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National Income Taxation and the Geographic Distribution of Population

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National Income Taxation and the Geographic Distribution of Population

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Abstract

Income taxation may affect the regional allocation of population when prices vary over space. Our contribution is to compare different income tax systems in a migration equilibrium model for Norway using improved measure of regional wage differences. We apply register data of individual wages for the entire population to identify wage differences, while controlling for both observable and unobservable worker characteristics and allowing for dynamic learning effects on wages. We estimate regional differences in cost of living based on detailed data on housing prices. The model is calibrated to the current nominal income tax system and compared to an undistorted equilibrium without income tax. We investigate two alternative tax systems: Real income taxation where the real tax burden is proportional to real wages and equal real taxes across regions motivated by taxation of amenities. The numerical simulations document large shifts in the regional distribution of the population as the result of income taxation. The elasticity of population with respect to tax payments comes out with a value of -2.64. Nominal income taxation creates a disincentive to locate in productive high-wage regions, and generates a deadweight loss due to locational inefficiencies equal to 0.028% of income. Real income taxation gives a geographic distribution of the population closer to the undistorted equilibrium, and hence with lower deadweight loss, while equal real taxes is the least efficient tax system.

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1. Introduction

National income taxes may influence the geographic distribution of population. The variation in regional wage and price levels reflects underlying productivities and amenities, and the handling of price variation in the tax system may affect households' choice of location. Most countries have nominal tax systems and the real tax burden depends on regional price and wage levels. In this situation, income taxes may distort the allocation of the population to the disadvantage of high-cost regions.

Our contribution is to study the quantitative importance of national income taxation for the regional distribution of the population. The research is an extension of the Albouy (2009) analysis of the effects of the US income tax system. The methodological approach is the same; calibration of a neoclassical migration equilibrium model based on micro data, in this case for Norway. We calibrate the model to the current nominal income tax system and compare with an undistorted equilibrium without income tax. We investigate two alternative tax systems: Real income taxation where the real tax burden is proportional to real wages and equal real taxes motivated by taxation of amenities and equalized utilities.

Only a limited literature has dealt with regional tax distortions. The income tax distortions generated by nominal price variation are discussed as a problem of cost of living adjustment. Interesting contributions are Kaplow (1996), Knoll and Griffith (2003) and Puckett (2012). 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 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 addresses 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.

We apply the neoclassical general equilibrium migration model developed by Albouy and associates, notably Albouy and Stuart (2014), but also Albouy (2012) and Albouy et al. (2013). The framework has primarily been used to value the bundle of consumption amenities across locations. Rappaport (2008) develops a similar model to determine

consumption amenities. Albouy and Hanson (2014) apply the model to analyze taxation of housing. The core of the migration equilibrium models in the Rosen (1979) – Roback (1982) tradition captures the equalization of utilities across regions and the determination of wage and price levels by amenities and productivities. 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 model is calibrated to capture basic aspects of the regional variation of wages and house prices and the income tax system in Norway. The full equilibrium of the distribution of population in 89 labor market regions is established. The quantitative effects of income taxation are worked out in counterfactual analyses. First, we compare with an undistorted zero income tax equilibrium and calculate deadweight losses of the three alternative income tax systems. Second, we discuss the consequences of tax reform moving from nominal income taxation to real income taxation and equal real taxes.

We benefit from detailed register data of individual wages and housing prices to identify regional differences in wages and cost of living. The heterogeneity of the population and endogenous sorting represents an important challenge in the identification of regional wage differences. Albouy (2009) controls for observable worker characteristics, while we also include unobservable worker characteristics (identification based on movers) and allow dynamic learning effects from work experience to vary across regions (as emphasized by De la Roca and Puga, 2015). In this way, the analysis captures the agglomeration effects contributing to regional wage differences. While the raw wage differences between rural and urban regions are large (urban more than 30% higher wages than rural), a large part of the wage gap disappears when we control for observable and unobservable (individual fixed effects) characteristics of the workers, while higher learning effects in cities add to the differences.

The data for Norway indicate small regional wage differences, large differences in housing prices and even larger differences in population size. In this setting, changes in prices may give large changes in the geographic distribution of population. The calibration comes out with an elasticity of population with respect to the income tax burden of -2.64. There is positive correlation between the calibrated regional measures of quality of life and

productivity. Wages and cost of living are highest in the large city regions, and consequently, they pay higher taxes in the current nominal income tax system. This distorts incentives to the disadvantage of productive high-wage cities, and generates a deadweight loss equal to 0.028% of income. Real income taxation internalizing cost of living differences, gives a regional allocation of the population closer to the undistorted equilibrium, and is hence more efficient than the current tax system.

The handling of amenities in the tax system is an old debate related to horizontal equity, and represents a potential source of tax distortion between regions when they affect the wage level. High quality of life allows for lower wages in migration equilibrium and income taxation may distort the allocation of population to the disadvantage of low amenity regions. It should be noticed that amenities not necessarily produce a tax distortion. If amenities are fully capitalized into land/housing prices, there are no regional disincentives of nominal income taxes. The details are elaborated by Knoll and Griffith (2003, section VII). In our simple model of homogenous population and migration equilibrium with uniform utility level, horizontal equity is obtained by equal real taxes across regions. The analysis shows that the population shifts to low productivity regions and the deadweight loss increases significantly.

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 of tax differentials and deadweight losses is covered in section 4. Section 5 offers concluding remarks.

2. The model

The neoclassical migration equilibrium model is the analytical framework used to analyze the geographic distribution of population. Earlier versions include Haughwout and Inman (2001), Rappaport (2008) and Albouy (2009). The model outlined by Albouy and Stuart (2014) is our starting point. They present the model at both level and log-linearized form and solve for the relationship between population, quality of life and productivity. Our contribution is to add alternative income tax systems. We work with the log-linearized version of their model, adding income tax structures, and simulate alternative tax designs based on similar

parameterization. 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 Albouy-Stuart model is given in section 2.1, while the added tax systems are outlined in section 2.2.

2.1 The basics of the migration equilibrium model

The model addresses the distribution of population across multiple regions in migration equilibrium. The population is homogenous and mobile. The production is divided between two sectors; traded goods and housing.¹ 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. 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). The budget constraint equalizes consumption expenditures with post-tax income. The traded good is the numeraire with price equal to unity in all regions, while the housing price ($p_{H,j}$) is endogenous and varies across regions. Post-tax income consists of wages (w_j) and income from land and capital, adjusted for nominal tax payments (Tax_j). Taxes depend on the chosen tax system, as further described in section 2.2. Land and capital income is equal across regions, while post-tax income varies as wages and tax payments vary. In log-differential form, the budget constraint is given as:

$$(1-\gamma)\hat{x}_j + \gamma(\hat{p}_{H,j} + \hat{y}_j) = s_w\hat{w}_j - s_{Tax}Tax_j \quad (1)$$

where s_w and s_{Tax} represent wages and tax payments, respectively, as shares of post-tax income, and γ is the budget share for housing.

¹ The traded sector includes non-traded goods other than housing.

The aggregate price index (p_j) measures the region's cost of living and is a weighted average of the housing price and the traded sector price, with budget shares as weights. Since the traded price is equal across regions, the log-differential of the aggregate price index is proportional to the housing price differential:

$$\hat{p}_j = \frac{\gamma}{\bar{p}} \hat{p}_{H,j} \quad (2)$$

where \bar{p} is the national geometric average of the price index.

Since households are fully mobile, the utility level is equalized across regions. 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 (with σ_c as the elasticity of substitution between the two goods):

$$\hat{x}_j - \hat{y}_j = \sigma_c \hat{p}_{H,j} \quad (3)$$

Inserting the demand functions into $e_j = x_j + p_{H,j}y_j$ gives the expenditure function, which must equal post-tax income. The migration equilibrium condition in log-linearized form follows as:

$$\gamma \hat{p}_{H,j} - s_w \hat{w}_j + s_{tax} Tax_j = \hat{Q}_j \quad (4)$$

Cost of living, wages, taxes and quality of life vary across regions, but in migration equilibrium the utility level is the same everywhere. Higher cost of living or lower quality of life is compensated with higher post-tax income.

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 total output of traded goods (X_j) depending on inputs of land ($L_{X,j}$), capital ($K_{X,j}$) and labor ($N_{X,j}$) along with traded sector productivity ($A_{X,j}$). Housing supply is represented by Y_j and factor inputs and productivity in the housing sector is denoted with subscript Y . 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:

$$\hat{L}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + \theta_N \sigma_X (\hat{w}_j + \hat{b}_j - \hat{r}_j) - \theta_K \sigma_X \hat{r}_j \quad (5)$$

$$\hat{K}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + \theta_L \sigma_X \hat{r}_j + \theta_N \sigma_X (\hat{w}_j + \hat{b}_j) \quad (6)$$

$$\hat{N}_{X,j} = \hat{X}_j - \hat{A}_{X,j} + \theta_L \sigma_X (\hat{r}_j - \hat{w}_j) - \theta_K \sigma_X \hat{w}_j - (\theta_L + \theta_K) \sigma_X \hat{b}_j \quad (7)$$

$$\hat{L}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + \phi_N \sigma_Y (\hat{w}_j + \hat{b}_j - \hat{r}_j) - \phi_K \sigma_Y \hat{r}_j \quad (8)$$

$$\hat{K}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + \phi_L \sigma_Y \hat{r}_j + \phi_N \sigma_Y (\hat{w}_j + \hat{b}_j) \quad (9)$$

$$\hat{N}_{Y,j} = \hat{Y}_j - \hat{A}_{Y,j} + \phi_L \sigma_Y (\hat{r}_j - \hat{w}_j) - \phi_K \sigma_Y \hat{w}_j - (\phi_L + \phi_K) \sigma_Y \hat{b}_j \quad (10)$$

The factor prices for land and labor are given by r_j and $b_j w_j$, respectively, where b_j equals one plus the payroll tax rate (which differs across regions). The capital price is the same in all regions and drops out of the log-linearized version of the model. In the traded sector, cost shares of land, capital and labor are given by θ_L , θ_K and θ_N . Similar cost shares in the housing sector are represented by ϕ_L , ϕ_K and ϕ_N . Substitution elasticities are set equal between all factors of production and are given by σ_X and σ_Y in the traded and housing sector, respectively.

Combining the first order conditions gives the unit cost functions, which must equal the price level of the sector. In log-differential form, these zero-profit conditions are given as:

$$\theta_L \hat{r}_j + \theta_N (\hat{w}_j + \hat{b}_j) = \hat{A}_{X,j} \quad (11)$$

$$\phi_L \hat{r}_j + \phi_N (\hat{w}_j + \hat{b}_j) - \hat{p}_{H,j} = \hat{A}_{Y,j} \quad (12)$$

For given output prices, firms in high-productive regions pay higher land rents and wages.

Factor market clearing is given by:

$$\hat{L}_j = \lambda_L \hat{L}_{X,j} + (1 - \lambda_L) \hat{L}_{Y,j} \quad (13)$$

$$\hat{K}_j = \lambda_K \hat{K}_{X,j} + (1 - \lambda_K) \hat{K}_{Y,j} \quad (14)$$

$$\hat{N}_j = \lambda_N \hat{N}_{X,j} + (1 - \lambda_N) \hat{N}_{Y,j} \quad (15)$$

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 with aggregate housing demand:

$$\hat{N}_j + \hat{y}_j = \hat{Y}_j \quad (16)$$

2.2 Alternative tax systems

To concentrate on the allocation of the population responding to income tax designs, we assume that the tax revenue finances a national collective good that does not influence the rest of the economy. In this case, lump sum taxes with no tax distortions are equivalent to zero income tax. We concentrate on the basics of the income tax system including deductions and progressivity. How would the population be distributed geographically without tax distortions? The base run scenario is nominal income taxation, where tax payments are given by $Tax_j = \mu w_j - D$, with μ as the marginal tax rate and D representing nominal deductions (both equal across regions). 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 higher nominal wages and higher housing costs pay more in taxes. To quantify the misallocation of the population with the current nominal income tax system we compare with the case where the tax rate and deductions are zero.

The first alternative tax system is real wage taxation, which relates real tax payments to real wages. Nominal tax payments are adjusted for cost of living differences through price-indexed deductions; $Tax_j = \mu w_j - D p_j$. 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. The second alternative tax system assumes equal real tax payments and represents

taxation of amenities in this simple model of homogenous population and equal utilities. The real tax burden is equal in regions with the same utility level.

We construct a common specification that captures the three tax systems, expressed in log differential form:

$$Tax_j = s_\tau \hat{w}_j - s_D \hat{p}_j \quad (17)$$

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. 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 equal real tax payments ($s_\tau = 0, s_D = -1$). With nominal income taxation, tax payments vary across regions as nominal wages vary. Real income taxation implies that nominal tax payments depend positively on nominal wages and negatively on cost of living, but with larger weight on the wage component. Finally, with equal real tax payments the nominal tax burden varies with the regional cost of living. Section 3 elaborates the calibration.

Equations (1) – (17) determine 17 endogenous variables in each region, all in log differential form; wages, taxes and land rent $(\hat{w}_j, Tax_j, \hat{r}_j)$, housing price and aggregate price index $(\hat{p}_{H,j}, \hat{p}_j)$, per capita consumption of traded goods and housing (\hat{x}_j, \hat{y}_j) , total output in the traded and housing sector (\hat{X}_j, \hat{Y}_j) , factor demands in each sector $(\hat{L}_{X,j}, \hat{K}_{X,j}, \hat{N}_{X,j}, \hat{L}_{Y,j}, \hat{K}_{Y,j}, \hat{N}_{Y,j})$ and aggregate capital and population in each region (\hat{K}_j, \hat{N}_j) .

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. 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. Carlsen and Leknes (2015) explain the econometric model in more detail. The estimated model is documented in Appendix A. 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 estimated regional fixed effects, adjusted to make their mean equal to the national mean price level, represent the housing price level of the respective regions. The expenditure share for housing (γ) is set consistent with Norwegian data from 2004 and equals about 20%. The aggregate price index (measuring cost of living) then follows from the regional housing cost data.

To quantify the effects of the income tax system we need good measures of regional wage differences. The heterogeneity of the population represents an important challenge in the estimation of regional wages, and geographical sorting may introduce measurement errors. The existing literature on tax distortions and population distribution controls for observable worker characteristics, while we are able to include unobservable worker characteristics using identification of differences based on movers. In addition, we allow dynamic learning effects from work experience to vary across regions, as emphasized by De la Roca and Puga (2015). 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. 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 specification allows for the value of experience to vary across regions. The econometric model is fully explained by Carlsen et al. (2013). Our measure of regional wages equals the estimated regional fixed effects plus the dynamic learning effect of work experience (calculated based on estimated coefficients and using the average 7.9 years of experience), adjusted to represent annual wages. The regional wage estimates are robust to controls for regional amenity values. Appendix A documents the estimated model for regional wages.

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

$$\begin{aligned} Tax_j &= 0.28(w_j - 115010) + 0.09(w_j - 456400) + 0.078w_j \\ &= 0.448w_j - 73279 \end{aligned}$$

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.² 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% and total deductions of NOK 73 279. 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 geographical 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 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, price indexed deductions as share of total tax payments (s_D) is set equal to zero, while it differs from zero in the alternative tax systems. The substitution elasticities in consumption, traded goods production and housing production, as well as key production parameters, follow the suggestions of Albouy and Stuart (2014). To establish the full equilibrium of the model the remaining variables are calibrated consistent with the model equilibrium. We do not have data on land rent (\hat{r}_j), so this variable is calculated from equation (12) 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 (4) and (11), respectively. Appendix B documents the rest of the calibration, as well as all parameter values.

² 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.

Table 1 documents the regional data on population, wages, cost of living and nominal tax burden, as well as the calibrated measures of quality of life and traded sector productivity. We separate between three groups of regions based on population size: cities of at least 150 000 inhabitants (7 regions), small cities with population between 65 000 and 150 000 (13 regions), and the remaining 69 regions classified as rural. In addition, we define top and bottom quintiles of regions with respect to nominal wage, cost of living, and real wage levels (each quintile consists of 18 regions).

Table 1 about here

Population size differs a lot across labor market regions, as seen in column 1 of Table 1. On average, cities are three times larger than the national geometric average. The many small regions reflect long distances between labor markets 'closed' by valleys, mountains and fjords. The estimated regional wage levels follow from hedonic regressions controlling for observable and unobservable heterogeneities, while allowing dynamic learning effects of work experience to vary across regions. Cities have 9.2% higher wages than the average, and with Oslo on top with a wage premium of 12%. Top quintile wage regions have wage differential of 5.2%, while the bottom quintile wage regions have 3.3% lower wages than the average. Regional differences in wage costs are larger since urban high-wage regions face higher payroll taxes.

The analysis concentrates on the role of tax differentials and column 3 shows regional differences in the nominal tax burden given the current income tax system. With nominal income taxation, the tax differentials follow nominal wage differences. The nominal tax burden varies from 4.7% below average in low-wage regions to 7.5% above average in high-wage regions. Cities have nominal tax burden 13% above average. Since high-wage regions have larger tax burdens, regional differences in post-tax income are limited and vary from 5% above average in cities to 2% below average in the poorest rural regions.

As seen in column 4, cost of living in cities is 11% higher than the national average, reflecting urban housing costs more than 50% above average. Cost of living is highest in the larger Oslo-area. The rich Asker/Bærum region west of Oslo has aggregate prices 16% above average, while Oslo city has a premium of 15%. The top and bottom 18 regions based on cost of living have prices about 9% above and below average, respectively. The differences

also show up when we separate regions according to nominal and real wages, with cost of living about 6% above average both in the top quintile regions with high nominal wages and in the bottom quintile regions with low real wages.

Given the data on regional wages, taxes and cost of living, we calibrate quality of life and traded sector productivity consistent with migration equilibrium and zero-profit conditions, as shown in the two last columns of Table 1. Quality of life is strongly negatively correlated with real wages after tax, as migration equilibrium balances quality of life and post-tax real wages to equalize utility levels across regions. Cities and small cities have quality of life above the national average, as high cost of living push down post-tax real wages in these regions. Peripheral regions with high real wages have the lowest amenity values. Traded sector productivity varies with nominal wages, and cities have 15% higher productivity than the average.

Figure 1 about here

The correlation between traded sector productivity and quality of life equals 0.74. City regions have high productivity and amenity value, while small peripheral regions score low on both dimensions. Norway seems to lack the consumer attractive regions where people want to live, but industry is disadvantaged. More surprisingly, high productivity regions of low popularity among the public are also lacking. The scatterplot in Figure 1 shows the positive correlation between traded sector productivity and quality of life. Quality of life varies from 15% below average to 11% above average, while productivity varies from 16% below average to 19% above average. The degree of regional variation is comparable to international studies, represented by Albouy et al. (2013) across Canadian cities and Albouy (2015) on US data.

4. Tax differentials and deadweight losses

The natural reference point for evaluation of tax systems is the situation without taxes. In this case, the distribution of the population is undistorted and reflects the underlying economic conditions – amenities and productivities. It should be noticed that this is not a policy neutral situation. Policies in the form of infrastructure investments will (possibly)

influence the allocation of population through amenities. In this study such factors are taken as given.

The approach is to calculate a nominal tax differential relative to zero income tax for each of the three alternative income tax systems – nominal wage taxation, real wage taxation and equal real taxes. The result of general interest is the relationship between tax differential and change in distribution of the population. The tax differential follows from wage and/or price differences across regions, depending on tax design. The tax differential generates an allocation of the population different from the zero tax benchmark. The key responsiveness of the model is described by the elasticity of population with respect to the nominal tax burden. The elasticity results from parameterization and data and comes out as $\varepsilon = -2.64$. Given the linear structure of the model, the elasticity is the same for all regions. The varying population responses follow from the relevant tax differentials. Albouy (2009) comes out with an elasticity of -6 given the US tax and production structure.

Table 2 shows the results for the same four classifications of regions as in Table 1. The first column gives the change in the population differential between zero taxation and nominal wage taxation. The allocation reflects a nominal tax differential for the specific groups of regions shown in column 4. The quantitative effects of the tax differentials can be large, and with nominal income tax, the variation in the wage level determines the strength of the migration incentive. The nominal tax system in Norway generates a tax differential of 7.5% in the top quintile high-wage regions, and the increased tax burden implies a decline in the population differential of about 20%-points (consistent with an elasticity of -2.64). The population in high-wage regions is 103% above the national average with zero taxation and decreases to 83% above average with nominal wage taxation. The city regions have the largest positive tax differentials with Oslo on top with 16.8%, which implies a decrease in the capital's population level by almost 200 000 inhabitants (from about 777 000 to 587 000). Nominal income taxation is favorable for low-wage regions, facing a tax burden 5% below the national average. The average population level in this group of regions expands from 78% below average to about 65% below average. As discussed in relation to Table 1, wage level, cost level, traded productivity and quality of life are strongly correlated in the data. It follows that population shifts out of high-cost regions, high productivity regions and high quality of life regions with nominal income taxation.

Table 2 about here

With real wage taxation, the real tax burden is proportional to real wages, which implies that the nominal tax burden depends positively on nominal wages and negatively on the cost of living, but with larger weight on the wage component. Real wage taxation generates high nominal tax burden for two types of regions: high-wage regions and low-cost regions (shown in column 5 of Table 2). High-wage regions are represented by cities, where very high nominal wages generate positive tax differentials despite high prices. These regions typically have relatively low real wages, and face real tax burdens below the national average. Low-cost regions are typically peripheral regions with very low prices and with nominal wages around the national average. These regions have high real wages and face the highest real tax burdens as well. While cities have nominal tax burdens 6.7% above average and lose population, small cities gain from real wage taxation. On average, the tax differential is 2.8% below average and the population differential increases by 7.4%-points. Small cities also have the lowest real tax burdens with this tax system.

Equal real tax burden across regions gives nominal tax differentials proportional to cost of living. The top quintile high-cost regions have positive tax differential of 8.3%, while the bottom quintile has negative differential of 7.6%, as shown in column 6 of Table 2. Since the correlation between cost of living and quality of life is strong, high quality of life regions have positive tax differentials. At the top of the list we again find the largest city regions. It follows that cities have less population while rural areas have more. The logic is that low quality of life regions gain from taxation of amenities.

The main economic issue involved is the cost of tax distortion and the model results allow for a calculation of the deadweight loss. We follow the calculations of Albouy (2009) derived from the Harberger triangle, also applied by Albouy and Hanson (2014) for housing taxation. The starting point is the tax differential, the additional taxes paid in a region relative to the national average. The tax differential as share of income is determined by the wage and/or price differentials, depending on the tax system. The tax differential can be positive or negative and gives incentive for migration between regions. The efficiency loss takes into account the population effect of the tax differential represented by the elasticity ϵ (with a value of -2.64 given our parameterization). The deadweight loss (DWL) can be written:

$$DWL = \frac{1}{2} \varepsilon \cdot Var(s_{Tax} Tax_j) \quad (18)$$

Nominal income taxation creates a disincentive to locate in productive high-wage regions, and generates a deadweight loss due to locational inefficiencies equal to 0.028% of income, as stated in row 1 of column 1 in Table 3. This is much lower than the US estimate of Albouy (2009) of 0.23% of income. However, the magnitude of the deadweight loss depends on the measured variation in regional wages. While we control for both observable and unobservable characteristics of workers and allow the dynamic learning effect of experience to vary across regions, the regional wage differences used in Albouy (2009) only control for observables. For comparison with the US results, we ignore the dynamic learning effect and control only for observable worker characteristics in the Mincer wage equation. The resulting deadweight loss given in row 3 of column 1 equals 0.052%. The remaining difference between US and Norwegian locational inefficiencies related to nominal income taxation is partly due to higher elasticity of population with respect to taxes with the US parametrization and possibly larger wage differences in general across US states. To illustrate the role of regional wage variation further, we show in row 4 of column 1 that nominal taxation has a deadweight loss of 0.132% in the case where raw wage differences are assumed to reflect productivity differences. In the other end of the scale, controlling for observables and unobservables while ignoring higher learning effects in cities implies lower regional wage differences and the deadweight loss is down at 0.013% of income (row 2, column 1).

Table 3 about here

Real income taxation generates a geographic distribution of the population closer to the undistorted equilibrium, and hence with lower deadweight loss than nominal income taxation. As seen from row 1 of column 2, the locational inefficiencies amount to 0.017% of income. The deadweight loss is somewhat less responsive to measured wage differences since the variation in taxation also depends on differences in cost of living. Equal real taxes are favorable for regions with low amenity value and low cost of living, which in our setting correspond to regions with low traded sector productivity. The deadweight loss is larger in this alternative, about 0.042% of income as shown in row 1 of column 3. The size of the deadweight loss is quite independent of measured wage differences. It is the variation in

cost of living that matters. The horizontal equity obtained by taxing amenities has real side costs when traded sector productivity is low in regions with low quality of life gaining population. Equal real taxes raise the population in small regions and have a more concentrated distribution of the population.

Given the quantitative analysis above, we discuss the consequences of tax reform in more detail. Nominal income taxes distort the allocation of the population. Since high productivity regions also have high nominal wages, too few people are allocated to high productivity regions. As discussed in the introduction, this is a cost of living distortion and can be solved by indexation of taxes – real wage taxation. The effects of a transition from nominal wage taxation to real wage taxation are shown in panel a of Table 4. The initial nominal price differences are quite large, with the Oslo area about 15% above the national average and the smallest peripheral region with a price index 17% below the average. Compared to the current tax system with nominal taxation, real wage taxation is to the advantage of urban areas. In the capital Oslo, the nominal tax burden decreases from 17% above average to 8% above average, and for the city group as a whole the nominal tax differential goes down by 6.7%-points (column 2). The population responds to the changes in taxation and migration increases from the peripheral regions to the cities. The increase in the population differential of the cities is about 18%-points, again consistent with the population to tax elasticity of -2.64. Compared to the zero tax scenario real wage taxation is a disadvantage to urban areas, but compared to the current nominal tax system, real wage taxation represents an improvement for cities. The overall population distribution is more efficient with real wage taxation than with the current tax system. The rural-urban migration leads to larger differences in housing costs, and the model implies an elasticity of about -0.9 for housing prices with respect to nominal tax payments.

Table 4 about here

As argued in the introduction, the real taxation model does not take into account the regional variation in quality of life. We modify the tax system so that we also include taxation of amenities. Given the assumptions of the model this implies equal real taxes across regions. The calculation assumes that all of quality of life is accounted for in this tax reform. The horizontal tax equalization 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 wage taxation to equal real taxes is shown in panel b of Table 4. Taxation of amenities favors peripheral regions with high real wages and low amenity values, while cities and in particular small cities lose population. As documented in Table 3, a tax system with equal real taxes generates the least efficient geographical distribution of the population.

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 population across regions is efficient. The tax system may distort this regional allocation and lead to locational inefficiencies and associated deadweight loss. The role of income taxation for the allocation of population has been analyzed in this paper based on a calibrated migration equilibrium model. Three alternative income tax systems are evaluated – nominal income taxation, real income taxation where the real tax burden depends on real wages, and equal real taxes motivated by taxation of amenities.

The data for Norway indicate small regional wage differences, large differences in housing prices and even larger differences in population size. In this setting, changes in prices may give large changes in the geographic distribution of population. The calibration comes out with an elasticity of population with respect to taxes of -2.64. The current nominal income tax system distorts incentives to the disadvantage of productive high-wage cities, and generates a deadweight loss equal to 0.028% of income. Real income taxation internalizing cost of living differences, gives a regional allocation of the population closer to the undistorted equilibrium, and is hence more efficient than the current tax system. The handling of amenities in the tax system is an old debate related to horizontal equity. High quality of life allows for lower wages in migration equilibrium and may distort the allocation of population to the disadvantage of low amenity regions. In our simple model of homogenous population and perfect mobility, horizontal equity is obtained by equal real taxes across regions. This tax system shifts population to low productivity regions and the deadweight loss increases significantly.

Regional misallocation is not much addressed in the tax literature. The findings in this paper indicate that the quantitative effects of tax distortions can be large. The analysis does not offer a full evaluation of the income tax system, and in particular, the handling of housing consumption in the tax system and possible heterogeneous effects across the population are interesting areas of future research.

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Appendix A: 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 B: 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 of 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 section 2. The price index (\hat{p}_j) and nominal tax payments (Tax_j) follow directly from equations (2) and (17), respectively. We do not have data on land rent (\hat{r}_j), so this variable is calculated from equation (12) 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 (4) and (11), respectively. We can then use equations (1) and (3) 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 (\hat{N}_j) housing production (\hat{Y}_j) follows from (16). Factor use in the housing sector

$(\hat{L}_{Y,j}, \hat{K}_{Y,j}, \hat{N}_{Y,j})$ is calibrated from equations (8) – (10). Labor demand in the traded sector $(\hat{N}_{X,j})$ follows from equation (15), and traded production (\hat{X}_j) from equation (7). Land and capital use in the traded sector $(\hat{L}_{X,j}, \hat{K}_{X,j})$ are calibrated based on equations (5) and (6). Finally, total supply of land and capital in region j (\hat{L}_j, \hat{K}_j) follow from equations (13) and (14).

Appendix Table 3 Calibrated model parameter values

Parameter	Description	Value
s_τ	Taxes net of deductions relative to total tax payments	
	- <i>Nominal income taxation</i>	1.45
	- <i>Real income taxation</i>	1.45
	- <i>Equal real taxes</i>	0
s_D	Price indexation of taxes	
	- <i>Nominal income taxation</i>	0
	- <i>Real income taxation</i>	0.45
	- <i>Equal real taxes</i>	-1
s_w	Wages as share of post-tax income	0.977
s_{Tax}	Tax payments as share of post-tax income	0.3026
γ	Expenditure share for housing	0.2087
σ_C	Elasticity of substitution in consumption	0.667
σ_X	Elasticity of substitution in traded goods production	0.667
σ_Y	Elasticity of substitution in housing production	0.667
θ_L	Traded sector cost share of land	0.025
θ_K	Traded sector cost share of capital	0.15
ϕ_L	Housing sector cost share of land	0.233
ϕ_K	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
\bar{p}	Geometric average of the price index	1.0077

Note: The parameters s_τ and s_D are used to capture different tax systems; see further descriptions in section 2.2.

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Table 1 Data on population, wages, nominal tax burden and cost of living, calibrated quality of life and traded productivity

Regions	Population \hat{N}_j	Wages \hat{w}_j	Nom tax burden Tax_j	Cost of living \hat{p}_j	Quality of life \hat{Q}_j	Traded productivity $\hat{A}_{x,j}$
<i>Panel a:</i>						
Cities	2.127	0.092	0.133	0.11	0.061	0.152
Small cities	1.136	0.002	0.003	0.052	0.051	0.045
Rural	-0.43	-0.01	-0.014	-0.021	-0.016	-0.024
<i>Panel b:</i>						
High-wage	0.829	0.052	0.075	0.059	0.032	0.088
Low-wage	-0.654	-0.033	-0.047	-0.05	-0.033	-0.064
<i>Panel c:</i>						
High-cost	1.099	0.036	0.052	0.088	0.07	0.087
Low-cost	-0.771	-0.018	-0.026	-0.085	-0.076	-0.075
<i>Panel d:</i>						
High real wage	-0.648	-0.005	-0.008	-0.077	-0.075	-0.055
Low real wage	0.495	0.003	0.004	0.064	0.063	0.038

Note: The regional population data is from 2010. Data on wages and housing costs are based on hedonic regressions, as documented in Appendix A. Cost of living is proportional to housing costs, weighted by the budget share for housing. The nominal tax burden follows from the wage data given the current income tax system in Norway. Quality of life and traded sector productivity are calibrated from the model based on data on wage, tax and cost of living. All variables are measured as percentage deviation from the national geometric average (approximated by log differentials). Panel *a* separates between three groups of regions according to population size. The city group is defined as regions with at least 150 000 inhabitants (7 regions), while small cities refer to regions with population in the range 65 000 – 150 000 (13 regions). The remaining 69 regions are classified as rural. Panels *b* – *d* separate between the top 20% and bottom 20% of regions according to wages, cost of living and real wages, respectively. Each group consists of 18 regions.

Table 2 Impact on population and tax differential across different tax schemes (relative to zero tax scenario)

Regions	Change in population differential			Change in tax differential		
	Nominal wage taxation	Real wage taxation	Equal real taxes	Nominal wage taxation	Real wage taxation	Equal real taxes
<i>Panel a:</i>						
Cities	-0.353	-0.176	-0.3	0.133	0.067	0.114
Small cities	-0.009	0.074	-0.117	0.003	-0.028	0.044
Rural	0.037	0.004	0.053	-0.014	-0.001	-0.02
<i>Panel b:</i>						
High-wage	-0.198	-0.103	-0.163	0.075	0.039	0.062
Low-wage	0.124	0.043	0.132	-0.047	-0.016	-0.05
<i>Panel c:</i>						
High-cost	-0.138	0.004	-0.219	0.052	-0.001	0.083
Low-cost	0.069	-0.068	0.202	-0.026	0.026	-0.076
<i>Panel d:</i>						
High real wage	0.021	-0.104	0.176	-0.008	0.039	-0.067
Low real wage	-0.012	0.092	-0.146	0.004	-0.035	0.055

Table 3 Deadweight loss (DWL) as percent of GDP across different tax systems (relative to zero tax scenario), dependent on estimation of regional wage differences

	Tax system:		
	Nominal wage taxation	Real wage taxation	Equal real taxes
<i>Estimation of regional wage differences:</i>			
Control for observable and unobservable characteristics, including dynamic learning effect	0.028%	0.017%	0.042%
Control for observable and unobservable characteristics	0.013%	0.013%	0.039%
Control for observable characteristics	0.052%	0.028%	0.045%
Raw wage differences	0.132%	0.084%	0.052%

Note: The deadweight loss as percent of GDP is calculated from equation (18).

Table 4 Impact of tax reform on population, nominal and real tax burden, housing cost and cost of living.

Regions	Change in differential from national average:				
	Population	Nom tax burden	Real tax burden	Housing prices	Cost of living
<i>Panel a: Nominal wage taxation → Real wage taxation</i>					
Cities	0.177	-0.067	-0.079	0.058	0.012
Small cities	0.083	-0.031	-0.037	0.027	0.006
Rural	-0.034	0.013	0.015	-0.011	-0.002
<i>Panel b: Real wage taxation → Equal real taxes</i>					
Cities	-0.124	0.047	0.055	-0.041	-0.008
Small cities	-0.192	0.073	0.086	-0.063	-0.013
Rural	0.049	-0.018	-0.022	0.016	0.003

Note: The real tax differential equals the nominal tax differential minus the aggregate price differential (cost of living).

Figure 1 Scatterplot of traded productivity and quality of life across 89 regions

