequests: ϕ_1 and ϕ_2. We set $\sigma_l = 1.22$, which implies a Frisch elasticity of 0.82. Blundell, Pistaferri and Saporta-Eksten (2016) report an estimate of 0.68 for males and 0.96 for females. Thus a value of 0.82 for a model of households seems broadly plausible. We choose θ so that at the equilibrium an average household allocates 35% of their time endowment to work.[17] We choose $\sigma_c = 1.5$, in the middle of the range typically used in the literature. The subjective discount factor β is chosen to match the Gini coefficient of wealth. This results in an annualized

[17]Data source: Statistics Canada Table 14-10-0036-01, 2010-17 average, assuming a time endowment of 14 hours per day. The corresponding figure for Canada is 36%.

Table 1: Labor Productivity Process

	$f_L + a_L$	$f_L + a_M$	$f_L + a_H$	$f_H + a_L$	$f_H + a_M$	$f_H + a_H$	z_7	z_8
$f_L + a_L$	A_{11}	A_{12}	A_{13}	0	0	0	λ_{in}	0
$f_L + a_M$	A_{21}	A_{22}	A_{23}	0	0	0	λ_{in}	0
$f_L + a_H$	A_{31}	A_{32}	A_{33}	0	0	0	λ_{in}	0
$f_H + a_L$	0	0	0	A_{11}	A_{12}	A_{13}	λ_{in}	0
$f_H + a_M$	0	0	0	A_{21}	A_{22}	A_{23}	λ_{in}	0
$f_H + a_H$	0	0	0	A_{31}	A_{32}	A_{33}	λ_{in}	0
z_7	λ_{out}	λ_{out}	λ_{out}	λ_{out}	λ_{out}	λ_{out}	λ_{ll}	λ_{lh}
z_8	0	0	0	0	0	0	λ_{hl}	λ_{hh}

value of β of 0.975. The implied (value-weighted) interest rate that clears the asset market is 5.3% (unweighted: 4.75%).[18]

3.4 Income Process

We assume that labour productivity can take on 8 distinct values, of which (when put in increasing order) the first six are ordinary states and the other two are extraordinary states corresponding to exceptionally high earnings levels. These are commonly censored in survey data, but relevant summary information is reported in Statistics Canada's table on high income tax filers. The ordinary levels of productivity consist in combinations of two components: a permanent component, $f \in \{f_H, f_L\}$, that is fixed over a household's lifespan, and a random component, $a \in \{a_L, a_M, a_H\}$, that may change every period. Let $A = [A_{ij}]$ with $i, j \in \{L, M, H\}$ be a 3-by-3 transition matrix governing transitions over the random component a. All individuals enter the model in an ordinary state. Idiosyncratic fluctuations in labour income risk along the life cycle are captured by A, apart from the possibility of reaching an extraordinary state.

The stochastic labour productivity process is summarized by the matrix in Table 1. The following additional assumptions are explicit in the formulation of the matrix. The probability of reaching an extraordinary status within one's lifetime, λ_{in}, is independent of one's current state. Likewise, if a household loses their extraordinary status, then it is equally likely to transition to any ordinary state.[19]

In calibrating the productivity process, our working assumption is that survey data are informative on the values for ordinary states and the transitions among them, but not on the values or transitions to, from and among extraordinary states. We thus jointly calibrate the levels of ordinary states and the elements of the transition matrix A in order to match the variance of log wages for working age households of 0.43 (source: own calculation using SLID data), the increase in the standard deviation of log wages from ages 25-30 to 55-59 of

[18] The corresponding numbers for Canada are: annualized β: 0.984, value-weighted r: 4.6%, unweighted mean r: 3.5%.

[19] The formulation of the transition matrix allows for the possibility of transitioning between different values of the permanent component f by passing through an extraordinary state. However, given the calibrated values for λ_{in} and λ_{out} below, the probability of such an event is extremely small.

0.185 (Brzozowski, Gervais, Klein and Suzuki 2010), as well as an annual autocorrelation of wages of 0.973, as estimated by Heathcote, Storesletten and Violante (2010) on US data. This leaves the transitional probabilities $(\lambda_{in}, \lambda_{out}, \lambda_{ll}, \lambda_{lh}, \lambda_{hl}, \lambda_{hh})$ and the extraordinary productivity levels z_7, z_8. Two of these parameters are pinned down by adding-up constraints. In order to identify the remaining six, we target moments on the marginal distribution of income (the top 0.1 and 1 percent market income shares), on top income dynamics (the probability of remaining in the top 0.1 and 1 percent income groups, respectively), and on the joint distribution of earnings and income (the share of labour earnings in the incomes of the top 1 and 5 percent income earners).[20]

3.5 Capital income process

In addition to the earnings process, we incorporate heterogeneous and stochastic returns to saving in our model. As stressed by Benhabib et al. (2015), this allows the model to better match observed wealth concentration at the top. Since asset returns are not directly observed in the data, we model them as following a stochastic process, and calibrate its parameters.

Concretely, we assume that the idiosyncratic return component κ can take on three values, $\kappa_L < \kappa_H < \kappa_{\text{top}}$. It follows a first-order Markov process governed by a transition matrix Π_κ, shown in equation (2).

$$\Pi_\kappa = \begin{pmatrix} \pi_{ll} & 1 - \pi_{ll} - \pi_{in} & \pi_{in} \\ 1 - \pi_{hh} - \pi_{in} & \pi_{hh} & \pi_{in} \\ 0 & 1 - \pi_{top,top} & \pi_{top,top} \end{pmatrix} \tag{2}$$

Similar to the labour productivity process, we assume that two return states are "ordinary" (κ_L, κ_H), and one state is "extraordinary" (κ_{top}). For each ordinary state, there is a probability of π_{in} of entering the extraordinary state. For parsimony, we assume that this probability is common for the two ordinary states, and that those exiting the extraordinary state all enter κ_H. In addition, we allow high returns to persist across generations. We denote the probability that the child of a dying adult with high or extraordinary κ has return κ_H or κ_{top} by π_{ig}.

This leaves us with the eight parameters $\kappa_L, \kappa_H, \kappa_{\text{top}}, \pi_{ll}, \pi_{hh}, \pi_{top,top}, \pi_{in}$ and π_{ig} to calibrate. Normalizing κ to be one on average, we require seven target moments. These are five moments from the marginal distribution of wealth, as well as two from the joint distribution of bequests, income and wealth. The first five are the wealth shares of the wealthiest 0.1%, 1%, 5%, 10% and 60% of households. The latter two are the share of bequests of those in percentiles 90 to 99 of the distributions of income and wealth, respectively.

Measuring these data moments for Québec and Canada is a challenge. As is well known (see for example Davies, Fortin and Lemieux (2017) for a discussion), the Canadian Survey of Financial Security (SFS) does not

[20] Sources: Statistics Canada Table 11-10-0055-01 on high income tax filers, as well as calculations using data from Saez and Veall (2003).

capture the top of the wealth distribution well.[21] Since the wealthiest hold a disproportionate share of aggregate wealth, this implies that it does not allow measuring shares below the top accurately, either. To get around this issue, we draw on data computed by Leung and Poschke (2021). These authors apply a Pareto-extrapolation method following Vermeulen (2016) and Davies and Di Matteo (2021) to compute top wealth shares using data from the SFS combined with information on billionaires from Forbes.[22]

3.6 Bequests

The model does not feature an explicit link between parents and their offspring, which would require a larger state space. On the other hand, redistribution of all bequests among younger agents, a simplification that is common in the literature, curbs the model's ability to capture the dynastic persistence of wealth. We proceed with a hybrid approach, which can be summarized as follows. We assume that when agents reach the age of 50, they randomly draw a bequest from the actual distribution of bequests left by the deceased in the model in that period. Agents receiving a bequest draw from a distribution that is a mixture of the bequest distributions of four types of deceased agents (low versus (high or extraordinary) productivity or return component), with weights that depend on the recipient's type. We model these weights as functions of two parameters, π_{ig} (discussed above) and λ_{ig}. Quantitatively, the empirically observed persistence of wages and wealth across generations imply that high-type recipients draw from distributions with a higher weight on higher types, and are thus likely to receive larger bequest.

In this setting, all agents know that they will receive a bequest, and know the distribution they will draw from, but have no information about their parents' specific state variables and therefore do not exactly know the size of the bequest that they will receive. This setup allows for dynastic wealth accumulation across generations, while limiting the state space to a computationally feasible level.[23]

The parameters related to bequests we need to calibrate are the parameters ϕ_1 and ϕ_2 of the bequest utility function for decedents, as well as λ_{ig} and π_{ig}. The target for the latter has been introduced above. To determine values of the other three, we target the following three moments: the ratio of total bequests to wealth and the share of bequests of bequest recipients in percentiles 90 to 99, both computed from the SFS, as well as the intergenerational correlation of wages of 0.2 reported by Corak and Heisz (1999).

The parameters calibrated outside the model are presented in Table 2. Table 3 presents data and model values

[21] This is in contrast to the US Survey of Consumer Finances (SCF), which is designed to capture the top of the distribution well.

[22] While Davies and Di Matteo (2021), Davies and Shorrocks (2016) and subsequent updates, as well as Woldrich, Worswick and Yan (2020) all use a similar method to compute measures of wealth concentration for Canada as a whole, Leung and Poschke (2021) is the only source for data at the provincial level.

[23] Leung and Poschke (2021) show that if bequests were equal, the wealth Gini would be 10 to 13 percentage points lower, and the top 1% and top 0.1% wealth shares would be up to 30% lower. These numbers are about a third lower for Canada, reflecting a larger role of earnings and smaller role of bequests in generating wealth concentration in that economy.

Table 2: Calibration of the Model: Preset Parameters

Parameter	Description	Value (QC / CAN)	Source
Demographics:			
J	Maximum life span	16	corresponds to age 100
j_R	Mandatory retirement age	10	corresponds to age 65
$\omega_0, \omega_1, \omega_2$	Survival probability by age	-5.45, 0.15, 0.0196	age distribution
$\bar{\gamma}_z$	Intergen. wage corr.	0.2	Corak and Heisz (1999)
Preferences:			
σ_c	Risk aversion	1.5	standard
σ_l	1 / Frisch elasticity	1.22	Blundell et al. (2016)
Technology:			
δ	Depreciation (annual)	0.045	standard
Taxes and Transfers:			
τ_l	Marginal corporate tax rate	0.182 / 0.209	Bazel et al. (2018)
τ_s	Consumption tax rate	0.102 / 0.093	Statistics Canada: Tax revenue / C
Tr	Two components:		
	Health transfers / GDP	0.079 / 0.082	Statistics Canada
	Other transfers / GDP	0.089 / 0.064	Statistics Canada
G	Government spending / GDP	0.079 / 0.066	Statistics Canada

for target moments, and Table 4 shows the associated parameter values.

4 Calibration Results

In this section we discuss the fit of the model to the distributions of income and wealth and the fit of the model tax system, followed by a discussion of the earnings and rate of return processes implied by the calibration. We also compare the model's implications for the evolution of earnings and assets over the life-cycle.

4.1 Marginal distributions of income and wealth

Figure 1 shows the cross-sectional distributions of the key variables in the model. Each panel shows data top shares as a line, and the equivalent top shares from the model as a square (for wealth) and a diamond (for income). While the model slightly understates the concentration of wealth at the top of the distribution, it generally does a good job of capturing the cross-sectional distributions.

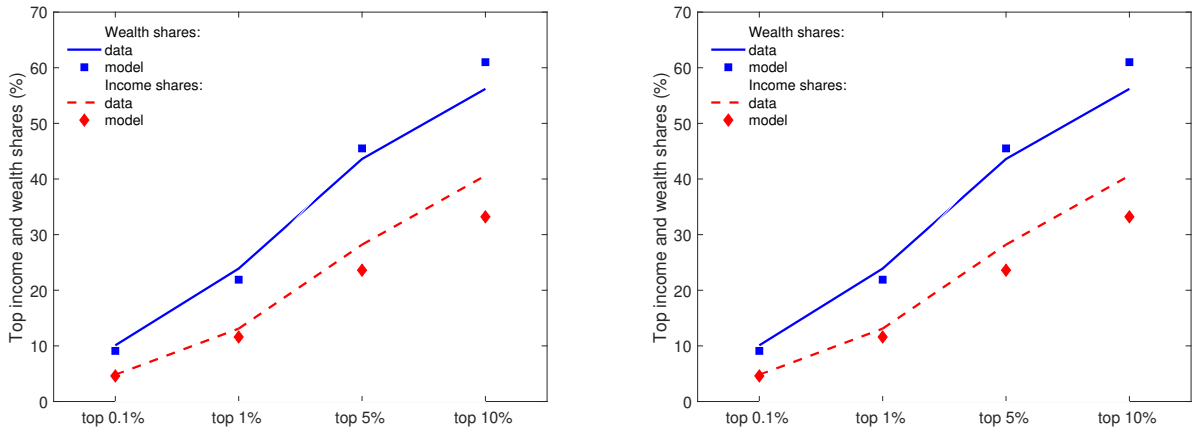
Table 5 shows Gini coefficients for wealth and income from the data and the model. The Gini coefficients for wealth were targeted in the calibration. Accordingly, the model economy displays similar measures. While the model slightly overstates wealth inequality in terms of the Gini coefficient, it slightly understates it in terms of the

Table 3: Summary of Target Moments

Moment	Source	Data Value (QC / CAN)	Model Fit (QC / CAN)
Top 0.1, 1% income shares	Statistics Canada	Figure 1	Figure 1
Top 0.1, 1, 5, 10% wealth shares	Leung and Poschke (2021)	Figure 1	Figure 1
Gini coefficient for wealth	Leung and Poschke (2021)	Table 5	Table 5
Probability of staying in top 1% income group	Statistics Canada	0.52 / 0.52	0.47 / 0.5
Probability of staying in top 0.1% income group	Statistics Canada	0.37 / 0.41	0.44 / 0.39
Labor income share of top 1% income group	Statistics Canada	0.67 / 0.75	0.65 / 0.73
Labor income share of top 5% income group	Statistics Canada	0.82 / 0.82	0.76 / 0.79
Average income tax rate, top 1% minus bottom 99%	Statistics Canada	0.175 / 0.17	0.16 / 0.17
Corporate income tax revenue/GDP	Statistics Canada	0.035 / 0.035	0.026 / 0.029
Bequest/K	SFS PUMF	1 / 1	1.7 / 1.5
P90-99 bequest share	SFS PUMF	0.37 / 0.35	0.39 / 0.37
Bequests of those in p90-99 of wealth relative to all	SFS PUMF	2.3 / 2.8	1.7 / 1.9
Bequests of those in p90-99 of income relative to all	SFS PUMF	1.6 / 1.3	1.5 / 1.5
Mean hours worked	Statistics Canada	0.35 / 0.36	0.35 / 0.36

Table 4: Calibration of the Model: Jointly Calibrated Parameters

Parameter	Description	Value (QC / CAN)
z_7, z_8	Top productivity states	Table 7
$\lambda_{in}, \lambda_{ll}, \lambda_{lh}, \lambda_{hh}$	Productivity transition rates	Table 7
$\kappa_L, \kappa_H, \kappa_{top}$	Rates of return	Table 8
$\pi_{ll}, \pi_{hh}, \pi_{in}, \pi_{top,top}$	Return transition rates	Table 8
β	Annual discount rate	0.975 / 0.984
θ	Labor disutility	5.5 / 5.5
α	Capital elasticity	0.27 / 0.27
τ_l	Tax progressivity	0.1 / 0.07
d_c	Corporate asset threshold	0.11 / 0.106
ϕ_1, ϕ_2	Bequest utility	-2.5, 3 / -0.42, 0.39
$\bar{\gamma}_\kappa$	Intergenerational return correlation	0.99 / 0.9



(a) Québec (b) Canada

Figure 1: Distributions of wealth and income, data and model

Note: The figure shows the marginal distributions of income and wealth in data and model. For data sources, see Section 3.

top shares shown in Figure 1. The empirical Gini coefficients of income displayed in the table are significantly lower than those implied by the model. This discrepancy arises although the top income shares from the model shown in Figure 1 are essentially identical to their empirical counterparts. The source for the discrepancy in the income Gini is an understatement of top incomes in the data used to compute them.[24]

Table 5: Gini coefficients of wealth and income, data and model

	Québec		Canada	
	wealth	income	wealth	income
Data	73.2	44.4	73.2	47.9
Model	77.7	52.3	74.6	53.9

Note: Wealth Ginis are calibration targets. Data Gini coefficients computed using data from the Canadian Income Survey (CIS) for 2017. For details, see the discussion in the text, and in particular in footnote 24.

Next we compare the model's fit for the factor composition of income for different income groups. Table 6 shows the share of labour earnings in total income for the top 1% and the top 5% of the income distribution. Since these statistics were targeted in the calibration, the model delivers a close fit to the data. In particular, it replicates the high share of labour income observed in the data, even at the top of the distribution.[25]

[24]The top income shares shown here are from Statistics Canada's Table 11-10-0055-01 on High income tax filers in Canada. This information is based on the Longitudinal Administrative Databank (LAD), the Canadian data source with the best coverage of top incomes. However, this table does not report a Gini coefficient. The Gini coefficients shown in Table 5 are thus computed using data from the Canadian Income Survey (CIS) for 2017. Unfortunately, this data source does not fully capture top incomes. For example, the top 1% market income share in CIS data for Canada is only 8.8%, compared to 13% in data from the LAD.

[25]Top income groups derive a large share of their income from labour in the US, too (see Kaymak et al. (2021)).

Table 6: Share of Income from Labor (in %)

	Québec		Canada	
	top 1%	top 5%	top 1%	top 5%
Data	67.0	82.4	75.0	82.4
Model	65.3	75.9	73.0	78.9

Note: All figures are calibration targets. For data sources, see Section 3.

The transition matrix for the earnings process and the earnings levels implied by the calibration procedure are shown in Table 7. (Table 12 shows the calibrated matrix for Canada.) The lowest earnings level is normalized to 1. The top two (extraordinary) earnings states represent about 0.5% of the working age population. The highest state, which is associated with extraordinary productivity, contains just 0.01% of the working age population. Nevertheless, this state is important in replicating the strong concentration of income observed in the data, with a top 0.1% income share of over 3% (almost 5% for Canada). This implies that average earnings of the top 0.1% exceed the population average by a factor 31. In the model, productivity in the second highest state is 12 times mean productivity, and productivity in the top state 189 times the mean. As a result, the top of the income distribution replicates the data closely, as shown above. All this indicates that the calibrated high productivity (wage) levels at the top are not excessive, but required to get close to the data.

For saving incentives, not only the productivity level, but also the persistence of top states are important. These are also calibration targets. As shown in Table 3, the model matches them closely. For Québec, it implies that the probabilities of staying in the top state for another period (5 years) is less than 50%. The second highest state, in contrast, is very persistent.

The levels of rates of returns on assets and the corresponding transition matrix are shown in Table 8. (Table 13 shows the corresponding matrix for Canada.) Like for most economies, data on the distribution and dynamics of investment returns in the population are not available for Québec or Canada. For comparison, the average return in the model is 4.76% (5.3% if weighted by asset holdings), with a standard deviation of 2.2% (1.9% if weighted).

4.2 Fit of the tax system

Figure 2 shows the fit of the tax system. The left panel plots the effective marginal personal income tax rate (MTR) against income (expressed as a multiple of mean income).[26] The blue line shows the tax system in the benchmark economy. It is evident how the MTR increases with income. In the benchmark (blue line), it reaches

[26] Average pre-tax total (market plus transfer) income was $44,000 in Québec in 2017 ($48,400 in Canada; Statistics Canada Table 11-10-0055-01).

Table 7: Productivity Transitions in the Benchmark Economy, Québec calibration

	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8
z_1 =1	0.875	0.120	0.004	0	0	0	0.0012	0
z_2 =2.2	0.060	0.879	0.060	0	0	0	0.0012	0
z_3 =4.7	0.004	0.120	0.875	0	0	0	0.0012	0
z_4 =3.0	0	0	0	0.875	0.120	0.004	0.0012	0
z_5 =6.4	0	0	0	0.060	0.879	0.060	0.0012	0
z_6 =13.9	0	0	0	0.004	0.120	0.875	0.0012	0
z_7 =63.3	0.013	0.013	0.013	0.013	0.013	0.013	0.900	0.021
z_8 =967	0	0	0	0	0	0	0.7	0.3
initial distribution (%)	0	50	0	0	50	0	0	0
population share (%)	7	35.7	7	7	35.7	7	0.4	0.01

Notes.– Table shows the calibrated relative productivity levels and the corresponding transition probabilities. The last row shows the fraction of working age population in each productivity state. The stationary distribution of productivity is [12, 25, 12, 12, 25, 12, 1.5, 0.045]%. Due to the low inflow rate, a lifetime is not sufficient to bring the mean size of the top group in the population to the stationary distribution.

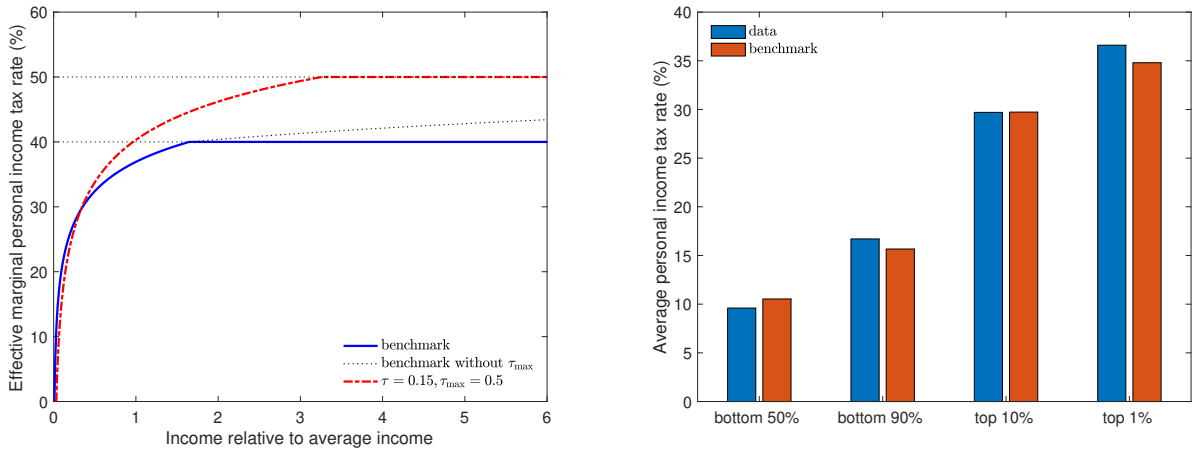
30% at median income and 36.9% at the mean income in the model. For higher income levels, it continues to increases slowly, until it reaches its maximum of 40% at 1.7 times mean income. The black line illustrates that without this cap, marginal rates would slowly rise further.

The right panel shows the fit of the tax system. It plots the average income tax rate (ATY) observed in the data and that implied by the model for four income groups. We compute the empirical average income tax rate as federal plus provincial or territorial income taxes paid divided by market income, using data from Statistics Canada Table 11-10-0055-01 on High income tax filers. Clearly, the model replicates the pattern in the data very closely: the ATY is low for the bottom 50% of the income distribution, at around 10%, slightly higher for the

Table 8: The Transition Matrix for Rates of Return on Assets, Québec calibration

from \ to	κ_L	κ_H	κ_{top}
κ_L	0.85	0.14995	0.00005
κ_H	0.04995	0.95	0.00005
κ_{top}	0.0	0.05	0.95
population share (%)	24.98	75	0.02
annual rate of return	0.01	0.06	0.19

Note.– Table shows the transition probabilities in the benchmark economy from the rate of return in Column 1 to rates of returns in Columns 2-4. The annual rates of return associated with each state and the share of the population in each state are reported in the last two rows. The stationary distribution of the process is $[24.96, 74.94, 0.1]\%$. Due to the low inflow rate, a lifetime is not enough to bring the size of the top return group to the stationary distribution.



(a) Marginal effective personal income tax rate (MTR) by income, in %, benchmark and more progressive scenario

(b) Average personal income tax rate (ATY) by income group, data and benchmark economy (%)

Figure 2: Average and marginal tax rates, model and data

Note: Left panel: plot of marginal personal income tax rates implied by the tax function in equation (1). The parameters for the benchmark case in the left panel are $\tau = 0.1, \tau_{\max} = 0.4$. Those for the alternative scenario with more progressive taxes are $\tau = 0.15, \tau_{\max} = 0.5$. Right panel: Data sources: Statistics Canada Table 11-10-0055-01 on high income tax filers, 2010-17 average. See Section 3.1 for details.

bottom 90%, and significantly higher for the top 10% and top 1%. The top average tax rate, at around 35%, significantly falls short of the top statutory rate of over 50% in Québec in both model and data. Since average rates lie below marginal ones, it also lies below the 40% effective top rate in the model.

4.3 Implications for Life-Cycle Dynamics

Next, we analyze the model's implications for the evolution of earnings and wealth over the life-cycle, and compare it with the data. Note that age-dependent distributions of earnings and wealth are not specifically targeted in the calibration. Therefore, this analysis provides an overidentification test of our model.

Figure 3 shows average earnings and wealth by age group in the model and compares it with data from Statistics Canada.[27] The productivity process is calibrated to match the observed wage profile by age in the data. The earnings profile depicted in Figure 3a is a result of households' labour supply decisions given wages. The model replicates the typical hump shape of earnings over the life cycle. It slightly overstates earnings at young ages, which are skewed in the data due to time spent in school by some young agents. This feature is absent in the model.[28] With age, households accumulate assets. Average wealth, shown in Figure 3b, increases up until the

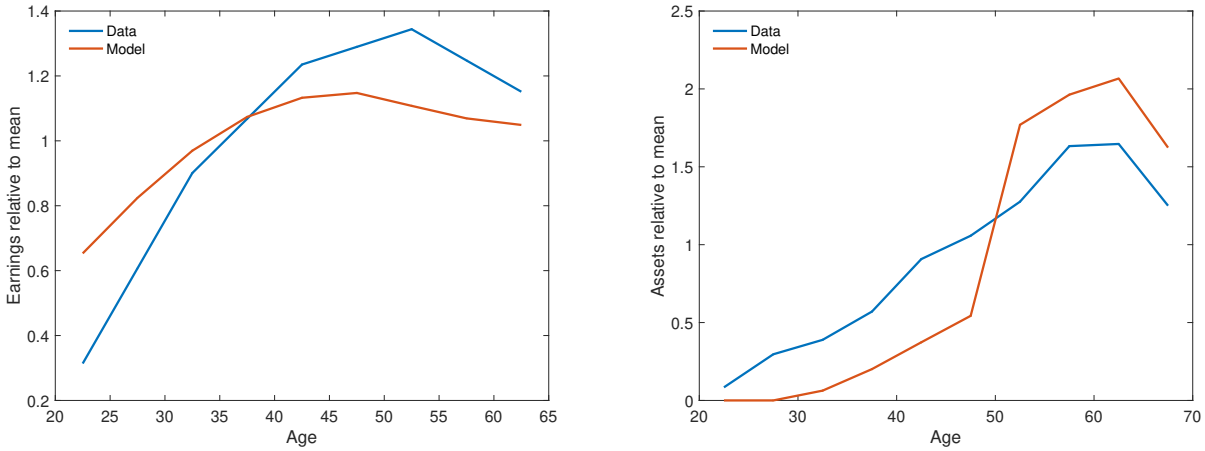
[27] Data on assets are from the 2016 the Survey of Financial Security (SFS). Results shown are for Canada. Patterns are similar in data for Québec.

[28] The model also closely replicates the average pension income. The ratio of mean CPP pension to mean labour earnings of the working age is 19% in the model, close to the value of 22% in the data.

retirement age. After retirement, agents rely only on capital income and pension benefits, and start consuming out of their savings. The model accurately captures the salient features of the life-cycle dynamics of earnings and wealth.

These figures illustrate how households' earnings and wealth change with age. This is useful to bear in mind, since when presenting results for tax reforms, we will show results for different age, income and wealth groups. It is clear from the graph that the young hold very few assets, and also have low values of earnings and income. The middle-aged on average have the highest earnings. The middle-aged and the old both hold much higher levels of assets than the young. Because the old do not work, they in turn have low values of income. In the benchmark economy, two thirds of retirees are in the upper half of the wealth distribution, but over 90% of retirees are in the bottom half of the income distribution. In a nutshell, the young are on average poor in terms of both wealth and earnings. The old are wealth-rich, but income-poor. The middle-aged on average enjoy high levels of earnings and wealth.

Figure 3: Average Earnings and Wealth over the Life-Cycle



(a) Earnings

(b) Assets

5 Tax reforms

This section presents results from simulating two types of tax reforms in the model: an increase of the weight of consumption taxes in the tax system, and an increase in the progressivity of the system. Before turning to the details of the reforms, a few methodological points need to be addressed.

First, tax reforms change government revenue. To keep the reforms revenue-neutral, income taxes are adjusted. We consider a few different reform scenarios for this, discussed below. Government spending remains constant, as a fraction of output.

Second, results below compare the benchmark stationary equilibrium of the model to stationary equilibria induced by the new tax systems, in general equilibrium. That is, in addition to the income tax system, prices (investment returns and wages) can change with a tax reform.[29]

Third, results shown below compare stationary equilibria. That is, we present results of simulations of long-run consequences of the tax reforms. For reasons of computational complexity, we leave an analysis of the transition from the current situation to the new equilibrium to future work. In principle, such transitions could take significant time, in particular for large reforms, and could affect which reforms are desirable. For example, Bakis et al. (2015) show in a simpler model that transitions affect which policies are optimal. Auerbach and Kotlikoff (1987) show that the welfare effects of reforms differ across different generations in the pre-reform economy, and discuss how to ensure that all generations benefit from a reform. While in principle, these are important concerns, they most likely are less problematic for the less radical reforms considered here. As a further check, we report results for a counterfactual economy that combines behaviour (labour supply, saving, consumption) and prices from the post-reform stationary equilibrium with distributions from the benchmark equilibrium. This comparison gives an idea of whether changes due to the tax reform are mostly due to changes in behaviour, or due to changes in the distribution. It is the latter in particular that would take place slowly over a transition.

This section discusses results for tax reforms in the Québec economy. Results for similar reforms in the model calibrated to the Canadian economy are shown in Appendix C. They are generally very similar, and discussed only where differences arise.

5.1 Consumption taxes

In the benchmark calibration, there is a single effective consumption tax rate of 10.2%. This corresponds to total consumption tax revenue divided by aggregate consumption. This rate is lower than the Québec headline sales tax rate of 14.975% because of the presence of exemptions and zero-rated goods. In this section, we show the consequences of increasing this rate to 15%.[30] Results for a smaller increase, to 11.2%, are shown in the Appendix.

We consider four ways of making the reform revenue-neutral. In the first one (reform C1), the tax system parameter λ is increased until the government's budget is balanced. Recall that higher λ implies higher dispos-

[29] Alternatively, one could think of Québec as a small open economy, and conduct the analysis in partial equilibrium. In that case, the post-reform economies have the same interest rate and thus investment returns and the same wage rate as the benchmark economy. Results for this scenario are presented in the Appendix. In general, they are close to the main results. Where there are discrepancies, they are noted in the text.

[30] One way of implementing this increase would be to increase the joint GST plus QST rate from 14.975% to 22%, while leaving zero rates and exemptions in place. The rate of 22% is well within the range of VAT rates in OECD countries, which had a mean and median around 20% in 2020.

able income at all income levels. This is a typical way of ensuring revenue neutrality in the literature using this income tax formulation, used e.g. by Bakis et al. (2015).

The next two reforms change marginal tax rates in a common way for all households. In reform C2, all effective marginal tax rates are reduced by the same amount. In reform C3, they are all reduced by the same proportion.[31]

Finally, in reform C4, the additional consumption tax revenue is redistributed as a lump sum transfer. Clearly, this is a more progressive change in the tax system than the previous three reforms.

In the results for the Canadian economy shown in Appendix C, for comparability, we also consider an increase in the sales tax rate by 47% (like that from 10.2% to 15%). For the Canadian economy, this corresponds to an increase from 9.3% to 13.7%. For this setting, we only discuss a reform of type C1 (λ adjusts).

In the following, we first show resulting changes in the tax system, then aggregate consequences, before delving into the behavioural and distributional changes underlying these changes.

5.1.1 Changes in the tax system

Figure 4 shows average personal income tax rates (ATY) for different income groups for the benchmark economy, the data, and for different tax reform scenarios. The figure shows that, in reforms C1 to C3, higher consumption taxes allow for reductions in income taxes for all income groups. These three reforms vary slightly in how much taxes decline for different income groups. In reform C2, by construction, marginal tax rates fall by the same amount, 5.4 percentage points, for all income groups. Average tax rates fall by slightly less because of transfers, and because the top marginal rate is kept constant. The change in ATYs has a similar order of magnitude as the change in the consumption tax rate because aggregate consumption and taxable income have similar magnitudes.

In reform C3, all marginal rates are reduced by the same proportion, 18.6%. By construction, this implies larger absolute reductions in marginal rates for higher incomes. As a result, in this scenario, top ATYs fall more than those at the bottom of the income distribution. Reform C1, in contrast, which implies higher disposable income via an upward adjustment of λ, implies the largest reduction in ATYs for low incomes. Reform C4 by construction hardly affects average tax rates. (Reform P, which increases the progressivity of income taxes, is discussed in Section 5.2.)

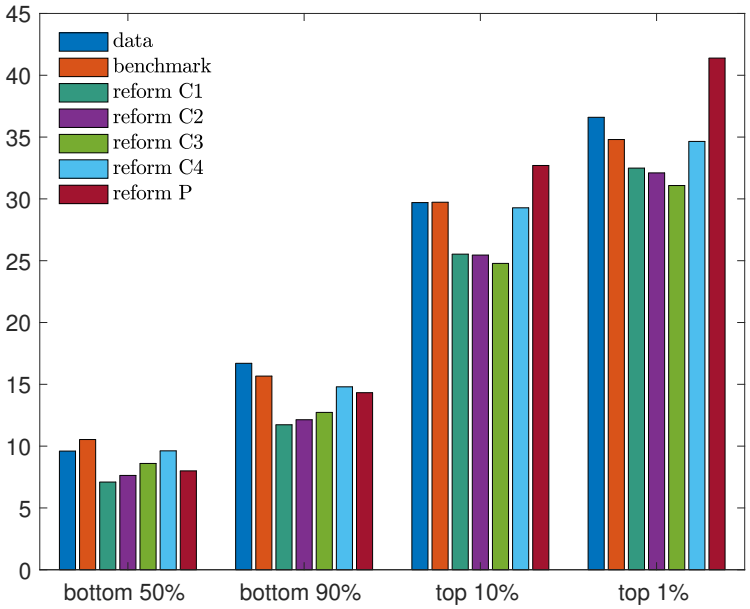


Figure 4: Average personal income tax rate (ATY) by income group, data and various scenarios (%)

Note: Data sources: Statistics Canada Table 11-10-0055-01 on high income tax filers, 2010-17 average. See Section 3.1 for details.

5.1.2 Aggregate consequences

The first three reforms have qualitatively similar aggregate consequences. In all three cases, lower income taxes stimulate saving – this is a manifestation of the well-known effect that, unlike income taxes, consumption taxes do not discourage saving. Higher personal savings lead to a significant increase in the capital stock. Combined with a small increase in labour supply, this implies increased output. Aggregate consumption also increases, mostly due to higher output in the post-reform equilibrium.

Prices change slightly. Increased saving drives down the equilibrium interest rate, and raises wages via increased marginal product of labour associated with a greater capital stock.

The results shown in Table 9 combine behavioural changes with changes in the distribution. Table 10 shows changes in aggregates, evaluated using behaviour from the new, post-reform stationary equilibrium, but aggregated using distributions from the benchmark equilibrium. Changes shown here reflect reactions to changes in the tax system and in prices, but not the knock-on effect of the higher aggregate capital stock on saving and labour supply. This table reveals that part of the increase in the capital stock shown in Table 9 is due to increased

[31] Recall that (for conciseness ignoring the bound on the MTR) after-tax income is given by $y^d = \lambda y_f^{1-\tau}$. The marginal tax rate is $1 - \lambda(1-\tau)y_f^{-\tau}$. Reducing this rate by a common amount η_1 requires changing after-tax income to $y^d = \lambda y_f^{1-\tau} + \eta_1 y_f$. Reducing marginal tax rates by a common factor $1 - \eta_2$ requires changing after-tax income to $y^d = \eta_2 \lambda y_f^{1-\tau} + (1-\eta_2) y_f$. In both cases, λ is kept as in the benchmark, and the maximum marginal rate $\tau_{\max}$ is kept unchanged.

Table 9: Aggregate effects of tax reforms

	Output	Capital stock	Labor supply	Consumption	r	wage
reform C1	0.9	3.2	0.3	0.7	-0.2	0.9
reform C2	1.2	3.5	0.7	0.7	-0.2	0.8
reform C3	2.1	5	1.3	1.3	-0.2	1
reform C4	-1.4	-0.9	-2.8	-1.6	0	0.2
reform P	-2.7	-4.6	-2	-2.4	0.2	-0.7

Notes: The first four columns as well as the last one show percentage changes between post-reform stationary general equilibrium economies and the benchmark. Column 5 shows percentage point differences. Labor supply refers to hours worked.

Table 10: Aggregate effects of tax reforms, using benchmark distributions

	Output	Capital stock	Labor supply	Consumption
reform C1	0.9	0.8	1.1	0
reform C2	1.2	0.9	1.4	-0.1
reform C3	1.8	1	2	0.2
reform C4	-1.3	-0.2	-2.9	-1.3
reform P	-1.9	-0.4	-2.1	-1.5

Notes: These results are computed using optimal behaviour after the reform, but the benchmark wealth distribution. Hence, these changes in aggregates do not reflect the change in wealth induced by the reform. All figures are percentage changes. Labor supply refers to hours worked.

saving under the changed tax regime, but a larger part arises from amplification, as an increase in the saving rate generates a more than proportional increase in the capital stock. For labour, the reverse is true: lower taxes stimulate labour supply (Table 10), but the higher level of wealth in the new equilibrium dampens this increase, cutting the increase in labour supply in response to the tax changes by half or more (Table 9). As these effects offset each other, the change in output and consumption is similar in both scenarios.

Overall, the main aggregate effect of the shift in tax burden from income taxes to consumption taxes is the increase in saving, which leads to a new equilibrium with a higher capital stock, output, and consumption. While this larger capital stock needs to be accumulated over a transitional period, the fact that aggregate consumption does not decline when evaluated using the benchmark distribution (last column of Table 10) as under the post-reform stationary equilibrium suggests that it is likely that the transition will feature higher consumption at almost all dates. Therefore, from an aggregate point of view, it seems very likely that the reform will also look attractive when the transition is taken into account.

Table 14 in the Appendix shows that in partial equilibrium, saving increases significantly more, since there is no decline in the interest rate that tempers the reaction of saving to a reduced distortion.

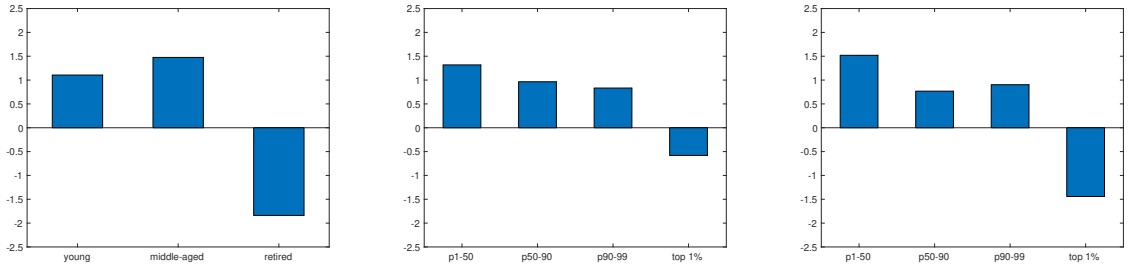
Results are different for reform C4, which involves redistributing consumption tax revenue as a flat lump sum to all households. Since this reform does not involve changes to the income tax system, distortions to saving

behaviour are not reduced in this scenario. Instead, the effective higher progressivity of the tax system implies an increased overall tax burden on high income and wealth groups, for who the lump sum transfer is not nearly sufficient to offset the consumption tax increase. This reduces their saving and labour supply, leading to lower aggregate saving, labour supply, output, and consumption.

5.1.3 Changes in incomes

Table 9 showed that in response to higher consumption taxes but lower personal income taxes, aggregate output increases (reforms C1 to C3). We next present changes in market income and disposable income for different population subgroups, defined by age, income and wealth. The following figures show results for three age groups: young (20-39 years), middle-aged (40-64 years) and retired (65 years and over). We define four wealth and income groups: percentiles 1 to 50, 50 to 90, 90 to 99, and the top 1%. In the main text, we show general equilibrium results for reform C2, which involves an increase in the consumption tax rate to 15% and a reduction in all marginal tax rates by 5.4 percentage points. Results for reforms C1 and C3 are qualitatively and quantitatively similar to those for C2 shown here. Those for a smaller increase, to 11.2%, are qualitatively similar and are shown in the Appendix. Results for reform C4 are different (see Appendix B.4). They are more similar to those for reforms that change progressivity of the income tax system, which are discussed in Section 5.2.

Figure 5 shows changes in the distribution of income following the reform (market income plus pension benefits). It is clear that all groups gain, with the exception of retirees and high income and wealth groups. Incomes for these groups are lower as they hold less capital after the reform, and also earn a lower return on it. Partial equilibrium results shown in Figure 20 in the Appendix reveal that income losses of retirees, the wealthy, and high income earners are all due price changes (i.e. the lower return to saving).

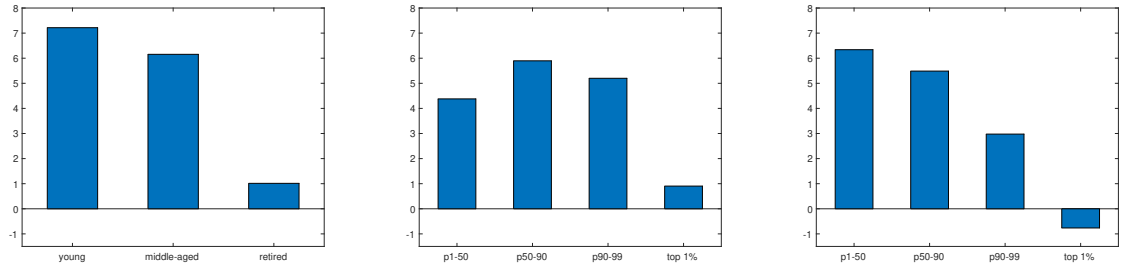


(a) by age group (b) by income group (c) by wealth group

Figure 5: Changes in income, sales taxes of 15% relative to the benchmark (%)

Disposable income (after-tax income plus transfers), in contrast, increases for all groups, with the exception of the 1% wealthiest (Figure 6). This is, of course, due to the decline in personal income taxes. The increase is largest for the young, the middle-aged, middle income groups, and the bottom 90% of the wealth distribution. It

is small for retirees and the top 1% of the income distribution, reflecting the smaller increases in pre-tax incomes of these groups. Importantly, the increase in disposable income is less than 5% for retirees and high income and wealth groups, indicating lower potential consumption for these groups.



(a) by age group (b) by income group (c) by wealth group

Figure 6: Changes in disposable income, sales taxes of 15% relative to the benchmark (%)

5.1.4 Behavioral changes

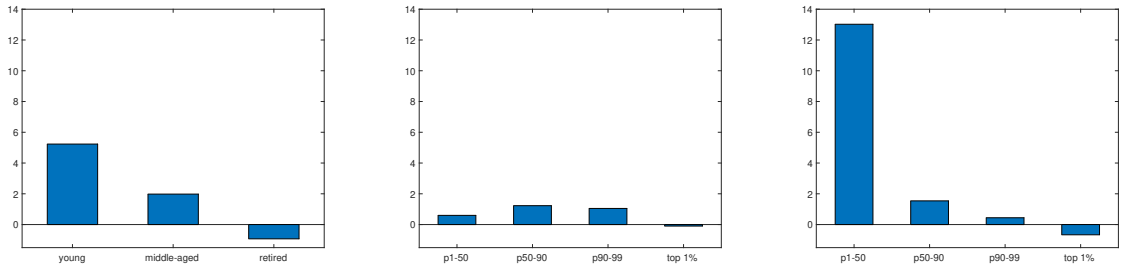
Table 9 showed that in response to higher consumption but lower personal income taxes, aggregate saving increases, aggregate labour supply increases slightly, and aggregate consumption rises.

Figure 7 shows that saving increases substantially for the young and the lower half of the wealth distribution, and moderately for the middle-aged, the bottom 99% of the income distribution, and percentiles 50-90 of wealth. For other groups, changes are small, with small declines for retirees and the top 1% by wealth. Recall that there is substantial overlap between these two groups.

Saving increases particularly strongly for the young and the wealth-poor. (These groups also overlap strongly. Also bear in mind that wealth of the bottom 50% is very low, so the large percentage change shown in the figure still corresponds to a small absolute change.) It is natural that the move to consumption taxes reduces the distortion to saving most for the young, who have the longest saving horizon in front of them, with income taxes applying each year of that horizon. The fact that retirees save less despite lower income taxes and higher disposable income reflects three factors. First, their disposable income net of consumption taxes declines. Second, due to the increase in wages and output, they receive larger pension benefits, which reduce the need for saving. Third, the pre-tax return to saving falls. Partial equilibrium results show that the last factor is crucial for generating declines in saving for all three groups that experience them.

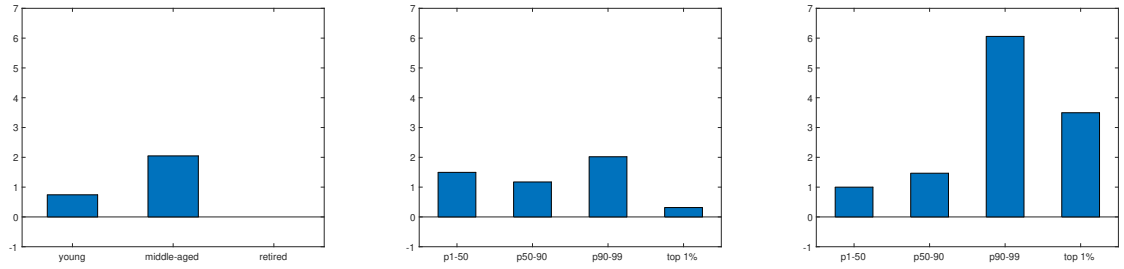
Figure 8 shows that labour supply increases slightly for all groups, and substantially for the wealthiest households. This reflects the reduced tax burden after the reform. Again, this is similar for reforms C1 and C3, as well as in partial equilibrium.

Figure 9 shows changes in consumption by group following reform C2. Consumption rises significantly for



(a) by age group (b) by income group (c) by wealth group

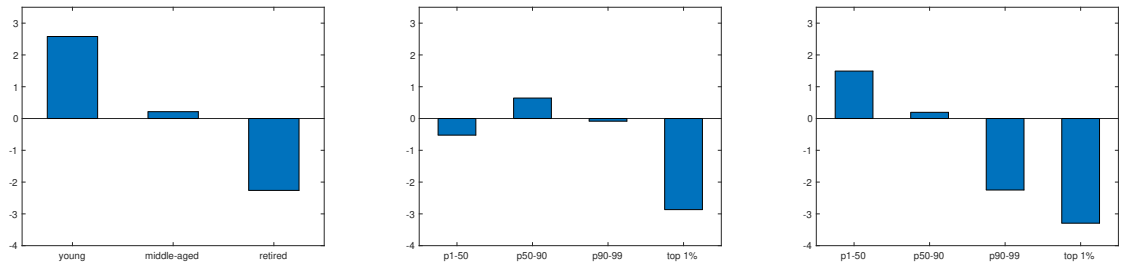
Figure 7: Changes in household saving, sales taxes of 15% relative to the benchmark (%)



(a) by age group (b) by income group (c) by wealth group

Figure 8: Changes in labour supply, sales taxes of 15% relative to the benchmark (%)

the young and the lower half of the wealth distribution. It rises slightly for the middle-aged and for those in the upper middle of the distributions of income and wealth. These changes reflect gains in disposable income for these groups. Consumption falls significantly for retirees and high income and wealth groups. The losses for these groups reflect the fact that their increase in disposable income is not sufficient to compensate for the increase in consumption taxes. Due to the large presence of retirees in the bottom half of the income distribution, mean consumption in that group also declines. These changes are similar for reforms C1 and C3, as well as in partial equilibrium.



(a) by age group (b) by income group (c) by wealth group

Figure 9: Changes in consumption, sales taxes of 15% relative to the benchmark (%)

5.1.5 Inequality

As a consequence of these income shifts, aggregate measures of inequality change, as shown in Table 11. Strikingly, inequality of both income and wealth decline with reforms C1 to C3, whether measured by the Gini coefficient or top shares.

The changes in income inequality reflect the fact that the reform induces higher incomes in the bottom 90% of the income distribution, and lower top incomes. Since these relative changes are even more pronounced for disposable income, disposable income inequality also declines.[32] The Gini coefficient for consumption also declines, despite lower consumption by the income-poor. Quantitatively, the changes in inequality are small relative to levels of inequality in the benchmark, but are comparable to those resulting from a significant increase in the progressivity of the income tax system shown below.

Changes in wealth inequality are a bit larger. This reflects the fact that consumption taxes are particularly effective at taxing those with high wealth, but less high income. (More on this below.) These changes are qualitatively similar but larger in partial equilibrium (see Table 15 in the Appendix).

Interestingly, reform C4, despite being the most progressive consumption tax reform, raises inequality of income and wealth instead of reducing it. This is because higher transfers reduce labour supply, and do so most strongly at the bottom of the income distribution. They also reduce saving, with a smaller effect at the top of the wealth distribution. As a result, inequality in both income and wealth increases. This effect is reminiscent of the effect of the introduction of social security on wealth inequality found by Kaymak and Poschke (2016). Inequality in disposable income and in consumption does fall, as higher transfers more than compensate for the changes in incomes.

In the calibration for the Canadian economy, a shift in the tax burden to sales taxes does not reduce inequality as clearly (see Table 22 in the Appendix). This reflects differences in income composition, as well as the lower progressivity of the Canadian tax system.[33]

5.1.6 Welfare

Who gains and who loses from the reform? Do gains outweigh losses? The results up to now are not sufficient to answer these questions, since they only show changes in income or behaviour at specific ages. A household's

[32] The Gini coefficient of disposable income increases very slightly in reform C3. This is the least progressive reform, and it sees larger increases in top than in bottom disposable incomes.

[33] With lower progressivity, the reduction in λ that is required to make the reform revenue-neutral leads to a larger reduction in the tax rate on the Canadian top 1% income earners, by 3.2 percentage points compared to 2.4 in Québec. (In contrast, the average income tax rate falls slightly more in Québec.) As a result, top income earners in Canada do not reduce their hours worked, unlike those in Québec. They also increase their saving by more. As a consequence, their income increases as much as that of other income groups, keeping income inequality unchanged. Because of the higher saving rate of top income groups, wealth inequality increases slightly. These differences illustrate the importance of using a model that replicates the distributions of income and wealth well. It also highlights the interdependence of different facets of the tax system.

Table 11: Effects of tax reforms on the distributions of income and wealth (percentage point changes)

	Income Gini	Top 1% share	Top 10% share	Wealth Gini	Top 1% share	Top 10% share	Disp.Inc. Gini	Cons. Gini
reform C1	-0.3	0	-0.2	-1.1	-0.7	-1.5	-0.5	-0.7
reform C2	-0.3	-0.1	-0.2	-1.1	-0.7	-1.6	-0.3	-0.6
reform C3	-0.2	-0.2	-0.2	-0.9	-1.1	-1.3	0.1	-0.4
reform C4	0.6	0.4	0.5	0.1	0.4	0.1	-1.4	-1.5
reform P	-0.4	-0.1	-0.3	-1.1	-1.1	-1.7	-1.7	-0.8

Notes: The tables shows percentage point changes compared to the benchmark economy. The first three columns show measures of market income inequality, the next three measures of wealth inequality.

overall welfare change due to a reform depends on its entire future sequences of consumption and labour supply, as well as the bequest left. We measure such total welfare changes using the compensating variation.

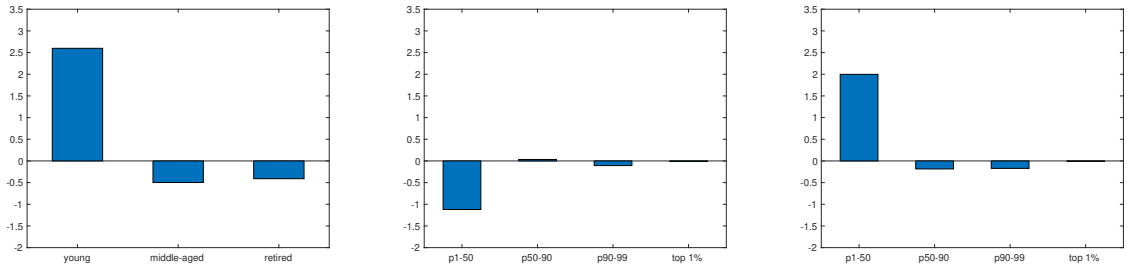
The compensating variation is defined and measured as the asset transfer a household in the post-reform equilibrium needs to receive to be indifferent to the benchmark equilibrium. For a household of given characteristics, this welfare measure includes expected changes at future dates, when the household will be older and have different levels of income and wealth. At this stage, a negative numbers indicates a gain: the household is better off in the post-reform equilibrium. For ease of interpretation, we first multiply this number by minus 1, so that positive numbers represent gains, and then scale it: we convert the asset transfer into a consumption flow by annuitizing it using the discount rate. Then we express this permanent consumption transfer relative to mean benchmark consumption. For example, a number of 1% means that a household's welfare gain due to the reform corresponds to the welfare gain that would be induced by a permanent increase in consumption by 1% of mean consumption in the benchmark economy.

Since the compensating variation is in units of consumption, not utility, it can be aggregated across households. Hence, we compute the compensating variation at each point of the state space, and show outcomes for different groups.

Figure 10 shows changes in welfare by age, income and wealth group. Qualitative patterns are clear: the young gain significantly, while retirees and the middle-aged lose. This reflects the decline in consumption suffered by retirees, its anticipation in middle age, as well as the effect of a lower return to saving. In addition, the upper half of the wealth distribution and the lower half of the income distribution lose. These welfare changes are similar in reforms C1 and C3.

In partial equilibrium, gains are more broad-based: apart from retirees, only the top 10% in terms of wealth lose. This illustrates that the losses by the middle-aged and percentiles 50 to 90 of the wealth distribution arise not so much from tax changes, but from the lower interest rate in the post-reform equilibrium.

Welfare changes correlate very strongly with a household's wealth to income ratio. This is shown in Figure



(a) by age group (b) by income group (c) by wealth group

Figure 10: Changes in welfare (compensating variation), sales taxes of 15% relative to the benchmark (%)

Notes: The figure shows the average compensating variation in each group, computed as follows. For each state, compute the compensating variation for the reform, in units of an asset transfer. That is, the amount of asset transfer that would make the individual indifferent between living in the benchmark economy or in the post-reform stationary equilibrium. Multiply by minus 1 so that positive numbers indicate that households are better off in the post-reform economy. Then aggregate these transfers across states and all generations, including those born in the future. Finally, we compute the annuity value of a consumption flow equivalent to this asset value, annuitizing using the discount rate, and express this relative to mean benchmark consumption.

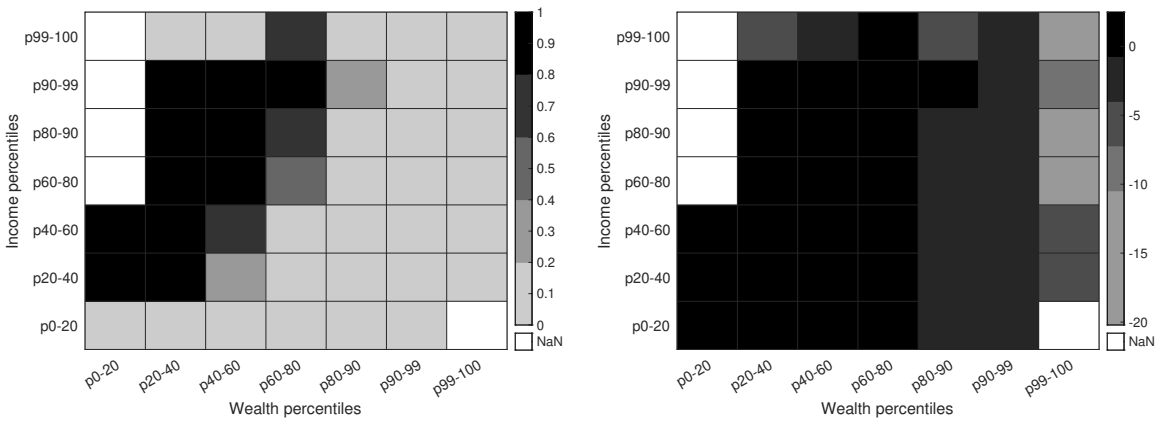
11. The left panel shows which fraction of different groups of the joint distribution of wealth and income gains from the reform. The right panel shows the average gain by income/wealth group. In the left panel, black areas indicate that more than 80% of the members of a group gain. Lighter areas indicate that fewer households gain. Areas that are white are empty. (There are no households with very low wealth but very high income). In the right panel, black areas indicate gains, dark grey areas small losses, and light grey areas large losses. Overall, it is evident that households above the diagonal, with low wealth relative to income, gain from the reform, whereas those with high wealth relative to income lose.[34]

These quantitive findings are in line with theoretical arguments. It is known (see e.g. Auerbach and Kotlikoff (1987), Coleman (2000)) that in an infinite horizon model, consumption taxes combined with a labour income subsidy correspond to a capital levy. This is in line with the effect of an increase in consumption taxes, combined with a decline in income taxes, on wealthy households that we observe here. Naturally, the reduction in labour income taxes benefits high-income households most. As a result, households with high wealth relative to income lose most.

Figure 12 shows the wealth to income ratio by group for the benchmark economy. It is clear from the figure that the young gain from the reform because they have low wealth relative to income, and therefore benefit more from lower income taxes. (Of course, their welfare gains do take into account that in the future, they will be older and wealthier.) Retirees and wealthy households have high wealth relative to income. The average ratio of wealth to income for retirees is more than two. As a result, they experience losses.[35] This occurs because after

[34]The correlation between compensating variation and the wealth to income ratio is 0.75, whereas it is only 65% for the compensating variation and the level of wealth, and 44% for the compensating variation and income. In partial equilibrium, the correlation with the wealth to income ratio is almost one.

[35]The wealth to income ratio for retirees is similar to that of the top 1% wealthiest households. While their wealth level is significantly below the top of the wealth distribution (it is centered on the 83rd percentile), they are still relatively wealthy (on average 60% wealthier than the average household), but also have relatively low incomes.

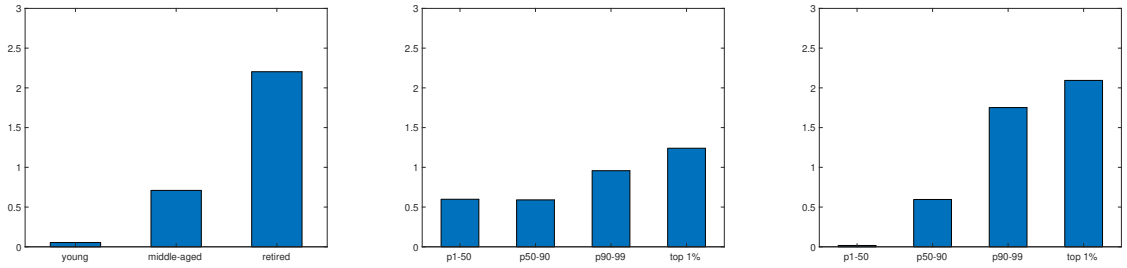


(a) Fraction better off in each group

(b) Mean welfare gain by each group (compensating variation)

Figure 11: Welfare changes by income and wealth groups, comparing sales taxes of 15% to benchmark

Notes: Groups are defined by percentiles of the benchmark distribution. Recall that negative compensating variation indicates gains. White fields are empty in the benchmark economy.



(a) by age group

(b) by income group

(c) by wealth group

Figure 12: Wealth relative to income by group in the benchmark economy

the reform, they pay more in terms of consumption taxes, but benefit less from the reduction in personal income taxes. Both wealth inequality and the life cycle dimension of the model thus are crucial for an evaluation of the effects of the policy reforms.

How do these changes aggregate? We evaluate the change in aggregate welfare as in Bénabou (2002) and Kindermann and Krueger (2014). To do so, we aggregate the compensating variation of all agents who are alive, as well as that of future generations. By this criterion, reform C2 raises aggregate welfare by an amount that is equivalent to a permanent increase in consumption for all agents by 0.2% of mean benchmark consumption.

However, this aggregate result hides important variation. In particular, an alternative criterion consists in examining the change in welfare of a newborn entering this economy under the veil of ignorance. By this criterion, reform C2 implies a gain that is equivalent to the gain from a permanent increase in consumption by

0.8% of the mean benchmark consumption level.[36] In contrast, total welfare of the alive is slightly lower post-reform, with a loss corresponding to 0.3% of aggregate consumption. As shown in Figure 10, this loss reflects losses by retirees and the middle-aged slightly outweighing the large gains for the young. Note that this is a partial welfare criterion that ignores welfare of future generations.

Overall, the reform improves aggregate welfare when all generations, including future ones, are taken into account. However, because welfare gains are quite concentrated among the young – the young gain substantially, while older generations lose, but lose less – only 47.5% of the population that is currently alive (i.e., not counting future generations) are better off in the post-reform stationary equilibrium. Future generations, who cannot currently vote but exceed current ones in population, should be added to that.

Reform 1 leads to slightly larger welfare gains – 0.3% when including future generations, 0.9% for the newborn, a loss of 0.3% for those alive at the time at the reform, and a gain of 0.1% for those of working age – as well as larger support, with gains for 51% of the population currently alive.[37] Reform 3 leads to slightly smaller welfare gains – 0.1% when including future generations, 0.7% for the newborn, -0.4% for those alive at the time at the reform, and no change for those of working age – but less support (only 40%) since it implies more concentrated gains.

The main difference between the three reforms is in their effect on working low-wealth groups. In the bottom half of the wealth distribution, the young gain from all reforms, and the middle-aged from reform C1. Those with low wealth gain most from reform C1, which is the most progressive. While that implies larger losses for the wealthy, the gains for the wealth poor dominate. This is the cause for the larger welfare gains from this reform.

The main losers from all three reforms are retirees. Their losses are similar in the three reforms, since consumption tax changes are identical, and income tax changes do not affect retirees much. As a result, the reforms could receive more support if they were coupled with measures that compensate retirees, whose losses reflect their high wealth to income ratios.

The reforms are more attractive when evaluated in partial equilibrium. In this case, newborns under the veil of ignorance continue to gain from reform C2, with a gain corresponding to a permanent increase in consumption by 1% of benchmark mean consumption. The combined welfare of those alive and those born in the future increases by roughly the same amount. In this case, both the young and the middle-aged are better off after the reform, while retirees still lose. As a result, welfare of those alive (that is, excluding future newborns) increases,

[36] This ~~gain is larger than that in the~~ welfare measure ~~above because it~~ does not double-count utility of older generations, who are less well off in the post-reform economy. The reason for this is that welfare of the young, and in particular the newborn, already encompasses welfare at older ages. Aggregating welfare of the young and old, in contrast, implies implicitly giving a higher weight to utility at older ages.

[37] These gains are about half as large when implementing reform C1 in the calibration for Canada, with gains for 38% of those currently alive.

by 0.3% of benchmark mean consumption. Welfare of the working age increases by 0.6% of benchmark mean consumption. Overall, 54% of the population gain. Figures are similar in reforms C1 and C3.

The main reason for this difference lies in the fact that in general equilibrium, the middle-aged experience welfare losses due to the reform, whereas in partial equilibrium, they gain. The reason lies in price changes: the middle-aged, who have a long consumption horizon, are harmed by the decline in the interest rate in general equilibrium, and benefit only moderately from higher wages due to their shorter work horizon. Although price changes are small, they push the average welfare change for this group over the zero threshold.

Finally, note that this welfare evaluation is a comparison of stationary equilibria, or the long-run consequences of tax reforms, and thus ignores welfare along the transition (Auerbach and Kotlikoff 1987). This could potentially matter, since capital accumulation and the output gains that come with it are an important source of higher wages, consumption and welfare in the post-reform equilibrium. However, since reforms C1 to C3 all increase consumption not just in the post-reform stationary equilibrium, but also in partial equilibrium and when evaluated using the initial distribution of assets, it appears likely that welfare will rise along the transition, too. We leave a full quantitative investigation of the transition to future research.

5.1.7 Summary

To summarize, higher consumption taxes allow for lower income taxes, which raises saving, capital accumulation, and output. Implied changes in labour supply are small. The reforms lead to a small decline in income inequality, and a larger decline in wealth inequality, reflecting the effect of consumption taxes on the wealthy.

The reforms as studied here reduce consumption of retirees, since higher disposable income is not sufficient to compensate higher sales taxes. As a result, retirees are the main losers from the reforms, apart from the wealthy. Retirees lose because they are relatively wealthy but have relatively low income, so benefit less from a reduction in personal income taxes.

Overall, the reforms imply moderate welfare gains, mostly due to the increased after-tax return to saving for the young. Households who are wealthy but do not generate high income suffer a loss, as they are hit by higher consumption taxes but do not benefit much from lower personal income taxes. Since welfare gains are concentrated among the young and among future generations, somewhat more than half of the currently alive would oppose a jump to the post-reform stationary equilibrium. However, it seems likely that compensating retirees for losses due to the reform could significantly enhance gains and support. (See also Section 5.3 below.)

5.2 More progressive personal income taxes

Currently, many jurisdiction are seeing active policy debates regarding the desirability of more progressive personal income taxes. We consider the effects of such a reform in this section.

5.2.1 Changes in the tax system

The progressivity of income taxes in the model is controlled by the parameter τ, and limited by a cap on the effective marginal tax rate. In the benchmark economy, τ takes the value 0.1, and the effective marginal tax rate cannot exceed 40%. In the following, we show the consequences of a reform that substantially increases progressivity, by raising τ to 0.15, and at the same time raising the maximum effective marginal tax rate to 50%. We include the second change since otherwise the increase in τ would not increase marginal tax rates on the top 1%, for who the maximum rate of 40% is already binding in the benchmark, and would only increase the marginal rate on the top 10% a little.[38]

Figure 2a above displays the effect of the reform on marginal tax rates, and Figure 4 that on average tax rates. Figure 2a shows that higher τ (red line) implies lower tax rates at low income levels, and higher tax rates at higher income levels. For this specific reform, the MTR declines for the bottom 41% of the income distribution, and increases for the top 59%. The increase in MTR is largest high up in the income distribution. The MTR at the 90th (99th) percentile of the income distribution increases by 5 (10) percentage points, from 37 to 42% (from 40 to 50%). These increases in the MTR for high incomes are almost entirely due to the increase in the maximum rate, $\tau_{\max}$. As a result, average tax rates paid by low income earners decline by about 20%, which amounts to a decline in the ATY by around 2 percentage points. The top 1% ATY in contrast increases by around 7 percentage points. In terms of income taxes, this reform is more progressive than reform C4, since it not only increases transfers, but also actively raises top income tax rates.

5.2.2 Aggregate consequences

Distortionary taxation almost always is a balancing act between equity and efficiency. This case is no exception. Table 9 above shows the aggregate consequences of more progressive income taxes. These are significant: more progressive taxes discourage work, leading to a reduction in aggregate labour supply of 2%. They have a much stronger effect on saving, implying a large reduction in the capital stock, by almost 5%. As a result, aggregate output declines significantly, by almost 3%. Aggregate consumption declines by almost 2.5%. Since the capital stock declines by more than labour supply, the capital-labour ratio falls, and wages decline.

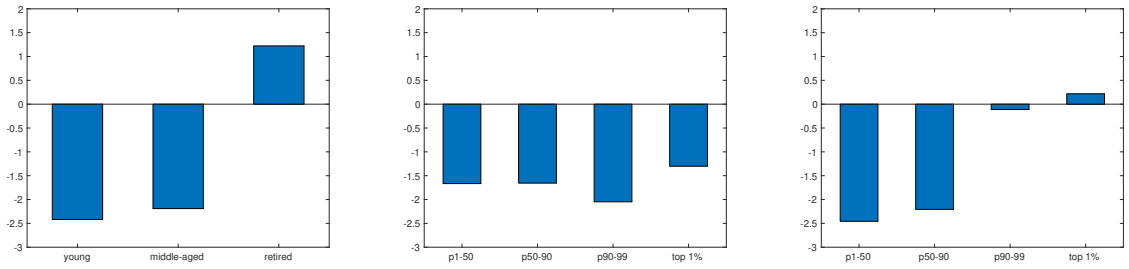
5.2.3 Distributional implications

The flip side of lower aggregate output and consumption is reduced inequality. Table 11 above shows changes in summary measures of inequality. These are similar in size to those induced by sales taxes of 15%. The Gini coefficient for market income declines by 0.4 percentage points, and top income shares by 0.1 to 0.3 percentage

[38] In the results for the Canadian economy shown in Appendix C, for comparability, we similarly consider an increase in τ by 50%, i.e. from 0.07 to .105.

points. Changes in wealth inequality are larger, with a decline in the Gini coefficient of slightly more than one percentage point, a decline in the top 1% share of one percentage point, and a decline in the top 10% wealth share of almost 2 percentage points. Nevertheless, these are small changes relative to the levels of these variables.

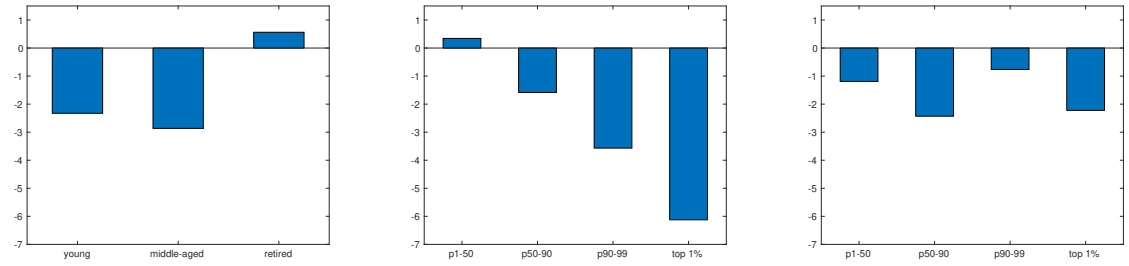
The next two figures show changes in pre-tax and disposable income for different groups. Figure 13 shows changes in the distribution of income following the reform (market income plus pension benefits). Due to the lower capital stock and lower hours worked, income declines for all age, income and wealth groups, with the exception of retirees and the wealthy, who benefit from a higher return to saving.



(a) by age group (b) by income group (c) by wealth group

Figure 13: Changes in market income, progressivity of 0.15 relative to the benchmark (%)

Disposable income also declines for all groups, as shown in Figure 14, with the exception of retirees and a minuscule increase for the bottom half of the income distribution. These two groups are large, and together account for slightly more than half of the population. (Recall that over 90% of retirees are in the lower half of the income distribution, so there is almost full overlap between the two groups.) However, the rest of the population experiences significant losses. The losses are qualitatively similar but slightly smaller in partial equilibrium, which abstracts from the wage declines that occur in general equilibrium.

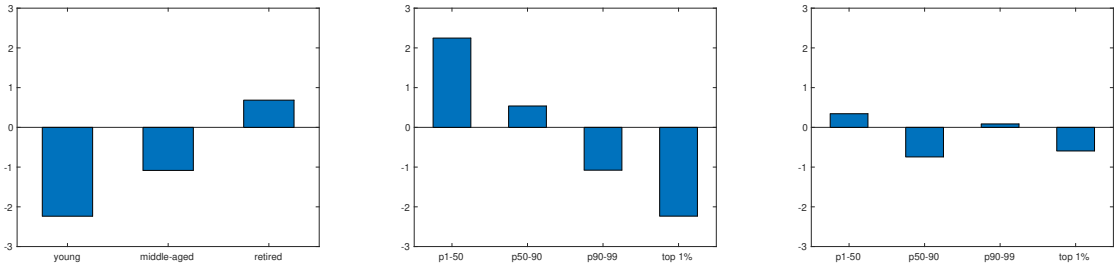


(a) by age group (b) by income group (c) by wealth group

Figure 14: Changes in disposable income, progressivity of 0.15 relative to the benchmark (%)

5.2.4 Behavioral changes

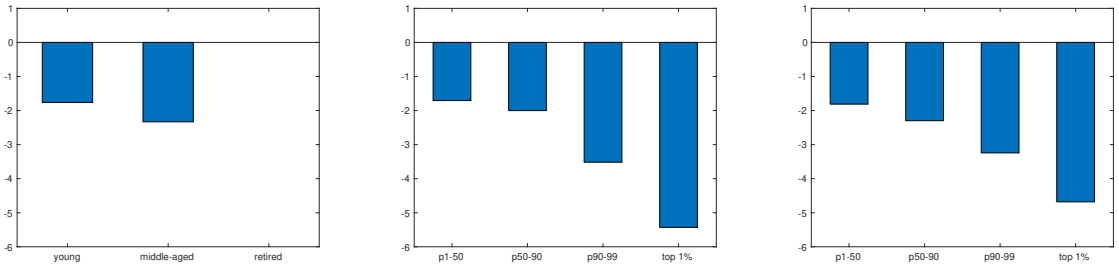
Table 9 showed that in response to more progressive income taxes, aggregate saving, labour supply, output and consumption all decline, with a particularly large decline in saving. Figure 15 shows that changes in saving differ across population subgroups. Savings decline strongly for the young and middle aged and those with high incomes, who now face much higher taxes. They increase for those with low incomes, and also increase slightly for retirees.



(a) by age group (b) by income group (c) by wealth group

Figure 15: Changes in household saving, progressivity of 0.15 relative to the benchmark (%)

Labor supply declines for all groups, as shown in Figure 16. It declines most strongly for high income earners and the wealthy.



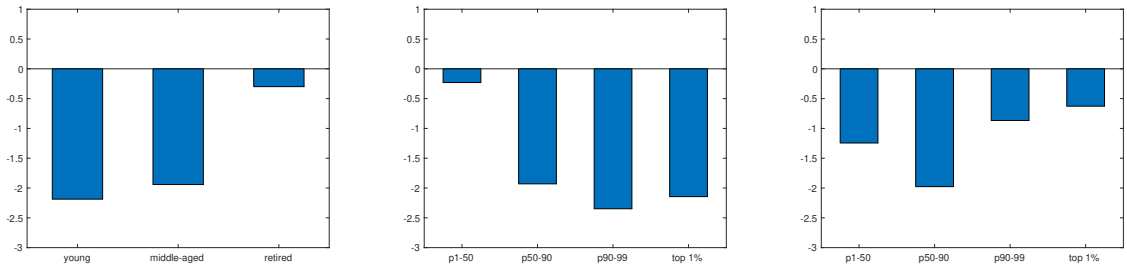
(a) by age group (b) by income group (c) by wealth group

Figure 16: Changes in labour supply, progressivity of 0.15 relative to the benchmark (%)

Figure 17 shows changes in consumption by group following the tax reform. Consumption declines for all groups. For retirees and the bottom half of the income distribution this occurs despite higher disposable income, as they choose a higher level of saving. The decline in consumption is particularly large for high income groups, the young, and the middle-aged.

5.2.5 Welfare

The main effect of this reform is redistributive. Changes in welfare by group are shown in Figure 18. The main group experiencing gains is the bottom half of the income distribution. Retirees and the wealthy also have small



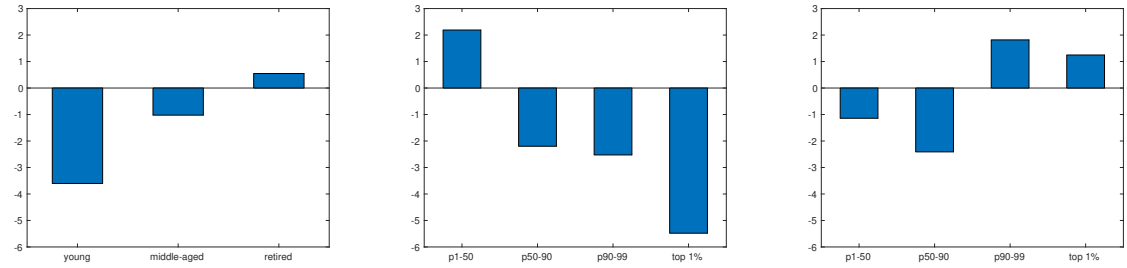
(a) by age group (b) by income group (c) by wealth group

Figure 17: Changes in consumption, progressivity of 0.15 relative to the benchmark (%)

gains, due to the higher return to saving. However, losses for other groups are much larger than these gains.

Figure 19 shows that for this reform, gains are concentrated among low-income households, and in particular those with low income and high wealth. The gains of the latter reflect the higher interest rate after the reform.

Aggregate welfare declines by all measures we consider. Total compensating variation of the alive plus future generations indicates a welfare loss corresponding to 0.2% of mean benchmark consumption. Welfare of the new-born under the veil of ignorance decreases by 0.2% of mean benchmark consumption. Mean welfare of those alive in the new stationary equilibrium compared to those in the benchmark falls by a similar amount, as does mean welfare of only those of working age. Overall, 63% of the population gain – but the size of gains is low compared to the losses incurred. Partial equilibrium results are very similar.



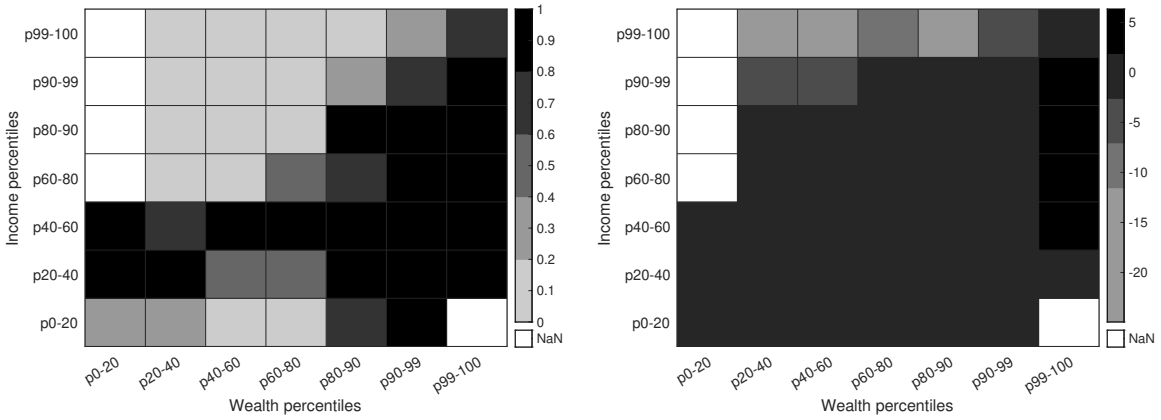
(a) by age group (b) by income group (c) by wealth group

Figure 18: Changes in welfare, progressivity of 0.15 relative to the benchmark (%)

5.2.6 Summary

In sum, more progressive taxes discourage labour supply and saving, thereby reducing aggregate output and consumption. At the same time, they reduce inequality and raise the welfare of low-income households. Yet, under the welfare criteria used here, the benefits of redistribution are outweighed by the output losses.

Reforms that change progressivity more have larger costs in terms of aggregate output and consumption, but also larger distributional benefits. Gains accrue to similar groups, implying similar levels of support.



(a) Fraction better off in each group

(b) Mean welfare gain by each group (compensating variation)

Figure 19: Welfare changes by income and wealth groups, comparing progressivity of 0.15 to benchmark

Notes: Groups are defined by percentiles of the benchmark distribution. Recall that negative compensating variation indicates gains. White fields are empty in the benchmark economy.

5.3 Joint reforms: a preliminary exploration

It is clear from the results above that shifting the burden of taxation from income to consumption taxes has the potential to generate significant increases in welfare. However, such reforms would be even more attractive if combined with others that compensate losers. This would also make these reforms politically much more acceptable.

The main losers from shifting the tax burden from income to consumption taxes are retirees, who pay little income taxes and therefore do not benefit much from income tax cuts. Compensating them would require either larger income tax cuts for them, or increases in public pensions. (It would be less practical, though not impossible, to increase consumption taxes less for them.) A full analysis of joint reforms is beyond the scope of this paper. We therefore only discuss a few indicative simulation results in this section.

First, note that raising pensions by 5% (the increase in consumption taxes) does not fully compensate retirees for their losses, since they also have other income sources. As a result, doing so still leaves retirees with lower consumption post-reform, and hardly increases support for the reform.

A larger increase in support requires a larger increase in pensions. For example, increasing pensions by 20% would take support for reform C2 just barely above the 50% mark. Since doing so leads to a smaller reduction in income taxes, it also cuts the increase in the capital stock and in output roughly in half. As a result, the gains to newborns, or to the alive plus future generations, are only half as large as those from reform C2 discussed above.

Finally, note that those who lose from reform C2 are really those who are retired in a world with higher consumption taxes and lower income taxes. The young benefit, even though they will eventually retire. This

suggests an improved reform: compensate only those who are already retired, or close to retirement, when the reform is implemented. Younger agents will reap benefits from the reform in their lifetime. Evaluating the benefits from this promising setting would require taking into account the full transition path to a new stationary equilibrium. We therefore leave it to future work.

6 Conclusion and Discussion

This paper has analyzed the effect of two types of tax reforms in a rich equilibrium model featuring heterogeneity in age, wealth, labour productivity, and investment returns. The model economy closely replicates the Québec economy in terms of the distributions of income, earnings, wealth, and taxes. It also replicates how these variables and their distributions change with age in the population. This model is ideally suited to the analysis of tax reforms that have distributional implications – as all such reforms do in a world of progressive taxes and heterogeneity in income sources.

A comparison of the two reforms considered here reveals stark differences. More progressive income taxes naturally reduce inequality. However, this effect is small, and comes at a substantial cost in terms of aggregate output and consumption. An increase in sales taxes, combined with a reduction in income taxes, not only raises saving and output, but also reduces inequality by a similar amount. However, this reform substantially reduces welfare of retirees, who benefit little from lower income taxes.

The findings regarding progressive income taxes are standard. In comparison to other jurisdictions, personal income taxes are already highly progressive in Québec. Results here suggest that a further increase in progressivity, as modelled here, would entail a small reduction in aggregate welfare. In general, welfare effects of moderate changes in tax progressivity are small in this model. Of course, this does not rule out that changes in other redistributive tools, like increases in transfers, increases in exemption levels in the tax system, or a stream-lining of tax expenditures, could be beneficial.

The most interesting findings of the analysis arise from the analysis of a shift in the tax structure that increases consumption taxes and reduces the burden of personal income taxes. The positive aggregate effects of this shift are in line with the well-known neutrality of consumption taxes in terms of saving: unlike income taxes, they do not discourage saving. As a result, a shift to consumption taxes leads to higher saving and output. However, consumption taxes are often thought to be regressive. The analysis here reveals that this is not necessarily the case – to the contrary, they can reduce inequality. The inequality-reducing effect of higher consumption taxes arises from the fact that a move from income to consumption taxes mostly harms those with high wealth relative to income, while it benefits those with low wealth relative to income. While this is a general property of consumption taxes, its quantitative importance depends on the extent of wealth inequality, income inequality,

and the correlation between wealth and income in an economy. Empirically, wealth inequality typically substantially exceeds income inequality, and the correlation of wealth and income is significant but imperfect. As a result, there is significant heterogeneity in wealth to income ratios, and the shift to consumption taxes can be progressive. These findings highlight that to gauge the effect of tax changes accurately, one critically requires a model economy that is consistent with the data in terms of the joint distribution of income and wealth.

These findings indicate substantial potential benefits from a shift in the tax structure towards consumption taxes. Mostly, these benefits reflect the distributions of wealth and income in the model economy. It seems likely that both overall benefits and support for the policy (in terms of the fraction of the population benefiting from it) could be increased even further by further fine-tuning the way the personal income tax system is changed to make the overall reform revenue neutral, or by compensating retirees for their losses from the reform. We leave this detailed analysis for future research.

A natural question that arises given these findings regards the relationship between consumption taxes and wealth taxes. Progressive wealth taxes currently are at the top of the tax policy discussion in many countries. Like consumption taxes in this model, the effects of a shift from personal income to wealth taxes on a household also mostly depend on the household's wealth to income ratio. Therefore, a comparison of the effects of consumption taxes and (progressive) wealth taxes is an intriguing question for future research.

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Appendix

A Additional tables and figures

Table 12: Productivity Transitions in the Benchmark Economy (Canada calibration)

	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8
z_1 =1	0.875	0.120	0.004	0	0	0	0.0018	0
z_2 =2.2	0.060	0.879	0.060	0	0	0	0.0018	0
z_3 =4.7	0.004	0.120	0.875	0	0	0	0.0018	0
z_4 =3.0	0	0	0	0.875	0.120	0.004	0.0018	0
z_5 =6.4	0	0	0	0.060	0.879	0.060	0.0018	0
z_6 =13.9	0	0	0	0.004	0.120	0.875	0.0018	0
z_7 =65.8	0.013	0.013	0.013	0.013	0.013	0.013	0.900	0.021
z_8 =1117	0	0	0	0	0	0	0.25	0.75
initial distribution (%)	0	50	0	0	50	0	0	0
population share (%)	7	35.6	7	7	35.6	7	0.6	0.02

Notes.– Table shows the calibrated relative productivity levels and the corresponding transition probabilities. The last row shows the fraction of working age population in each productivity state. The stationary distribution of productivity is [12, 25, 12, 12, 25, 12, 2.2, 0.2]%. Due to the low inflow rate, a lifetime is not sufficient to bring the mean size of the top group in the population to the stationary distribution.

Table 13: The Transition Matrix for Rates of Return on Assets, Canada calibration

from \ to	κ_L	κ_H	κ_{top}
κ_L	0.95	0.0498	0.0002
κ_H	0.0498	0.95	0.0002
κ_{top}	0.0	0.10	0.90
population share (%)	49.95	49.97	0.08
annual rate of return	0.01	0.06	0.16

Note.– Table shows the transition probabilities in the benchmark economy from the rate of return in Column 1 to rates of returns in Columns 2-4. The annual rates of return associated with each state and the share of the population in each state are reported in the last two rows. The stationary distribution of the process is $[49.8, 50, 0.2]\%$.

B Additional reform simulations, Québec

B.1 Additional reform simulations, aggregate results

Table 14: Aggregate effects of raising sales taxes to 15%, partial equilibrium

	Capital stock	Labor supply	Consumption	ATY	Tax burden
reform C1	9.8	-0.3	2	-8.3	-8.2
reform C2	9.6	0.1	2.1	-8.1	-8.1
reform C3	12.6	0.5	2.9	-8.1	-8
reform C4	1.3	-2.9	-1	-5.1	-5.8
reform P	-9.1	-1.6	-3.2	-4.1	-8.3

Notes: The first three columns show percentage changes between post-reform stationary partial equilibrium economies and the benchmark. The next two columns show percentage point differences. Labor supply refers to hours worked. ATY stands for the average income tax rate, defined as personal income taxes paid over taxable income. The tax burden is computed as the sum of personal income, corporate income and consumption taxes, divided by total income.

Table 15: Effects of raising sales taxes to 15% on the distributions of income and wealth (percentage point changes), partial equilibrium

	Income Gini	Top 1% share	Top 10% share	Wealth Gini	Top 1% share	Top 10% share	Disp.Inc. Gini	Cons. Gini
reform C1	-0.6	-0.1	-0.2	-1.6	-1.1	-1.9	-0.3	-0.1
reform C2	-0.6	-0.1	-0.2	-1.5	-1.2	-1.8	-0.2	0
reform C3	-0.6	-0.1	-0.1	-1.3	-1.4	-1.4	0.4	0.3
reform C4	0.4	0.3	0.5	0	0.1	0.1	-1.3	-1.3
reform P	-0.1	-0.1	-0.2	-0.7	-0.5	-1.3	-1.9	-1.3

Table 16: Aggregate effects of raising sales taxes to 11.2%, general equilibrium

	Output	Capital stock	Labor supply	Consumption	ATY	r	wage
reform C1 (11.2%)	0.1	0.6	0.1	0.3	-1.6	0	0.1
reform C2 (11.2%)	0.3	1	0.1	0.3	-1.5	0	0.1
reform C3 (11.2%)	0.3	0.5	0.3	0.2	-1.3	0	0.1
reform C4 (11.2%)	-0.3	-0.3	-0.6	-0.2	-0.8	0	0

Notes: The first four columns show percentage changes between post-reform stationary general equilibrium economies and the benchmark. The next two columns show percentage point differences. The final column again shows a percentage change. Labor supply refers to hours worked. ATY stands for the average income tax rate, defined as personal income taxes paid over taxable income.

Table 17: Effects of raising sales taxes to 11.2% on the distributions of income and wealth (percentage point changes), general equilibrium

	Income Gini	Top 1% share	Top 10% share	Wealth Gini	Top 1% share	Top 10% share	Disp.Inc. Gini	Cons. Gini
reform C1 (11.2%)	0	0.2	0	-0.2	0	-0.3	-0.1	-0.1
reform C2 (11.2%)	-0.1	0.1	-0.1	-0.3	-0.1	-0.4	-0.1	-0.1
reform C3 (11.2%)	-0.1	0	0	-0.3	0	-0.4	0	-0.1
reform C4 (11.2%)	0.1	0	0.1	0	0	-0.1	-0.3	-0.4

Table 18: Aggregate effects of raising sales taxes to 10.76% (raising sales tax revenue by CAD 2bn), general equilibrium

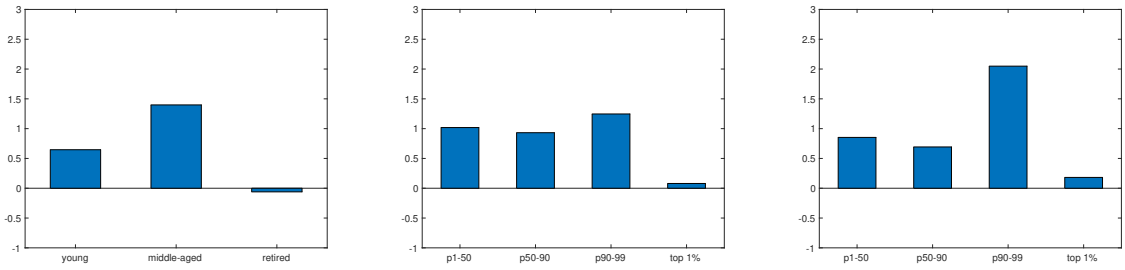
	Output	Capital stock	Labor supply	Consumption	ATY	r	wage
reform C1 ($2bn)	0	0.3	0	0.1	-1.1	0	0
reform C2 ($2bn)	0.2	0.5	0.1	0.1	-1.1	0	0.1
reform C3 ($2bn)	0.2	0.4	0.1	0.1	-1	0	0.1
reform C4 ($2bn)	-0.2	-0.2	-0.4	-0.1	-0.7	0	0

Notes: The first four columns show percentage changes between post-reform stationary general equilibrium economies and the benchmark. The next two columns show percentage point differences. The final column again shows a percentage change. Labor supply refers to hours worked. ATY stands for the average income tax rate, defined as personal income taxes paid over taxable income.

Table 19: Effects of raising sales taxes to 10.76% on the distributions of income and wealth (percentage point changes), general equilibrium

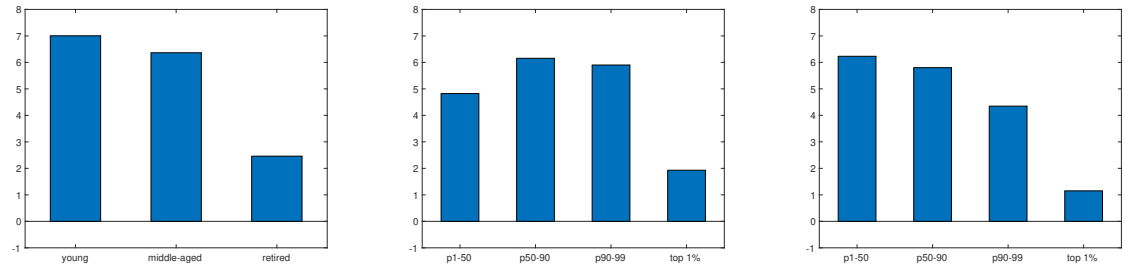
	Income Gini	Top 1% share	Top 10% share	Wealth Gini	Top 1% share	Top 10% share	Disp.Inc. Gini	Cons. Gini
reform C1 ($2bn)	0	0.1	0	-0.1	0	-0.1	-0.1	-0.1
reform C2 ($2bn)	0	0.1	0	-0.2	-0.1	-0.2	-0.1	-0.1
reform C3 ($2bn)	0	0.1	0	-0.1	0	-0.1	0	-0.1
reform C4 ($2bn)	0.1	0	0.1	0	0	0	-0.2	-0.2

B.2 Increase sales tax to 15% (reform C2), partial equilibrium results



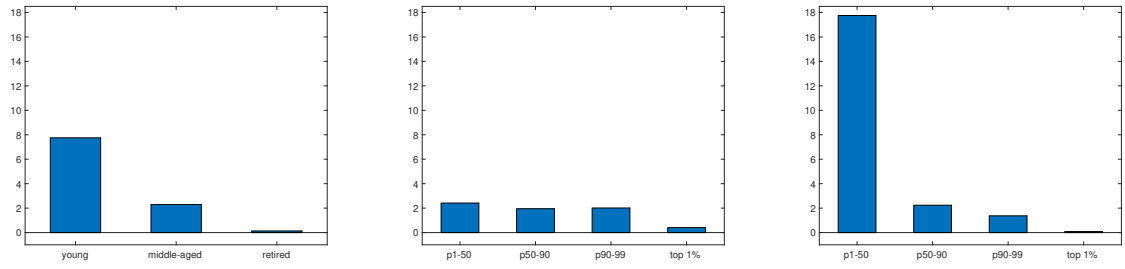
(a) by age group (b) by income group (c) by wealth group

Figure 20: Changes in market income, sales taxes of 15% relative to the benchmark, partial equilibrium (%)



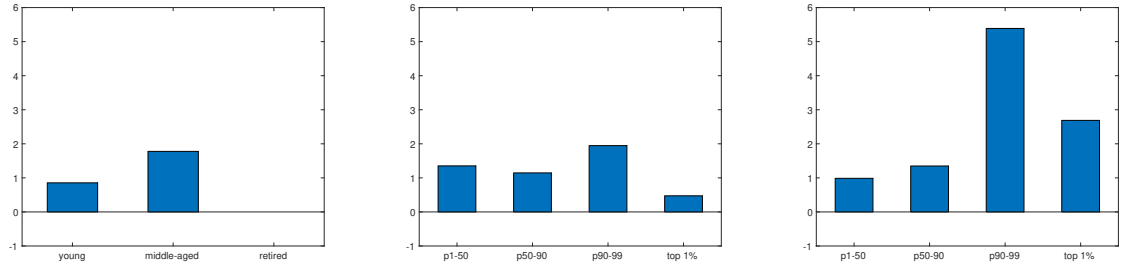
(a) by age group (b) by income group (c) by wealth group

Figure 21: Changes in disposable income, sales taxes of 15% relative to the benchmark, partial equilibrium (%)



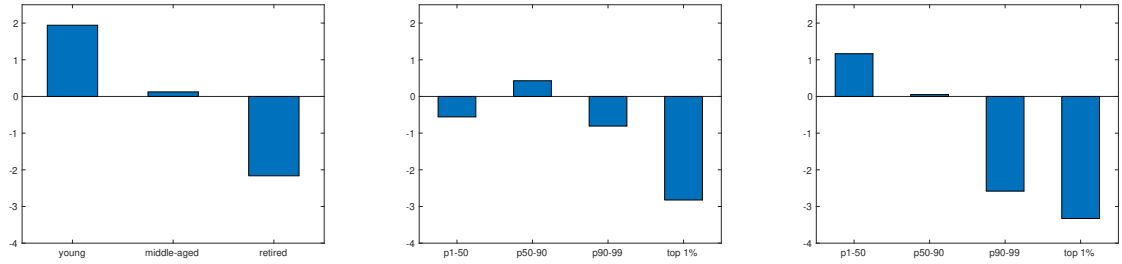
(a) by age group (b) by income group (c) by wealth group

Figure 22: Changes in household saving, sales taxes of 15% relative to the benchmark, partial equilibrium (%)



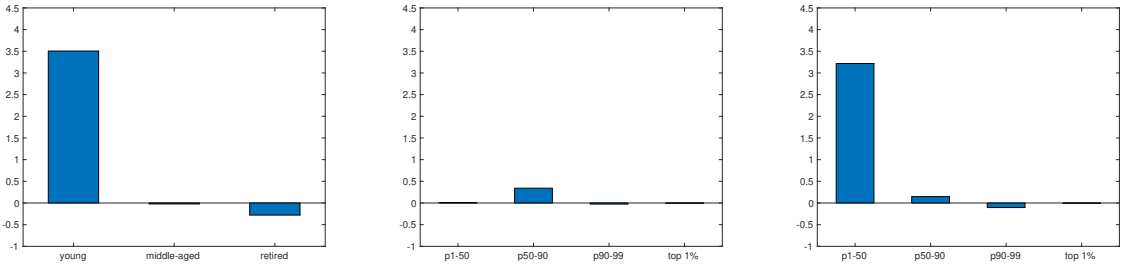
(a) by age group (b) by income group (c) by wealth group

Figure 23: Changes in labour supply, sales taxes of 15% relative to the benchmark, partial equilibrium (%)



(a) by age group (b) by income group (c) by wealth group

Figure 24: Changes in consumption, sales taxes of 15% relative to the benchmark, partial equilibrium (%)



(a) by age group (b) by income group (c) by wealth group

Figure 25: Changes in welfare (compensating variation), sales taxes of 15% relative to the benchmark, partial equilibrium (%)

B.3 Increase sales tax to 11.2%, reform type C2, general equilibrium results

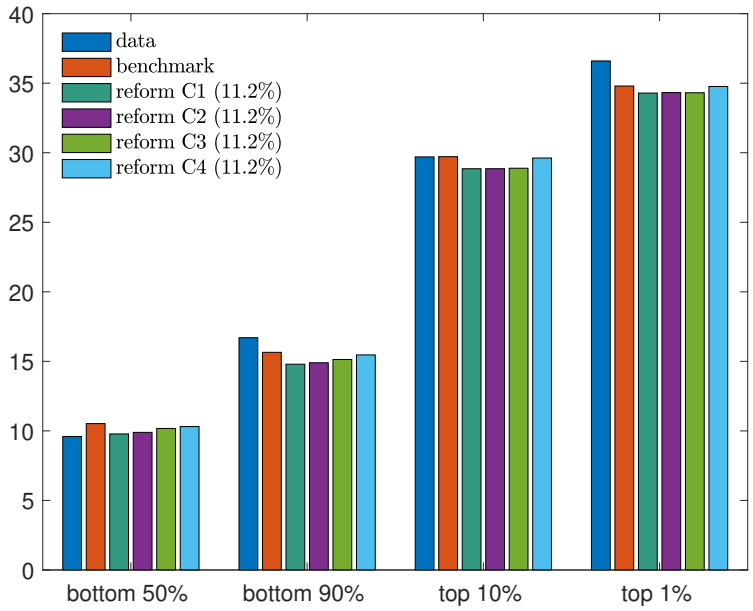
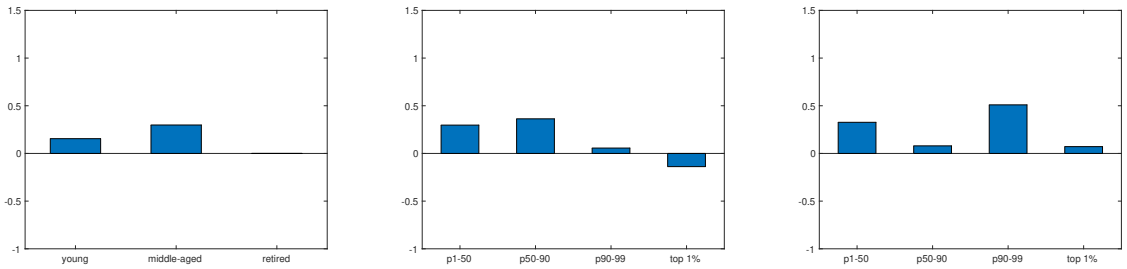


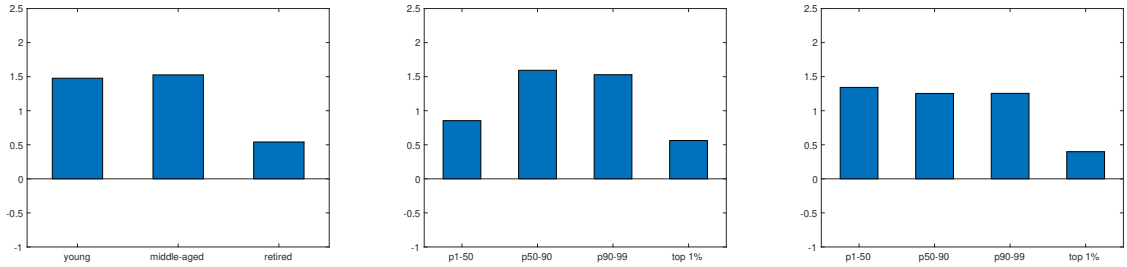
Figure 26: Average personal income tax rate (ATY) by income group, data and various scenarios (%)

Note: Data sources: Statistics Canada Table 11-10-0055-01 on high income tax filers, 2010-17 average. See Section 3.1 for details.



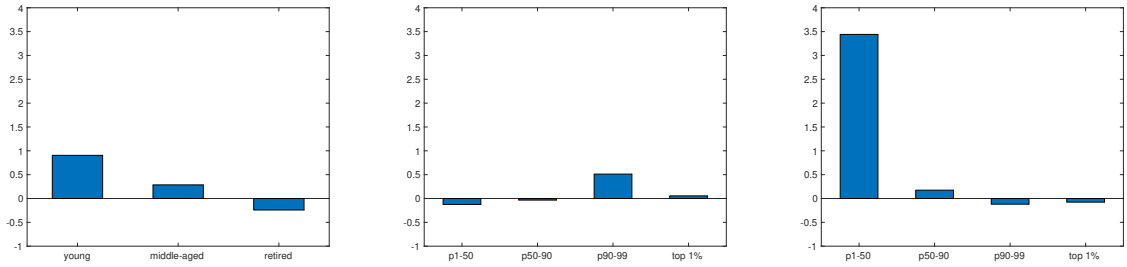
(a) by age group (b) by income group (c) by wealth group

Figure 27: Changes in market income, sales taxes of 11.2% relative to the benchmark, general equilibrium (%)



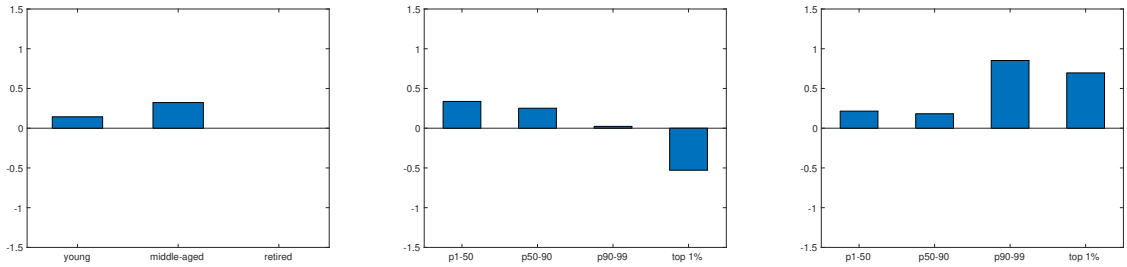
(a) by age group (b) by income group (c) by wealth group

Figure 28: Changes in disposable income, sales taxes of 11.2% relative to the benchmark, general equilibrium (%)



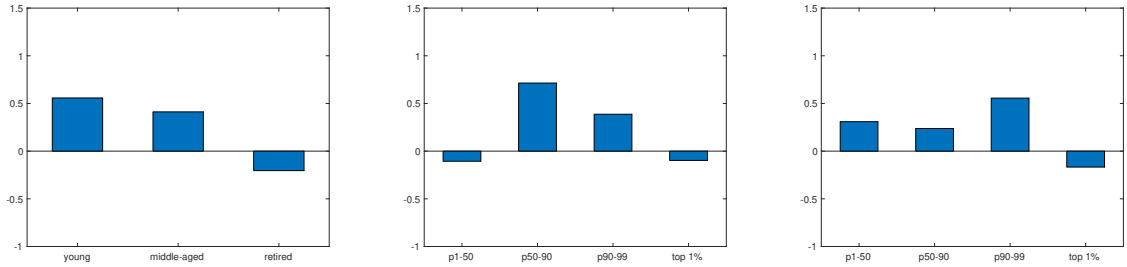
(a) by age group (b) by income group (c) by wealth group

Figure 29: Changes in household saving, sales taxes of 11.2% relative to the benchmark, general equilibrium (%)



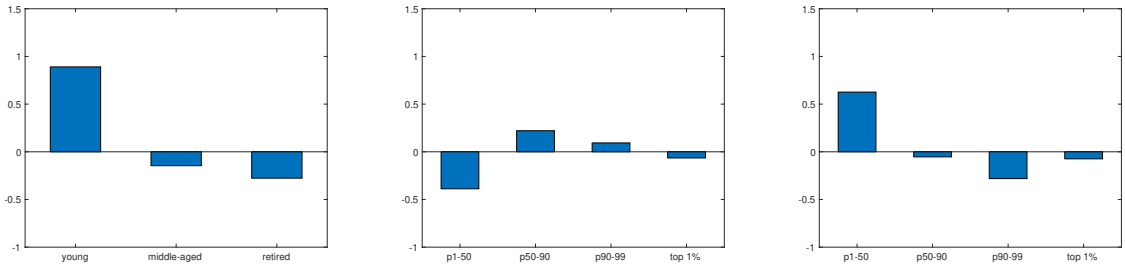
(a) by age group (b) by income group (c) by wealth group

Figure 30: Changes in labour supply, sales taxes of 11.2% relative to the benchmark, general equilibrium (%)



(a) by age group (b) by income group (c) by wealth group

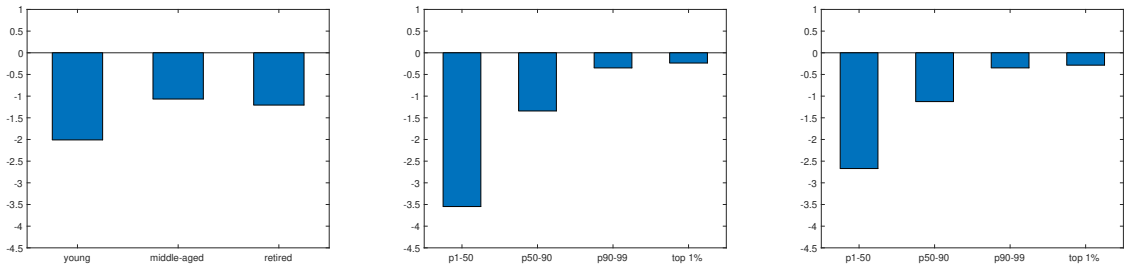
Figure 31: Changes in consumption, sales taxes of 11.2% relative to the benchmark, general equilibrium (%)



(a) by age group (b) by income group (c) by wealth group

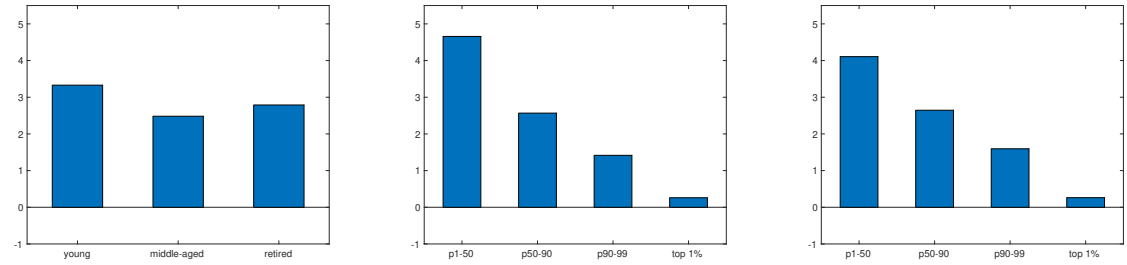
Figure 32: Changes in welfare (compensating variation), sales taxes of 11.2% relative to the benchmark, general equilibrium (%)

B.4 Increase sales tax to 15% and increase transfers (reform C4), general equilibrium results



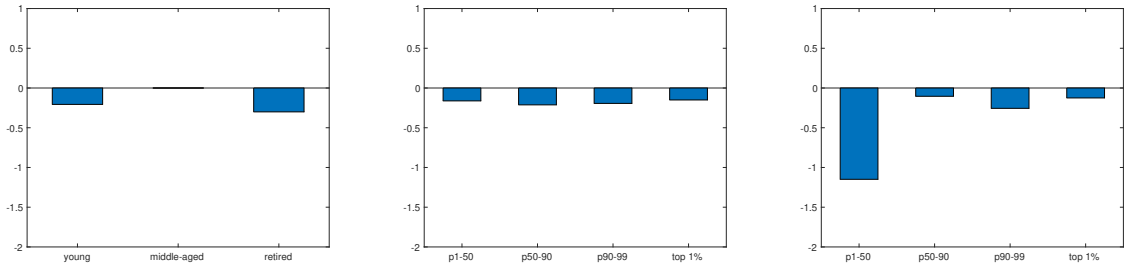
(a) by age group (b) by income group (c) by wealth group

Figure 33: Changes in market income, sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



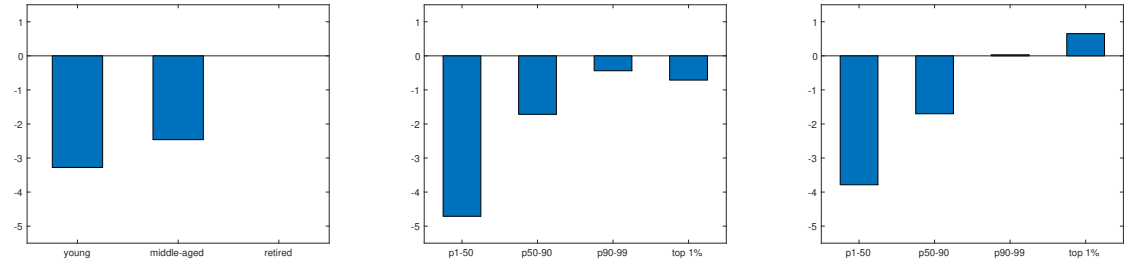
(a) by age group (b) by income group (c) by wealth group

Figure 34: Changes in disposable income, sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



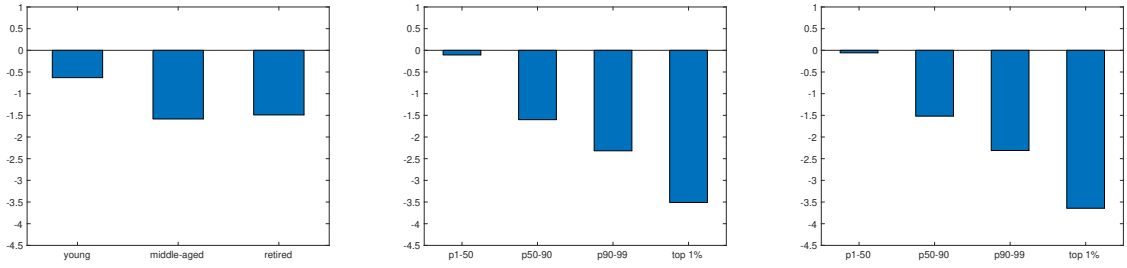
(a) by age group (b) by income group (c) by wealth group

Figure 35: Changes in household saving, sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



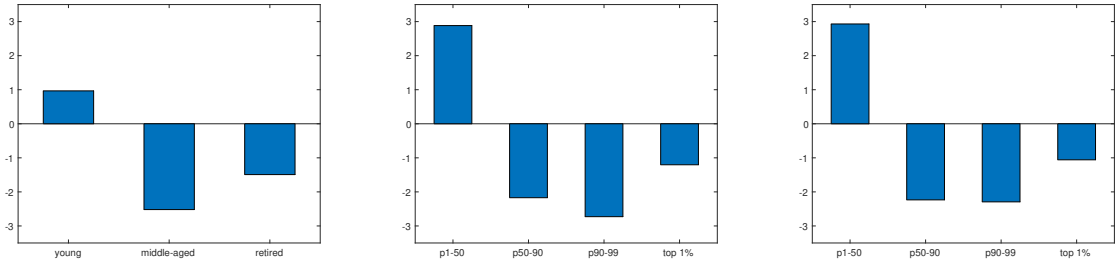
(a) by age group (b) by income group (c) by wealth group

Figure 36: Changes in labour supply, sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



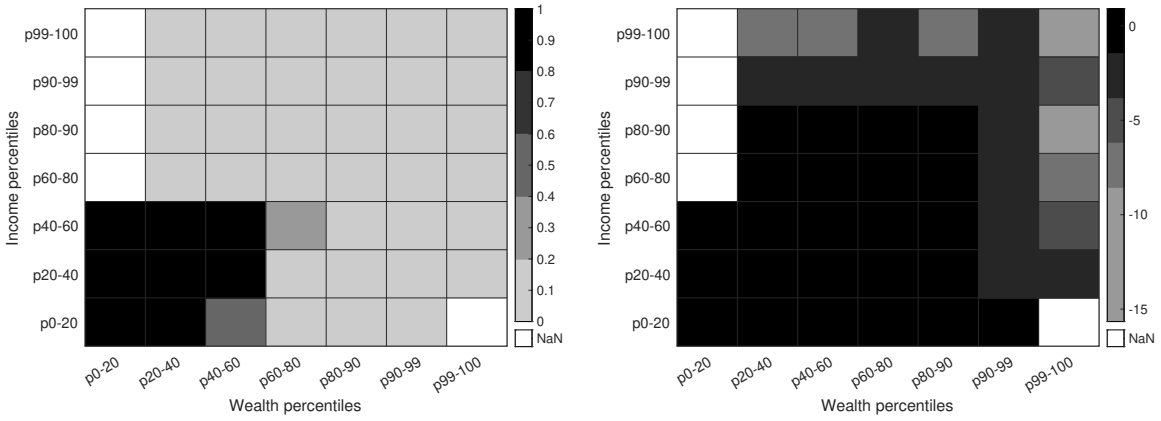
(a) by age group (b) by income group (c) by wealth group

Figure 37: Changes in consumption, sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



(a) by age group (b) by income group (c) by wealth group

Figure 38: Changes in welfare (compensating variation), sales taxes of 15% relative to the benchmark (reform C4), general equilibrium (%)



(a) Fraction better off in each group (b) Mean welfare gain by each group (compensating variation)

Figure 39: Welfare changes by income and wealth groups, comparing sales taxes of 15% to benchmark (reform C4)

Notes: Groups are defined by percentiles of the benchmark distribution. Recall that negative compensating variation indicates gains. White fields are empty in the benchmark economy.

C Tax reform simulations, Canadian economy

Table 20: Aggregate effects of tax reforms, Canadian economy

	Output	Capital stock	Labor supply	Consumption	ATY	Tax burden	r	wage
GE, sales tax = 0.137	1.2	3.5	0.4	1.4	-4.6	-2.3	-0.2	0.7
GE, τ =0.105, $\tau_{\max}$ =0.5	-1.5	-2.6	-1.4	-1.8	-0.2	-1.6	0.1	-0.4
PE, sales tax = 0.137	1.8	7.3	-0.1	1.2	-4.8	-2.4	0	0
PE, τ =0.105, $\tau_{\max}$ =0.5	-1.8	-4.1	-1.2	-1.7	-0.1	-1.6	0	0

Notes: GE stands for general equilibrium and PE for partial equilibrium. The first four columns as well as the last one show percentage changes between post-reform stationary equilibrium economies and the benchmark. Columns 5 to 7 show percentage point differences. Labor supply refers to hours worked. ATY stands for the average income tax rate, defined as personal income taxes paid over taxable income. The tax burden is computed as the sum of personal income, corporate income and consumption taxes, divided by total income.

Table 21: Aggregate effects of tax reforms, using benchmark distributions, Canadian economy

	Output	Capital stock	Labor supply	Consumption
GE, sales tax = 0.137	0.6	0.5	0.7	1.2
GE, τ =0.105, $\tau_{\max}$ =0.5	-1.2	-0.5	-1.5	-1.5
PE, sales tax = 0.137	1.1	1.4	0.8	0.2
PE, τ =0.105, $\tau_{\max}$ =0.5	-1.2	-0.7	-1.5	-1.1

Notes: These results are computed using optimal behaviour after the reform, but the benchmark wealth distribution. Hence, these changes in aggregates do not reflect the change in wealth induced by the reform. GE stands for general equilibrium and PE for partial equilibrium. All figures are percentage changes. Labor supply refers to hours worked.

Table 22: Effects of tax reforms on the distributions of income and wealth (percentage point changes), Canadian economy

	Income Gini	Top 1% share	Top 10% share	Wealth Gini	Top 1% share	Top 10% share
GE, sales tax = 0.137	0.1	-0.1	0.6	0	0.1	-0.1
GE, τ =0.105, $\tau_{\max}$ =0.5	0	0	-0.6	-0.1	0.1	-0.1
PE, sales tax = 0.137	-0.2	0	-0.4	-0.6	-0.5	-0.6
PE, τ =0.105, $\tau_{\max}$ =0.5	0.1	0	-0.6	0	0.2	0.1

Notes: GE stands for general equilibrium and PE for partial equilibrium. The tables shows percentage point changes compared to the benchmark economy. The first three columns show measures of market income inequality, the last three measures of wealth inequality.

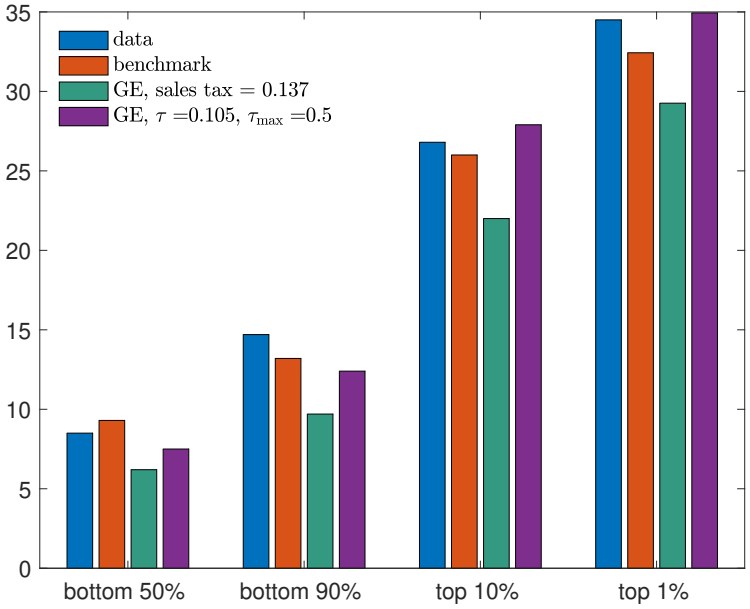
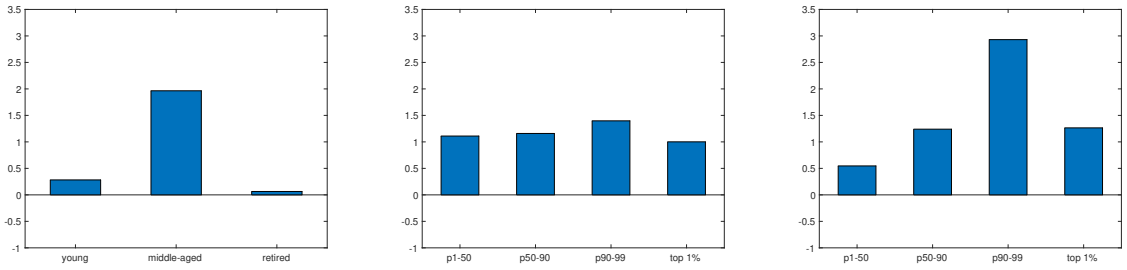


Figure 40: Average personal income tax rate (ATY) by income group, data and various scenarios (%), Canadian economy

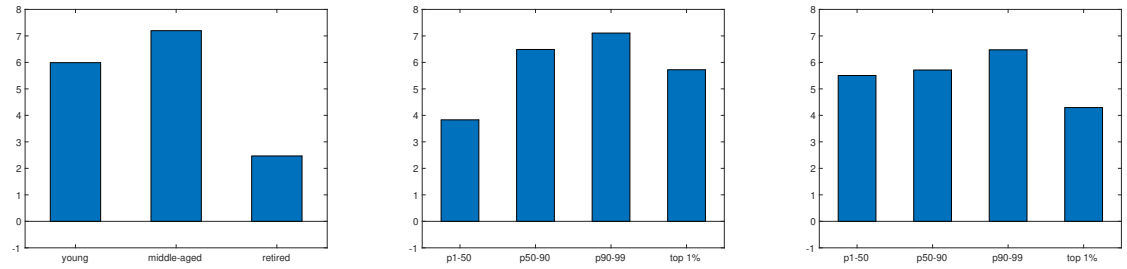
Note: Data sources: Statistics Canada Table 11-10-0055-01 on high income tax filers, 2010-17 average. See subsection 3.1 for details.

C.1 Increase sales tax to 13.7%, Canadian economy



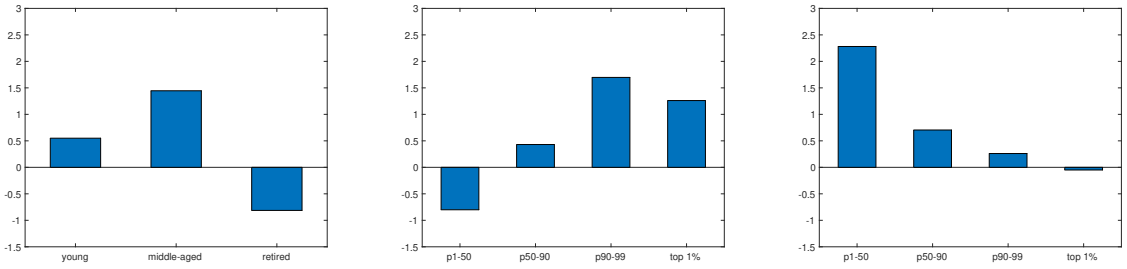
(a) by age group (b) by income group (c) by wealth group

Figure 41: Changes in income, sales taxes of 13.7% relative to the benchmark (%)



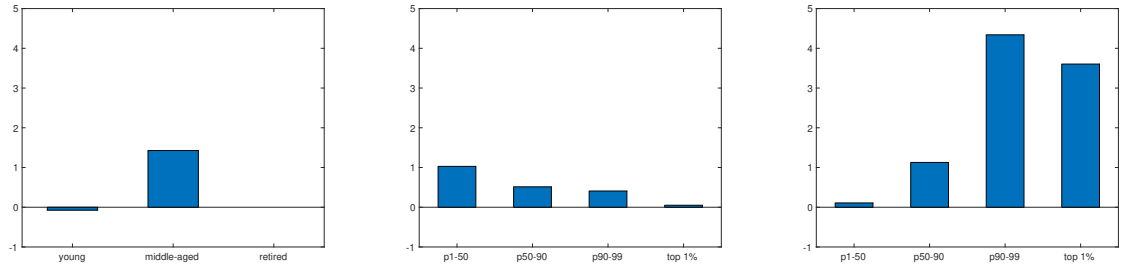
(a) by age group (b) by income group (c) by wealth group

Figure 42: Changes in disposable income, sales taxes of 13.7% relative to the benchmark (%)



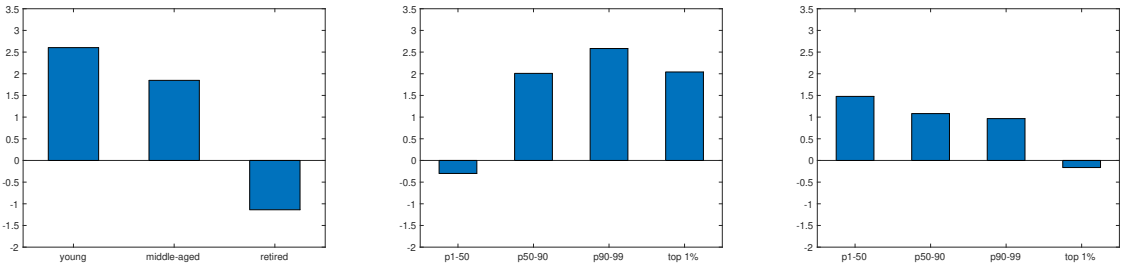
(a) by age group (b) by income group (c) by wealth group

Figure 43: Changes in household saving, sales taxes of 13.7% relative to the benchmark (%)



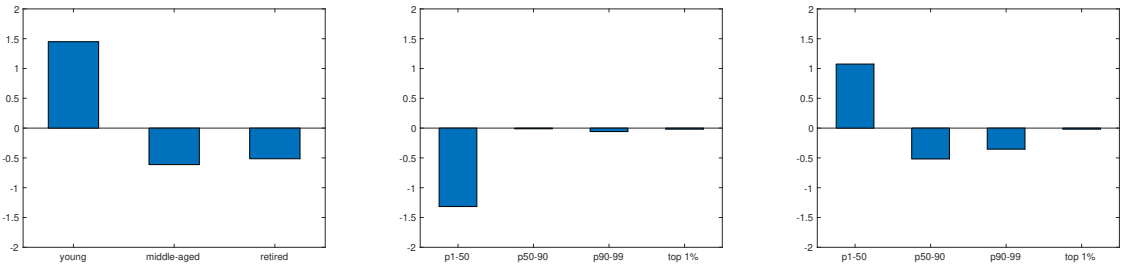
(a) by age group (b) by income group (c) by wealth group

Figure 44: Changes in labour supply, sales taxes of 13.7% relative to the benchmark (%)



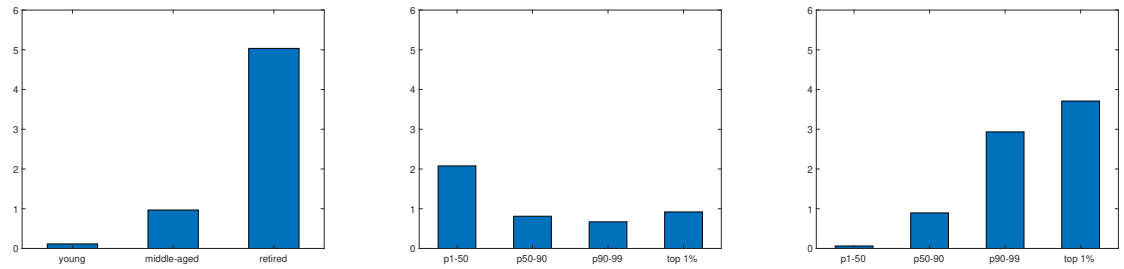
(a) by age group (b) by income group (c) by wealth group

Figure 45: Changes in consumption, sales taxes of 13.7% relative to the benchmark (%)



(a) by age group (b) by income group (c) by wealth group

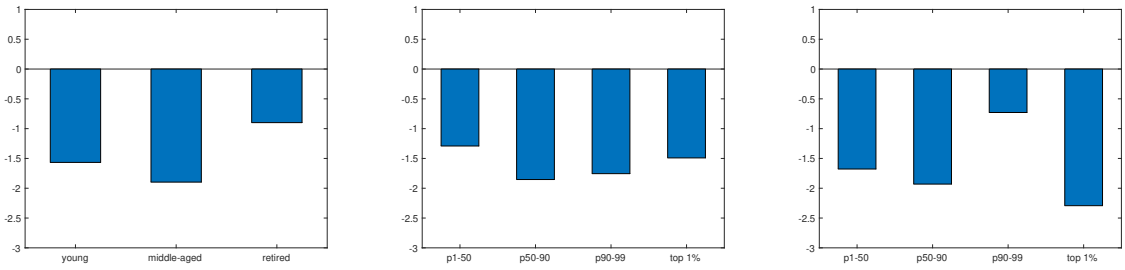
Figure 46: Changes in welfare (compensating variation), sales taxes of 13.7% relative to the benchmark (%)



(a) by age group (b) by income group (c) by wealth group

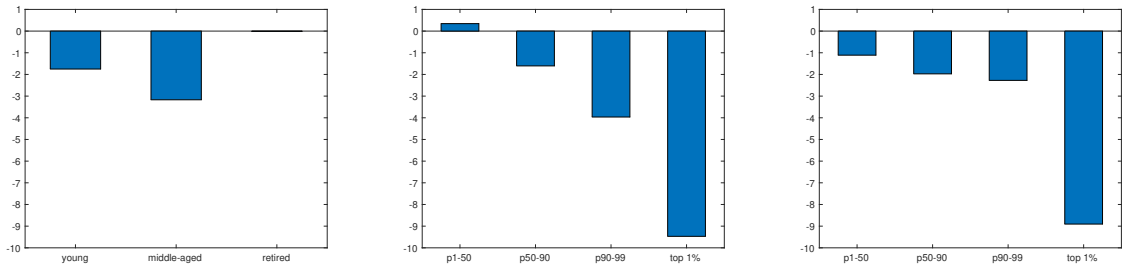
Figure 47: Wealth relative to income by group in the benchmark economy (Canada)

C.2 Increase tax progressivity to 0.105, Canadian economy



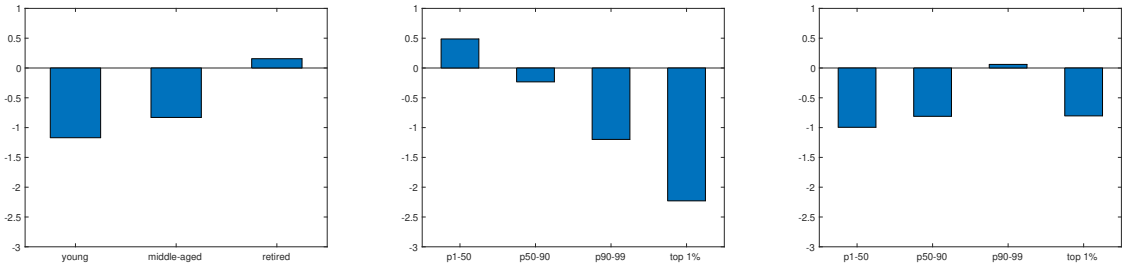
(a) by age group (b) by income group (c) by wealth group

Figure 48: Changes in income, progressivity of 0.105 relative to the benchmark (%)



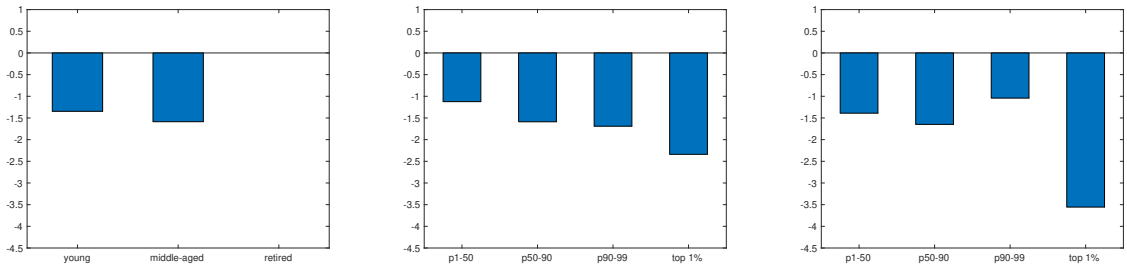
(a) by age group (b) by income group (c) by wealth group

Figure 49: Changes in disposable income, progressivity of 0.105 relative to the benchmark (%)



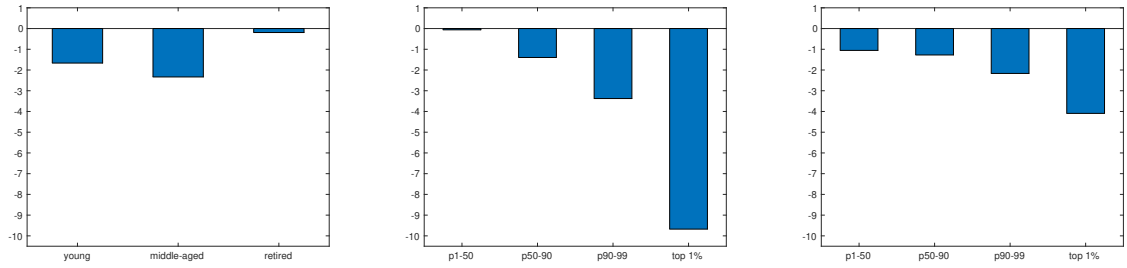
(a) by age group (b) by income group (c) by wealth group

Figure 50: Changes in household saving, progressivity of 0.105 relative to the benchmark (%)



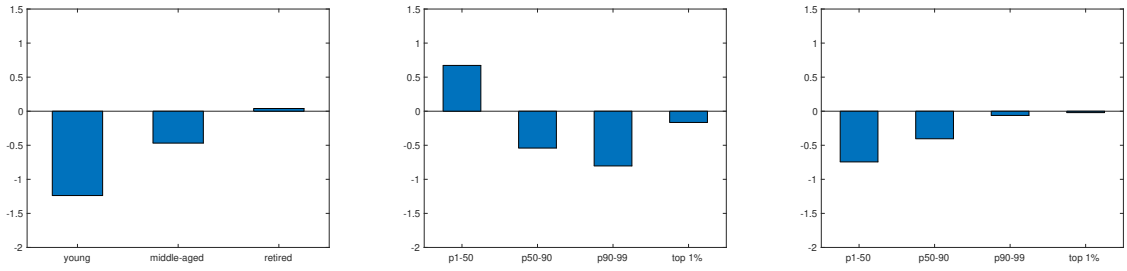
(a) by age group (b) by income group (c) by wealth group

Figure 51: Changes in labour supply, progressivity of 0.105 relative to the benchmark (%)



(a) by age group (b) by income group (c) by wealth group

Figure 52: Changes in consumption, progressivity of 0.105 relative to the benchmark (%)



(a) by age group (b) by income group (c) by wealth group

Figure 53: Changes in welfare (compensating variation), progressivity of 0.105 relative to the benchmark (%)