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Handling amenities in income taxation: Analysis of tax distortions in a migration equilibrium model

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Abstract

The tax system may have welfare costs associated with the regional allocation of resources. Nominal income taxation distorts incentives to the disadvantage of high-cost regions. The incentive problem can be addressed by real income taxation internalizing cost of living differences. Our contribution is to expand the handling of regional allocation by including amenities in a broader horizontal equitable taxation. Good amenities and high quality of life allow for lower wages in migration equilibrium and may distort the resource allocation to the disadvantage of low amenity regions. We use a large dataset of individual wages and housing prices to identify regional wage and price differences. The regional resource allocation is analyzed in a calibrated migration equilibrium model of a representative household capturing the basics of the Norwegian income tax system. Tax reform handling the two types of distortions has important and opposite quantitative effects for the resource allocation across regions when amenities and cost of living are positively correlated as in the Norwegian data.

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Keywords: Income taxation, regional taxation, cost of living, amenities

JEL codes: H24, H77, J61, R23

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1. Introduction

We analyze how income taxes affect and distort the allocation of resources across regions. The variation in regional wage and price levels reflect underlying productivities and amenities, and the tax system may distort regional resource allocation and lead to welfare costs. Most countries have nominal tax systems and the real tax burden depends on regional price and wage levels. In this situation the income taxes may distort the resource allocation to the disadvantage of high-cost regions. The incentive problem can be addressed by real income taxation internalizing cost of living differences. Cost of living adjustments of the tax system are discussed by Kaplow (1996), Knoll and Griffith (2003) and Puckett (2012). Albouy (2009) has calibrated the quantitative effects of the US income tax system and shows how long-run employment levels in high-cost regions are reduced.

We expand the analysis beyond real income taxation and the distortion generated by nominal price variation. Our starting point is the principle of horizontal equity. Horizontal equity in taxation implies equal tax treatment of equals – across regions. Horizontal equity as a principle of taxation is discussed in the influential text of Musgrave (1959) and later clarified by Feldstein (1976), Musgrave (1976) and Rosen (1978). Musgrave (1990) offers an overview discussion. The key issue here is the 'income' concept applied in taxation. Wildasin (1990) relates this to the original contributions of Haig (1921) and Simons (1938) and argues that 'it is the flow of utility that constitutes true income'. The broader debate has addressed the taxation of non-economic benefits and in particular the separation between taxed wages and untaxed amenities. Both workers and employers may gain from arranging some of the compensation as amenities, here measured as quality of life.

Amenities represent another source of misallocation between regions when they affect the wage level. High quality of life may allow for lower wages in migration equilibrium and income taxation may distort resource allocation to the disadvantage of low amenity regions. It should be noticed that amenities not necessarily produce a tax distortion. In the case where they are fully capitalized into land/housing prices there will be no regional disincentives of the nominal income taxes. The details are elaborated by Knoll and Griffith (2003, section VII). We study the potential distortionary effects of income taxation taking into account both cost of living and quality of life and call this horizontal equitable taxation.

We follow the methodological approach of Albouy (2009) and calibrate a numerical neoclassical general equilibrium migration model. The core of the migration equilibrium models in the Rosen (1979) – Roback (1982) tradition capture the equalization of utilities across regions and the relationship between wage and price levels and amenities. Wage levels can be high reflecting high productivities or compensating for bad consumer amenities. Price levels, primarily housing prices, also reflect the attractiveness of the city.

The amenity-based theory of migration equilibrium is developed by Brueckner et al. (1999). A large literature has investigated the preferences for and migration responses to amenities (Carlsen and Leknes 2015; Chen and Rosenthal 2008; Gabriel and Rosenthal 2004; Glaeser et al. 2001; Rappaport 2007). Consumer sunbelt cities are shown to be important determinants of migration flows in the US. A related literature has calibrated quality of life based on migration equilibrium models (Albouy 2012; Albouy et al. 2013; Albouy and Stuart 2014; Rappaport 2008). Jeanty et al. (2010) have estimated a simultaneous model of migration dynamics.

In the migration equilibrium model the regional allocation of population and factors of production are determined by characteristics of the regions – quality of life reflecting consumer amenities and productivity responding to producer amenities. The model is calibrated to capture basic aspects of the income tax system in Norway, notably progressivity and deductions. The full equilibrium of the distribution of population in 89 labor market regions is established, and a counterfactual analysis of tax reform is made to show how real income taxation and horizontal equitable taxation affect the regional allocation of resources.

The consequences of tax reform depend on the regional variation in wages and prices. We benefit from detailed register data of individual wages and housing prices to identify the regional differences. As shown by the analysis, there is positive correlation between quality of life and productivity in the Norwegian data, and cost of living is highest in the large city regions. In this situation real income taxation taking into account the variation in cost of living is to the advantage of large city regions. When we implement horizontal equitable taxation also taking into account variation in amenities, the resource allocation shifts to the advantage of periphery regions. The handling of the two types of distortions has important and opposite effects for the resource allocation across regions when amenities and cost of living are positively correlated. The analysis does not offer a full evaluation of the income tax system, and in particular the handling of housing consumption in the income tax system is expected to be to the disadvantage of large cities.

Section 2 presents the model, and section 3 documents the data and the calibration, including the nominal aspect of the income tax system. The analysis is covered in section 4, and section 5 offers concluding remarks.

2. Model

The model addresses the quality of life and productivity across multiple regions (indexed *j*) in migration equilibrium. The model of Albouy and Stuart (2014) is modified to fit the basics of the Norwegian income tax system. The production is divided between two sectors, traded goods and housing, where traded goods include non-traded goods other than housing. Factors of production include land, capital and labor. Factor prices are equal within regions (independent of sector). Land is immobile and receives a region-specific price. Capital is fully mobile across regions and receives the same price everywhere. The supply of capital in each region is perfectly elastic, while the national level of capital is fixed. Labor is fully mobile and wages vary across regions (since households also care about housing prices and quality of life). International migration is ignored and national population is hence fixed. Regions differ exogenously in three aspects; quality of life, productivity in the traded sector and productivity in the housing sector.

The consumer side of the model assumes a quasi-concave utility function dependent on per capita consumption of the traded good (x_j) and housing (y_j) given the exogenous level of quality of life (Q_j):

$$U_j = Q_j\left((1-\gamma)x_j^{\frac{\sigma_C-1}{\sigma_C}} + \gamma y_j^{\frac{\sigma_C-1}{\sigma_C}}\right)^{\frac{\sigma_C}{\sigma_C-1}}$$

where γ is the budget share for housing and σ_C the elasticity of substitution between the two goods.

The budget constraint is given as:

$$x_j + p_{H,j} y_j = w_j + R + I - Tax_j \tag{1}$$

The right hand side adds up post-tax income from wages (w_j) and income from land and capital (*R* and *I*, respectively). Nominal tax payments (Tax_j) depend on the chosen tax system and are described in equations (11a) – (11c) below. Land and capital income is equal across regions, while post-tax income varies since wages and tax payments vary. The traded good is the numeraire with price equal unity, while the housing price ($p_{H,j}$) is endogenous. The aggregate price index (p_j) follows as:

$$p_j = \gamma p_{H,j} + (1-\gamma) \tag{2}$$

Minimization of consumption expenditures subject to a constant utility level gives the demand functions for traded goods and housing, which is combined to the tangency condition:

$$x_j = \left(\frac{1-\gamma}{\gamma}\right)^{\sigma_C} p_{H,j}^{\sigma_C} y_j \tag{3}$$

Inserting the demand functions into $e_j = x_j + p_{H,j} y_j$, we get the expenditure function, which must equal post-tax income:

$$\left[(1-\gamma)^{\sigma_C} + p_{H,j}^{1-\sigma_C} \gamma^{\sigma_C}\right]^{\frac{1}{1-\sigma_C}} \bar{u} / Q_j = w_j + R + I - Tax_j \tag{4}$$

Income, housing prices and quality of life vary across regions, but this equation makes sure that the utility level is the same everywhere (equal to $\bar{u}$).

The production side of the model assumes constant return to scale production functions with Hicks neutral productivity. The production functions for the two sectors are similar, and in the traded sector we have:

$$X_j = A_{X,j}\left(\alpha_1 L_{X,j}^{\frac{\sigma_X-1}{\sigma_X}} + \alpha_2 K_{X,j}^{\frac{\sigma_X-1}{\sigma_X}} + (1-\alpha_1-\alpha_2) N_{X,j}^{\frac{\sigma_X-1}{\sigma_X}}\right)^{\frac{\sigma_X}{\sigma_X-1}}$$

where total output of traded goods (X_j) depends on inputs of land $(L_{X,j})$, capital $(K_{X,j})$ and labor $(N_{X,j})$ along with traded sector productivity $(A_{X,j})$. The elasticity of substitution between the different factors of production is given by σ_X, while α_1 and α_2 are share parameters. Minimization of total costs subject to constant production generates three first order conditions for each sector, which equilibrate factor price with the marginal product of the factor for land, capital and labor, respectively. Combining the first order conditions gives the unit cost functions, which must equal the price level of the sector:

$$\left(\alpha_1^{\sigma_X} r_j^{1-\sigma_X} + (1-\alpha_1-\alpha_2)^{\sigma_X} (b_j w_j)^{1-\sigma_X} + \alpha_2^{\sigma_X} i^{1-\sigma_X}\right)^{\frac{1}{1-\sigma_X}} = A_{X,j} \tag{5}$$

$$\left(\beta_1^{\sigma_Y} r_j^{1-\sigma_Y} + (1-\beta_1-\beta_2)^{\sigma_Y} (b_j w_j)^{1-\sigma_Y} + \beta_2^{\sigma_Y} i^{1-\sigma_Y}\right)^{\frac{1}{1-\sigma_Y}} = A_{Y,j} p_{H,j} \tag{6}$$

Factor prices for land, capital and labor are given by r_j, i and $b_j w_j$, respectively, where $b_j = 1 + a_j$ with a_j as the payroll tax rate (which differs across regions). Productivity in the housing sector is represented by $A_{Y,j}$, β_1 and β_2 are share parameters in the housing production function, while σ_Y is the constant elasticity of substitution between input factors in the housing sector.

Factor market clearing is given by:

$$L_j = L_{X,j} + L_{Y,j} \tag{7}$$

$$K_j = K_{X,j} + K_{Y,j} \tag{8}$$

$$N_j = N_{X,j} + N_{Y,j} \tag{9}$$

where subscripts *X* and *Y* refer to factor demands from the traded sector and the housing sector, respectively. Total land supply in region *j* (L_j) is fixed, and the market clearing of land determines the endogenous land price. Given the sectoral demands for capital and employment, the other two conditions add up total capital (K_j) and total population (N_j) in region *j*.

Finally, market clearing of the housing sector equilibrates housing supply (Y_j) with aggregate housing demand:

$$Y_j = N_j y_j \tag{10}$$

We concentrate on the basics of the income tax system including deductions and progressivity, and consider three alternatives. The base run scenario is nominal income taxation, where nominal and real tax payments are represented by:

$$Tax_j = \tau w_j - D \tag{11a}$$

$$\frac{Tax_j}{p_j} = \tau \frac{w_j}{p_j} - \frac{D}{p_j} \tag{11a'}$$

where τ and *D* represent the tax rate and deductions, respectively. It follows that regions with different price levels and equal real wage levels face different tax burdens, both in terms of nominal and real tax payments. Regions with high nominal wages and high housing costs pay more in taxes than regions with low nominal wages and low housing costs.

An alternative tax system is real wage taxation, which relates real tax payments to real wages:

$$Tax_j = \tau w_j - Dp_j \tag{11b}$$

$$\frac{Tax_j}{p_j} = \tau \frac{w_j}{p_j} - D \tag{11b'}$$

The price variable introduced in the last term of equation (11b) represents an indexation of tax payments and thereby real taxation.

Even though real wage taxation implies equal real tax burden for regions with the same real wage level, regions with the same utility level (but different real wage levels) face different real tax burdens. A region with high real wage and low quality of life pays more in real taxes than a region with low real wages and high quality of life.

Horizontal equitable taxation relates real tax payments to the utility level by also taxing quality of life (amenities), where the tax rate on amenities is chosen so that the real tax burden is equal in regions with the same utility level. In our migration equilibrium model the utility level is equal across all regions, and a tax system based on horizontal equitable taxation can be given the following reduced form representation:

$$Tax_j = \mu p_j \tag{11c}$$

$$\frac{Tax_j}{p_j} = \mu \tag{11c'}$$

where μ is set so that average nominal tax payments across regions are the same as in the nominal wage taxation scenario.

Equations (1) – (11) together with the six first order conditions from cost minimization determine 17 endogenous variables in each region; wages, taxes and land rent (w_j, Tax_j, r_j), housing price and aggregate price index $(p_{H,j}, p_j)$, per capita consumption of traded goods and housing (x_j, y_j), total output in the traded and housing sector (X_j, Y_j), factor demands in each sector $(L_{X,j}, K_{X,j}, N_{X,j}, L_{Y,j}, K_{Y,j}, N_{Y,j})$ and aggregate capital and population in each region (K_j, N_j).

In the empirical application of the model (documented in the following sections) we work with log-linearized relationships. For any variable z_j, the log differential $\hat{z}_j = \ln z_j - \ln \bar{z}$ approximates the percentage difference between region *j* and the national geometric average $\bar{z}$. The log-linearized version of the nominal tax equations given in (11a) – (11c) follows as:

$T\hat{a}x_j = s_\tau \hat{w}_j$ *(Nominal income taxation)*

$T\hat{a}x_j = s_\tau \hat{w}_j - s_D \hat{p}_j$ *(Real income taxation)*

$T\hat{a}x_j = \hat{p}_j$ *(Horizontal equitable taxation)* where s_τ is taxes net of deductions relative to total tax payments and s_D is price indexed deductions as share of total tax payments. We construct a common specification that captures all three tax systems:

$$T\hat{a}x_j = s_\tau \hat{w}_j - s_D \hat{p}_j$$

where the parameters s_τ and s_D are used to distinguish between nominal income taxation $(s_\tau > 1, s_D = 0)$, real income taxation $(s_\tau > 1, s_D > 0)$ and horizontal equitable taxation $(s_\tau = 0, s_D = -1)$. Section 3 elaborates the calibration, while the complete log-linearized model is shown in Appendix A.

3. Data and calibration

The calibration of the model is based on Norwegian data for wages, housing costs, taxes and population across 89 labor market regions, together with data and stylized facts of model parameters.

The regional housing costs are estimated from data on house transactions. The transaction data base of Statistics Norway contains information on all house transactions with the exception of transactions administered by the housing co-operatives. Data for about 427 000 house transactions are available for the period 2005-2010. The regression model assumes that the transaction price is a function of housing attributes (square meters, square meters squared, age of house, type of house, type of ownership, number of rooms, and other characteristics) and a full set of regional fixed effects. The econometric model is explained in more detail by Carlsen and Leknes (2015). The estimated fixed effects, adjusted to make their mean equal to the national mean price level, are taken to represent the housing price level of the respective regions. The estimated model is documented in Appendix B. The housing price is increasing in size, declining in age, increasing in number of rooms, and affected by type of house and type of ownership.

The regional wage levels are estimated from administrative register data. The dataset covers all full-time workers in the private sector aged 25-65 during 2001-2010, which includes about 6.5 million worker-year observations. The heterogeneity of the population represents an important challenge in the estimation of regional wages, and geographical sorting may introduce measurement errors. We exploit the panel dimension of the data, and use movements between regions to control for unobservable worker characteristics. The hedonic regression of hourly wages includes a set of worker observables (work experience, education, age) together with regional, worker, sector and year fixed effects. The econometric model is fully explained by Carlsen et al. (2013). The estimated regional fixed effects, adjusted to represent annual wages, are our measure of regional wages. The estimated model for regional wages is documented in Appendix B.

Taking into account deductions and progressivity in the current income tax system, nominal tax payments are given as (based on 2010 values):

$$Tax_j = 0.28(w_j - 115010) + 0.09(w_j - 456400) + 0.078 w_j$$

$$= 0.448 w_j - 73279$$

The income tax has fixed nominal deductions, NOK 115.010 for the basic 28% income tax and NOK 456.400 for the top 9% income tax.[1] Wages above this level are taxed at nominal values. In addition there is a social security tax of 7.8%. This gives a tax rate of 44.8% $(\tau = 0.448)$ and total deductions of NOK 73.279 $(D = 73279)$. Nominal tax payments then follow directly from the wage data, and post-tax income is calculated under the assumption that wages account for 75% of total income. The payroll tax is differentiated across five geographic zones and we use the actual rates as of 2010 to find total wage costs. The regional population data is also from the year 2010.

The 89 regions investigated show large differences in population size and housing costs, but only small differences in wages and post-tax income. The data are presented in Table 1, and we have ranked the top 10 and bottom 10 regions with respect to the aggregate price index. The highest housing costs are found in the large city regions, notably around the capital Oslo. The rich Asker/Bærum region west of Oslo has housing costs 77% above the national geometric average, while Oslo city has a premium of 70%. The three large city regions outside the Oslo area are Stavanger/Sandnes (‘the oil capital’), Bergen and Trondheim. They

[1] The five most Northern labor market regions have lower tax rates and larger deductions, but this is ignored in order to focus on the effect of the tax system.

all have a premium of 50% or more compared to the geometric average. At the other end of the distribution we find the smallest regions in the periphery, the bottom part of Table 1. The smallest, Grong, has housing costs 80% below the national average. Several of the other small periphery regions have housing costs 50% or more below the average.

Table 1 Population, wage, post-tax income, housing costs, nominal tax burden, calibrated quality of life and calibrated traded productivity

Region	Population	Wages	Post-tax income	Housing cost	Nom tax burden	Quality of life	Traded productivity
Asker/Bærum	165 836	0.06	0.03	0.77	0.08	0.13	0.15
Oslo	586 860	0.06	0.03	0.70	0.09	0.11	0.15
Stavanger/Sandnes	254 042	0.05	0.03	0.60	0.07	0.10	0.13
Tromsø	80 231	0.00	0.00	0.55	0.01	0.11	0.04
Follo	115 634	0.05	0.03	0.55	0.07	0.09	0.12
Bergen	392 156	0.02	0.01	0.52	0.03	0.10	0.10
Trondheim	228 071	0.01	0.00	0.50	0.01	0.10	0.08
Kristiansand	110 860	0.01	0.01	0.47	0.02	0.09	0.08
Lillestrøm	191 708	0.04	0.02	0.43	0.06	0.07	0.10
Jæren	49 337	0.04	0.02	0.34	0.06	0.05	0.09
Andselv	14 832	0.02	0.01	-0.37	0.03	-0.09	-0.06
Rørvik	9 705	-0.01	-0.01	-0.37	-0.02	-0.07	-0.09
Midt-Gudbrandsdalen	13 515	0.00	0.00	-0.38	0.00	-0.08	-0.04
Brekstad	14 921	-0.02	-0.01	-0.40	-0.03	-0.07	-0.07
Vest-Telemark	14 251	-0.03	-0.02	-0.45	-0.04	-0.08	-0.07
Tynset	15 302	-0.03	-0.02	-0.46	-0.04	-0.08	-0.10
Odda	12 423	0.01	0.00	-0.53	0.01	-0.12	-0.05
Høyanger	8 769	-0.01	-0.01	-0.53	-0.02	-0.10	-0.06
Rjukan	6 022	0.01	0.01	-0.71	0.02	-0.15	-0.07
Grong	5 219	-0.04	-0.02	-0.80	-0.06	-0.15	-0.15

Note: The table illustrates the top and bottom 10 regions based on the initial price index. The population data is from 2010. Data on wages and housing costs are based on hedonic regressions, as documented in Appendix B. Quality of life and traded sector productivity are calibrated from the model based on the wage, tax and housing cost data. All variables (except the population level) are measured as percentage deviation from the national geometric average (approximated by log differentials).

Interestingly, the differences in wages are much smaller. When observable and unobservable heterogeneities are taken out of the hedonic wage equations, the large cities have a wage level of only 6% above average, while the periphery regions are up to 4% below. The differences are a bit larger in wage costs, since the cities pay higher payroll tax. Taking this into account the wage cost differences are spelled out in the range 12% below to 10% above the average. Since regions with relatively higher nominal wages also pay more in taxes, the differences in post-tax income are negligible. The largest city-regions are at most 3% above the average, and the periphery regions are only close to or slightly below the average.

The model parameters are set based on available data and stylized facts. Taxes net of deductions relative to total tax payments (s_τ), wages as share of post-tax income (s_w) and tax payments as share of post-tax income (s_{Tax}) are all calculated from our data based on average values across regions. In the base run scenario with nominal income taxation the parameter s_D equals zero. The expenditure share for housing (γ) is set consistent with Norwegian data from 2004 and equals about 20%. The aggregate price index then follows from the regional housing cost data. The substitution elasticities in consumption, traded goods production and housing production are all set equal to 0.3, while key production parameters are based on Albouy and Stuart (2014). The values of all parameters are documented in Appendix C.

To establish the full equilibrium of the model the remaining variables are calibrated based on the model equations given in Appendix A. We do not have data on land rent $(\hat{r}_j)$, so this variable is calculated from equation (A7) under the assumption that productivity in the housing sector is equal across regions $(\hat{A}_{Y,j} = 0)$. The exogenous levels of quality of life $(\hat{Q}_j)$ and traded sector productivity $(\hat{A}_{X,j})$ follow from equations (A4) and (A6), respectively. The rest of the calibration is described in detail in Appendix C.

4. Allocation effects of tax reform

The calibrated quality of life shown in Table 1 is higher in the cities in the upper panel compared to the periphery regions in the lower panel. Quality of life is about 10 percent above the average in the top 10 regions and approximately 10 percent below the average in the bottom 10. The urban-rural differences in quality of life reflect a situation with higher traded sector productivity and housing costs in the cities and fairly equalized wages. The migration equilibrium 'requires' high quality of life to balance utility levels. The details investigated by Stokke (2015) show that the correlation between traded sector productivity and quality of life is positive. Large city regions have high productivity and amenity value, while small periphery regions score low on both dimensions. Norway seems to lack the consumer attractive regions where people want to live, but industry is disadvantaged. And more surprisingly, high productivity regions of low popularity among the public are also lacking.

Table 2 From nominal income taxation to real income taxation: Impact on nominal and real tax burden, population, housing cost and post-tax income.

Eliminating the cost of living distortion Nominal income taxation → Real income taxation					
		%-point change in deviation from national average:			
Region	% change in pop level	Nom tax burden	Real tax burden	Housing cost	Post-tax income
Asker/Bærum	7.1	-9.3	-11.1	8.3	1.7
Oslo	6.1	-8.5	-10.1	7.5	1.6
Stavanger/Sandnes	4.5	-7.3	-8.6	6.4	1.3
Tromsø	3.8	-6.8	-8.0	6.0	1.2
Follo	3.8	-6.8	-8.0	6.0	1.2
Bergen	3.3	-6.3	-7.5	5.6	1.2
Trondheim	3.0	-6.0	-7.2	5.3	1.1
Kristiansand	2.6	-5.8	-6.9	5.1	1.1
Lillestrøm	1.9	-5.2	-6.2	4.6	1.0
Jæren	0.6	-4.2	-4.9	3.7	0.8
Andselv	-9.3	4.5	5.3	-4.0	-0.8
Rørvik	-9.4	4.6	5.4	-4.0	-0.8
Midt-Gudbrandsdalen	-9.5	4.7	5.5	-4.1	-0.9
Brekstad	-9.7	4.9	5.8	-4.3	-0.9
Vest-Telemark	-10.3	5.4	6.4	-4.8	-1.0
Tynset	-10.5	5.6	6.6	-4.9	-1.0
Odda	-11.5	6.5	7.7	-5.7	-1.2
Høyanger	-11.5	6.5	7.7	-5.7	-1.2
Rjukan	-13.7	8.6	10.2	-7.6	-1.6
Grong	-14.9	9.8	11.6	-8.7	-1.8

Note: The table illustrates the top and bottom 10 regions based on the initial price index. The first column gives the percentage change in the population level, while the last four columns give the percentage point change in the percentage deviation from the national geometric average for nominal tax burden, real tax burden, housing cost and post-tax income, respectively.

The analysis of real taxation is shown in Table 2 and is reported for the top 10 and bottom 10 regions with respect to the initial price index. Starting out from regional allocation equilibrium with nominal taxes, we report the changes in tax burden, post-tax income, housing costs and population size in the regions. The initial nominal price differences are quite large, with the Oslo area more than 20% above the national average and the smallest periphery region with a price index of 88% of the average.

The real tax burden is reduced by about 10% in the rich Asker/Bærum and Oslo regions with real taxation, while it increases by 5-7% in the smallest periphery regions. The population responds to the changes in taxation and broadly migration increase from the periphery regions to the large cities. Given the elasticities assumed, the responses are quite large with a drop in population size of about 10% in the smallest regions and an increase of population in the largest regions of about 5%. The migration leads to larger differences in housing costs, and the size of the effects is similar to the shifts in population. It follows that the model implies an elasticity of about 1 for housing prices with respect to population. The change in the post-tax income is smaller since changes in tax burden and nominal wages work in opposite directions.

Real income taxation is to the advantage of the large city regions. The tax burden is reduced in the large cities and they expand with population inflow. As argued in the introduction, the real taxation model does not take into account the variation in quality of life. We modify the analysis so that we also address the second source of distortion of the nominal tax system, the variation in quality of life internalized in horizontal equitable taxation. The calculation assumes that all of quality of life is accounted for in this tax reform. The real tax burden is set equal across all regions. The horizontal equitable tax generates a reallocation of the population and adjustment of housing costs and wages to a new equilibrium.

The modification of the regional allocation moving from real taxation to horizontal equitable taxation is shown in Table 3. Since quality of life is much higher in the large city regions, the reallocation and price adjustment effects are quite large. The increases in the tax burden are in the order of 12-15% in the largest cities with approximately same size shifts downwards in housing costs. The periphery regions gain population of 20% and more and experience higher housing costs and post-tax income levels.

Table 3 From real income taxation to horizontal equitable taxation: Impact on nominal and real tax burden, population, housing cost and post-tax income.

Eliminating the quality of life distortion Real income taxation → Horizontal equitable taxation					
		%-point change in deviation from national average:			
Region	% change in pop level	Nom tax burden	Real tax burden	Housing cost	Post-tax income
Asker/Bærum	-10.7	15.7	18.6	-13.9	-2.9
Oslo	-7.7	13.0	15.4	-11.5	-2.4
Stavanger/Sandnes	-6.4	11.8	14.0	-10.4	-2.2
Tromsø	-11.0	15.9	18.8	-14.1	-2.9
Follo	-5.1	10.7	12.6	-9.4	-2.0
Bergen	-7.7	12.9	15.3	-11.4	-2.4
Trondheim	-8.4	13.6	16.1	-12.0	-2.5
Kristiansand	-7.5	12.8	15.1	-11.3	-2.4
Lillestrøm	-1.3	7.4	8.7	-6.5	-1.4
Jæren	1.7	4.9	5.8	-4.3	-0.9
Andselv	26.6	-13.3	-15.7	11.7	2.4
Rørvik	20.8	-9.4	-11.1	8.3	1.7
Midt-Gudbrandsdalen	23.0	-10.9	-12.9	9.6	2.0
Brekstad	20.3	-9.1	-10.7	8.0	1.7
Vest-Telemark	21.3	-9.8	-11.6	8.6	1.8
Tynset	21.5	-9.9	-11.7	8.7	1.8
Odda	32.0	-16.8	-19.8	14.8	3.1
Høyanger	28.2	-14.4	-17.0	12.7	2.6
Rjukan	41.2	-22.4	-26.4	19.7	4.1
Grong	35.4	-18.9	-22.3	16.7	3.5

Note: The table illustrates the top and bottom 10 regions based on the initial price index. The first column gives the percentage change in the population level, while the last four columns give the percentage point change in the percentage deviation from the national geometric average for nominal tax burden, real tax burden, housing cost and post-tax income, respectively.

The net effect of handling both distortions is shown in the comparison of nominal taxation and horizontal equitable taxation in Table 4. The equilibrium adjustment implies that households relocate away from the largest cities, as shown in column 1 of Table 4. The eight largest cities loose population in the order of 2-5%. On the other hand, the four smallest periphery regions with low quality of life gain population of about 15-20%.

Table 4 From nominal income taxation to horizontal equitable taxation: Impact on nominal and real tax burden, population, housing cost and post-tax income.

Eliminating both cost of living and quality of life distortions Nominal income taxation → Horizontal equitable taxation					
		%-point change in deviation from national average:			
Region	% change in pop level	Nom tax burden	Real tax burden	Housing cost	Post-tax income
Asker/Bærum	-4.4	6.4	7.5	-5.6	-1.2
Oslo	-2.1	4.4	5.3	-3.9	-0.8
Stavanger/Sandnes	-2.2	4.5	5.3	-4.0	-0.8
Tromsø	-7.5	9.2	10.8	-8.1	-1.7
Follo	-1.5	3.9	4.6	-3.4	-0.7
Bergen	-4.6	6.6	7.8	-5.8	-1.2
Trondheim	-5.7	7.6	8.9	-6.7	-1.4
Kristiansand	-5.1	7.0	8.3	-6.2	-1.3
Lillestrøm	0.6	2.1	2.5	-1.9	-0.4
Jæren	2.4	0.7	0.9	-0.6	-0.1
Andselv	14.8	-8.8	-10.4	7.8	1.6
Rørvik	9.5	-4.9	-5.7	4.3	0.9
Midt-Gudbrandsdalen	11.4	-6.3	-7.4	5.5	1.2
Brekstad	8.6	-4.2	-4.9	3.7	0.8
Vest-Telemark	8.8	-4.3	-5.1	3.8	0.8
Tynset	8.7	-4.3	-5.1	3.8	0.8
Odda	16.8	-10.3	-12.1	9.1	1.9
Høyanger	13.5	-7.9	-9.3	7.0	1.5
Rjukan	21.8	-13.7	-16.2	12.1	2.5
Grong	15.2	-9.1	-10.7	8.0	1.7

Note: The table illustrates the top and bottom 10 regions based on the initial price index. The first column gives the percentage change in the population level, while the last four columns give the percentage point change in the percentage deviation from the national geometric average for nominal tax burden, real tax burden, housing cost and post-tax income, respectively.

The households try to get away from the higher income tax in the large cities, but still both the nominal and the real tax burden increase in these cities, as shown in columns 2 and 3. The rural regions receiving the migrating households will have reduced tax burdens. Furthermore, the equilibrium household flows will be associated with lower housing costs and lower wages in the large cities, while housing costs and wages go up in the periphery regions. The net effect of handing the two distortions compared to nominal taxation is to the disadvantage of large city regions. The analysis does not offer a complete evaluation of the income system. In future extension of this work we will study the handling of housing consumption in the income tax system and expect this to be to the disadvantage of large cities.

5. Concluding remarks

Regional wage and price levels vary across regions reflecting underlying productivities and amenities. In a perfect competition economy with perfect mobility, the allocation of capital and employment across regions will be efficient. The tax system may distort this regional allocation and lead to welfare costs. A nominal tax system distorts incentives to the disadvantage of high-cost regions. The incentive problem can be addressed by real income taxation internalizing cost of living differences. Another possible source of misallocation is the handling of amenities. High quality of life allows for lower wages in migration equilibrium and may distort resource allocation to the disadvantage of low amenity regions. A system of taxation based on horizontal equity takes the variation in both cost of living and quality of life into account. The paper offers an analysis of real income taxation and horizontal equitable taxation in a calibrated migration equilibrium model capturing the basics of the Norwegian income tax system. In the Norwegian data there is positive correlation between quality of life and productivity, and cost of living is highest in the large city regions. In this situation real income taxation is to the advantage of large city regions. When both distortions are taken into account, horizontal equitable taxation, the resource allocation shifts towards periphery regions. The handling of the two types of distortions has important and opposite effects for the resource allocation across regions when amenities and cost of living are positively correlated as shown in Norway.

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Appendix A: Complete log-linearized version of the model

$$(1-\gamma)\hat{x}_j + \gamma(\hat{p}_{H,j} + \hat{y}_j) = s_w \hat{w}_j - s_{Tax} T\hat{a}x_j \tag{A1}$$

$$\hat{p}_j = \frac{\gamma}{\overline{p}} \hat{p}_{H,j} \tag{A2}$$

$$\hat{x}_j - \hat{y}_j = \sigma_C \hat{p}_{H,j} \tag{A3}$$

$$\gamma \hat{p}_{H,j} - s_w \hat{w}_j + s_{Tax} T\hat{a}x_j = \hat{Q}_j \tag{A4}$$

$$T\hat{a}x_j = s_\tau \hat{w}_j - s_D \hat{p}_j \tag{A5}$$

$$\alpha_1 \hat{r}_j + (1-\alpha_1-\alpha_2)(\hat{w}_j + \hat{b}_j) = \hat{A}_{X,j} \tag{A6}$$

$$\beta_1 \hat{r}_j + (1-\beta_1-\beta_2)(\hat{w}_j + \hat{b}_j) - \hat{p}_{H,j} = \hat{A}_{Y,j} \tag{A7}$$

$$\hat{L}_j = \lambda_L \hat{L}_{X,j} + (1-\lambda_L)\hat{L}_{Y,j} \tag{A8}$$

$$\hat{K}_j = \lambda_K \hat{K}_{X,j} + (1-\lambda_K)\hat{K}_{Y,j} \tag{A9}$$

$$\hat{N}_j = \lambda_N \hat{N}_{X,j} + (1-\lambda_N)\hat{N}_{Y,j} \tag{A10}$$

$$\hat{N}_j + \hat{y}_j = \hat{Y}_j \tag{A11}$$

$$\hat{L}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + (1-\alpha_1-\alpha_2)\sigma_X(\hat{w}_j + \hat{b}_j - \hat{r}_j) - \alpha_2\sigma_X \hat{r}_j \tag{A12}$$

$$\hat{K}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + \alpha_1\sigma_X \hat{r}_j + (1-\alpha_1-\alpha_2)\sigma_X(\hat{w}_j + \hat{b}_j) \tag{A13}$$

$$\hat{N}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + \alpha_1\sigma_X(\hat{r}_j - \hat{w}_j) - \alpha_2\sigma_X \hat{w}_j - (\alpha_1+\alpha_2)\sigma_X \hat{b}_j \tag{A14}$$

$$\hat{L}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + (1-\beta_1-\beta_2)\sigma_Y(\hat{w}_j + \hat{b}_j - \hat{r}_j) - \beta_2\sigma_Y \hat{r}_j \tag{A15}$$

$$\hat{K}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + \beta_1 \sigma_Y \hat{r}_j + (1-\beta_1-\beta_2)\sigma_Y (\hat{w}_j + \hat{b}_j) \quad \text{(A16)}$$

$$\hat{N}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + \beta_1 \sigma_Y (\hat{r}_j - \hat{w}_j) - \beta_2 \sigma_Y \hat{w}_j - (\beta_1+\beta_2)\sigma_Y \hat{b}_j \quad \text{(A17)}$$

Appendix B: Hedonic regressions behind the regional measures of wages and housing costs

Appendix Table 1 Estimation of regional wages

	Log hourly wage
Experience	0.08***
	(0.0003)
(Experience)^2	-0.001***
	(0.0000)
Experience cities	0.011***
	(0.0002)
(Experience cities)^2	-0.000***
	(0.0000)
Experience cities x now in smaller	-0.000
	(0.0002)
Experience high wage sector	0.005***
	(0.0004)
(Experience high wage sector)^2	-0.000***
	(0.0000)
Experience high wage sector in cities	0.003***
	(0.0003)
Secondary education	0.021***
	(0.0019)
Tertiary education	0.119***
	(0.0029)
Regional indicators	Yes
Worker fixed effects	Yes
Year fixed effects	Yes
Sector fixed effects	Yes
High wage sector x Year fixed effects	Yes
Age controls	Yes
Observations	6 512 359

Notes: The regression is based on yearly data for all full time workers in the private sector during 2001-2010. Sector fixed effects are at the 2-digit level and include 54 sectors. Regional indicators are at the NUTS-4 level, and correspond to 89 labor market regions. The age controls are given as 5-year intervals. Work experience is calculated in days from 1993 onwards, and expressed in years. We separate between city regions and the rest. The city group is defined as regions with more than 150 000 inhabitants in 2010, which includes 7 regions. We also separate out the top 10 high wage sectors based on fixed sectoral effects. Standard errors are given in parenthesis. *** indicates significance at the 1 percent level. The regression includes a constant term.

Appendix Table 2 Estimation of regional housing costs

	Log housing costs
Size (in square meters)	0.002***
	(0.0000)
Size squared	-0.000***
	(0.0000)
Gross size	0.002***
	(0.0000)
Gross size squared	-0.000***
	(0.0000)
Age of house	
1-5 years	-0.064***
	(0.0055)
6-10 years	-0.107***
	(0.0061)
11-20 years	-0.214***
	(0.0057)
21-30 years	-0.303***
	(0.0056)
31-50 years	-0.354***
	(0.0053)
51-100 years	-0.323***
	(0.0054)
> 100 years	-0.237***
	(0.006)
Type of house	
Detached	0.13***
	(0.0129)
Semi-detached	0.125***
	(0.0133)
Townhome	0.125***
	(0.0132)
Apartment	0.125***
	(0.013)
Multi-family residential/Apartment building	0.311***
	(0.0336)
Farm	0.155***
	(0.0183)
Type of ownership	
Share	-0.172***
	(0.002)
Stock	-0.033***
	(0.0052)
Bond	-0.664***
	(0.047)
Other	-0.161***
	(0.0285)

The table continues on the next page

	Log housing costs
No. of rooms	
2	0.241***
	(0.0061)
3	0.263***
	(0.0061)
4	0.295***
	(0.0064)
5	0.313***
	(0.007)
≥ 6	0.352***
	(0.0073)
Regional indicators	Yes
Monthly dummies	Yes
R^2	0.41
Observations	427 184

Notes: The regression is based on 427 184 house transactions during 2005-2010. Regional indicators are at the NUTS-4 level, and correspond to 89 labor market regions. The reference category for age of house, type of house and type of ownership is 0 years, other house types, and owner, respectively. The regression also controls for floor, number of bedrooms, whether the house has been renovated, whether it has a balcony, boat place, carport, fireplace, common washroom, garden, elevator and owned plot. Standard errors are given in parenthesis. *** indicates significance at the 1 percent level. The regression includes a constant term.

Appendix C: Parameter values and model calibration

As described in section 3, the model calibration is based on Norwegian data for wages, housing costs, taxes and population across 89 labor market regions, together with data and stylized facts on model parameters. Values for all parameters are given in Appendix Table 3 below.

To establish the full equilibrium of the model the remaining variables are calibrated based on the model equations given in Appendix A. The price index $(\hat{p}_j)$ and nominal tax payments $(T\hat{a}x_j)$ follow directly from equations (A2) and (A5), respectively. We do not have data on land rent $(\hat{r}_j)$, so this variable is calculated from equation (A7) under the assumption that productivity in the housing sector is equal across regions $(\hat{A}_{Y,j} = 0)$. The exogenous levels of quality of life $(\hat{Q}_j)$ and traded sector productivity $(\hat{A}_{X,j})$ follow from equations (A4) and (A6), respectively. We can then use equations (A1) and (A3) to solve for per capita consumption of traded goods and housing ($\hat{x}_j$ and $\hat{y}_j$, respectively). Given our data on regional population size (N_j) housing production ($\hat{Y}_j$) follows from (A11). Factor use in the housing sector $(\hat{L}_{Y,j}, \hat{K}_{Y,j}, \hat{N}_{Y,j})$ is calibrated from equations (A15) – (A17). Labor demand in the traded sector $(\hat{N}_{X,j})$ follows from equation (A10), and traded production $(\hat{X}_j)$ from equation (A14). Land and capital use in the traded sector $(\hat{L}_{X,j}, \hat{K}_{X,j})$ are calibrated based on equations (A12) and (A13). Finally, total supply of land and capital in region *j* ($\hat{L}_j$, $\hat{K}_j$) follow from equations (A8) and (A9).

Appendix Table 3 Calibrated model parameter values

Parameter	Description	Value
s_τ	Taxes net of deductions relative to total tax payments	1.432
s_w	Wages as share of post-tax income	0.98
s_{Tax}	Tax payments as share of post-tax income	0.3066
s_D	Price indexation of taxes	0
γ	Expenditure share for housing	0.2087
σ_C	Elasticity of substitution in consumption	0.3
σ_X	Elasticity of substitution in traded goods production	0.3
σ_Y	Elasticity of substitution in housing production	0.3
α_1	Traded sector cost share of land	0.025
α_2	Traded sector cost share of capital	0.15
β_1	Housing sector cost share of land	0.233
β_2	Housing sector cost share of capital	0.15
λ_L	Share of land used in traded goods production	0.17
λ_N	Share of labor used in traded goods production	0.7
λ_K	Share of capital used in traded goods production	0.7913
$\overline{p}$	Geometric average of the price index	1.0077
τ	Marginal tax rate	0.448
D	Deductions	73279

Note: The parameters s_τ and s_D are used to capture different tax systems. The base run values correspond to nominal wage taxation. See further descriptions in section 2.

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