Tax policy for innovation

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Introduction – some questions

• How does taxation affect innovation?
• Why are there special tax incentives for innovative activity?
• How should R&D tax credits be designed?
• Are patent boxes a good way to spur innovation?
• Do countries provide enough resources to support private R&D?
• Should there be coordination across countries?
Taxation and innovation

• Two broad topics
  – Via personal and corporate taxes imposed for other purposes, see Akcigit et al. (2018)
    • Measure incentive effects using cross-state data, negative and stronger for corporate inventors
    • Show that international inventor migration depends strongly on effective tax rates, especially for corporate inventors and those where local research weak
  – Direct tax subsidies – topic of this talk
Rationale(s) for innovation support

• Innovative activity generates unpriced spillovers to other firms and to the overall economy
  – Some of these may be local to a region or economy

• Resources for innovation may be undersupplied because of
  – (relative) ease of imitation
  – risk and uncertainty that cannot be diversified away or insured against
  – high cost of financing (esp. for SMEs)
  – related to the production of public goods (health, environment, defense, etc.)
What comprises innovative activity?

• R&D
  – Research – basic and applied
  – Development (sometimes modified by “experimental”)
• Purchase of external IP (patents, knowhow, etc.)
• Purchase, installation, and use of new (technologically advanced) equipment
• Training of employees in new processes, or in supporting new products
• Marketing new goods and services
• Costs of organizational innovation

The extent of potential spillovers varies across the type of spending, as does appropriability via IP protection or other means
Possible remedies

• Property rights (IPRs)
  – at the cost of restricted output; cumulative invention
  – under TRIPS, less variation across countries possible
• Subsidies
  – often targeted to particular type of firm or project
  – high administrative costs
• Tax credits of various kinds
  – firm chooses projects
  – some audit costs
• Direct government spending
  – Especially for R&D towards public goods
Corporate tax and innovation

• R&D tax credit – widely used
  – Sometimes targeted towards basic research - university cooperation, use of PROs, etc.

• Investment tax credits; accelerated depreciation
  – Reducing the cost of acquiring new equipment and IT

• Various IP “boxes”
  – Reduced corporate tax rates on income from IP (patents, design rights, copyright, trademarks, etc.)

• Relative treatment of debt vs equity finance.
  – If debt favored, cost of intangible non-securable finance relatively more expensive
(Innovation) tax policy design

• Some issues in design
  – Is the policy instrument visible to the firm’s decision-makers?
  – Does the time horizon of benefits match that of investment?
    • Does it reduce cost or increase profits in the near term, when they may have losses?
    • Is the system stable enough to allow forward planning?
  – Does it target activities with spillovers?
  – Is it comparatively easy to audit?
R&D tax incentives & IP boxes

• R&D tax incentives
  – Reduces cost of R&D input
  – Does not cover other innovation inputs

• IP boxes
  – Reduced tax rate on income from intellectual property (patents, copyrights, designs, etc.)
  – Broader coverage, but rewards more appropriable innovation
Which countries have R&D tax relief?

• 2000: 16 OECD countries.
• 2017: 30 out of 35 OECD countries
  – Also Brazil, China, and the Russian Federation
• Average decrease in B-index relative to neutral treatment of R&D cost between 2000-2017
  – Profit-making SME - 0.06 to 0.17
  – Loss-making SME - 0.04 to 0.15
  – Profit-making large firm - 0.04 to 0.14
  – Loss-making large firm - 0.03 to 0.12

(Warda and Lester 2018)
Which countries have R&D tax relief?

Source: OECD

Tax relief & social charge reduction  Tax relief only
Which countries have IP boxes?

Mostly European (+ Japan):

Belgium  Luxembourg
Cyprus    Malta
France    Netherlands
Greece    Portugal
Hungary   Slovakia
Iceland   Spain
Ireland   Switzerland
Italy     Turkey
Liechtenstein  UK

Countries with a patent box in 2016

[Map showing countries with patent boxes in blue and no patent boxes in light blue]
Tax incentive share of government R&D support

G-7 countries in red

Source: OECD STI Scoreboard 2017
R&D tax incentive design

• Incremental schemes can be cheaper but more difficult to design and administer
  – Avoid basing on recent firm R&D spending
• If targeted, should be towards larger spillovers or credit constraints:
  – Collaboration with universities or non-profit research institutions
  – Small or new firms
• Loss carry-forwards, especially for new firms
• Why use a ceiling?
• Alternative form – reduced social charges on S&E employment for R&D
  – Avoids carry-forward problem, an immediate subsidy
Incremental tax credits

- Currently used by
  - Czech Republic, (Ireland), Italy, Portugal, Spain
  - Mexico, Korea, Japan, USA
- Rate is generally higher than level tax credit
- Good idea in principle, but problem determining increment when firms are heterogeneous
Special tax credits for SMEs

• Currently used by
  – Level: Australia, Canada, Norway
  – Incremental: Japan, Korea
  – Payroll-based: Poland, UK
  – Startups or young firms: Belgium, France, Netherlands, Portugal, Spain

• Difference between large and SME subsidy rate varies from 20% in UK to 1% in France

Source: Warda and Lester 2018
R&D tax credit evaluation

• Does it increase business R&D as intended?
  – Well studied – generally yes
• Do private rates of return fall? - as they should, theoretically
  – Not studied as much, and sometimes misinterpreted
• Do spillovers to other firms increase?
  – Not much studied at all
Evidence on R&D tax credits

• Hall and Van Reenen (2000) – cross-country survey finds credits are effective
  – Estimated price elasticity about one or even higher
  – Increased R&D spending by the amount of lost tax revenue (on the margin)

• Recent research generally confirms above results
  – Chang (2018) – IV estimates using US state data give high elasticities of 2.8-3.8
  – Mairesse-Mulkay (2012) for France – 2008 reform, elasticity of 0.4, higher in their newer work
  – Dechezlepretre et al. (2016) for UK – RD study obtains elasticity of 2.6 (SMEs, financially constrained)
  – Acconcia & Cantabene (2017) – Italian R&D tax credit 2009 - higher response if firm has cash available; elasticity 0.8
What about spillover benefits?

- **Balsmeier et al. 2018** - California credit introduced in 1987
  
  - Large private returns from exploitation of current firm technologies and not from entry into new markets.

  - Competitors’ market value reactions positive overall but negative when firms close in technology space; increased patent blocking

  - Inventors more likely to cite patents from California firms following the credit - greater knowledge spillovers?
R&D tax incentives & patent boxes

• Is the widespread adoption of patent boxes a good development to spur innovation?
  my answer: NO!

• Why are R&D tax credits preferred?
  – Directly related to cost and location of activity (firm decisions)
  – No incentives to transfer patents to low tax jurisdictions
  – No tax subsidy for patent trolling
  – No incentive to keep zombie patents alive to reduce taxes
  – Patent boxes target the most appropriable part of innovation
  – Much higher audit cost for patent box income; depending on box design,
    • Relative size of non-R&E budget can affect credit
    • Incentive to choose projects with high non-R&E expenses
Gaessler, Hall, & Harhoff 2018

• Our questions:
  – Do patent boxes induce transfers of patent ownership to lower tax countries?
    • How is this affected by features of the patent box and other tax regulations?
  – Do patent boxes increase patentable invention in a country?
Details on patent box incentives

• Variations in IP covered (sometimes even informal IP)
• Variations in treatment of income and expense
  – Gross income in some countries, rather than net
  – Recapture of past R&D expense deductions in some cases
• Use affected by CFC rules (home country taxes income received in low tax country at domestic rate)
  – However, the ECJ has limited the application of CFC rules within the EEA area.
• In practice, variation in patent box features
  – Use of patent box as a “natural experiment” somewhat imprecise
  – Accounting for the features leaves little variation for identification
• Note: can transfer patent income to low tax jurisdiction even without a patent box (subject to CFC rules)
Summary of evidence on patent boxes

• Do firms transfer patents to patent box countries?
  – Evidence that patent location responds to corporate tax rates even before the boxes
  – Some additional transfer from patent boxes
  – Griffith et al. 2014 - empirical model of patent location and taxes to simulate introduction of a patent box.
    • Attracts patent income, lose large amounts of revenue

• Do patent boxes increase domestic invention?
  – Mixed evidence, mostly no

• Also, some evidence of international spillovers and profit shifting to lower tax areas
Tax variables

Statutory corporate tax rate

Corporate tax rate less patent box rate
Patent transfers around the time of patent box introduction

Years before and after pat box introduction

- EP transfers to pat box countries
- EP transfers within group
Summary of aggregate results

• Seller corporate tax rate remains a strong influence on patent transfer, regardless of the presence of a patent box

• Patent boxes do not seem to encourage transfer to a country unless existing and/or acquired patents are included without a development condition
  – A 10 per cent increase in patent tax advantage associated with 14 per cent increase in transfers in this case
  – Intra-group transfers respond to patent box wedge if there is also a CFC restriction
Patent boxes and invention

• Does the presence of a patent box increase patentable invention in a country?
  – Difficult to see because all countries have an upward trend in patents
  – We estimate regressions for the log (EP filings in a country-year) on the patent box, corporate tax rates, log population, log GDP per capita, log R&D per GDP, country and year dummies.
  – We find a negative impact of the patent box on patented invention.
  – Similar but insignificant results for R&D.
## Patent boxes and invention

<table>
<thead>
<tr>
<th>Dependent variable: Log (EP filings by inventor country and year)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D (patent box)</strong></td>
<td>-0.13 (0.06)*</td>
</tr>
<tr>
<td><strong>Patent box tax wedge</strong></td>
<td>-0.48** (0.24)</td>
</tr>
<tr>
<td><strong>Corporate tax rate</strong></td>
<td>-1.47 (1.09)</td>
</tr>
<tr>
<td><strong>Log population</strong></td>
<td>-0.94 (1.18)</td>
</tr>
<tr>
<td><strong>Log GDP per capita</strong></td>
<td>1.54*** (0.34)</td>
</tr>
<tr>
<td><strong>Log R&amp;D per GDP</strong></td>
<td>0.70*** (0.19)</td>
</tr>
<tr>
<td><strong>Standard error</strong></td>
<td>0.255</td>
</tr>
</tbody>
</table>

555 observations on 37 countries, 2000-2014

All regressions include a complete set of country and year dummies

Standard errors are robust and clustered on country.

Development/existing/acquired patent restrictions are insignificant.
Summary

• Do patent boxes induce transfers of patent ownership to lower tax countries?
  – Transfers respond to seller country corporate tax
  – Also respond to patent boxes, but only if existing/acquired patents without development condition included
  – CFC rules do impact transfer by MNEs

• Do patent boxes increase patentable invention in a country?
  – Controlling for country characteristics, patented invention falls!
  – Controlling for country characteristics, R&D does not change

• Are more valuable patents transferred internationally?
  – Yes, as expected.
Do countries provide enough support for R&D?

• Much evidence that social returns are much higher than private (Kao et al 1999, Keller 1998, Coe and Helpman 1995). Some nuances:
  – Domestic spillovers larger than those from other countries (Branstetter 2001, Peri 2004)
  – Spillovers from foreign R&D more important for smaller open economies than for US, Japan, and Germany (Park 1995, van Pottelsberghe 1997)
  – Absorptive capacity of recipient country important for making use of R&D spillovers (Guellec and van Pottelsberghe 2001)
  – Typical social rates of return are quite large, but imprecise

• Jones and Williams (1998) – using endogenous growth model, argue that socially optimal R&D investment 2-4 times actual in US
International coordination

• Should these policies be better coordinated between countries?
  – To exploit cross-border spillovers? **Maybe**
  – To avoid wasteful tax competition? **YES**

• Evidence
  – **Corrado et al. (2016)** find similar results for 10 EU countries, 1995-2007
  – **Wilson (2009)** finds similar, but even larger, results for US states
  – Note that equal and opposite elasticities does not imply zero-sum
Some questions, answered

• How does taxation affect innovation? Mostly negatively
• Why are there special tax incentives for innovative activity? Externalities, financing constraints
• How should R&D tax credits be designed? Carefully
• Are patent boxes a good way to spur innovation? No
• Do countries provide enough resources to support private R&D? Probably not
• Should there be coordination across countries? Yes
For discussion

- Recent EU proposal for a common corporate tax base in Europe - super deduction of 150 percent, to replace patent boxes and existing R&D tax credit schemes
  - Good idea but effectiveness depends on corporate tax rate
  - One caveat: costs of adjustment of supply of S&Es; wage impacts
For discussion

• How much extra growth could countries achieve if they were to expand support for private R&D?
  – Very difficult to answer, especially given the other factors that influence growth
  – Typical numbers for “back of envelope” computation:
    • Elasticity of R&D wrt cost about 1.0
    • Elasticity of output wrt R&D about 0.1
    • => 20% fall in cost => 2% greater output
  – Partial equilibrium, not general
BACKUP SLIDES
Incremental tax credits

\[ \theta = \text{tax credit rate} \quad R = \text{R&D} \]

\[ \pi = \text{current profit} \quad \Pi = \text{PDV of profits} \]

\[ \beta = \text{discount rate} \]

Year \( t \): increase \( R_t \) by \( \Delta R_t \)

Tax credit benefit is \( \Delta \pi_t = \theta \Delta R_t \)

For the next 3 years, this increase is in the base R&D, so there is a cost each year given by \( (\theta/3) \Delta R_t \)

Total (cost) impact of increase in R&D at year \( t \):
Implication of rolling base

\[
\frac{\partial \Delta \Pi_t}{\partial \Delta R_t} = \theta \left[ 1 - \frac{(\beta + \beta^2 + \beta^3)}{3} \right]
\]

Nominal credit rate = 30%

<table>
<thead>
<tr>
<th>Discount rate</th>
<th>Actual credit rate</th>
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<tbody>
<tr>
<td>1.0</td>
<td>0.0</td>
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<tr>
<td>0.95</td>
<td>0.03 = 0.1 * 0.3</td>
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<tr>
<td>0.9</td>
<td>0.057 = 0.19 * 0.3</td>
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</table>
Recent studies on patent boxes

- Most studies on applications, two studies on transfers, none on priority filings and only one on subsequent invention

<table>
<thead>
<tr>
<th>Authors</th>
<th>Years</th>
<th>Level of observation</th>
<th>Dependent variable</th>
<th>Result</th>
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<tbody>
<tr>
<td>Alstadsæter et al. (2015)</td>
<td>2000-2011</td>
<td>Firm-tech-country</td>
<td>Number of EP patent filings by applicant country-tech field</td>
<td>Broader pat box makes affiliate locations more attractive but small negative impact on invention</td>
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<tr>
<td>Bradley et al. (2015)</td>
<td>1990-2012</td>
<td>Country</td>
<td>Inventor pats; owner pats; mismatch</td>
<td>Domestic inventing increases if rate falls; no impact on mismatch</td>
</tr>
<tr>
<td>Bösenberg &amp; Egger (2015)</td>
<td>1996-2012</td>
<td>Country-technology</td>
<td>Number of EP applications and <em>pre-grant</em> transfers by applicant country-tech field</td>
<td>Filings respond to tax rates; more valuable patents transferred.</td>
</tr>
<tr>
<td>Schwab &amp; Todtenhaupt (2016)</td>
<td>2000-2012</td>
<td>MNC affiliate</td>
<td>Worldwide patent grants</td>
<td>Pat box in other countries generates positive spillovers on R&amp;D</td>
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<tr>
<td>Koethenbuerger et al. (2016)</td>
<td>2007-2013</td>
<td>MNC affiliate</td>
<td>Stated profit before tax by subsidiary</td>
<td>Evidence that pat box used for profit shifting</td>
</tr>
</tbody>
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REQUEST FOR REGISTRATION OF A TRANSFER (Rule 20(1), EPC)

Re: European Patent Application No. 99202415.8
Applicant: Koninklijke Philips Electronics N.V.
Assignment to BROADBAND ROYALTY CORPORATION

I, the undersigned, hereby request the registration of the transfer of the above-identified European Patent Application to BROADBAND ROYALTY CORPORATION on the basis of the enclosed instrument of assignment.

The Professional Representative

J.L. van der Veer

November 2018 Schumpeter lecture
## Basic patent box features

<table>
<thead>
<tr>
<th>Country</th>
<th>Years with IP box</th>
<th>R&amp;E tax credit@</th>
<th>Includes existing patents</th>
<th>Includes acquired patents</th>
<th>Corp tax rate (statutory)</th>
<th>IP box rate (statutory)</th>
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<td>Belgium</td>
<td>2007-</td>
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<td>yes%</td>
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<td>yes#</td>
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<td>10</td>
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<td>x</td>
<td>yes</td>
<td>yes%</td>
<td>22</td>
<td>10</td>
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</tbody>
</table>

*# if held for at least 2 years.  % if further developed.*

@Some kind of R&D tax credit (beyond expensing) available during the period.
MPI for Innovation and Competition
Patent Transfers Data 2016

- **Dataset Covers Transfers of European Patents (EP) 1981-2014**
  - 1.2 million registered patent ownership transfers
  - Patents with “change in ownership information” in WIPO, DPMA and EPO data
  - Sector allocation: firms, individuals, universities, non-profit, etc.
  - Distinction between market, M&A and intra-group patent transfers
  - About 12% of these transfer are cross-country
  - For further info, see Gaessler and Harhoff (2016)


<table>
<thead>
<tr>
<th>Code</th>
<th>Country</th>
<th>Year patent box introduced</th>
<th>Patents transferred out</th>
<th>Patents transferred in</th>
<th>Difference in patents transfers</th>
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<tbody>
<tr>
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<td>6049</td>
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<td>219</td>
<td>61</td>
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<td>CY</td>
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<td>Sweden</td>
<td>2007</td>
<td>861</td>
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</tr>
</tbody>
</table>

- generally positive balance for countries with patent boxes
- exception: UK
# Patent Transfer in and out Flows – Rest of World and Tax Havens (2000-2014)

<table>
<thead>
<tr>
<th>Code</th>
<th>Country</th>
<th>Tax haven</th>
<th>Patents transferred out</th>
<th>Patents transferred in</th>
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<tbody>
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<td>211</td>
<td>269</td>
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<td>GI</td>
<td>Gibraltar</td>
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<td>Hong Kong</td>
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<td>Israel</td>
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<td>643</td>
<td>-228</td>
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<td>IM</td>
<td>Isle of Man</td>
<td>yes</td>
<td>105</td>
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<td>JE</td>
<td>Jersey</td>
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<td>KR</td>
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<td></td>
<td>528</td>
<td>809</td>
<td>281</td>
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<td>KY</td>
<td>Cayman Islands</td>
<td>yes</td>
<td>500</td>
<td>1507</td>
<td>1007</td>
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<tr>
<td>MC</td>
<td>Monaco</td>
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<td>MX</td>
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<td>New Zealand</td>
<td></td>
<td>161</td>
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<td>SG</td>
<td>Singapore</td>
<td>yes</td>
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<td>1354</td>
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<td>US</td>
<td>US</td>
<td></td>
<td>23520</td>
<td>20293</td>
<td>-3227</td>
</tr>
</tbody>
</table>

- generally negative balance for large countries (US, JP, CA, AU)
- generally positive balance for tax havens
Model for aggregate patent transfers

• # patents transferred from “seller” country S to “buyer” country B

\[
E(\#\text{transfers}_{S \rightarrow B} \mid S, B, t, \text{tax}) = \alpha_S + \beta_B + \lambda_t + f(\text{tax}_{St}, \text{tax}_{Bt})
\]

where \( t = \) calendar time.

• Tax variables:
  • Statutory corporate tax rates in \( B \) and \( S \)
  • Dummies for patent box or difference between corp tax rate and patent box rate in each country
  • Alternatively: difference in corp tax rates and difference in patent box wedge between countries \( B \) and \( S \).

• Unit of observation: country pairs at time \( t \)

• 37 countries: EU24, NO, IS, CH, US, JP, KR, CA, AU, NZ, CL, MX, TR, IL
• Method of estimation is Poisson with robust standard errors
## Aggregate results – patent transfers

<table>
<thead>
<tr>
<th></th>
<th>All transfers</th>
<th>Within group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># patents transferred from seller to buyer country during the year</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Buyer corp tax rate</strong></td>
<td>0.81 (1.28)</td>
<td></td>
</tr>
<tr>
<td><strong>Buyer patent tax wedge</strong></td>
<td>-0.04 (0.76)</td>
<td></td>
</tr>
<tr>
<td><strong>Seller-buyer corp tax</strong></td>
<td>0.35 (0.90)</td>
<td>-0.31 (0.95)</td>
</tr>
<tr>
<td><strong>Buyer-seller pat tax wedge</strong></td>
<td>1.35** (0.63)</td>
<td>0.33 (0.55)</td>
</tr>
<tr>
<td>*<em>D (dev condition)<em>wedge</em></em></td>
<td>-1.95* (1.03)</td>
<td></td>
</tr>
<tr>
<td><strong>D (CFC rules for buyer)</strong></td>
<td>-0.37** (0.17)</td>
<td>-0.02 (0.27)</td>
</tr>
<tr>
<td>*<em>D (CFC)<em>corp tax diff</em></em></td>
<td>3.31*** (1.13)</td>
<td>1.20 (1.77)</td>
</tr>
<tr>
<td>*<em>D (CFC)<em>wedge diff</em></em></td>
<td>1.27 (1.04)</td>
<td>2.22* (1.26)</td>
</tr>
<tr>
<td><strong>Seller corp tax rate</strong></td>
<td>1.11 (1.03)</td>
<td></td>
</tr>
<tr>
<td><strong>Seller patent tax wedge</strong></td>
<td>-1.52** (0.63)</td>
<td></td>
</tr>
</tbody>
</table>

19,980 observations on 1,332 country pairs; robust s.e. clustered on pairs.

All regressions include dummies for buyer and seller countries, and years 2000-2014.
Patent level analysis

- Sample: ~700,000 EP granted patents filed 2000-2012, granted by 2014
- Look at first transfer only
- Either Probit or hazard rate model of probability of an international transfer as a function of
  - Patent characteristics – family size, claims, forward citations, number of inventors
  - Applicant characteristics – patent portfolio size, D (research active in more than one country), D (corporation, not research active MNC)
  - Dummies for applicant country, application year
- 3,428,110 observations at risk, with 104,664 transfers, 343,154 patents.
## Patent level analysis

**Dependent variable:** Dummy for first international transfer of patent

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent family size (docdb)</td>
<td>0.063***</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Claims</td>
<td>0.021***</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Forward citations</td>
<td>0.010***</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Inventors</td>
<td>0.040***</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Applicant patent portfolio size</td>
<td>-0.040***</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Dummy for research active MNE</td>
<td>0.271***</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Dummy for corporation, not MNE</td>
<td>-0.022***</td>
<td>(0.003)</td>
</tr>
</tbody>
</table>

A complete set of applicant country and application year dummies included in all regressions. Left-out category is individuals and non-profits.

Estimates - average marginal impact on probability; all non-dummy variables in logs. 3,428,110 observations on 343,154 patents; 104,664 transfers.

Standard errors are clustered by patent.