The Recovery of the Input-Output Analysis in the Czech Republic

Jaroslav Sixta[1] | *University of Economics, Prague, Czech Republic*

Abstract

The input-output analysis has a long tradition in the former Czechoslovakia starting in the 1960s. These models were originally used for central planning and price re-construction during socialism. Since the 1970s, there have been three sets of tables, for Czechoslovakia, the Czech Republic and the Slovak Republic. After 1989, input-output models gained a label of socialist planning instrument and they were mostly abandoned in Eastern countries. On the contrary, sophisticated input-output models became accessible for the most researchers in the West because of common usage of personal computers. Matrix computations that took months in the past became available to everyone. Alongside with the supply of input-output tables of the EU countries, also researchers in the Central and East Europe started to use these sets of models again. In the recent time, the input-output models are widely used both on national and international level, ranging from private agencies to the OECD. Nowadays, the recovery of Leontief models and theory has been used in the Czech Republic, as well. Such models have become a standard part of the research for macroeconomic, environmental, regional and similar purposes.[2]

Keywords

Input-output analysis, supply and use tables, national accounts

JEL code

C67, E20

INTRODUCTION

The history and objectives of the input-output analysis are fascinating. The ideas that led people to the construction of the input-output model, predictions and assessment of the development of the economy, grew into different branches of economics and among them we cannot omit Leontief' input-output analysis. The history of the concept and its applications around the world from the early 1920s to the contemporary sophisticated models shows us how a relatively simple concept at the beginning can be extended and searched for by many followers.

The roots of input-output tables are usually located to the time of Francois Quesnay, a Belgian, acting in France in the 18th century and, among other things, he brought Tableau Économique. W. Leontief

[1] Department of Economic Statistics, Faculty of Informatics and Statistics, University of Economics, Prague, Nám. W. Churchilla 4, 130 67 Prague 3, Czech Republic. The author is also working at the Czech Statistical Office, Na Padesátém 81, 100 82 Prague 10, Czech Republic. E-mail: sixta@vse.cz, jaroslav.sixta@czso.cz.

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also followed the General Equilibrium Theory developed by L. Walras. Nowadays, it is pretty difficult to identify whose ideas were implemented at first. It is obvious that Human efforts for generalising and graphical description of the economic flows were perpetual and extended dynamic gained at the beginning of the 20th century. The link between production, consumption and wealth is an outstanding issue and input-output based tools are often used for similar analyses. The production function that stands behind the input-output model cannot be omitted, neither can other assumptions. The potential of input-output tables is extraordinary since a detailed description of the economy allows connection between many different areas of human being. Beside economics, a lot of different input-output based applications can be found in environmental area or social science.

There is probably no single author of input-output tables since Leontief presented input-output tables but similar tables were used in the Soviet Union, as well. Soviet scientists as Vladimir G. Groman, Pavel I. Popov and Lev N. Litoschenko were working on the description of the centrally planned economy and construction of the first five-years plans. Similar processes used for the systematic description of the economy were applied in Nazi Gemany, as well, see Staeglin and Fremdling, 2012. Anyway, the milestone of input-output analysis came along with the work of Wassily Leontief despite all disputations about the invention of input-output tables. However, the invention of input-output analysis can be hardly disputed. The work of W. Leontief awarded by Nobel Prize in 1973 went into history of economics. His definition of production function and fixed input constraints have been used as a basis for future more or less flexible econometric models. Among Leontief's pupils, we can find such great economists as Rober Sollow, Vernon Smith, Paul Samuelson and others. There is also a lot of literature devoted to the input-output analysis, such as Miller and Blair (2009).

1 FOUNDATIONS OF THE INPUT-OUTPUT TABLES AND ANALYSIS IN THE CZECH REPUBLIC

The roots of the input-output analysis are connected with central planning in the former Czechoslovakia in the late 1950s. The first practical estimates were realised in the 1960s when the Federal Statistical Office published symmetric the input-output tables for former Czechoslovakia. These so-called commodity-by-commodity or commodity-by-organisation structural balances were compiled every five years. It was predominantly a tool for central planning processed in high detail (hundreds of commodities) but the computational issue became one of the most relevant problems associated with the use of this tool. The demands for dimension due to planning purposes became very challenging. The planning commission intended to use input-output tables mainly for price reconstructions (Sixta, 2015) and central planning in line with the Soviet model. Separate input-output tables for the Czech Republic then used for the Czech Socialist Republic began to be compiled from the 1970s. The first set was published for 1973, see Sixta (2013). The detail of the breakdown of individual Czech and Slovak input-output tables was lower than the federal one. Initial attempts for combination of western System of National Accounts and socialist Material Product System failed, see Arvay (1992) and, later, former Czechoslovakia and other socialist countries switched to national accounts.

At the begging of the 1990s, when the previous statistical system – System of the Balances of National Economy was abandoned and the System of National Accounts began to be implemented, a big gap appeared in the use of the input-output analysis. The stigma of the planning tool that input-output tables gained from the socialist era was difficult to overcome. Moreover, the problem of the data availability was also serious. The set input-output framework was often regarded as a supplementary issue of national accounts rather than core business. To date, this is very much reflected in the priorities of statistical offices.

The Czech Statistical Office published the first set of input-output tables in 1995 for the Czech Republic for 1992. Since then the publication of supply and use tables at purchasers' prices has been started. The Czech Statistical Office had been working on the incorporation of supply and use tables into regular compilation process, but these tables were compiled seldom and later finished for 1995 and 1997.

The Czech Statistical Office carried out the first comprehensive revision of national accounts in 2004 and since then input-output tables are fully incorporated into Czech national accounts. These tables are compiled less frequently than in obligatory five year period. Currently, the Czech Statistical Office publishes supply and use tables (SUTs), symmetric product-by-products tables and symmetric industry-by-industry tables at basic prices. These tables are also available for total economy, the use of domestic output and the use of imported products. Since 2014 when the latest revision took place, new economic elements such as processing services, merchanting and re-exports have been introduced into national accounts and input-output tables, see Musil and Cihlář (2016). These latest amendments are easy to confuse scientists who are used to traditional input-output tables. Some of changes very often offer a strange view on the economy on the first sight. In many cases the efforts for statistical purity leads to very complicated statistical outcome and the figures lose their explanatory purpose.

2 WHAT IS A MODERN INPUT-OUTPUT TABLE?

Lots of experts think that the input-output table is still the same as it was in the 1930s or at least that some of the changes and updates done were relatively negligible. From the technical point of view, they are right, the table is the same, and it still has three quadrants. However, the content has changed

Figure 1 Symmetric Input-Output Table for 1973, Czech Republic, CSK mil.

Industry	Intermediate consumption (IC)				TOTAL (IC)	Personal consum-ption	Social consum-ption.	Investment + inventories	Export	Transfers with Slovakia	Losses and differences	Uses
	Agric.	Industry	Constr.	Services								
Agriculture	20 837	34 629	129	60	55 655	11 673	1 866	2 742	1 575	–1 249	1 553	73 815
Industry	17 602	302 596	28 775	23 864	372 838	121 141	24 006	36 826	73 255	4 130	–1 502	630 694
Construction	503	2 706	1 923	2 306	7 437	697	7 455	54 440	918	–70	–101	70 776
Services	2 690	39 115	6 414	9 420	57 638	8 963	1 650	1	18 037	0	–214	86 075
Total IC	41 631	379 045	37 242	35 650	493 568	142 473	34 977	94 008	93 785	2 811	–263	861 359
Depreciation	2 626	14 687	1 241	7 132	25 686							
Wages	20 058	52 079	14 066	23 427	109 630							
Other net production	4 558	30 481	9 343	14 014	58 396							
Profit	–2 013	48 590	7 097	917	54 591							
Sales tax	99	38 469	1	0	38 568							
Gross value added	25 329	184 306	31 747	45 490	286 872							
Output	66 960	563 351	68 989	81 141	780 440							
Import	6 854	67 342	1 787	4 934	80 918							
Resources	73 814	630 694	70 776	86 075	861 358							

Source: Sixta (2013)

significantly in line with the development of national accounts and development of the measurement of the product (Sixta, 2015).

The question what and how it should be measured has been discussed just from the foundation of input-output tables. Input-output tables describe production, i.e. output in national accounts methodology[3] and therefore core issue lies in the definition of production. The scope of human activities defining range of production has been still developing. From a relatively narrow set of activities in F. Quesnay table to very broad categories of output that are not traded on the market and just imputed. Some activities are easily measured such as selling goods, providing service but some of them are measured with difficulties such as imputed rentals, agriculture self-supply or outcomes of publicity available research.

It can be easily demonstrated on the case of socialist and modern input-output table. In line with the state ideology of Marxism, so called non-productive sphere providing non-market services or pseudo-market services for households were not measured. It means that about 1/3 of domestic products was not covered even though the table look like the same as used in the West, see Figure 1.

It can be mentioned that some tricky situation appeared when studying these tables. For example, telecommunication services were relatively expensive and profitable in the late 1970s and 1980s and despite that, they were regarded as non-productive if purchased by households. Such tricky issues complicated statistical picture of the economy as well as data compilation. In this particular case it means that the profit and loss statements of the telecommunication company had to be artificially divided into two parts. We could find many different examples how the measurement issues had to be put in line with the state ideology.

When we compare socialist input-output table with the modern one, we will not find significant difference on the first sight, see Figure 2.

In fact, the crucial difference lies in the definitions of indicators within the cells of the input-output table. The scope of national accounts has been constantly increasing in line with the development of the society. Currently, the definition of production is very wide and the same stands for the definition of final use. It is not useful to recall all the changes in national accounts' standard and it is important to focus on the latest one.[4] The SNA 2008 and its European modification ESA 2010 brought some important changes that affected the input-output tables on a large scale. At least the following two changes influence input-output tables significantly.

ESA 2010 and SNA 1993 brought the most notable changes connected with **wider definition of investments** (asset borderline). Gross capital formation currently comprises intellectual assets such as expenditure on research and development, software, databases etc. In practice, it means that new products appeared in the gross capital formation column for particular rows (products).

The second change is connected with different **treatment of foreign trade**. Incorporation of re-export means that the country can export products even though these products are not produced within the country. Thus, we can have zero output and non-zero exports (and imports). This change is not very logical for input-output tables' users, but it reflects the pure change of the ownership of goods. This affects only the table for totals. The tables describing the use of domestic output are not influenced. Therefore, more issues that are serious are connected with the methodical change of the recording of processing. Processing is the activity when the producer is working on the someone else´s goods. Despite that, according to SNA 1993, the goods entered into intermediate consumption and then into output. Producer was selling the goods at higher price composed from material costs and producer margin. Similarly, it was recorded in imports and exports. However, SNA 2008 requires that only producers´ margin should be recorded and exported. Therefore, a significant change in the notion of both foreign trade and output

[3] The question when input-output tables became a standard set of official national accounts is discussed in Sixta (2015).
[4] To those who are interested in the changes of national accounts, I can recommend Bos (1992) or Hronová et al. (2019).

Figure 2 Symmetric Input-Output Table for 2015, Czech Republic, CZK mil.

CZ-CPA	Label	Products CZ-CPA						TOTAL	Households	Governm +NPISH	GFCF	Inventories	Exports (F.O.B.)	Final use	Total uses
		A	B	C	D+E	F	G-U		P.3		P.51+P.53	P.52	P.6		
A	Agriculture	33 227	172	128 668	2827	917	21 555	187 366	63 644	352	3 143	7 821	57 152	132 112	319 478
B	Mining	560	2 870	104 812	64 640	7 496	6 071	186 449	3 062	0	0	2 564	48 138	53 764	240 213
C	Manufacturingl	66 778	12 629	2 076 707	61 293	149 744	435 572	2 802 723	502 796	30 790	480 424	54 272	3 018 110	4 086 392	6 889 115
D+E	Energy	4 711	3 258	92 543	104 561	6 951	74 984	287 008	162 681	2686	0	–1885	63 599	227 081	514 089
F	Construction	3 900	587	22 472	7 838	270 578	116 947	422 322	10 006	90	454 479	932	17 732	483 239	905 561
G-U	Setvices	41 339	10 666	568 676	60 305	195 206	1 619 213	2 495 405	1 106 134	870 549	238 959	–749	549 265	2 764 158	5 259 563
P.2	**Intermediates (bp)**	**150 515**	**30 182**	**2 993 878**	**301 464**	**630 892**	**2 274 342**	**6 381 273**	**1 848 323**	**904 467**	**1 177 005**	**62 955**	**3 753 996**	**7 746 746**	**14 128 019**
D.21 -D.31	Net taxes on p	4 947	402	19 849	691	7 327	84 170	117 386	276 705	5 812	44 827	0	15 474	342 818	460 204
P.2	**Intermediates (pp)**	**155 462**	**30 584**	**3 013 727**	**302 155**	**638 219**	**2 358 512**	**6 498 659**	**2 125 028**	**910 279**	**1 221 832**	**62 955**	**3 769 470**	**8 089 564**	**14 588 223**
D.1	Compensations	39 438	18 845	470 529	37 710	99 657	1 154 910	1 821 089							
D.29 -D.39	Other taxes	–28 310	–630	–2 319	2 221	740	2 151	–26 147							
K.1	CFC	22 660	8 900	202 169	68 183	35 801	631 064	968 777							
B.2n +B.3n	NOS	69 024	4 151	365 090	61 371	121 703	750 521	1 371 860							
B.1g	**GVA (bp)**	**102 812**	**31 266**	**1 035 469**	**169 485**	**257 901**	**2 538 646**	**4 135 579**							
P.1	**Output (bp)**	**258 274**	**61 850**	**4 049 196**	**471 640**	**896 120**	**4 897 158**	**10 634 238**							
P.7	**Imports (C.I.F)**	**61 204**	**178 363**	**2 839 919**	**42 449**	**9 441**	**362 405**	**3 493 781**							
P.1+P.7	**Resources**	**319 478**	**240 213**	**6 889 115**	**514 089**	**905 561**	**5 259 563**	**14 128 019**							

Source: Czech Statistical Office, own computations

took place. For example, the refinery does not produce petroleum from imported oil but produces only a service for a processing fee that exports to the owner of crude oil and finished petroleum. The last tricky point connected with foreign trade is co-called merchanting. It means that goods purchased and sold abroad is recorded on the gross concept on exports side. When purchasing goods as a negative export, it is recorded as export. Hence, the export for a particular product can be negative. Of course, when selling it is recorded in exports, as well. This change is not logical and it contributes to the confusion of the input-output tables' users.

Apart from directly visible changes, some other changes significant in the matter are not visible directly. One of the most important relates to the capitalisation of expenditures on research and development. The capitalisation caused that government expenditures were reclassified from the government expenditures to gross fixed capital formation of government sector. In some cases, reclassification of non-market output to output for own final use may lead to changes in product classification depending on the instruction. For example, the output of universities investing in research and development was classified as the product of education according to SNA 1993. However, in line with SNA 2008 at least two different products are produced, education and research and development. Expenditures on education are still used within government consumption expenditures but expenditures on research and development are classified as gross fixed capital formation.

Similarly as ESA 1995, ESA 2010 comprises in the chapter Input-Output Tables also Supply and Use tables. Supply and use tables are used mainly by statisticians for computational purposes such as deflation and balancing in national accounts. Supply and use tables also serve as a basis for modern input-output tables since the input-output tables are derived from supply and use tables at basic prices by mathematical models. The readers can find standard applications and links for both supply and use tables and input-output tables in the Manual (Eurostat, 2008). The Czech Statistical Office devoted a special web page to publication and methodology.[5]

3 WHO USES INPUT-OUTPUT TABLES AND WHY?

When compiling input-output tables statistical authorities should know their users. It allows both sides to avoid misunderstanding. Currently, there is a wide range of users covering statisticians, economists and environmentalists, etc. We can construct many models for different purposes using both statistic and dynamic description of the economy, see Šafr (2016). We can also find non-monetary models such as time input-output tables, see Zbranek and Fischer (2014). We can find many of examples in the Manual or we can use different publicly available applications.

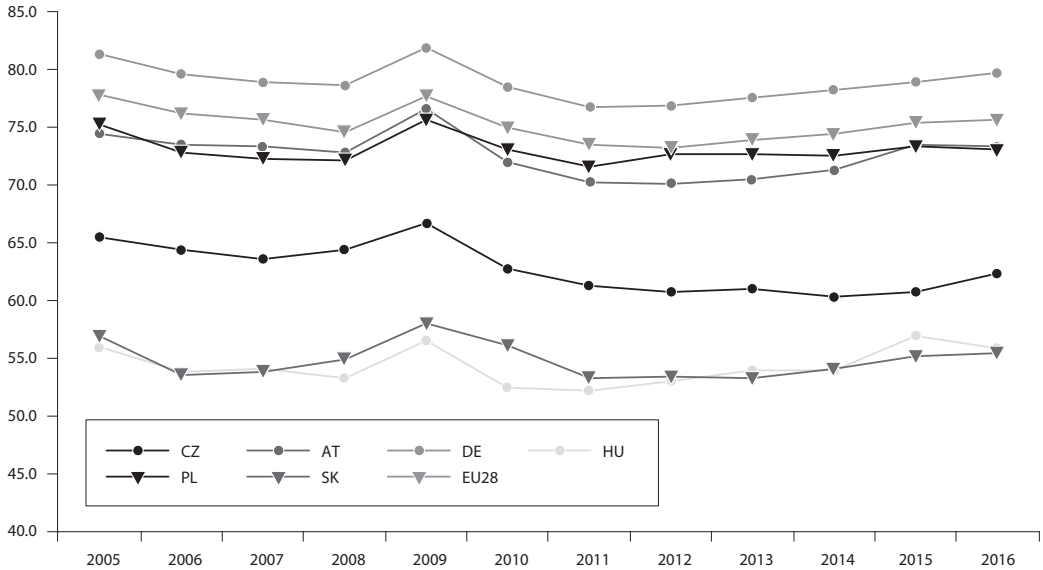
The OECD represents one of the most useful application that is available nowadays. This project is called "TiVA"[6] (Trade in Value Added). The extraordinary benefit of the TiVA database consists in the input-output approach to the value added that provides interesting qualitative information about country's economy. Among lots of interesting indicators, the share of domestic value added embodied in exports belongs to the most important, see Figure 3. It expresses how much gross value added created by domestic producers is embodied in the country's exports. The input-output model behind includes all subcomponents provided by domestic producers and excludes imported intermediates. This indicator shows both the country dependency on the imports and ability to provide high value added goods and services for foreign markets.

In many cases, simple indicators such as the share of export in GDP do not provide adequate information. In the Czech Republic where the share of exports in GDP reaches 80% in 2016, the situation is more complex. It is useful to discuss what the contribution of domestic economy and net befits are.

[5] *<http://apl.czso.cz/pll/rocenka/rocenkaout.dod_uziti?mylang=EN>.*

[6] For details see: *<http://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm>.*

Figure 3 The share of domestic value added in exports, in %



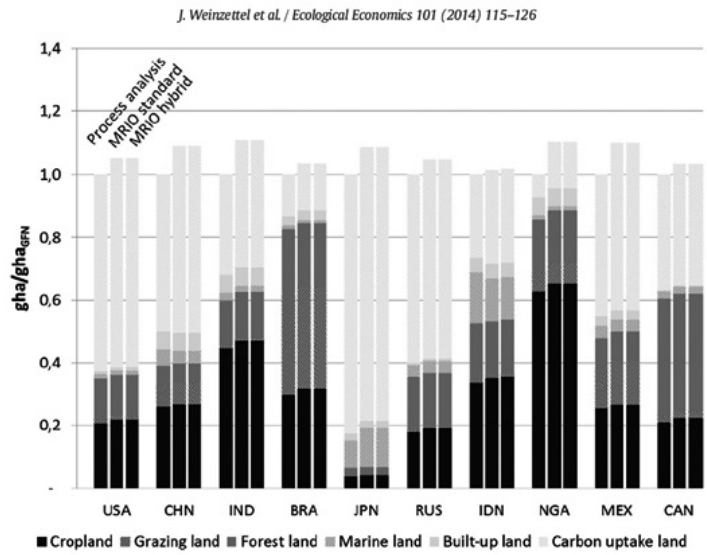
Source: Database TiVa, OECD

Data presented on the Figure 3 may help understand the issue. In 2005, the share of value added embodied in exports was 66% in the Czech Republic while the EU average was 78%. For available years (2005 to 2016), we can see slow downward trend. On the one side, the share of domestic value added in Czech exports is declining that indicates low ability to produce high-level value added goods. On the other side, the figures for the Czech Republic are influenced by the location of the country since many multinational enterprises locate their factories and distribution centres in the Centre of Europe. The exception was the year 2009 when the economy was influenced by economic crisis. Similar situation stands for Slovakia and Hungary. On the contrary, German economy reaches about 80% of value added in exports in the whole period and it shows us that the trade in value added for Germany is positive.

Beside economic studies,[7] input-output tables are very often used for environmental studies. Mostly when input-output tables can be arranged in the form of multiregional model describing simultaneously different regions and the links between them. This is very useful for environmental modelling since the effects of consumption or production can be distributed around the world. Such research is also conducted in the Czech Republic at the Charles University Environment Centre. Environment usage of input-output tables is focused on bringing the answers to the serious issues connected with the change of the climate, biodiversity, global warming etc. Figure 4 brings an example from this broad category of possible use, national requirements on bio-productive land, Weinzettel (2014). The picture shows requirements estimated by three different approaches based on enlarged input-output tables (multi-regional tables). The information presented in the chart refers to the necessary CO_2 absorption by the plants on the ground. We can find many different analyses relating to environmental research and input-output tables that fit very well for these purposes. The logic and assumption about the technology that stay behind the input-output tables is optimal for environmental studies.

[7] In many cases, input-output tables serve as a data source for other statistical computations, for example the structure of consumption of non-residents is used in computation of remittances, see Šimková and Langhamrová (2015).

Figure 4 National direct requirements on domestic bio-productive land



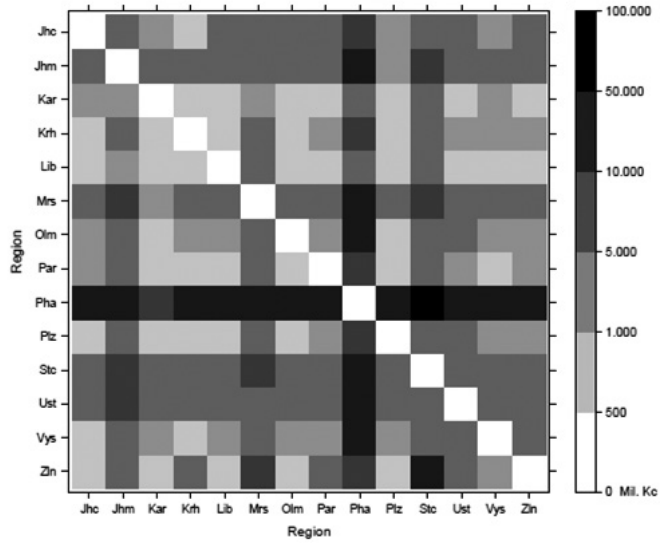
Source: Weinzettel (2014)

4 EXTENSION AND FOLLOW UP OF THE INPUT-OUTPUT ANALYSIS

Traditional usage of input-output tables is still very popular but the number of users of extended input-output tables is still rising. The focus on input-output tables is currently on extended input-output models. Among them, very popular branch is represented by regional extensions, see Leontief and Strout (1963). Regional extensions contain single regional input-output tables and interdependent multiregional tables. These tables are used for economic and environmental studies. That is why that the demand for regional input-output tables still exists despite the official supply of such data is relatively rare. Unfortunately, in the most cases this agenda is usually on the very edge of the interest of the official statistics. In some developed countries such as the United States, Finland, Spain or Australia they have sound experience with regional input-output tables. In the Czech Republic, the construction of regional input-output tables is an academic issue since the Czech Statistical Office does not compile them. Despite that, these tables exist due to the compilation by several scientists. The substantial difference between official statistical construction and scientific approach used mainly for the construction of technical confidents lies in the detail and consistency with nation accounts data.

One example of Czech regional input-output tables that are fully consistent with national symmetric input-output tables comes from the Department of Economic Statistics of the University of Economics in Prague. These regional input-output tables were compiled for 2011 and 2013 as sole regional tables for 14 regions of the Czech Republic (NUTS 3 level), see Sixta and Vltavská (2016). Later on, these tables were inter-connected by various approaches by Šafr (2018) and arranged in the form of the multiregional model. Figure 5 brings the illustration of the production flows between the regions of the Czech Republic that is a precondition for the construction of inter-regional model. This example was constructed on the basis of the Newton gravity approach. Interregional links are a subject of many input-output based studies despite general lack of data, e.g. Květoň and Šafr (2019). Similarly, the macroeconomic impact of the expenditures on specific events such as cultural events, educational events, etc. can be studied on regional level in a better way than on the total economy, see Vltavská and Fischer (2017). The issue of planning potential on the regional level is also tempting for policymakers.

Figure 5 Newton gravity approach used for estimation of production flows, CZK mil.



Note: Abbreviations of the codes are in the Annex.
Source: Šafr (2018)

Regional input-output tables are not compiled for the countries only. In fact, they are mostly constructed for the groups of regions, countries or economic blocks. We have also a good example on the European level, where Eurostat participated in the project 'Full International and Global Accounts for Research in Input-Output Analysis' (FIGARO), see Rueda-Cantuche and Rémond-Tiedrez (2016). This project was supported by the European Commission's Directorate-General 'Joint Research Centre'. The project is aimed to produce experimental EU-Inter Country Supply, Use and Input-Output Tables (EU-IC-SUIOTs) for the reference year 2010 in line with the ESA 2010 methodology, see Eurostat (2016). The project lasted 3 years and the results were published in 2018. It offers integrated sets of tables broken down by industries with linked capital and labour productivity indicators. It is a nice example of extending of rigid statistics for experimental approach. Moreover, the Eurostat plans to integrate it with environmental accounts and explore possible extensions with global business statistics.[8]

We can also identify input-output roots in Computable General Equilibrium (CGE) models that are very popular for economic modeling. The class of CGE models is very wide and due to increased computable possibilities available to nearly to anyone. There are many useful projects aimed at impacts of external shocks on economic equilibrium. The possibility of CGE models is very wide and currently in line with demographic ageing (Lisenkova et al., 2010). The Study of Lisenkova et al. is aimed at the economic impact of ageing on Scotland. The advantage of the CGE models is the possibility to incorporate decline in population, labour supply and economic activity or different migration scenarios. Similar project is also being solved for the Czech Republic at the University of Economics.[9] The key idea that social and demographic events in the society can be linked with economic statistics and with its main part

[8] The data can be approached at: <*https://ec.europa.eu/eurostat/web/experimental-statistics/figaro*>.
[9] The project "Economy of Successful Ageing", no. 19-03984S " is expected to be finished by December 2021. It should provide economic scenarios for population ageing of the Czech Republic by 2080.

(production) has been proved several times. I expect that multi-dimensional project combining different indicators and assumptions from wide area of human life will become more frequent.

CONCLUSION

Input-output agenda covering both input-output tables compiled by the official statistics and input-output analysis have long tradition in the Czech Republic. Usually, Czech scientist preferred product-by-product symmetric input-output tables. The popularity of input-output tables has its roots in the time of former socialist Czechoslovakia when this tool was used for central planning. Despite the fact, that the assumptions of input-output models clearly show that these models need to fit for centrally planning economies. In other words, I seriously doubt if input-output tables based planning under centrally planned economy is possible. Anyway, this usage put a bad stamp or stigma on the Input-Output Analysis in the Czech Republic and it took a long time to disappear.

Contemporary input-output analysis has many followers covered by the International Input-Output Association.[10] Many fans are also in the Czech Republic. Input-output analysis is currently easy to use since computational possibilities are incomparable with the situation in 1960s when this idea came to Czechoslovakia as a tool for planning. Currently, we can find lots of databases of useful data suitable for different studies that are freely available on websites.

The input-output analysis has been used for many different purposes since the 1930's but the original one, description of the economy, is not the prevailing. The most common applications are connected to environmental, ecological or social applications. It underlines that input-output tables and input-output analysis and this way of thinking is far from being forgotten and it keeps its popularity onwards.

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[10] For more information see: <*www.iioa.org*>.

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ANNEX

Nb	NUTS3 code	Abbreviation	Region name
1	CZ010	Pha	Prague
2	CZ020	Stc	Central Bohemian
3	CZ031	Jhc	South Bohemian Region
4	CZ032	Plz	Plzeň Region
5	CZ041	Kar	Karlovy Vary Region
6	CZ042	Ust	Ústí nad Labem Region
7	CZ051	Lib	Liberec Region
8	CZ052	Krh	Hradec Králové Region
9	CZ053	Par	Pardubice Region
10	CZ061	Vys	Vysočina Region
11	CZ062	Jhm	South Moravian Region
12	CZ071	Olm	Olomouc Region
13	CZ072	Zln	Zlín Region
14	CZ080	Mrs	Moravian-Silesian Region