TO WHICH TAX RATE DOES INVESTMENT RESPOND? A SYNTHESIS OF EMPIRICAL RESEARCH ON TAXATION AND FOREIGN DIRECT INVESTMENT

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Introduction

Differences in corporate taxation can affect the allocation of foreign direct investment (FDI) by driving a wedge between the post- and pre-tax rates of return. Tax authorities can therefore try to attract internationally footloose business activity by lowering the tax rate. In discussions about tax harmonisation in Europe, Ireland is often cited as an example of the effectiveness of such a strategy. Whereas corporate tax rates in Ireland have been lowered from 43 per cent in 1990 to 24 per cent in 2000 and even substantially less for manufacturing corporations, the inflow of FDI into Ireland has increased a hundredfold (OECD, 2002). Although this example suggests a strong impact of taxation on FDI, the increase may also be due to different factors. Since the mid-Eighties, a number of papers have attempted to estimate the actual strength of the response. A review of this literature by Hines (1997 and 1999) suggests a consensus estimate of about –0.5, that is a one per cent higher tax rate on companies leads to a reduction in inward FDI by 0.5 per cent.

Such a literature survey, albeit very useful to get an impression of the empirical literature, has some important limitations. First of all, a direct comparison of the values in the literature is virtually impossible because the underlying studies report different types of elasticities. And second, different studies also use different specifications and different data. In particular, a plethora of tax rates is used. Although it is clear that the relevant tax rate is the one effectively experienced by firms, it is not at all clear how to calculate it. Many different variants exist and they are all used in econometric analyses. But how can we compare the results obtained with statutory rates, average tax rates and effective tax rates? These qualifications form the motivation for this paper. In particular, in addition to reviewing the empirical literature, its main contribution is the meta-analysis that is performed. This meta-analysis copes with both limitations of ordinary literature surveys.[1]

First, we translate the findings of 25 empirical studies into comparable elasticities.[2] With meta-analysis, the selection process is explicit and verifiable. Selection is justified to the extent that the quality of studies differs, but it is also unavoidable to the extent that it originates from publication bias. In many surveys the selection process remains implicit.

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[1] See Stanley (2001) for a more extensive discussion of the potential of meta-analysis in economics.

[2] Annex 5A of the Ruding report (CEC, 1992) does a similar exercise, but they had only three studies available at that time.

A second contribution of the meta-analysis is that it yields useful information for future research. In particular, we explore whether there are systematic differences between studies that use different types of effective tax rates on capital income. In a sense, the meta-analysis is used to rethink the current state of the art in the literature, and to explore fruitful directions for future research. In this respect, meta-analysis is more rigorous than an ordinary survey of the literature because of the multivariate character of the analysis. For instance, as this paper reveals, simple pair wise comparisons of study characteristics and effect size can yield misleading conclusions.

The rest of this paper is organized as follows. We start in section 1 with a discussion of different approaches to measure the effective tax rate. Section 2 gives a review of the empirical literature and provides a summary table with the main characteristics of the 25 studies that form our meta sample. Section 3 presents the meta-analysis, starting with a simple univariate analysis of variation, followed by a number of regressions. Finally, section 4 concludes.

1. Taxation and FDI: which tax matters?

During the last decade, European countries have reduced company tax rates. Indeed, the mean corporate income tax rate in the EU has dropped from 38 per cent in 1990 to 33 per cent in 2000 (Gorter and de Mooij, 2001). Although the average tax burden on companies has been rather stable during this period, some EU governments have recently launched proposals to also reduce it. To illustrate, Germany, Ireland and Portugal have recently reduced their taxes while the Netherlands, Italy and France are discussing proposals for tax reform and relief. These proposals are motivated by the growing internationalisation of businesses and the increasing mobility of capital. By reducing tax rates, European countries aim to improve their investment climate for foreign companies. However, the tax rates effectively experienced by firms are not necessarily the same as the statutory tax rates. In this section, we discuss the impact of company taxes on investment behaviour of multinational enterprises and elaborate on different methods of measuring the effective tax rate.

1.1 Theory

Economic theory suggests that, when capital is perfectly mobile across borders, the after-tax rate of return to capital should be equal across countries in equilibrium. According to this arbitrage condition, differences in tax rates across two countries should be matched by differences in the before-tax rates of return. With decreasing returns to scale with respect to capital in production, equality is accomplished through changes in the capital stock. For instance, if The Netherlands and Belgium start from an equal tax rate and Belgium increases its tax above that of The Netherlands, equality can be maintained by a reallocation of real capital from Belgium to The Netherlands. The speed with which the before-tax returns to capital

in both countries respond to changes in the capital stock determines the sensitivity of international capital allocation to source-based taxes. Note that it is the marginal effective tax rate that matters. Indeed, not only the statutory rates but also parameters that influence the tax base determine the after-tax rate of return on real investment.

Studies that analyse the impact of taxation on investment should therefore focus on the tax rate effectively experienced by firms. It is impossible, however, to capture all the complex details of the tax system that potentially affect foreign investment in an empirical analysis. Some studies therefore abstract from these problems and simply use the statutory corporate income tax to measure the tax effects on FDI. Although the statutory tax rate is important for profit shifting by multinational corporations, it does not necessarily influence the allocation of real capital. Using the statutory tax rate can therefore be misleading.

Next to differences in statutory rates, differences between capital income tax bases also impact upon the behaviour of capital owners. In particular, international differences between depreciation allowances for machinery and buildings, valuation of inventories, general investment relief, the treatment of reserves and provisions, and the tax treatment of capital gains at the company level cause differences between the taxable corporate income of two otherwise equivalent corporations (see OECD, 1991, for a review). Similarly, international differences between the treatment of health insurance premiums, social security contributions, pension savings, and education expenses cause differences between the taxable personal income of two otherwise equivalent persons. Therefore, tax payments differ, even if tax rates would be the same. This calls for information about tax codes that supplements statutory tax rates. It is provided by so-called effective tax rates, which usually, but not always, refer to tax payment divided by a measure of taxable income. They capture the entire capital or corporate income tax system in one single number. Although in many instances this figure provides a highly desirable summary of the capital income tax system, it may not do justice to underlying aspects that are important economically.

Effective tax rates can be computed in alternative ways. Each method of computation has its merits and demerits; there is not a single preferred methodology (OECD, 2000). To illustrate, Gordon, Kalambokidis and Slemrod (2003) recently defined a new effective tax rate measure and claim that it should be added to "the pantheon of existing measures". Different effective tax rates simply measure different things. Hence, there is no such thing as the effective tax rate. The various methods differ in at least three important ways:

- Forward looking versus backward looking methods.

  Forward looking effective tax rates are usually based on tax codes. Their advantage is that they measure the impact of taxes on new investment projects. Instead, backward looking methods refer to existing capital. The effective tax rates on existing and new capital differ because the mix of new investment can differ from that of existing assets. Moreover, the tax burden on existing capital

can be distorted by the carry forward of losses or tax credits. Compared to the forward looking methods, the backward looking methods have the advantage that they take account of tax planning activities, complex tax provisions and discretionary administrative practices of tax authorities.

- Average versus marginal tax rates

  Marginal effective tax rates measure the wedge between the pre- and post tax return on a marginal investment project that does not yield an economic rent. Hence, they measures the incentive effects of taxes on marginal investment and/or savings decisions. In contrast, average tax rates measure the overall tax burden on a typical investment. This can be important for decisions regarding lumpy investment, investment in the presence of imperfect competition, or for locational decisions of firms. Further, the average effective tax rates give an indication of the tax that bears on companies which may be important for distributional reasons.

- Corporate versus capital income tax

  Effective tax rates can either refer to the tax burden on corporations or on the overall tax burden on capital income that is levied on the corporate and the personal level.

1.2 Effective tax rates

We distinguish four methods to compute effective tax rates. Each has its own properties, with corresponding merits and problems. We will discuss these methods in turn.

1.2.1 Effective tax rates on the basis of macro data

Measures for the tax burden using aggregate economic data from national accounts are computed as a percentage of domestic corporate taxes (in general only corporate income tax) relative to various income measures, such as aggregated domestic corporate profits or the corporate operating surplus. It is therefore a backward-looking method.

Mendoza *et al.* (1994) provide a well-known example of this methodology. They divide the sum of the corporate income tax and personal capital income tax by the total operating surplus of the economy. Thus, these effective capital income tax rates correspond to the weighted mean of the total capital income tax rate that actually applies, where the weights are the proportions of dividend, retained profit, and interest in capital income.

Mendoza's method of calculating effective capital income tax rates is, although widely used, not undisputed. A fundamental problem is that tax revenue statistics do not attribute tax revenue to capital income per se, but to corporate and personal income. Similarly, national accounts do not list capital income per se, but

operating surplus of corporate and unincorporated enterprises and property and entrepreneurial income of households. Therefore, the effective capital income tax rate – capital income tax divided by capital income – can only be calculated with some ingenuity in extracting the required information from the available data. For this reason, a number of authors have sought to refine Mendoza's method. For example, Volkerink and de Haan (1999) exploit additional data sources in calculating their effective capital income tax rates.

1.2.2 Effective tax rates on the basis of micro data

An alternative backward-looking method of calculating effective tax rates is based upon micro data from the financial accounts of individual firms. The corporate income tax paid by the firm is divided by its pre-tax corporate income. Data can either be taken from individual financial statements or consolidated returns. The effective tax rate for a specific country is then defined as the median ratio, because the mean is too sensitive for outliers if there is a limited number of firms.

The effective tax rates on the basis of micro data suffer from the practice of consolidating the financial accounts of parents and their foreign controlled corporations. For instance, the Dutch effective tax rate is contaminated by German taxes because multinational Philips consolidates the accounts of the Dutch parent with its German affiliates, subsidiaries, and branches. However, one can eliminate this contamination in several ways. Collins and Shackelford (1995) show that these adjustments hardly change the results. This is consistent with MARC (1999) who show that firm characteristics do not have a significant impact on the average tax rate of firms.

1.2.3 Marginal effective tax rates on the basis of tax codes

A third class of effective tax rates is calculated on the basis the tax code, not on the basis of tax data. This method is originally due to Hall and Jorgenson (1967), and updated by King and Fullerton (1984), who derive the "marginal effective tax rate", the percentage wedge that a tax code drives between the pre and post tax required rates of return on marginal investment projects. The King-Fullerton effective tax rate can explicitly take into account the fiscal details such as depreciation allowance, inventory valuation, investment incentives, and preferential savings provisions. Hence, the King-Fullerton tax rate intends to capture the main tenets of the tax code that impact upon investment decisions in a single number.

However, one disadvantage of the King-Fullerton rate is that it is difficult to calculate and interpret, another that it is sensitive to minor changes in the assumptions underlying its calculation. For instance, the marginal effective tax rate is sensitive to the assumed interest rate or the inflation rate. Furthermore, it is derived under strong assumptions regarding optimal investment behaviour, perfect competition, a small open economy that cannot exert market power, infinitely

divisible investment and decreasing returns to scale with respect to capital in production (OECD, 2000). For these reasons, the absolute figures of the King-Fullerton rates are not so informative. However, they can be informative to compare the tax burdens across countries and over time.

1.2.4 Average effective tax rates from tax codes

Instead of focussing on marginal investment decisions, it is also possible to calculate the effective tax rate for investment projects that are more profitable. Indeed, a company often has to choose between two mutually exclusive locations for its investment. In such a case, it is the average tax rate that counts, and not the marginal rate.

Devereux and Griffith (1998a) therefore adjust the King-Fullerton approach in order to calculate the "average effective tax rate", that is the average percentage wedge on a range of inframarginal investment projects on which firms earn an economic rent. In the same tradition, Jacobs and Spengel (1999) use the "European Tax Analyzer", a computer simulation program containing a lot of institutional detail, to calculate the wedge between the pre- and post-tax wealth of hypothetical firms. The latter methodology is usually referred to as "project-based" analysis of effective tax rates.

The average effective tax rate based on tax codes is usually higher than the marginal effective tax rate. The reason is that many tax deductions apply to the cost of investment projects (which, for the marginal investment project, are equal to the rate of return) but are irrelevant for economic rent.

1.2.5 Which effective tax rate?

In arguments about tax competition one often refers to *the* effective tax rate. However, there are many different variants. Which one does one mean? There exist substantial differences between the values of the effective tax rates according to the different methods. Even worse, these differences differ also across countries. To bring this point home, consider Table 1, which is taken from Gorter and de Mooij (2001) and lists different effective tax rates for the three largest EU countries for 1994.

It may be noted that the ranking of the countries changes radically. Germany tops the list according to the King-Fullerton effective tax rate, France according to the Jacobs-Spengel effective tax rates, and Great Britain according to the Mendoza effective tax rate. This does not necessarily mean that one effective tax rate is "false" and another "true". They simply measure different things.

So, which is the appropriate measure for the tax rate to be included in regressions that investigate the responsiveness of foreign direct investment to taxation? Most authors (see, e.g., Devereux and Griffith, 1998b, and Jacobs and

Table 1

Effective Tax Rates, 1994
(rankings in parentheses)

	King-Fullerton (METR)	Jacobs-Spengel (AETR)	Mendoza (Average Macro)	Worldscope (Average Micro)
France	9 (3)	41 (1)	25 (2)	33 (2)
Germany	19 (1)	37 (2)	25 (2)	41 (1)
Great Britain	17 (2)	20 (3)	42 (1)	30 (3)

Source: Gorter and de Mooij (2001).

Spengel, 1999) claim that the *ex ante* effective tax rates are superior to *ex post* average tax rates for econometric analyses because using the latter may cause severe endogeneity problems. In particular, the tax measure may well reflect the underlying profitability of the location. Fullerton (1984) even lists eleven reasons why the average tax rates would be poor proxies for the marginal effective tax rates on new investment.

This is not undisputed, however. For instance, Swenson (1994) argues that average tax rates based on data are more informative than are effective tax rates based on tax codes as the latter usually do not pick up all elements of the tax code (including non-linearities) and are extremely sensitive to assumptions regarding interest rates, financing mix, and so on. In our meta-analysis, we explore this issue further. In particular, we investigate whether the responsiveness of FDI on taxation that is reported by studies systematically differs with the tax rate that is used.

2. A review of empirical studies

This section starts with a review of empirical studies on taxation and foreign direct investment. In particular, all empirical studies that include foreign capital on the left hand side of the equation and a measure for the tax rate on the right hand side have been considered, including working papers and unpublished articles. Only if we were unable to derive the appropriate elasticity values, we removed a study from our sample. In subsection 2.2, we make the outcomes of the studies comparable by deriving uniformly defined elasticities. These form the basis for our meta-analysis of the next section.

2.1 A review of the literature

The literature on taxation and FDI starts with Hartman (1984). He explains the aggregate inflow of direct investment in the United States as a ratio of GNP (K/Y) between 1965 and 1979 by the rate of return on US investment and taxes, measured as averages on the basis of macro data. The focus of Hartman's paper is on the distinction between FDI financed out of retained earnings and transfer of funds. Hartman claims that retained earnings should be more sensitive to US taxes because mature firms will use retained earnings as the marginal source of finance (which is cheaper than transfer of new funds). Hartman's results imply that, indeed, the tax rate elasticity for retained earnings is significant while for transfers the results are insignificant.

A number of subsequent papers have extended, modified or criticized Hartman's paper. Boskin and Gale (1987) extend the Hartman analysis by using a longer time series (from 1956 to 1984) and alternative data for the rate of return. They also experiment with a linear instead of a log specification. The results of Boskin and Gale more or less confirm the main findings of Hartman, that is the impact of US taxes on retained earnings is more robust than the impact on transfer of funds. Young (1988) also extends the Hartman analysis by means of a somewhat longer sample period (from 1953 to 1984), a slightly different specification with a lagged investment term, and revised investment data. He also confirms Hartman's original conclusions and even reports positive rather than negative semi-elasticities for transfer of funds. Murthy (1989) reestimates Young's result by maximum likelihood estimation, rather than OLS, in order to adjust for the presence of autocorrelation. His elasticities are somewhat larger than those in Young (1988) while the significance of the parameters improves. The qualitative conclusions, however, remain the same.

Newlon (1987) casts doubts on the studies in the realm of Hartman. First, Newlon shows that these studies have not used the appropriate data for the rate of return on FDI for the period 1965-73. Second, he notes that there is a problem of spurious correlation. In particular, the after-tax rate of return on FDI is constructed as the total earnings by foreign controlled companies, divided by invested capital. Since total earnings comprise reinvested earnings and repatriations, the rate of return variable contains the same component (and is almost equivalent if repatriations are low) as the dependent variable. To deal with these problems, Newlon (1987) uses alternative data. His conclusions are nevertheless in line with the previous findings of Hartman and others.[3]

Another contribution of Slemrod is that he controls for the tax system in the home country of the parent. The picture that emerges from this exercise is not clear, though. In fact, the country-specific evidence yields mixed results on the tax effect on FDI, including many insignificant coefficients. Moreover, Slemrod finds that the

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[3] We rely on the paper by Slemrod (1990) to include Newlon's (1987) elasticities since we were unable to get the original PhD thesis of Newlon.

level of the home country tax rate and the difference in statutory tax rates between the investing country and the US do not change the results much.

These earlier studies all rely on average tax rates based on macro data. Slemrod (1990) is the first to use an alternative measure for the tax rate, namely the marginal effective tax rate derived by Auerbach and Hines (1988). He also criticizes the earlier studies in a number of other ways. First, he argues that the focus of the literature on the Hartman specification is unjustified since it lacks a perfectly specified model. In such a situation, one should investigate different specifications. Second, Slemrod raises doubts on the FDI data which are constructed from periodic benchmark surveys. He includes dummies to correct for this. Third, Slemrod controls for other variables that affect FDI (and which are potentially correlated with the tax term). With these modifications, Slemrod re-estimates the tax rate elasticities in several ways. He finds that retained earnings are not responsive to US taxes, while for transfers a significant elasticity is found. This result is opposite to that of Hartman and others. Slemrod also explores the response of aggregate FDI, which is equal to the sum of retained earnings and transfers. The results suggest that taxes exert a significant negative effect on this aggregate FDI variable.

Slemrod's qualifications to the earlier literature have made researchers reluctant to continue using aggregate time series data along the lines of Hartman. Indeed, aggregate time series have been rarely used in subsequent contributions. Only recently, Billington (1999) and Broekman and van Vliet (2000) have used aggregate FDI flows to estimate the tax elasticity. Billington uses a panel of 7 OECD countries between 1986 and 1993 with aggregate FDI inflows. He regresses the log of FDI to the square of the country statutory tax rates and reports significant but small elasticities. Broekman and van Vliet focus on aggregate FDI inflows in 15 EU countries using data spanning from 1989 to 1998 and average tax rates based on micro data. Using a simple linear specification, they report elasticities in the order of –2.

Swenson (1994) uses aggregate FDI inflows into the US between 1979 and 1991, but distinguishes 18 different industries. She regresses the log of FDI in the entire panel to the average micro tax rates, distinguished for the respective industries. For FDI, she uses different data than previous studies. In particular, instead of financial flows, she uses data that better correspond to foreign investment.[4] Swenson reports a positive elasticity for alternative specifications and alternative tax measures. She thus confirms the Scholes and Wolfson (1990) hypothesis, suggesting that higher effective tax rates in the US will raise FDI from investors in tax credit countries.

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[4] Swenson (1994) refers to Auerbach and Hassett (1993) to motivate her choice of data. They distinguish three alternatives, namely affiliate data on new plant and equipment, acquisitions of existing US companies, and the establishment of new companies by foreign investors. It is not clear which series is used by Swenson (1994). She might also have used the sum of the three series as was done by Auerbach and Hassett. In our analysis, we have assumed that her capital data are similar to data on property, plant and equipment.

Some studies during the Nineties have taken up Slemrod's idea to exploit bilateral FDI flows. Cassou (1997) repeats Slemrod's analysis for individual countries investing in the US, thereby using average tax rates based on aggregate data between 1970 and 1989. He reports primarily insignificant results, especially for retained earnings.

Other studies have pooled bilateral FDI flows in order to construct a panel. First of all, Jun (1994) constructs a panel of FDI flows from 10 OECD countries into the US. He uses both average tax rates based on micro data as marginal effective tax rates to explore the responsiveness of FDI using a linear specification. His results are mainly insignificant. Devereux and Freeman (1995) use a panel of bilateral FDI flows between 7 OECD countries within the 1985-89 timeframe. Using a linear specification, they regress FDI flows to the user cost of capital, derived from Devereux and Pearson (1995). Devereux and Freeman find small and, mostly insignificant, negative elasticity values. Pain and Young (1996) focus on FDI from Germany and the UK into 11 locations during the period 1977-92. They use simply the statutory rates of the country and stress the importance of the home country tax for the responsiveness of FDI to host country tax rates. The long-run elasticity in Pain and Young's study is significantly negative and large for the UK, but insignificant and small for Germany. Using a similar specification, but with average tax rates based on firm data, and with bilateral FDI from 11 investing countries into 46 locations in 1991, Shang-Jin (1997) finds significant negative elasticities.

Studies using data on financial FDI flows or stocks have some serious limitations. As illustrated by Auerbach and Hassett (1993), FDI comprises a number of different components that can respond very differently to tax rates. Therefore, studies using aggregate FDI flows are difficult to interpret and strongly influenced by the composition of the FDI aggregate. A number of cross section studies in the US have therefore used data on property, plant and equipment which is believed to be more closely related to real investment. Grubert and Mutti (1991) explore the sensitivity of US investors in 33 countries with respect to foreign effective tax rates. They find a significant semi-elasticity of investment of around –0.7. Using the same method, Hines and Rice (1994) find a higher semi-elasticity between –3.3 and –6.6. Both studies base their tax rates on micro data. However, Hines and Rice use data for more countries, including a number of tax havens. Furthermore, they use data on all nonbank companies while Grubert and Mutti concentrate on manufacturing firms alone. The higher elasticity reported by Hines and Rice suggests that capital flows to tax havens and by non-manufacturing firms (which may contain much more financial capital) are more responsive to taxes than is real capital.

Grubert and Mutti (2000) exploit micro data of more than 500 US tax returns to construct an aggregated data set on average tax rates and investment in plant and equipment by US multinationals in 60 locations. Using different specifications and different concepts of the average tax rate, Grubert and Mutti report significantly negative elasticities. Altshuler *et al.* (2001) have exploited similar data as Grubert and Mutti and use a similar specification. They focus on the distinction in elasticities between 1984 and 1992. For 1984, they find an elasticity that is smaller than for

1992. This suggests that capital has become more responsive to taxes during the 1980s.

Hines (1996) builds on Slemrod's idea to use information on individual countries' direct investment into the US. He uses data on property, plant and equipment from seven investing countries into 50 different US states and explores the impact of corporate income taxes, measured by the state statutory rates, on the allocation of FDI. Hines uses a different specification than Slemrod: he explains the share of FDI by an investing country in each of the 50 US states in terms of total investment in the US. Hines assumes that countries using the tax credit system will not respond to US tax rates since investors in these countries will be compensated by means for foreign tax credits. Hence, the elasticity for territorial countries is derived conditional on a zero elasticity for worldwide investors. Hines reports significantly negative elasticities that are larger than found in most previous studies. The approach of Hines was later used by Gorter and Parikh (2000) and Benassy-Quere *et al.* (2001), who both use a panel of bilateral FDI flows between OECD countries. Both studies use an average tax rate; but Gorter-Parikh's tax rate is based on firm-specific data, whereas Benassy-Quere *et al.* rely on aggregate data. They both report significant tax effects on FDI by exemption countries.

Swenson (2001) takes up the qualifications by Auerbach and Hassett (1993) and distinguishes six different components of FDI: new plants, plant expansions, mergers and acquisitions, joint ventures, equity increases, and other FDI. The data refer to the number of investment projects, rather than the total amount of investment and comprise 46 countries investing in 50 US states, with the statutory corporate tax rates of the states as a proxy for the effective tax rate. The tax elasticity of new plants and plant expansions appear to be significantly negative for most investing countries. However, the effect of mergers and acquisitions is significantly positive in all cases. This suggests that, if mergers and acquisitions take up a larger share of aggregate FDI, it becomes less likely that the tax effect on aggregate FDI will be significantly negative.

A different strand of literature on taxation and foreign investment analyses the impact of host country taxes on the probability that a multinational chooses a location for an investment. In particular, Bartik (1985) explains the probability of location for new plants into each of the 50 US states by, among others, the state statutory corporate income tax. He reports a significantly negative elasticity. In the same spirit, Papke (1991) explains the location of plant births in 50 US states by the marginal effective tax rates on specific industries. He reports very different elasticity values for the various industries. Devereux and Griffith (1998b) also find a significant adverse impact of the average effective tax rate on the probability of US firms locating in either France, Germany or the UK.

2.2 Constructing a database

The studies discussed above use different specifications, thus producing coefficients with different interpretations. Moreover, authors either do not report the

corresponding elasticity values or adopt different definitions of elasticities. To make the outcomes of various studies comparable, we transformed the coefficients of each of the studies into a uniformly defined elasticity, namely, the semi-elasticity (or tax rate elasticity). Its interpretation is easy: it measures the percentage change in FDI in response to a one percentage point change in the tax rate, for example a decline from 35 to 34 per cent. Hence, the level of the tax rate is irrelevant for the size of the semi-elasticity. More formally, the semi-elasticity is defined as:

$$\text{Semi-elasticity} = \frac{\partial \ln FDI}{\partial t}$$

Table 2 lists the 25 studies that we reported above and shows some characteristics of the semi-elasticities that we obtained from them. Overall, we have obtained 371 semi-elasticities that, together, form our meta sample.[5]

Table 2 reveals a great variation among the 25 studies. First of all, the number of semi-elasticities derived from each study differs: it ranges from 2 (Newlon, Papke and Billington) to 95 (Swenson, 2001). Secondly, there is great variation in the mean value of the semi-elasticity, ranging from –10.9 (Hines) to +1.3 (Swenson, 1994). As shown by the maxima in Table 2, ten of the 25 studies report at least one positive semi-elasticity. The majority of semi-elasticities, however, is negative. A third observation from Table 2 involves the standard deviation of the reported semi-elasticities. In some studies, the elasticities feature a large dispersion with standard deviations exceeding ten (Slemrod, Hines and Rice and Cassou), while others show more moderate dispersions. A final source of heterogeneity among the studies concerns the use of different measures for the tax rate.

The distribution of the entire meta sample of 371 semi-elasticities is depicted in Figure 1. The mean value in the meta sample is –4.8 and the standard deviation equals 9. More than 80 per cent of all observations (300 out of 371) has a negative sign. The most extreme observations have values of –84.5 and +17.8, both obtained from Slemrod's study. Because of some extreme values left from the mean, the median semi-elasticity in the sample is smaller than the mean, namely –3.2. The extreme values thus seem to have an important impact on the characteristics of the distribution of semi-elasticities.

In Figure 2, we have eliminated some extreme values from the sample. In particular, the figure excludes semi-elasticities that are two standard deviations larger or smaller than the mean. Thus, it includes only semi-elasticities between –22.8 and +13.2. This comprises 95 per cent of the observations, that is the sample size drops from 371 to 351. The mean value of the semi-elasticity in Figure 2 is –3.3, *i.e.* 1.5 smaller in absolute terms than the mean value in Figure 1. Also the median drops slightly. Apparently, the number of extreme negative semi-elasticities is larger than the number of extreme positive semi-elasticities. As

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[5] The procedure to derive semi-elasticities from each of the original studies is described in more detail in de Mooij and Ederveen (2001). The sample can be downloaded from http://www.cpb.nl/goto/taxcompetition.

Table 2

Summary Statistics of the Studies in Our Meta Sample

		Number	Mean	Median	Max	Min	Std Dev	Tax rate
1	Hartman, 1984	6	–2.6	–3.5	2.0	–4.0	2.3	Macro ATR
2	Bartik, 1985	3	–6.9	–6.6	–5.7	–8.5	1.4	State STR
3	Boskin and Gale, 1987	12	–5.8	–2.7	0.3	–21.2	7.6	Macro ATR
4	Newlon, 1987	2	–0.4	–0.4	3.5	–4.3	5.5	Macro ATR
5	Young, 1988	12	–1.1	–2.1	5.3	–9.2	4.2	Macro ATR
6	Murthy, 1989	4	–0.6	–0.7	0.5	–1.6	1.0	Macro ATR
7	Slemrod, 1990	58	–5.5	–3.5	17.8	–84.5	14.4	METR
8	Grubert and Mutti, 1991	6	–1.7	–1.6	–0.6	–3.3	1.2	Micro ATR
9	Papke, 1991	2	–4.9	–4.9	–0.9	–8.8	5.6	METR
10	Hines and Rice, 1994	4	–10.7	–5.0	–1.2	–31.7	14.1	Micro ATR
11	Jun, 1994	10	–0.5	–1.3	5.9	–5.4	3.2	Micro ATR
12	Swenson, 1994	10	1.3	2.7	5.1	–8.1	4.3	Micro ATR
13	Devereux and Freeman, 1995	4	–1.6	–1.6	–1.4	–1.7	0.1	METR
14	Hines, 1996	46	–10.9	–10.2	–1.1	–36.7	8.2	State STR
15	Pain and Young, 1996	6	–1.5	–1.4	–0.4	–2.8	1.2	Country STR
16	Cassou, 1997	17	–7.5	–2.8	3.1	–44.7	13.5	Macro ATR
17	Shang-Jin, 1997	5	–5.2	–5.0	–4.7	–6.2	0.6	Micro ATR
18	Devereux and Griffith, 1998	10	–0.8	–0.9	0.0	–1.2	0.4	AETR
19	Billington, 1999	2	–0.1	–0.1	–0.1	–0.1	0.0	Country STR
20	Broekman and Vliet, 2000	3	–3.3	–3.5	–2.5	–4.0	0.8	Micro ATR
21	Gorter and Parikh, 2000	15	–4.6	–4.6	4.3	–14.3	4.3	Micro ATR
22	Grubert and Mutti, 2000	15	–4.0	–4.2	–1.7	–5.8	1.2	Micro ATR
23	Altshuler *et al.*, 2001	20	–2.7	–2.6	–1.4	–4.0	0.8	Micro ATR
24	Benassy *et al.*, 2001	4	–5.0	–5.0	–2.2	–7.9	3.0	Macro ATR
25	Swenson, 2001	95	–4.0	–3.2	8.0	–29.9	8.4	State STR
		371	–4.8	–3.2	17.8	–84.5	9.0	

Figure 1

Distribution of Semi-Elasticities

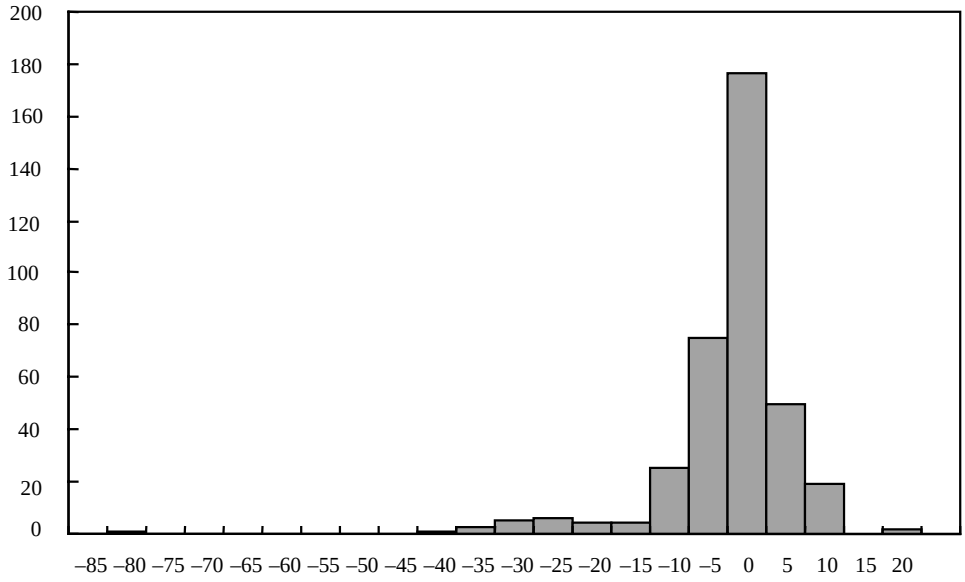
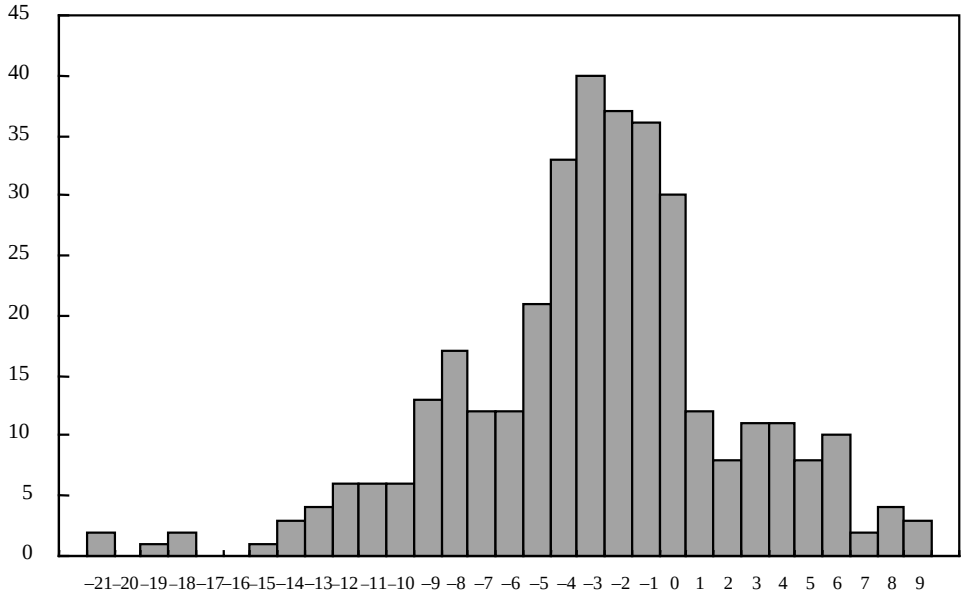


Figure 2

Distribution of Semi-Elasticities, Excluding Extreme Values



we can see from Figure 2, the majority of observations lies between minus five and zero.

3. Meta-analysis of the tax-rate elasticities

This section presents the meta-analysis of the semi-elasticities. Meta-analysis refers to the statistical analysis of results from individual studies. Next to summarizing results found by previous studies, it aims to add knowledge by relating the variation in estimates of elasticities to the underlying differences in study characteristics. In doing so, meta-analysis goes beyond an ordinary survey of the literature. Moreover, the statistical analysis forces one to be explicit in the selection process of the original studies. This is not to say that meta-analysis is without problems. Especially, sample selection and publication bias, heterogeneity, and dependence of observations may cause problems.

First of all, an important methodological problem of meta-analysis is the possibility of "publication bias". This occurs if only statistically significant results with the "correct" size are being published. One reason might be that editors of journals prefer to publish these "correct" results. In our sample, we included several unpublished studies. In this way, we gain some insight in the importance of this aspect of publication bias. It should be noted, however, that some of these papers may be published in a journal in the future. An example is the paper of Gorter and Parikh (2000), that will be published in *De Economist* later this year. When performing our meta-analysis, we still considered it unpublished. Another aspect of publication bias is that researchers do not write up their "unsatisfactory" results. It is therefore impossible to include these results in the meta-analysis.[6] Incidentally, about half of the semi-elasticities in our sample is statistically insignificant at the five per cent level.

A closely related concept is sample selection bias (or "retrieval bias"). This occurs when only studies are collected that use the same theoretical perspective, or studies that are published in the same journal. This can be harmful when there is a systematic relationship between the characteristics of the sampling process and the significance of the effect size.

Heterogeneity is almost inherent to meta-analysis as studies differ in numerous dimensions. In particular, different studies use different variables, different samples, and different estimation techniques. In our meta sample, the estimated elasticities are obtained from 25 studies, each with its own characteristics. Indeed, the studies show considerable heterogeneity, not only in terms of the type of tax rate used, but also in the kind of foreign capital data that is explored, and the countries that are considered. This heterogeneity renders a direct comparison of studies difficult. At the same time, however, the diversity in study characteristics

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[6] Florax (2001) discusses several techniques to identify and remedy this type of publication bias.

makes it possible to examine their effect on the magnitude and significance of the elasticity.

Related to heterogeneity is the problem of dependence. Because multiple elasticities are used from each study, the observations in our meta sample are mutually dependent. For instance, we draw no less than 95 elasticities from the Swenson (2001) study. Bijmolt and Pieters (2001) show, however, that taking all elasticities from the underlying studies in a meta-analysis is preferable to representing each study by a single value only.[7]

These problems of meta-analysis imply that the results should be interpreted with caution. However, the same problems apply to ordinary literature surveys. As illustrated before, meta-analysis may still yield additional insights as compared to surveys.

Literature surveys usually implicitly assign more value to one study over the other because quality typically differs among papers. In fact, this selection process might be seen as the main value added of the author of a literature review. Such a selection is also possible in meta-analysis. What is more, meta-analysis seems even more appropriate since it can assign explicit values to each of the primary studies. Hence, the reviewer is forced to be explicit on how he weights one study compared to the other. It is less straightforward, however, to find an objective measure for these weights. Therefore, people often assign an equal value to each of the underlying studies.[8] This is also done in this study, albeit that some problematic results from the literature have been eliminated from the sample (thus assigned a zero weight).[9]

Below, we start with a simple analysis of variation in subsection 3.1. Subsection 3.2 presents the meta regressions.

3.1 Univariate analysis of variation

This section performs an univariate ANalysis Of VAriation (ANOVA) which refers to the pair wise correlations between the elasticities and their underlying study characteristics. This gives a first indication of how the variation in elasticities is correlated with the variation in the tax data used. The ANOVA does not yet justify firm conclusions on the systematic impact of these study characteristics on the elasticities, however. Indeed, this would require a multivariate analysis which is

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7 Bijmolt and Pieters (2001) also discuss different approaches to deal with multiple measurements and show that the optimal procedure explicitly deals with the nested error structure.

8 Natural candidates as weights are the standard error of the elasticity, the number of observations that are used to estimate the elasticity, or the journal impact factor.

9 Originally, we had over 400 elasticity values. For thirty of these we were unable to derive reliable elasticities.

Table 3

Analysis Of Variation

Semi-elasticity[a]	Base sample		Including Extremes	
Number of observations	351		371	
Type of tax data				
State statutory rate (CSTR[b])	2.81	*	4.56	*
Marginal effective tax rate (CSTR[b])	1.08		3.60	
Average effective tax rate (CSTR[b])	–0.76		–0.76	
Micro average tax rate (CSTR[b])	0.92		1.28	
Macro average tax rate (CSTR[b])	1.25		2.54	

* Variable significant at 10 per cent confidence level.
[a] All semi-elasticities are pre-multiplied by a minus sign.
[b] CSTR = Country Statutory Tax Rate (benchmark choice).

presented in section 3.2. The ANOVA is only a first step in analysing the variation in elasticities.[10]

We perform the ANOVA for two different samples. First, we look at the meta sample that excludes extreme values, that is semi-elasticities that lie outside the range of plus and minus two times the standard deviation from the mean. This so-called base sample contains 351 observations. Second, we analyse the meta sample when these extreme observations are included as well. This sample contains 371 observations.

In Table 3 we present the ANOVA results for both samples. The correlations are shown relative to the country statutory tax rate. For visual convenience, we have put a minus sign for all semi-elasticities before doing the ANOVA analysis and the regression analysis. Thus, we transformed the majority of semi-elasticities into positive figures. A value of 1.08 for the marginal effective tax rate therefore means that results obtained with the marginal effective tax rate are on average 1.08 percentage points higher (more responsive) than results obtained by studies that use the country statutory rate.

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[10] In a sense, the ANOVA reflects what might be implicitly done in ordinary literature surveys. The advantage of the ANOVA is that it makes the procedure explicit and reproducable.

Table 3 reveals that studies using marginal effective tax rates or average tax rates based on either micro or macro data, yield higher semi-elasticities than studies adopting the country statutory rates. This is consistent with the view that effective or average tax rates are better approximations of the tax burden on foreign investment. However, Table 3 shows that the differences are typically insignificant, so it does not provide strong support for this hypothesis. Furthermore, the average effective tax rates exert an unexpected opposite effect.

From Table 3 we also learn that studies using state statutory tax rates in the US (Hines; Swenson, 2001) yield significantly larger elasticities. This may be because these rates are proportional to the marginal effective tax rate as the tax base of US states is, to a large extent, uniformly determined at the federal level.

Overall, the results from the ANOVA do not seem very informative. The coefficients are mostly insignificant. A possible reason could be that the results are contaminated by differences in other characteristics. That is what we will explore in the meta-regressions in the next section.

3.2 Meta-regressions

This section presents the meta-regressions. That is, we estimate $y = \exists X + \in$, where y represents the vector of elasticities and X is a matrix of dummy variables that reflect various study characteristics. The parameters in the vector $\exists$ thus measure the impact of each of the study characteristics (relative to some benchmark) on the effect size.

Next to different tax rates, we included a number of other variables in the regressions. In particular, we felt that the distinction between retained earnings and transfers, the relief system to avoid double taxation (exemption or credit), and the type of capital data (FDI, New plants, Mergers and Acquisitions etc.) could systematically influence the results. Therefore we controlled for these characteristics in the regressions. A footnote to Table 4 lists all the variables that were included in the regressions.[11]

Just as in the ANOVA, we have put a minus sign for all semi-elasticities before doing the regression analysis. This simplifies the interpretation of the regression results, which are presented in Table 4. The coefficients in the table show the estimated differential impact of the use of a different type of tax data, relative to the use of the country statutory rate. For example, a value of 3.08 for the marginal effective tax rate indicates that semi-elasticities estimated with the marginal effective tax rate are 3.08 higher (in absolute terms) than similar elasticities estimated with the country statutory rate. The other results can be interpreted similarly.

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[11] The results for the whole set of variables are available from the authors upon request.

Table 4

Meta Regressions With Different Samples

	Base regression	(351 observations) [a]	With extremes	(371 observations) [a]
State statutory rate	7.87 (1.30)	**	6.94 (2.22)	**
Marginal effective tax rate	3.08 (1.07)	**	3.89 (1.44)	**
Average effective tax rate	8.09 (2.21)	**	3.27 (4.16)	
Micro tax rate	1.27 (0.62)	**	0.46 (1.15)	
Macro average tax rate	2.64 (1.26)	**	2.98 (2.61)	

[a] In addition, the regression includes a constant, the average sample year and dummies for the source of finance (retained earnings, transfers), the taxation of foreign source income (exempt, credit), the type of foreign capital data (number of locations; property, plant and equipment; plants; mergers and acquisitions), the distinction between manufacturing firms and all firms, an indication whether there is controlled for home taxes and a dummy for Belgium.
White heteroskedasticity-consistent standard errors are shown between parentheses.
** Variable significant at 5 per cent confidence level.

We have explored two samples in our regressions. The first column of Table 4 shows the regressions with the sample of 351 observations and excludes the extreme values. The second column of Table 4 includes the 20 extreme observations and contains all 371 semi-elasticities. It turns out that the extreme values have a substantial impact on the results, especially with respect to the average effective tax rate. This does not come as a surprise, as we saw in section 2 that the extreme values also had a significant effect on the characteristics of the sample. Still, our main conclusions are supported in both cases. We have explored the robustness of the results by including additional study characteristics in the benchmark regression. The results of this sensitivity analysis can be found in the Appendix. They support the general notion that arises from the regression results in Table 4 and that we will discuss below.

A result that holds in all the regressions is that the responsiveness of foreign direct investment to state statutory rates is higher than the sensitivity to country statutory rates. This finding is in line with the results of the ANOVA. There we already mentioned that because of similar tax bases across US states, the state statutory rate probably bears a similar interpretation as the marginal effective tax rate.

Another clear conclusion that arises from the results of our meta-regressions is that both average tax rates (based on either micro or macro data) and effective tax rates (marginal or average) exert a larger effect on foreign direct investment than country statutory rates do. Indeed, the coefficients for the former categories of tax rates are always positive and usually significant.

Compared to the micro and macro average tax rates, the marginal effective tax rate (METR) yields bigger elasticities. The coefficient for the METR is significant at the 5 per cent level in all regressions. Its difference with the average tax rates is not statistically significant, however.

Important to note is that the average effective tax rate (AETR) appears in both the base regression as in the results in the Appendix with a positive, high and mostly significant coefficient. This contrasts with the findings from the ANOVA. Hence, the pair wise comparisons tend to be misleading. In particular, the AETR is used only by the study of Devereux and Griffith. Their relatively small semi-elasticities are not due to the AETR, but because of other characteristics. For instance, the Devereux and Griffith study uses data on the number of locations which exerts a negative impact on the value of the semi-elasticity. By including the variation in other dimensions, the regressions in Table 4 and in the Appendix suggest that the AETR yields a positive, rather than a negative, impact on the size of the semi-elasticity.

3.3 Typical elasticities

The meta-regressions can be used to compute the typical semi-elasticity for a study with particular study characteristics. These calculations serve to illustrate the quantitative implications of the regression results. However, because of "out-of-sample" prediction, the accuracy of these estimates may differ substantially between the presented cases. Nevertheless, we think these values are illustrative. Table 5 shows some of these typical values, which are based on the base regression in Table 4. As a benchmark, we take the elasticity based on country statutory rates, ordinary FDI data and an average sample year of 1987. The benchmark makes no distinction between credit or exemption systems. We see from Table 5 that a study with these characteristics yields a typical semi-elasticity of –1.2.

For alternative tax rate measures, Table 5 shows typical values for the corresponding semi-elasticities. In particular, if a study has the same characteristics as the benchmark except that it adopts the micro average tax rate instead of the country statutory tax rate, the typical elasticity becomes –2.4. If a study uses a forward-looking concept for the tax rate, the typical elasticity increases significantly. Elasticities based on marginal effective tax rates are typically –4.2, whereas the average effective tax rate even yields a value of –9.3. These values may serve as benchmark values in future research on the relation between company taxes and FDI.

Table 5

Typical Elasticities According to Our Meta Regression

Elasticity benchmark based on country statutory rates*	–1.2
Elasticities based on alternative tax rates:	
• State statutory tax rate	–9.0
• Average tax rate based on firm-level data	–2.4
• Average tax rate based on aggregate data	–3.8
• Marginal effective tax rate	–4.2
• Average effective tax rate	–9.3

* Benchmark: Ordinary FDI data; average sample year 1987; no distinction with respect to credit/exemption system.

4. Conclusions

Applying meta-analysis to the tax rate elasticity of FDI has some pitfalls. First of all, the substantial heterogeneity among studies renders a direct comparison of elasticities problematic. This makes it difficult to specify the appropriate meta-regressions to identify study characteristics responsible for the variation in elasticities. Second, some observations in the meta sample are dependent because they originate from the same study. Indeed, a relatively small number of studies has a disproportional impact on the meta sample because some authors have (and others have not) decided to present a whole set of regression results. A third pitfall refers to publication bias. In particular, a number of elasticities might not have been reported by authors because they were either insignificant or of the unexpected sign.

These pitfalls qualify the results from our meta-analysis. However, the same limitations apply to ordinary literature surveys. Moreover, compared to ordinary surveys, meta-analysis contains an important value added in making the heterogeneity among studies more transparent, the selection process verifiable, and studies better comparable. Furthermore, the meta-regressions provide a rigorous analysis in the variation of elasticities and the structural impact of various study characteristics. Thus, meta-analysis teaches us more about the literature. In fact, whereas regression analysis in general can be seen as a method to better understand the underlying data, meta-regressions can be seen as a method to better understand the existing literature, which comprises the data of the meta sample.

The paper reveals a number of insights that are relevant for policy makers. On average, we find that the tax rate elasticity of foreign capital is around –3.3. There is, however, substantial variation among studies. This can be partly explained by the choice of the tax data. Most economists argue that country statutory tax rates are imperfect measures to determine the impact on investment behaviour by multinational firms. Indeed, when we control for other characteristics, we find that studies using country statutory tax rates yield substantially smaller elasticities than studies adopting effective tax rates or average tax rates. It is also often claimed that *ex ante* proxies of effective tax rates are superior to *ex post* measures. In our meta-analysis, this seems to be confirmed by the fact that effective tax rates based on tax codes (marginal and average) tend to yield higher elasticities. A typical elasticity based on marginal effective tax rates is –4.2, that is a one percentage point reduction in the host-country tax rate raises foreign direct investment in that country by 4.2 per cent. This value may serve as a benchmark for future research on the relation between company taxes and FDI.

APPENDIX

REGRESSION RESULTS WITH ADDITIONAL STUDY CHARACTERISTICS

To analyze the robustness of our results, we have experimented with different combinations of study characteristics. Table 6 shows the regression results for five different specifications.

The first column repeats the results for our benchmark specification, that is the one discussed in the main text. In the second column of Table 6, we control for some additional study characteristics such as published/unpublished, log/linear

Table 6

Meta-Regressions for Different Combinations of Study Characteristics

	Base regression[a]	More characteristics[b]	Study effects[c]	Control variables[d]	Country effects[e]
State stat. rate (CSTR)	7.87 **	5.84 **	12.78 **	3.29	10.83 **
METR (CSTR)	3.08 **	4.95 **	4.02 **	3.92 **	3.64 **
AETR (CSTR)	8.09 **	2.02	5.81 **	8.15 **	5.25 **
Micro ATR (CSTR)	1.27 **	0.60	1.08	0.14	0.61
Macro ATR (CSTR)	2.64 **	4.31 **	3.19 **	3.40 **	2.61 *

[a] See Table 4 in the main text.
[b] As column 1 plus dummies for unpublished (published), log(linear), OLS(other), cross section/time series (panel), stock (flow) data, inward (outward) investment.
[c] As column 1 plus dummies for the studies of Swenson (2001), Slemrod, Hines, Altshuler *et al.*, Cassou, Gorter and Parikh, Grubert and Mutti, Boskin and Gale, and Young.
[d] As column 1 plus dummies if the following control variables were included: tax on domestic investors, GDP, population, openness, agglomeration effects, unemployment, exchange rate, wages.
[e] As column 1 plus dummies for US, UK, Japan, France, Germany, Canada, Netherlands, Australia, Sweden, Italy, Switzerland, Denmark, Portugal and Finland.
* Variable significant at 10 per cent confidence level.
** Variable significant at 5 per cent confidence level.

specification, OLS/other estimator, cross section/time series/panel data, stock/flow of FDI and inward/outward investment. The third column of Table 6 shows the regression results if we include country-effects,[12] that is a dummy variable for each investing country if it could be identified from the underlying study. This controls for unobserved heterogeneity of investing countries, such as special features of their tax systems.[13] The last two columns explore the effects of two methodological problems in meta-analysis on the main results. The fourth column show the effects of including a number of study-effects, that is a dummy variable for each study from which we obtained more than ten semi-elasticities. This may be seen as a modest attempt to deal with the dependency problem due to multiple measurement, as discussed above. The final column reruns the basic regression for the sample of published studies only. This eliminates 43 observations taken from six unpublished studies. The regression results from these analyses support our main results.

[12] The claim that intra-EU capital flows are more responsive than are continental flows cannot be investigated appropriately since Gorter and Parikh is the only study that includes only intra-EU flows.

[13] We control for Belgium as an investing country in all regressions. The reason is that Belgium is only distinguished separately in the Swenson (2001) study in which it yields very high semi-elasticities.

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