

How increasing investments in R&D would contribute to development of Poland and its regions?

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Abstract

The paper investigates impact of several scenarios of increasing investments in R&D in Poland with use of a regional CGE model for Poland. The Europe 2020 strategy sets the target of increasing combined public and private investment in R&D to achieve a level of 3 % of R&D in EU's GDP by 2020. Currently it is 2.1% of GDP on average in the EU, and in Poland only 0.89% of GDP. Specific target established by the EU for Poland to be achieved by year 2020 is 1.7% of GDP. So the policy is very challenging as the R&D expenditure must double in Poland in relatively short time. Yet no specific actions were planned to fulfill the requirement. Hence we simulate two scenarios of possible increase of regional shares of R&D investments in regional GRPs taking into account that regions in Poland differ significantly in their R&D shares in GDP from 0.2% to 1.38%. The main method applied in the paper is a regional CGE model for Poland called POLTERMDyn. Several scenario are analyzed and compared. The first scenario assumes that all regions increase R&D proportionally to their current shares in total R&D spending. The second scenario assumes that all regions increase their R&D share in GDP up to 1,7% by 2020, no matter what were the initial shares of R&D in their GRPs. The results show that the 'proportional' and 'converging' scenarios have similar and positive impact on Poland's economy in terms of GDP growth and employment. They boosts several sectors of the economy in addition to R&D services, in particular: construction, accommodation and food, public administration, education and health, in particular. It is important to stress, that regional impacts differ significantly.

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1. Introduction

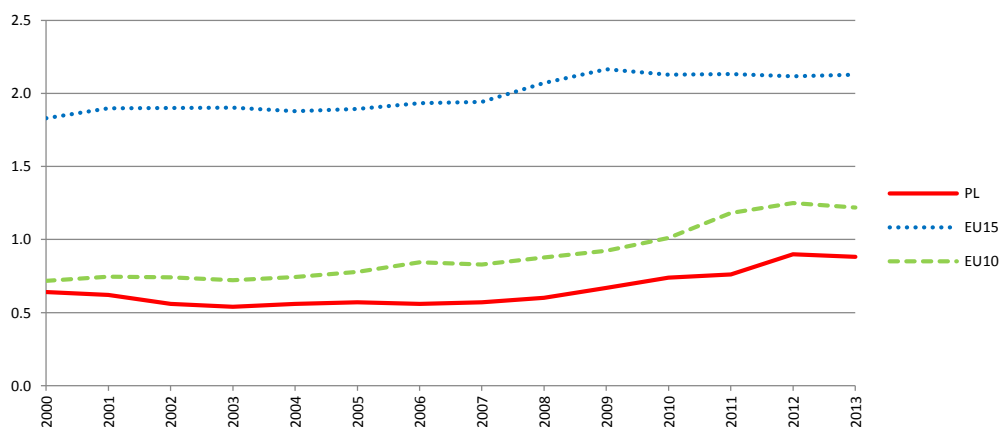
The European Union's research and development (R&D) policy, similarly to the other EU policies, is based on objectives stated in the Treaties of the European Union, documents that create the EU's constitutional basis. In the last few decades R&D has gained much importance and political attention, due to its role in innovativeness and, as a result, in growth and socio-economic development. The main documents in this area are two successive EU's strategies: the Lisbon Strategy (the Lisbon Agenda, the Lisbon Process) and Europe 2020. The Lisbon Strategy is a development plan adopted in 2000 with 10-year perspective. Its aim was to make

the European Union "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion". One of the targets that the Strategy set was spending at least 3 per cent of GDP on research and development (R&D) by the end 2010. This goal was not achieved: across the EU-27 the overall spending on R&D had increased from 1.8 per cent in 2000 to about 2.0 per cent in 2010. In this situation in 2010 another strategic 10-year document was devised – Europe 2020. Its main aim was EU's "smart, sustainable, inclusive growth". The strategy continued Lisbon Strategy's target of at least 3 per cent of GDP on research and development. This European target was translated into national goals. For Poland the target value of overall spending on R&D is 1.7 per cent of GDP, so almost two times lower than the EU average.

2. R&D investments in Poland

The graph below presents dynamic of gross domestic expenditure on R&D as a share of GDP in Poland and two groups of the EU member states. EU10 includes the ten countries of Central and Eastern Europe (EU10) which acceded to the EU as part of expansion in 2004 and 2007. These are: the Czech Republic, Estonia, Lithuania, Latvia, Poland, Slovakia, Slovenia, Hungary, Bulgaria and Romania. EU15 ('the fifteen') contains the so-called 'old' member states: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

Fig 1. GERD as % of GDP



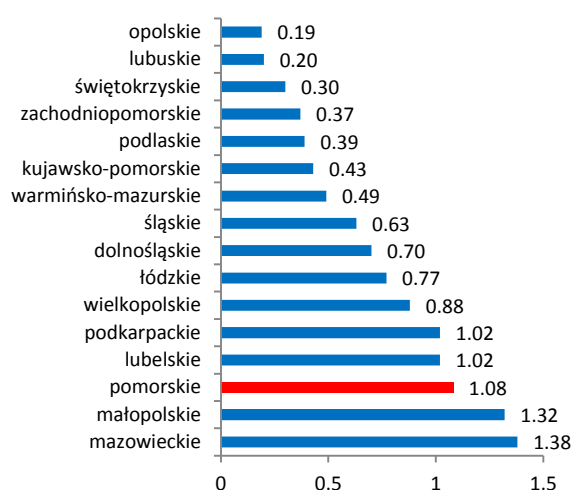
Source: own study based on data from EUROSTAT and Polish Statistical Office.

In 2000-2013 both analyzed groups of countries, as well as Poland, noted increase in R&D expenditures, measured in relation to GDP. Interestingly, this growth was not restrained by the economic crisis (started in 2009), and even slight increase in the value of this indicator was visible. Although convergence is visible, the distance between old and new EU member states (EU15 and EU10) in terms of R&D expenditures (in relation to GDP) is still significant. In 2000 this indicator in the EU10 reached only 39 per cent of that in the EU15, and till 2013 increased to 57 per cent. Apart from that general picture it should be stressed that there are

important differences among the EU10 countries. For example in the last few years Slovenia and Estonia achieved a level of R&D expenditures higher than the EU15 average. In Slovenia this trend was quite permanent and visible from 2011, while in Estonia the spectacular growth in 2010-2012 was followed by a dramatic drop. Besides the two mentioned countries, only the Czech Republic and Hungary noted R%D expenditures (as % of GDP) higher than the EU10 average.

Apart from differences between countries also regional disparities are quite significant. In Poland share of R&D expenditures in regional GDP in 2012 varied from 0.19 per cent in opolskie region to 1.38 in the mazowieckie (capital region). It means that in opolskie level of GERD's share in GDP was more than seven times lower than in the best performing region, and at the same time almost nine times lower than Europe 2020 target for Poland (1.7 per cent).

Fig 2. GERD as % of GDP in 2012 in Polish regions



Source: own study based on Polish Statistical Office data.

3. Dynamic CGE - POLTERM model

We apply a POLTERMdyn model, which is an implementation of the TERM model by Horridge et al., (2005) to the Polish economy later extended by Zawalińska, Giesecke, Horridge (2013) with recursive dynamic features as described by Wittwer (2012). It is a bottom-up multi-regional CGE model that explicitly captures the behaviour of industries, households, investors, government and exporters at the regional level. Producers in each region are assumed to minimize production costs subject to industry-specific production technologies. A representative household in each region purchases goods in order to obtain the optimal bundle in accordance with its preferences and disposable income. In TERM, economic agents decide on the geographical source of their purchases according to relative prices and a nested structure of substitution possibilities. In the case of each regional user, account is also taken of the taxes payable on the purchase (more details will be in the paper).

In this application we use the (recursive) dynamic version of the TERM model where the capital accumulates according to the following rule:

$$K_{j,t+1} = K_{j,t}(1-D) + I_{j,t},$$

where K_{jt} is the quantity of capital available to industry j in year t , I_{jt} is the quantity of investment (new) capital in industry j in year t ; $D_{j,t}$ is the rate of depreciation. The expected rate of return in industry j determines its level of investment in a given period. More details on dynamic TERM model can be found in Wittwer (2012).

There are also attempts to build-in to the model the endogenous technical change linked to R&D investments in relevant sectors.

2.1 POLTERMdyn data source

The Polish version of TERMdyn models 19 sectors¹ in the 16 NUTS2 regions. The sectoral dimensions of dynamic POLTERM have been tailored in this study for analyses of research and development investments (R&D). It led us to aggregate our database to 19 sectors (including explicit R&D sector) in all 16 regions (16x19 matrix).

The main data source is the latest version of Input-Output tables, including Supply and Use tables, as of 2010 issued by the Main Statistical Office of Poland in mid-2014. Hence, the benchmark year for the model is 2010. There are no regional IO tables in Poland, so we disaggregate them on ourselves with top down techniques.

Baseline values for the forecast were calculated from the anticipated scenarios of increase in R&D share in GDP over 11 years (2010-2013 past values and 2014-2020 of forecast). See the Annex for the values of shocks in two scenarios.

2.2 Modelling R&D investments in POLTERM

R&D sector definition in our paper is consistent with NACE and applied to all EU IO tables. It is a part of M section (Professional, Scientific and activities). R&D stands for *Research and experimental development*, and it refers to creative work undertaken on a systematic basis in order to increase the stock of knowledge (including knowledge of man, culture and society), and the use of this knowledge to devise new applications.

In our model the goal of increasing R&D shares in GDP are modeled via increase in investments in all regions at specific values - $x_{invitot} (IND * DST)$ – different for each scenario (as explained below).

In POLTERMDyn the R&D investments in majority are located in construction (53.7% in terms of investments' value), then in manufacturing such as hardware, software, etc. (37.7%) then the in professional services (5%). The rest goes to ICT (2.6%), public administration (0.1%), real estate (0.1%), agriculture (0.1%) and rest in other services (0.7%) - see Table 1.

R&D's costs structure at the national level for Poland – based on IO tables 2010 (EUROSTAT) - shows that the highest costs of the sector are related to scientific research (29.8%), chemical products (10.5%), computer programming (2.4%)- see Table #. In the VA structure dominate labor costs (compensations of employees 76%) while capital is much less (operating surplus gross 18.%)

¹ The sectors are NACE Rev.2 sections with M section desegregated into R&D and the rest of M, see Annex 1.

R&D demand structure at the national level shows that the most demand for R&D comes from scientific research (26.3%), electrical equipment (10.8%), wholesale trade (7%), vehicles and motors (4.1%), paper products (3.8%), plastic products (3%), coke and refined products (3%), pharmaceuticals (2.9%), computer programming (2.3%), telecommunication (2.2%) - see Table #.

Table 1 Investments structure of R&D sector in Poland

INVESTMENT SHARES	
1 Agri	0.1%
2 MinQuar	0%
3 Manuf	37.7%
4 ElecGas	0%
5 WatWast	0%
6 Constr	53.7%
7 Trade	0%
8 Transp	0%
9 AccFood	0%
10 ICT	2.6%
11 FinInsur	0%
12 RealEst	0.1%
13 RandD	0%
14 Proffes	5.2%
15 AdmSup	0%
16 PubAdm	0.1%
17 Educat	0%
18 Health	0%
19 RecrOther	0.5%
Total	100.0%

Source: POLTERMDyn model

The final demand for R&D was the following: intermediate use of R&D by industries (54%), final consumption (30%), exports intra EU (10%), exports extra EU (5%) and gross fixed capital formation is the rest. The major demand for R&D comes from public sources while only 5% by NGOs.

3.3. Simulation design: closure rules and scenarios

Closure

The closure used in this simulations is a standard TERM long run closure with dynamic mechanisms (capital accumulation switched on). For now we assume that the financing is exogenous.

Scenarios

The three scenarios where the following common conditions are maintained: a) the policy starts being implemented in 2014; b) in all scenarios the level of R&D in national GDP is targeted in 2020 at the level of 1.7%;c) the policy continues after 2020, so that the level of 1.7% is maintained.

Scenario 1 (**Proportional**): All regions increase R&D proportionally to their current (2013) shares in total R&D spending until the national average is 1.7% of GDP by 2020.

Scenario 2 (**Converging**): All regions increase R&D spending at the same time to the same level of 1.7% of GDP by 2020.

Scenario 3 (**Concentrated**): Only those regions would receive funding for R&D investments, which have already a critical mass of R&D investments in their GRP.

We also test different sources of financing of such policy. On the one hand, it can be financed from external EU sources, on the other hand, it can be financed by redistribution of current budgetary transfers, e.g. from unprofitable mining sector, generous top-ups to farmers within Common Agricultural Policy, or by increase in taxes.

4. Discussion of the results

4.1 The impact of R&D investments on the national macroeconomy

Investments in R&D are effective in creating welfare and employment for Poland. This is also true for almost all NUTS 2 regions. The results suggest this for the long run provided economic growth covers the investment costs. If these costs would be covered in the short run by increasing for instance the value-added tax rate, then the favorable results would be lower or even negative.

It seems that the design for implementing the R&D investments does not matter too much. The results suggest that S2 (converging) brings slightly more welfare and employment compared to S1 (proportional). The difference is some 60 million zlotys in welfare and 600 person working years. In fact, in case of S2:converging scenario it seems that maximum GDP growth is achieved one year earlier than in case of S1:proportional scenario.

Table 2 Macro results of Scenario 1 (Proportional) (%change YoY)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1 RealHou	0.00494	0.01552	0.01521	0.02574	0.03784	0.05166	0.06723	0.08445	0.10317	0.12316	0.11722
2 Reallnv	0.03318	0.10303	0.10106	0.16552	0.23743	0.31747	0.40609	0.50369	0.61075	0.72767	0.74274
3 RealGov	0.005	0.01575	0.01548	0.02611	0.03829	0.0522	0.06787	0.08523	0.10412	0.12432	0.11856
4 ExpVol	-0.01696	-0.04991	-0.0395	-0.06355	-0.08481	-0.10315	-0.11866	-0.13172	-0.14301	-0.15341	-0.13154
5 ImpVolUsed	0.0073	0.02294	0.02355	0.03981	0.05955	0.08353	0.1124	0.14655	0.18612	0.23104	0.23074
6 ImpsLanded	0.0073	0.02294	0.02355	0.03981	0.05955	0.08355	0.11242	0.14658	0.18615	0.23108	0.23077
7 RealGDP	0.00086	0.00384	0.00717	0.0123	0.01993	0.03008	0.04263	0.05728	0.07368	0.09141	0.10054
8 AggEmploy	0.00155	0.00516	0.00603	0.01047	0.01641	0.02412	0.03377	0.04536	0.05876	0.07372	0.07401
9 realwage_io	0.0031	0.01032	0.01207	0.02094	0.03282	0.04825	0.06755	0.09074	0.11756	0.14748	0.14808
10 plab_io	0.00315	0.01045	0.01221	0.02125	0.03334	0.04903	0.06866	0.09225	0.11952	0.14996	0.15043
11 AggCapStock	0	0.00208	0.0078	0.01331	0.02214	0.03404	0.04858	0.0652	0.08336	0.10251	0.1215
12 GDPPI	0.00408	0.01169	0.00804	0.01343	0.01791	0.02157	0.02459	0.02716	0.02947	0.03172	0.01667
13 CPI	0	0	0	0	0	0	0	0	0	0	0
14 ExportPI	-0.00233	-0.00836	-0.01131	-0.02038	-0.03357	-0.05128	-0.07366	-0.10053	-0.13138	-0.16552	-0.15812
15 ImpsLandedPI	-0.00657	-0.02084	-0.02119	-0.03627	-0.05477	-0.07706	-0.10332	-0.13344	-0.1671	-0.20383	-0.19097
16 Population	0	0	0	0	0	0	0	0	0	0	0
17 NomHou	0.00494	0.01552	0.01521	0.02574	0.03784	0.05166	0.06723	0.08445	0.10317	0.12317	0.11722
18 NomGDP	0.00494	0.01552	0.01521	0.02574	0.03784	0.05166	0.06723	0.08445	0.10317	0.12317	0.11722

Source: POTERMDyn results

Table 3 Macro results of Scenario 2 (Converging) (%change YoY)

NatMacro(D)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1 RealHou	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12044	0.14272	0.13474
2 RealInv	0.03318	0.10303	0.10106	0.18062	0.26954	0.36833	0.47733	0.59692	0.72761	0.87	0.88698
3 RealGov	0.005	0.01575	0.01548	0.02844	0.04376	0.06133	0.08085	0.10188	0.12404	0.14704	0.13961
4 ExpVol	-0.01696	-0.04991	-0.0395	-0.07151	-0.10074	-0.12728	-0.15175	-0.17518	-0.1988	-0.22392	-0.20571
5 ImpVolUsed	0.0073	0.02294	0.02355	0.04308	0.06672	0.09529	0.12929	0.16881	0.21362	0.26332	0.26075
6 ImpsLanded	0.0073	0.02294	0.02355	0.04309	0.06673	0.0953	0.1293	0.16882	0.21363	0.26334	0.26077
7 RealGDP	0.00086	0.00384	0.00717	0.01267	0.02121	0.03255	0.04612	0.0613	0.07749	0.09426	0.10183
8 AggEmploy	0.00155	0.00516	0.00603	0.01119	0.01816	0.02711	0.03797	0.05051	0.06436	0.07914	0.07851
9 realwage_io	0.0031	0.01032	0.01207	0.02238	0.03632	0.05421	0.07596	0.10105	0.12876	0.15832	0.15706
10 plab_io	0.00315	0.01045	0.01221	0.02263	0.03664	0.05459	0.0764	0.10159	0.12944	0.15918	0.15773
11 AggCapStock	0	0.00208	0.0078	0.01331	0.02296	0.03603	0.05147	0.0683	0.08575	0.1033	0.11996
12 GDPI	0.00408	0.01169	0.00804	0.01541	0.02182	0.02746	0.03266	0.03774	0.04292	0.04842	0.03288
13 CPI	0	0	0	0	0	0	0	0	0	0	0
14 ExportPI	-0.00233	-0.00836	-0.01131	-0.02133	-0.03584	-0.05512	-0.07894	-0.1066	-0.13717	-0.16968	-0.15678
15 ImpsLandedPI	-0.00657	-0.02084	-0.02119	-0.0392	-0.06102	-0.08694	-0.11687	-0.15037	-0.18683	-0.22561	-0.20817
16 Population	0	0	0	0	0	0	0	0	0	0	0
17 NomHou	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12045	0.14272	0.13474
18 NomGDP	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12045	0.14272	0.13474

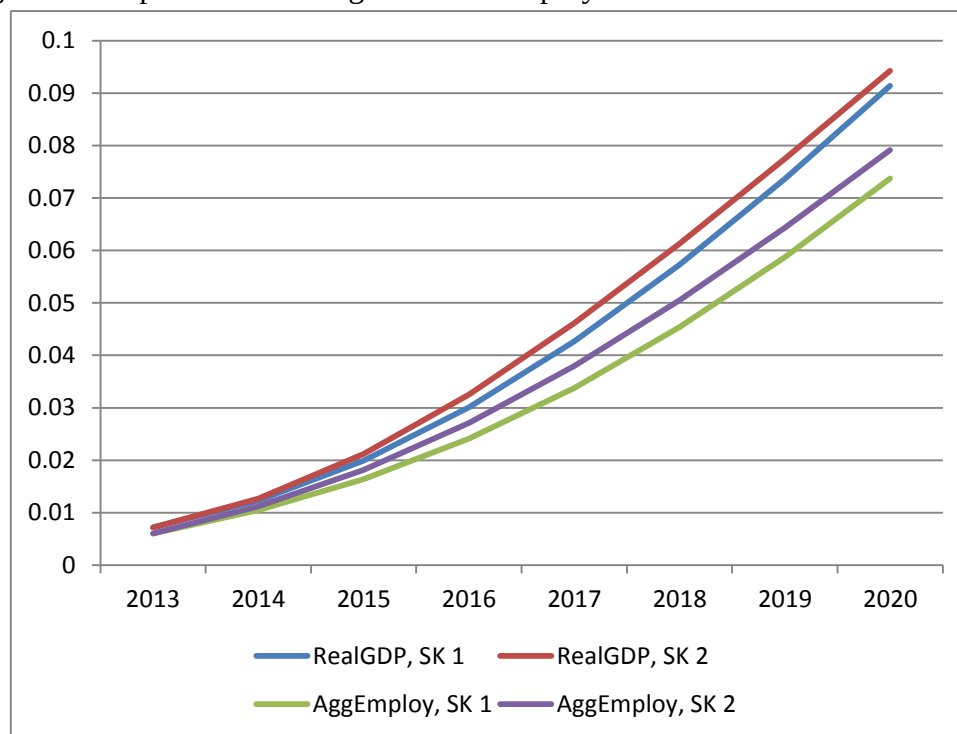
Source: POTERMDyn results

Table 4 Comparison of real GDP and aggregated employment in two scenarios

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average
RealGDP, SK 1	0.00086	0.00384	0.00717	0.0123	0.01993	0.03008	0.04263	0.05728	0.07368	0.09141	0.046759
RealGDP, SK 2	0.00086	0.00384	0.00717	0.01267	0.02121	0.03255	0.04612	0.0613	0.07749	0.09426	0.049371
AggEmploy, SK 1	0.00155	0.00516	0.00603	0.01047	0.01641	0.02412	0.03377	0.04536	0.05876	0.07372	0.037516
AggEmploy, SK 2	0.00155	0.00516	0.00603	0.01119	0.01816	0.02711	0.03797	0.05051	0.06436	0.07914	0.041206

Source: POLERMDyn results

Figure 3 Comparison of GDP growth and employment between the two scenarios



Source: POLTERMDyn results

4.2 The impact of R&D investments on national industries

The R&D investments have sectoral effects on output and employment. The key sector growing in both scenarios are: R&D, construction, accommodation and food, public administration, education and health.

4.3 The impact of R&D investments on Poland's regional economies

See tables in the Annex.

5. Conclusions

The increase of R&D spending to 1.7% or 3% of GDP - even if large in terms of money may have medium impact where R&D are is not well integrated with the rest of the economy. One example from the Polish reality was that large and modern laboratories built for R&D which now stay empty and only generate costs, due to lack of experts and financing there. What matters more for GDP creation is the links of R&D with the rest of the economy, rather than the amount of funds going to R&D investments.

The scenarios give similar results with slightly higher figures for Scenario assuming convergence. In reality it is however less likely one, because there is in fact an absorption limit in R&D investments, especially in those regions which have share of R&D in GDP at level of 0.2% or so.

For R&D to boost GDP growth, the characteristics of the regions matter; the regions which have universities, high technologies, patents etc. will gain more growth due to the same amount of R&D than those lacking it.

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Annexes

Table A1 Sectoral aggregation in the POLTERMDyn model for R&D analyses (consistent with NACE Rev. 2 sections)

# Sectors	Sections	Names of sectors	Short names
1	A	AGRICULTURE, FORESTRY AND FISHING	1 Agri
2	B	MINING AND QUARRYING	2 MinQuar
3	C	MANUFACTURING	3 Manuf
4	D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	4 ElecGas
5	E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	5 WatWast
6	F	CONSTRUCTION	6 Constr
7	G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	7 Trade
8	H	TRANSPORTATION AND STORAGE	8 Transp
9	I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	9 AccFood
10	J	INFORMATION AND COMMUNICATION	10 ICT
11	K	FINANCIAL AND INSURANCE ACTIVITIES	11 FinInsur
12	L	REAL ESTATE ACTIVITIES	12 RealEst
13	M.1	RESERACH AND DEVELOPMENT (R&D)	13 RandD
14	M.2	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES (no R&D)	14 Proffes
15	N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	15 AdmSup
16	O	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY	16 PubAdm
17	P	EDUCATION	17 Educat
18	Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES	18 Health
19	R,S,T,U	OTHER SERVICES, incl. ARTS, ENTERTAINMENT AND RECREATION ,OTHER SERVICE ACTIVITIES, ACTIVITIES OF HOUSEHOLDS AS EMPLOYERS; U0NDIFFERENTIATED GOODS- AND SERVICES-PRODUCING ACTIVITIES OF HOUSEHOLDS FOR OWN USE , ACTIVITIES OF EXTRATERRITORIAL ORGANISATIONS AND BODIES	19 RecrOther

Source: POTERMDyn database

Table A2. Data for scenarios

Scenario 0 Baseline: constant share of R&D expenditures in GDP																				
mln PLN	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
POLSKA	4522.1	4558.3	5155.4	5574.5	5892.8	6673.0	7706.2	9070.0	10416.2	11686.7	14352.9	14423.8	15072.9	15751.2	16460.0	17200.6	17974.7	18783.5	19628.8	
ŁÓDZKIE	298.6	274.4	299.9	320.5	355.1	372.8	424.7	492.9	553.2	578.5	762.8	677.0	707.5	739.3	772.6	807.3	843.7	881.6	921.3	
MAZOWIECKIE	1994.3	1997.5	2261.7	2322.8	2462.6	2742.3	3322.1	3498.1	4248.7	4675.6	4886.3	5688.8	5944.8	6212.3	6491.9	6794.0	7089.3	7408.3	7741.7	
MAŁOPOLSKIE *	496.5	520.0	645.6	731.9	726.8	799.8	895.3	922.6	1091.4	1210.5	1638.1	1660.3	1660.3	1735.0	1813.1	1894.7	1979.9	2069.0	2162.1	
ŚLĄSKIE *	342.5	374.9	402.8	438.5	495.6	587.1	609.2	956.5	848.8	1033.7	1298.5	1268.9	1326.0	1385.7	1448.0	1513.2	1581.3	1652.4	1726.8	
LUBELSKIE	138.5	136.7	168.0	182.9	180.8	246.1	239.9	295.9	362.2	378.0	652.2	402.1	420.2	439.1	458.9	479.5	501.1	523.6	547.2	
PODKARPACKIE *	119.0	115.4	104.0	111.6	157.3	156.4	177.4	189.0	508.3	542.2	634.4	793.7	829.4	866.7	905.7	946.5	989.1	1033.6	1080.1	
PODLASKIE	38.0	39.1	51.5	61.4	61.0	55.4	74.7	66.3	103.9	139.5	139.0	204.7	213.9	223.5	233.6	244.1	255.1	266.6	278.6	
ŚWIĘTOKRZYSKIE	14.1	12.7	18.3	19.5	21.5	35.6	92.2	146.7	167.9	143.0	121.5	140.3	146.6	153.2	160.1	167.3	174.8	182.7	190.9	
LUBUSKIE	25.2	32.7	23.2	35.8	23.8	25.9	28.2	29.0	45.5	56.0	70.0	94.7	99.0	103.4	108.1	112.9	118.0	123.3	128.9	
WIELKOPOLSKIE	324.7	358.2	372.6	435.5	454.7	563.7	611.5	845.9	777.8	910.1	1360.5	996.5	1041.3	1088.2	1137.2	1188.3	1241.8	1297.7	1356.1	
ZACHODNIOPOMORSKIE	90.6	57.7	64.2	70.0	81.6	111.0	125.2	117.8	173.8	196.5	224.5	184.6	192.9	201.6	210.7	220.1	230.0	240.4	251.2	
DOLNOŚLĄSKIE	276.5	258.2	289.8	346.5	298.2	393.5	457.4	581.3	630.0	725.2	971.4	908.8	949.7	992.4	1037.1	1083.8	1132.5	1183.5	1236.8	
OPOLSKIE	30.2	28.3	29.4	28.0	36.3	36.3	40.4	68.4	38.5	84.2	66.1	79.3	82.9	86.6	90.5	94.6	98.8	103.3	107.9	
KUJAWSKO-POMORSKIE	110.4	101.0	120.4	114.7	175.3	109.5	129.4	346.8	204.2	187.3	304.4	228.9	239.2	250.0	261.2	273.0	285.3	298.1	311.5	
POMORSKIE	166.6	198.4	247.6	288.7	307.1	340.9	398.2	397.4	488.4	625.3	1011.1	933.7	975.7	1019.6	1065.5	1113.5	1163.6	1215.9	1270.6	
WARMIŃSKO-MAZURSKIE	56.4	53.1	56.3	66.2	55.1	96.6	80.5	115.5	173.8	201.1	212.1	161.5	168.8	176.4	184.3	192.6	201.3	210.3	219.8	

Scenario 1 Proportional: All regions increase R&D proportionally to their current (2013) shares in total R&D spending

mln PLN	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
POLSKA	4522.1	4558.3	5155.4	5574.5	5892.8	6673.0	7706.2	9070.0	10416.2	11686.7	14352.9	14423.8	17137.7	20066.5	23224.3	26625.7	30286.1	34222.1	38451.0
ŁÓDZKIE	298.6	274.4	299.9	320.5	355.1	372.8	424.7	492.9	553.2	578.5	762.8	677.0	804.4	941.8	1090.1	1249.7	1421.5	1606.3	1804.7
MAZOWIECKIE	1994.3	1997.5	2261.7	2322.8	2462.6	2742.3	3322.1	3498.1	4248.7	4675.6	4886.3	5688.8	6759.2	7914.3	9159.8	10501.3	11945.0	13497.3	15165.2
MAŁOPOLSKIE *	496.5	520.0	645.6	731.9	726.8	799.8	895.3	922.6	1091.4	1210.5	1638.1	1660.3	1972.7	2309.8	2673.3	3064.8	3486.2	3939.3	4426.0
ŚLĄSKIE *	342.5	374.9	402.8	438.5	495.6	587.1	609.2	956.5	848.8	1033.7	1298.5	1268.9	1507.6	1765.3	2043.1	2342.3	2664.4	3010.6	3382.6
LUBELSKIE	138.5	136.7	168.0	182.9	180.8	246.1	239.9	295.9	362.2	378.0	652.2	402.1	477.8	559.4	647.4	742.3	844.3	954.0	1071.9
PODKARPACKIE *	119.0	115.4	104.0	111.6	157.3	156.4	177.4	189.0	508.3	542.2	634.4	793.7	943.0	1104.2	1278.0	1465.1	1666.6	1883.1	2115.8
PODLASKIE	38.0	39.1	51.5	61.4	61.0	55.4	74.7	66.3	103.9	139.5	139.0	204.7	243.2	284.8	329.6	377.9	429.8	485.7	545.7
ŚWIĘTOKRZYSKIE	14.1	12.7	18.3	19.5	21.5	35.6	92.2	146.7	167.9	143.0	121.5	140.3	166.7	195.2	225.9	259.0	294.6	332.9	374.0
LUBUSKIE	25.2	32.7	23.2	35.8	23.8	25.9	28.2	29.0	45.5	56.0	70.0	94.7	112.5	131.7	152.5	174.8	198.8	224.7	252.5
WIELKOPOLSKIE	324.7	358.2	372.6	435.5	454.7	563.7	611.5	845.9	777.8	910.1	1360.5	996.5	1184.0	1386.3	1604.5	1839.5	2092.4	2364.3	2656.5
ZACHODNIOPOMORSKIE	90.6	57.7	64.2	70.0	81.6	111.0	125.2	117.8	173.8	196.5	224.5	184.6	219.3	256.8	297.2	340.8	387.6	438.0	492.1
DOLNOŚLĄSKIE	276.5	258.2	289.8	346.5	298.2	393.5	457.4	581.3	630.0	725.2	971.4	908.8	1079.8	1264.3	1463.3	1677.6	1908.2	2156.2	2422.7
OPOLSKIE	30.2	28.3	29.4	28.0	36.3	36.3	40.4	68.4	38.5	84.2	66.1	79.3	94.2	110.3	127.7	146.4	166.5	188.1	211.4
KUJAWSKO-POMORSKIE	110.4	101.0	120.4	114.7	175.3	109.5	129.4	346.8	204.2	187.3	304.4	228.9	272.0	318.4	368.6	422.5	480.6	543.1	610.2
POMORSKIE	166.6	198.4	247.6	288.7	307.1	340.9	398.2	397.4	488.4	625.3	1011.1	933.7	1109.4	1299.0	1503.4	1723.6	1960.5	2215.3	2489.1
WARMIŃSKO-MAZURSKIE	56.4	53.1	56.3	66.2	55.1	96.6	80.5	115.5	173.8	201.1	212.1	161.5	191.9	224.7	260.0	298.1	339.1	383.2	430.5

Scenario 2 Convergence: All regions increase R&D spending to 1,7% od GDP by 2020

mln PLN	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
POLSKA	4522.1	4558.3	5155.4	5574.5	5892.8	6673.0	7706.2	9070.0	10416.2	11686.7	14352.9	14423.8	17137.7	20066.5	23224.3	26625.7	30286.1	34222.1	38451.0
ŁÓDZKIE	298.6	274.4	299.9	320.5	355.1	372.8	424.7	492.9	553.2	578.5	762.8	677.0	863.8	1066.0	1284.7	1520.9	1775.8	2050.5	2346.4
MAZOWIECKIE	1994.3	1997.5	2261.7	2322.8	2462.6	2742.3	3322.1	3498.1	4248.7	4675.6	4886.3	5688.8	6020.6	6370.8	6740.3	7130.1	7541.4	7975.3	8432.9
MAŁOPOLSKIE *	496.5	520.0	645.6	731.9	726.8	799.8	895.3	922.6	1091.4	1210.5	1638.1	1660.3	1812.0	1974.0	2147.0	2331.5	2528.2	2737.9	2961.4
ŚLĄSKIE *	342.5	374.9	402.8	438.5	495.6	587.1	609.2	956.5	848.8	1033.7	1298.5	1268.9	1662.2	2088.3	2549.3	3047.7	3585.7	4166.0	4791.3
LUBELSKIE	138.5	136.7	168.0	182.9	180.8	246.1	239.9	295.9	362.2	378.0	652.2	402.1	527.3	662.9	809.7	968.3	1139.5	1324.3	1523.3
PODKARPACKIE *	119.0	115.4	104.0	111.6	157.3	156.4	177.4	189.0	508.3	542.2	634.4	793.7	876.8	965.8	1061.0	1162.9	1271.7	1388.0	1512.2
PODLASKIE	38.0	39.1	51.5	61.4	61.0	55.4	74.7	66.3	103.9	139.5	139.0	204.7	278.8	359.1	446.1	540.2	641.9	751.6	869.9
ŚWIĘTOKRZYSKIE	14.1	12.7	18.3	19.5	21.5	35.6	92.2	146.7	167.9	143.0	121.5	140.3	227.3	321.9	424.9	535.6	656.0	786.0	926.5
LUBUSKIE	25.2	32.7	23.2	35.8	23.8	25.9	28.2	29.0	45.5	56.0	70.0	94.7	178.6	269.8	368.9	476.3	592.7	718.6	854.6
WIELKOPOLSKIE	324.7	358.2	372.6	435.5	454.7	563.7	611.5	845.9	777.8	910.1	1360.5	996.5	1302.4	1633.8	1992.4	2380.0	2798.4	3249.7	3735.9
ZACHODNIOPOMORSKIE	90.6	57.7	64.2	70.0	81.6	111.0	125.2	117.8	173.8	196.5	224.5	184.6	323.9	475.3	639.7	817.9	1010.9	1219.6	1445.1
DOLNOŚLĄSKIE	276.5	258.2	289.8	346.5	298.2	393.5	457.4	581.3	630.0	725.2	971.4	908.8	1171.6	1456.2	1764.1	2096.7	2455.7	2842.8	3259.7
OPOLSKIE	30.2	28.3	29.4	28.0	36.3	36.3	40.4	68.4	38.5	84.2	66.1	79.3	160.2	248.2	343.8	447.5	559.8	681.4	812.7
KUJAWSKO-POMORSKIE	110.4	101.0	120.4	114.7	175.3	109.5	129.4	346.8	204.2	187.3	304.4	228.9	394.1	573.8	768.8	980.2	1209.1	1456.6	1723.9
POMORSKIE	166.6	198.4	247.6	288.7	307.1	340.9	398.2	397.4	488.4	625.3	1011.1	933.7	1079.2	1235.9	1404.5	1585.8	1780.6	1989.7	2214.0
WARMIŃSKO-MAZURSKIE	56.4	53.1	56.3	66.2	55.1	96.6	80.5	115.5	173.8	201.1	212.1	161.5	258.9	364.7	479.5	603.9	738.6	884.1	1041.2

Source: Own calculations

Table A.3 Scenario 1 regional macroeconomic results for targeted year 2020

MainMacro(D)	1 DOLNOL	2 KUJPO	3 LUBELSK	4 LUBUSKI	5 LODZKIE	6 MALOPC	7 MAZOW	8 OPOLSKI	9 PODKAR	10 PODLA	11 POMOR	12 SLASKIE	13 SWIETC	14 WARM	15 WIELKC	16 ZACHPC
1 RealHou	0.03111	-0.03385	0.00356	0.15548	-0.00244	0.30665	0.27178	0.16925	0.07087	0.19459	0.23699	0.07922	-0.1123	-0.11399	0.04166	0.06453
2 RealInv	0.64361	0.31417	0.42473	0.6676	0.27933	1.13566	0.91447	0.28836	0.62404	0.49034	0.90573	1.30106	0.11387	0.22209	0.5898	0.30013
3 RealGov	0.03111	-0.03385	0.00356	0.15548	-0.00244	0.30665	0.27178	0.16925	0.07087	0.19459	0.23699	0.07923	-0.11229	-0.11399	0.04166	0.06453
4 ExpVol	-0.10866	-0.09535	-0.17803	-0.16597	-0.13231	-0.20972	0.00755	-0.16709	-0.21462	-0.22448	-0.18653	-0.21708	-0.14565	-0.10377	-0.11458	-0.10456
5 ImpVolUsed	0.12545	0.08344	0.15692	0.21021	0.10286	0.39823	0.43221	0.17486	0.1659	0.23937	0.29522	0.24088	0.04414	0.0341	0.14447	0.1641
6 ImpsLanded	0.14897	0.11351	0.16403	0.2111	0.12867	0.36625	0.40494	0.18517	0.17693	0.23353	0.22374	0.24989	0.0841	0.07292	0.16381	0.11797
7 RealGDP	0.06773	0.02765	0.04049	0.1106	0.03843	0.17903	0.17593	0.11854	0.0649	0.111	0.14814	0.0816	-0.01073	-0.00284	0.06308	0.07013
8 AggEmploy	0.02673	-0.00729	0.01231	0.09186	0.00916	0.17097	0.15272	0.09907	0.04756	0.11233	0.13452	0.05193	-0.0484	-0.04929	0.03226	0.04424
9 realwage_io	0.10507	0.07411	0.09193	0.16432	0.08908	0.23628	0.21968	0.17087	0.12401	0.18293	0.20312	0.12799	0.0367	0.03589	0.11009	0.12099
10 plab_io	0.05032	0.00593	0.07149	0.13242	0.0497	0.30733	0.30358	0.1458	0.10015	0.18962	0.22096	0.12421	-0.01972	-0.03686	0.06008	0.10388
11 AggCapStock	0.10403	0.05688	0.06012	0.12418	0.0652	0.18356	0.19158	0.12954	0.07986	0.11187	0.15465	0.10482	0.02474	0.0347	0.08711	0.09185
12 GDPPi	-0.06547	-0.05672	0.00378	-0.01765	-0.02522	0.12253	0.06805	-0.02084	0.01773	0.03768	0.05344	0.03706	-0.0312	-0.07643	-0.03417	0.00208
13 CPI	-0.05468	-0.06812	-0.02042	-0.03184	-0.03935	0.07088	0.08372	-0.02503	-0.02383	0.00667	0.0178	-0.00378	-0.0564	-0.07273	-0.04996	-0.01709
14 ExportPI	-0.16384	-0.16716	-0.1465	-0.14951	-0.15793	-0.13857	-0.19285	-0.14923	-0.13735	-0.13488	-0.14437	-0.13673	-0.15459	-0.16506	-0.16236	-0.16486
15 ImpsLandedPI	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097	-0.19097
16 Population	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 NomHou	-0.02359	-0.10194	-0.01686	0.12359	-0.04179	0.37775	0.35571	0.14418	0.04702	0.20127	0.25483	0.07543	-0.16863	-0.18664	-0.00832	0.04743
18 NomGDP	0.00221	-0.02908	0.04427	0.09294	0.01321	0.30177	0.2441	0.09768	0.08264	0.14872	0.20165	0.11869	-0.04193	-0.07928	0.02889	0.07221

Source: POTERMDyn results

Table A.4. Macro results of Scenario 2 (Converging)

NatMacro(D)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1 RealHou	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12044	0.14272	0.13474
2 RealInv	0.03318	0.10303	0.10106	0.18062	0.26954	0.36833	0.47733	0.59692	0.72761	0.87	0.88698
3 RealGov	0.005	0.01575	0.01548	0.02844	0.04376	0.06133	0.08085	0.10188	0.12404	0.14704	0.13961
4 ExpVol	-0.01696	-0.04991	-0.0395	-0.07151	-0.10074	-0.12728	-0.15175	-0.17518	-0.1988	-0.22392	-0.20571
5 ImpVolUsed	0.0073	0.02294	0.02355	0.04308	0.06672	0.09529	0.12929	0.16881	0.21362	0.26332	0.26075
6 ImpsLanded	0.0073	0.02294	0.02355	0.04309	0.06673	0.0953	0.1293	0.16882	0.21363	0.26334	0.26077
7 RealGDP	0.00086	0.00384	0.00717	0.01267	0.02121	0.03255	0.04612	0.0613	0.07749	0.09426	0.10183
8 AggEmploy	0.00155	0.00516	0.00603	0.01119	0.01816	0.02711	0.03797	0.05051	0.06436	0.07914	0.07851
9 realwage_io	0.0031	0.01032	0.01207	0.02238	0.03632	0.05421	0.07596	0.10105	0.12876	0.15832	0.15706
10 plab_io	0.00315	0.01045	0.01221	0.02263	0.03664	0.05459	0.0764	0.10159	0.12944	0.15918	0.15773
11 AggCapStock	0	0.00208	0.0078	0.01331	0.02296	0.03603	0.05147	0.0683	0.08575	0.1033	0.11996
12 GDPPi	0.00408	0.01169	0.00804	0.01541	0.02182	0.02746	0.03266	0.03774	0.04292	0.04842	0.03288
13 CPI	0	0	0	0	0	0	0	0	0	0	0
14 ExportPI	-0.00233	-0.00836	-0.01131	-0.02133	-0.03584	-0.05512	-0.07894	-0.1066	-0.13717	-0.16968	-0.15678
15 ImpsLandedPI	-0.00657	-0.02084	-0.02119	-0.0392	-0.06102	-0.08694	-0.11687	-0.15037	-0.18683	-0.22561	-0.20817
16 Population	0	0	0	0	0	0	0	0	0	0	0
17 NomHou	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12045	0.14272	0.13474
18 NomGDP	0.00494	0.01552	0.01521	0.02808	0.04303	0.06002	0.0788	0.09905	0.12045	0.14272	0.13474

Source: POTERMDyn results

Table 4A.b Scenario 2 regional macroeconomic results for targeted year 2020

MainMacro(D)	1 DOLNOSL	2 KUJPOM	3 LUBELSK	4 LUBUSKI	5 LODZKIE	6 MALOPC	7 MAZOW	8 OPOLSKI	9 PODKAR	10 PODLA	11 POMOF	12 SLASKII	13 SWIETC	14 WARM	15 WIELKC	16 ZACHPC
1 RealHou	0.09482	0.28528	0.10496	0.48248	0.05681	0.13559	-0.01565	0.56578	-0.02769	0.32958	0.1752	0.17069	0.12121	0.16704	0.12122	0.46167
2 RealInv	0.94071	1.2675	0.7092	2.57986	0.42053	0.67685	0.34232	1.30921	0.39157	0.83644	0.79174	2.027	0.42311	0.85662	0.92731	1.15542
3 RealGov	0.09482	0.28528	0.10496	0.48249	0.05681	0.13559	-0.01565	0.56578	-0.0277	0.32958	0.1752	0.1707	0.12122	0.16704	0.12122	0.46167
4 ExpVol	-0.16775	-0.33927	-0.21315	-0.4749	-0.16701	-0.19945	-0.02221	-0.37999	-0.15404	-0.29641	-0.17831	-0.32997	-0.22621	-0.25879	-0.20133	-0.23037
5 ImpVolUsed	0.19326	0.3455	0.23587	0.5957	0.15255	0.25955	0.18264	0.48217	0.10073	0.34488	0.26313	0.36387	0.18319	0.23965	0.22886	0.49598
6 ImpsLanded	0.2225	0.33367	0.22948	0.52582	0.17705	0.25823	0.19928	0.43981	0.12689	0.32179	0.2204	0.35693	0.19719	0.22369	0.2535	0.29086
7 RealGDP	0.09213	0.14091	0.07609	0.23606	0.06172	0.11202	0.05867	0.26844	0.03115	0.15598	0.12696	0.11669	0.07642	0.09407	0.09172	0.22274
8 AggEmploy	0.05808	0.15777	0.06339	0.26088	0.03818	0.07943	0.00022	0.30441	-0.00609	0.18094	0.10017	0.09781	0.0719	0.09589	0.07191	0.25
9 realwage_io	0.13848	0.22917	0.1433	0.32298	0.12037	0.1579	0.08584	0.36257	0.08009	0.25025	0.17676	0.17462	0.15105	0.17288	0.15106	0.31308
10 plab_io	0.10385	0.26574	0.13808	0.41984	0.0848	0.17013	0.05569	0.43527	0.01438	0.28868	0.17931	0.20686	0.13269	0.16795	0.13223	0.46504
11 AggCapStock	0.12372	0.13591	0.08709	0.2085	0.08467	0.13332	0.09718	0.23189	0.05945	0.14291	0.14237	0.13084	0.09175	0.10282	0.10958	0.21296
12 GDPPPI	-0.02119	0.12601	0.03513	0.21105	-0.01382	0.03875	-0.05588	0.15231	-0.04746	0.0969	0.02993	0.11359	0.03233	0.04786	0.02496	0.22808
13 CPI	-0.03458	0.03649	-0.00522	0.09655	-0.03553	0.01222	-0.03012	0.07244	-0.06566	0.03834	0.00254	0.03218	-0.01833	-0.00492	-0.0188	0.15149
14 ExportPI	-0.16628	-0.12335	-0.15492	-0.08934	-0.16646	-0.15835	-0.20263	-0.11314	-0.1697	-0.13409	-0.16364	-0.12568	-0.15165	-0.1435	-0.15788	-0.15062
15 ImpsLandedPI	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817	-0.20817
16 Population	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17 NomHou	0.06021	0.32187	0.09973	0.5795	0.02126	0.14782	-0.04578	0.63863	-0.09334	0.36805	0.17775	0.20293	0.10287	0.16211	0.1024	0.61386
18 NomGDP	0.07091	0.26711	0.11125	0.44761	0.04789	0.15081	0.00276	0.42116	-0.01632	0.25302	0.15693	0.23042	0.10878	0.14197	0.1167	0.45134

Source: POTERMDyn results