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Tax Policy and the Globalisation of R&D

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Abstract

This paper examines the factors influencing the globalisation of R&D, with a particular focus on the role of tax policy, using panel data for 25 OECD countries over the period 1980- 2005. Two measures of globalisation are considered - R&D directly financed from abroad and R&D expenditure by affiliates of US multinational enterprises (MNEs). The econometric analysis, which controls for other determinants of inter-country differences in R&D investment, finds no evidence that host country tax policy is an important determinant of MNE location decisions or in attracting cross-border contract R&D. There is evidence that affiliate fixed capital stock and total sales are strong determinants of R&D performed by affiliates of US MNEs. Controlling for these variables, host country attributes seemed to be less important. In the case of cross-border contract R&D, host country expenditure on R&D via institutions of higher education is also found to be important.

JEL classification: O38, O31, O32, F21

Key words: Globalisation of R&D, tax policy, foreign direct investment, multinational enterprises

1. Introduction

Policies aimed at increasing national research and development (R&D) investment are now a central component of national strategies to increase productivity, long run economic growth and international competitiveness in most OECD countries.[1] In the light of this objective, policy makers are increasingly conscious of the large and growing role foreign firms play in determining aggregate R&D investment. R&D attributable to foreign firms include that which is undertaken by foreign owned affiliates of multinational enterprises (MNE) as well as R&D contracted to unaffiliated firms from abroad. This globalisation has been portrayed as representing increased competition between nations to attract and maintain a share of global R&D activity. The footloose R&D hypothesis holds that firms are increasingly able to shift the location in which they undertake R&D in response to locational advantages such as lower costs or the availability of skilled researchers. The alternative view emphasises the powerful incentives firms face to keep R&D functions in house in the home country.

Tax incentives are seen as an important policy instrument to attract a share of increasingly globalised R&D activities (OECD 2002b). However, the effectiveness of tax incentives in attracting R&D investment from abroad hinges on how ‘footloose’ R&D activities actually are. Additionally, taxation of repatriated income by home country governments may make tax incentives offered by host countries an ineffective way to reduce MNE R&D costs. For example, US MNEs pay tax on all global income but tax paid to foreign governments is credited against US company tax liabilities (Hall 1995b). That is, tax paid to foreign governments is reimbursed via reductions in liabilities of the parent, implying that any savings from host country tax incentives are ultimately paid by the parent when profits are repatriated.[2]

Despite the practical importance, and the theoretical ambiguity of the effectiveness of tax policy, this issue remains relatively unstudied. A handful of studies have considered the globalisation of R&D activity either by considering R&D activities of MNE affiliates or through more indirect approaches (see for example Bloom and Griffith 2001; Hines and Jaffe 2001; Athukorala and Kohpaiboon 2006). These have failed to reach a consensus as to whether host country tax policy is effective in attracting R&D investment from abroad.

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[1] For example, in 2000, European Union member countries agreed to the Lisbon Agenda which set as a goal an increase of R&D investment intensity to 3% of GDP by 2010. Many other countries have also set R&D expenditure targets and goals. For example, Canada aims to increase R&D intensity to the level of the top five countries in the OECD by 2010. The increased emphasis on R&D effort is not limited to OECD countries. For example, China recently committed to achieving an R&D intensity of 2.5% of GDP by 2020.

[2] In this case, firms only stand to benefit from tax incentives where they have excess unused foreign tax credits.

This study aims to throw some light on this issue, based on an analysis of a panel data set for 25 OECD countries over up to 25 years to 2005. Two measures of globalisation are considered: R&D investment by majority owned affiliates of US multinationals; and, R&D financed (or contracted) from abroad. Analysis of the former extends the existing literature by employing a measure of R&D tax policy that closely reflects both implicit and explicit subsidies available through host country tax systems. The second measure considered in this study, R&D financed from abroad, essentially reflects cross border contract R&D and includes transactions between MNE affiliates (arms-length) as well as transactions between unaffiliated firms (international outsourcing). This study represents the first attempt to empirically assess the determinants of foreign financed R&D.

The paper is organised as follows. Section 2 introduces key measures of R&D globalisation and demonstrates that a large and growing share of R&D in countries considered in this study is attributable to foreign firms. Section 3 outlines a framework for understanding the forces driving the globalisation and outlines the existing evidence that host country tax policy is effective in influencing this process. Section 4 outlines the model and approach adopted by this study. The empirical results are presented in sections 5 and 6. Section 7 concludes.

2. Trends in R&D Globalisation

This study considers three measures of R&D activity of foreign firms aggregated to the host country level. These are: business performed R&D that is financed from abroad (OECD 2007a); R&D conducted by affiliates of US MNEs in manufacturing (BEA various years); and total R&D conducted by all foreign affiliates in all industries (OECD 2007a). The first two are employed in the regression analysis aimed at assessing the factors which influence foreign R&D and these are discussed in further below. The third measure, total R&D performed by all MNE affiliates, is used for comparative purposes, however, the coverage of this data is too limited to provide a basis for formal econometric analysis.

R&D investment by US MNEs in manufacturing is taken from the BEA annual survey of US investment abroad (various years).[3] The series covers 25 countries between 1990 and 2005. As previously noted R&D expenditure by foreign controlled affiliates includes both a foreign financed component and a component financed from retained earnings (OECD 2005c). This is because "[MNE] affiliates pay for most of their own R&D, but parent companies often enter into contracts with their affiliates to carry out specific research" (OECD 1998b p.11). Acquisitions of

[3] BEA data in this study came from two sources. For the years 1991-1999, data previously compiled by Athukorala and Kohpaiboon (2006) was provided by the authors. Data for the years 2000-2005 were obtained directly from the BEA annual survey reports.

large capital assets are not directly included in the BEA data, but the measures include amortisation and depreciation. This study focuses on the activities of MNE affiliates in the manufacturing sector thereby allowing deeper investigation into firm level attributes that drive the off-shoring decision. In 1999, the manufacturing sector accounted for 90% of total R&D conducted by MNE affiliates, but less than half of MNE affiliate fixed capital stock (plant and equipment).

The second principal indicator of cross-border R&D activity considered in this study is business R&D financed from abroad, taken from OECD Main Science and Technology Indicators (OECD 2007a). The criteria for recording R&D as financed from abroad stipulates that "there must be a direct transfer of resources [and] the transfer must be both intended and used for the performance of R&D" (OECD 2002a p.114). Cross-border contracting or foreign financed R&D includes transactions between MNE affiliates (arms-length) as well as transactions between unaffiliated firms (international outsourcing). It does not include foreign sourced loans or other general capital raising which would be recorded under own funds. As a result the measure does not capture the potentially important role of foreign equity and venture capital markets in financing R&D. It also does not include R&D performed by MNE affiliates that is financed through retained earnings or general transfers from the parent firm.[4]

Figure 1 depicts three measures of foreign contribution to host country R&D expressed as a percentage of aggregate business expenditure on R&D (BERD) for 2004. Countries are ordered from left to right according to increasing GDP. The blue-grey bars represent R&D expenditure by all foreign affiliates in all sectors. Because of data availability theses figures reflect the nearest available year which varies between 1999 and 2004. Even so, data are not available for every country in the sample. The available data clearly demonstrates the substantial contribution of MNE affiliates to national R&D. The unweighted average contribution of foreign MNE affiliates to national BERD is 33%. Data on the R&D expenditure of majority owned affiliates of US MNEs in manufacturing are represented by the black bars in Figure 1. To remove the effect of short run volatility the average for the years 2003-2005 is reported. The unweighted average contribution of US MNEs to national BERD is nearly 10%. In Figure 1, the unfilled bars depict foreign financed R&D. As discussed, this includes parent firms contracting to affiliates as well as contracts between unaffiliated firms. R&D financed from abroad is significantly less than total expenditure by MNEs. Across the sample, on average, just under 10% of BERD if financed from abroad, though again there is considerable variation between countries.

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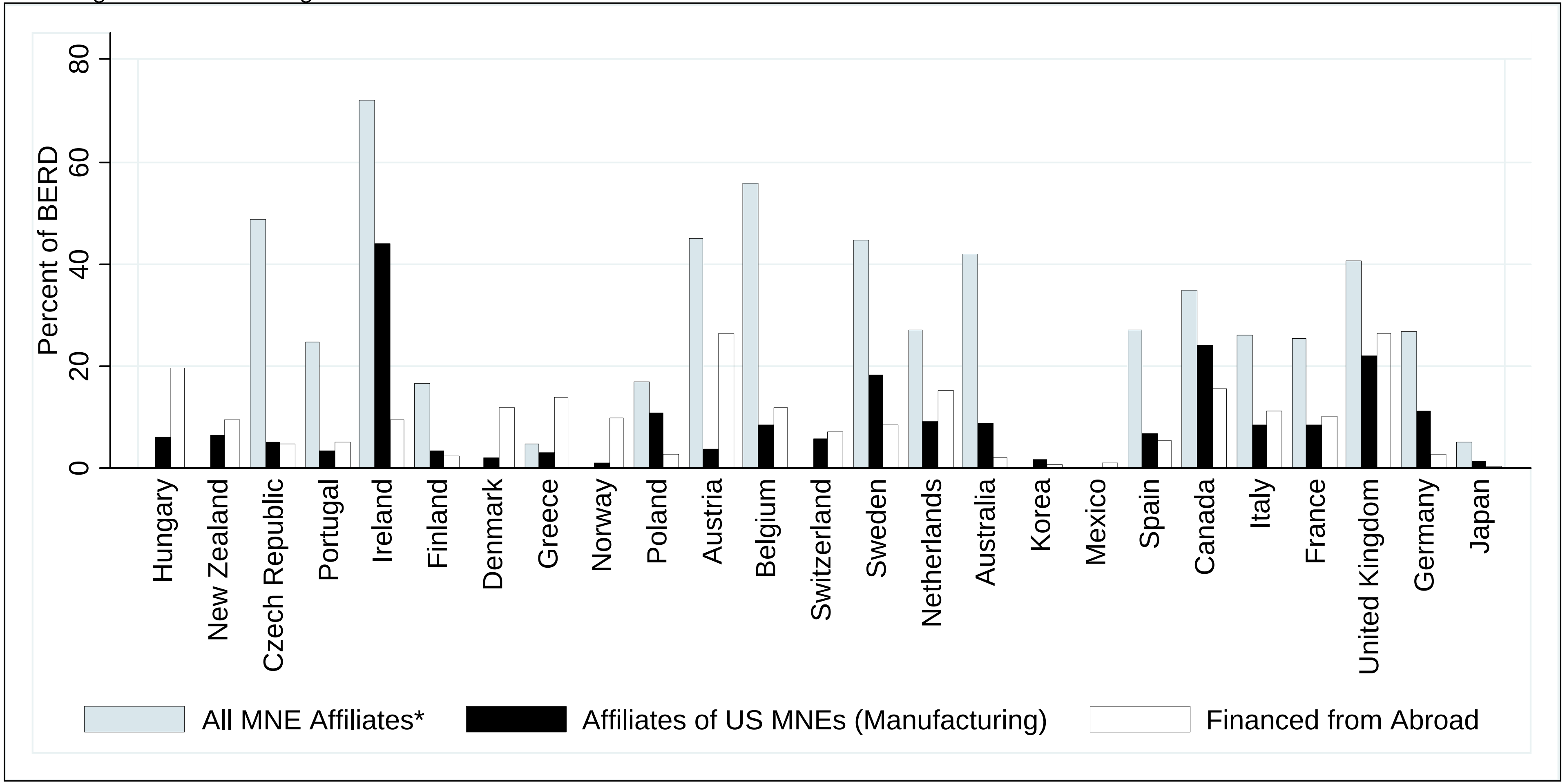
[4] In principle, foreign financed R&D can also include contracts from foreign governments and the not-for-profit sector, for example defence procurement. However, it is anticipated that this represents a very small amount because, for a range of reasons, governments generally award R&D contracts to domestic firms.

These indicators reveal that foreign firms contribute an unusually low proportion of BERD in the case of Japan. Ireland is at the other end of the spectrum. In Ireland, MNE affiliates, and particularly affiliates of US MNEs, appear to contribute far more than in the average country in the sample. In Austria, Greece, Hungary and the UK, the share of BERD financed from abroad is atypically high. The high proportion of R&D financed from abroad in Austria was examined by Gassler and Nones (2008). They claim that the "high share of foreign financing is a result of the considerably high amount of foreign ownership of Austrian industry" (ibid p.410). However, comparing between countries depicted on Figure 1 reveals that a high contribution of MNE R&D is not necessarily associated with a high proportion of R&D *financed* from abroad. Further, in the sample considered, an average of 80% R&D conducted by MNE affiliates is self financed (i.e., for their own use).

Figure 2 depicts the average annual growth rate of each measure between 1991 and 2005 (unless stated). For comparative purposes the growth rate in total BERD is also depicted. In the countries where the growth rate of foreign R&D is larger than the growth rate of total BERD it can be inferred that the proportional contribution of foreign R&D has increased. The average annual growth rate of R&D by affiliates of US MNEs in the manufacturing sector is also depicted. It can be seen that in most OECD countries the contribution of foreign firms to total BERD has increased, with the notable exceptions of Australia and Canada.

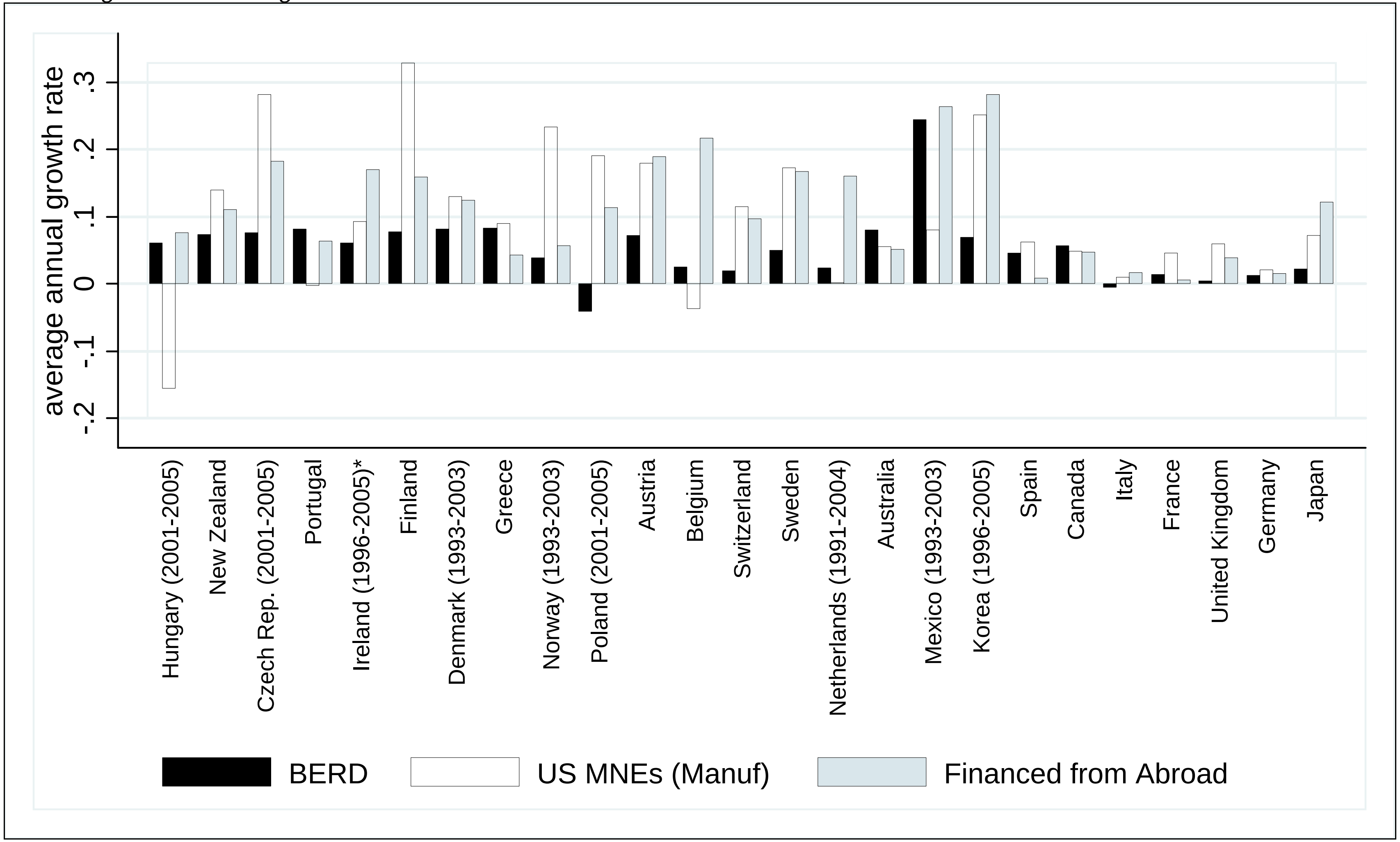
Figure 1 Foreign R&D as a Percentage of BERD 2004



Source: Compiled from BEA and OECD MSTI. Countries are arranged from left to right in increasing total GDP.

* Note figures for R&D performed by all MNE affiliates reported reflect the 2004 figures with the following exceptions: 1999 is shown for Greece and Australia and 2003 is shown for Germany, Ireland, Netherlands, Portugal, and Sweden.

Figure 2 Average Growth in Foreign R&D 1991-2005



Source: Compiled from OECD (2007a), BEA (various years).
Countries are ordered from left to right according to increasing GDP
* Data on R&D investment in Ireland before 1996 appears anomalous, see note at Appendix 6.1.

3. Framework and Existing Evidence

R&D attributable to foreign firms include R&D undertaken by foreign owned MNE affiliates (arms-length) as well as R&D contracted to unaffiliated firms from abroad (international outsourcing). In general, firms face strong incentives to undertake R&D in house and in the home country. For example, a recent experience of Motorola and BenQ illustrates the perils of international R&D outsourcing. Motorola contracted not only the manufacture but also the design of cell phones to BenQ. Subsequently, BenQ began selling phones under their own brand creating a competitor for Motorola and eroding their technological advantage (Engardio et al. 2005). Firms will conduct R&D abroad when advantages to doing so outweigh the costs and risks. The question asked in this paper is whether host country tax policy can play a significant role in this process. As such, we begin by outlining the factors through to be driving the globalisation of R&D, and subsequently, existing evidence as to the efficacy of tax policy.

MNEs conduct nearly two thirds of total global business R&D (UN 2005). Traditionally, MNEs conduct the majority of their R&D in the home country, and there are well-established reasons for this. Dunning (1988a; 1988b; 1994) proposes an eclectic paradigm for understanding MNE activity which highlights the ability of MNEs to solve the range of market failures associated with intangible assets such as technology. Technology and business know-how are amongst MNEs' principal sources of competitive advantage; arguably these are the raison d'être of the MNE. As a result, R&D has long been seen as an inseparable part of the 'core business' of MNEs. The desire to protect and control technology and technology creation underpins a powerful incentive to centralise R&D functions in the home country. Centralising R&D activities in the home country also facilitates economies of scale in research.

A range of other forces have been identified which promote the locating of R&D activities away from an MNE's home base. These are referred to as centrifugal forces and include asset exploiting and asset augmenting motives (Caves 1996). Asset exploiting R&D is conducted to exploit existing firm ownership advantages and technological know-how (Dunning 1994). Asset exploiting R&D is generally associated with the need to co-locate R&D and production activities. For instance, asset exploiting R&D required to support local production and to adapt products for local markets has a long recognised history (UN 2005). It may also be associated with R&D supporting resource extraction.

Asset augmenting R&D is motivated to the acquisition of technology and research capacity. Such cross-border investments in R&D aim to overcome a limited supply of technical skills in a domestic market or to capture spillovers from technology clusters and international centres of excellence (Cantwell 1995; UN 2005 p.121). The availability of high quality, low cost human capital is an important determinant of asset augmenting R&D. It has been suggested that in recent years this "technology seeking" has become an increasingly important motive (Athukorala and Kohpaiboon 2006).

Cross-border R&D contracting between unaffiliated firms represents a second distinct mechanism of globalisation and is a specific type of a more general phenomenon of R&D outsourcing. Key advantages of R&D outsourcing include the ability to exploit economies of specialisation, and also enhanced speed and responsiveness. As regards to the former, the development of complex products that incorporate an increasing number of technologies may require input from multiple specialised firms (UN 2005 p.168). For example, Nokia gave up making its own silicone chips, once a source of company pride, because "Nobody can master it all," (Engardio et al. 2005).[5] Outsourcing is also thought to infer benefits relating to speed, responsiveness and flexibility in achieving R&D tasks, especially relative to developing R&D capacity de novo (Howells 1997).

Although the data used in this study do not allow us to distinguish between outsourcing and cross border contracting between affiliated firms, there is substantial evidence that the extent of R&D outsourcing is increasing[6] and that it is becoming increasingly internationalised (Howells 1997; Engardio et al. 2005). Outsourcing to foreign firms can facilitate the acquisition of the best technology from leading innovators wherever they may be located. Further, where the contracted firm is located in a country with relatively low costs and an abundant supply of highly skilled researchers this may be a source of substantial cost savings.

3.1. The Role of Tax Incentives

Existing empirical evidence regarding the impact of tax incentives on R&D investment by foreign firms is at a nascent stage and does not yet point to an emerging consensus. Most existing evidence is indirect. For example, Bloom and Griffith (2001) consider the impact of

[5] The quote is Pertti Korhonen the Chief Technology Officer of Nokia.

[6] Contract R&D doubled in the United States between 1998 and 2001 (UN 2005 p.177); in the UK, it increased from 5.5 to 10% of BERD between 1985 and 1995 (Howells 1997); in Australia, the proportion of business R&D undertaken by the scientific research industry increased from 3 to 6% over the 13 years to 2003 (ABS Cat. 8140 various years).

the average foreign tax price (i.e., tax price in other countries weighted by FDI flows) on *domestic* investment in R&D using a panel of 8 countries over 11 years. The hypothesis being tested is that if R&D is footloose, domestic firms will move some of their R&D activities overseas in response to lower user costs abroad. The authors preferred results find the short run elasticity of R&D with respect to foreign tax price is -0.75 and the long run elasticity to be -5.3. This is interpreted as strong support for the footloose R&D hypothesis. In fact, their results suggest the tax policy abroad has a stronger effect on domestic R&D than does the domestic tax policy, which might be considered implausibly high.

In contrast to Bloom and Griffith (2001), Hines and Jaffe (2001) find that R&D performed by MNEs in the USA and in host countries are *complements*. The authors find that when the cost of undertaking R&D in the United States for use in foreign markets is reduced, the proportion of patents registered by MNEs that are attributable to affiliates outside the USA increase. Extrapolating from this result, the authors suggest that "foreign tax incentives should influence the rate at which US multinationals innovate in their domestic markets" (ibid p. 203). Further indirect evidence is provided by Feldstein and Hines (1995), who find that when a host country increases taxes on royalty payments for foreign technology, affiliates expenditure on R&D increases. This result is interpreted to imply that tax policy has a strong impact on MNE R&D location decisions and those R&D and technology transfers (licensing etc) are substitutes. Jaffe (1995) notes that the estimates of the effect of royalty taxes seem implausibly large, as they imply affiliate R&D investment responds more to the variation in royalty tax than royalty payments do.

Athukorala and Kohpaiboon (2006) directly examine the role of host country characteristics in determining the R&D expenditure of affiliates of US MNEs using data aggregated to the host country level, covering the decade to 2001. The authors find tax incentives have no statistically significant effect on MNE affiliate R&D investment, and they suggest the positive finding in previous studies may be the result of omitted variable bias. The measure of tax policy applied by Athukorala and Kohpaiboon (2006) is a simple ordinal indicator that reflects the policies in place in 2000-2001. This measure does not reflect the many policy changes over this period and as such, this is a poor indicator of the actual prevailing tax treatment of R&D in each country.

4. Model and Approach

Unlike much of the existing literature, this study directly considers the role of host country R&D tax incentives on the R&D activity of foreign firms in each host country. Two separate equations are estimated using the different dependent variables: R&D investment by US MNEs in manufacturing and R&D financed from abroad. The same host country characteristics are included in both models. Host country attributes include cost considerations, supply of human capital and host country technological capacity. The explanatory variables relating to firm attributes are different for each model, because each dependent variable represent the activities of different groups of firms.

4.1. Host Country Factors

Tax treatment of R&D differs between countries, particularly in regard to the design and implementation of incentives. Policies differ in their treatment of various types of expenditure; types of tax incentives including deductions, allowances and offsets; and, the definition of eligible expenditure. A standard measure of the relative generosity of a tax system is known as the b-index. The measure is extremely flexible and can accommodate a wide range of implicit and explicit tax incentives. The formula for the b-index is given by

$$B = \frac{1-A}{1-\tau} \qquad (1)$$

where A is the net present discounted value of all reductions to tax liabilities resulting from one dollar of R&D and τ is the corporate income tax rate.

The b-index represents the before tax project hurdle rate i.e., the minimum before tax return the marginal R&D investment must generate to be financially viable after tax (Warda 2006). Note that the lower b-index reflects more generous tax treatment of R&D. It is described as the tax price of R&D because it is the price a firm is willing to pay for the marginal investment.

To construct the measure used in this study, an audit of national tax policies for 25 countries between 1980 and 2005 was undertaken from a wide range of sources (see appendix A for data summary). The measure calculated aims to capture the principal features of depreciation, deductions and special credits applicable to a representative large firm. The calculations assume that firms can benefit fully from the incentive, i.e., it assumes firms have sufficient tax liabilities to claim the full amount of R&D tax incentives in the current year. The standard methodology does not consider caps and floors in the scheme nor does it incorporate differences in tax treatment of dividends or withholding taxes on international transfers of profit.

Special attention was paid to identify aspects of policy that differentially effect foreign owned firms and foreign financed R&D. Restrictions to foreign owned firms were not identified in any country. However, the tax system in France, Korea and Switzerland and all policies in place by which foreign firms undertaking R&D can be granted tax holidays (Rashkin 2007). Few countries were found to have limitations on claims for foreign contracted R&D. Australia has had the most explicit restriction. In Australia, R&D conducted on behalf of another firm is not eligible to receive enhanced deduction (BIE 1993; ATO 2002).[7] The scheme in Portugal also requires that the claimant must self-finance at least 25% of the total investment (IBFD 2004 p.154). No information regarding such restrictions in any other countries could be identified.[8] Since a substantial share of MNE affiliate R&D activity is self financed, the restrictions in Australia and Portugal are unlikely to significantly affect the attractiveness of R&D tax incentives to US MNE affiliates. As a robustness check, a modified version of the b-index was calculated that does not include the special incentives in Portugal and Australia. This alternative 'foreign contract' b-index is denoted by BFC.

Other host country attributes that are considered to be strong determinants of the ability to attract R&D investment by foreign include technological capacity, labour costs and market size. Firms undertake asset exploiting R&D when products sold into different markets require modification to meet local regulations or to cater to different consumer tastes. On this basis, it is sometimes argued that larger host country markets justify greater investment in adaptive R&D. Real GDP is included in the current analysis to capture market size.

To control for host country technological capacity and opportunities for foreign firms to tap into cutting edge research the model includes the aggregate number of articles published in international journals on science and engineering (WB 2007).[9] The importance of academic research as input to commercial innovation is reflected by the fact that published scientific research is commonly cited as prior art in patent applications (see for example Branstetter 2003). Scientific and technical journal articles refer to the number of peer reviewed scientific and engineering articles published annually, by location of the institution of the author. This measure has the great advantage of being widely available both across country and over time. However, as well as general noise, journal article publications are recognised to have an

[7] However, a special scheme was introduced in 2007 to provide enhanced deduction for foreign contract R&D. This reform is outside of the period of this study.

[8] The absence of restrictions was positively confirmed in the case of Austria, Canada, Ireland and the UK (Canadian Embassy Berlin 2003; IBFD 2004; IRC 2005; McAlpine 2005). In some countries, including Belgium and France, taxpayers cannot claim R&D expenses that are contracted out to other firms (IBFD 2004). However, this does not appear to limit the contracted firm from claiming expenses. In the case of France some ambiguity existed prior to 2007, though it seems firms conducting R&D under contract did claim the tax credit (DTT 2008).

[9] Scientific and engineering articles published in the fields of physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

English language bias (NSF 2008) which, like other time invariant heterogeneity, must be taken into account when estimating the model.

R&D performed by the tertiary education sector (HERD) provides a proxy for the quality and extent of postgraduate research education. HERD includes research by students at the PhD level including supervisory costs but does not include expenditure in relation to coursework degrees and teaching related activities (OECD 2002a). This measure is superior to the percentage of the population with tertiary education because it more directly reflects both the number as well as the quality of research based degrees, which is of primary interest. It also has wider coverage.

A strong host country intellectual property right (IPR) regime may encourage MNEs to undertake R&D without fear of imitation. On the other hand, it has been conjectured that stronger IPR may facilitate technology transfer via licensing which may be a substitute for R&D investments. Existing evidence as to the net effect of IPR strength is mixed, though more recent evidence appears to suggest IPR is an important determinant of MNE R&D investment decisions (see for example Kumar 1996; 2001; Athukorala and Kohpaiboon 2006; Branstetter et al. 2006). To further investigate this issue, Ginarte and Park's (1997) IPR score is included in the model. The index is an ordinal assessment of IPR legislation of each host country. Despite the fact that the sample of countries considered are typically associated with strong institutional quality and broadly similar approach to private property rights the Park IPR score exhibits substantial variation over the sample with a standard deviation 13% of the mean.

To control for the cost of R&D labour, average labour compensation for the total host country economy is included, taken from OECD Outlook (various years). This is converted to current USD and deflated using US GDP Deflator (WB 2007). It is proposed that this captures relative changes in labour costs over time across-country, particularly those arising from large movements in exchange rates. A limitation of this measure is that it will also reflect the relative share of skilled workers in each country,[10] though to the extent that this remains constant over time this can be addressed using fixed effects estimation.

[10] The ideal variable would be total compensation of a 'standardised' unit of research labour. Another possible proxy would be the real wages of researchers. However a complete time series for all countries included in the sample was not available.

4.2. Firm specific factors

Firm specific drivers of R&D globalisation relate to asset exploiting motives such as the need to support local production and to adapt products for host country markets. The two alternative dependent variables represent the activities of different groups of firms. For this reason, different variables reflecting the attributes of investing firms are used in each model.

R&D by Affiliates of US MNEs

Asset exploiting R&D is predicted to increase with the scale of MNEs operations in a host country host country. To control for the scale of host country operations the regressions explaining R&D investment by MNE affiliates include the book value of plant and equipment, as well as total sales. Export orientation of MNE affiliate has a theoretically ambiguous impact on the requirement to undertake R&D. On one hand, it has been argued that that affiliates that serve larger export markets will be more likely to undertake R&D (Athukorala and Kohpaiboon 2006). However, there exists some debate as to the impact of export orientation of an MNE affiliates R&D activity. For example, it has been argued that production is exclusively focused on serving a differentiated host country market may be associated with more market specific adaptive type R&D (Lall 1979). To test these hypotheses, export orientation, given by total exports divided by total sales, is included in the model.

Determinants of R&D Financed from Abroad

It is believed that a substantial share of foreign financed R&D represents transactions between MNE affiliates. For this reason it is desirable to control for total foreign firm activity in each host country. FDI stock is included as a control variable, which is imputed from total FDI inflows reported in WDI (WB 2007) using the perpetual inventory method assuming a depreciation rate of 5% and that the initial FDI stock is zero. Where available, pre-sample FDI flow data from 1975 are employed in this calculation.

As R&D intensity is known to vary across industry sectors, it would also be preferable to control for the industrial mix of foreign firm operations. Unfortunately, time series data on the industry profile of all foreign firm activity (i.e., industrial composition of total FDI stock) is not available for the entire 20 year series for each country. As an alternative the model includes total manufacturing value added (WB 2007) to control for national industrial specialisation. It is proposed that the industrial composition of the economy as a whole is likely to be related to a host of factors that will independently drive innovative performance.

4.3. Specification and Estimation

The theoretical framework outlined in section 2 does not give rise to an obvious structural equation. Traditional structural models of investment assume firms invest in R&D to maintain optimal (technology) stock, given other inputs to production. For example, the modified neoclassical model or Euler equations derived from a convex adjustment cost model include total output as an explanatory variable. In the case of foreign R&D, the technology produced may be applied in host country operations or across the firms global operations – meaning there is no natural measure of 'total' output. For this reason, the empirical starting point employed here is a simple linear log-log model.

When estimating the model, it is important to take into account unobserved time invariant heterogeneity. Unobserved characteristics include language and historical ties to large investor nations. It is also important that several control variables are correlated to important fixed effects. Scientific journal article publications have an English language bias (NSF2008). Average labour compensation reflects industrial structure and institutional factors that will also evolve slowly over time and can therefore largely be controlled with fixed effects. Other important time invariant determinants of foreign R&D include geographic factors such as distance to major markets and the MNE head office. Therefore, on a priori grounds, fixed effects estimates are preferred. Year dummies are also included to control for global technology shocks and shifts in the global investment and trading architecture that affect firms in all countries.

There are reasons for and against the appropriateness of a dynamic specification. On one hand, once MNEs set up R&D facilities their utilisation may persist for some time. Similarly, the relationships and communication channels opened up through cross-border R&D contracting may be utilised repeatedly once one project is successfully completed. On the other hand, speed and reflexivity are sometimes considered important benefits of the R&D outsourcing. A dynamic specification has not been widely applied in the literature concerning international investments in R&D (see for e.g., Kumar 1996; 2001; , and Athukorala and Kohpaiboon 2006). Taking into account the theoretical ambiguity, the approach of this paper will be to estimate both a dynamic and a static model.

4.4. Summary of the Models

In summary, different models are estimated for each dependent variable: for R&D conducted by affiliates of US MNEs in the manufacturing sector (RDUS) and for R&D

financed from abroad (RDFABR). The two models, including variable definition and data summary are given below:

Model (1) R&D undertaken by affiliates of US MNEs:

$$RDUS_{it} = \beta_0 B_{it} + \beta_1 LC_{it} + \beta_2 GDP_{it} + \beta_3 HERD_{it} + \beta_4 SJA_{it} + \beta_5 IPR_{it} + \beta_6 EO_{it} + \beta_7 PE_{it} + \beta_8 SALES_{it}$$

Model (2) R&D financed from abroad:

$$RDFABR_{it} = \theta_0 B_{it} + \theta_1 LC_{it} + \beta_0 GDP_{it} + \beta_1 HERD_{it} + \beta_2 SJA_{it} + \beta_3 IPR_{it} + \gamma_1 K_{it\,t} + \varepsilon_{it}$$

Table 1 Variable Definitions and Economic Concepts

Variable	Economic Concept	Measure
	Host Country Variables: Common to Both Models	
LC	Labour costs	Average Labour Compensation Rate (USD per Employee)
B	R&D Tax Policy	B-Index
GDP	Host country market size	GDP
HERD	Supply of skilled researchers	R&D performed by Higher Education Sector
SJA	Technological Capacity	Scientific and Technical Journal Article Publications
IPR	Intellectual Property Rights	Park (1997) IPR Score
	Firm Level Variables: Model 1. US MNE Affiliates	
PE	Total Fixed Capital Stock in the Host Country	Value of Plant and Equipment (Survey value)
EO	Export Orientation of Affiliates	Exports / Total Sales
SALES	Scale of Operations in host country	Affiliate Total Sales
	Firm Level Variables: Model 2. R&D financed from Abroad	
FDI	Total Fixed Capital Stock in the Host Country	Total FDI Stock
MANUF	Industry composition	Manufacturing value added

4.5. Data Summary

Table 2 Data Summary Model 1: R&D Performed by Affiliates of US MNEs in Manufacturing

		Obs	Mean	Std. Dev.	Min	Max
RDUS	*R&D undertaken by Affiliates of US MNEs ($m)*	264	695	973	1.16	4,092
B	Tax Price of R&D (b-index)	264	0.95	0.10	0.57	1.06
LC	Average Labour Compensation Rate (USD per Employee)	264	31,810	11,006	5,819	61,314
GDP	GDP ($b)	264	743	1,048	48	4,885
HERD	R&D performed by Higher Education Sector ($m)	264	2,982	4,289	77	21,122
SJA	Scientific and Technical Journal Article Publications	264	15,742	15,233	990	57,228
IPR	Intellectual Property Rights	264	3.92	0.51	2.57	4.86
PE	Fixed Capital Stock (Plant and Equipment) ($m)	264	8,616	10,623	89	47,834
SALES	Affiliate Total Sales	264	37,393	46,517	403	231,796
EO	Export Orientation of Affiliates (Exports/ Total Sales)	264	0.33	0.17	0.03	0.69

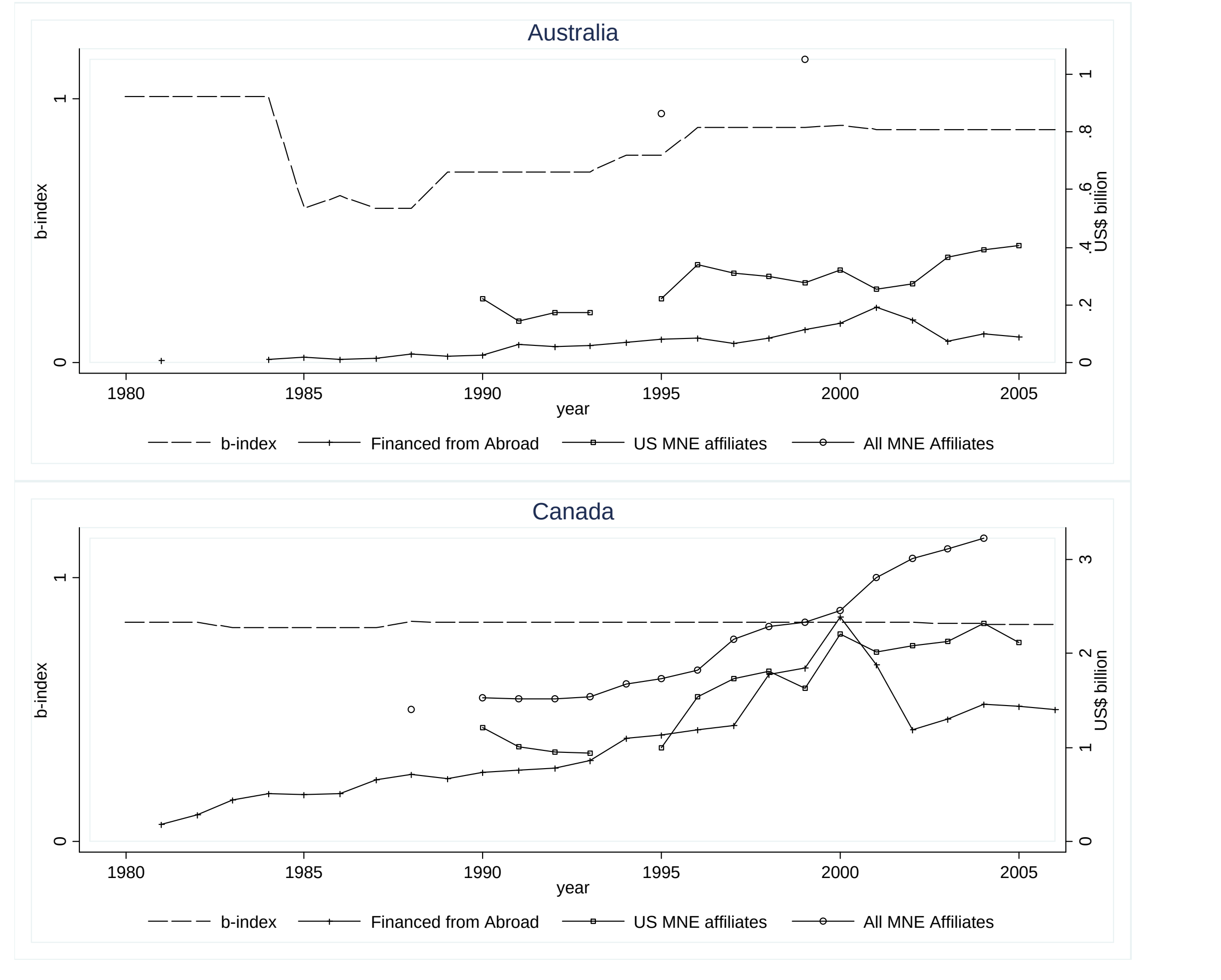
Table 3 Summary of Data Used in Foreign Financed R&D Regressions

		Obs	Mean	Std. Dev.	Min	Max
RDFABR	R&D financed from Abroad ($m)	407	441	809	0.62	5,285
B	Tax Price (b-index)	407	0.96	0.11	0.57	1.08
LC	Average Labour Compensation Rate (USD per Employee)	352	28,976	10,641	5,775	61,314
GDP	GDP ($b)	407	664	973	38	4,885
HERD	R&D performed by Higher Education Sector ($m)	407	2,454	3,925	35	21,122
SJA	Scientific and Technical Journal Article Publications	407	13,290	14,126	184	57,228
IPR	Intellectual Property Rights	407	3.66	0.65	1.63	4.86
FK	FDI Stock ($m)	407	60,310	89,996	484	490,341
MANUF	Manufacturing value added ($m)	407	142,126	225,620	7,105	1,098,437

4.6. A First Look at the Data

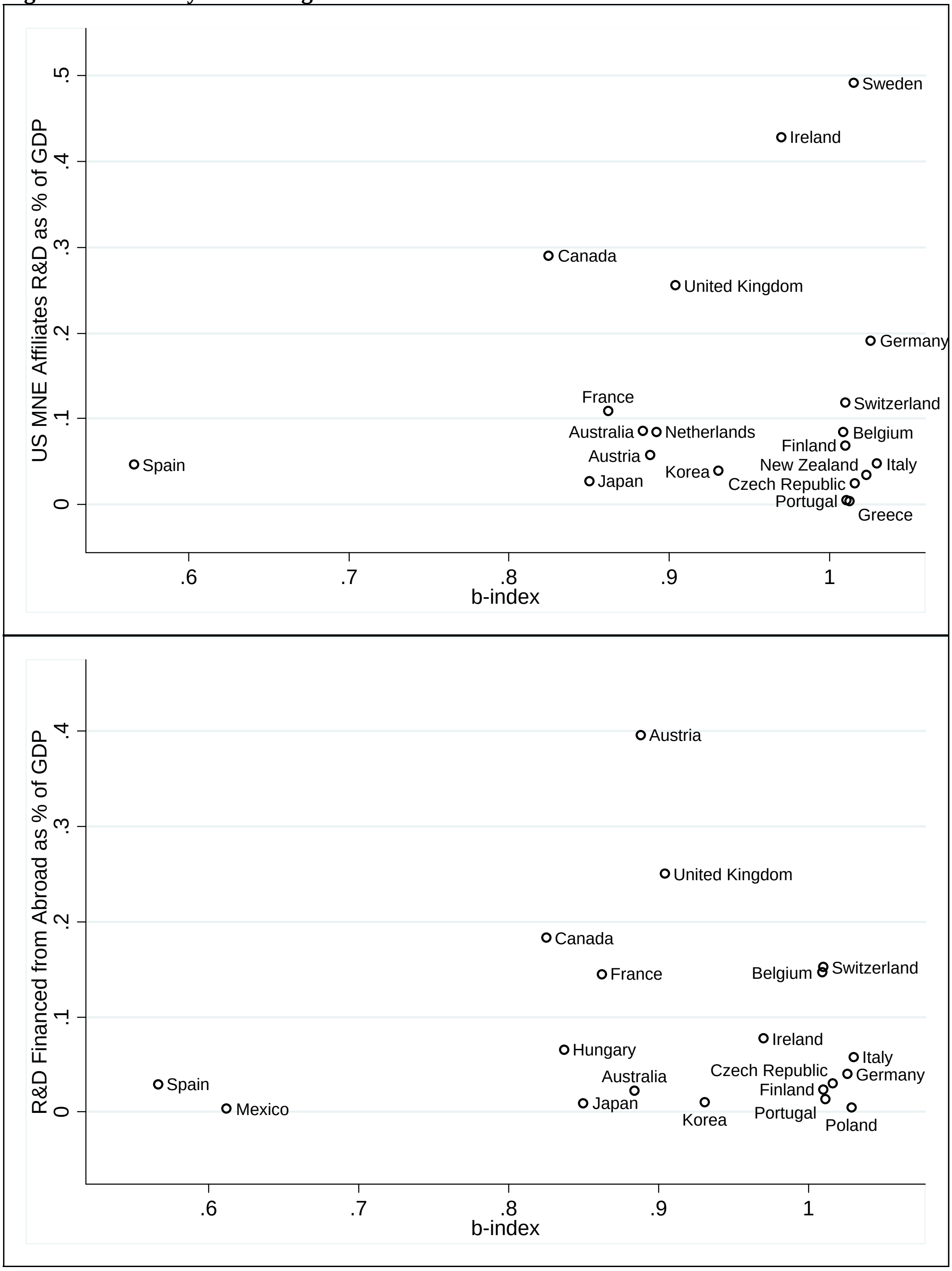
This section examines the bivariate relationship between tax price and measures of R&D investment from abroad in order to set the scene for interpretation of the results of the multivariate regression analysis. Figure 3 depicts b-index (tax price) against the three measures of foreign R&D investment for a sample of countries which were chosen for illustrative purposes. as they have higher than average data availability. Both foreign financed R&D and R&D expenditure by majority owned affiliates of US MNEs follow an upward trend and exhibit substantial variation over time. There is no obvious relationship between either measure of foreign R&D and the tax price (b-index).

Figure 3 Foreign R&D investment and Tax Policy 1982-2005 Australia and Canada



The cross sectional distribution of each measure of foreign R&D against national b-index in 2004 is depicted in Figure 4. The upper panel shows the R&D investment by affiliates of US MNEs expressed as a fraction of host country GDP. The generosity of the R&D tax policy in Spain shows it to be somewhat of an outlier at that time. The lower panel depicts the b-index against R&D financed from abroad expressed as a percentage of host country GDP. Figure 4 shows that there is no clear relationship between tax policy and foreign R&D. Several countries with relatively generous tax policy such as Spain, Mexico and Japan exhibit low foreign R&D intensity. Conversely countries like Sweden and Germany that have less generous tax treatment of R&D have attracted substantial foreign R&D.

Figure 4 Tax Policy and Foreign R&D 2004



5. Results for Model 1: R&D Expenditure by US MNE Affiliates

Table 4 presents the regression results for model 1, considering the determinants of R&D investment by affiliates of US MNEs in the manufacturing sector. Column (I) presents random effects (RE) estimates and column (II) presents fixed effects (FE) estimates. These exhibit some important differences. Using RE, the coefficient on tax price is positive and significant which is contrary to theoretical expectations. As already noted, there is substantial reason to believe a range of unobserved time invariant effects, including cultural, linguistic and geographic factors, may result in omitted variable bias. The FE estimates, presented in column (II), control for unobserved time invariant heterogeneity. According to the Hausman test, the difference between the FE and RE estimates is statistically significant at 1% and as such the fixed effects estimates are preferred.

The results in column (II) suggest variables associated with asset exploiting R&D are important determinants of MNE R&D investment. The coefficient on aggregate MNE affiliate plant and equipment stock is positive and significant. The magnitude of this coefficient suggests that doubling of total MNE capital stock in a host country is associated with a 49% increase in R&D. Similarly, the results suggest R&D investment increases as affiliate total sales increase. Ceteris paribus, an increase in affiliate sales is reflected in an 80% increase in R&D investment. These results also suggest that the more export oriented an MNE affiliate sales are, the more R&D the firm is likely to undertake which is consistent with recent evidence (Athukorala and Kohpaiboon 2006).

Turning now to factors associated with asset augmenting, or knowledge seeking, R&D the results find no evidence that these are important determinants of R&D investment by US MNEs. R&D undertaken by the higher education sector, the proxy for availability of high level human capital, is not significant. Rates of publications in science and engineering journals are also not found to be significant.

The strength of national intellectual property rights is positive and significant at the 10% level. The coefficient on the index suggests an increase of one point on Park's (1997) IPR scale is associated with a 27% increase in R&D. It is not simple to interpret the quantitative effect of this ordinal IPR index. Some sense of scale can be garnered by noting that an increase of this magnitude is roughly commensurate with the IPR reform in Australia in 1995 which increased patent duration from 16 to 25 years. Based on this, it might be argued that the size of the coefficient is implausibly high.

Neither of the measures associated with cost of R&D is found to be significant. Labour compensation rate is not found to be significant. Importantly, the measure of tax policy, the b-index, is found to have no explanatory power of the amount of R&D undertaken by affiliates of US MNEs in manufacturing.

Table 4 Regression Results R&D performed by Affiliates of US MNEs

	(I) RE	(II) FE	(III) FE	(IV) GMM
$RDUS_{t-1}$			0.533***	0.487***
			(0.085)	(0.19)
B_{t-1}	1.098***	1.616	0.903	0.780
	(0.29)	(0.99)	(0.70)	(0.49)
LC_{t-1}	0.0885	-0.477	-0.252	-0.335
	(0.19)	(0.35)	(0.32)	(0.28)
GDP_{t-1}	-0.542***	0.142	-0.0182	0.249
	(0.14)	(0.63)	(0.47)	(0.63)
$HERD_{t-1}$	0.780***	-0.00346	-0.0341	-0.101
	(0.21)	(0.27)	(0.22)	(0.24)
SJA_{t-1}	0.209	0.208	0.0653	0.119
	(0.18)	(0.25)	(0.15)	(0.18)
IPR_{t-1}	0.0832	0.270*	-0.00281	0.111
	(0.12)	(0.15)	(0.14)	(0.20)
EO_{t-1}	0.165***	0.583***	0.413***	0.447***
	(0.052)	(0.16)	(0.15)	(0.17)
PE_{t-1}	0.488***	0.487**	0.217	0.193
	(0.15)	(0.20)	(0.18)	(0.22)
$SALES_{t-1}$	0.425***	0.784***	0.376**	0.403*
	(0.16)	(0.16)	(0.17)	(0.21)
Observations	264	264	243	207
Countries	22	22	22	21
Rho		0.80	0.74	
m1, m2, S				0.0; 0.45; 0.36

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables are in logs and estimates include time dummies

Columns (III) and (IV) present estimates of a dynamic version of the model including a single lagged depended variable. The dynamic model tells a reasonably consistent story with the static version. Column (III) presents FE estimates. With lagged R&D investment included as an explanatory variable only total sales and export orientation remain significant. Applied to a dynamic model such as this, fixed effects estimates may suffer Nickel (1981) bias resulting from the correlation between the LDV and the transformed error term. Differenced GMM estimates are reported in Column (IV). To maximise the data available for the estimation the forward orthogonal deviations transformation rather than first differencing is applied as suggested by Roodman (2006).[11] The results pass the usual tests regarding over identifying restrictions and the requirement of no second order serial correlation. The GMM estimates generally conform to the estimates under FE, again suggesting export orientation and total sales are key determinants of R&D investment by MNE affiliates.

It was noted previously that large changes in tax price because of major policy reform are very rare and can dominate results. For a further robustness check, the model was re-estimated omitting such observations. This was not found to change the result. The results were tested for omitting the countries that are identified as offering the possibility of tax holidays (France, Korea, and Switzerland) and were found to be qualitatively unchanged.

On balance, the FE results presented in column (II) are preferred. The fixed effects estimator is well justified economically and the resulting estimates of the coefficients conform well to existing priors. It is reassuring that the alternate estimators above are suggestive of a reasonably consistent story, which is to highlight the central role of the asset exploiting motive as a determinant of R&D investment by MNEs.

6. Results for Model 2: R&D financed from Abroad

This section considers the results for model 2, which aims to explore the determinants of R&D financed from abroad. Results are presented in Table 5. RE and FE estimates are presented in columns (I) and (II), respectively. As in the case of R&D by MNEs, FE and RE estimates differ considerably therefore on both a priori economic and statistical grounds the FE estimates are preferred.

Perhaps more importantly, both FE and RE estimates reflect an anomalous coefficient on total labour compensation rate; the proxy which aims to capturing time series variation in R&D labour cost. Both sets of estimates find this to be large and positive which is contrary to the theoretical prediction that firms will contract R&D to host countries with the lowest labour costs. There are a number of possible explanations for this unexpected result. For example, it may reflect an ‘efficiency wage’ effect. That is, average labour compensation is serving as a proxy for skill mix or the productivity of workers rather than the costs of equivalent R&D labour.

[11] The orthogonal transformation involves purging the fixed effects by subtracting the average of all available future observations rather than first differencing (Roodman 2006). Additionally, to reduce the instrument count the collapse option on xtabond2 command is applied. Described in Roodman (2006)

While this interpretation seems plausible, it is prudent to consider the model without labour compensation rate which is generating the counterintuitive sign. The preferred FE estimates omit labour compensation and are reported in column (III).

Table 5 Determinants of Foreign Financed R&D

	(I) (RE)	(II) FE	(III) FE
B_{t-1}	1.276***	-0.152	-0.0515
	(0.43)	(0.48)	(0.47)
LC_{t-1}	1.186***	0.541*	
	(0.25)	(0.29)	
GDP_{t-1}	-0.0952	-0.190	0.487
	(0.32)	(1.01)	(0.73)
$HERD_{t-1}$	-0.109	0.315	0.637***
	(0.23)	(0.24)	(0.23)
SJA_{t-1}	0.937***	0.158	-0.316
	(0.19)	(0.26)	(0.26)
IPR_{t-1}	-0.0864	0.0459	-0.0217
	(0.12)	(0.17)	(0.17)
PK_{t-1}	0.619***	0.449***	0.488***
	(0.055)	(0.088)	(0.074)
$MANUF_{t-1}$	-0.00398	0.731	-0.269
	(0.28)	(0.50)	(0.45)
Observations	353	353	407
Number of cn	22	22	25
Rho	.	0.71	0.67

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables are in logs and estimates include time dummies

Host country market size is not found to be statistically significant. Foreign owned capital stock is the most important determinant of R&D financed from abroad. This suggests that cross-border R&D contracting is in fact strongly associated with the globalisation of production. The coefficient on existing capital stock is 0.35, about 14% lower than in the case of R&D undertaken by US MNEs (c.f. the coefficient on affiliate fixed capital stock in column (II) of Table 4). This substantial difference means cross-border R&D contracting does not increase as rapidly as R&D by MNE affiliates as the capital stock of foreign firms in a host country increases.

In the preferred estimates, HERD is found to have a positive effect on R&D financed from abroad which is significant at the 10% level. The coefficient suggests increasing HERD by 10% can be anticipated to drive a 6% increase in R&D financed from abroad holding everything else constant. This is important as HERD is generally under the control of government and hence represents a policy option for attracting foreign R&D.

Given the conjecture that cross-border R&D contracts are driven primarily by cost and technology seeking incentives, it is perhaps surprising that journal article publication rate, which reflects technological capacity and opportunities for knowledge seeking R&D, is found to be insignificant in the fixed effects estimates. It is premature to draw strong conclusions but this could reflect that R&D undertaken abroad under contract is not 'cutting edge' core research, but rather reflects more 'routine' product development activities.

Industrial composition and intellectual property rights are not found to be significant. The impotency of host country IPR regime may reflect that firms do not contract out R&D that constitute critical ownership advantages. Alternatively, it may simply be that, across the OECD countries considered in this sample, differences in IPR are not sufficient to influence firm behaviour. As in the case of R&D undertaken by affiliates of US MNEs, tax price is not found to be a significant determinant of cross-border R&D contracting. That is, the results provide no evidence that tax incentives are effective in attracting additional R&D financed from abroad.

Robustness Checking

Additional estimates performed for the purpose of robustness checking. These include estimating a dynamic model and considering the alternative measure of b-index that does not include the tax incentives offered in Australia and Portugal (see section 4.1). As discussed previously, it is widely conjectured that an advantage of contract R&D is reflexivity and responsiveness. On the other hand, parent-affiliates relationships are thought to constitute a substantial share of R&D financed from abroad and these may represent more persistent relationships. For completeness, FE estimates of a simple dynamic model with a single LDV are presented in column IV. The results do not contradict the previous findings. HERD and existing FDI stock remain significant in the dynamic fixed effects estimates. Central to the research question considered in this thesis, tax policy as measured by the b-index is not found to be significant at conventional levels. Estimates using the alternative measure of b-index of the static and dynamic version of the model are included in columns (II) and (III), respectively. These are also entirely consistent with those reported previously.

Table 6 Additional Robustness Checking for R&D Financed from Abroad

	(I) FE	(II) LSDV	(III) FE
$RDFABR_{t-1}$	0.546***		0.544***
	(0.12)		(0.12)
B_{t-1}	0.0454		
	(0.39)		
BFC		-0.507	-0.210
		(0.72)	(0.58)
GDP_{t-1}	0.827	0.384	0.781
	(0.85)	(0.74)	(0.87)
$HERD_{t-1}$	0.523*	0.651***	0.526*
	(0.30)	(0.23)	(0.30)
SJA_{t-1}	-0.266	-0.331	-0.284
	(0.28)	(0.23)	(0.25)
IPR_{t-1}	-0.225	-0.0208	-0.219
	(0.15)	(0.16)	(0.15)
PK_{t-1}	0.272***	0.496***	0.277***
	(0.091)	(0.075)	(0.090)
$MANUF_{t-1}$	-0.428	-0.217	-0.398
	(0.51)	(0.46)	(0.53)
Observations	340	407	340
Number of cn	23	25	23
Rho	0.68	0.78	0.67

Robust Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

All variables are in logs and estimates include time dummies

7. Conclusion

In most of the OECD countries considered here foreign firms are responsible for a large and growing share of all R&D activities. This paper has investigated the determinants on foreign R&D investment with an emphasis on the efficacy of R&D tax policy. The empirical analysis is based on a panel of 25 countries over a period of up to 25 years and it considered two overlapping measures of foreign R&D activity. One is R&D undertaken by affiliates of US MNEs and the other is R&D financed from abroad.

It is generally considered that MNEs will tend to concentrate R&D functions in the home base, reflecting a desire to maintain control of commercial advantages embodied in technological assets. However, for a range of reasons, MNE affiliates undertake some R&D in host countries. Traditionally, it has been considered that affiliates undertake R&D in order to support host country production and adapt products to local markets. It has also been argued that MNEs are increasingly engaging in technology seeking R&D. This involves MNEs tasking affiliates to develop technology for application outside the host country, and potentially around the world. This type of R&D is focused on acquiring the best technology at the lowest cost.

MNEs contracting affiliates to undertake R&D on their behalf represent a subset of all foreign financed R&D. Cross-border R&D contracting to unaffiliated firms is a special case of the general phenomenon of R&D outsourcing. Such R&D outsourcing is though to be driven by the need to access outside expertise and advantages relating to speed and flexibility. Outsourcing R&D to foreign firms may have the added advantage of cost savings achieved by arbitraging between locations, particularly where a contracted firm is located in a country with relatively low costs and an abundant supply of highly skilled researchers.

To formally assess the determinants of foreign R&D activity two overlapping measures were considered: R&D undertaken by affiliates of US MNEs and R&D financed from abroad. Two encompassing models were estimated, one for each measure of globalisation of R&D. Each draws on the same fundamental framework incorporating two broad groups of explanatory variables. The first group relate to host country attributes and these include cost considerations and domestic technological capacity. Estimates employ a measure of tax price of R&D which is a more descriptive measure than has been applied in previous studies. The second important group of control variables relate to the attributes of the investing firms aggregated to the host country level. For example, foreign owned production and distribution assets are thought to reflect the need for adaptive R&D.

In the case of R&D undertaken by MNE affiliates, most R&D is undertaken to support operations within the host country. It is not surprising then that attributes of the affiliate were found to be key determinants of R&D expenditure by US MNEs. The plant and equipment capital stock and total sales of affiliates were both found to be strong determinants of R&D performed by affiliates of US MNEs. Controlling for these factors, host country attributes seemed to be less important, only intellectual property rights were found to be significant, and then only weakly so.

Foreign owned fixed capital stock is also a significant predictor of cross-border R&D contracts. This may reflect that a substantial portion of cross-border contracts are between affiliates and parents. This is contrary to the suggestion that cross-border contracting is driven by the need to outsource R&D functions to achieve greater responsiveness and flexibility. In the case of foreign financed R&D the preferred estimates suggest the availability of graduates with research based degrees is also an important determinant. This is consistent with the prediction that contract R&D will be focused on technological acquisition.

The principal result is that no evidence was found to support the hypothesis that tax incentives are effective in either inducing MNEs affiliates to undertake additional R&D or to encourage additional international R&D contracts. It may be that the intended subsidies provided by the R&D tax policy are ‘washed out’ in the broader treatment of international transfers of capital and profits. Alternatively, it may be that other factors are dominant in driving cross boarder R&D investment decisions. For example, once firms take into account the supply of workers with research degrees, as well as existing fixed capital assets and the degree to which they are ‘embedded’ in the country, any potential small cost saving available through the tax system is insignificant.

Appendix A Tax Policy Data and Variable Construction

There are a range of implicit and explicit incentives provided by the tax system of different countries. The b-index, introduced in the body of this paper, provides a consistent means of comparing generosity between policy designs. The b-index is given by $B = \frac{1-A}{1-\tau}$ where A is the NPV of the reduction of tax liabilities arising from investment in R&D, τ is the corporate tax rate. Aspects of policy design that are incorporated into the measure employed in this paper include:

- Tax credits - incentives given as reduced corporate tax liabilities.
- Enhanced/augmented deductions - deductions of a multiple (greater than one) of all eligible R&D expenditure from taxable income. Note that the value of deductions will change in response to change in corporate income tax rate.
- Incremental incentives, which are available on expenditure above some defined base. To calculate the vale of these to a representative firm, the standard assumption that firms make a constant real expenditure; or more specifically "a constant R&D – sales ratio in the presence of constant real sales" (McFetridge and Warda 1983 p.32).
- Different treatment of current and capital expenditures. The standard assumption is followed that representative R&D investment is comprised of 90% current expenditure two thirds of which represents the wages of researchers; 5% machinery and equipment and 5% buildings and structures (B&S).

Various years of a b-index for domestic firms have been prepared by the OECD (see in particular OECD 2006 p.242). Unpublished OECD data are also cited in a few recent studies (Guellec and Pottelsberghe 2003; Falk 2006). For this paper, an audit of national tax policies for 25 countries between 1980 and 2005 was undertaken from a wide range of sources. This this was important to consider any special treatment for foreign firms, it also enabled an expanded series to be calculated based on consistent methodology and assumptions. Sources include McFetridge and Warda (1983) OECD (1996; 2000b; 2002b; 2005a), Warda (1996a; 1996b; 1999; 2001; 2003; 2006), ETAN (1999a; 1999b), IBFD (2004; 2007), WTD (2007), OECD (2007b), KPMG (2007) Full details about tax treatment of R&D in each host country can be found in Thomson (2009). The calculated values are summarised in Tables 7 and 8 below.

Table 7 B-index for OECD Countries 1980-2006

yr	*AUS*	*AUT*	*BEL*	*CAN*	*CHE*	*CZE*	*DNK*	*ESP*	*FIN*	*FRA*	*GBR*	*GER*	*GRC*
1980	1.01	0.95	0.98	0.83	1.01	.	1.00	0.86	1.02	1.03	1.00	1.07	1.02
1981	1.01	0.95	1.02	0.83	1.01	.	1.00	0.86	1.02	1.03	1.00	1.07	1.02
1982	1.01	0.95	1.02	0.83	1.01	.	1.00	0.86	1.02	1.03	1.00	1.07	1.02
1983	1.01	0.95	1.02	0.81	1.01	.	1.00	0.86	0.93	0.98	1.00	1.07	1.02
1984	1.01	0.99	1.02	0.81	1.01	.	1.00	0.75	0.93	0.98	1.00	1.07	1.02
1985	0.59	0.99	1.02	0.81	1.01	.	1.00	0.75	0.93	0.93	1.00	1.07	1.02
1986	0.59	0.99	1.02	0.81	1.01	.	1.00	0.75	0.95	0.93	1.00	1.07	1.02
1987	0.59	0.99	1.02	0.81	1.01	.	1.00	0.75	0.95	0.95	1.00	1.07	1.02
1988	0.59	0.99	1.02	0.83	1.01	.	1.00	0.75	1.01	0.95	1.00	1.07	1.02
1989	0.72	1.00	1.02	0.83	1.01	.	1.00	0.75	1.01	0.94	1.00	1.07	1.02
1990	0.72	1.00	1.01	0.83	1.01	.	1.00	0.75	1.01	0.91	1.00	1.06	1.02
1991	0.72	1.00	1.01	0.83	1.01	.	1.00	0.75	1.01	0.92	1.00	1.06	1.02
1992	0.72	0.94	1.01	0.83	1.01	1.03	1.00	0.72	1.01	0.92	1.00	1.06	1.02
1993	0.72	0.94	1.01	0.83	1.01	1.03	1.00	0.72	1.01	0.92	1.00	1.06	1.01
1994	0.79	0.93	1.01	0.83	1.01	1.03	1.00	0.72	1.01	0.92	1.00	1.05	1.01
1995	0.79	0.93	1.01	0.83	1.01	1.03	1.00	0.72	1.01	0.92	1.00	1.06	1.01
1996	0.89	0.93	1.01	0.83	1.01	1.03	1.00	0.68	1.01	0.92	1.00	1.06	1.01
1997	0.89	0.93	1.01	0.83	1.01	1.03	1.00	0.69	1.01	0.92	1.00	1.06	1.01
1998	0.89	0.93	1.01	0.83	1.01	1.02	1.02	0.69	1.01	0.92	1.00	1.06	1.01
1999	0.89	0.93	1.01	0.83	1.01	1.02	1.02	0.69	1.01	0.92	1.00	1.05	1.01
2000	0.90	0.89	1.01	0.83	1.01	1.02	1.02	0.69	1.01	0.92	1.00	1.05	1.01
2001	0.88	0.89	1.01	0.83	1.01	1.02	1.02	0.57	1.01	0.92	0.90	1.03	1.01
2002	0.88	0.89	1.01	0.83	1.01	1.02	1.02	0.57	1.01	0.92	0.90	1.03	1.01
2003	0.88	0.89	1.01	0.83	1.01	1.02	1.02	0.57	1.01	0.92	0.90	1.03	1.01
2004	0.88	0.89	1.01	0.83	1.01	1.02	1.02	0.57	1.01	0.86	0.90	1.03	1.01
2005	0.88	0.92	1.01	0.83	1.01	0.70	1.01	0.57	1.01	0.86	0.90	1.03	1.01
2006	0.88	0.92	1.01	0.83	1.01	0.73	1.01	0.57	1.01	0.80	0.90	1.03	1.01

Table 8 B-index for OECD Countries 1980-2006

yr	HUN	IRL	ITA	JPN	KOR	MEX	NLD	NOR	NZL	POL	PRT	SWE	USA
1980	.	1.00	1.03	1.02	1.02	1.02	1.04	1.05	1.04	.	1.01	0.95	1.03
1981	.	1.00	1.03	1.03	1.02	0.97	1.04	1.05	1.04	.	1.01	0.95	0.96
1982	.	1.00	1.03	1.03	1.02	0.97	1.04	1.05	1.04	.	1.02	0.97	0.96
1983	.	1.00	1.04	1.03	1.02	1.02	1.04	1.05	1.04	.	1.02	0.97	0.96
1984	.	1.00	1.04	1.03	1.02	1.02	1.03	1.05	1.04	.	1.02	1.02	0.96
1985	.	1.00	1.04	1.03	1.02	1.02	1.03	1.05	1.04	.	1.02	1.04	0.96
1986	.	1.00	1.04	1.03	1.02	1.02	1.03	1.05	1.04	.	1.02	1.04	0.97
1987	.	1.00	1.04	1.03	1.02	1.02	1.03	1.05	1.04	.	1.02	1.04	0.98
1988	.	1.00	1.04	1.03	0.91	1.02	1.03	1.05	1.04	.	1.02	1.04	0.98
1989	.	1.00	1.04	1.02	0.91	1.02	1.02	1.05	1.02	.	1.02	1.04	0.99
1990	1.03	1.00	1.04	1.02	0.91	1.02	1.02	1.05	1.02	.	1.02	1.03	0.99
1991	1.03	1.00	1.05	1.02	0.91	1.02	1.02	1.05	1.02	1.08	1.02	1.02	0.99
1992	1.03	1.00	1.05	1.02	0.91	1.02	1.02	1.02	1.02	1.08	1.02	1.02	0.99
1993	1.03	1.00	1.06	1.02	0.91	1.02	1.02	1.02	1.02	1.08	1.02	1.02	0.99
1994	1.02	1.00	1.06	1.02	0.91	1.02	0.91	1.02	1.02	1.08	1.02	1.02	0.99
1995	1.01	1.00	1.06	1.02	0.91	1.02	0.91	1.02	1.02	1.08	1.02	1.02	1.02
1996	1.01	0.97	1.06	1.02	0.91	1.02	0.90	1.02	1.02	1.08	1.02	1.02	0.99
1997	0.97	0.97	1.06	1.02	0.91	0.97	0.90	1.02	1.02	1.08	0.85	1.02	0.99
1998	0.97	0.97	1.04	1.02	0.91	0.97	0.91	1.02	1.02	1.07	0.85	1.02	0.99
1999	0.97	1.00	1.04	1.00	0.91	0.97	0.91	1.02	1.02	1.06	0.86	1.02	0.99
2000	0.81	1.00	1.04	1.00	0.91	0.97	0.91	1.02	1.02	1.05	0.86	1.02	0.99
2001	0.81	1.00	1.03	1.00	0.91	0.97	0.91	1.02	1.02	1.05	0.70	1.02	0.99
2002	0.81	1.00	1.03	1.00	0.91	0.97	0.90	0.79	1.02	1.05	0.71	1.02	0.99
2003	0.81	1.00	1.03	1.00	0.93	0.61	0.90	0.79	1.02	1.05	0.71	1.02	0.99
2004	0.84	0.97	1.03	0.85	0.93	0.61	0.89	0.79	1.02	1.03	1.01	1.02	0.99
2005	0.84	0.95	1.03	0.85	0.93	0.63	0.90	0.79	1.02	0.98	0.72	1.02	0.99
2006	0.84	0.94	1.03	0.85	0.93	0.63	0.90	0.79	1.02	0.98	0.72	1.02	0.99

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