Evaluation of R&D subsidies in the case of industry-specific technology stocks with spillovers

Dirk Verwerft

plan.be

Introduction

Objective: design R&D wage subsidization scheme taking knowledge spillovers between industries into account

Network perspective: industry-specific stocks of knowledge – influencing one another positively and asymmetrically

Dynamic general equilibrium framework: taking into account input-output structure of production including international competitiveness; investment decisions; labour markets

Structure of the presentation

1. Knowledge spillovers
2. Model description
3. Calibration
4. Results

Knowledge spillovers

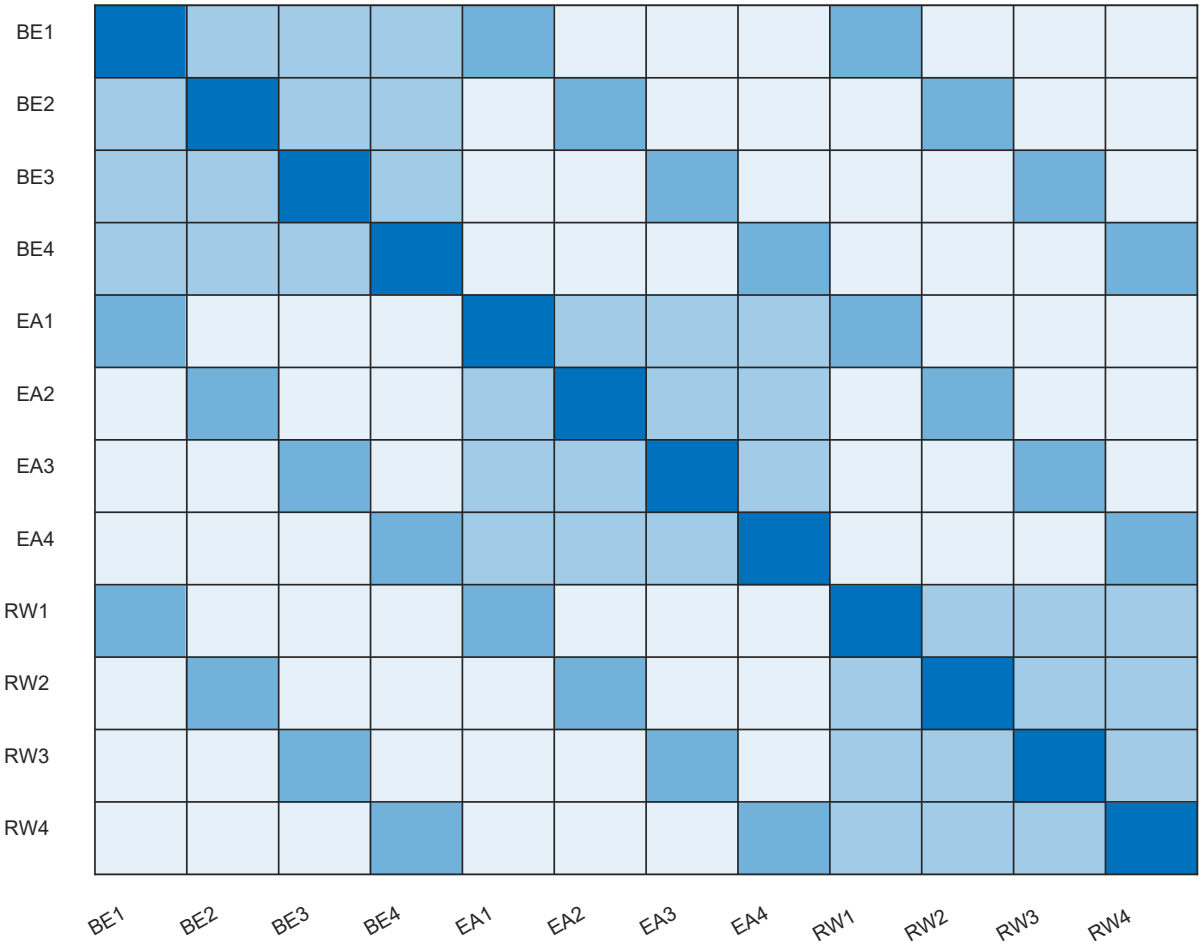
Literature: elasticities of “external” knowledge between 0.05 and 0.09 (Hall, Mairesse & Mohnen, 2010)

Knowledge stocks are usually highly aggregated because of multicollinearity issues

Most detailed level: Verspagen (1997), Keller (2002)

4 distinct effects: intra/inter-industry x domestic/foreign

Knowledge spillovers



Knowledge spillovers

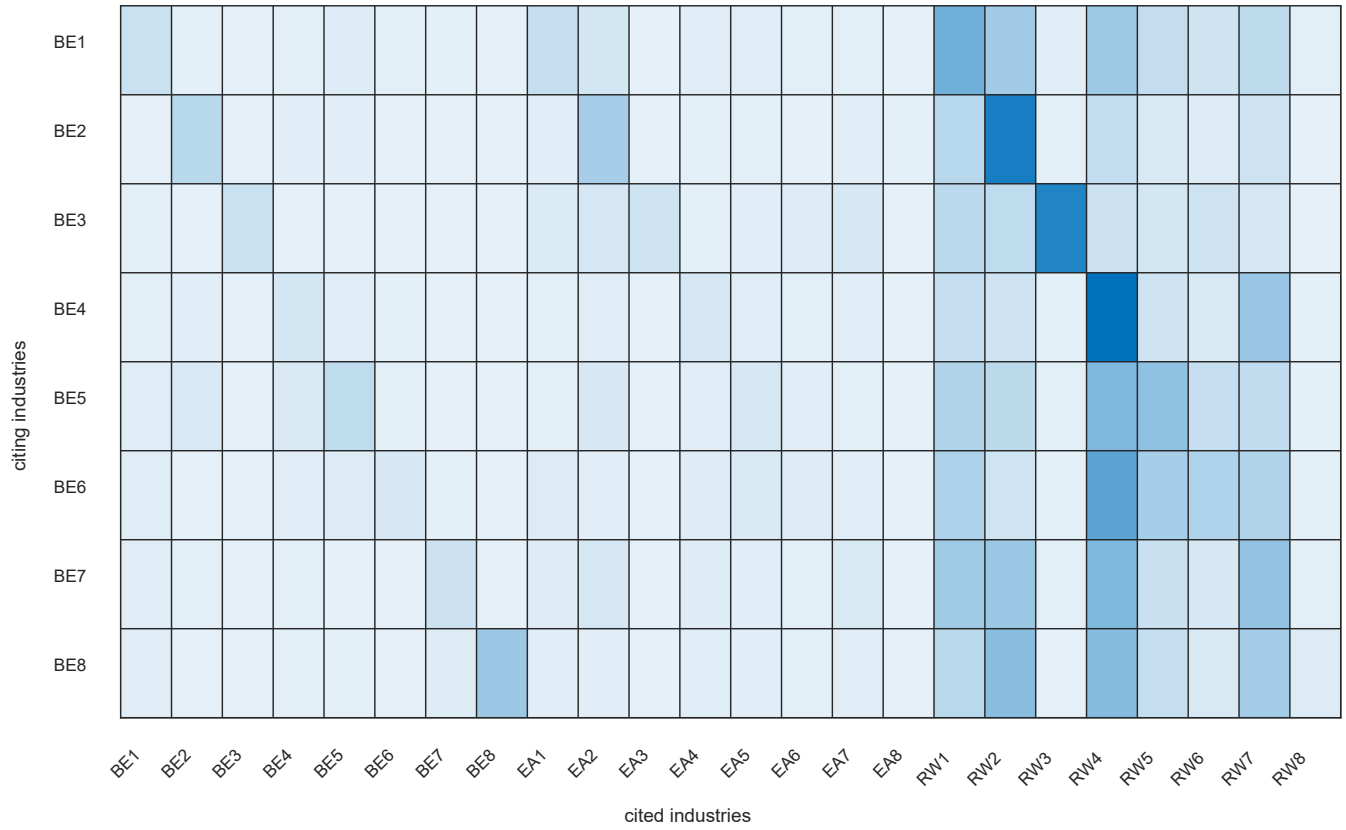
Liu & Ma: innovation network defined by patent citation shares

-> some industries are more central than others

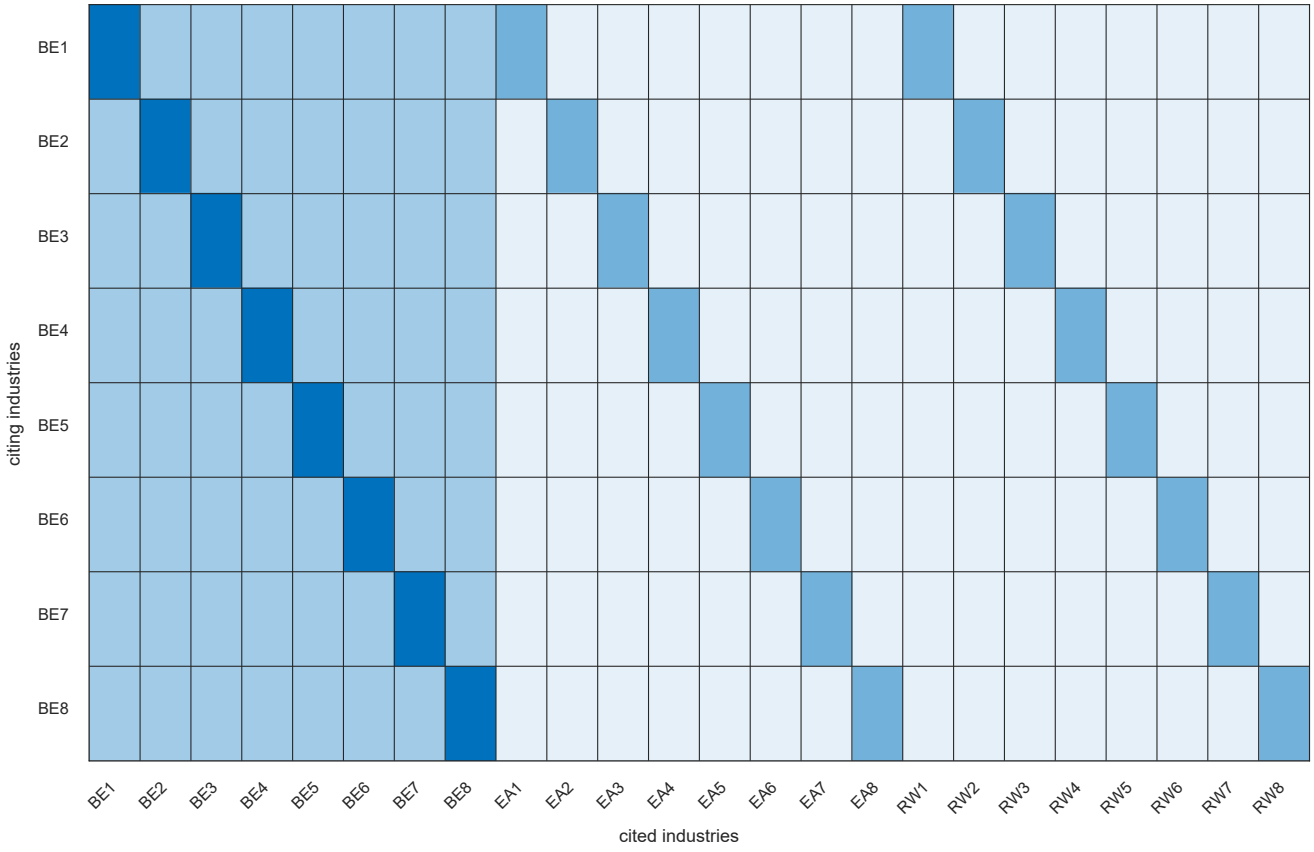
Derive optimal allocation of R&D resources (labour force) across industries, given the innovation network

Optimal allocation proportional to network centrality vector (= contribution of each industry's R&D to economic growth)

Knowledge spillovers



Knowledge spillovers (symmetric)



Model description

DynEMItE: inspired on QUEST III R&D model (DG ECFIN - EC)

General characteristics:

- Household, n firms / industries, government
- Industry-specific R&D stocks with cross-industry spillovers; labour-augmenting tech ~ steady state growth theorem
- Balanced growth is guaranteed in the long run because of semi-endogenous growth

Model description

- 3 regions: BE, EA, RW, first two in monetary union
- Labour markets for 3 skill levels and n industries: inter-industry wage differentials
- Monopolistic competition, both within and between sectors

  Price-cost mark-ups within industries, substitution possibilities between industries and regions
- Quadratic adjustment costs

  Labour, wages, investment, capital utilization

Model description

Cobb Douglas production function

$$Y_{i,t} = B_{i,t}\, KG_t^{\alpha_{G,i}} \left(K_{i,t-1}\right)^{\alpha_i\left(1-\sigma_i^M\right)} \left(A_{i,t-1}\, L_{i,t}\right)^{(1-\alpha_i)\left(1-\sigma_i^M\right)} M_{i,t}^{\sigma_i^M}$$

Extra FOC for technology:

$$\frac{\tilde{A}_{i,t-1}}{1+\gamma_A} = \frac{(1-\alpha_i)\left(1-\sigma_i^M\right)}{rrd_{i,t}\, prd_{i,t}} mc_{i,t}\, \tilde{y}_{i,t}$$

Remark 1: constant returns to scale in “traditional” inputs

⇒ economic sustainability condition: economic profit must be sufficient to allow rental of R&D capital (~ ½ Aghion)

Model description

Remark 2 (from labour and R&D FOCS): for reasonable values, the R&D intensity should be 50-75% of the labour income share

Solution: general technology term (unintentional knowledge)

$$\frac{\tilde{A}_{i,t-1} + \widetilde{GT}_{i,t-1}}{1+\gamma_A} = \frac{(1-\alpha_i)\left(1-\sigma_i^M\right)}{rrd_{i,t}\, prd_{i,t}} mc_{i,t}\, \tilde{y}_{i,t}$$

$GT_{i,rel} \equiv \frac{GT_{i,0}}{A_{i,0}}$ is calibrated by the deviation between the labour income share and the R&D intensity

Model description

Knowledge creation process, as in QUEST, inspired by Bottazzi & Peri (2007):

*New R&D production depends on domestic and foreign stocks of capital, as well as R&D labour

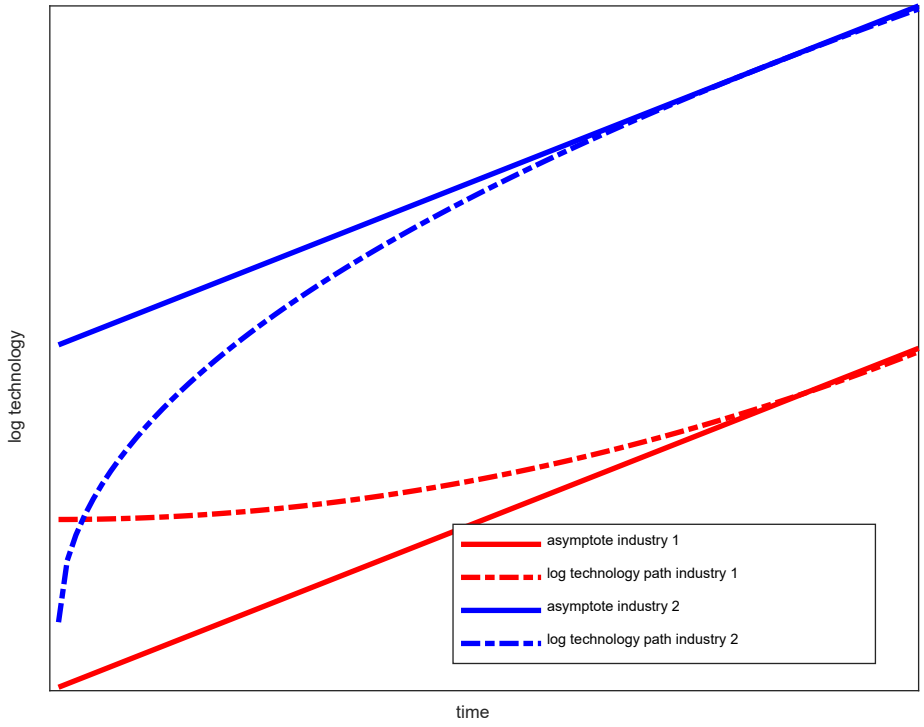
$$IRD_{i,t} = \nu_i \, A_{i,t-1}^{\varphi_i} \, A_{ROW-i,t-1}^{\xi_i} \, LRD_{i,t}^{\lambda_{rd,i}}$$

But separate spillover coefficient per stock of knowledge (as in Liu & Ma, 2022):

$$IRD_{i,t} = \nu_i \prod_{j=1}^{n} A_{j,t-1}^{\varphi_{ij}} \, LRD_{i,t}^{\lambda_{rd,i}}$$

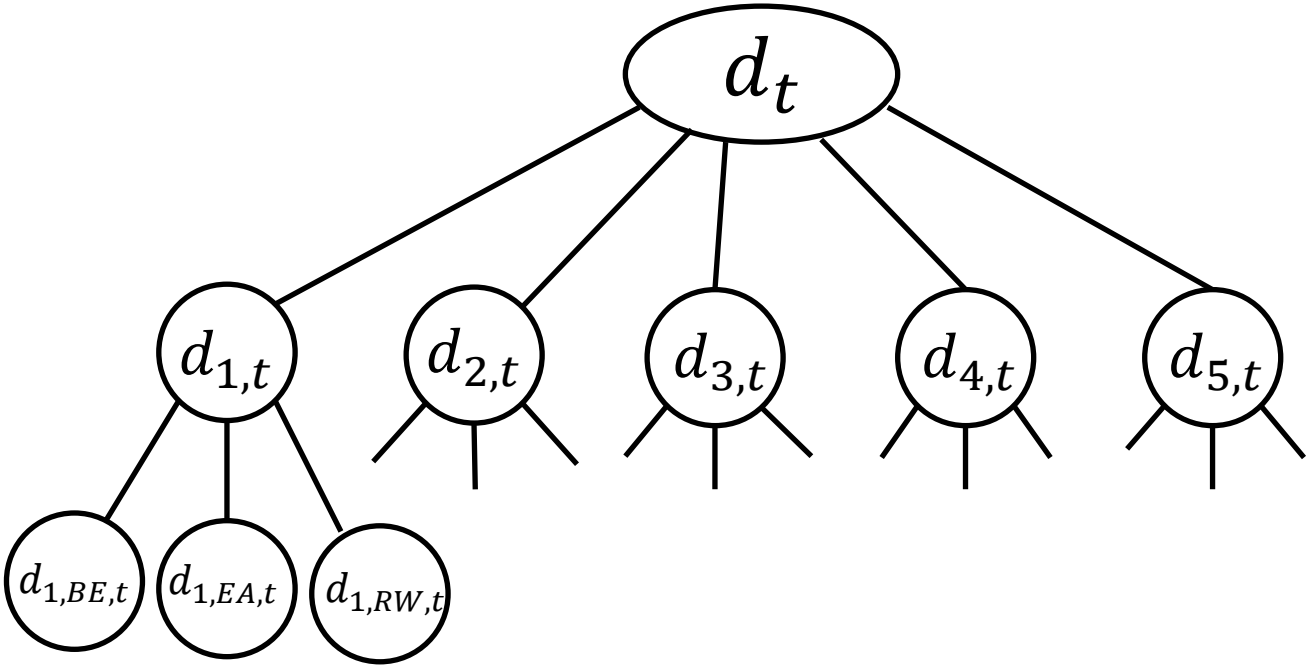
Model description

Semi-endogenous growth: balanced growth in the long run, but different short-term growth may affect relative technology levels between industries

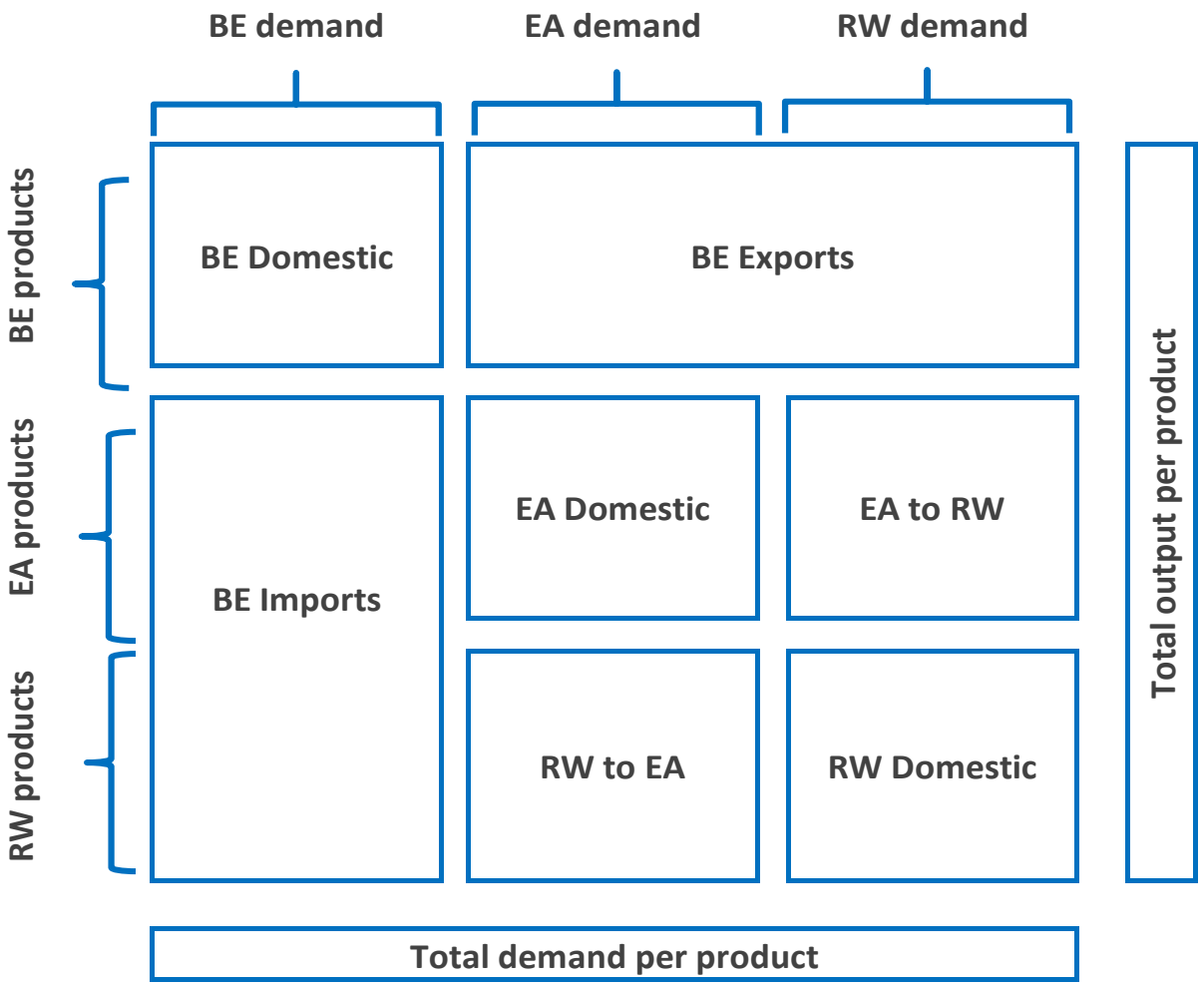


Model description

$6n + 9$ demand components: double layer structure



Calibration



Calibration

Figaro symmetric product x product table (64 x 64)

BE: 15% difference with official National Accounts table for investment in R&D -> insert BE domestic matrix in Figaro, reweigh BE exports and imports

Symmetric BE matrix derived from use matrix using industry technology assumption for transparency and consistency -> supply matrix

Calibration

Investment: disaggregated into specific investment assets for each industry and the government

For BE: detailed data available

EA and RW: data on investment per industry and per asset (Eurostat, OECD)
Correspondence table between assets and products

Government: info on stocks of capital per asset and institutional sector; subtract from industry O, P and R

Calibration

Missing data strategy:

1) If economy-wide investment per product or investment per industry (A64) are not known -> “generic” country
2) If aggregate data is known but detailed information is missing:
   a) Impute using a key based on data of other year
   b) Impute using a key based on data of other countries in region -> ranking countries from complete to incomplete information

Calibration

Labour market:

Employment per industry (Eurostat / OECD)

Distribution of skill levels per industry (World KLEMS)

Unemployment per industry calculated using aggregate, skill-specific unemployment rates

-> labour force

Wage income shares per skill level

Simulation

Increase wage subsidies for R&D workers by 10 ppt in 8 industries:

Industry	NACE rev. 2 codes	Description
1	A-F (without sectors 2-6 below)	Agriculture, Mining, Low-tech manufacturing, Utilities, Construction
2	C20-21	Chemicals, Pharmaceuticals
3	C22	Rubber and plastics
4	C26-27	Electronics, Electrical equipment
5	C28	Machinery and equipment
6	C29-30	Transport equipment
7	G-N	Market services
8	O-U	Non-market services

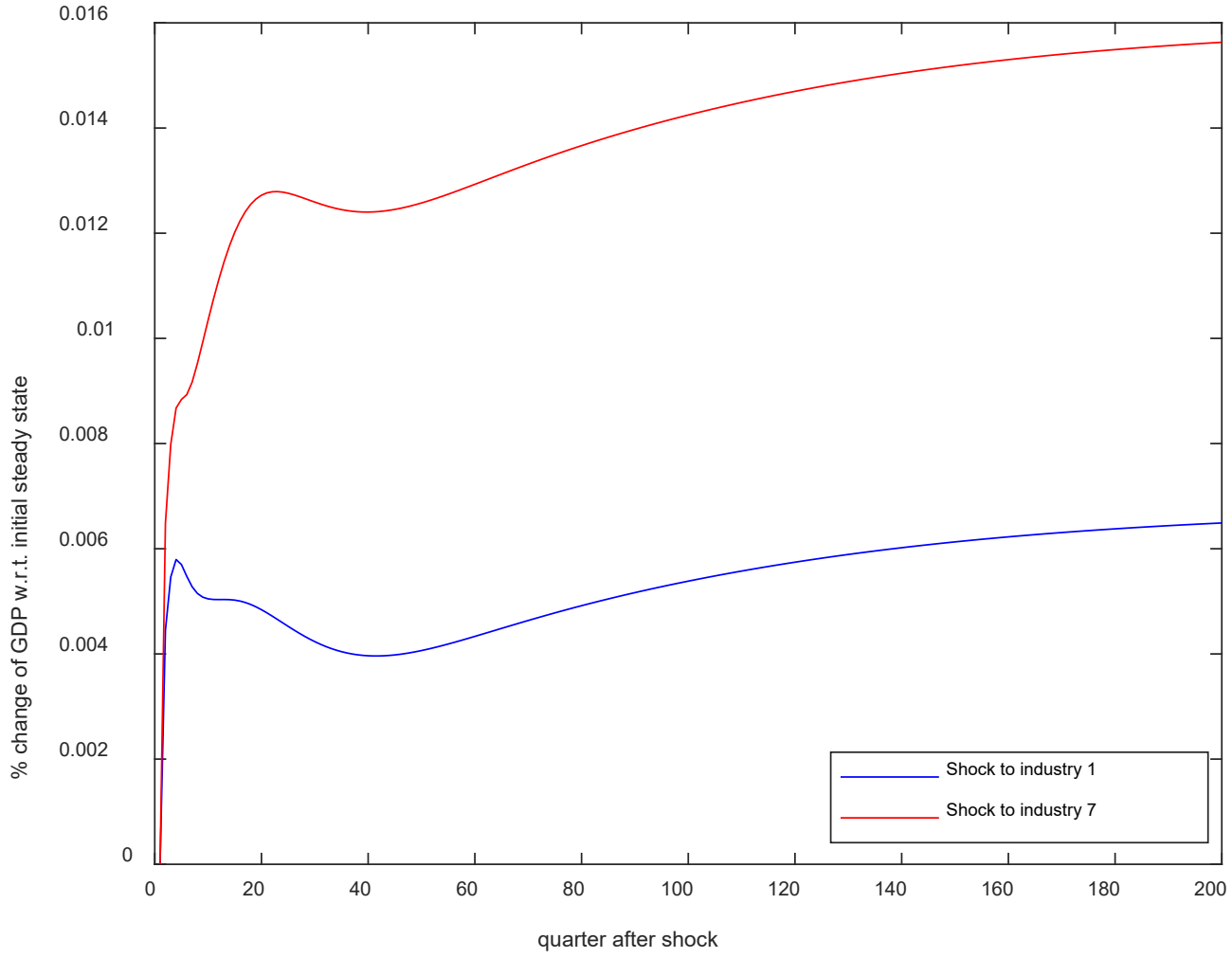
Results

Industry	Share in total output	Share in total VA	Price-wage mark-up	Share of costs in total output	Intermediate share	Labour income share	Rest	Investment share
1	0.254	0.150	1.12	0.89	0.74	0.14	0.007	0.06
2	0.054	0.034	1.20	0.83	0.73	0.11	-0.005	0.13
3	0.008	0.005	1.11	0.90	0.72	0.19	0.000	0.06
4	0.007	0.006	1.15	0.87	0.64	0.21	0.015	0.10
5	0.011	0.008	1.20	0.84	0.65	0.20	-0.011	0.06
6	0.018	0.007	1.06	0.95	0.84	0.13	-0.023	0.04
7	0.500	0.563	1.29	0.78	0.51	0.22	0.052	0.13
8	0.149	0.227	1.10	0.91	0.33	0.57	0.003	0.04

Results

Industry	Long term change in GDP (%)	Ex post cost in % of GDP	"Bang for the buck"
1	0.67	0.0088	76.0
2	0.04	0.0168	2.6
3	0.01	0.0011	12.7
4	0.03	0.0077	4.2
5	0.03	0.0032	9.0
6	0.02	0.0027	7.3
7	1.57	0.0353	44.4

Results


0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
% change of GDP w.r.t. initial steady state
0
20
40
60
80
100
120
140
160
180
200
quarter after shock
Shock to industry 1
Shock to industry 7