Facoltà di Economia
Università di Roma "Tor Vergata"
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Primo semestre

Corso:

Economia Industriale e dell'Innovazione

Docente
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LEZIONE 11

Il MODELLO DEI NETWORK E I PROCESSI DI APPRENDIMENTO INTERATTIVO

ISTAT: http://www.istat.it/it/archivio/145089

Il sistema di tavole input-output

Disponibile il quadro intersettoriale di Contabilità nazionale secondo il Sec 2010: tavole delle risorse e degli impieghi (anni 2010 e 2011) e tavole simmetriche (anno 2010)

L'Istat rende disponibili le tavole delle risorse e degli impieghi (o tavole *supply and use*) ai prezzi correnti e ai prezzi dell'anno precedente per gli anni 2010 e 2011, coerenti con gli aggregati di Contabilità nazionale secondo il Sec 2010, diffusi il 22 settembre 2014.

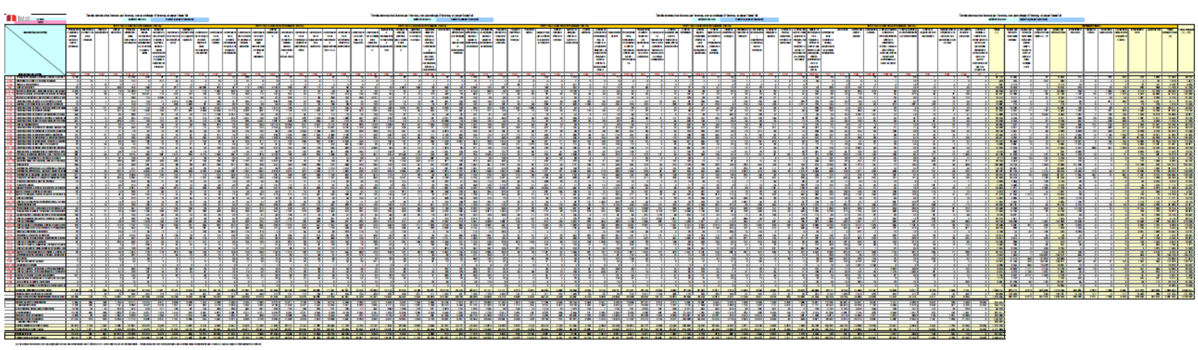
Completano il quadro intersettoriale le tavole simmetriche ai prezzi base, basate sulla tecnologia di branca, relative all'anno 2010, che vengono aggiornate ogni cinque anni.

La classificazione utilizzata per le attività economiche è la Nace Rev. 2 mentre quella per i prodotti è la Cpa 2008. Le due classificazioni sono tra loro perfettamente allineate in modo che, a ciascun livello di aggregazione, la Cpa mostri i principali raggruppamenti di prodotti delle corrispondenti branche della classificazione Nace.

Le tavole risorse impieghi sono fornite per due diversi livelli di dettaglio: 1) a 63 branche di attività economica e 63 raggruppamenti di prodotti; 2) a 20 branche di attività economica e a 20 raggruppamenti di prodotti. Le due classificazioni escludono l'attività delle organizzazioni e degli organismi extraterritoriali.

Le tavole simmetriche sono fornite a 63 branche di attività economica o a 63 raggruppamenti di prodotti, con l'esclusione dell'attività delle organizzazioni e degli organismi extraterritoriali

Per maggiori dettagli consultare la nota informativa.



Istat — Anno 2010

Tavola simmetrica branca per branca, con tecnologia di branca, ai prezzi base (a)

Milioni di euro — Valori a prezzi correnti

INPUT DELLE BRANCHE INTERMEDIE (NACE)

	BRANCHE (NACE*63)	Produzioni vegetali e animali, caccia e servizi connessi	Silvicoltura e utilizzo di aree forestali	Pesca e acquicoltura	Attività estrattiva	Industrie alimentari, delle bevande e del tabacco	Industrie tessili, confezione di articoli di abbigliamento e di articoli in pelle e simili	Industria del legno e dei prodotti in legno e sughero, esclusi i mobili; fabbricazione di articoli in paglia e materiali da intreccio	Fabbricazione di carta e di prodotti di carta	Stampa e riproduzione su supporti registrati	Fabbricazione di coke e prodotti derivanti dalla raffinazione del petrolio	Fabbricazione di prodotti chimici	Fabbricazione di prodotti farmaceutici di base e di preparati farmaceutici	Fabbricazione di articoli in gomma e materie plastiche	Fabbricazione di altri prodotti della lavorazione di minerali non metalliferi	Attività metallurgiche	Fabbricazione di prodotti in metallo, esclusi macchinari e attrezzature
	BRANCHE (NACE*63)	V01	V02	V03	VB	V10_12	V13_15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
V01	Produzioni vegetali e animali, caccia e servizi	5 799	0	1	2	24 498	622	37	20	9	6	44	34	290	12	19	42
V02	Silvicoltura e utilizzo di aree forestali	0	10	1	0	144	0	211	62	3	0	19	1	21	9	9	4
V03	Pesca e acquicoltura	0	0	16	0	77	0	0	0	0	0	41	2	0	0	0	0
VB	Attività estrattiva	23	0	0	238	465	238	21	277	44	30 296	478	57	115	2 233	2 120	282
V10_12	Industrie alimentari, delle bevande e del tabac	3 978	0	67	19	31 009	717	15	61	15	113	1 381	232	103	37	34	47
V13_15	Industrie tessili, confezione di articoli di abbigl	197	1	50	16	162	28 501	113	343	124	105	454	104	520	75	134	264
V16	Industria del legno e dei prodotti in legno e sug	69	0	6	7	390	115	5 283	34	46	16	45	11	114	83	81	522
V17	Fabbricazione di carta e di prodotti di carta	18	0	7	12	919	149	71	5 778	2 209	15	236	47	200	111	295	238
V18	Stampa e riproduzione su supporti registrati	19	0	1	6	169	119	8	985	1 382	87	346	82	100	28	63	184
V19	Fabbricazione di coke e prodotti derivanti dalla	1 401	15	111	190	175	110	149	51	30	6 951	5 347	60	255	951	1 314	193
V20	Fabbricazione di prodotti chimici	1 928	4	14	461	1 138	1 805	450	774	904	2 008	16 503	2 113	8 022	807	710	1 102
V21	Fabbricazione di prodotti farmaceutici di base	332	0	1	26	288	114	26	40	45	141	1 786	5 451	436	50	42	71
V22	Fabbricazione di articoli in gomma e materie p	276	7	14	30	604	2 010	174	480	217	173	1 031	242	4 847	198	494	1 246
V23	Fabbricazione di altri prodotti della lavorazione	321	0	5	229	1 241	123	176	61	22	110	1 108	173	285	6 691	1 297	890
V24	Attività metallurgiche	75	1	5	55	111	84	32	57	68	246	470	45	526	563	18 115	12 000
V25	Fabbricazione di prodotti in metallo, esclusi m	231	13	42	35	330	219	158	116	141	76	214	59	497	445	2 453	15 687
V26	Fabbricazione di computer e prodotti di elettro	52	0	7	17	79	84	10	20	56	68	151	83	136	132	88	430
V27	Fabbricazione di apparecchiature elettriche	124	1	21	35	123	133	24	40	67	60	174	43	174	140	299	1 235
V28	Fabbricazione di macchinari e apparecchiatur	179	2	8	118	480	209	56	214	85	235	215	119	292	229	1 029	2 266
V29	Fabbricazione di autoveicoli, rimorchi e semir	20	0	3	83	220	190	24	55	44	152	50	57	243	171	171	742
V30	Fabbricazione di altri mezzi di trasporto	22	0	63	45	63	76	12	12	21	47	16	33	60	57	67	187
V31_32	Fabbricazione di mobili; altre industrie manifat	49	0	11	9	178	252	445	34	67	60	120	156	164	100	244	484
V33	Riparazione e installazione di macchine e app	356	2	11	38	119	84	41	31	38	78	27	19	55	117	90	431

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Totale (1)	Spesa per consumi finali delle famiglie	Spesa per consumi finali delle istituzioni sociali senza scopo di lucro al servizio delle famiglie (ISP)	Spesa per consumi finali delle AA. PP.	Spesa per consumi finali	Investimenti fissi lordi	Oggetti di valore	Variazione delle scorte	Variazione delle scorte e oggetti di valore	Investimenti lordi	Esportazioni	Totale impieghi finali (2)	Totale impieghi (1) + (2)
V												
37 145	16 036	7	22	16 065	416	1	225	226	642	4 882	21 589	58 734
659	466	0	464	930	0	0	- 6	- 6	- 6	94	1 018	1 677
657	2 179	0	0	2 179	42	0	4	4	46	181	2 406	3 063
49 693	10 539	1	5	10 546	243	0	43	43	286	908	11 739	61 433
58 495	65 775	5	101	65 880	458	6	1 956	1 961	2 419	21 229	89 529	148 024
37 347	31 096	4	90	31 190	1 102	25	1 245	1 270	2 372	33 982	67 543	104 890
15 612	2 411	11	44	2 466	1 140	6	- 69	- 63	1 077	2 202	5 745	21 357
18 936	2 626	0	6	2 632	82	2	377	380	462	5 017	8 111	27 047
12 987	716	0	2	718	72	5	2	7	78	723	1 519	14 506
36 896	16 496	0	12	16 507	105	2	89	91	196	11 908	28 611	65 507
51 262	6 231	11	122	6 365	1 425	4	251	255	1 680	19 480	27 525	78 786
16 988	3 713	9	5 638	9 360	1 054	4	193	196	1 250	13 279	23 888	40 877
28 450	5 455	2	14	5 471	800	29	228	257	1 057	11 811	18 339	46 789
30 238	2 465	1	27	2 493	534	14	- 599	- 585	- 50	8 600	11 043	41 280
58 286	1 621	1	8	1 629	593	176	733	910	1 503	21 351	24 483	82 769
63 000	3 571	3	22	3 596	8 683	41	380	421	9 104	17 949	30 649	93 649
20 738	6 851	11	58	6 920	9 829	72	399	471	10 299	9 722	26 942	47 680
26 358	5 761	4	10	5 775	5 352	10	1 193	1 203	6 556	18 674	31 005	57 363
39 621	3 284	10	25	3 319	26 258	17	910	927	27 185	56 202	86 705	126 326
24 675	20 385	13	13	20 410	10 221	0	- 136	- 136	10 085	24 263	54 758	79 433
8 890	2 867	8	10	2 886	7 576	4	- 712	- 708	6 868	11 327	21 081	29 971
16 235	11 348	2	19	11 369	4 401	888	351	1 239	5 640	15 494	32 504	48 739
8 440	686	1	7	694	8 820	1	1	2	8 822	1 831	11 346	19 787
67 708	17 529	0	107	17 636	1 429	10	6	17	1 446	697	19 779	87 487
2 774	4 032	19	197	4 248	159	0	0	0	159	14	4 421	7 194
28 433	6 679	4	157	6 841	123	1	0	1	124	1 038	8 002	36 435
100 088	10 743	1	1 339	12 083	141 496	5	- 3	2	141 498	894	154 476	254 564
13 766	23 361	0	21	23 382	3 173	0	- 1	- 1	3 172	1 094	27 648	41 414
88 187	57 123	3	1 416	58 543	12 355	179	62	241	12 596	9 703	80 842	169 029
20 245	84 479	40	3 002	87 521	7 266	337	44	381	7 647	5 216	100 383	120 628
57 805	26 349	1	1 189	27 539	1 622	30	- 1	29	1 651	4 289	33 480	91 285
3 803	4 968	43	109	5 120	80	2	0	2	82	3 040	8 242	12 046
7 205	5 386	0	155	5 542	33	0	0	0	33	1 540	7 114	14 319
45 863	7 271	2	4 485	11 758	456	4	- 1	2	458	5 272	17 488	63 351
6 918	1 075	0	16	1 091	64	1	- 1	0	64	359	1 513	8 431
21 579	77 536	1 213	815	79 563	99	3	0	3	102	45	79 709	101 288
6 004	4 806	3	11	4 820	1 778	0	0	0	1 778	1 144	7 741	13 745
11 004	4 854	4	6	4 863	1 180	1	- 2	- 1	1 178	1 104	7 145	18 149
29 392	20 147	7	32	20 185	2 443	2	62	65	2 508	5 292	27 985	57 377
34 688	2 399	6	659	3 064	14 152	3	12	14	14 166	1 932	19 163	53 851
71 303	16 730	3	25	16 758	789	0	0	0	789	1 725	19 272	90 575
5 782	13 817	0	6	13 823	50	0	0	0	50	1 282	15 155	20 937
25 470	1 571	0	7	1 578	154	0	0	0	154	1 408	3 140	28 610
52 758	153 598	3	1 384	154 985	10 338	0	0	0	10 338	1 507	166 830	219 588
70 698	3 597	401	300	4 297	2 848	0	2	2	2 850	1 781	8 928	79 626
30 783	890	2	167	1 059	1 433	0	0	0	1 433	1 161	3 653	34 436
3 188	64	84	192	340	9 259	0	3	3	9 261	1 002	10 604	13 791
18 813	69	0	23	92	45	0	0	0	46	1 107	1 245	20 057
19 941	2 814	7	629	3 450	214	3	0	3	217	1 768	5 435	25 376
15 406	899	0	10	910	101	1	1	2	103	1 662	2 675	18 081
5 682	496	0	95	591	38	0	0	0	38	865	1 495	7 177
7 284	5 453	0	303	5 756	5	0	0	0	5	1 275	7 036	14 320
52 154	4 167	2	1 553	5 722	180	2	2	4	184	3 518	9 424	61 578
3 534	1 660	1	130 984	132 644	365	0	0	0	365	99	133 109	136 643
4 610	11 413	568	57 902	69 883	114	0	1	1	116	63	70 062	74 672
10 524	17 430	348	90 495	108 274	922	95	37	132	1 054	932	110 259	120 784
3 095	3 466	835	15 629	19 931	10	0	0	0	10	1	19 942	23 037
9 343	10 852	1 111	4 165	16 128	382	79	0	79	461	303	16 892	26 234
8 316	5 478	1 150	1 237	7 865	65	2	1	3	68	234	8 167	16 483
4 156	2 691	2 717	1 320	6 728	67	0	0	0	67	50	6 844	11 000
1 775	1 442	0	9	1 450	340	1	4	6	346	217	2 014	3 788
2 067	21 799	95	123	22 017	36	0	2	3	39	114	22 169	24 236
0	18 006	0	0	18 006	0	0	0	0	0	0	18 006	18 006
1 633 751	879 714	8 779	326 990	1 215 483	304 867	2 070	7 288	9 357	314 224	375 855	1 905 563	3 539 314
39 805	104 509	0	658	105 167	15 135	171	0	171	15 306	990	121 463	161 268
1 673 556	984 224	8 779	327 648	1 320 650	320 002	2 241	7 288	9 529	329 530	376 845	2 027 026	3 700 582

Ministero dell'Economia e delle Finanze
Dipartimento del Tesoro
Analisi e Programmazione Economico Finanziaria
Note Tematiche
N°7 - Novembre 2008

ANALISI INPUT-OUTPUT: PRESUPPOSTI TEORICI E POSSIBILI APPLICAZIONI

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I. Modello I/O nazionale

Notazioni

Con riferimento alla sezione delle branche produttive, per un generico *input* della branca *j* proveniente dalla branca *i* indichiamo con:

- ${}_{P}x_{ij}$ il flusso di produzione interna,
- ${}_{I}x_{ij}$ il flusso di importazione,
- x_{ij} il flusso totale.

Con riferimento alla sezione delle risorse primarie, relativamente ai fattori primari della branca della branca *j*, indichiamo con:

- W_j i salari,
- S_j gli oneri sociali,
- K_j gli altri redditi,
- D_j gli ammortamenti,
- T_j le imposte indirette al netto dei contributi correnti alla produzione.

Tavola Input-Output con 4 settori

Destinazione / Origine	Agricoltura	Industria	Trasporti	Servizi	Tot. Impieghi Intermedi	Consumi privati	Consumi pubblici	Investimenti	Variazioni scorte	Esportazioni	Tot. Impieghi
	Impieghi Intermedi					**Impieghi Finali**					
Agricoltura	X_{11}	X_{12}	X_{13}	X_{14}	$\Sigma_j X_{1j}$	C_1	G_1	I_1	VS_1	E_1	R_1
Industria	X_{21}	X_{22}	X_{23}	X_{24}	$\Sigma_j X_{2j}$	C_2	G_2	I_2	VS_2	E_2	R_2
Trasporti	X_{31}	X_{32}	X_{33}	X_{34}	$\Sigma_j X_{3j}$	C_3	G_3	I_3	VS_3	E_3	R_3
Servizi	X_{41}	X_{42}	X_{43}	X_{44}	$\Sigma_j X_{4j}$	C_4	G_4	I_4	VS_4	E_4	R_4
Totale costi intermedi	$\Sigma_i X_{i1}$	$\Sigma_i X_{i2}$	$\Sigma_i X_{i3}$	$\Sigma_i X_{i4}$	$\Sigma_{ij} X_{ij}$	$\Sigma_i C_i$	$\Sigma_i G_i$	$\Sigma_i I_i$	$\Sigma_i VS_i$	$\Sigma_i E_i$	$\Sigma_i R_i$
Conti Produzione e Distribuzione Valore Aggiunto											
Totale costi intermedi	$\Sigma_i X_{i1}$	$\Sigma_i X_{i2}$	$\Sigma_i X_{i3}$	$\Sigma_i X_{i4}$	$\Sigma_{ij} X_{ij}$						
Redditi lavoro dipendente	W_1	W_2	W_3	W_4	$\Sigma_j W_j$						
Altri redditi	K_1	K_2	K_3	K_4	$\Sigma_j K_j$						
Valore aggiunto	V_1	V_2	V_3	V_4	$\Sigma_j V_j$						
Produzione al costo dei fattori	X_1	X_2	X_3	X_4	$\Sigma_j X_j$						
Risorse Disponibili											
Produzione al costo dei fattori	X_1	X_2	X_3	X_4	$\Sigma_j X_j$						
Importazioni	M_1	M_2	M_3	M_4	$\Sigma_j M_j$						
Imposte indirette nette	Im_1	Im_2	Im_3	Im_4	$\Sigma_j Im_j$						
Totale risorse	R_1	R_2	R_3	R_4	$\Sigma_j R_j$						

Tav. II.1 – Matrice I/O

Siot 2000	Agricoltura ed industria estrattiva	Industria e costruzioni	Servizi	Totale	Totale impieghi finali	Totale impieghi ai prezzi
Agricoltura ed industria estrattiv	6 025	62 835	8 763	77 623	15 650	93 273
Industria e costruzioni	8 922	403 241	154 751	566 915	636 799	1 203 714
Servizi	5 441	202 823	364 334	572 598	745 438	1 318 036
Totale	20 388	668 898	527 849	1 217 135	1 397 887	2 615 022
Imposte meno contributi ai proc	440	11 124	21 752	33 316	93 704	127 020
Totale consumi intermedi/Im	**20 828**	**680 022**	**549 600**	**1 250 451**	**1 491 591**	**2 742 042**
Redditi da lavoro dipendente	***8 731***	***147 846***	***310 816***	***467 393***		
Altre imposte nette sulla produz	***808***	***14 603***	***18 840***	***34 251***		
Ammortamenti	***8 883***	***50 052***	***93 421***	***152 355***		
Risultato netto di gestione	15 133	90 349	304 555	410 037		
Risultato lordo di gestione	24 016	140 400	397 976	562 393		
Valore aggiunto ai prezzi base	33 555	302 850	727 631	1 064 036		
Produzione ai prezzi base	**54 383**	**982 872**	**1 277 232**	**2 314 487**		
Importazioni	38 889	220 842	40 804	***300 535***		
Totale Risorse	**93 273**	**1 203 714**	**1 318 036**	**2 615 022**		

Tav. II.2- Matrice dei coefficienti diretti

Dom 2000	Agricoltura ed industria estrattiva	Industria e costruzioni	Servizi	Totale
Agricoltura ed industria estrattiva	0,1011	0,0293	0,0059	0,0181
Industria e costruzioni	0,1550	0,2863	0,1070	0,1843
Servizi	0,0951	0,1906	0,2678	0,2310
Totale	0,3512	0,5062	0,3808	0,4333
Totale costi di prodotti importati cif	0,0237	0,1744	0,0325	0,0926
Imposte meno contributi ai prodotti	0,0081	0,0113	0,0170	0,0144
Totale consumi intermedi/Impieghi finali ai prezzi di acquisto	**0,3830**	**0,6919**	**0,4303**	**0,5403**
ULA dipendenti (1000 ULA)	*0,0093*	*0,0053*	*0,0083*	*0,0070*
ULA totali (1000 ULA)	*0,0277*	*0,0070*	*0,0118*	*0,0101*
Redditi da lavoro dipendente	0,1605	0,1504	0,2434	0,2019
Altre imposte nette sulla produzione	0,0149	0,0149	0,0148	0,0148
Capitale netto totale (mln di euro 2000)	*2,6476*	*0,7240*	*2,1399*	*1,5506*
Ammortamenti	0,1633	0,0509	0,0731	0,0658
Risultato netto di gestione	0,2783	0,0919	0,2384	0,1772
Risultato lordo di gestione	0,4416	0,1428	0,3116	0,2430
Valore aggiunto ai prezzi base	**0,6170**	**0,3081**	**0,5697**	**0,4597**
Produzione ai prezzi base	**1,0000**	**1,0000**	**1,0000**	**1,0000**

Le tavole input-output nella contabilità nazionale

Da Wikipedia, l'enciclopedia libera.

Le tavole simmetriche

Si tratta di tavole che hanno la stessa struttura della tavola degli impieghi a prezzi base, ma a differenza di questa, che è una matrice prodotto × branca, hanno uguali intestazioni per le righe e le colonne. Vi sono:

- una *tavola branca per branca*, che indica le relazioni interindustriali, ovvero quanto della produzione di ciascuna branca è impiegato nell'attività produttiva delle altre;
- una *tavola prodotto per prodotto*, che indica le relazioni tecnologiche, ovvero i prodotti necessari per la produzione di ciascun prodotto, indipendemente dalla branca di provenienza.

Le tavole sono due, mentre la matrice di Leontief è unica, in quanto nel metodo di Leontief branca e prodotto coincidono (ad esempio, l'output del settore agricolo è costituito solo da prodotti agricoli), mentre nel metodo rettangolare si considerano anche le produzioni secondarie.

Si cerca comunque di riallocare le produzioni secondarie lungo le righe o lungo le colonne, secondo il tipo di tavola, utilizzando due metodi, a loro volta basati su due ipotesi:

- *tecnologia di prodotto*: si assume che ciascun bene sia prodotto sempre con la stessa tecnologia;
- *tecnologia di branca*: si assume che ciascuna branca utilizzi la stessa tecnologia per tutte le sue produzioni, anche per le secondarie.

Ne segue che entrambe le tavole vengono in realtà costruite ciascuna in due versioni, una secondo la prima ipotesi e una secondo l'altra.

Uso delle tavole per analisi e previsione

La struttura di una tavola simmetrica può essere rappresentata simbolicamente come nello schema seguente (nel quale si prescinde, per semplicità, dagli scambi con l'estero):

$$\begin{bmatrix} x_{11} & x_{12} & x_{12} \\ x_{21} & x_{22} & x_{23} \\ x_{31} & x_{32} & x_{33} \end{bmatrix} \begin{bmatrix} X_{1.} \\ X_{2.} \\ X_{3.} \end{bmatrix} \begin{bmatrix} c_1 & i_1 \\ c_2 & i_2 \\ c_3 & i_3 \end{bmatrix} \begin{bmatrix} Z_1 \\ Z_2 \\ Z_3 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix}$$

$$\begin{bmatrix} X_{.1} & X_{.2} & X_{.3} \end{bmatrix} \begin{bmatrix} X_{..} \end{bmatrix} \begin{bmatrix} C & I \end{bmatrix} \begin{bmatrix} Z \end{bmatrix} \begin{bmatrix} X \end{bmatrix}$$

$$\begin{bmatrix} Y_1 & Y_2 & Y_3 \end{bmatrix} \begin{bmatrix} Y \end{bmatrix}$$

$$\begin{bmatrix} X_1 & X_2 & X_3 \end{bmatrix} \begin{bmatrix} X \end{bmatrix}$$

Metodi di calcolo del PIL

Utilizzo della matrice

La matrice (x_{ij}) in alto a sinistra, detta *matrice intermedia*, è la vera e propria parte simmetrica (prodotto × prodotto oppure branca × branca), contenente gli impieghi intermedi. Procedendo verso destra si hanno:

- le somme per riga (prodotto o branca fornitrice) degli impieghi intermedi, $X_{i.}$;
- gli impieghi finali di riga, costituiti dai consumi c_i, dagli investimenti i_i e dalle loro somme Z_i;
- gli impieghi totali di riga, X_i.

Procedendo verso il basso:

- le somme per colonna (prodotto o branca utilizzatrice) degli impieghi intermedi, $X_{.j}$, seguite dalle somme degli impieghi intermedi, finali (consumi e investimenti) e totali;
- i valori aggiunti per prodotto o per branca a prezzo di mercato, Y_j, ed il loro totale, il prodotto interno lordo Y (v. il Conto della produzione);
- i costi totali per prodotto o branca e la loro somma, la produzione totale X.

Considerando le n righe e colonne della matrice intermedia, per ciascuna riga si ha:

$$X_i = X_{i.} + Z_i = \sum_{j=1}^{n} x_{ij} + Z_i$$

e per ciascuna colonna:

$$X_j = X_{.j} + Y_j = \sum_{i=1}^{n} x_{ij} + Y_j$$

Sommando poi su tutte le righe e colonne:

$$\sum_{i=1}^{n} X_i = \sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij} + \sum_{i=1}^{n} Z_i = X_{..} + Z = X$$

ed anche:

$$\sum_{j=1}^{n} X_j = \sum_{j=1}^{n}\sum_{i=1}^{n} x_{ij} + \sum_{j=1}^{n} Y_i = X_{..} + Y = X$$

Ne segue Y=Z; essendo Z=C+I, si ha l'identità macroeconomica:

$$Y = C + I$$

Lo schema costituisce il presupposto delle attività di analisi e di previsione, di cui sono esempi l'analisi strutturale e l'analisi di impatto.

Analisi strutturale

Una tavola prodotto × prodotto o branca × branca consente di analizzare le interrelazioni del sistema economico.

Ad esempio, i *coefficienti di spesa* ricavabili da una tavola prodotto × prodotto:

$$a_{ij} = \frac{x_{ij}}{X_j}$$

consentono di determinare le unità monetarie del prodotto *i* necessarie per produrre un'unità momentaria del prodotto *j*.

Dalla tavola branca × branca, invece, si possono ricavare *coefficienti di mercato*:

$$s_{ij} = \frac{x_{ij}}{X_i}$$

che dicono quanto della produzione della branca *i* è utilizzato nell'attività produttiva dalla branca *j*.

Analisi di impatto

Poiché, in linea di massima, ciascun prodotto viene realizzato usando altri prodotti e ciascuna branca usa i prodotti di altre branche, qualsiasi variazione nel livello della produzione di un prodotto o da parte di una branca ha effetti su tutti gli altri.

Per valutare tali effetti, si osserva che:

$$x_{ij} = a_{ij} X_j$$

quindi:

$$X_{.} = AX$$

dove $X_{.}$ è il vettore dei flussi intermedi, A è la matrice dei coefficienti di spesa e X è il vettore della produzione.

Ne segue:

$$X = AX + Z, \quad X - AX = Z, \quad (I - A)X = Z, \quad X = (I - A)^{-1} Z$$

Gli elementi delle matrice $(I\text{-}A)^{-1}$, detta «inversa di Leontief», indicano quante unità del prodotto della *i*-esima riga sono globalmente necessarie per soddisfare una domanda finale unitaria del prodotto *j*.

Se cambia la domanda finale di un prodotto, la somma degli elementi della *i*-esima riga della matrice esprime gli effetti *ricevuti* dal prodotto *i*; la somma degli elementi della *j*-esima colonna esprime gli effetti *distribuiti* dal prodotto *j*.

Cappellin, R. and Wink, R. (2009), **International Knowledge and Innovation Networks: Knowledge Creation and Innovation in Medium Technology Clusters**. Cheltenham: Edward Elgar Publishing.

http://books.google.it/books?id=1BpcJGekx18C&printsec=frontcover&source=gbs_navlinks_s#v=onepage&q=&f=false

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9. The model of knowledge and innovation networks

The relationships between the firms become **more complex, risky** and require to be redesigned in a long-term perspective.

The role of **interactive learning process** for knowledge creation and the access to **tacit knowledge** underline the importance of the concept of **knowledge and innovation networks**

In fact, **networks are an appropriate form of organization** facilitating the interaction and the flows of information and knowledge. Knowledge circulates within networks through formal and informal institutions. Explicit or codified knowledge may be exchanged on technology markets.

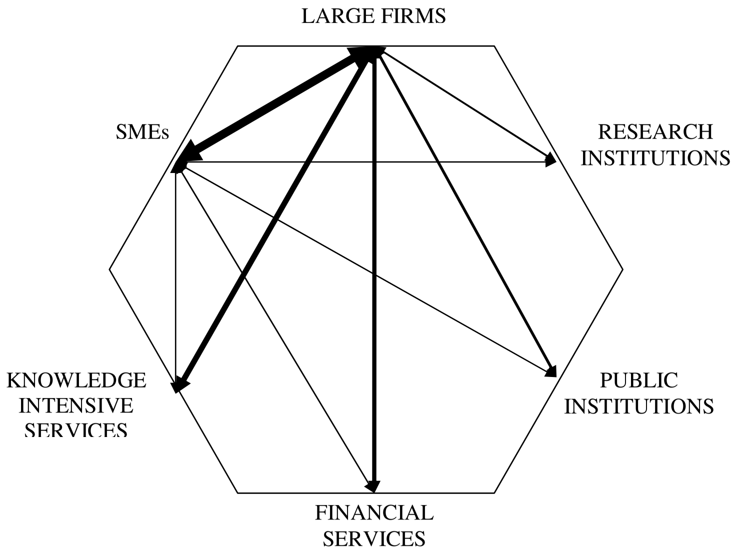

Figure 4: Information and knowledge links in a regional innovation system

The structure of a network can be illustrated by the relationships between various actors, which can be classified in six groups: large industrial firms, industrial SMEs, business services, financial services, research institutions and public institutions, as indicated in figure 4.

In particular, the structure of a network is characterized by:

- **nodes**, which may be firms and other private and public actors,
- **links,** which connect directly or indirectly the various nodes,
- **flows,** which may be material or immaterial, such as product, services, financial, labour, power, information and knowledge flows,
- **distances**, which may be geographical but also technological, organizational, cultural, institutional and determines obstacles or transaction costs in the circulation of the flows,
- **infrastructures**, which may be material or immaterial, such as norms, institutions and social capital, and reduce the transaction costs, thus facilitating the circulation of the flows between the nodes.

Network relations present **five characteristics**.

First of all, the relationship between two nodes is characterized by **a precise direction and a hierarchical character**.

Secondly, each node has a **specific function.**

Thirdly, the various networks are **interconnected between themselves**.

Fourth, networks have a **different geographical reach**.

Fifth, the relations existing within a specific network **in a particular time** are normally related to the relations existing in the previous periods.

In fact, networks can be analysed in a dynamic perspective and are characterized by their flexibility. Their evolution (figure 5) is related to:

- the change in the **nodes** and in the **capabilities** of the various nodes,
- the change in the **intensity of the various flows**,
- the **creation and disappearance of some links,**
- the **change in the alternative paths** linking directly or indirectly the same nodes,
- the **creation of hard or soft infrastructures** between particular nodes,
- the path of evolution of the **overall structure of the network**.

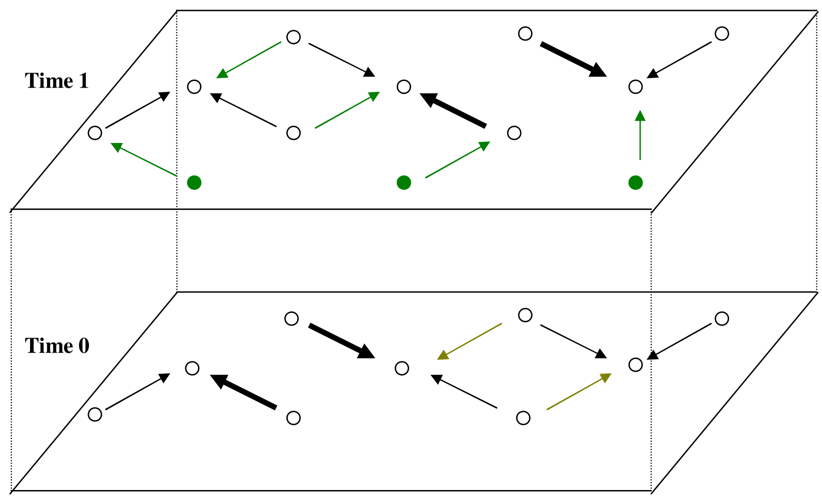

Figure 5: The evolution of the network form

The network approach is very **different from the neoclassical approach**

In the model of the networks the **firms are all different** and integrated between them through different types of relations.

The network paradigm **underlines the vertical dimension** of the relations of production integration between the firms.

The crucial characteristic of a network of firms is indicated by the **concepts of integration, sequential interaction, circulation, diffusion, feedback, recursive processes, symbiosis and co-evolution**.

Reference:

* Cappellin, R. (2009), La *governance* dell'innovazione: libero mercato e concertazione nell'economia della conoscenza, *Rivista di Politica Economica*, 99, 4-6: 221-282.
http://www.rivistapoliticaeconomica.it/2009/apr-giu/Cappellin.pdf

Cappellin, R. and Wink, R. (2009), **International Knowledge and Innovation Networks: Knowledge Creation and Innovation in Medium Technology Clusters**. Cheltenham: Edward Elgar Publishing.

http://books.google.it/books?id=1BpcJGekx18C&printsec=frontcover&source=gbs_navlinks_s#v=onepage&q=&f=false

Cap. 4.12, pp. 127-130

12. Three types and phases of a regional innovation network

Regional production systems are evolving from the model of industrial clusters and industrial districts based on many rather homogenous firms linked by flows of knowledge spill-over to the model of territorial innovation networks made by complementary specialized firms, linked by formal forms of cooperation in production, commercial and technological field, not only locally but increasingly also at the interregional and international level. Territorial networks may be classified into three types of networks: "ecological networks", "identity networks" and "strategic networks", which have different characteristics, as indicated in table 7.

'Ecology networks' may be assimilated to 'agglomeration economies', which are also defined as "localization economies" or "urbanization economies".

'Identity networks' are based on specialised intermediate institutions ("social capital"). They may be defined as places of collective learning.

Table 7: Types and phases of a regional innovation network

	Ecological networks	Identity networks	Strategy networks
Type of relationship	External economies	Exchange	Joint investment
Form of interaction	Interdependence	Cooperation	Strategic coordination
Self-consciousness	Objective homogeneity	Subjective factors, intended relationships, sense of identity	Subjective factors, intended relationships, joint aims
Formalism	Informal relationships: imitation	Informal relationships: trust relationships	Formal relationships: contracts
External support	Geographical proximity	Common infrastructures, intermediate institutions and social capital	Joint decision making and policy making
Key knowledge Base	Symbolic/synthetic knowledge	Synthetic/symbolic knowledge	Analytical/ synthetic knowledge
Key knowledge Phase	Exploitation	Examination/ Exploitation	Exploration/ Examination
Knowledge interaction	Knowledge spill-over	Interactive learning	TKM and R&D
Differentiation process	Homogeneity	Autonomous specialization	Division of tasks
Innovation	Process	Organizational	Product
New firms	Imitative	More specialized	Innovative
Sectors	Low tech	Medium tech	High tech

'**Strategy networks'** are based on cooperative agreements between firms and other organisations. They are the result of negotiations, agreements on specific strategies and the creation of formal and explicit 'joint ventures' by the participating actors.

These three types of networks are characterized by different forms of knowledge interactions. In fact, knowledge spill-overs characterize the ecological networks, interactive learning processes are characterizing the identity networks and explicit governance of knowledge relations between the various local and non local actors is a characteristic of strategy networks.

Moreover, it is useful to distinguish three types knowledge (Asheim and Coenen, 2005, Asheim, Boschma and Cooke, 2007), such as: 1) the science based or "analytical" knowledge, which is important in high tech sectors, 2) the engineering based or "synthetic" knowledge, which is most important in medium technology sectors, and 3) the creativity based or "symbolic" knowledge, which is most important in low technology sectors.

The shift to the model of "strategy" networks implies the design and creation of specific infrastructures, institutions and procedures, which may facilitate the knowledge flows. These policy measures may be represented by the "territorial knowledge management" and the "competence centres", in the case of synthetic or engineering based knowledge, and by international integrated projects and networks of excellence, in the case of analytic or science based knowledge.

Table 8: The knowledge flows in different types of networks

Forms of governance -------------------------- Types of knowledge	**Ecological networks**	**Identity networks**	**Strategic networks**
Symbolic knowledge	Localized knowledge spillover, labour mobility, competitors imitations	Interactive learning within professional communities	Interdisciplinary integration and collaboration
Synthetic knowledge	Localized knowledge spillover, labour mobility, competitors imitations	Interactive learning between SMEs and with clients	Technological collaborations within the supply chain
Analytic knowledge	Localized knowledge spillover, university education	Technology transfers from universities and service centres to SMEs	Joint R&D projects and networks of centres of excellence

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http://books.google.it/books?id=1BpcJGekx18C&printsec=frontcover&source=gbs_navlinks_s#v=onepage&q=&f=false

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18. The evolution of industrial clusters toward the "learning region"

The factors of competitiveness of a cluster have changed.

Defining a region as a 'learning region' means that the actors of the system are committed to an interactive learning process allowing the development of knowledge, know-how and other capabilities required for creating innovation and maintaining regional competitiveness (Maillat and Kebir, 1999).

The objective of a 'learning region' is the integration of tacit or traditional production knowledge, which is bounded within the local context, with the codified knowledge available at the world level, in order to stimulate the regional endogenous potential. A 'learning region' may represent the final outcome of the evolution of an 'industrial district'.

The increasing complexity of technology requires a broadening of the scope of the technologies to be adopted.

Traditional boundaries between pure and basic research and applied research can no longer hold and medium and **high-technology knowledge should be connected in industrial products**. This means the need to **connect synthetic or traditional engineering and problem-solving knowledge with analytical or science-based knowledge.**

The transfer of scientific knowledge to SMEs requires **a long-term effort for strengthening the multi-dimensioned and multi-institutional regional knowledge infrastructure.**

Moreover, the increasing complexity and differentiation of needs by the users require that firms **improve their cognitive proximity with the users**.

The more radical an innovation is the more important it is to change the cognitive perspective of the customers on needs and solutions so that they will be satisfied by the innovation. Consequently, knowledge exploitation requires a perspective on potential demanders, their hidden, needs and channels to reach them. That requires to invest in the design, the perceived quality and the brand value of the product or services and to improve the relationships between the industrial firms and the modern knowledge intensive business services (KIBS) (Muller and Zenker, 2001). Thus, **symbolic or creativity-based knowledge has to be combined with technological excellence or synthetic knowledge.**

Table 11: From an industrial to a knowledge economy in medium technology clusters

	Knowledge economy: competitiveness through innovation, high creativity		
Governance: identity Networks	Interactive learning and incremental innovation	Systemic innovation and territorial knowledge management	**Governance: strategic networks**
	Process innovation, technology suppliers, competitors imitation and lock-in effect	Vertical integration, large firms and technology transfers to subcontractors	
	Industrial economy: cost competition, low creativity		

The linkages between SMEs in the process of interactive learning within a cluster are often informal, rather chaotic and time-consuming. That highlights the need for an explicit effort to be devoted to the organization of knowledge networks and knowledge interactions between the firms and the shift from a model of automatic free market interdependence, as in "identity" networks, to a strategic model, as in the "strategic" networks. Table 11 illustrates this shift.

The risks of lock-in in traditional productions and technologies. In the perspective of a knowledge economy, identity networks imply, as indicated above, interactive learning and incremental innovation. However, regional production systems may evolve toward the form of ‘strategy networks’, which are based on intended relationships and formalized cooperative agreements between firms and other organisations.

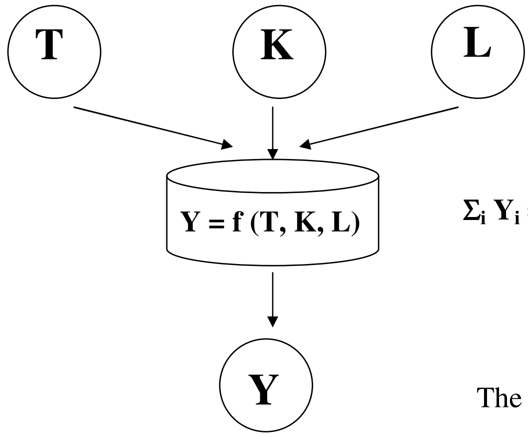
Strategy networks imply **forms of central coordination**, the creation of procedures for the exchange of information, **the codification of individual tacit knowledge and the investment in the creation of collective codified knowledge**.

Instead of traditional ways of control within a strategic process, strategic governance is needed. **The model of “territorial knowledge management” aims to** formulate a theoretical framework for such a governance to enhance **the adoption of systemic innovations, which are based on the coordination of the investments made by various SMEs and are focused on strategic joint projects.**

Cappellin, R. (2003), Networks and Technological Change in Regional Clusters in Bröcker, J., Dohse, D. and Soltwedel, R. eds., **Innovation Clusters and Interregional Competition**, Springer Verlag, Heidelberg.

The neoclassical model of the production function

In a neoclassical model, the growth of the production in a regional or national economy is determined through the tool of the aggregate production function, which indicates the effect on the production level of the use of various production factors, such as capital (K) and labor (L), given the characteristics of the technology (T), as this latter is supposed constant among all firms, as indicated in figure 1.



$\Sigma_i Y_i = f(T, \Sigma_i K_i, \Sigma_i L_i)$ **aggregate production function**

Figure 1:
The model of the neoclassical production function

The networks of firms in the local production systems

According to the approach of “territorial networks” the various forms of integration or the various networks, which may be identified in a local economy, may be described as in table 1 (Cappellin and Orsenigo 2000).

Table 1: Different networks in a local production system

Technological integration, pointed out by the development of the local production know how, the sharing of knowledge and values promoted by learning processes on the job, the continuous education of the workers, the vocational education of young workers, the joint investments in R&D by local firms and the technological cooperation with external firms.
Integration of the local labor market, related with the cooperation between the workers and the firms and the mobility of the workers between the firms of the same sector and also the capability to attract qualified workers from other regions and from other sectors.
Production integration between the firms, through subcontracting relationships between the firms which play a crucial role in promoting the gradual diversification of the local productions.
Integration between the service sectors and the manufacturing firms, related to the development of modern commercial distribution services, transport and logistic services and also qualified services in the certification of the quality of the productions and in the diffusion of modern technologies.

Financial integration of the firms, as it is indicated by the creation of groups made by several firms belonging to the same entrepreneurial family and by pro-active bank-industry relationships, which promote the creation of spin-off and the capability to attract external investments or the investments of local firms in other countries and regions.
Territorial integration at the local level, which requires an improvement in the infrastructure endowment and it is linked to an effective physical planning aiming to defend the quality of the territory.
Social and cultural integration, which determines the existence of a local identity and the creation of the consensus within the local community on a shared developed strategy.
Relationships of institutional integration, which are related to the development of local administrative capabilities and the capability of the local institution to interact with the regional and national institutions in the implementation of strategic development projects.
Territorial integration at the interregional and international level, which leads to a greater openness in an interregional perspective, to the development of a local “foreign policy” or of a “territorial marketing” measures, which are crucial in attracting external investments and in promoting the internationalization of local firms.

An analytical representation of the model of territorial networks

The firms of a local production system may be represented as in the figure 2**:**

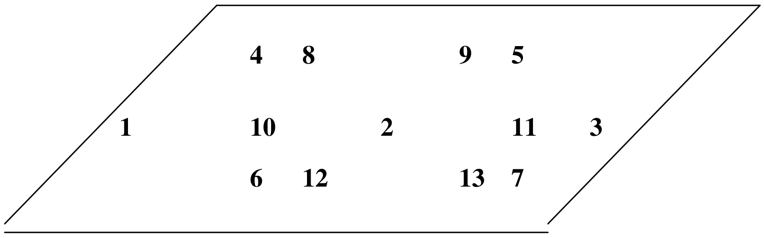


Fig. 2 The firm in a local production system

According to a network perspective, the working of a national or regional economy is explained by the integration between the various firms. These relationships may concern the same four variables, such as product (Y), labor (L), capital (K) and technology (T), which are traditionally considered in the neoclassical model of the production function. That allows to extend this model to the case of four interactive networks. Thus, an economic system may be described by four functional networks, as indicated in figure 3.

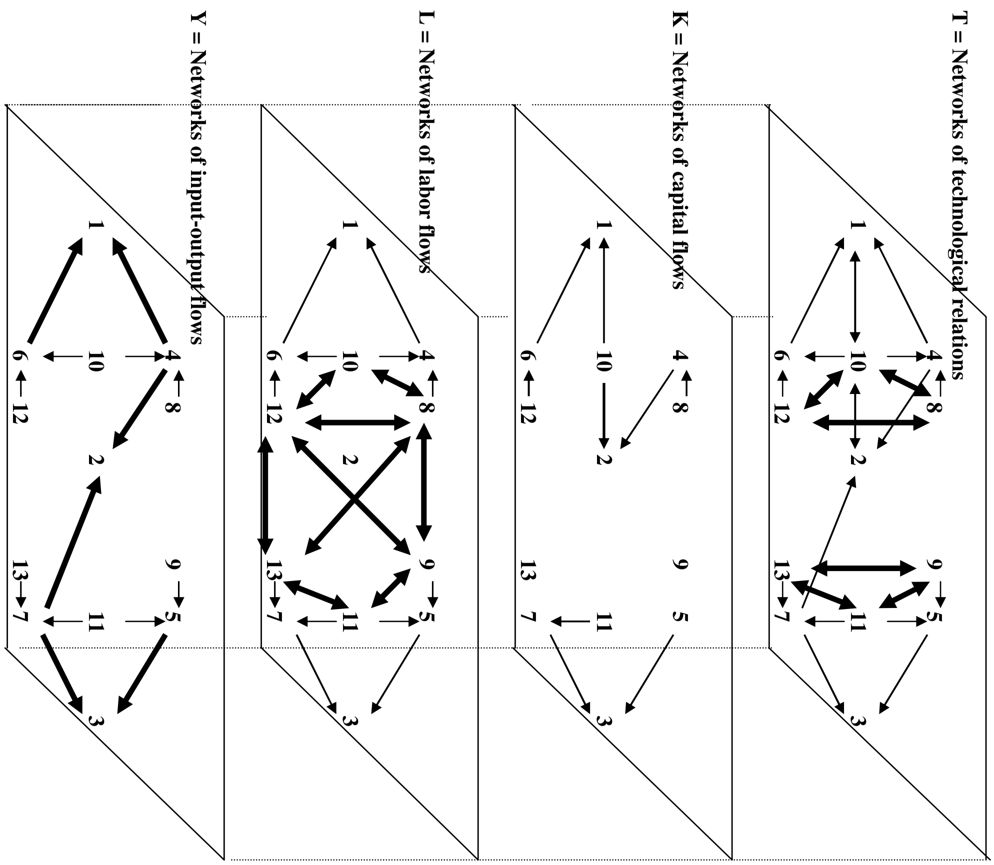


Fig. 3: The connectivity between the flows of production factors, technology and productions

A matrix representation of networks

The flows between the various firms indicated in the various networks of figure 2 may be also **represented in a matrix form**. In particular, the commercial flows of products and services (Y), the relationships of financial control (K) and the relationships of technological dependence or co-operation (T) between the various firms may be represented with the matrices along the diagonal of table 2.

	1	2	3		1	2	3		1	2	3		1	2	3	
1																
2		T				TK				TN				TY		
3																
1																
2		KT				K				KN				KY		
3																
1																
2		NT				NK				N				NY		
3																
1																
2		YT				YK				YN				Y		
3																

Table 2: The connectivity between flows of goods, labor, capital and technology

Clearly, the elements of these matrices indicate first of all the existence or the absence of those relations between the nodes, which were considered in the networks of figure 2. However, a matrix representation, allows also to illustrate in a clearer way some further crucial characteristics of a network and of the relationships between different networks.

In particular, these matrices may be used to represent **three crucial dimensions of the relations between the nodes of a network**, such as the **intensity of the flows (x_{ij}),** the level of the reciprocal **distance (d_{ij})** and the existence of adequate **infrastructures (f_{ij})** in the connection between two nodes.

Thus, **the flows (x_{ij}) from a node (i) to a node (j) may consist of flows of goods, financial flows, information, workers**, or other variables. The flows may be measured in monetary or physical term according to their respective nature.

These matrices may also be used in order to **represent the distance (d_{ij}) between two nodes** or the obstacles, which hinder the relation between the actors (i) and (j). The distance may be measured not only in a geographical perspective (e.g. transport costs), but also in a "functional" perspective as organizational distance (e.g. "transaction costs") and technological distance (e.g. "technology gap"). Thus, it may be expressed through different units of measurement, according to the nature of the relations represented in the specific network considered and the unit of measurement of the particular flow (x_{ij}).

Thirdly, these matrices may be used to **represent the stocks of infrastructures (f_{ij})** allowing a tight integration between the various nodes and facilitating the flows between them. Clearly these infrastructures are important in order to reduce the distance between two particular nodes (d_{ij}) and to increase the respective flows (x_{ij}). In particular, the infrastructures of a network may be represented by:

- **material infrastructures**, such as the existence of transport, ICT and Internet connections,
- **immaterial infrastructures**, such as the existence of institutions, organizations and rules, which govern and coordinate the relations between the actors considered and, thus, decrease the transaction costs between them.

Two nodes, which are not directly linked, may be indirectly linked by the existence of the complex links **through various intermediate nodes**. In particular, within a particular network or matrix, the average unit flow (x_{ij}/x_j) indicates the units of the production of firm (i) required in the production of one unit of the firm (j). This ratio, differently from the Input Output model, is not constant. Thus, **the total distance and the cost (transaction cost) in linking two nodes (i) e (j),** which are not directly linked between themselves, may be measured as:

$$c_{ij} = \Sigma_s \Sigma_{z\ A} d_{is}\ (x_{is}/x_s)(x_{sz}/x_z)(x_{zj}/x_j) + \Sigma_s\ \Sigma_{z\ A} d_{sz}\ (x_{sz}/x_z)(x_{zj}/x_j)\ {}_{+} \Sigma_{z\ A} d_{zj}\ (x_{zj}/x_j)$$

when up to two consecutive intermediate nodes (s) and (z) are considered.

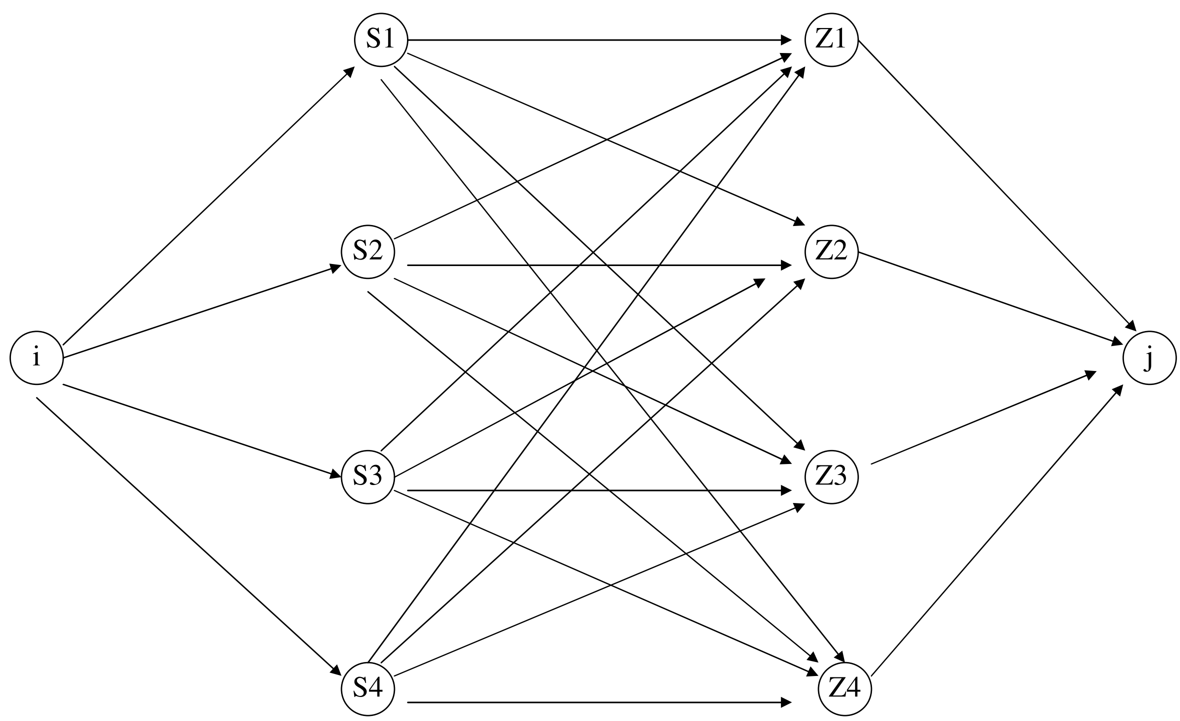


Fig. 5 – The indirect links between two nodes i and j through two intermediate nodes

The interdependence between different networks

The matrices, which are off the diagonal in table 2, may be defined as **"transition" or "interconnection" matrices**. In particular, the matrices TK and TN may indicate the effect of the process of knowledge creation on the competencies or the capabilities respectively of the capital and labor inputs. Instead. the interconnection matrices KY and LY of table 2 may be used to formally indicate respectively the productivity of capital and labor inputs on the output of the various firms.

An interconnection matrix allows to relate between themselves different measures of distance appropriate for two different networks. That allows to define a mathematical expression which measures **the distance between two nodes, which do not belong to the same network,** but are indirectly connected by another node. This latter performs the role of a gateway or of a synapsis, as it belongs to both considered networks.

In fact, the **coefficient ($_{AB}d_{ij}$) of an interconnection matrix AB** can indicate how to convert the cost of the distance between two specific nodes, as measured in the network A, according to the measurement unit of the distance in a different network B. For example two small firms belonging to two different local subcontracting networks or located in different regions/countries may be both financially controlled by the same large firm. That will certainly facilitate the future establishment of a direct subcontracting relations between these two small firms. Thus, the proximity between the two firms in the financial network reduces the obstacles or distance, which hinder a direct contact in the Input Output network and increases the probability of the establishing a direct link in this latter network.

In general terms, given two nodes (j) and (z), which may respectively belong to the networks A and B and are indirectly connected through various intermediate nodes (s) belonging to both A and B networks, the unit cost of the relation between these two nodes may be measured as:

$$c_{iz} = \Sigma_s \, {}_{AB}d_s \, {}_{A}d_{is} \, ({}_{A}x_{is}/{}_{A}x_s) + \Sigma_s \, {}_{B}d_{sz} \, ({}_{B}x_{sz}/{}_{B}x_z)$$

where the coefficient ($_{AB}d_s$) indicates the element of the interconnection or transition matrix between the network A and the network B and it **allows to transform the measure of the distance in the network A in the unit of measurement of the distance in the network B,** in order to compute the total transaction cost.

Therefore, the multilayer network model allows to **identify relations**, which may be measured in quantitative terms, not only within the same network, but **also between different networks**. In particular, instead of confusing different types of relationships existing between a set of nodes within the same network, the approach illustrated above is characterized by **the distinction of different layers or different networks.** The concept of interconnectivity between these different networks allows to represent each relationships or flow in a different network, while providing an analytical or quantitative framework to describe the interdependence between different types of relationships or flows.

The network model and the explanation of aggregate growth

In this **model of multilayer networks**, **the output of a firm may be determined both by the demand of its products and by the supply of the intermediate inputs as also of the various production factors,** indicated by the various flows represented in the four networks of figure 3.

In particular, **the output of the economy will depends not only on the aggregate endowment of production factors, but also on the very different forms of organization of the material and immaterial flows between firms, institutions and others actors involved in the economic system.**

The network model may be used as a growth model of the economy. In fact, the relationships between the network of Input Output flows (Y), the network of labor flows (L), the network of capital flows (K) and the network of technological relations (T) in **the determination of the overall growth of the economy** considered may be formally described with the following relationships:

1) Output = n_1 (output flows, final local demand, export)

2) Final local demand = n_2 (output)

3) Export = n_3 (output/production capacity, external demand)

4) Output < Production capacity

5) Production capacity = Resources * Productivity

6) Resources = n_4 (input flows$_t$ …………, input flows$_{t-n}$)

7) Productivity = n_5 (knowledge flows$_t$, ………….knowledge flows$_{t-n}$)

8) knowledge flows$_t$ =n_6 (output flows, input flows, knowledge flows)$_{t-1}$

9) input flows$_t$ =n_7 (output flows, input flows, knowledge flows)$_{t-1}$

10) output flows$_t$ =n_8 (output flows, input flows, knowledge flows)$_{t-1}$

Where:

Relationship:1) indicates that the production of an economy is equal to the flows of products (x_{ij}) which are sold by the different firms to other firms and to the final internal and external demand.

Relationship 2) indicates the levels of the final demand (consumption, investment, public expenditure) as a function of the income

Relationship 3) indicates the level of exports as a function of the output capacity and of the external demand

Relationship 4) indicates that the level of production of the various firms is lower or equal to their respective production capacity.

Relationship 5) indicates that the production capacity of the individual firms is determined by the availability of resources (as labor and capital) times the respective productivity.

Relationship 6) indicates that the availability of resources depends on the flows of these resources in the same and in the previous period. The role of internal resources is underlined by the resource based theory of the firm.

Relationship 7) indicates that the productivity of resources is a function of the actual and previous flows of knowledge. The level of production is a function not only of the internal resources but also of the skills or capabilities to use these latter.

Relationships [8, 9 and 10] indicate that the structure of a network is linked to the structure of the same network and of that of other complementary networks in the previous periods.

Moreover, the relations [8, 9 and 10] indicate that **the evolution of the various networks is interdependent**, due to the existence links assuring their interconnectivity. **In fact, the form of the real flows of inputs and outputs affect the form of the knowledge flows**, while these latter determine the productivity of production factors and hence the overall output growth of the economy.

The flows within the various networks are affected by accessibility and receptivity or by the various forms of distance (geographical, organizational and institutional distance) and by the different characteristics of the nodes (cognitive distance). Distance is affected by the endowment and investments in soft and hard infrastructures. These investments indicated a link to the equation (1) as they are related to the use or demand of actual production.

The system may be solved in the eight types of unknown: the levels of input, productivity, production capacity and production of the various firms, subject to the constraint indicated by the inequality (2). Moreover, it may also determine the flows of material inputs (capital, labour), of knowledge and of output between the various firms.

Thus, the transition or interconnection matrices allow to investigate the mechanisms, which lead to an integration and even to a **co-evolution between the various functional networks.** In particular this integration is facilitated by closer geographical distance and it indicates the role of territory and of local institutions. In fact, **the territory allows an indirect relation between the different sectoral/functional networks**. Therefore, **local institutions, which design and implement sectoral policies**, such as transport policies, labor market policies and technological and industrial policies, are capable to modify the respective different functional networks and **should integrate these sectoral policies among themselves,** in order to enhance the development of territorially embedded firms.

Technological change and the evolving structure of networks

The approach of networks does not only allow to represent the spatial dimension, as it is indicated by the concept distance in a geographical or functional space illustrated in figure 3, **but also the time dimension**. In fact, **the structure of a network is continuously changing**, due to the establishment of new links between couples of actors and the change or rupture of the existing bilateral links. In particular, **indirect links ("weak ties") may gradually transform into direct links ("dyadic ties").**

The incentive for a couple of actors or nodes to establish a new link or also to increase/decrease an existing link depends on the respective **perception of the other actor or node characteristics, such as its position within the overall network or its distance with other nodes**, taken into account the existence of intermediate nodes.

Moreover, this incentive depend on **the direct and indirect relationships developed in the past or the existence of a cumulative learning process.**

Thus, **the adoption of a network perspective allows to focus some new aspects of the process of technological change**. In fact, in a network perspective, technological change may be interpreted as the result of the **continuous or gradual search by each node, of the most appropriate level and form of integration or co-operation with the other nodes or actors within the network**.

Technological change is related to the effort to adapt, decrease or also increase the distances (d_{ij}) and ($_{AB}d_{ij}$) existing between the various nodes, by establishing new links or forms of connectivity, which may be both direct or indirect, and by improving and making more intense the existing links.

Technological change is similar to a process of **iterative adaptation of the direct and indirect links between any couple of nodes in order to maximize their respective interaction and integration. That process does not** depend not only on **the distances (d_{ij}) and ($_{AB}d_s$)** but also on the **recent history of these links**.

This process of adaptation and co-evolution of the relationships between the nodes of a network may be defined as **a process of learning and of knowledge accumulation.**

A cognitive approach to knowledge networks

As in the models of neural networks, an innovation is the result of an **adaptive learning or searching process**, which leads to new synaptic connections of various nodes. A scientific breakthrough and an innovation occurs, when the **joint impulses or signals coming from other nodes** not only are **compatible** with the node considered, but also **overcome a certain threshold of intensity**. That allows the considered node to **perceive this stimulus**. The node may then decide whether to **conflict with it or rather to adapt to it**. In fact, whether the stimulus is compatible with the **existing cognitive system**, an interactive processing may lead to identify an incremental solution to an existing problem and that stimulates the act of **innovation**.

On the other hand, **a cognitive blockade or lock-in effect** may be determined by a **too low accessibility** or by a **too low receptivity**. In particular, the accessibility is affected by the existence of infrastructures and institutions which may decrease the distance between any two nodes. On the other hand, the receptivity is related mainly to the scope of the diversified knowledge available within a node, since that allows it to identify useful forms of complementarity in the relations with another node. Clearly also **time is a crucial factor** as it facilitates to perceive a continuous stimulus or to absorb and adapt gradually to it.

In particular, **technological change may be related to:**
- **the intensity of the interaction** between the various nodes of a network **through the existing links**. That is related to **the interactive characteristic** of technological change, as it is based on interactive learning processes,
- **the speed of change of the links** between the various nodes of a network **through the creation of new links**. That is related to the **combinatory** characteristics of technological change**,** which is made by an original combination of logical concepts or concrete artefacts, which may already known, but which were previously disjoint.

In fact, technological change is based on the interaction of various economic actors with different and complementary knowledge and competencies and on the integration of various abstract logical concepts or pieces of knowledge. Thus, **technological change has both a productive dimension and a cognitive dimension**.

The process of interaction is related to the changes in the division of labor (Cappellin 1983, Cappellin and Nijkamp 1990), **between different firms** or to the change in the adopted technologies and it is related to the flows of product and services, which jointly determine the overall national production and to the existence of adjustment or change costs.

The process of integration is related to the combination of information flows and **to the process of knowledge creation,** which has a crucial role in **a modern "learning economy".**

These two processes demonstrate the tight connection or complementarity among the networks of production (Y) and those of the input flows (K and L) and the respective actors and the networks of knowledge flows (T), as indicated in figure 3.

Thus, **knowledge generates organizational change** (e.g. technological change and innovation and the change in the input-output flows between the firms and actors), while **knowledge is also generated** through the process of interactive learning **by organizational change,** which is related to the change in the structure of the networks of production relationships between the various firms and actors (Capra 1996).

The difference between the network model and the market model

The network approach is very different from the neoclassical approach, which represents the traditional base of economic analysis. On the other hand, in a methodological perspective, the **Input Output model** could be considered as the prototype of the network approach. The model of networks is also related to the concept of **transaction costs** (Coase 1992, Williamson 2000) and it is intermediate between the concept of market of the neoclassical approach and that of the hierarchy of the business economics.

While, the traditional neoclassical paradigm underlines the **horizontal dimension of the competition** between the firms on the market and the process of determination of an equilibrium price, the network paradigm underlines **the vertical dimension of the relations of production integration** between the firms, which participate to different phases of the value chain.

Within the neoclassical model of perfect competition **the firms are all equal** and connected through **the anonymous mechanism of the market**, while in the model of the networks **the firms are all different** and **integrated between them through different types of relations, which have an intentional character**.

In particular, within a network, a crucial role is performed by relations and processes of **exchange, negotiation, conflict, agreement and integration between actors**, which are different and potentially complementary. For example, the network model allows to interpret the relations of **vertical integration between clients and suppliers**, or the contracts between various firms collaborating in **a joint investment** or the joint creation of a new firm, to which the partners transfer particular resources for the achievement of a common aim.

The concept of equilibrium and the balance between the two forces of demand and supply characterize the neoclassical paradigm and seem a very rudimentary approach mainly based on the concepts of physics or mechanics. The crucial characteristic of a network of firms is not **the concept of equilibrium and disequilibrium**, as in the neoclassical model of the market, but rather **the concepts of integration, sequential interaction, circulation diffusion and feedback, recursive processes, symbiosis and co-evolution**.

Thus, **the neoclassical approach is methodologically appropriate mainly in order to explain the mechanisms of price determination ("price theory").** Instead, **the model of networks aims to analyse a different type of problems, such as the characteristics of cognitive processes.** This aim is shared also by the research in other fields, such as: neurophysiology, artificial intelligence and also psychology, sociology, institutionalism and it seems particularly appropriate for the field of **economics of innovation**.

In conclusion, **the market of the neoclassical model may be considered as a network. However, the market is a very simple network,** in which **all actors are homogenous**, although they may have a different supply schedule, and **the distance or the transaction costs between actors are zero.**