Effective Corporate Taxation, Tax Incidence and Tax Reforms: Evidence of OECD Countries

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This version: February 2014.

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Abstract

The present study provides estimates of the Effective Marginal Tax Rate (EMTR) in a single framework encompassing capital, labor and energy taxes for a sample of 14 EU and 2 non-EU (i.e. the US and Japan) countries. The use of the EMTR and its comparison across sectors and countries is particularly useful when assessing the potential consequences of tax policy changes on the total cost of business activity. To date, however, existing studies have focused on capital taxation only. Research support to tax policy formulation should consider other production factors as well, especially when devising strategies aimed at shifting the tax burden between factors in order to favour growth and employment creation. In particular, our cross-country/cross-sector approach allows us to gauge the effects of tax changes on the competitive position of EU firms by taking explicitly into account the possible substitution and tax incidence between different production factors. To do so we combine state-of the art estimates of the EMTR on capital (from the Centre for European Economic Research - ZEW) with indicators on the EMTR concerning energy products (drawing mainly from the IEA database) and with EMTR on labour, using the OECD Taxing Wage model and detailed data from the EUROSTAT Labour Force Survey. Our results suggest that the OECD tax systems provide very different incentives for manufacturing activity across countries and that the tax systems are relatively neutral with respect to the sectoral composition of manufacturing activities. These results are also robust to alternative hypotheses regarding the tax incidence parameters. We in addition conduct an analysis of the impact of alternative tax shifting strategies between production factors and show that strategies favoring tax increases on energy consumption and lowering taxes on labor, often advocated in the EU in order to promote environmental and employment goals, can entail competitiveness gains for EU businesses. We find that environment-friendly and employment-friendly tax reforms should in some instances be ambitious enough in order to produce desired effects on firms' productive efficiency.

Keywords: Taxation, Tax incidence, Effective Taxation
JEL-classification: H20, H22, H24, H25.

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1. Introduction

Since the seminal works of Jorgenson (1963) and Hall and Jorgenson (1967), economists have been interested in the effect of corporate income taxation on the cost of capital of companies. Such work has been extended to cover various types of corporate and non-corporate taxpayers, sources of financing and assets in which to invest (see e.g. Jorgenson and Yun, 1991 and Jorgenson, 1992). This literature has led in turn to the development of Effective Marginal Tax Rates (EMTR) to capture the tax burden on marginal investment projects - that is new additional projects with a marginal return on the last unit invested just equal to the marginal cost of the project – by comparing the pre-tax and post-tax cost of capital of such projects (Auerbach, 1979; King and Fullerton, 1984).[2] A large economic literature has consequently looked at the effect of effective corporate tax rates on the economic behavior of companies, including their location, investment choices and profit-shifting strategies, while other papers have used these rates to address questions of tax competition between jurisdictions. Effective corporate tax rates are now available from various sources on a periodic basis (see ZEW, 2012).

The focus on corporate taxation nevertheless limits the analysis to the effects of corporate income taxation in the home and host countries and their interactions under the provisions of tax treaties to prevent double imposition. In reality, firms face a much larger set of taxes ranging from taxes on their labour employed (social security contributions, payroll taxes, etc.), environmental taxes (e.g. taxes on extraction, on energy use and on emissions), VAT (to the extent that the sector is exempted and cannot deduct the input VAT), property taxes, or (mainly local or regional) taxes on their turnover or their production. Desai, Foley and Hines (2004) find that the high degree of correlation between corporate income tax rates and other tax rates may have mixed their respective effects whereas the alternative taxes are much larger than corporate income taxes and their effects important, not least because they are often not subject to any international relief in bilateral tax treaties.

This paper uses the approach developed by McKenzie, Mintz and Scharf (1997) to compute multi-factor effective marginal tax rates at sectoral level. Thanks to this approach we

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[2] This strand of the literature on effective taxation is also called forward-looking as opposed to backward-looking approaches that look at ex-post data on actual taxes paid. See Nicodeme (2001, 2007) for a review. In addition, the concept of Effective Average Tax Rates (EATR) was developed by Devereux and Griffith (1999) as summarising the distribution of tax rates for an investment project over a range of profitability,

can consider the effect of changes in production costs when the use of all production factors are altered simultaneously. It is therefore a measure of the additional taxes that need to be paid not only when capital investment is increased but, in more general terms, when the use of all factors rises as a result of increased economic activity and the tax burden is split and/or shifted between production factors.

Our paper provides a synthetic measure of effective marginal taxation on firms´ activities by using detailed information on the tax codes aggregated at sector level using weights based on sector-specific intensity of factor use. Each production factor is considered in a detailed way. For labor, we make use of the OECD taxing wage model that allows us to take into account of the progressivity of the tax system, including the influence of the social benefit paid or received by both employers and employees. For each potential wage level, we simulate the net tax paid by both employers and employees and combine these figures with detailed data from the EUROSTAT Labor Force Surveys (LFS) in order to calculate weighted average of the EMTR on labor considering differences in wages due to education level, firm size, gender and sector of activity. For capital, we make use of the estimates provided by the Centre for European Economic Research (ZEW) based on detailed corporate tax codes for three assets classes, namely Machinery, Buildings and Intangibles. We then construct weighted average measures of the EMTR on capital based on sector-specific investment level. Finally, for energy, we construct weighted average estimates of the EMTR based on detailed energy effective tax for each fuel and energy type drawing from the IEA/OECD database. Here again sector and country-specific weighted average tax levels are calculated taking due account of the intensity of energy uses by sector. To our knowledge this is the first study of this type providing a synthetic measure of the effective marginal tax level on a cross-country/cross-sector basis. By computing such an indicator over different countries and sectors of activity, we get a clear picture on how the tax system may favour certain types of activity.

A recent focus of tax policy, notably in the European Union, is the recommendation made to the Member States to shift taxes away from personal and corporate income towards taxes that are less detrimental to growth, among which environmental taxes.[3] This paper provides simulations of such shifts and their effects on the multi-factor marginal effective tax rates faced by businesses. Our results show that the OECD tax systems provide very different

[3] See the recommendations made in the context of the European Semester and contained in the Annual Growth Survey (European Commission, 2013). This ranking of taxes is derived from several academic works, among which Johansson et al. (2008).

incentives for manufacturing activity across countries and that the tax systems are relatively neutral with respect to the sectoral composition of manufacturing activities. We also perform tax policy change simulation consisting in shifting taxation away from labour and capital and towards energy taxation. Finally, this paper also provides guidance in the debate of whether an increase in environmental taxes leads to a loss of competitiveness of some sectors. The change in firms´ production cost entailed by tax reforms can yield a competitive advantage as long as their design allow firms to lower their production cost and/or develop their innovative capability. For instance, Porter (1995) suggests that green taxes can lead firms to develop a competitive edge through forced green innovation, which may yield a productivity gain. Our results suggest that the tax shifting of labour vs. energy taxes would lower the marginal tax burden and would prove the most beneficial for manufacturing activities across countries and sectors of activity. By contrast the shifting of capital vs. energy taxes would not alter the production cost in a substantial way.

The remainder of the paper is organized as follows. Section 2 describes the methodology used and modeling approach, Section 3 provides data sources and details on the calculation of the effective tax indicator. Section 4 describes the main results and provides simulations of the impact of tax shifting on production cost.

2. Modeling approach and methodology

This paper develops an indicator of multi-factors marginal effective marginal effective taxation with imperfect competition in product and factor markets. We borrow from McKenzie et al. (1997) and extend their approach to consider monopolistic pricing in the final product market. Each supplier can impose a mark-up (μ) on its price that reflects its market power. Following standard monopolistic price setting, the total marginal cost of production *T* can be expressed as a function of each factor's marginal cost and of the final product mark-up such that:

$$T = \frac{MC\left(q^{'};V^{'}\right)}{MC(q^{'};\mathrm{V}^{0})\left(1+\mu\right)} - 1 \tag{1}$$

Where *MC* is the marginal cost function, *q* is the level of output, *V* the vector of input prices evaluated at net (V^0) and gross value (V'), the later including the effect of the various taxes on the input prices. Such an approach thus requires the specification of a production function and of its related hypotheses regarding the degree of substitution between production factors as well as the characterization of the supply and conditions in the inputs markets (i.e.

supply and demand elasticity) that determine the extent to which the effect of a tax change are passed through changes in user costs.

For instance considering a CES production function of the form, the nominal value of the final production is:

$$q = H\left[\sum_i \frac{a_i}{f_i} x_i^0\right]^{\frac{1}{\rho}} \qquad (2)$$

where x_f is the quantity of input i employed, a, f and ρ are production function parameters with the elasticity of substitution between inputs being equal to $\sigma = \rho/(\rho\text{-}1)$ and $q=p_f.q^r$ where p_f is the final price of the output being produced and q^r is the real value of output. The value of p_f is defined in a standard way in monopolistic market such that the price is the marginal cost augmented by the mark-up:

$$p_f = (1+\mu).MC\left(q';V'\right)$$

The gross of tax marginal cost function arising from the production function is:

$$MC(q';V') = H^{-1}\left[\sum_i a_i^{\frac{-b}{\rho}} (f_i V_i')\right]^{\frac{1}{b}} \qquad (3)$$

with $V_i' = V_i^0(1+t_i\beta_i)$, v_i being the unit price of input i and $\beta_i = \left[\frac{\eta_i^S}{\eta_i^S + \eta_i^D}\right]$, where η_i^S and η_i^D are the elasticity of supply and demand characterising the market for input i. In other words, the gross value of the unit price is the net value plus the incidence of the taxation of the input that falls on the producer.

Using (1) and (3) one can calculate the EMTR specific to the CES production (2) such that:

$$T = \frac{1}{1+\mu}\left[\sum_i A_i(1+t_i\beta_i)^b\right]^{\frac{1}{b}} - 1 \qquad (4)$$

Where the factor share of input i is given by $A_i = \dfrac{a_i^{\frac{-b}{\rho}}(v_i^0 f_i)^b}{\sum_i a_i^{\frac{-b}{\rho}}(v_i^0 f_i)^b}$ with $\sum_i A_i = 1$

By calculating the EMTR on total production cost, we consider alternative hypotheses regarding the extent to which firms can pass through the impact of marginal tax increment onto their production factors, represented by β_i, or onto their customer, though μ, which implicitly reflect the relative values of the supply and demand curves in these respective markets. The term β_i thus reflects the tax incidence and can be considered to vary from zero (i.e. the firm cannot pass-through the taxes on its inputs to its own costumers) to one (the taxes on inputs to the firm are fully passed-through to the customers) following the McKenzie et al. (1997) approach.

The value of these tax incidence parameters is ultimately an empirical issue. We thus draw on the existing empirical literature in order to carry out a sensitivity analysis.

3. Calculating the effective tax level by country and sector of activity

The usual approach for calculating the marginal tax rate on production factors is to consider a marginal increase in the use of production factors. In practice, this requires having detailed information on the tax systems. In the case of labor taxation, this means that one needs to consider individual characteristics to account for e.g. elements such as marital status, number of dependents, benefits entitlements, etc., which all determines the marginal burden shall labour income increase by a given amount. Existing studies such as McKenzie et al. (1997) therefore usually focused on a single country and need to consider the marginal burden faced by an average worker. Unlike these previous authors, our measure of the total EMTR includes labor marginal taxation form paid directly by firms (payroll taxes, mostly in the form of social security contributions) and by workers (wage taxes, including the effect of labour income tax, social security contributions and social benefits) for different levels of income and not only for the average. This information is obtained from the OECD Tax analyser model and allows covering several OECD countries. For capital, our measure is also truly "marginal" to the extent that we, like McKenzie et al. (1997), adopt the King and Fullerton (1984) methodology and account for the existence of allowance and credit and asset-specific special fiscal treatment depending on its mode of financing and asset-specific amortization rules using the ZEW indicators. In addition, we extend our measurement of the effective marginal tax to energy inputs. In this case, however, we only avail of average measures of the effective tax burden, assuming a one-to-one relationship between input use and its extra marginal tax cost. One must note that the measure of the EMTR for the three inputs is not strictly comparable. For instance, in the case of capital, one usually considers a hypothetical incremental investment undertaken by a given firm considering a post-tax real rate of return required by its shareholders and using the tax code to compute the implied required real pre-tax rate of return. For labor, we consider the marginal increment of earnings that is taken away by the tax system, accounting also with potential interactions with the benefit systems, i.e. foregone benefits or loss of benefits entitlement due to wage increments. For energy and CO2 emissions, effective taxation is calculated based on a point-input/point-output basis as mentioned earlier. In all three cases, we therefore assume that the firm can vary their use without considering the possible existence of discontinuity and extensive margin in factor supply. This means in particular that we assume that the absence or shortage of specific production factors (e.g. skilled labour or specific capital assets) is fully reflected in the factors´ pricing and directly influences the tax incidence parameters β_i and μ. Furthermore, the influence of each production factor on the total effective marginal taxation is captured by the factor-specific weights, which are taken from the OECD STAN database. For capital, these weights are specific to each types of investment, i.e. building, machinery and stock. For labor the weights depend on the wage distribution within each sector/country, taking into account the categories of workers differentiated by level of education, gender and size of the employing firm. Since each sector makes different use of different type of labor, in particular in terms of its skill content, in doing so we thus further differentiate sectors depending on their specific employment characteristics. For energy/CO2, the weights depend on the quantity of fossil fuels and the levy applying to different energy sources, which ultimately reflect cross-sector technological differences. In the sequel we provide more details on the calculation of each sector-specific effective marginal tax rate.

3.1. Capital

For the capital component, the EMTR is derived directly using the King and Fullerton (1984) methodology and can be expressed as[4]:

$$t_k = \frac{Y^* - Y}{Y^*} = \frac{r^* Y_0 - r Y_0}{r^* Y_0} = \frac{r^* - r}{r^*} \qquad (5)$$

Where Y_0 is the initial investment, Y^* *and* r^* (Y and r) are the net present value and the rates of return of the pre-tax (post-tax) income stream generated by the hypothetical investment net of depreciation, respectively.

The variables are defined as:

4 See e.g. http://ec.europa.eu/taxation_customs/resources/documents/annexes_en.pdf

$$r = \frac{\pi - r^*}{(1+\pi)} \quad (6)$$

where π is the real return on a specific investment project and r^* the general economy real market interest rate (e.g. a risk-free public bond) and the net income stream is given by:

$$Y^* = \frac{r^*}{(1+\pi)} \quad (7)$$

The EMTR must therefore incorporate a wide range of elements going beyond the statutory corporate taxes, such as elements of the tax base, the mode of financing of the investment (debt, retained earnings or new equity), amortization rules or the level of inflation. In presence of taxes the return to investment projects is altered and optimality requires equality of return of different investment types *at the margin*. We thus adopt an incremental approach, which consists in determining the share of extra-revenues foregone in tax payment if investment revenues are increased by one euro. Such marginal investment needs to generate an expected rate of return sufficient to convince investors. Such "break-even" (pre-tax) rate of return can be calculated considering the tax code and its interactions with other aforementioned economic factors in order to determine the so-called cost of capital financing different types of assets. The main source to calculate the EMTR on capital is the ZEW database on corporate taxation including detailed country-level on information on tax allowances for capital taxation (ZEW, 2013). The ZEW dataset provides estimates of the effective marginal tax rate (EMTR) for all EU countries, Japan and the US (California) split by type of asset and source of financing for the all years 1998 to 2012. The three asset categories considered are industrial buildings, intangibles and machinery.[5] In order to calculate an average EMTR by country/industry we require the share of each type of capital purchased by industry. For this purpose we used data from the EUROSTAT structural Business Statistics. The data for the period 2008-2011 was the most complete, although it must be said that the recession experimented by a number of EU countries might introduce some abnormal variations in the share spent in each asset type. Data on investment in intangibles are taken from the Eurostat survey for 2009 on intangible investment in the context of the Structural Business Statistics covering all EU countries and the NACE 2-digit sectors considered in the study. The information concerns Gross investment in concessions,

[5] The ZEW database also provides estimates of the EMTR financial assets and inventories. These other investment categories are not considered here due to insufficient comparable data. Also ZEW provides EMTR by mode of financing (i.e. debt, equity, retained earnings) which are not considered here for sake of brevity.

patents, licences and trademarks and similar rights, investment in purchased software, investment in software produced by the enterprise and payments to subcontractors. [6] [7]

Table 1 provides the weighted average values of the EMTR for capital, where the weights are determined by the share of each asset in total investment. The country with the highest EMTR on capital is by far Japan, with an average EMTR around 40% for all sectors. Interestingly, the US is the country with the second highest EMTR on capital with a rate between 35%-36% depending on the sector considered. In both these countries, the cross-sector variation in EMTR on capital is well below the values observed for the other countries as indicated by the last two columns. The countries with the lowest EMTR are Belgium (2.8%), the Czech republic (7.4%) and Ireland (8.3%). The first two countries display rather wide variation in their EMTR on capital across sectors of activity however, as a result of the differences in asset-type used. For instance, some sector such as the Chemical and Petrochemical, Machinery and Mining & quarrying industries display negative effective marginal tax rate on capital in the Belgian case. Cross-sectors variations are also non-negligible in the case of Portugal and Italy. In countries such as Austria, Finland and Sweden, corporate taxation is relatively low while the tax system does not seem to favour any specific type of activity. In these cases changes in corporate tax policies can be thought as having a lower distortionary effect on investment opportunities across different types of activities. In contrast, in countries such as Belgium, the Czech Republic or Italy, the tax system is likely to have non-neutral effect on cross-sectoral investment choices given the relatively large dispersion of the EMTR on capital compared to the average value.

3.2. Labor

For labor taxation we also adopt a *marginal* approach that calculates the supplement of taxed paid by having an average worker working an extra-hour of time. A recurrent debate

[6] For Japan and the US we did not avail of comparable data such that the average of a selected sample of EU countries deemed to be close technologically from these two countries. These countries are Belgium, Germany, France, the Netherlands, Italy and the UK.

[7] The share of investment in Machinery displays the highest average values (62.9%) followed by investment in intangibles (20%) and investment in buildings (17%). Investment in machinery is particularly high in Mining and Quarrying (71.3% on average), Paper, pulp & print (71%) and Non-metallic minerals (68.2%) and the Transport equipment industries (66.1%). Investment in intangibles is particularly high in Machinery (32.2%), Chemicals and Petrochemicals (28.6%), Transport Equipment (22.8%) and Textile & Leather (22.3%). Building investment on the other hand are relatively more important for Wood & wood products (21.9%), Non-ferrous metals (19.9%), Mining & quarrying (19.4%) and Other manufacturing industries (19.3%). Despite these average figures, the data shows a great heterogeneity in country/sector shares. See table in Appendix

is whether taxes whose legal incidence is on the employees display an economic incidence that is shared by the employers and hence represents a cost for them. Our framework allows us to provide a sensitivity analysis for this. In contrast to previous research - which has so far focused on payroll taxes paid by employers, making simplifying assumptions regarding the burden sharing of those taxes between employers and employees (see for instance McKenzie et al.,1998 and Vermaeten et al., 1994) - this paper provides measures of the EMTR based on a net tax approach (i.e. additional taxes net out of additional social benefits and tax rebates) including both the taxes paid by employers and employees. In doing so, we are thus also able to consider the entire tax wedge on labour and thus the possibility for employers to partly absorb part of the tax increases that is initially paid by employees though higher wages. We assume that the overall tax incidence on labour is the combination of the tax incidence affecting the payroll taxes given by β_l^{er} and the tax incidence affecting the tax paid by workers directly β_l^{ee}.

Assuming perfect competition in labour market, the gross wage value (i.e. including the effect of taxes) is given by:

$$w^g = p^f MP_l \quad (8)$$

We also consider that the gross wage is determined *ad valorem* such that:

$$w^g = \left(1 + t_l^{ee} + t_l^{er}\right)w \quad (9)$$

We can then use equations (8) and (9) to calculate the difference between the gross and the net wage in proportion of the net wage, i.e. the tax wedge, as a function of the tax incidence parameters and the tax rates such that:

$$\frac{w^g - w}{w} = t_l^{ee}\beta_l^{ee} + t_l^{er}\beta_l^{er} \quad (10)$$

By considering the possibility that part of the labour tax is partly shifted way from workers to employers we assume that labour supply might be imperfectly elastic. Since employees´ labour tax might be shifted onto firms we need to consider the progressivity of the tax systems and netting out taxes (including personal income taxes, social contributions and other payroll taxes) of benefits, which are directly or indirectly tied to labor income. This is done by considering the full details of each country tax and benefit codes, including social contribution and thus covering compulsory health insurance, pensions and unemployment insurance. For this, we use of the OECD Taxing Wage model that provides the EMTR for each level of earnings (expressed in percentage of the average-country earning). Labour taxation is measured by the effective marginal tax rates, i.e., the additional tax paid for an additional 1% increase in labour earnings. The OECD Taxing Wage model we are using defines the EMTR as the proportion of earnings is *"taxed away by the combined operation of taxes, social security contributions (SSCs), and any withdrawal of earnings related social benefits"*.[8] The EMTR directly falling onto employees can be calculated for each earning level.[9] We have obtained estimates of the EMTR for levels of wages ranging from 30% to 200% of the average wage, using 5% successively. We have then allocated the corresponding EMTR to each hourly average wage of each sector/country pair using manufacturing sectors wage statistics from the U.S. Bureau of Labor Statistics. The EMTR on labor paid directly by employers are also obtained using the OECD Taxing wage model for various levels of effective average taxation (67%, 100% and 167% of average wage). We use a weighted average of the employers´ tax rates on labor corresponding to the different relative wage levels by country/industry.

Given that the EMTR is a *marginal* measure - it concerns a small increment of the tax bill corresponding to an equally small increment in wage - it is convenient to use hourly wages in order to determine the level of EMTR corresponding to each sector of activity reflecting both the sector-specific average wage and labour composition. The weights used to calculate the EMTR by sector therefore reflect the hourly wages values by sector and country as provided by the US Bureau of Labor Statistics database for a number of OECD and emerging economies according to the ISIC classification.[10] Table 2 provides a description of the average hourly labour cost by sector and country for the period considered here. As can be seen, the standard deviations (last column of Table 2) are broadly comparable across sectors but vary widely across countries, ranging from 10% in Denmark to 28% in Hungary.

Beyond the sector and country-differences in wages, the existing empirical literature has provided ample evidence on wages differences being determined by labor's and firms' characteristics, see e.g. Willis, 1985 for a review. In order to consider these differences, we use results of a recent study conducted by the OECD estimating Mincerian wage equation for a large sample of OECD countries where these characteristics are covered for the sample of

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8 See OECD (2011).

9 We have obtained estimates of the EMTR for levels of wages ranging from 30% to 200% of the average. In order to simplify this exercise we increased each time this value by 5%, i.e. from 30%, 35%, 40% until 200%. We then allocated the EMTR corresponding to each hourly average wage of each sector/country pair.

10 The database is available at: http://www.bls.gov/data/#international. Missing values were filled in using linear interpolation based on countries´ general economy hourly labour cost index.

countries considered here (see Strauss and de la Maisonneuve, 2009). In particular, country-specific estimates of the determinants of wage levels are provided in this study, along their statistical significance. We have focused on four such variables: gender, education attainment, plant-size and the interaction between higher education and gender. The coefficients estimated by Strauss and de la Maisonneuve (2009) are reported in Table 3. Importantly, these estimate account for the interaction between education level and gender and show in particular that in many countries, women with a higher education degree still earn less than the average. In order to account for these individual and firm-specific determinants of wages differentials we re-calculated the average of sector-specific wages using as weights the proportions of women employed, including women with higher education degree, the proportion of employment in large firms and the proportion of employees with higher education degree using detailed data of the Eurostat Labour Force Survey (ELFS). [11] Because the ELFS does not cover Japan and the US, we had to use average values based on the EU countries with the closest characteristics by taking average values belonging to the same quartile as Japan and the US respectively. To do so, we have used country level data such as the Barro and Lee database on education attainment (Barro and Lee, 2010), the OECD STAN database for the firm size and the OECD Labour Force Survey for the share of women in total employment. These proportions were calculated for the different sectors of activity

The EMTR on labour paid by employers and employees was thus calculated depending on the level of sector-specific hourly wage vs. the average, taking into account individual and firm-level characteristics and sector-specific employment composition. For each country we have thus calculated the EMTR on labour as a weighted average of the EMTR corresponding to each category of worker, taking as benchmark the average hourly wages values at sector level as indicated below:

$$t_l = \sum_h a_h \, . \, t_l^h \tag{11}$$

with h indexing individuals according to their characteristics and the weight a_h correspond to the proportion of individuals with characteristics h (i.e. women, highly educated, women with higher education and workers of large firms and the rest of individuals, i.e., male with no higher education degree working in small firms). The EMTR calculated using the OECD Taxing Wages simulated taxes were thus allocated to each of these groups

11 Large firms were defined as those with more than 50 employees.

depending on the level of relative sectoral wage which were in turn determined by adjusting the wages levels by considering the Mincerian estimations provided by Strauss and de la Maisonneuve (2009).

3.3. Energy

The approach for energy/CO2 taxes is slightly different form the one considered for capital and labor. Here, we assume a direct relationship between the level of input used and the level of output. In this case, one can simply calculate the *average* rather than the *marginal* tax rate since the return on factor used is assumed to be known and follows linearly the level of input used, so that the marginal and average tax rates are identical. In order to build our measure of EMTR on energy, we use the Energy Prices & Taxes Quarterly Dataset published by the International Energy Agency (IEA, 2012a). This database contains the final prices as well as the net prices (taxes excluded) for 14 primary energy inputs.[12]

As a general rule, these end-use prices: (i) include transport costs to the consumer; (ii) are prices actually paid (i.e. net of rebates); (iii) include taxes which have to be paid by the consumer as part of the transaction and which are not refundable. This excludes value added tax (VAT) paid in many European countries by industry (including electric power stations) and commercial end-users for all goods and services (including energy).[13] Similarly, net prices only includes (i) and (ii), leaving out the whole variety of excise duties applied to each energy product (excise taxes and special taxes as well) which are grouped to form our energy taxes variable.[14]

This database provides also information by sectors (industry, households and electricity) and further disaggregation for the manufacturing industry that is used here. By combining these indicators, we are able to recover the total tax applied to each energy source. Importantly, the IEA database provides tax rates using homogeneous units across energy inputs – expressed in Tonnes of Oil Equivalent (toe) over a relatively long time period (as from 1978) for a representative panel of EU countries and the Rest of the World (including

12 These inputs are High sulphur fuel oil, Low sulphur fuel oil, Light fuel oil, Automotive diesel, Premium leaded gasoline, Regular leaded gasoline, Premium unleaded 95 RON, Premium unleaded 98 RON, Regular unleaded gasoline, Liquefied petroleum gas, Natural gas, Steam coal, Coking coal and Electricity.

13 In these cases, (input) VAT is generally refunded to the (VAT registered) customer. Therefore, it is not included in the prices and taxes columns in the tables. This also applies to automotive diesel for the EU countries.

14 A detailed description of taxes applied to energy products in each country goes beyond the objectives of this paper. In this regard, IEA (2012b) contains country specific notes for the interested readers.

Japan and the US). We consider the full range of energy sources[15] in each country to build a measure of the EMTR on energy along two dimensions: in terms of energy content and carbon emissions. IEA (2012b) contains a very detailed energy balance for a wide number of energy sources in which 93 categories are distinguished. We focus on final consumption of energy by the manufacturing sectors (i.e. from codes 51 to 93 of the IE classification).

For the data on CO2 emissions, we use the Carbon Emissions Factors of each energy source to transform energy use expressed in terms of "energy content" into corresponding CO2 emissions reported in table 4. We follow the approach by the OECD (2013) by computing a weighted average of excise duties applied to each energy sources, although we consider a more detailed classification of energy use relying on the extended energy balance published by the IEA (2012a). Final (i.e. tax inclusive) and net price are used to determine the tax rate applying to each primary energy input. We then transform the total taxes applied to each primary input into the total tax applied to each energy source. One should note that in some cases, energy sources can be affected by more than one primary energy inputs. From the IEA (2012b) data, we consider End-Use Energy Prices for 14 primary energy products and related end-user taxes by calculating the difference between the final price and the net of tax price and aggregating these for each energy source included in Table 4 based on the reported consumption by sector.[16] In general, the matching of energy sources is straightforward, with only a few exceptions that could be assigned manually.[17] In these cases, the average price of related products is considered instead. See table A1 for a detailed description of the matching process.

The EMTR on energy products can be calculated for each country and sector as indicated below:

$$t_e = \sum_s t_e^s \frac{E_s}{\sum_s E_s} \tag{12}$$

where s indexes the energy sources and E_s is expressed in physical units (i.e. tons of CO2 or TJ).

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[15] See Table A1 for a full description of energy sources included.

[16] The energy products considered are: (A) High sulphur fuel oil (B) Low sulphur fuel oil (C) Light fuel oil (D) Automotive diesel (E) Premium leaded gasoline (F) Regular leaded gasoline (G) Premium unleaded 95 RON (H) Premium unleaded 98 RON (I) Regular unleaded gasoline (J) Liquefied petroleum gas (K) Natural gas (L) Steam coal (M) Coking coal (N), and Electricity.

[17] For instance, "Motor gasoline" could be matched using different prices (leaded vs. unleaded gasoline)

An alternative would be to consider $P_s.E_{s,k}$ where P_s is the price of specific energy source *s* such that one obtains a percentage figure comparable to the percentage figures calculated for the other production factors. One must admit that the coverage of our measure of EMTR on energy is somewhat limited for three main reasons. First, we assume that end-users prices apply equally to all energy purchasers within a given sector of activity. Generally speaking, companies can negotiate specific conditions for different fuels such that applying the same price to all energy purchase is likely to bias the measure of the EMTR upward. More detailed information would be needed at a micro-level on energy bills and associated tax payment by company size in order to reduce this bias but such information is however not available. Second, we do not account for own-energy production that might be taxed differently from end-user energy purchase. Here again, lack of detailed and comparable information prevents us from considering this other aspect as well. Finally, a limitation might come from the fact that we do not consider the case of ETS permits for European countries. In practice not considering the ETS should have only a limited impact on our measure of the EMTR, however. The ETS is a system of cap and trade for CO2 emission rights, launched in 2005 in the EU, was first implemented through a system of grandfathered allowances. This system only covered CO2 emissions from power generators and energy-intensive industrial sectors i.e., namely, Iron & Steel, Chemicals, Non-ferrous metals, Non-metallic minerals, Mining & Quarrying, Paper, pulp & print. While in its second phase (i.e. as from 2008) the cap on emissions was significantly reduced coinciding with the first commitment period of the Kyoto Protocol and included other gases as well.[18] However, the implications of the ETS from a tax perspective are far from clear. Most EU countries treat ETS allowances as commodity and thus as intermediate consumption with immediate or time-of-use deduction. Other participating countries treat ETS as intangible asset and allow firms to depreciate them over their expected lifetime. Furthermore for the period covered in the study, the ETS worked mainly as grandfathered allowances system, which effects are smaller from a tax perspective to an intermediate product since such allocation is made on yearly basis without allowing time depreciation as for a classical physical investment, see in particular Copenhagen Economics (2010). In addition, the economic crisis that erupted in 2008 depressed emissions substantially in the subsequent years, and thus the demand for allowances. This led to a large and growing surplus of unused allowances and credits, which weighed heavily on the carbon price throughout the second trading period. For the time period considered here not considering the

[18] This concerned nitrous oxide emissions from the production of nitric acid by a number of Member States.

ETS in our measure of the EMTR does not seem to be a major issue although future tax treatment of the ETS might be warranted with full-auctioning and longer bankability period for emission rights foreseen in the future.

Tables 5 and 6 show sector and country average values of the energy effective average tax rate for the period 2001-2010. The sectors "Non metallic minerals" (12.8%), "Non-specified industries" (12.8%) and "Textile and leather" (12.6%) have the highest EMTRs. With respect to the trend, although the path is almost stable, one can observe a slight increase in 2004-2005, followed by a slight decline as well as a reduced heterogeneity among sectors over time. The Great Recession period (2008-2010) has not witnessed a rather marked decrease in EMTR on energy, with a difference between the average value during the periods 2000-2007 (11.14%) and 2008-2010 (10.50%) below 1 pp. Turning to table 6, Denmark shows the highest EMTR at 28.4%, followed by Italy (20.9%) and Austria (15.8%), while Czech Republic, Hungary and the U.S. are the lowest (under 3%).

4. Effective taxation on total production cost

Using a CES production function, we consider the overall marginal tax burden imposed on firms by combining the EMTR calculated on the three production factors as indicated in equation (4). In order to calculate the weight of each production factor (represented by the term A_i in equation 4), we use the OECD STAN database - which provides the total salary paid by country and sector of activity and the total level of capital investment – and the IEA database on energy purchased by sector and energy source as described in Section 3. The factor-specific weights are averaged over the period 2001-2010 in order to avoid short-term fluctuations, which might reflect adjustments to the business cycle without reflecting the factor use depending on relative tax burden. Tables 7 to 9 provide the share of energy, labor and capital, in total factor spending respectively.

The weights are the highest for the labor factor representing on average (across country and sectors) 67.7% of the total production costs, while capital and energy represent 19% and 13.3% respectively. The sectors with the highest energy share are Non-ferrous metals (25.7%), Iron & Steel (25.3%) and Paper, pulp & print (18%), those with the highest labor share are Textile & leather (80.2%), Machinery (78.3%) and Transport equipment (73.4%). Finally, those with the highest capital share are Chemicals and petrochemical products (23.9%), Transport equipment (22.5%) and Food & tobacco (22.5%). The labor input share is by far the most homogenously distributed across countries and manufacturing sectors while the energy and capital intensity are more unequally distributed across countries. The latter could be due to the rather coarse definition of sectors used here, although countries are expected to differ in terms of factor intensity due to difference in technological level as well.

All factors of production are combined in order to determine the effective marginal tax rate on total production cost according to the expression in (4) assuming the production process can be described with a CES specification. From the perspective of the firm, the relevant part of taxes is the one that increases the production cost *at the margin*. Firms can however smooth the impact of a given tax increase either on other production factors or on their customers. The EMTR calculated for each production factor separately might thus differ from the real tax burden effectively falling upon firm. The question is therefore to determine the extent to which the taxes on these three production factors do increase the total production cost of a given firm.[19] This in turns leads us to make a number of alternative assumptions drawing on the existing literature on tax incidence, i.e. the extent to which the demand and/or the supply of each production factor will share the burden of an extra marginal taxation. We consider the relevant literature and describe the different scenarios in what follows.

4.1 Assumptions on tax incidence: review of the literature

In the case of labor, the interplay between demand and supply of labor shall determine the relative influence of tax changes on employers vs. employees on the one hand and on employees vs. capital and energy on the other hand. The same question holds when considering other production factors. For energy inputs in particular demanders and suppliers face specific (and often different) taxes and the shift of the tax burden on either side of the energy markets depends on energy market conditions, i.e., on the elasticity of supply and demand which themselves depend on the market structure, energy source scarcity, short and medium term technical constraints, etc. For capital this question is treated more indirectly by considering the taxation of different forms of investment against which productive investments are considered. In this case, a change in taxation will alter the relative profitability of different investment projects that can eventually lead to changes in business investment types. The power to pass through the effect of taxes to final consumers will equally depend on market conditions for the product or service being produced by the firm.

[19] One shall also note that the elasticity of substitution in the CES function allows us to control for the incidence of taxation applied to one factor of production on the others. In this study, the elasticity of substitutions are by default set to one (full substituability).

Thereby, the consequences of a change in tax affecting a specific factor of production will therefore also depend on the ability of firms to pass-through this change onto their consumers. The literature on tax incidence has dealt with these different issues extensively in the past, see in particular Fullerton and Metcalf (2002).

For all three factors of production the influence of demand and supply conditions and the incidence of taxes on the user cost of a given factor *i* for the firm will be given by the expression of the direct tax incidence on production factors β_i and the indirect incidence on final product consumers μ.[20] The direct tax incidence on production factors is given by the ratio between supply and demand elasticity:

$$\beta_i = \left[\frac{\eta_i^S}{\eta_i^S + \eta_i^D} \right] \tag{13}$$

One should expect that the share of the tax burden borne by the suppliers of the taxed factor decreases as their supply elasticity increases relative to the elasticity of demand (see Feldstein, 1974). The value of β_i should therefore increase if the effects of a tax increase are primarily passed onto firms via production cost. Alternatively the value of β_i decreases if the marginal tax burden is passed onto the suppliers of factors through lower returns, i.e. lower wages (*w*) for workers, lower pre-tax of return (*r*) offered to capital owners and lower energy price (P_s).

The relevance of using different values of β_i is especially warranted in the case of labor, since we explicitly distinguish between two types of EMTR depending on which side of the factor demand is being considered. The existing literature on labour tax incidence provides a wide array of results and tends to point to country-specific patterns. For instance Hamermesh (1979) finds that only 1/3 of payroll taxes in the US are actually passed onto workers via lower wages. Gruber (1997) reports that employees face the burden of Chilean payroll tax because of full shifting of the burden from employers into workers earning. Anderson and Meyer (1997,1998) also find full shifting of the burden of higher payroll tax from employers to workers in the form of lower earnings. In contrast, Bingley and Lanot

[20] We do not distinguish explicitly between final household and intermediate firms´ consumption assuming that in each case the same conditions holds in the product markets. This is a simplifying assumption since one might consider that market conditions are governed by different types of contracts and pricing depending on whether the final user is an individual or another company. This is for instance particularly relevant in the case of the energy input. In order to make such distinction one would need more precise information on the supply and demand condition in final vs. intermediary product markets, which is to the best of our knowledge not available on a comparable basis across countries and sectors.

(2002) find strong evidence in Denmark for partial shifting of the burden of income tax from workers to employers as higher marginal wage tax rates are associated with increases in gross wages and earnings. They show that ignoring the potential labour supply response to a tax change, following the methodology of Gruber (1997) or Anderson and Meyer (1998), as well as ignoring the endogeneity of the marginal tax rate, may lead to the erroneous conclusion that the tax is fully shifted onto labour earnings. With respect to the marginal rate of income tax, their estimated elasticity of gross earnings is +0.36 while the elasticity of gross wages is +0.44 (both showing a partial burden shifting). Ooghe et al. (2007), investigating six European countries (Belgium, Denmark, France, Germany, Italy and Luxembourg), find that over half of social security contributions on employers are passed onto workers. Recent evidence suggests however that the degree of tax incidence from firms to workers depends on the skill levels, which directly affect wage bargaining power. In particular Bauer et al. (2012) find in the German case that low-skilled workers are affected most from business tax shifting, indicating that business-tax incidence involves distributional effects among different categories of workers. Fuest et al. (2012) provide micro evidence suggesting that low-skilled labour bear a relatively higher burden of the corporate tax bill as well.

The case of capital is more straightforward. Under the traditional open economy assumption capital supply is assumed to be perfectly elastic and the entire burden of capital taxes falls onto capital demand, such that $\beta_k = 1$ (see McKenzie et al., 1997). For large countries such an assumption is unlikely to be validated, however. We will consider alternative assumptions for large countries included in our sample. The interaction between the tax burdens of the different production factors needs also to be considered in the analysis in order to capture the real incidence of tax rates on the total production cost. For instance, an increase in corporate taxation is generally considered to affect growth prospects negatively through lower investment and thus reduce earning of other production factors, such as labour, in the long-run, see for instance Feldstein (1974) and the recent empirical evidence provided by Arulampalam et al. (2012) and Fuest et al. (2013). We do include this effect via the elasticities of substitution in our CES production function. Considering energy inputs, existing evidence suggests that the buyers of energy products are likely to bear the biggest share of the marginal tax burden. Most recent papers have focused in particular on the tax incidence concerning fuel prices, see in particular Marion and Muelhlegger (2011) and Jametti et al (2013) suggesting that taxes on energy products tend to be fully shifted onto final prices. The assumption made for energy taxes is therefore similar to the case of capital, i.e. we assume that firms are energy price takers such that β_e = 1.

Finally, another key aspect in our analytical framework concerns the mark-up margin μ included in equation (4). Accordingly, a greater mark-up will also act as a shift factor of the tax incidence away from the firm total production cost onto final consumers. The evidence available on final product tax incidence concerns in most very specific products such as cigarettes, TV sets, etc., see in particular Harris (1987) and Karp and Perloff (1989) such that little guidance can be gained from this literature in order to estimate the μ parameter. A better approximation of the potential tax incidence that also fit our analytical framework is therefore to consider the potential existing evidence on the mark-up. The most comprehensive study in this respect is the paper by Oliveira Martins et al, (1996) covering the manufacturing sectors for a number of OECD countries. These authors provide ample evidence for a positive mark-up in most OECD countries and manufacturing sectors suggesting that companies usually fix a positive mark-up on their marginal cost of production such that $\mu>0$.

The previous review of the literature suggests that there is wide variety of possible assumption regarding the tax incidence parameters. The various cases considered are summarised in Table 10. A plausible baseline hypothesis seems to suggest that firms bear the full burden of payroll taxes (i.e. social security paid by employers) and a part of the labour taxes falling legally onto employees. As benchmark we assume that firms bear their payroll taxes in full and a third of employees´ wage taxes. In doing so we are therefore able to extend McKenzie et al. (1997) approach to earning taxes as well, taking account the non-linearity of the tax system and its interactions with social benefits which prove a key feature determining OECD economies´ labour markets outcome and wage setting. Next, we also consider the small open economy case and assume that firms bear the full amount of taxes in input capital. We assume equally that firm bear the full amount of the energy taxation and that final product markets are perfectly competitive such that $\mu=0$, i.e. the final price mark-up is zero.

Five alternative scenarios are then considered. In the first scenario, we consider the literature reviewed above and assume that firms only bear half of the tax incidence on their own payroll taxes. In the second scenario, we consider instead that workers, including skilled workers, bear the full amount of the effective marginal tax rate. In a third scenario, we assume that firm can pass half of their capital taxes back onto investors through lower pre-tax returns on capital. In a fourth scenario, we assume that half of the marginal effect of energy taxes can be passed onto energy suppliers. Finally, in a fifth scenario, we consider the case where final product markets are imperfectly competitive and replace the value of the mark-up coefficient (μ) by those values estimated in Oliveira Martins et al. (1996) by country and sector. In addition, we use similar estimates provided by Badinger (2014), Halpern and Kőrösi (2001) and Estrada and López-Salido (2005) for countries not covered in the Oliveira Martins et al. (1996).

4.2 Effective marginal tax rate on total production cost: country-level results

The results of calculating the EMTR on total production cost following the baseline and scenarios 1 to 5 are reported in Table 11. According to our baseline scenario, the country with the highest EMTR on total production cost is France, which stands out from the rest of countries with an average EMTR of 42.1%. Three other countries have also high EMTR: Austria (36.5%), Italy (35.1%) and Sweden (35.1%). Countries with particularly low EMTR values are Ireland (16.8%), Denmark (18.7%), the Netherlands (18.9%) and the US (20%).

Comparing the baseline EMTR with scenarios 1 to 5 does not alter substantially the ranking of countries. The values of the EMTR in certain cases change significantly, however. For instance while France remains the country with the highest EMTR in all cases, its distinctive position is most altered when considering Scenario 1, i.e. whereby the tax incidence of employers´ payroll taxes is reduced to 0.5. In such case, the EMTR for this country fall by 14 percentage points (*pp*) thus illustrating the high burden represented by payroll taxes on total production cost in this country. Other countries would also see their EMTR falls significantly such as Austria (-10.2*pp*), Sweden (-11 *pp*), Spain (-10.1*pp*) or Belgium (-9.6*pp*). The fall in the EMTR is also pronounced in Scenario 2 where the incidence of earning taxes is removed is even more sizeable on average. The country most affected in this case is Denmark (-14.4*pp*), followed by Germany (-12.6*pp*), Finland (11.4*pp*), Belgium (11.4*pp*) and Austria (-10.8*pp*). The variations in the EMTR when the values given to the tax incidence parameters change is much less pronounced when considering Scenarios 3 to 5 compared to the baseline scenario thus suggesting that labour taxation is likely to be the most important factor of variation in the EMTR on total production cost, over capital and energy taxes. This result should not come as a surprise given the high level weight of labour in total production costs illustrated earlier.

We now consider the extent to which cross-sectors difference in factors uses could bear on the overall manufacturing-wide EMTR. In order to do so in Table 12 and Figure 1, we compare we calculate the difference between the weighted average values reflecting the sectoral composition and the simple average of sector EMTR by country. A positive sign of this difference would indicate that the sectoral composition of the manufacturing industry tends to increase the overall manufacturing marginal tax rate while a negative sign would suggest the opposite. In the first case, the tax and benefit system would thus tend to penalise the manufacturing industry because of its structure while in the second case the industrial structure would tend to lower the negative effect of the tax system on the manufacturing activity. Overall our results suggest that the tax system tends to be relatively neutral with respect to the structure of manufacturing activity with a slight tendency to act against manufacturing activity. The latter is effect is the most pronounced in France, Sweden and Germany although in these three case this effect is moderate and close to 1*pp* only. Comparing the EU vs. non-EU countries, i.e. the US and Japan suggests that the discriminatory effect of the tax system vs. the industrial structure is larger in the non-EU countries (of 0.9*pp* on average) compared to the EU average (0.4*pp*).

4.3 The impact of a tax policy shift

One of the benefits of our approach is that we can jointly discuss the role of different productive factors in the overall production cost structure. We can therefore analyse how the global EMTR would change if some proportion of tax burden applied to one factor were shifted away from one factor to another one (i.e. tax shift). In this section, we aim to illustrate the potential gains in terms of reduction of observed EMTR while keeping constant the level of tax revenues collected on the use of the three factors considered here (i.e. revenue-neutral tax shifts).[21] Particularly, we will focus on a set of scenarios in which we reduce taxes on labor and, correspondingly, increase energy taxes enough to keep unchanged the tax receipts. This type of reforms has long been advocated as a way to effectively reduce CO2 emissions while improving employment in while providing incentives to improve cost effectiveness and innovation through improved energy efficiency, see in particular, European Commission (2011) and OECD (2006, 2010). In to analyse the consequences of such reforms on the productive efficiency of OECD manufacturing sectors we simulate the impact of a reduction of the tax revenue collected on labour through payroll taxes and a simultaneous increase in the taxes collected on energy products on the total EMTR. Such simulation is relatively

[21] The budget neutrality is ex-ante as our model is static such that possible behavioral effects that could lead to a change in the tax bases or economy-wide interactions are not considered.

straightforward since the effective energy tax used is an average tax rate while the payroll taxes is in most cases a flat tax on payroll to be paid by employers.[22] These two taxes can therefore be changed directly to reflect the change in the tax revenue collected.

Figure 2 shows the alternative overall EMTR when increasing deviations from baseline scenario is considered. To fix ideas, we consider alternative scenarios ranging from 5% to 50% decreases in the tax revenues collected through payroll taxes using a bandwidth of the 5%. Note that some of the countries (ES, JP, IE, PT and UK) are not included due to the lack of available data on production cost.

The main results show that the changes in the EMTR observed are not dramatic even though we have considered a wide range of deviations. Interestingly, the pattern of EMTR appears to be in many instances non-linear and rather heterogenous across countries. However, we clearly observe an almost general decline in the resulting EMTR (and, consequently, efficiency gains) if the tax shifting operated is ambitious enough. In this respect, Austria, Germany and Sweden can be highlighted as those for which the largest reductions in EMTR are obtained (around 5 percentage points) while in countries such as France, Finland, Hungary, Belgium or the Czech republic the tax shift should be relatively large in order to yield desired reduction in overall EMTR. Finally, institutional factors are also helpful to explain some of trends observed. For instance, those countries in which payroll taxes are relatively low (NL, and US) or non-existent (DK) are those in which the change of the EMTR is the lowest. These simulations are of course subject to a number of caveats, however. We assume for instance that productive factors shares remain unchanged when the tax shifting is implemented thus excluding possible changes in production structure that could alter the relative proportion in which production factors are used. Alternative specifications of the production function could allow checking the variability in our results depending on the degree of substitution between production factors.

5. Conclusions.

The present study provides estimates of the effective marginal tax rate (EMTR) in a single framework encompassing capital, labor and energy taxes for a sample of 14 EU and 2 non-EU (i.e. the US and Japan) countries. The use of the EMTR and its comparison across sectors and countries is particularly useful when assessing the potential consequences of tax policy changes on the total cost of business activity. To date, however, existing studies have

[22] We do not consider alternative tax shifts between capital and labor since the equivalence between marginal and average tax rates is not verified for capital.

focused on capital taxation only. Research in support of tax policy formulation should consider other production factors as well, especially when devising strategies aimed at shifting the tax burden in order to favour growth and employment creation. In particular, our cross-country/cross-sector approach allows us gauging the effects of tax changes on the competitive position of EU firms by taking explicitly into account the possible substitution and tax shifting between different production factors. To do so, we combine estimates of the EMTR on capital (from the Centre for European Economic Research - ZEW) with indicators on the EMTR concerning energy products (drawing mainly from the IEA database) and EMTR on labour, using the OECD Taxing Wage model and detailed data from the EUROSTAT Labour Force Survey. We also conduct an analysis of the impact of alternative tax shifting between production factors and show that strategies favouring tax increases on energy consumption and lowering taxes on labor can entail substantial competitiveness gains for EU businesses. Our results suggest that the OECD tax systems provide very different incentives for manufacturing activity across countries and that the tax systems are relatively neutral with respect to the sectoral composition of manufacturing activities. We also perform tax policy change simulation consisting in shifting taxation away from labor towards energy taxation. Our results suggest that the tax shifting of labor to energy taxes would lower the marginal tax burden for most countries.

This work is arguably the first cross-country/cross-sector study providing a synthetic and comparable measure of the effective marginal tax rate in a multi-production factors framework based on detailed tax codes. Because it is the first of the kind, it also faces a number of limitations that could be tackled in the future. For instance the tax treatment of inventories or financial assets has not been considered due to the lack of sufficient data. Our analysis has also focused on the manufacturing industry, thus excluding the service sector which represents two third of economic activities. Additional EU and non-EU countries could be added to the dataset, although this depends to a large extent on future data availability. We have also dealt with the potential interaction between tax incidence and product market structure indirectly by altering mark-up rates in final product pricing. Further work should aim at embedding more directly indirect (value added) taxation in the analysis in order to provide more direct policy interpretation of the results. Considering this other aspect of business taxation would also enable us to analyse the interaction between changes in indirect taxation on consumption (i.e. mostly VAT in EU countries) and changes in the taxation of factor used (e.g. labor) which are often put forward in EC or OECD policy recommendations.

Finally while simulations concerning alternative tax shifting between production factors are conducted, further work would be needed in order to provide a more detailed assessment of the impact of such shifts by sector of activity and different specification of the production function, especially when considering energy vs. labor taxation depending on the intensity of energy use, which can prove important in order to meet environmental objectives.

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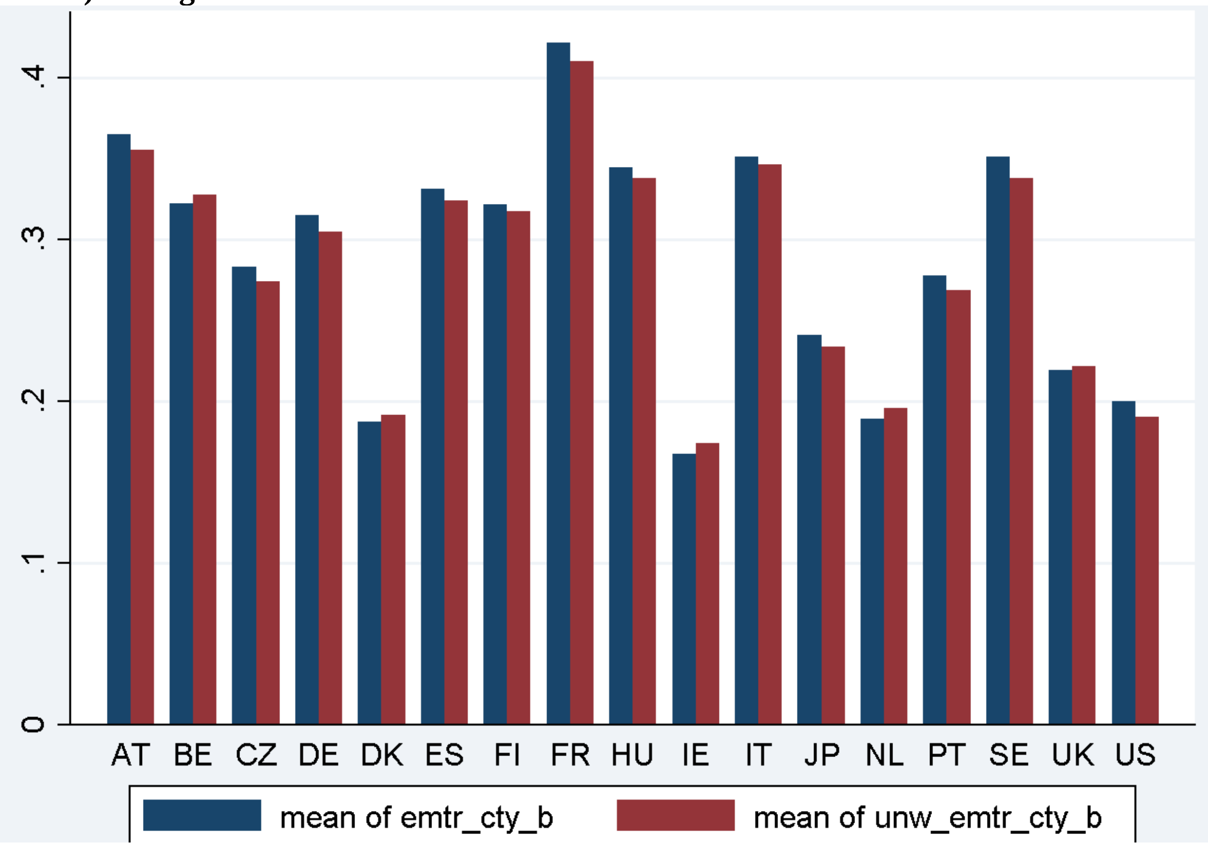
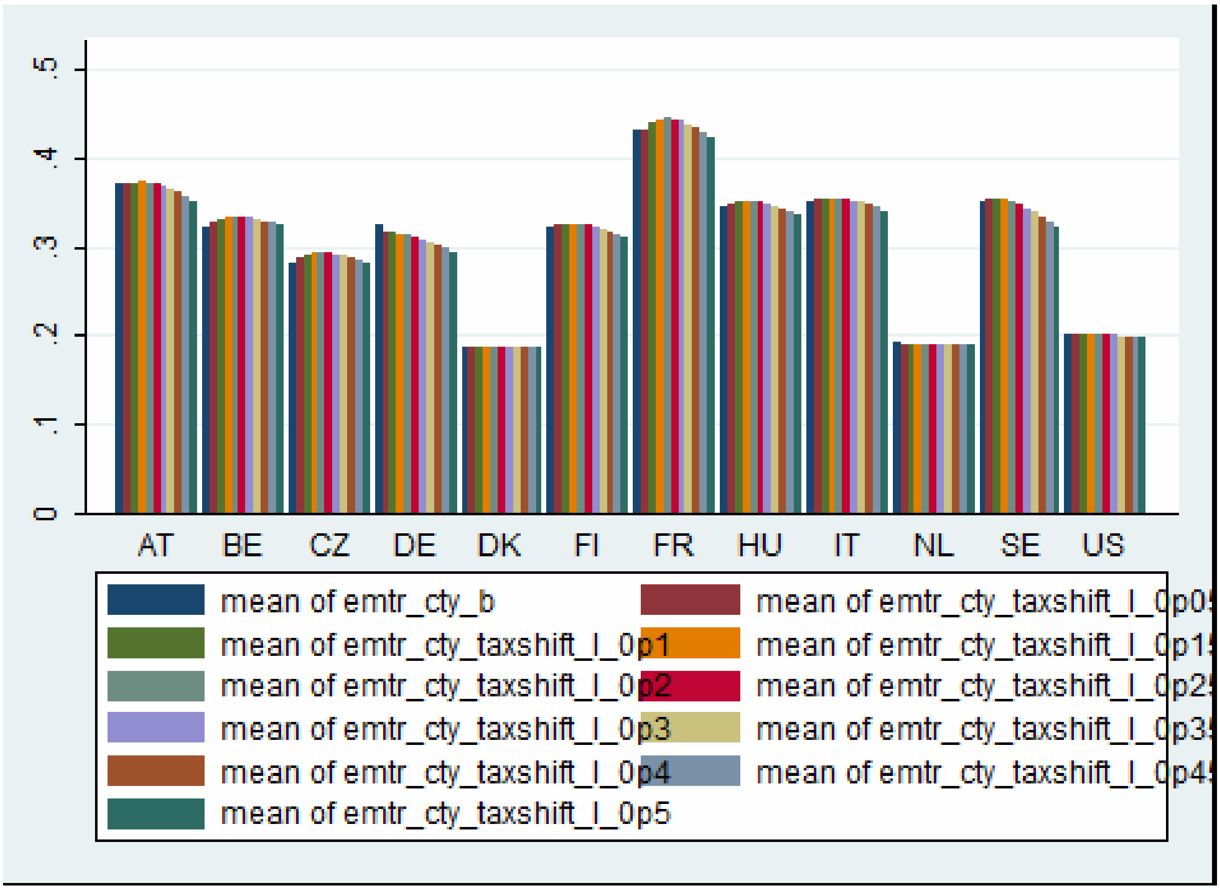
Figures

Figure (1): EMTR on total production cost – unweighted vs. weighted (sector value added) averages



Note: EMTR correspond to baseline scenario with parameters as specified in Table 10.

Figure (2): Labor to Energy Tax Shifting Simulation. Range from 5 % to 50 % of labor EMTR



Note: EMTR correspond to baseline scenario with parameters as specified in Table 10.

Tables

Table (1): Effective marginal capital tax rate (average across all assets)

country	Iron & Steel	Chemicals & Petrochemicals	Non-ferrous metals	Non-metallic minerals	Transport equipment	Machinery	Mining & Quarrying	Food & tobacco	Paper, pulp & print	Wood & wood products	Textile & leather	Other manuf. Industries	*average*	*Standard dev.*	*Stdev. / average*
Austria	15.9%	16.8%	16.4%	16.3%	15.8%	17.3%	15.7%	17.0%	16.2%	16.4%	17.3%	16.8%	*16.5%*	*0.6%*	3.3%
Belgium	4.4%	-5.8%	7.8%	5.8%	4.8%	-1.8%	-4.6%	4.2%	5.3%	6.7%	0.5%	6.8%	*2.8%*	*4.6%*	*163.2%*
Czech rep.	5.7%	13.8%	5.2%	4.8%	9.0%	11.0%	4.6%	7.6%	7.2%	4.3%	5.8%	9.7%	*7.4%*	*3.0%*	*40.0%*
Germany	23.0%	22.4%	23.6%	23.4%	22.5%	22.4%	22.5%	22.9%	23.0%	23.8%	23.2%	23.0%	*23.0%*	*0.5%*	*2.0%*
Spain	27.5%	27.1%	28.2%	28.0%	27.0%	27.8%	27.1%	28.3%	27.2%	27.8%	27.7%	28.0%	*27.6%*	*0.4%*	*1.6%*
Finland	15.6%	15.5%	15.3%	15.6%	15.7%	15.1%	17.3%	15.7%	14.2%	16.0%	14.7%	15.2%	*15.5%*	*0.8%*	*4.9%*
France	25.9%	24.1%	26.0%	26.3%	24.9%	24.0%	25.2%	24.8%	25.3%	26.5%	25.5%	25.2%	*25.3%*	*0.8%*	*3.1%*
Hungary	15.0%	14.6%	15.9%	15.5%	13.9%	13.1%	16.9%	14.8%	14.6%	16.1%	12.8%	14.0%	*14.8%*	*1.2%*	*8.2%*
Ireland	8.1%	9.2%	7.9%	8.4%	7.7%	9.4%	8.0%	8.4%	8.0%	8.8%	8.0%	8.1%	*8.3%*	*0.5%*	*6.4%*
Italy	12.4%	10.1%	17.4%	13.6%	11.1%	10.1%	17.3%	17.4%	12.6%	14.5%	11.8%	11.8%	*13.3%*	*2.7%*	*20.4%*
Japan	40.1%	40.2%	40.4%	40.3%	40.1%	40.3%	40.5%	40.3%	40.2%	40.4%	40.3%	40.4%	*40.3%*	*0.1%*	*0.3%*
Netherlands	18.6%	19.3%	19.3%	18.7%	19.1%	18.7%	22.4%	19.4%	17.4%	18.9%	17.5%	18.1%	*19.0%*	*1.3%*	*6.7%*
Portugal	12.5%	15.6%	13.1%	12.5%	18.5%	19.4%	20.9%	16.8%	13.3%	12.6%	12.8%	13.8%	*15.1%*	*3.0%*	*20.0%*
Sweden	12.3%	11.4%	12.3%	12.2%	11.5%	11.3%	11.9%	11.2%	11.9%	12.5%	11.4%	11.9%	*11.8%*	*0.4%*	*3.7%*
United Kingdom	22.2%	22.8%	26.1%	25.4%	21.8%	23.2%	30.5%	23.0%	24.9%	28.8%	26.9%	27.6%	*25.3%*	*2.8%*	*11.0%*
United States	35.5%	36.4%	35.4%	35.5%	35.8%	36.1%	36.0%	35.7%	35.4%	35.4%	35.8%	35.7%	*35.7%*	*0.3%*	*0.9%*
average	*18.4%*	*18.3%*	*19.4%*	*18.9%*	*18.7%*	*18.6%*	*19.5%*	*19.2%*	*18.5%*	*19.3%*	*18.3%*	*19.1%*			
Std. dev.	*10.1%*	*10.9%*	*9.9%*	*10.2%*	*9.8%*	*10.5%*	*11.4%*	*9.8%*	*10.0%*	*10.3%*	*10.9%*	*9.9%*			
Stdev. / average	*55.0%*	*59.5%*	*51.2%*	*53.9%*	*52.3%*	*56.5%*	*58.7%*	*51.1%*	*53.9%*	*53.0%*	*59.6%*	*51.8%*			

Sources: ZEW and authors´ calculations

Table (2): Relative hourly wages in the manufacturing industry (ratio between sector and average manufacturing wages for 2000-2011)

country	Iron & Steel	Chemical and petrochemical	Non-ferrous metals	Non-metallic minerals	Transport equipment	Machinery	Food & tobacco	Paper, pulp & print	Wood and wood products	Textile & leather	Other industries	STD Dev.
Austria	1.08	1.07	1.10	0.94	1.21	1.26	0.82	1.04	0.75	0.75	0.97	0.17
Belgium	1.16	1.16	1.07	0.88	1.36	1.23	0.80	0.90	0.71	0.73	1.01	0.21
Czech rep.	N/A	1.23	1.15	1.04	N/A	N/A	0.97	1.05	0.79	0.78	N/A	0.17
Germany	1.03	1.30	1.08	0.82	1.41	1.26	0.68	0.89	0.72	0.75	1.05	0.25
Denmark	0.99	1.24	0.96	0.89	1.02	1.09	0.88	1.04	0.92	0.96	1.00	0.10
Greece	0.95	1.27	1.02	1.22	1.21	0.99	0.90	0.90	0.93	0.75	0.84	0.17
Spain	1.06	1.25	1.12	0.87	1.34	1.19	0.77	0.97	0.63	0.66	1.14	0.24
Finland	N/A	1.13	1.14	0.88	N/A	N/A	0.92	1.31	0.82	0.81	N/A	0.19
France	1.05	1.26	1.03	0.91	1.28	1.36	0.75	0.92	0.70	0.73	1.01	0.23
Hungary	0.98	1.53	1.22	1.00	1.23	1.09	0.80	1.09	0.60	0.59	0.87	0.28
Ireland	0.99	1.22	0.89	0.92	N/A	1.36	0.98	1.01	0.73	0.80	1.10	0.19
Italy	1.06	1.26	0.98	0.91	1.20	1.25	0.91	0.91	0.71	0.77	1.03	0.18
Japan	1.10	1.39	1.29	0.98	1.22	N/A	0.75	0.97	0.75	0.74	0.83	0.24
Netherl.	0.91	1.38	1.13	0.95	0.95	1.10	0.99	1.03	0.80	0.88	0.89	0.16
Poland	1.18	1.25	1.07	0.92	1.28	1.21	0.79	0.96	0.65	0.61	1.08	0.24
Portugal	1.17	1.45	N/A	0.98	N/A	N/A	0.87	N/A	0.66	0.87	N/A	0.27

Source: U.S. Bureau of Labor Statistics and authors´calculations

Table (3): Wage differentials according to individual and firm-characteristics

country	*higher education*	*Gender*	*Interaction Higher education X gender*	*Firm size*
Austria	43.3%	-16.0%	-14.4%	4.4%
Belgium	33.4%	-5.6%	-2.4%	4.9%
Czech rep.	40.4%	-14.4%	1.9%	4.0%
Denmark	38.7%	-8.0%	-3.3%	2.7%
Finland	42.4%	-12.1%	-6.5%	4.5%
France	46.2%	-7.3%	-1.0%	4.1%
Germany	38.3%	-13.7%	2.3%	6.2%
Hungary	47.7%	-10.1%	-1.1%	4.0%
Ireland	43.4%	-13.6%	8.6%	4.1%
Italy	41.1%	-11.4%	-8.3%	3.1%
Japan	40.3%	-14.3%	2.8%	4.0%
Luxembourg	42.4%	-8.3%	-2.3%	4.1%
Netherlands	34.8%	-13.1%	3.0%	2.2%
Poland	30.6%	-30.9%	30.7%	4.1%
Portugal	50.5%	-27.9%	14.8%	4.4%
Spain	23.4%	-27.9%	7.9%	5.4%
Sweden	26.0%	-5.0%	-4.6%	2.5%
United Kingdom	50.2%	-12.2%	3.8%	4.1%
United States	65.0%	-18.6%	-1.1%	3.7%

Source: Strauss and de la Maisonneuve (2009).

Table (4): List of energy sources and Carbon Emissions Factors (CEF)

Code	English Desc	Emission rate (ton CO2/tJ)
HARDCOAL	Hard coal (if no detail)	20
BROWN	Brown coal (if no detail)	26.6
ANTCOAL	Anthracite	26.8
COKCOAL	Coking coal	25.8
BITCOAL	Other bituminous coal	25.8
SUBCOAL	Sub-bituminous coal	26.2
LIGNITE	Lignite	27.6
PATFUEL	Patent fuel	26.6
OVENCOKE	Coke oven coke	29.2
GASCOKE	Gas coke	29.2
COALTAR	Coal tar	22
BKB	BKB/peat briquettes	25.8
GASWKSGS	Gas works gas	12.1
COKEOVGS	Coke oven gas	12.1
BLFURGS	Blast furnace gas	70.8
OXYSTGS	Other recovered gases	49.6
PEAT	Peat	28.9
NATGAS	Natural Gas	15.3
CRNGFEED	Crude/NGL/feedstocks (if no detail)	20
CRUDEOIL	Crude oil	20
NGL	Natural gas liquids	17.5
REFFEEDS	Refinery feedstocks	20
ADDITIVE	Additives/blending components	20
NONCRUDE	Other hydrocarbons	20
REFINGAS	Refinery gas	15.7
ETHANE	Ethane	16.8
LPG	Liquefied petroleum gases (LPG)	17.2
MOTORGAS	Motor gasoline	18.9
AVGAS	Aviation gasoline	19.1
JETGAS	Gasoline type jet fuel	19.1
JETKERO	Kerosene type jet fuel	19.5
OTHKERO	Other Kerosene	19.6
GASDIES	Gas/diesel oil	20.2
RESFUEL	Fuel oil	21.1
NAPHTHA	Naphtha	20
WHITESP	White spirit & SBP	20
LUBRIC	Lubricants	20
BITUMEN	Bitumen	22
PARWAX	Paraffin waxes	20
PETCOKE	Petroleum coke	26.6
ONONSPEC	Non-specified oil products	20
INDWASTE	Industrial waste	39
MUNWASTER	Municipal waste (renewable)	25
MUNWASTEN	Municipal waste (non-renewable)	27.3
SBIOMASS	Primary solid biofuels	29.9
GBIOMASS	Biogases	30.6
BIOGASOL	Biogasoline	19.3
BIODIESEL	Biodiesels	19.3
OBIOLIQ	Other liquid biofuels	21.7
RENEWNS	Non-specified primary biofuels and waste	20
CHARCOAL	Charcoal	30.5
MANGAS	Elec/heat output from non-specified manufactured gases	20
HEATNS	Heat output from non-specified combustible fuels	20
NUCLEAR	Nuclear	0
HYDRO	Hydro	0
GEOTHERM	Geothermal	0
SOLARPV	Solar photovoltaics	0
SOLARTH	Solar thermal	0
TIDE	Tide, wave and ocean	0
WIND	Wind	0
OTHER	Other sources	0
ELECTR	Electricity	10
HEAT	Heat	20

Source: IEA (2012a)

Tables (5): sector average values of effective average tax rate for the period 2000-2010

Panel A: Energy

	Iron and Steel	*Chemicals and petrochemical*	*Non-ferrous metals*	*Non-metallic minerals*	*Transport equipment*	*Machinery*	*Food and tobacco*	*Paper, pulp and print*	*Wood and wood products*	*Textile and leather*	*Non-specified (industry)*
2001	7.5%	7.4%	8.4%	12.8%	11.2%	11.1%	13.0%	7.4%	12.0%	12.7%	11.8%
2002	9.0%	8.0%	8.3%	13.3%	11.0%	11.6%	13.1%	7.8%	12.3%	13.1%	11.6%
2003	9.7%	8.4%	8.0%	13.0%	11.2%	12.3%	12.7%	8.1%	13.0%	13.4%	13.0%
2004	10.3%	10.5%	9.9%	15.0%	13.2%	13.9%	15.0%	10.2%	12.1%	15.3%	15.3%
2005	10.5%	10.2%	9.4%	14.2%	12.5%	13.7%	14.1%	10.5%	12.0%	13.9%	14.7%
2006	8.7%	8.3%	8.1%	12.0%	9.7%	10.9%	12.0%	8.5%	10.4%	12.0%	12.6%
2007	9.3%	8.0%	8.0%	12.0%	10.1%	10.4%	11.5%	8.6%	10.1%	11.4%	11.6%
2008	9.1%	8.2%	8.4%	11.1%	10.0%	9.9%	11.1%	8.7%	10.1%	10.3%	11.0%
2009	9.7%	8.9%	8.4%	12.3%	10.7%	10.4%	11.7%	9.1%	11.3%	12.1%	13.1%
2010	10.3%	9.3%	9.2%	12.7%	10.9%	10.5%	11.9%	9.5%	11.5%	12.0%	13.0%

Panel B: Capital

2001	16.4%	16.6%	17.9%	17.3%	17.4%	17.4%	17.9%	17.1%	17.7%	16.7%	17.3%
2002	18.1%	18.5%	19.3%	18.9%	19.1%	19.2%	19.4%	18.8%	19.2%	18.4%	19.0%
2003	18.2%	18.7%	19.4%	18.9%	19.2%	19.3%	19.4%	18.9%	19.3%	18.6%	19.1%
2004	18.4%	17.9%	19.7%	19.3%	19.0%	18.8%	19.4%	18.9%	19.7%	18.8%	18.9%
2005	17.6%	16.9%	18.9%	18.5%	18.1%	17.8%	18.5%	18.0%	18.2%	17.7%	18.0%
2006	17.9%	17.2%	19.1%	18.7%	16.9%	18.1%	18.8%	18.3%	17.0%	16.4%	18.4%
2007	17.8%	16.6%	18.4%	18.0%	16.3%	17.3%	18.0%	17.6%	16.4%	15.8%	17.7%
2008	17.7%	16.3%	18.4%	18.0%	16.2%	17.0%	17.9%	17.5%	16.1%	15.6%	17.5%
2009	15.5%	14.3%	16.5%	16.0%	14.1%	14.9%	16.1%	15.2%	14.0%	13.3%	15.5%
2010	15.2%	14.2%	16.3%	15.8%	13.9%	14.9%	16.0%	14.9%	13.7%	13.1%	15.3%

Table (6): country average values of effective average tax rate for the period 2000-2010

Panel A: Energy

	AT	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	JP	NL	PT	SE	UK	US
2001	4.3%	6.9%	1.7%	9.7%	32.2%	8.0%	16.9%	4.7%	0.5%	6.1%	16.5%	-	8.8%	4.9%	13.4%	22.6%	-
2002	2.9%	6.9%	1.2%	9.4%	30.1%	8.2%	16.0%	4.5%	0.3%	7.7%	23.2%	-	10.3%	3.8%	14.4%	23.7%	-
2003	2.8%	8.2%	0.4%	10.9%	29.0%	8.5%	13.9%	9.2%	0.3%	9.2%	21.6%	-	10.4%	3.7%	16.6%	22.5%	-
2004	26.8%	9.5%	0.8%	10.7%	26.8%	8.6%	14.7%	11.1%	2.2%	8.4%	22.5%	-	11.8%	3.7%	16.5%	17.7%	-
2005	25.0%	10.6%	0.9%	9.3%	28.7%	8.0%	13.7%	10.8%	2.1%	-	20.7%	-	10.9%	3.1%	15.4%	13.5%	-
2006	23.7%	9.8%	0.9%	8.1%	28.2%	6.1%	9.3%	10.1%	1.7%	4.8%	20.9%	10.8%	9.6%	3.1%	14.1%	10.8%	2.8%
2007	19.3%	10.7%	0.6%	8.0%	29.1%	6.8%	9.2%	10.2%	1.5%	5.8%	22.2%	10.4%	8.9%	2.9%	12.0%	11.0%	2.7%
2008	17.8%	8.8%	2.4%	18.5%	26.7%	6.0%	9.0%	8.8%	1.6%	4.9%	19.3%	9.5%	9.0%	2.6%	9.6%	9.0%	2.5%
2009	17.9%	9.5%	2.4%	17.9%	27.8%	7.0%	10.5%	10.6%	1.5%	7.0%	20.3%	9.8%	12.3%	3.0%	10.2%	9.7%	3.3%
2010	17.7%	10.8%	2.4%	21.5%	25.7%	8.0%	8.7%	10.4%	2.8%	7.2%	21.7%	9.6%	13.4%	2.7%	9.7%	10.0%	3.2%

Panel B: Capital

	AT	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	JP	NL	PT	SE	UK	US
2001	23.1%	16.0%	6.7%	25.5%	17.1%	28.8%	18.4%	27.1%	20.3%	5.1%	-6.2%	-	24.7%	17.4%	11.5%	23.0%	-
2002	22.6%	16.3%	6.7%	25.5%	17.1%	28.8%	18.4%	26.8%	20.3%	5.1%	20.0%	-	24.3%	16.2%	11.5%	23.9%	-
2003	22.6%	13.9%	6.7%	26.4%	17.1%	28.8%	18.4%	27.0%	20.3%	9.4%	18.9%	-	24.3%	15.7%	11.5%	23.9%	-
2004	23.1%	13.9%	10.6%	25.5%	17.1%	28.8%	18.4%	27.1%	19.3%	9.5%	18.3%	-	24.3%	12.8%	11.5%	24.1%	-
2005	16.6%	13.9%	8.6%	25.5%	16.1%	28.8%	16.6%	27.2%	10.1%	-	18.3%	-	22.0%	12.8%	12.4%	23.7%	-
2006	16.6%	-7.7%	7.9%	21.2%	16.1%	28.8%	16.6%	27.0%	9.5%	9.6%	18.3%	42.3%	20.6%	12.8%	12.4%	23.4%	36.7%
2007	16.6%	-10.0%	7.9%	21.2%	14.5%	27.3%	16.6%	27.4%	9.3%	9.7%	18.3%	39.5%	17.6%	12.3%	12.4%	23.6%	36.1%
2008	16.6%	-14.3%	6.8%	20.0%	14.8%	26.1%	16.6%	27.5%	9.3%	9.6%	20.5%	39.5%	17.6%	12.3%	12.4%	26.2%	36.1%
2009	12.5%	-16.4%	6.4%	17.0%	14.9%	26.1%	3.1%	27.6%	9.3%	9.8%	22.4%	39.5%	4.4%	12.3%	11.5%	26.9%	36.1%
2010	12.5%	-10.8%	6.1%	17.0%	14.9%	26.1%	3.7%	16.9%	10.9%	9.7%	22.4%	39.5%	4.4%	12.8%	11.5%	27.0%	35.4%

Table (7): Energy inputs weights, average 2001-2010

	Chemicals & petr.	Food& tobacco	Iron & Steel	Machinery	Non-ferrous metals	Non-metallic minerals	Non-specified (industry)	Paper, pulp & print	Textile & leather	Transport equipment	Wood & wood products
Austria	6.8%	7.0%	25.7%	3.6%	26.4%	12.5%	8.0%	20.3%	6.8%	3.1%	9.4%
Belgium	13.0%	9.3%	25.7%	3.9%	26.4%	15.5%	27.6%	10.9%	9.3%	3.2%	11.1%
Czech_rep	10.5%	11.2%	25.7%	7.7%	26.4%	24.3%	27.5%	18.9%	11.4%	5.1%	7.5%
Germany	8.4%	7.6%	26.6%	2.1%	22.0%	17.6%	18.2%	15.4%	6.2%	2.6%	7.1%
Denmark	2.4%	6.5%	17.5%	3.1%	11.6%	10.1%	7.9%	5.5%	4.1%	4.0%	4.7%
Spain	10.5%	9.3%	25.7%	4.5%	26.4%	17.9%	17.0%	18.6%	7.2%	3.6%	9.0%
Finland	11.1%	6.5%	24.1%	2.5%	28.8%	12.2%	16.4%	34.6%	5.1%	4.3%	9.3%
France	10.5%	9.3%	25.7%	4.5%	26.4%	17.9%	17.0%	18.6%	7.2%	3.6%	9.0%
Hungary	10.2%	11.8%	32.2%	5.3%	29.7%	23.6%	13.1%	10.8%	3.7%	4.6%	7.5%
Ireland	10.5%	9.4%	23.6%	4.5%	26.4%	18.0%	17.0%	18.6%	7.2%	3.6%	9.0%
Italy	9.5%	12.9%	25.7%	10.2%	26.4%	24.0%	23.7%	19.2%	8.6%	4.2%	14.4%
Japan	11.9%	10.6%	28.3%	5.2%	26.5%	19.9%	17.3%	21.4%	N/A	N/A	N/A
Netherlands	17.4%	11.0%	25.7%	4.3%	26.4%	15.6%	6.8%	12.1%	6.8%	3.4%	4.1%
Portugal	10.5%	9.3%	25.7%	4.5%	26.4%	17.9%	17.0%	18.6%	7.2%	3.6%	9.0%
Sweden	6.2%	6.2%	20.2%	1.9%	23.7%	13.1%	18.3%	27.3%	5.5%	2.3%	6.9%
UK	10.5%	9.3%	25.7%	4.5%	26.4%	17.9%	17.0%	18.6%	7.2%	3.6%	6.4%
US	14.9%	11.3%	27.4%	3.8%	29.8%	25.5%	4.3%	16.8%	10.6%	3.4%	17.6%

Table (8): Labour inputs weights, average 2001-2010

	Chemicals & petr.	Food& tobacco	Iron & Steel	Machinery	Non-ferrous metals	Non-metallic minerals	Non-specified (industry)	Paper, pulp & print	Textile & leather	Transport equipment	Wood & wood products
Austria	71.1%	73.5%	55.6%	81.0%	56.4%	68.5%	79.8%	59.4%	81.8%	75.2%	69.7%
Belgium	66.1%	67.2%	55.6%	82.4%	56.4%	64.9%	58.2%	65.0%	76.1%	79.9%	65.8%
Czech_rep	56.9%	58.1%	55.6%	65.7%	56.4%	50.5%	55.4%	50.8%	70.0%	56.4%	60.4%
Germany	74.3%	77.0%	59.5%	84.9%	64.1%	68.4%	73.4%	68.5%	83.3%	79.5%	79.8%
Denmark	73.7%	70.9%	64.5%	81.5%	72.6%	70.3%	77.2%	76.5%	80.4%	82.0%	81.1%
Spain	65.2%	67.9%	55.6%	78.0%	56.4%	62.6%	69.6%	59.3%	80.2%	72.4%	70.5%
Finland	70.5%	73.6%	53.0%	83.8%	54.2%	72.6%	75.7%	48.6%	86.9%	86.6%	74.1%
France	65.2%	67.9%	55.6%	78.0%	56.4%	62.6%	69.6%	59.3%	80.2%	72.4%	70.5%
Hungary	52.1%	63.9%	49.1%	68.6%	49.1%	46.1%	64.7%	59.2%	85.2%	52.0%	68.8%
Ireland	65.2%	67.8%	56.5%	78.0%	56.6%	62.6%	69.5%	59.2%	80.1%	72.5%	70.6%
Italy	61.0%	53.6%	55.6%	69.9%	56.4%	51.4%	57.0%	54.4%	74.0%	63.2%	59.3%
Japan	64.9%	67.8%	53.9%	78.3%	57.4%	61.3%	69.6%	58.6%	N/A	N/A	N/A
Netherlands	62.6%	68.3%	55.6%	80.5%	56.4%	71.7%	84.7%	70.1%	81.1%	82.8%	82.3%
Portugal	65.2%	67.9%	55.6%	78.0%	56.4%	62.6%	69.6%	59.3%	80.2%	72.4%	70.5%
Sweden	71.1%	73.7%	59.5%	84.5%	59.3%	69.5%	69.6%	51.7%	81.9%	71.9%	72.1%
UK	65.2%	67.9%	55.6%	78.0%	56.4%	62.6%	69.6%	59.3%	80.2%	72.4%	72.4%
US	67.7%	71.8%	56.2%	80.4%	55.0%	61.7%	85.6%	70.6%	82.6%	82.5%	73.5%

Table (9): Capital inputs weights, average 2001-2010

	Chemicals & petr.	Food& tobacco	Iron & Steel	Machinery	Non-ferrous metals	Non-metallic minerals	Non-specified (industry)	Paper, pulp & print	Textile & leather	Transport equipment	Wood & wood products
Austria	22.1%	19.5%	18.8%	15.4%	17.2%	19.0%	12.3%	20.3%	11.5%	21.7%	20.8%
Belgium	20.9%	23.6%	18.8%	13.6%	17.2%	19.6%	14.2%	24.2%	14.6%	16.9%	23.1%
Czech_rep	32.5%	30.8%	18.8%	26.6%	17.2%	25.2%	17.1%	30.3%	18.6%	38.5%	32.1%
Germany	17.3%	15.5%	13.9%	13.0%	13.8%	14.0%	8.4%	16.1%	10.4%	17.9%	13.1%
Denmark	23.8%	22.6%	17.9%	15.5%	15.7%	19.6%	14.9%	18.0%	15.5%	14.0%	14.2%
Spain	24.2%	22.8%	18.8%	17.4%	17.2%	19.4%	13.4%	22.1%	12.7%	24.0%	20.5%
Finland	18.4%	19.9%	22.9%	13.6%	17.0%	15.2%	7.9%	16.8%	8.0%	9.1%	16.6%
France	24.2%	22.8%	18.8%	17.4%	17.2%	19.4%	13.4%	22.1%	12.7%	24.0%	20.5%
Hungary	37.7%	24.4%	18.7%	26.1%	21.2%	30.3%	22.3%	30.0%	11.2%	43.4%	23.7%
Ireland	24.3%	22.8%	19.9%	17.5%	17.0%	19.3%	13.4%	22.1%	12.7%	23.8%	20.5%
Italy	29.4%	33.5%	18.8%	19.9%	17.2%	24.6%	19.3%	26.4%	17.4%	32.6%	26.3%
Japan	23.2%	21.6%	17.8%	16.5%	16.0%	18.8%	13.0%	20.0%	N/A	N/A	N/A
Netherlands	20.0%	20.8%	18.8%	15.2%	17.2%	12.8%	8.5%	17.9%	12.1%	13.8%	13.6%
Portugal	24.2%	22.8%	18.8%	17.4%	17.2%	19.4%	13.4%	22.1%	12.7%	24.0%	20.5%
Sweden	22.8%	20.1%	20.3%	13.6%	17.0%	17.4%	12.1%	21.0%	12.6%	25.7%	21.0%
UK	24.2%	22.8%	18.8%	17.4%	17.2%	19.4%	13.4%	22.1%	12.7%	24.0%	21.2%
US	17.4%	16.9%	16.4%	15.8%	15.2%	12.8%	10.0%	12.6%	6.8%	14.0%	8.8%

Table (10): Tax incidence and mark-up parameters used to calculate the effective marginal tax rate on total production cost.

	Tax incidence on labour (employers payroll taxes)	Tax incidence on labour (employee – taxes & benefits)	Tax incidence on capital	Tax incidence on energy	Mark-up on final prices
Baseline	$\beta_l^{er} = 1$	$\beta_l^{ee} = 0.33$	$\beta_k = 1$	$\beta_e = 1$	$\mu = 0$
Scenario 1:	$\beta_l^{er} = 0.5$	$\beta_l^{ee} = 0.33$	$\beta_k = 1$	$\beta_e = 1$	$\mu = 0$
Scenario 2:	$\beta_l^{er} = 1$	$\beta_l^{ee} = 0$	$\beta_k = 1$	$\beta_e = 1$	$\mu = 0$
Scenario 3:	$\beta_l^{er} = 1$	$\beta_l^{ee} = 0.33$	$\beta_k = 0.5$	$\beta_e = 1$	$\mu = 0$
Scenario 4:	$\beta_l^{er} = 1$	$\beta_l^{ee} = 0.33$	$\beta_k = 1$	$\beta_e = 0.5$	$\mu = 0$
Scenario 5:	$\beta_l^{er} = 1$	$\beta_l^{ee} = 0.33$	$\beta_k = 1$	$\beta_e = 1$	$\mu \geq 0$ in sector/country specific estimates

Table (11) : Effective Marginal Tax Rates on Total Production Cost : country-results and differences across scenarios

country	*Baseline*	*Scenario 1 Partial payroll taxes*	*Scenario 2 No wage taxes*	*Scenario 3 Partial capital taxes*	*Scenario 4 Partial energy taxes*	*Scenario 5 Mark-ups in final product price*	*Baseline vs. S1*	*Baseline vs. S2*	*Baseline vs. S3*	*Baseline vs. S4*
FR	42.1%	28.2%	35.0%	39.1%	41.5%	41.5%	*-14.0%*	*-7.2%*	*-3.1%*	*-0.6%*
AT	36.5%	26.3%	25.7%	34.4%	35.8%	35.8%	*-10.2%*	*-10.8%*	*-2.0%*	*-0.7%*
IT	35.1%	25.5%	26.8%	32.8%	33.5%	33.5%	*-9.6%*	*-8.3%*	*-2.3%*	*-1.6%*
SE	35.1%	24.1%	26.1%	33.7%	34.5%	34.5%	*-11.0%*	*-8.9%*	*-1.4%*	*-0.6%*
HU	34.4%	25.0%	24.5%	32.0%	34.4%	34.4%	-9.4%	-9.9%	*-2.5%*	*-0.1%*
ES	33.1%	23.1%	26.9%	30.0%	32.6%	32.6%	-10.1%	-6.2%	*-3.1%*	*-0.5%*
BE	32.2%	22.6%	20.8%	32.6%	31.6%	31.6%	-9.6%	-11.4%	*0.4%*	*-0.6%*
FI	32.1%	23.8%	20.7%	30.8%	31.5%	31.5%	8.4%	-11.4%	*-1.4%*	*-0.6%*
DE	31.5%	24.2%	18.9%	29.6%	30.9%	30.9%	-7.2%	-12.6%	*-1.8%*	*-0.5%*
CZ	28.3%	19.0%	22.6%	26.7%	28.2%	28.2%	-9.3%	-5.7%	*-1.6%*	*-0.1%*
PT	27.8%	19.8%	19.6%	26.2%	27.5%	27.5%	-8.0%	-8.1%	*-1.6%*	*-0.2%*
JP	24.1%	19.5%	17.2%	20.5%	23.5%	23.5%	-4.5%	-6.9%	*-3.6%*	*-0.6%*
UK	21.9%	18.2%	13.3%	19.4%	21.3%	21.3%	-3.7%	-8.6%	*-2.5%*	*-0.6%*
US	20.0%	16.7%	12.0%	17.4%	19.8%	19.8%	-3.3%	-8.0%	*-2.6%*	*-0.2%*
NL	18.9%	15.4%	11.3%	17.3%	18.3%	18.3%	-3.5%	-7.6%	*-1.6%*	*-0.6%*
DK	18.7%	18.7%	4.3%	17.3%	17.8%	17.8%	-0.0%	-14.4%	*-1.5%*	*-0.9%*
IE	16.8%	13.2%	9.9%	15.7%	16.5%	16.5%	-3.6%	-6.9%	*-1.1%*	*-0.3%*
Average	**28.7%**	**21.4%**	**19.7%**	**26.8%**	**28.2%**	**28.2%**	***-7.4%***	***9.0%***	***-1.9%***	***-0.6%***

Table (12) : Effective Marginal Tax rates on total production cost: sector composition effects

Country	*(1) Baseline weighted average EMTR*	*(2) Unweighted baseline average EMTR*	*Dif (1) - (2)*
AT	36.5%	35.5%	0.9%
BE	32.2%	32.7%	-0.6%
CZ	28.3%	27.4%	0.9%
DE	31.5%	30.5%	1.0%
DK	18.7%	19.2%	-0.4%
ES	33.1%	32.4%	0.7%
FI	32.1%	31.7%	0.4%
FR	42.1%	41.0%	1.1%
HU	34.4%	33.7%	0.7%
IE	16.8%	17.4%	-0.7%
IT	35.1%	34.6%	0.5%
JP	24.1%	23.4%	0.7%
NL	18.9%	19.6%	-0.7%
PT	27.8%	26.9%	0.9%
SE	35.1%	33.8%	1.3%
UK	21.9%	22.2%	-0.2%
US	20.0%	19.0%	1.0%

Table A1: Matching between End-Use prices and Energy sources prices and taxes

Energy source code	Energy source description	Assignment
HARDCOAL	Hard coal (if no detail)	(L)
BROWN	Brown coal (if no detail)	(L)
ANTCOAL	Anthracite	(L)
COKCOAL	Coking coal	(M)
BITCOAL	Other bituminous coal	(L)
SUBCOAL	Sub-bituminous coal	(L)
LIGNITE	Lignite	(L)
PATFUEL	Patent fuel	avg(A;B)
GASCOKE	Gas coke	(K)
GASWKSGS	Gas works gas	(K)
COKEOVGS	Coke oven gas	(K)
BLFURGS	Blast furnace gas	(K)
OXYSTGS	Other recovered gases	(K)
NATGAS	Natural Gas	(K)
CRNGFEED	Crude/NGL/feedstocks (if no detail)	(K)
CRUDEOIL	Crude oil	(C)
NGL	Natural gas liquids	(K)
REFFEEDS	Refinery feedstocks	(K)
REFINGAS	Refinery gas	(K)
ETHANE	Ethane	(K)
LPG	Liquefied petroleum gases (LPG)	(J)
MOTORGAS	Motor gasoline	avg(E;F;G;H)
GASDIES	Gas/diesel oil	(D)
RESFUEL	Fuel oil	avg(A;B)
CHARCOAL	Charcoal	(L)
MANGAS	Elec/heat output from non-specified manufactured gases	(N)
ELECTR	Electricity	(N)

Source: IEA (2012b).

Legend: (A) High sulphur fuel oil (B) Low sulphur fuel oil (C) Light fuel oil (D) Automotive diesel (E) Premium leaded gasoline (F) Regular leaded gasoline (G) Premium unleaded 95 RON (H) Premium unleaded 98 RON (I) Regular unleaded gasoline (J) Liquefied petroleum gas (K) Natural gas (L) Steam coal (M) Coking coal (N) Electricity.