Internal and External Effects of R&D Subsidies and Fiscal Incentives
Empirical Evidence Using Spatial Dynamic Panel Models

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Context

- Most OECD countries have set objective for (private) R&D intensity
- For most of them, public R&D objective has been achieved but...
- ...**the private contribution is lagging**

Context

Consequences :

- Generalized and increasing implementation of R&D financial support (especially fiscal incentives)

- Fiscal incentives
  In 12 OECD coutries in 1996 $\rightarrow$ 26 in 2013

- Increasing public budget devoted to such policies
  France [Tax credit+Direct subsidies (Region and State levels)] :
  2001 : 2,5 billion euros (Tax credit : $\simeq$ 500 millions)
  2011 : 8 billion euros (Tax credit : more than 6 billions)

So...what's the problem empirically ?

- Macroeconomic facts question the efficiency of these policies (especially fiscal incentives)

  ▷ Relatively flat private R&D intensity in countries that have substantially raised fiscal incentives (France, Czech Republik, Belgium, Japan, Norway, UK, Mexico)

  ▷ Countries with the highest level of private R&D intensity are countries with a (relatively) low level of public support (Germany, Denmark, Finland, Sweden, Korea, US)

The specificities of the related literature

- An extensive empirical literature evaluating the impact of financial support on private investment in R&D
- Most of them are carried out at a microeconomic level and evaluate the capacity of a specific measure to increase private R&D investment
- Numerous Surveys : Capron et al. (1997), David, Hall & Toole (2000), Hall and Van Reenen (2000), Berube and Mohnen (2009), Lentille and Mairesse (2009)
- Micro-results : **Mixed**
- **Globally :** Ambiguous effect for direct subsidies and Positive Effect for tax credits (except for level-based tax credits ? - see Baghana-Mohnen (2009), Lokshin and Mohnen (2009))

Why is there more need of macroeconometric works ?

- Allow to evaluate the global effect of R&D policies (including crowding-out effects, distortions between firms and sectors generated by these measures, price-effect...)
- Allow to discuss the complementarity of instruments and the pertinence of the policy mix
- Allow to understand their cross-border effects (the existence of a competition or complementary effect of such policies)

...And finally provide complementary arguments (to the micro ones) to explain observed facts

Objectives of the paper

Investigate more comprehensively the global effects of R&D subsidies and tax credits by considering both temporal and spatial dependence of R&D activities because...

- the empirical literature mostly ignores the possibility of an external (out-of-country) impact of R&D policies
- efficiency cannot be address correctly without considering both internal (in-country) and external (out-of-country) effects of R&D policies
- econometric methods ignoring spatial effects generate biased estimates

Results

- There exists a non-linear (convex - U) relationship between the effect of instruments on private R&D and their level of use
- R&D policies implemented within a country are substitutes
- R&D policies implemented by different countries are substitutes
- Private R&D generates positive spatial spillovers

Outline

I. Theoretical and empirical elements

II. Econometric models and Methods

III. Results

The internal (in-country) effect of R&D subsidies and fiscal incentives

Internal (In-country) effect =

Direct effect (Reduce the marginal cost of R&D project)

+ Direct externalities

- Positive : learning and training effect, positive signal for future demand,..
- Negative : substitutes to private R&D funding, sectoral distortions, price effect

+ Indirect externalities (between instruments)

The internal (in-country) effect of R&D subsidies and fiscal incentives

External (Out-of-country) effect

Correspond to the macroeconomic effect that the R&D subsidies and fiscal incentives of other countries generate for a specific country

Related to :

- Fiscal competition to attract R&D and/or fiscal optimization
- Access to new sources of fund, learning and training effects

Can be complements or substitutes to national R&D support

Two main empirical models tested

1. The basic model with only temporal dependence

$$y_t = \tau y_{t-1} + x_t\beta + \mu + \eta_t\iota_n + \varepsilon_t$$

$\varepsilon_t \sim \mathcal{N}\left(0, \sigma_\varepsilon^2 I_n\right)$, $\mu^{'} = [\mu_1, \mu_2, \ldots, \mu_n]$ and ι_n a $(n \times 1)$ vector.

2. The model with internal and external effects (SDM) with temporal and spatial dependence

$$y_t = \tau y_{t-1} + \rho W y_t + x_t\beta + W x_t\theta + \mu + \eta_t\iota_n + \varepsilon_t$$

Two assumptions other assumptions tested

1. The non linear effect of R&D subsidies and fiscal incentives

$$\beta_{sub} = \alpha_1 sub + \alpha_2 sub^2$$
$$\beta_{bindex} = \alpha_1 bindex + \alpha_2 bindex^2$$

2. The externalities between instruments

Introduction of a crossed variable in the model :

$$\beta_{interact}(sub \times bindex)$$

Estimation strategy

- Data : 25 OECD countries (1990-2009) mainly from OECD and IMF
- Relative measure for R&D subsidies and Fiscal incentives
  ▷ direct subsidy rate = direct subsidies per $ spent on R&D
  ▷ indirect subsidy rate = fiscal subsidies per $ spent on R&D
- Two other variables : Interest rate and Public R&D intensity
- All variables are I(1) $\Rightarrow$ First-differences model
- Potential unbiaised estimators : LSDVC, GMM and QML

Basic statistics

Basic Statistics

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Dirdefi (% GDP)	500	0.96	0.66	0.004	2.96
Interetlt	500	7.95	6.73	1.00	66.94
Dirdpub (% GDP)	500	0.67	0.25	0.016	1.34
Sub (% BERD)	500	8.28	7.92	0.053	94.40
Bindex	500	0.94	0.11	0.57	1.08

Evolution of Variables over time

Variable	1990-1993	1994-1997	1998-2001	2002-2005	2006-2009
Dirdefi (% GDP)	0.83	0.87	0.97	1.02	1.11
Interetlt	13.28	10.41	6.79	4.69	4.57
Dirdpub (% GDP)	0.59	0.63	0.66	0.71	0.76
Sub (% BERD)	10.01	9.25	7.42	7.01	6.91
Bindex	0.98	0.97	0.96	0.91	0.88

First results

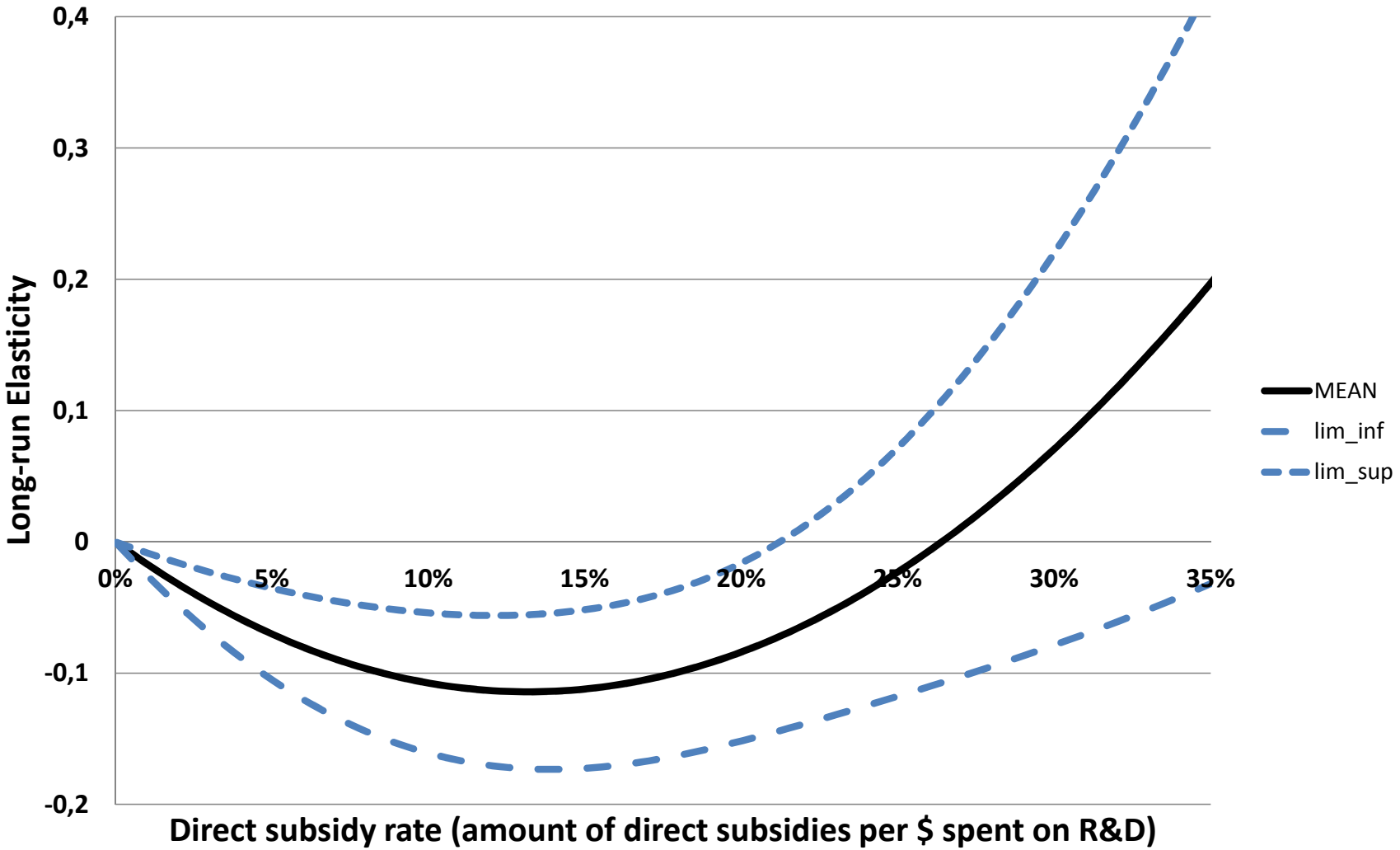
$$\Delta y_t = \tau \triangle y_{t-1} + \triangle x_t \beta + \mu + \eta_t \iota_n + \varepsilon_t$$

VARIABLE	MODEL 1		MODEL 2		MODEL 3	
	GMM	CLSDV	GMM	CLSDV	GMM	CLSDV
$\Delta ldirdefi_{-1}$	0.379^{***}	0.434^{***}	0.373^{***}	0.429^{***}	0.366^{***}	0.419^{***}
$\Delta interetlt$	-0.008^{***}	-0.005^{**}	-0.008^{***}	-0.006^{**}	-0.009^{***}	-0.008^{***}
$\Delta lsub$	-0.042^{***}	-0.045^{***}	-0.034^{***}	-0.037^{***}		
$\Delta lsub \times sub$					-1.009^{***}	-1.000^{***}
$\Delta lsub \times sub^2$					3.966^{***}	3.787^{***}
$\Delta ldirpub_{-1}$	0.317^{***}	0.245^{***}	0.310^{***}	0.237^{***}	0.288^{***}	0.233^{***}
$\Delta lbindex_{-1}$	-0.196^{***}	-0.198^{***}	-0.251^{***}	-0.248^{***}		
$\Delta lbindex_{-1} \times lbindex$					-3.765^{***}	-3.176^{***}
$\Delta lbindex_{-1} \times lbindex^2$					4.623^{***}	3.819^{***}
$\Delta interact$			0.589^{***}	0.581^{***}	1.097^{***}	1.020^{***}
$constant$	-0.038^{**}		-0.039^{**}		-0.033^{**}	

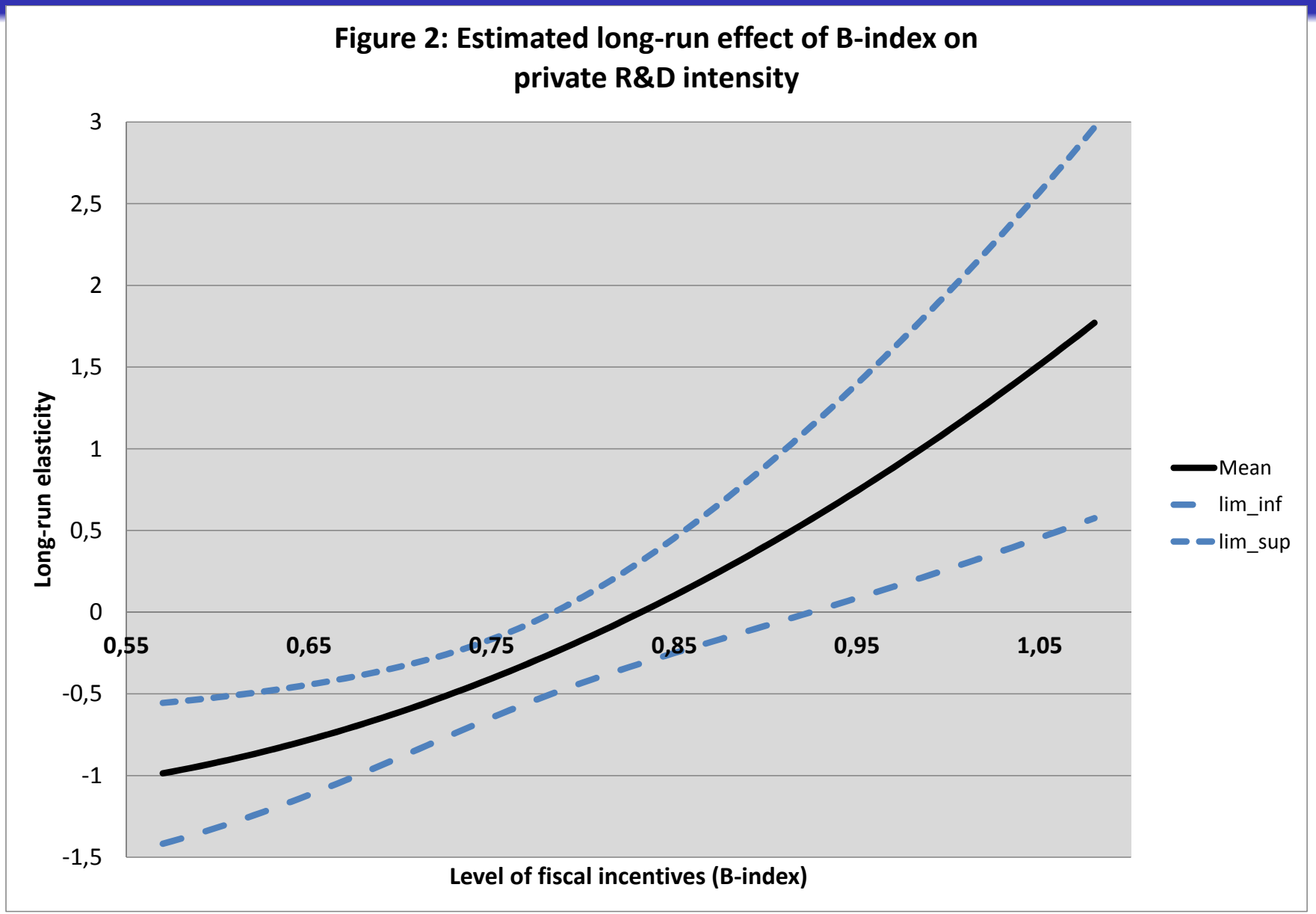
Notes : *, ** and *** denotes significance at 10%, 5% and 1%. Dep. variable is log Dirdefi %GDP (first difference). Terms Δ and l denotes first diff. and log. All tests are based on robust std. errors. Time effects are included but not reported.

The non-linear effect of R&D subsidies

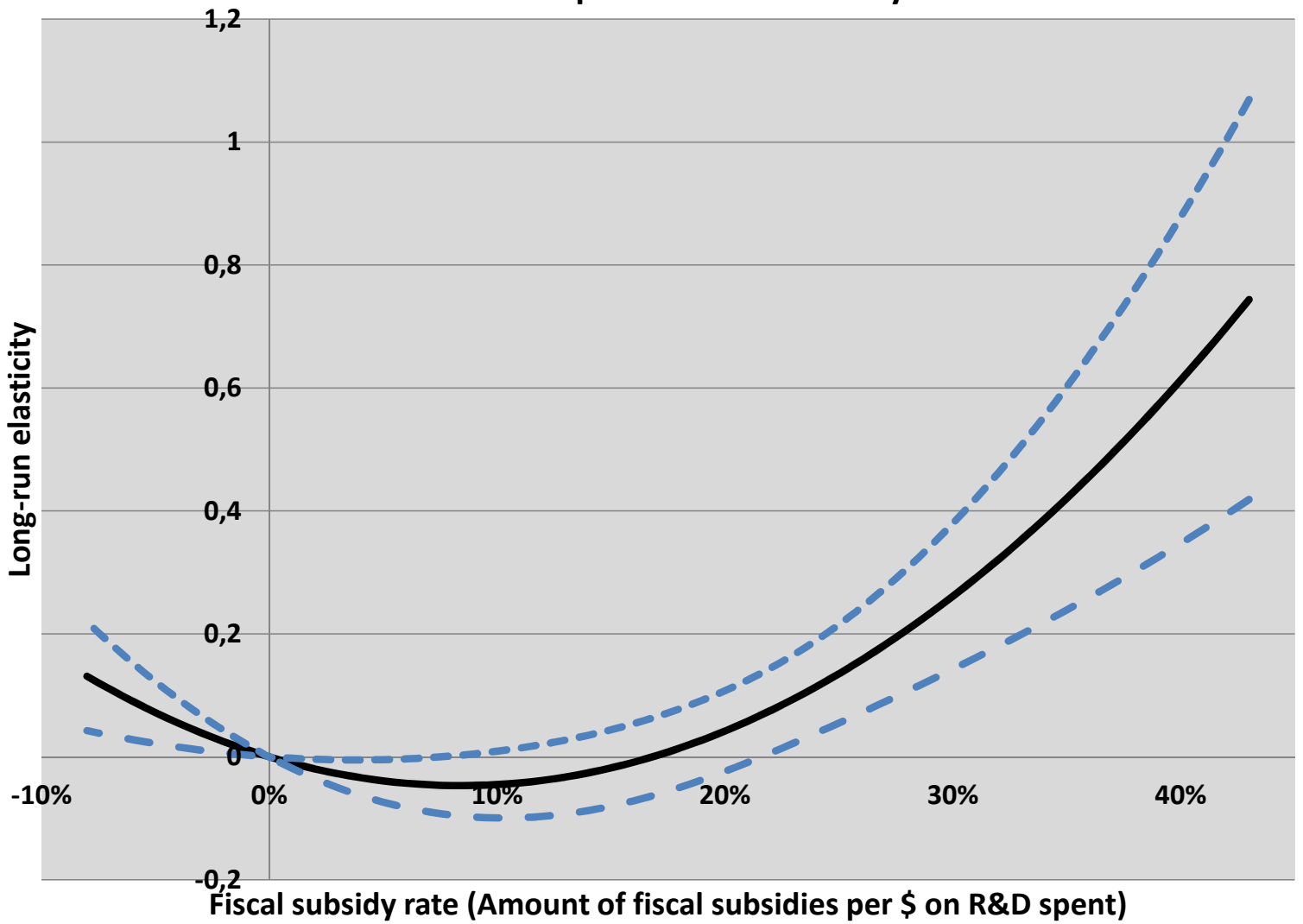
Figure 1: Estimated long-run effect of direct subsidies on private R&D intensity



The non-linear effect of Fiscal incentives



The non-linear effect of Fiscal incentives



The introduction of spatial effects

Idea : private R&D of a country could be impacted by private R&D of its neighbors and their R&D policy incentives

Spatial dependence is understood as proximity, not necessarily geographical distance

• We introduce spatial dependence using two alternative criteria :

$$w_{ij} = \frac{1}{2T} \sum_{t \in T} \left(\frac{export_{ij,t}}{\sum_j export_{ij,t}} + \frac{import_{ij,t}}{\sum_j import_{ij,t}} \right)$$

$$w_{ij} = \frac{\frac{1}{T} \sum_{t \in T} p_{ij,t}}{\sum_j \left[\frac{1}{T} \sum_{t \in T} p_{ij,t} \right]}$$

• We use a binary transformation to avoid endogeneity problems and break down the connection between countries :

$$w_{ij} = \begin{cases} 1 & if \quad \sum_j w_{ij}^o \leq 0.75 \\ 0 & otherwise \end{cases},$$

Dynamic spatial estimates

	dynSDM 1		*dynSDM* 2		*dynSDM* 3	
	W (trade)	**W (patent)**	**W (trade)**	**W (patent)**	**W (trade)**	**W (patent)**
MAIN EFFECTS						
$\Delta ldirdefi_{-1}$	0.372^{***}	0.371^{***}	0.367^{***}	0.363^{***}	0.359^{***}	0.349^{***}
$\Delta interetlt$	-0.005^{***}	-0.005^{***}	-0.005^{***}	-0.005^{***}	-0.007^{***}	-0.007^{***}
$\Delta lsub$	-0.044^{***}	-0.044^{***}	-0.036^{***}	-0.036^{***}		
$\Delta lsub \times sub$					-1.029^{***}	-0.974^{***}
$\Delta lsub \times sub^2$					3.862^{***}	3.662^{***}
$\Delta ldirpub_{-1}$	0.256^{*}	0.258^{**}	0.247^{*}	0.248^{**}	0.241^{*}	0.241^{**}
$\Delta lbindex_{-1}$	-0.193^{***}	-0.198^{***}	-0.247^{***}	-0.260^{***}		
$\Delta lbindex_{-1} \times bindex$					-3.286^{***}	-3.214^{***}
$\Delta lbindex_{-1} \times bindex^2$					3.958^{***}	3.843^{***}
$\Delta interact$			0.608^{***}	0.584^{***}	1.066^{***}	1.060^{***}
SPATIAL EFFECTS						
$W\Delta ldirdefi$	0.139^{**}	0.321^{**}	0.161^{**}	0.323^{**}	0.147^{**}	0.272^{**}
$W\Delta interetlt$	0.014^{*}	-0.038^{**}	0.013^{*}	-0.043^{**}	0.011^{*}	-0.044^{**}
$W\Delta lsub$	0.006	0.063	0.017	0.077		
$W\Delta lsub \times sub$					0.140	-0.108
$W\Delta lsub \times sub^2$					-0.698	21.729
$W\Delta ldirpub_{-1}$	-0.047	0.150	-0.042	0.086	-0.052	0.072
$W\Delta lbindex_{-1}$	-0.027	-0.091	-0.116	1.047^{*}		
$W\Delta lbindex_{-1} \times bindex$					-2.939	-0.348
$W\Delta lbindex_{-1} \times bindex^2$					3.556	2.053
$W\Delta interact$			0.589	15.427^{***}	1.221	15.239^{***}
AIC	-1049	-1050	-1046	-1055	-1044	-1055
BIC	-954	-955	-931	-940	-887	-899

Core results

- R&D policies influence significantly the private R&D investment
- Non linear (convex - U) effect of both R&D subsidies and fiscal incentives ⇒ possibility of crowding-out and leveraging effect depending on the level of use
- R&D subsidies and fiscal incentives (within a country) are substitutes in stimulating private R&D
- **Spatial dependence is present :**
  ⇒ Positive externalities generated by private R&D
  ⇒ National R&D policies could be substitutes (especially for fiscal incentives)

Conclusions

- Necessity to take into account internal AND external effects of R&D policies to assess their global effect
- Based on our results, if governments do not take into account the spatial dependence in the definition of their R&D policies, then there will be likely to be in favor of indirect support compared to direct support...
- ...even if the global effect of indirect support could be less positive

Thank you