A Spatial Model of Corporate Tax Incidence

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Abstract

Using a unique, self-compiled dataset on international tax rates, we explore the link between taxes and manufacturing wages for a panel of 65 countries over 25 years. We find, controlling for other macroeconomic variables, that wages are significantly responsive to corporate taxation. Higher corporate tax rates depress wages. Using spatial modeling techniques, we also find that tax characteristics of neighboring countries, whether geographic or economic, have a significant effect on domestic wages. Our paper fits in with the new economic geography literature as well as the urban economics literature which attempt to explain the spatial distribution of wages.

JEL Codes: F21, H2, J3, C3

I. Introduction

The incidence of the corporation income tax is a fundamental question in the study of public economics. Corporation income taxes are levied on the earnings of capital in the corporate sector of the economy. Corporations, or businesses, however are legal structures that bring together shareholders or investors, workers and consumers. Therefore it is natural to question which of these entities, in fact, bears the economic burden of repaying the tax.[i] The contribution of economic theory to this study has been the recognition that while the statutory burden of the tax is on corporate income, the economic burden could be shifted forward to consumers in the form of higher prices, to shareholders in the form of lower returns or shifted backwards to workers in the form of lower wages. In this paper, we contribute to the study of the incidence of the corporate income tax by focusing on the long-term impact of higher corporate tax rates on wages using cross-country panel data on corporate taxes and wages. Higher corporate taxes have negative effects on capital formation, which in turn lead to lower worker productivity as well as lower wages over time. This channel has not been explored in the literature and we test it using data on capital-labor ratios across countries. Moreover, the international tax competition literature suggests that corporate taxes cause capital to flow from high to low tax jurisdictions. As a result, for any country, corporate taxes in its competing, neighbor countries could have large impacts on its domestic wages. This is the first paper to model the impact of corporate taxes in spatial neighbors on domestic wages.

In this paper, we abstract from the effect of the corporate income tax on shareholder returns and consumer prices and focus on the extent to which workers may inadvertently bear a portion of the corporation tax. This narrow focus is justified

somewhat since economic models relying on open economy assumptions predict no changes in output prices and rates of return to capital due to tradability of output and perfect capital mobility. In these models, workers are shown to bear a large part of the corporate tax burden since the only option for firms to remain competitive is to pass on the tax to workers in the form of lower wages. For instance, Harberger (2006) shows that under these conditions, workers could bear more than 100% of the corporate tax burden.

The idea that workers may bear a portion of the corporate income tax is neither surprising nor new. Basic incidence analysis suggests that the burden of the tax will always be larger on the side of the market that is more inelastic. In the short run, the incidence will necessarily be borne out of the earnings of fixed capital since the supply of capital is fixed. However, it is the long run effects which are of greatest theoretical and practical interest. Since capital is relatively more mobile in the long-run than labor (which is relatively inelastically supplied), labor could bear a larger portion of the tax burden.

The actual mechanism by which the tax burden is transferred to workers is a question of extreme interest in our paper. One channel through which this works is the effect of a higher tax rate on capital investment. Since the imposition of the corporate tax lowers the post-tax return on capital, this reduces the firms' incentive to invest. In the long-run, as the stock of capital declines, worker productivity suffers since workers have relatively lower stocks of capital to work with. A decline in the marginal product of labor then lowers the wage.

These effects could be large in a domestic setting, but are probably magnified in an open economy setting. With open borders and free capital mobility, corporate capital

can move to other countries that have lower rates of corporate taxation. Over the previous decade, almost every member of the European Union has cut its rate. Within our sample period, Germany reduced its corporate rate from around 56 percent in 1981 to 30.5 percent in 2005. U.K. also cut its corporate rate from 52 percent in 1981 to 30 percent in 2005.[ii] These reductions reflect a growing perception among governments worldwide that low corporate taxes attract businesses and investment and stimulate long-term competitiveness. The international tax literature, recently summarized by Gordon and Hines (2002) and Devereux and Griffith (1998), as well as Devereux, Lockwood and Redoano (2008) documents that tax competition may cause mobile capital to flow to low tax jurisdictions.[iii] The spur in economic activity as a result of the shifting of investment to low-tax jurisdictions is likely to have long-term wage impacts. Our paper attempts to model this wage impact by including as an explanatory variable, the average tax rate in the neighboring country.

Accordingly, the paper addresses two main questions: One, do corporate tax rates systematically affect wage rates? Two, if tax rate differentials lead to international capital mobility, are wages in the domestic economy affected by taxes in competing economies? These questions are addressed using a sample of developing and developed economies. Our empirical results indicate that domestic corporate taxes are negatively and significantly related to wage rates across countries. Our coefficient estimates suggest that a 1 percent increase in corporate tax rates leads to a 0.5 percent decrease in wage rates. These results also hold for effective marginal and average tax rates. This suggests that wages are as likely to be influenced by the top statutory corporate tax rate, as by the effective marginal and average tax rates. Hence corporate tax cuts in the form of large

allowances for depreciation of equipment and structures which reduce effective marginal rates could effectively influence wage levels as well.

We find evidence that international corporate tax rates affect domestic wages. Capital formation and therefore wage rates are affected not only by domestic tax rates, but also tax rates in competing economies. The coefficient estimates for the spatial tax variables range from 0.6 to 1.4 suggesting significant quantitative impacts. Further, relatively higher corporate taxes in a country's neighbors lead to higher domestic wages due to capital flight from high tax jurisdictions.

Section II provides a literature survey. Section III describes the data and our empirical methodology. Section IV presents the empirical results. Section V tests the mechanism by which taxes affect wages. Section VI concludes.

II. Literature Review

The debate surrounding the incidence of the corporate income tax has a long history and evolution, starting from Harberger's seminal 1962 contribution which placed the entire burden of the corporate tax on capital, to his most recent 2006 paper in which he concludes that for a small country which is a price taker in product markets for tradable goods "labor will bear more than the full burden of the corporation income tax".

Feldstein (1974) develops a theoretical model of the incidence of a corporate income tax. Replacing the Harberger (1962) assumptions of a fixed capital stock in a static model with a growing economy with a variable savings rate, Feldstein (1974) concludes that a substantial fraction of the burden of a corporate tax may fall on workers.

Other studies along the same vein which argue that the burden of the tax would fall on the immobile factors include Bradford (1978), Kotlikoff and Summers (1987), Mutti and Grubert (1985) and Randolph (2006). The paper by Randolph suggests that domestic labor and capital bear the tax burden roughly in proportion to their factor income shares: labor bears 73% of the tax burden. A few authors however question the assumptions of perfect capital mobility and product substitutability which drive Harberger's open economy results. For instance, Gravelle and Smetters (2001, 2006) and Gravelle (1994) argue that relaxing these assumptions leads us back to the closed economy outcome of capital bearing the larger share of the tax burden.

While much of the debate on the incidence of the corporate income tax has been waged on theoretical grounds, in recent times there has been a spurt of empirical papers that have attempted to address the topic using real world data on corporate tax rates and wage rates. For instance, Arulampalam et al. (2012) use company level data for nine major European countries for the period 1996-2003. Their results suggest that $1 of additional tax reduces wages by 49 cents in the long run. Mihir A. Desai, C. Fritz Foley, and James R. Hines (2007) use aggregate data on the activities of US companies in around 50 countries in four years to estimate jointly the impact of the corporate income tax on the wage rate and the rate of profit. Fixing the sum of these effects to be unity, they find that between 45 and 75 percent of the corporate tax borne is borne by labor with the remainder falling on capital. Felix (2007) also finds a large negative effect of corporate taxes on worker wages. Using cross-country panel data from the Luxembourg Income Study for 19 countries, she estimates that a 10 percentage point increase in the corporate tax rate would reduces annual gross wages by 7 percent. None of these papers

has estimated the impact of corporate taxation on wages which occurs through changes in capital formation as we do in our study. Further, none of the papers accounts for the spatial tax effects that are essential to any such study.

Our paper also fits in with the new economic geography literature as well as the urban economics literature. In new economic geography models, the spatial distribution of wages across geographic regions is explained using product market linkages across regions. For example, Hanson (1998) explains the determination of nominal wages in a given location using a market-potential function, which is a measure of proximity to consumer markets. Other papers along these lines include Brakman et al. (2004), Niebuhr (2006) and Amaral et al. (2010), among others. The urban economics literature also explains the spatial distribution of wages but uses economic density as an explanatory variable. For example, Fingleton (2003) shows that wage rate variations among local areas of Great Britain are significantly positively related to employment density. The idea behind these papers is to explain spatial agglomeration using economic variables such as market potential and the density of economic activity. While these papers offer interesting insights into the spatial distribution of wages, an issue that is of relevance in our paper as well, they do not directly address the issue of corporate tax incidence which is the focus of our paper.

Finally, we turn to the empirical literature on wage determination. To date, studies seeking to explain the cross-country variation in wage growth have not focused on the role of capital taxation. Rodrik (1999) finds that there is a robust and statistically significant association between the extent of democracy and the level of manufacturing wages in a country. Freeman and Ostendorp (2002) explain cross-country differences in

terms of the level of gross domestic product per capita and unionization and wage setting institutions. Rama (2003) concludes that in the short run, wages fall with openness to trade and rise with foreign direct investment, but after a few years the effect of trade on wages is reversed. Other papers, such as Davis and Henrekson (2004) study the effect of high personal income tax rates on hours worked in the market sector and other labor market outcomes. Some papers also study the effect of foreign direct investment on wage determination in a spatial setting. Hanson and Feenstra (1999) find that increased foreign direct investment in Mexico, just across the US border, caused an increase in the relative wages of skilled workers, in *both* countries along the border. They, however, did not explicitly model or estimate this relationship using regression analysis or spatial econometrics techniques.

III. Data and Empirical Strategy

The data cover the period 1981-2005 and include 65 countries.[iv] The dependent variable in the empirical analysis is the average nominal U.S. dollar wage earned in manufacturing per hour. The main source of data on wages is the Labor Statistics database available from the International Labor Organization (http://laborsta.ilo.org/). This source provides information on wages for a broad sample of countries, for the period 1981-2005. International comparability of the data is made possible through use of various controls for differences in coverage and definitions. In most countries, the statistics on wages refer to "wages and salaries" which include direct wages and salaries, bonuses and gratuities, etc. whereas in some countries they refer to "earnings", which include, more broadly, all compensation such as paid leave, pension and insurance

schemes. We then converted these total wage payments to hourly wage payments by dividing by the total number of hours worked, data which was again obtained from the ILO. We check for the robustness of empirical results when controls for differences in coverage are included. Average wages have been rising over the period 1981-2005 for all countries, though there is wide variation in countries both cross-sectionally and over time.

The other key variables in this paper are the tax rate variables. For these we draw on a new source, the AEI International Tax Database. The AEI tax database has been compiled over a number of years and includes information on several tax variables, such as (national and local) corporate taxes, personal income taxes, VAT, employer and employee payroll taxes, etc for about 128 countries starting in 1981. The main source for the corporate and personal income tax data has been the PriceWaterhouseCoopers "Corporate Taxes Worldwide Summaries" and "Individual Taxes Worldwide Summaries", however several other sources have been used to validate the numbers. An attempt has been made as far as possible to standardize the definition of the tax rate used across countries, and to incorporate all the information available in the corporate tax summaries. [v]

Table 1 provides summary statistics for our data. The average dollar wage over our sample period for all countries was approximately $5.2 per hour, while the average headline corporate tax rate was 34 percent. The effective average rate was lower at 30 percent, and the effective marginal rate was nearly 10 percentage points lower at 26.5 percent. In general average wages have increased between 1981 and 2005 from $3.5 to $9

per hour, while average tax rates have declined substantially. In 1981, the average top rate was 42 percent. In 2005, the average rate was 25 percent.

Using the Harberger (2006) open economy model as our motivation to study the incidence of the corporate income tax on labor, we use a standard wage determination model along the lines described in Rodrick (1999) but allow for long-run changes and international capital mobility to affect wages. Our baseline empirical specification is as follows:

$$Log(\overline{Wage}_{is_p}) = \alpha_i + \beta_1 \tau_{it_p} + \beta_2 \nu_{it\,p} + \beta_3 \sum_{j=1}^{n} w_{ijt\,p}\,\tau_{jt_p} + \overline{P_{is_p}} + D_{t_p} + \varepsilon_{t\,p}; \mathrm{p} = 1,..,5$$

$$\text{where } \mathrm{s}_1 = 1981-1985, \mathrm{s}_2 = 1986-1990, \mathrm{s}_3 = 1991-1995, \mathrm{s}_4 = 1996-2000, s_5 = 2001-2005$$

$$t_1 = 1981, \mathrm{t}_2 = 1986, \mathrm{t}_3 = 1991, \mathrm{t}_4 = 1996, t_5 = 2001$$

The dependent variable in this specification is the five year (Log) average of the nominal US$ wage rate in manufacturing for country *i* in sub-period s_p. We use five year averages over five distinct sub-periods indicated by s_1 to s_5. Country-specific fixed effects are captured by α_i. To ensure exogeneity of the right hand side variables, we use beginning-of-period values of τ, the (Log) Top Statutory Corporate Tax Rate and the (Log) Value Added per worker (υ) in manufacturing. Note that $t_1..t_5$ refer to the first year in each sub-period, respectively. The spatial weights matrix takes the form, $W_{t_p} = \left[W'_{1t_p}, \ldots\ldots, W'_{Nt_p}\right]'$. At any time t_p, the *i*th row of this matrix is given by W_{it_p} , which specifies "neighborhood sets" for each observation *i*. The *ij-th* element of W_{t_p}, namely, w_{ijt_p} is positive if *j* is a "neighbor" of *i*, and is zero otherwise. We will describe this matrix more fully later in this section. Following Rodrik (1999), we also included an index of average consumer prices $\left(\overline{P_{is_p}}\right)$ which is comparable across countries. This

captures cost-of-living differences across countries that are not captured by exchange rate conversions. We use the five year average of this index (averaged over the years in the sub-period) since it works like a deflator for our nominal wage variable. The index is available from the Penn World Tables. Finally, we also include dummy variables $\left(D_{t_p}\right)$ for each sub-period in our sample.

We use beginning of period (or lagged) values of the independent variables since in our model corporate taxes affect wages by first affecting the capital-labor (K/L) ratio. Thus the response of wages to corporate taxation depends first on the speed with which capital-labor ratios adjust to corporate taxation, and second, on the speed with which wages adjust to changes in productivity as a result of changes in K/L. Domestic firms may respond to lower corporate taxes by increasing their stock of capital and theory suggests that this adjustment may not be instantaneous. Global capital may be more flexible, but will only gradually flow into the low-tax country thereby increasing the stock of domestic capital. Wages will respond to this increase in capital-labor ratios with some lag as firms observe productivity gains and workers renegotiate fixed wage contracts. Hence we look for changes over long periods of time.

We present results with different measures of the corporate tax rates, such as the top national corporate tax rate, the effective marginal (EMTR) and the effective average corporate tax rate (EATR). A word about these rates is warranted here since we are not using the realized values of taxes and incomes to generate these rates. In fact, these rates are constructed using the methodology discussed in Devereux and Griffith (1999). The EMTR is the tax rate on the marginal investment, where the marginal investment equates the net present value of the income stream to the net present value of costs from the

investment. The EATR can be computed as the difference between the pre-tax and the post-tax economic rent scaled by the net present value of the pre-tax income stream.

We computed the EATR and the EMTR for all countries in the sample and for each time period using the methodology outlined in Devereux et al (1999), assuming fixed parameter values for the economic depreciation rates, the inflation rate and the annual discount rate.[vi]

An interesting addition in the paper is the exploration of tax competition issues. Wages in the home country are affected by capital flows to the country as we discussed above. However, capital flows are subject to the forces of competition from other countries that are keen to divert these flows to themselves. Tax competition occurs through the lowering of relative tax rates across countries. Therefore, to account for the effect of tax rates in other countries on capital flows and therefore wages in the home country, we include variables measuring the weighted average tax rates in similar income and geographically close economies.

In our model, we consider many forms of the weighting matrix. One is based on regional economic weights. In this, the countries are assigned to be "neighbors" if they are in the same region as country *i*. For example, Zambia would have as its neighbors, Zimbabwe, Malawi and Mauritius since they are all in the East African region, but would not include Bolivia, Australia, etc. since they are in other regions. Countries within the same region would then be weighted by their GDP. A second form of the weighting matrix is based on Income weights, i.e., countries within the same income group, such as high income, low income, or upper middle income, etc. are classified as neighbors. These

countries are then weighted by their GDP. The third kind of weighting we used was to assign distance weights to countries within the same income group.

These weighting matrices were used to create weighted averages of corporate tax rates in "neighbor" countries. In somewhat more detail, the *ijth* element of the weighting matrix at time *t*, is,

$$w_{ijt} = \frac{GDP_{ijt}}{\sum_{k} GDP_{ikt}}$$ where k is the number of "neighbor" countries for country i.

The weighting matrix based on distance is defined in a similar manner. By convention, a cross sectional unit is not a neighbor to itself, so that the diagonal elements of W_t are all zero i.e $w_{ii,t}=0$. The significance of these spatial variables in the regressions suggests that tax competition affects capital flows and wages in the home country.

We expand upon the baseline regression by including variables to measure the openness of the economy. These include trade as a fraction of GDP (available from the ILO KILM database) and an index of capital mobility (from the Economic Freedom of the World Database). We also experiment with additional variables such as the level of schooling, computerization and urbanization, highlighted by other papers in the literature.

To allow for the effect of labor market institutions, we use two variables. One of these measures the percentage of workers in a country covered by collective bargaining agreements, as a percent of total salaried or dependent workers. The second is a broader measure which is a count of the cumulative number of ILO conventions ratified by the country. The ILO conventions include ratification of conventions on child labor, forced or compulsory labor, discrimination, the right to organize and the right to bargain collectively. Thus the greater the number of ratified conventions, the greater the

protection of workers rights. Information on these variables is available from the Fraser Institute's Economic Freedom of the World dataset and the World Bank Labor Market Database (WBLMD), (Rama, 1996), respectively.

Following Rodrik (1999), ideally we would like to include both the level of gross domestic product (GDP) per capita (available from Penn World Tables) and manufacturing Value Added (MVA) per worker in the same regression. We obtained value added per worker data from the ILO. The correlation between this variable and the GDP variable is high, above 0.70. Hence while we get similar results with the two variables, we report results using the Value Added variable to measure productivity. Finally, we obtained information on capital-labor ratios from the extended Penn World Tables (Version 2.1, April 2006).[vii] These data are not specific to the manufacturing sector and are not as extensive as for the tax variables in our model.[viii]

IV. Regression Results

IV.A. Empirical Results

Table 2 presents the first set of regression results. All the regressions, unless otherwise stated, are estimated using fixed effects. All specifications also control for sub-period (time) dummies and the regressions are run allowing for clustering within country groups. This option calculates the Huber/White/sandwich estimator of variance and also allows observations within a group to be correlated. (We also ran GLS regressions allowing for panel heteroscedasticity with similar results).

The main variable of interest in this paper is the corporate tax rate. Regressions in Table 2 present estimates without the spatial variables. Column (1) presents a simple

regression of the wage on the headline rate. The coefficient is highly significant at 5 percent, with a value of -0.78. Therefore, the elasticity of wages w.r.t. corporate taxes is fairly high and negative. A 1 percent increase in the corporate tax rate is associated with a nearly 0.8 percent decrease in hourly wages. The coefficient on Log (Value Added) is also significant and positive, implying that higher worker productivity is associated with higher wages. Finally, the higher the price level of consumption, the higher the nominal wage.

To test for endogeneity of the corporate tax variable, we re-estimate the model using 2SLS with the one period (in this case, five year) lag of the corporate tax variable as an instrument. The F-value for the first stage regression is 127, suggesting that the instrument is not weak (Stock, Wright and Yogo, 2002). Moreover, the coefficient on the corporate tax variable increases marginally to -0.98.[ix]

In Columns (2) and (3), we test to see if the results from our baseline specification in Column (1) carry over to other measures of the corporate tax rate, such as the effective marginal tax rate and the effective average tax rate. The coefficient on the effective average tax rate variable is negative and significant at 5 percent, while on the effective marginal tax rate variable is significant only at 10 percent. These results are interesting since they suggest that the effective average rates of taxation matter almost as much for investment behavior as the statutory rate. Ultimately, firms care about what rate they will end up paying rather than the top rate, which a lot of firms can avoid paying through use of allowances and deductions. This supports the results of Devereux and Griffith (1998) and Hassett and Hubbard (2002) of the impact of tax rates on investment for effective average tax rates.

In Column (4), we test our intuition that the longer term elasticity of wages w.r.t. the corporate tax is likely to be higher than the short-term elasticity. To do so, we do a regression of annual wages on the contemporaneous corporate tax rate and a one-year lagged wage rate. To account for endogeneity of the lagged wage rate and the corporate tax rate variables, we estimate the model using two-stage least squares. As instruments, we include the two year lag of the wage rate, as well as the one year lag of the corporate tax variable. The F value in the first stage regression for both the instrumented variables was high (73.37 for wages and 83 for corporate tax, respectively), suggesting that these were not weak instruments (Stock, Wright and Yogo, 2002). In this case, the elasticity of the wage w.r.t. the corporate tax variable is significantly lower in magnitude at approximately -0.3, as opposed to -0.8 for our earlier regressions.[x] Thus our results suggest that changes in corporate tax rates have long-term impacts on wages and productivity, and looking only at annual impacts may understate the true elasticity.

As a final specification check, we divided countries into different regions and then re-estimated the equation using OLS with a set of region dummies, time dummies and the interaction of the two i.e region-specific time trends. This allows for common shocks across countries within a region and over time. For instance, many East European countries faced common economic and political shocks in the aftermath of the collapse of the Soviet Union which may have affected labor markets, productivity and wage levels. This was also true of the East Asian economies in the wake of the currency crisis in the late 1990s. Note that the use of the region dummies implies that we are no longer using fixed effects for countries, since in that case the region dummies would drop out. Results in Column (5) suggest that adding these controls causes our estimated elasticity to be

marginally lower than in earlier specifications. Further, in this specification, the value added variable loses significance. This could be because this variable is mainly identified through cross-sectional variation with limited over time variation mainly in the later years, and including the full set of region and time dummies, as well as the interaction of the two, absorbs much of the variation in this variable.

Hence this first set of regressions without the spatial variables suggests that the long-term elasticity (i.e. over a five year period) of wages with respect to the corporate tax may be approximately 0.6 to 0.8. The tables also report the adjusted R-square for these regressions, which is fairly high at approximately 0.86 for the first three regressions and is much lower for the OLS regression which includes only region dummies and not country-specific dummies.

In a recent paper, Gordon and Lee (2005) find that corporate taxation negatively affected country growth rates between 1970-1997. Our results suggest that these slower GDP per capita growth rates in the 1980s and 1990s may have also translated into slower wage growth, hence workers must be bearing some of the burden of corporate taxes.

Table 3 presents results with the spatial tax variables included in the regression. These regressions incorporate measures of weighted average tax rates in "neighbor" countries. The choice of weights is guided by previous literature using spatial econometrics techniques, but we also experiment with different weighting schemes that are relevant to our analysis.[xi] In specification (1) "neighbor" countries are defined as all those countries that are in the *same physical region*, as described before.[xii] Every country in the region is assigned a uniform weight. This provides a benchmark specification from which we go on to test different weighting schemes and different neighbor groups. In this

case, the top corporate tax rates is negative and significant at 5 percent. Both value added and average consumer prices are positive and significant. However, the spatial tax variable is not significant. This could imply either that regional neighbors have no impact on domestic wages, or that the uniform weighting assigned to each neighbor is somehow negating the overall impact of corporate taxes on wages. To explore this further, we keep the definition of neighbor as regional neighbors, but change the weighting. Now the weights that we use for these countries are GDP (per capita) weights. Thus every country is weighted by its economic strength in the region. In this specification, the domestic top corporate rate remains significant, but the weighted average tax rate in the region is again not significant. This suggests that tax rate competition within regional neighbors is not a significant determinant of wage levels across countries.

In Column (2), we change the spatial neighbors by defining as neighbors those countries that are in the same *income* group (rather than in the same region). Countries within the same income group are then weighted by their respective GDP per capita. This specification would be justified if capital is more likely to flow between countries with the same per capita income rather than from very high to very low income countries or vice-versa. In this specification, the coefficient on the domestic corporate tax rate is marginally smaller than without the spatial tax variables. Also, the neighbor tax rates are significant and positive, suggesting that higher tax rates in neighbor countries have a positive impact on wages in the domestic country. The magnitude of the spatial tax coefficient is marginally higher than 1, suggesting that these tax linkages are stronger than for the regional neighbors.

Note that in Table 3, the coefficient on value added becomes insignificant once we define the spatial neighbors as countries in the same income group, particularly when we use income weighting for the income neighbors. A possible reason for this is that the value added variable is positively correlated with the spatial tax variable, either with the income weights or with the income group. The reason this could happen is because worker productivity in the host country and income in neighboring countries are likely to be highly correlated since the host country is also defined as being in the same income group. For example, the U.S. has high income and high value added per worker, and all the income-neighbors of the U.S. also belong to the same high income category. Therefore, this creates a correlation between value added in the U.S. and the income of the neighboring countries. To check our results, we changed the specification of the income weights so that for each income neighbor, the weight is now defined as the square of its original value. Results with this weighting matrix are shown in specification 4. In this case, both the value added variable and the weighted neighbor tax variable are positive and significant at 10 percent.

Finally, column (5) presents results with another weighting scheme. While neighbors continue to be defined in terms of income groups, the countries within the group are now weighted using (inverse) distance weights.[xiii] Thus the farther the country, the lower the weight it receives within the group. In this specification the coefficient on the spatial tax variable is 0.6, implying an elasticity of domestic capital formation to neighbor tax rates that is nearly the same as that with respect to domestic corporate tax rates. Thus tax linkages among countries within the same income group are a significant predictor of domestic wages.[xiv]

In Table 4, we tested for robustness of the coefficient on domestic and neighbor tax rates by including additional variables. In specification 1 of that table, we report results from the regression without the spatial variables but with additional explanatory variables such as the level of openness of the economy measured by the share of total trade in GDP and an index of capital mobility. Comparing the coefficient on the corporate tax rate from this specification to Specification 1 in Table 2, we find that including the additional variables makes only a marginal impact to the size of the estimate which drops from (negative) 0.781 to 0.735. However, when we compare this estimate to specifications 2 and 3 in Table 4, which include the spatial variables, then we get a sense of how excluding the spatial variables tends to bias the coefficient on domestic corporate tax rates upwards. Specifications 2 and 3 in that table report the spatial regressions with the additional explanatory variables. The coefficient estimate on the domestic corporate tax rate drops to negative 0.528, which is significantly lower than the estimate from the regression without the spatial variables included in the regression. Further, the income weighted tax rates in income neighbor countries enter with coefficients higher than 1, implying that all types of corporate taxation have an effect on wages, even after controlling for standard explanatory variables as suggested by the literature. Hence this paper suggests that the literature studying the incidence of corporate taxes on workers has typically overstated the impact of corporate taxes on wages, since none of the papers have incorporated the spatial tax variables in the regression.

Finally, in unreported regressions, we included labor market regulations[xv], schooling[xvi] and the extent of computerization[xvii].However, none of these enters significantly, since we control for labor productivity directly.[xviii]

Note that it is likely that the income weights in our specification are endogenous since the dependent variable, wages, are a component of income. For example, income in neighboring countries may have an effect on domestic wages through trade or other commerce links. However, we believe that the lags involved in inter-country commerce may weaken that endogeneity. Also, we are not the first to use GDP weights when modeling spatial tax competition between countries. Other papers, such as by Basinger and Hallerberg (2004), use GDP weights on spatial tax variables when explaining corporate tax competition across countries.

V. Estimating the Long-Term Impact of Taxes On Wages

If we accept the results in Tables 2, 3 and 4 that corporate taxes affect wages, the natural next step is to question the mechanism by which they do so. Our hypothesis is that corporate tax rates affect wages through their impact on capital-labor ratios. We use different measures of the corporate tax rate, since high taxes on capital affect investment and therefore the capital stock by raising the user cost of capital. The user cost of capital is defined as the minimum return a firm needs to cover depreciation, taxes and the opportunity cost of funds (Jorgenson (1963), Hall and Jorgenson (1967), Auerbach (1983)). Typically studies have found that high taxes lead to high user costs.

Table 5 presents various tests of our hypothesis. In specification (1), we use a five year (log) average of the capital-labor ratio as the dependent variable. We find that all measures of corporate taxation, such as the top national corporate tax rate, the effective average and the effective marginal tax rate negatively affect capital formation, though only the first two measures show up as significant. The coefficient on (Log) Top

Corporate Tax Rate implies a value of the elasticity of close to -0.14. Clearly, higher top rates discourage capital formation. This result is even stronger for effective average tax rates which take into account depreciation allowances, inflation and interest rates and other factors that affect capital formation through the user cost of capital (specification 2). The estimated elasticity in this case is close to (negative) 0.16. Other studies, using micro data and the actual user cost (not only the tax rate) estimate elasticities that are higher than this. Balistreri, McDaniel and Wong (2002) using industry data from the Bureau of Economic Analysis estimate elasticities in the range of 1-1.22, using different weighting schemes. Leung and Yuen (2005) using industry-level data on Canadian manufacturing estimate an elasticity of 0.33. While our coefficient estimate is likely to be heavily biased due to aggregation, measurement issues and data constraints (the capital-labor ratio is not specific to the manufacturing sector), we present these results simply to show that different measures of corporate taxation can significantly and negatively affect capital-labor ratios. In column (4), we test to see if spatial tax rates have any effect on domestic capital labor ratios. Our results indicate that both domestic and neighbor country tax rates are important in explaining the formation of domestic capital labor ratios. Higher tax rates in neighboring countries have a positive and significant effect on capital formation in the domestic country, which supports our hypothesis that capital flows out of high tax jurisdictions and to low tax jurisdictions.

The final column, Column (5), studies the link between high capital-labor ratios and average wages. Since capital-labor ratios are a direct proxy for worker productivity, it is not surprising that higher capital-labor ratios are associated with significantly higher

wages. In general, a 1 percent increase in the capital-labor ratios is associated with a 0.45 percent increase in wages.[xix]

While these results are obviously not conclusive of the mechanism, much less that this is the only means by which corporate taxes affect workers, it is clearly evidence that corporate taxes could have long-term impacts on wages by affecting the availability of capital to combine with labor.

VI. Conclusion

To summarize, our results indicate that corporate taxes are significantly related to wage rates across countries. Our coefficient estimates suggest that a 1 percent increase in corporate tax rates leads to a 0.5 percent decrease in wage rates. These results also hold for effective marginal and average tax rates. The coefficient estimate is (on average) close to 0.5. This suggests that wages are as likely to be influenced by the top statutory corporate tax rate, as by the effective marginal and average tax rates. Hence corporate tax cuts in the form of large allowances for depreciation of equipment and structures which reduce effective marginal rates could effectively influence wage levels as well.

We find evidence that international corporate tax rates affect domestic wages. Capital formation and therefore wage rates are affected not only by domestic tax rates, but also tax rates in competing economies. The coefficient estimates for the spatial tax variables range from 0.6 to 1.4 suggesting significant quantitative impacts. Comparing different weighting schemes, the effects are largest when "neighbors" are defined as countries within the same *income* group, rather than within the same region. This suggests that tax competition is most intense among, say, high income countries such as

Canada, France and Italy, rather than between geographic neighbors. This makes sense intuitively since there do not appear to be large transport costs associated with moving capital across large distances, so capital can easily flow to the most remunerative locations.

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Figure 1: Corporate Tax and Wage Links, Panel Data, 1981-2005

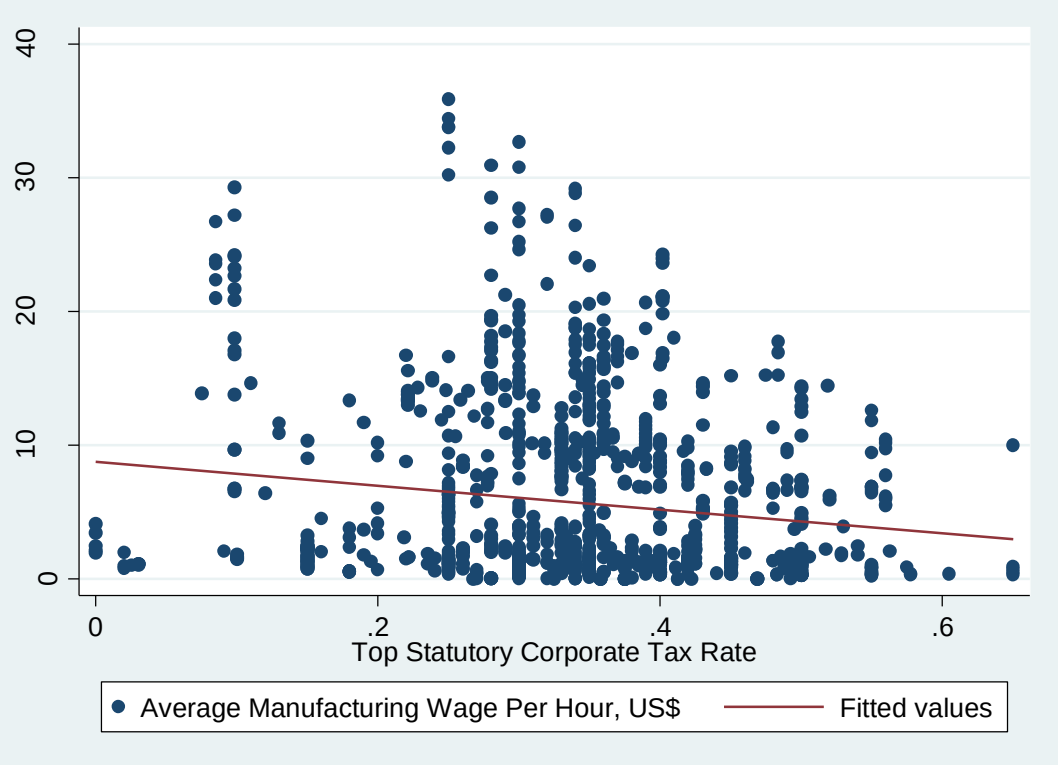

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev
Average Wage Per Hour, US $	5.185	6.402
Top Corporate Tax Rate	.343	.105
Log (Capital-Labor Ratio)	9.979	1.176
Effective Average Tax Rate	.305	.093
Effective Marginal tax Rate	.265	.117
Average Personal Income Tax Rate	.263	.097
Capital Mobility	4.264	3.248
Value Added Per Worker	19776.44	14570.41
Log (GDP per capita)	8.091	1.398
Log (Trade/GDP)	4.108	.624
Log (Schooling)	3.845	.609
ILO Conventions	47.257	27.867
Log (Consumer Price Level)	3.935	.607

Table 2: Regressions Without Spatial Effects

	(1) FE	(2) FE	(3) FE	(4) 2SLS	(5) OLS
Log(Top Corp. Tax)	-.781			-0.249	-.581
	(.278)**			(.114)**	(.266)***
Log(Eff. Avg. Tax)		-.643			
		(.304)**			
Log(Eff. Marg. Tax)			-.385		
			(.208)*		
Log(Value Added)	0.558	.451	.501	.052	.199
	(.242)**	(.252)*	(.248)**	(.095)	(.132)
Log(Consumer Price)	.464	.548	.526	.172	1.148
	(.245)*	(.270)**	(.274)*	(.078)**	(.271)*
Log(Wage,*t-1*)				.806	
				(.029)***	
Constant	-7.094	-6.397	-6.509	-1.267	-5.422
	(2.311)***	(2.412)***	(2.449)**	(.897)***	(1.409)***
Period Dummies	Yes	Yes	Yes	Yes	Yes
Region Dummies	No	No	No	No	Yes
Period x Region Dummies	No	No	No	No	Yes
Observations	223	204	200	846	223
Adj. R-Squared	.8653	.8722	.8715	.9476	.4617

Standard Errors in parentheses
***significant at 1%; **significant at 5%;*significant at 10%

1. Specifications (1), (2) and (3) are estimated using fixed effects. Specification (4) uses 2SLS estimation. Specification (5) uses OLS with region and period dummy variables, and the interaction of these dummy variables.
2. In specifications (1)-(3) and (5), the dependent variable is the 5 year average of the wage rate over sub-periods: 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005. The independent variables are the beginning of period values of these variables (except for the consumer price variable which is also the five year average). In specification (4), we use annual data on wages.

Table 3: Regressions With Spatial Variables

	(1)	(2)	(3)	(4)	(5)
Weight:	Uniform	Income	Income	Income-Sq	Distance
Nbr. Group:	Region	Region	Income	Income	Income
Log(Top Corp. Tax)	-0.657	-.727	-.536	-0.821	-.601
	(.293)**	(.299)**	(.299)*	(.289)**	(.308)*
Log(Value Added)	.450	.532	.154	.504	.179
	(.255)*	(.254)**	(.290)	(.262)*	(.294)
Log(Consumer Price)	.484	.466	.706	.620	.617
	(.245)**	(.251)*	(.246)***	(.246)**	(.244)**
Weighted Nbr. Tax	-.276	-.149	1.195	9.793	.628
	(.212)	(.238)	(.451)***	(5.904)*	(.324)*
Constant	-6.299	-6.956	-3.367	-6.741	-3.786
	(2.386)***	(2.365)***	(2.675)	(2.401)	(2.706)
Observations	223	221	223	223	223
Adj. R-Squared	.8660	.8627	.8744	.8676	.8717

Standard errors in parentheses
***significant at 1%; **significant at 5%;*significant at 10%

1.All specifications include country fixed effects and period dummies.

2.The dependent variable is the 5 year average of the wage rate over sub-periods: 1981-1985, 1986-1990, 1991-1995, 1996-2000,2001-2005.

3. The weight variable shows the weights applied to each spatial tax variable. Uniform weights imply equal weight to each country in the neighbor set. Income weights refer to GDP based weighting. Distance weights refer to weights that are the inverse of the distance between the two countries. Income Squared weights refer to the square of the GDP based weights.

Table 4: Testing Robustness

	(1)	(2)	(3)	(4)	(5)
Log(Top Corp. Tax)	-.735	-.527	-.528		
	(.297)**	(.299)*	(.306)*		
Log (Eff. Avg. Tax)				-.513	
				(.325)	
Log (Eff. Marg. Tax)					-.309
					(.213)
Inc. Wt.Nbr. Tax		1.365	1.277	1.175	1.245
		(.492)***	(.507)**	(.580)**	(.458)**
Log(Value Added)	.577	.102	.144	.223	.236
	(.260)**	(.297)	(.300)	(.308)	(.306)
Log(Consumer Price)	.394	.870	.868	.941	.981
	(.301)	(.312)***	(.322)**	(.332)**	(.334)**
Log(Trade/GDP)	-.078	.242	.251	0.276	.344
	(.278)	(.282)	(.292)	(.312)	(.314)
Cap. Mobility	.0003		-.025	-.040	-.031
	(.028)		(.031)	(.033)	(.033)
Constant	-6.639	-4.367	-4.586	-5.669	-5.925
	(2.733)**	(2.919)	(2.980)	(2.945)*	(2.972)**
Observations	216	223	216	182	181
Adj. R-Squared	.8632	.8741	.8721	.8818	.8756

Standard errors in parentheses
***significant at 1%; **significant at 5%;*significant at 10%

1.All specifications include country fixed effects and period dummies.
2.The dependent variable is the 5 year average of the wage rate over sub-periods: 1981-1985, 1986-1990, 1991-1995, 1996-2000,2001-2005.
3. The tax rate for the spatial variable corresponds to the tax rate used in the specification. In (1), (2) and (3), the spatial neighbor tax rate is the top corporate rate. In (4), the effective average tax rate.

Table 5: Capital-Labor Ratios, Taxes and Wages

	(1)	(2)	(3)	(4)	(5)
	Log (K/L)	Log (K/L)	Log (K/L)	Log(K/L)	Log(Wage)
Log(Top Corp.Tax)	-.137 (.058)**			-.126 (.057)**	
Log(Eff. Avg. Tax)		-.161 (.073)**			
Log(Eff. Marg. Tax)			-.093 (.057)		
Inc. Wt.Nbr. Tax				0.253 (.080)***	
Log (K/L)					.450 (.176)**
Constant	9.876 (.064)***	9.873 (.090)***	9.949 (.080)***	10.212 (.116)***	3.722 (1.780)***
Observations	256	229	225	251	247
Adj. R-Squared	.9618	.9592	.9605	0.9639	.8722

Standard errors in parentheses
***significant at 1%; **significant at 5%;*significant at 10%

1.The dependent variable is the 5 year average of the wage rate in (4) and the capital-labor ratio in (1), (2) and (3) over sub-periods: 1981-1985, 1986-1990, 1991-1995, 1996-2000,2001-2005. The independent variables are the beginning of period values of these variables.

[i] See Auerbach (2005) for a more recent analysis of who bears the burden of the corporate tax.

[ii] AEI International Tax Database

[iii] Other recent papers model how countries can choose to set tax rates to attract foreign firms in such a way that they either compensate for high labor costs as measured by higher wages or rigid labor markets, as measured by a higher degree of unionization. These are Haufler and Mittermaier (2011) and Mittermaier and Rincke(2012) respectively.

[iv] This is not a balanced panel, since data on taxes is missing for several countries, both OECD and non-OECD.

[v] Access to the AEI International Tax Database can be provided by writing to the authors.

[vi] To calculate EATR and EMTR, we assume an economic depreciation rate of 12.25%, a real annual discount rate of 10% and an expected annual inflation rate of 3.5% for all countries and all years. These are the assumptions made by Devereux, Griffith and Klemm (2002). Author calculations are available upon request.

[vii] http://homepage.newschool.edu/~foleyd/epwt/ . This data has been compiled by Adalmir Marquetti from the Penn World Table and other sources.

[viii] This is not ideal since manufacturing is more capital intensive than other sectors, and therefore may be more responsive to capital costs than other sectors. However, we are unaware of a cross-country data source for manufacturing capital-labor ratios.

[ix] These results are not presented, but are available upon request.

[x] Note that a regression of the contemporaneous corporate tax variable on lagged values of corporate tax rates yields a significant coefficient only on the one year lag. Hence we use that as an instrument rather than longer lags of the corporate tax variable.

[xi] See Bloningen et al. (2005) and Franzese and Hays (2005) for an application of different spatial weighting matrices.

[xii] Immigration and trade flow linkages are likely to be better captured by using within region income weights rather than across regions, since geographic distance increases the costs of labor mobility and transportation of goods.

[xiii] Distances are calculated as the physical distance between two capital cities.

[xiv] Gordon and Lee (2005) estimate the impact of corporate taxes on economic growth. They use neighbor tax rates as instruments for the domestic tax rate. We believe this is incorrect since both variables may have independent effects on growth and wages, and both therefore need to be included in the regression.

[xv] Measured by the number of ILO conventions ratified by the country or the percent of workers covered by collective bargaining agreements.

[xvi] Measured by enrollment at different levels of schooling, such as primary, secondary and tertiary (ILO)

[xvii] Measured as the estimated number of personal computers in use as a fraction of the population, available from ILO.

[xviii] In addition, we tested our model using different specifications to see if the results were robust. For example, we tested to see if our results were significantly different for small economies as opposed to large economies. The intuition for this is that relatively small economies are much more likely to experience a sudden spurt in productivity and wages as a result of increased capital investment as compared to the richer economies that have capital stocks relative to the world supply of investment. Hence we should expect to see a larger impact of corporate taxes on wages in these small economies, in terms of a larger size estimate of the coefficient on tax rates. Therefore we ran a regression with the highest income economies excluded from the sample.[xviii] As we expected, the coefficient on the corporate tax rate increased to -0.965 from its value of -0.781 in Column (1) of Table 2. These results suggest that at least in the medium to short-run (in the five year period used in the sample) smaller economies are significantly more likely to respond to corporate tax rates and see visible changes in productivity and wage rates. In other specifications, we added in a measure of average personal taxes in the regression.

[xix] It is also interesting that when we include capital-labor ratios in the wage equation, the effect of neighbor country and own tax rates becomes insignificant. This suggests that tax rates are important to the extent that they influence capital formation and affect worker productivity, and thereby affect wages. However, the

fact that controlling for K/L makes the coefficients insignificant, implies that they are unlikely to have other direct impacts on wages.