GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

10. INPUT-OUTPUT-WORKSHOP 2018

Tagungsband zum
10. Input-Output-Workshop 2018

Bremen

Anke Mönnig (Hrsg.)

Impressum

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Tagungsband zum 10. Input-Output-Workshop 2018 – Bremen

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Vorwort

Sehr geehrte Teilnehmer des 10. I-O-Workshops, Kollegen und Interessierte an der Input-Output-Forschung,

2018 fand der 10. Input-Output-Workshop erstmalig in Bremen an der Universität Bremen statt. Das im Vorjahr eingeführte Konzept der Bilingualität und parallelen Sessions wurde weitergeführt. Zwei hervorragende Gastredner, Prof. Dr. Erik Dietzenbacher von der Universität Groningen, Niederlande, und Dr. Doug Meade von der Universität Maryland, USA, sowie eine Special-Session zum Thema Datenqualität versus Datenquantität unter Leitung von Dr. Josef Richter und unter Mitwirkung von Frau Höh vom Statistischen Bundesamt sowie Dr. Marc Ingo Wolter von der GWS bereicherten das Programm.

Zur großen Freude der Veranstalter – Gesellschaft für Wirtschaftliche Strukturforschung (GWS), Hochschule Bochum und Universität Bremen – stieß der Workshop auf hohes Interesse in der nationalen und internationalen I-O-Community. Sehr viele Abstracts mit hoher Qualität wurden eingereicht, unter denen aufgrund der begrenzten Teilnehmerplätze leider nur rund 30 Vortragende ausgewählt werden konnten. Das Scientific Committee hat hier hervorragende Arbeit geleistet. Der I-O-Workshop konnte zudem weitere rund 20 Gasthörer als interessierte Teilnehmer begrüßen.

Die Vorträge deckten einen weiten Kranz an Input-Output-relevanten Themen ab. Die Beiträge erstreckten sich von der Datenexegese von Input-Output Tabellen in Panama (Juan Rafael Vargas), über den THG-Fußabdruck der Bioökonomie (Christian Lutz), Subventionen und Steuern in der I-O-Modellierung (Bert Steenge) bis hin zur Anwendung von CGE-Modellen zur Evaluierung der Mehrwertsteuerreform in China (Shen Xuemi) oder der Handelsspezialisierung in globalen Wertschöpfungsketten (Filippo Bontadini).

Der vorliegende Tagungsband umfasst das Programm des I-O-Workshops mitsamt den zu den Vorträgen gehörenden Abstracts – soweit sie für die Veröffentlichung freigegeben worden sind. Einzelne Teilnehmer reichten dankenswerter Weise eine erweiterte Ausführung ihres Vortrages zur Veröffentlichung in diesem Tagungsband nach. Wir wünschen viel Spaß bei Lesen und Nachschlagen der gesammelten Beiträge. Die Präsentationen, Abstracts und ausgeführten Beiträge können auch auf der Homepage unter io-workshop.gws-os.com abgerufen werden.

2019 wird der Input-Output-Workshop erstmalig in Bochum, ausgerichtet von der Hochschule Bochum, stattfinden. Es wird sich wieder um einen themenspezifischen Workshop handeln, der dazu einlädt, aktuelle Themen in der Input-Output-Forschung im Bereich „Nachhaltigkeit" vorzustellen und zu diskutieren. Mit Dr. Maike Bouwemeester von Eurostat konnte bislang ein hochkarätiger Name der Input-Output-Gemeinschaft als Gastrednerin gewonnen werden. Erstmalig konnten auch Special-Sessions von Teilnehmern eingereicht werden. Der im März 2019 stattfindende Workshop verspricht schon jetzt, eine spannende Veranstaltung zu werden.

Abschließend möchte ich mich herzlich bei allen Vortragenden und Mitdiskutanten des 10. Input-Output-Workshops bedanken, die maßgeblich dafür verantwortlich waren, dass auch 2018 wieder ein mit viel Spirit und Engagement geladener Workshop gefüllt mit äußerst spannenden Input-Output-Themen durchgeführt werden konnte. Nicht zu vergessen sind die in gelockerter Atmosphäre verbrachten Abende, die dazu dienten, sich außerhalb universitärer Räume kennenzulernen und auszutauschen.

An dieser Stelle nicht zu vergessen sind die Helfer im Hintergrund, die den reibungslosen Ablauf des Workshops gestützt haben. Hierfür gebührt dem gesamten Organisationsteam der Universität Bremen unter Leitung von Prof. Dr. Jutta Günther und unter Koordination von Maria Kristalova der herzlichste Dank. Auch Ingrid Suilmann soll herzlich gedankt werden, die sich um die Abwicklung der Workshopgebühren gekümmert hat. Dank gehört auch Inka Peters, ohne deren Hilfe die Zusammenstellung des Konferenzbandes auch dieses Jahr kaum möglich gewesen wäre.

Es freut sich auf ein spannendes neues Input-Output-Jahr 2019

Anke Mönnig — Osnabrück, Januar 2019

Programm des 10. Input-Output-Workshops

DONNERSTAG, 15. MÄRZ 2018

10:00 – 10:10	BEGRÜßUNG Prof. Dr. Günther
10:10 – 11:10	KEYNOTE PROF. DR. E. DIETZENBACHER Global Value Chain Analysis

11:10 – 11:30	KAFFEEPAUSE

SESSION 1		
	SESSION 1A | DE	SESSION 1B | EN
11:30 – 12:00	EMMENEGGER, J.-F. Konvexe Kegel in Sraffas Ökonomien der Kuppelproduktion	HARDADI, G. Effects of Sector Aggregation on Elasticities of Substitution and Production Functions: Modelling Substitutability between Production Factors in EXIOBASE 3
12:00 – 12:30	REICH, U. England gegen Cambridge, Massachussets: Input-Output-Analyse einer einst berühmten Kontroverse	STEENGE, B. Taxes and Subsidies in Input-Output Modelling: Lloyd Metzler Revisited
12:30 – 13:00	GROßMANN, A. Wirkungsanalyse mit Input-Output-Modellen – Möglichkeiten und Limitationen einfacher und komplexer I-O-Modelle	JAHN, M. & FLEGG, T. Using the FLQ Formula in Estimating Interregional Output Multipliers

13:00 – 14:00	MITTAGESSEN

SESSION 2		
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	Session Chair: Prof. Dr. Utz Reich	Session Chair: Prof. Dr. Reiner Stäglin
14:00 – 14:30	Lutz, C. Ein THG-Fußabdruck der Bioökonomie – MRIO Analysen für Deutschland	Lábaj, M. Deindustrialization: New measures and policy implications
14:30 – 15:00	Paniccià, R. Analyzing the regional economic structure from a bottom up/local perspective, through a multilabour Market Areas I-O model: the case of Tuscany	Bardadym, T. Optimisation Problems for Planning Structural and Technological Changes
15:00 – 15:30	Vargas, J.-R. Data creation: input-output table for Panama	Chaitanya, T. Exploring the evolution of India's economic structure: the case of manufacturing-services interlinkages

13:00 – 14:00	Kaffeepause

STATISTIK-SESSION DE	
Session Chair: Prof. Dr. Josef Richter Statistikproduzenten und Statistiknutzer – eine harmonische Beziehung?	
15:45 – 16:15	Höh, A. Aufkommens-, Verwendungs- und Input-Output-Tabellen – ein Werkstattbericht vom Datenproduzent
16:15 – 16:45	Wolter, M.-I. Steigende Ansprüche an Input-Output-Modelle?
16:45 – 17:15	Offene Diskussion Q&A mit den Experten

FREITAG, 16. MÄRZ 2018

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10:15–10:45	LUDWIG, U. Deutschlands "Basar-Ökonomie" nach der Finanz- und Wirtschaftskrise	KOLLER, W. Economic drivers of greenhouse gas-emissions in small open economies: A hierarchical structural decomposition analysis
10:45–11:15	SEIBERT, D. Die ökonomische Bedeutung von Bildung in Deutschland: das Bildungssatellitenkonto als neues Instrument der Bildungspolitik	YAMANO, N. Inter-country comparison of carbon footprint with purchasing price index adjustment
11:15 –11:45	KOCH, A. Wird Baden-Württemberg zu einem Dienstleistungsland? Veränderungen an der Schnittstelle von Industrie und Dienstleistungsbereich	CAI, M. Bridging macroeconomic data between statistical classifications

11:45–12:00	KAFFEEPAUSE

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12:00 –12:30	STÖVER, B. The local economic impact of universities	WIEBE, K. Circular economy scenarios in a multi-regional input-output framework

12:30 – 13:00	BIERITZ, L. Sectoral analysis of the Chilean economy using the Input-Output-based model COFORCE	TÖBBEN, J. Land-use and biodiversity footprints of palm oil embodied in final product consumption
13:00 – 13:30	ALBU, N. Lohnstückkosten des deutschen Verarbeitenden Gewerbes: inländische und globale Verflechtungen	KRONENBERG, T. Organic Farming in the Input-Output Framework

13:30 – 14:15	MITTAGESSEN

SESSION 5		
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Konvexe Kegel in Sraffas Ökonomien der Kuppelproduktion

Emmenegger, Jean-François & Nour Eldin, Hassan Ahmed – Universität Freiburg (CH)

Abstract: Im Falle der Kuppelproduktion ist die Satzgruppe von Perron-Frobenius zur Bestimmung positiver Preisvektoren in Sraffa-Preismodellen [7] nicht direkt anwendbar. Manara [2] hat vier Bedingungen ausgearbeitet und vorgeschlagen, welche positive Preisvektoren und positive Sektor Lohnvektoren zu bestimmen erlauben, so dass die Lösungen analog zu den Sraffa-Preismodellen von Ein-Produkt Industieren ermittelt werden können. Im vorliegenden Aufsatz werden die Manara-Bedingungen vollständig raumgeometrisch interpretiert. Die Rechenverfahren mit Matrizen sind ausgearbeitet. Der Zusammenhang der Manara-Bedingungen mit der Ergiebigkeit R der Ökonomie, die im Falle brutto-integrierter Industrien aus der Frobeniuszahl λ_C der Input-Output Koeffizienten Matrix berechnet werden kann, $\lambda_C^{-1} = 1 + R$, ist ausgeleuchtet.

1 EINLEITUNG

Im ersten Teil seines Buches Warenproduktion mittels Waren, [7] behandelt Piero Sraffa (1898-1983) aus n Sektoren bestehende Ökonomien. Jeder der n Sektoren erzeugt genau eine der n Waren.

Man betrachte die semi-positive $(n\ x\ n)$ Matrix $\mathbf{S}$ und den semi-positiven Überschussvektor $\mathbf{d}$, womit man den Outputvektor $\mathbf{q} = \mathbf{Se} + \mathbf{d}$ der gesamten Verwendung bildet. Man hat ferner den Vektor $\mathbf{L}$ der Arbeitszeiten je Sektor.

Sraffas Produktionsschema stellt jeden Sektor $j\ \in \{1, \dots, n\}$, (Zeile) zusammen mit dem Arbeitsaufwand L_j und der erzeugten Menge $q_j > 0$ dar,

$$\begin{array}{ccccccc} (s_{11}, & s_{21}, & s_{31}, & \dots, & s_{n1}, & L_1) \\ (s_{12}, & s_{22}, & s_{32}, & \dots, & s_{n2}, & L_2) \\ (\dots, & \dots, & \dots, & \dots, & \dots, & \dots\ ) \\ (s_{1n}, & s_{2n}, & s_{3n}, & \dots, & s_{nn}, & L_n) \end{array} \rightarrow \begin{array}{ccccc} (q_1, & 0, & 0, & \dots, & 0), \\ (0, & q_2, & 0, & \dots, & 0), \\ (0, & 0, & q_3, & \dots, & 0), \\ (0, & 0, & 0, & \dots, & q_n), \end{array} \qquad (1)$$

$$(\mathbf{S}, \mathbf{L}) \rightarrow (\hat{\mathbf{q}}).$$

Man erkennt die Ein-Produkt Sektoren daran, die die Ergebnismatrix $\hat{\mathbf{q}}$ diagonal ist.

Eines der Grundanliegen von Sraffa besteht darin, zur Lösung des Verteilungsproblems von David Ricardo beizutragen. Es geht darum, die Bedingungen zu formulieren, dass eine gegebene Produktionsökonomie die verwendeten Produktionsmittel innerhalb einer Periode, meistens eines Jahres, voll ersetzt und einen positiven Überschuss erwirtschaftet. Dieser Überschuss ist in Profite für Unternehmer und Löhne für Arbeitnehmer gleichmäßig aufzuteilen.

Die Produktionspreise aller Sektoren müssen positiv sein, denn sonst überlebt der entsprechende Industriesektor nicht, da er für die nächste Periode keine Produktionsmittel erzeugen könnte. Ist etwa $p_1 = 0$, so ist der Wert der in der laufenden Periode erwirtschafteten Ware 1 des Sektors 1 gleich Null, $x_1 = p_1 \cdot q_1 = 0$. Ist $p_2 > 0$, so kann der Sektor 1 für die nächste Periode die notwendige Ware $s_{21} > 0$ nicht erstehen, deren Wert grösser als Null ist, $z_{21} = s_{21} \cdot p_2 > 0$, da Sektor 1 eben über keine Zahlungsmittel verfügt..

Sraffa setzt in seinem vollständigen Modell uniforme Profitraten $r > 0$ und uniforme Lohnraten $w > 0$ voraus, die nicht unabhängig voneinander gewählt werden können.

Damit gewinnt man das vollständige Sraffa Preismodell. Man definiert noch die semi-positive Input-Output Koeffizienten Matrix $\mathbf{C} = \mathbf{S}\hat{\mathbf{q}}^{-1}$ und erhält die Preisgleichung,

$$\mathbf{S}'\mathbf{p}(1+r) + w \cdot \mathbf{L} = \hat{\mathbf{q}}\mathbf{p} \Rightarrow \mathbf{C}'\mathbf{p}(1+r) + w \cdot \hat{\mathbf{q}}^{-1}\mathbf{L} = \mathbf{p}. \qquad (2)$$

Unter der zusätzlichen Bedingungen $\mathbf{L} > \mathbf{o}$, erhält man positive Preisvektoren $\mathbf{p} > \mathbf{o}$ aufgrund des Satzes von Perron-Frobenius.

2 ERWEITERUNG AUF KUPPELPRODUKTION

In reellen Volkswirtschaften muss man eher davon ausgehen, dass verschiedene Industriezweige in Kuppelproduktion Produkte und Nebenprodukte erzeugen. Dabei stößt man auf strukturelle Fragen. Wie unterteilt man die Ökonomie in Sektoren; welche Industriezweige werden mit welchen Industrien in einen Sektor zusammengefasst !

Nehmen wir ein erstes Beispiel von *Kuppelproduktion*: Die *klassische Uhrenindustrie* (Swatch, Omega, Rolex)) und die Computerindustrie (Apple Watch seit 09.09.2014) erzeugen je das Fertigungsprodukt *Uhren*.

Weitere Beispiele: (https://de.wikipedia.org/wiki/Kuppelproduktion, 17.02.2018)

- die zwangsläufige Produktion von Benzin, Dieselkraftstoff und Schweröl bei der Verarbeitung von Erdöl,
- die Erzeugung von Glycerin bei der Herstellung von Biodiesel,
- die Erzeugung von Strom und Wärme im Heizkraftwerk,
- die Gewinnung von Restholz aus dem Verschnitt der Nutzholzproduktion,
- die Erzeugung von Kleie und Grieß bei der Herstellung von Mehl aus Getreide.

Kuppelproduktionsmodelle stehen also näher an der reellen Wirtschaft als Modelle von Ein-Produkt Industrien.

Im zweiten Teil seines Buches [7] behandelt Sraffa die *Kuppelproduktion*. Er betrachtet eine aus n Sektoren bestehende Ökonomie, die insgesamt genau n Waren erzeugt, wobei jeder Sektor mindestens eine Ware produzieren muss. Man hat jetzt Multi-Produkt Zweige. Jeder Sektor kann eine oder mehrere verschiedene Waren erzeugen.

Formal erstellt man zwei reelle, *semi-positive* $(n \ x \ n)$ Matrizen, eine ist die *Warenfluss* Matrix $\mathbf{S} = (s_{ij}) \geq \mathbf{0}$ und die andere ist die *Output* Matrix $\mathbf{F} = \left(f_{ij}\right) \geq \mathbf{0}$ (Schefold [6], p. 49), deren Größen in *physischen Einheiten* gemessen sind. Das Element $s_{ij} \geq 0$ bezeichnet die Menge der Ware i, welche vom Sektor j bearbeitet wird, während $f_{ij} \geq 0$ die Menge der Ware i bezeichnet, welche vom Sektor j erzeugt wird. Weiterhin braucht man noch einen *nicht-negativen Arbeitsvektor* $\mathbf{L} = (L_j) > \mathbf{o}$, wobei $L_j > 0$ die im Sektor j benötigte Gesamtarbeitszeit bezeichnet.

Mit den Spaltenvektoren[1] $\mathbf{s}_{.j} = \left[s_{1j}, s_{2j}, \dots, s_{nj}\right]'$ und $\mathbf{f}_{.j} = [f_{1j}, f_{2j}, \dots, f_{nj}]'$ beschreibt man die n Produktionsprozesse $\left(\mathbf{s}_{.j}, L_j\right) \rightarrow (\mathbf{f}_{.j})$. Ausgehend von *Ein-Produkt Industrien*, die neben einem produzierten Überschuss ihre Produktionsmittel *gesamthaft selbst ersetzen*, ist man übergegangen zu *Kuppelproduktionsindustrien*, die ebenfalls einen Überschuss produzieren und ihre Produktionsmittel ebenfalls gesamthaft selbst ersetzen. Dabei beobachten wir, dass die Diagonalmatrix $\hat{\mathbf{q}} > \mathbf{o}$ der *Ein-Produkt Industrien* im Produktionsschema (1) durch die transponierte *semi-positive Outputmatrix* $\mathbf{F}'$ ersetzt wird.

Manara [2] (in Pasinetti [4] Ed., p. 2) bezeichnet f_{ij} als die "Menge der Ware i, die durch die j-te Industrie produziert wird". Damit ergibt sich das Produktionsschema der *Kuppelproduktion*,

$$\begin{matrix} (s_{11}, & s_{21}, & s_{31}, & \dots, & s_{n1}, & L_1) & & (f_{11}, & f_{21}, & f_{31}, & \dots, & f_{n1}), \\ (s_{12}, & s_{22}, & s_{32}, & \dots, & s_{n2}, & L_2) & & (f_{12}, & f_{22}, & f_{32}, & \dots, & f_{n2}), \\ (s_{13}, & s_{23}, & s_{33}, & \dots, & s_{n3}, & L_3) & \rightarrow & (f_{13}, & f_{23}, & f_{33}, & \dots, & f_{n3}), \\ (\dots, & \dots, & \dots, & \dots, & \dots, & \dots) & & (\dots, & \dots, & \dots, & \dots, & \dots), \\ (s_{1n}, & s_{2n}, & s_{3n}, & \dots, & s_{nn}, & L_n) & & (f_{1n}, & f_{2n}, & f_{3n}, & \dots, & f_{nn}), \end{matrix} \qquad (4)$$

$$(\mathbf{S}', \mathbf{L}) \quad \rightarrow \quad (\mathbf{F}').$$

Man beobachtet, dass jede Zeile die Produktion einer Industrie darstellt, die nicht mehr einer einzigen Ware zugeordnet werden kann, da jede Industrie mehr als eine Ware produzieren kann. Aber wir haben eine kompakt geschriebene Form des *Produktionsprozesses* mit den Matrizen $\mathbf{S}$, $\mathbf{F}$ und dem Arbeitsvektor $\mathbf{L}$. Das Sraffa-Preissystem präsentiert sich wie folgt:

$$\mathbf{S}'\mathbf{p}(1+r) + \mathbf{L} \cdot w = \mathbf{F}'\mathbf{p} \quad \Leftrightarrow \quad \mathbf{L} \cdot w = \left(\mathbf{F}' - \mathbf{S}'(1+r)\right)\mathbf{p}, \qquad (5)$$

Wir lösen die Gleichung (5) nach dem Vektor der *Sektor Löhne* $\mathbf{w} \coloneqq w \cdot \mathbf{L}$ auf. Die Matrix $(\mathbf{F}' - \mathbf{S}'(1+r))$ ist jedoch nicht unbedingt invertierbar. Es gilt aber offensichtlich die Grenzwertaussage

$$\lim_{\mathbf{p} \rightarrow \mathbf{o}} (w \cdot \mathbf{L}) = \lim_{\mathbf{p} \rightarrow \mathbf{o}} \left(\mathbf{F}' - \mathbf{S}'(1+r)\right)\mathbf{p} = \mathbf{o}. \qquad (6)$$

Es stellt sich nun die Frage, unter welchen *hinreichenden Bedingungen* für die Matrizen $\mathbf{S}$ und $\mathbf{F}$ positive *Preisvektoren* $\mathbf{p} > \mathbf{o}$ zu gegebenen positiven Arbeitsvektoren $\mathbf{L} > \mathbf{o}$ existieren. Man stellt fest, dass die Satzgruppe von Perron [5] und Frobenius [1] im Falle der Kuppelproduktion nicht zur Anwendung kommen kann, da das Preismodell (2) im allgemeinen nicht so umgeformt werden kann, dass *nicht negative* Matrizen entstehen. Die Frage ist also beträchtlich komplexer!

3 ÖKONOMISCHE BEDINGUNGEN

Manara [2] hat Bedingungen formuliert, damit das Preismodell (5) im Falle der *Kuppelproduktion* positive Preisevektoren $\mathbf{p} > \mathbf{o}$ aufweist.

[1] Das Zeichen Apostroph (´) ist der Transpositionsoperator.

Manaras erste Bedingung (*B1)* besteht darin, wie bei Ein-Produkt Sektoren einen Produktionsüberschuss zu verlangen. Mit dem $(n\ x\ 1)$ Summenvektor $\mathbf{e} = [1,1,,1,\dots.,1]'$ berechnet man den Überschussvektor $\mathbf{d} = (\mathbf{F} - \mathbf{S})\mathbf{e} > \mathbf{o}$, den Manara in diesem Kontext sogar positiv voraussetzt, wo doch *Semipositivität* genügen würde.

Annahme (*B1)*: *(Annahme betreffend Überschuss in Kuppelproduktion)*

Im Falle der Kuppelproduktion ergeben sich die Bedingungen des Selbstersatzes auf drei Arten, ausgedrückt durch den Vektor des Überschusses, auch Vektor der Nettoproduktion genannt (Schefold (6), S. 49):

$$\mathbf{d} = (\mathbf{F} - \mathbf{S})\mathbf{e} = \mathbf{o}, \qquad \text{kein Überschuss,}$$
$$\mathbf{d} = (\mathbf{F} - \mathbf{S})\mathbf{e} \geq \mathbf{o}, \qquad \text{Selbstersatz,} \tag{7}$$
$$\mathbf{d} = (\mathbf{F} - \mathbf{S})\mathbf{e} > \mathbf{o} \qquad \text{positiver Selbstersatz.}$$

Manaras zweite Bedingung *(B2)* setzt lineare Unabhängigkeit der einzelnen Produktionsprozesse $(\mathbf{s}_{.j}, L_j) \rightarrow (\mathbf{f}_{.j}),\ j \in \{1,\dots,n\}$, voraus, denn sonst könnten Prozesse zusammengelegt werden. Deshalb ist Matrix $\mathbf{F}' - \mathbf{S}'$ regulär vorauszusetzen.

Annahme *(B2)*: *(Annahme über lineare Unabhängigkeit der Prozesse)*

Bei Kuppelproduktion mit Überschuss ist die Matrix $(\mathbf{F}' - \mathbf{S}')$ regulär,

$$\det(\mathbf{F}' - \mathbf{S}') \neq 0 \quad \Leftrightarrow \quad \det(\mathbf{F} - \mathbf{S}) \neq 0 \tag{8}$$

Damit sind die Produktionsprozesse $(s_{.j}, L_j) \rightarrow (f_{.j}),\ j \in \{1,\dots,n\},\ (4)$ linear unabhängig und paarweise verschieden, was einer erwarteten Eigenschaft entspricht.

Es gilt auch: $$\mathrm{Rang}([\mathbf{S}', \mathbf{F}']) = \mathrm{Rang}([\mathbf{S}', \mathbf{F}' - \mathbf{S}']) = n. \tag{9}$$

Schefold[2] hat zusätzlich die ökonomische Bedingung formuliert, dass jeder Prozess j neben positiver Arbeitszeit $L_j > 0$ mindestens einen Input und mindestens einen Output enthalten muss, dies impliziert *Semi-Positivität* der Matrizen $\mathbf{S} \geq \mathbf{0}$ und $\mathbf{F} \geq \mathbf{0}$.

Schefold-Annahme: *(Existenz von Inputs und Outputs, brutto-integrierte Industrien)*

Jeder Produktionsprozess muss neben Arbeitszeit mindestens einen Input und mindestens einen Output besitzen, $\mathbf{s}_{.j} \geq \mathbf{o}$, $\mathbf{f}_{.j} \geq \mathbf{o}$, Schefold ([6], p. 49), siehe Fußnote 2.

Aus diesen ökonomischen Gründen hat man semi-positive Matrizen, $\mathbf{S} \geq \mathbf{0}$, $\mathbf{F} \geq \mathbf{0}$.

Wenn die Matrix $\mathbf{F}$ vollen Rang hat,

$$\mathrm{Rang}(\mathbf{F}) = n \quad \Leftrightarrow \quad \det(\mathbf{F}) \neq 0, \tag{10}$$

dann kann das *Ein-Produkt-System* $(\mathbf{F}'^{-1}\mathbf{S}', \mathbf{F}'^{-1}\mathbf{L}) \rightarrow (\mathbf{I})$, bezeichnet als *System brutto-*

[2] Aus der Sicht der Autoren ist Schefold ([6], p. 49) der erste Wirtschaftswissenschafter, der diese Forderung klar und deutlich formulierte: Er sagte: *(…[E]very process has an input besides labour and an output).* Die Bedingung $\det(\mathbf{F}) \neq 0$ ist genügend aber nicht notwendig für die Semi-Positivität der Vektoren $\mathbf{f}_{.j} \geq \mathbf{o}$. Aber es ist eine notwendige Bedingung für Produktions-Systeme, die man als *brutto-integrierte Industrien* bezeichnet (*gross integrated industries)*, siehe Schefold [6], p. 56).

integrierter Industrien, aus dem Kuppelproduktionssystem $(\mathbf{S}', \mathbf{L}) \rightarrow (\mathbf{F}')$ erzeugt werden.

Um das Problem nicht unnötig schwierig zu gestalten, hat Manara generell vorausgesetzt, dass in den beschriebenen Ökonomien ausschließlich *Basisprodukte* auftreten. Das heißt, mit $1 \leq m < n$ und $(m\ x\ m)$ Teilmatrizen $\mathbf{S}_{22}$, $\mathbf{F}_{22}$, bildet man die Matrixeinteilung,

$$\mathbf{S}' = \begin{bmatrix} \mathbf{S}_{11}' & \mathbf{S}_{21}' \\ \mathbf{S}_{12}' & \mathbf{S}_{22}' \end{bmatrix} \Rightarrow \mathbf{S}_2' = \begin{bmatrix} \mathbf{S}_{21}' \\ \mathbf{S}_{22}' \end{bmatrix}, \qquad \mathbf{F}' = \begin{bmatrix} \mathbf{F}_{11}' & \mathbf{F}_{21}' \\ \mathbf{F}_{12}' & \mathbf{F}_{22}' \end{bmatrix} \Rightarrow \mathbf{F}_2' = \begin{bmatrix} \mathbf{F}_{21}' \\ \mathbf{F}_{22}' \end{bmatrix}.$$

Dann konstruiert man folgende Matrix

$$[\mathbf{S}_2' \quad \mathbf{F}_2'] := \begin{bmatrix} \mathbf{S}_{21}' & \mathbf{F}_{21}' \\ \mathbf{S}_{22}' & \mathbf{F}_{22}' \end{bmatrix}.$$

Nun kann man nach Schefold [6], p. 58, Nicht-Basisprodukte definieren: „Ein Produktionssystem $(\mathbf{S}', \mathbf{F}')$ enthält m Nicht-Basisprodukte, wenn eine Permutation der Spalten“ (ausgeführt durch Permutationsmatrizen auf den Matrizen $\mathbf{S}'$ und $\mathbf{F}'$) „und eine Zahl m existieren, so dass die Matrix $[\mathbf{S}'_2 \quad \mathbf{F}'_2]$, bestehend je aus den m letzten $(1 \leq m \leq n-1)$ Spalten der Matrizen $\mathbf{S}'$ und $\mathbf{F}'$, höchstens Rang m aufweist.“

Man sagt, dass das *Matrix Rangkriterium* für die Existenz von m Nicht-Basisprodukten im Produktionssystem $(\mathbf{S}', \mathbf{F}')$ erfüllt ist, wenn $\mathrm{Rang}([\mathbf{S}_2' \quad \mathbf{F}_2']) \leq m$ gilt.

4 BEDINGUNGEN FÜR POSITIVE PREISVEKTOREN IN ÜBERSCHUSS ERZEUGENDEN KUPPELPRODUKTIONSWIRTSCHAFTEN

Es soll nun folgende Frage behandelt werden:

Unter welchen Bedingungen gibt es bei *Kuppelproduktion* positive Preise, $\mathbf{p} > \mathbf{o}$?

Pasinetti (Ed.) ([4], Kapitel. II, S. 17) schreibt im Sinne von WmW: "*Es wird ein ökonomisches System betrachtet, in welchem alle Waren mittels Waren produziert werden. Waren sind also Kapitalgüter. Waren treten zu Beginn jedes Jahres als Inputs in den Produktionsprozess ein, zusammen mit Arbeitsdiensten. Waren sind das Ergebnis dieses Prozesses am Ende des Jahres und treten als Output auf. Ein ökonomisches System ist lebensfähig (“viable”), in dem Sinne als es fähig ist eine größere Quantität von Waren zu produzieren, als jene die es braucht, um die als Kapitalgut verwendeten Waren zu ersetzen*."

Manara in Pasinetti (Ed.) [4] (Kapitel. I, S. 4, Originalarbeit publiziert im Jahre 1968) untersuchte hinreichende Bedingungen um positive Preise zu erhalten: Er sagt:

„Es ist ganz klar, dass solche Preise positive Komponenten eines Preisvektors bilden müssen.“

Dann macht Manara die oben besprochene vereinfachende Annahme:

"…. Nehmen wir einfachheitshalber an, dass alle Waren Basiswaren sind...."

Es geht darum, diese *hinreichenden aber nicht notwendigen Bedingungen* für positive Preise darzustellen, welche Manara vor 50 Jahren formuliert hat. Es handelt sich um *Stabilitätsbedingungen* ökonomischer Systeme. Wir beginnen damit, das *Sraffa-Preismodel* der Kuppelproduktion in seiner allgemeinsten Form (5) für *semi-positive* Matrizen $\mathbf{S} \geq \mathbf{0}$,

$\mathbf{F} \geq \mathbf{0}$ zu betrachten. Dabei setzt man: $w = (\widetilde{w} \cdot Y)/L,\ r > 0$.

$$\mathbf{S}'\mathbf{p}(1 + r) + \mathbf{L} \cdot w = \mathbf{F}'\mathbf{p}. \tag{11}$$

Wir bleiben auf der Stufe der Warenflüsse. Wir verlangen keine *brutto-integrierten Industrien* (10), so dass wir die Regularität der Matrix $\mathbf{F}$, $\det(\mathbf{F}) \neq 0$, nicht fordern können und somit die *Input-Output Koeffizienten* Matrix nicht berechnen können. Konsequenterweise haben wir keine Eigenwertgleichung, der Satz von Perron-Frobenius ist außer Reichweite.

Man muss einen anderen Weg suchen. Wir kennen bereits die Annahmen *(B1)* und *(B2)* von Manara. Es werden nun seine zwei weiteren *hinreichenden raumgeometrischen* Annahmen *(B3)*, *(B4)* formuliert. Die Idee besteht darin, *konvexe polyedrische Kegel* zu verwenden, um *Stabilitätsbedingungen* zu finden und zu formulieren, die positive *Preisvektoren* $\mathbf{p} > \mathbf{o}$ und positive Vektoren von Sektor Löhnen $\mathbf{L} > \mathbf{o}$ garantieren.

Definition 1: (Konvexe polyedrische Kegel)

1) Eine Teilmenge C des Vektorraumes $\mathbb{R}^n$ ist ein Kegel, falls für jeden Vektor $\mathbf{x} \in C$ und jeden positiven Skalar $\alpha \in \mathbb{R}_+$ das Produkt $\alpha\,\mathbf{x} \in C$ ist.

2) Ein Kegel C ist *konvex*, wenn für alle möglichen positiven Skalare $\alpha, \beta \in \mathbb{R}_+$ und beliebige Vektoren $\mathbf{x}, \mathbf{y} \in C$ gilt: $\alpha\,\mathbf{x} + \beta\,\mathbf{y} \in C$.

3) Ein Kegel C heißt *polyedrisch*, falls es eine quadratische $(n\ x\ n)$ Matrix $\mathbf{J}$ gibt, so dass $C = \{\mathbf{x} \mid \mathbf{J}\,\mathbf{x} \geq \mathbf{o}\}$**.** Dies ist die Beschreibung durch eine Ungleichung. Es gibt eine zweite Beschreibung polyedrischer Kegel durch *gewichtete Summen*. Der Kegel C ist durch eine endliche Menge von Vektoren $\{\mathbf{v}_1, \dots, \mathbf{v}_k\}$ gegeben, so dass er geschrieben werden kann wie $C = \{\alpha_1 v_1 + \alpha_2 v_2 + \cdots + \alpha_k v_k | \alpha_1 > 0, \dots, \alpha_k > 0\}$, die *gewichtete Summe* der Vektormenge $\{v_1, \dots, v_k\}$, die als *Generator* des Kegels wirkt.

Notation 1: Wir beobachten auch, dass der Rang der Matrix $\mathbf{J}$, $\mathrm{Rang}(\mathbf{J}) = k \leq n$, gleich der Dimension des Vektorraumes ist, der durch die Vektoren $\{\mathbf{v}_1, \dots, \mathbf{v}_k\}$ aufgespannt ist. Wir sagen dann, dass der durch $\{\mathbf{v}_1, \dots, \mathbf{v}_k\}$ aufgespannte Kegel die Dimension $\dim(C) = k$ hat, und zwar im gleichen Sinne wie ein $3 - dim$ Würfel in einem $3 - dim$ euklidischen Raum eingebettet. Wenn $\mathbf{J}\,\mathbf{x} > \mathbf{o}$ gilt, sind die Vektoren $\mathbf{x}$ im Innern des Kegel, wenn aber $\mathbf{J}\,\mathbf{x} = \mathbf{o}$ sind die Vektoren $\mathbf{x}$ auf der Mantelfläche des Kegels.

Manara geht vom umgeschriebenen *Sraffa-Preismodell der Kuppelproduktion* (11) aus:

$$\mathbf{L} \cdot w = [\mathbf{F}' - \mathbf{S}'(1 + r)]\mathbf{p}. \tag{12}$$

Wir folgen Manara und präsentieren die beiden raumgeometrischen Bedingungen, [2] (in Pasinetti (Ed.) [4], Kapitel I). Die beiden Annahmen *(B1), (B2)* werden ergänzt.

Annahme *(B3): (Bedingung der Existenz positiver Preisvektoren)*.

Manara postuliert: „*Es existiert mindestens ein positiver Vektor* $\overline{\mathbf{p}}$*, so dass der Wert der Waren, die als Produktionsmittel durch jede der individuellen Industrien, evaluiert mit jenen Preisen, kleiner ist als der Wert der produzierten Waren, die zu den selben Preisen evaluiert sind.*“ Die Hypothese ist wie folgt formuliert:,

$$\exists\ \overline{\mathbf{p}}, \text{so dass}\ \{\overline{\mathbf{p}} > \mathbf{o}\ \wedge\ (\mathbf{F}' - \mathbf{S}')\overline{\mathbf{p}} > \mathbf{o}. \tag{13}$$

Hier verlangt Manara, dass zu jeder Ware ein positiver Überschuss produziert wird.

Dann definiert Manara zwei verschiedene *konvexe polyedrische Kegel*. Er beginnt damit, zwei Quadranten von $\mathbb{R}^n$ von *semi-positiven* Vektoren zu definieren:

$$X = \{\mathbf{x} \mid \mathbf{x} > o\} \subset \mathbb{R}^n, \qquad P = \{\mathbf{y} \mid \mathbf{y} > o\} \subset \mathbb{R}^n \tag{14}$$

Zur nicht-negativen Profitrate $r > 0$ definiert er dann die Vektormengen:

$$\begin{aligned} U(r) &= \{\mathbf{x} | \mathbf{x} \in X \wedge \mathbf{x}'(\mathbf{F}' - \mathbf{S}'(1+r)) \geq \mathbf{o}\}, \\ V(r) &= \{\mathbf{y} | \mathbf{y} \in P \wedge (\mathbf{F}' - \mathbf{S}'(1+r))\,\mathbf{y} \geq \mathbf{o}\}. \end{aligned} \tag{15}$$

Beide Vektormengen $U(r)$ und $V(r)$ repräsentieren *konvexe polyedrische Kegel*. Es wird später illustriert, dass beide Vektormengen $U(r)$ und $V(r)$ nicht leer sind. Zuerst ist klarerweise $\overline{\mathbf{p}} \in P$, mit $r = 0$ und zusammen mit der Annahme *(B3)* (13), folgern wir auf die Existenz mindestens eines positiven Preisvektor $\overline{\mathbf{p}} \in V(0) \neq \emptyset$. Zweitens, mit (7) liegt der Summationsvektor in X, $\mathbf{e} \in X$, und zusammen mit $r = 0$ erhalten wir wiederum $\mathbf{e} \in U(0) \neq \emptyset$.

Manara geht aus von der Annahme *(B2)* der linearen Unabhängigkeit der Kuppelproduktionsprozesse aus (8), siehe Pasinetti (Ed.) [3], (Seite 6). Manara sagt: "*Dies versichert uns, dass für wenigstens einen Wert r (den Wert $r = 0$), die Vektoren, die die Zeilen der Matrix $\boldsymbol{F}' - \boldsymbol{S}'(1+r)$ bilden, linear unabhängig sind*.". Dann ist das reelle Polynom $f(r)$ in der reellen Variable r definiert,

$$f(r) = \det(\mathbf{F} - \mathbf{S}(1+r)) \neq 0, \tag{17}$$

welches klarerweise kontinuierlich (stetig) ist. Manara definiert dann weiter die Teilmenge der Halbgerade $[0, \infty]$, definiert für die nicht-negative Profitrate $r \geq 0$, so dass

$$\Phi = \{r \mid f(r) = \det(\mathbf{F} - \mathbf{S}(1+r)) \neq 0\}. \tag{18}$$

Die Menge Φ *"ist linker Hand abgeschlossen, da $r = 0$ ihr Minimum ist"*. Abschließend beziehen wir uns auf das Intervall $\Phi \subset [0, \infty]$, für welches $U(r)$ und $V(r)$ (15) nicht leere Mengen sind. Definieren wir $\mathbf{J}(r) \coloneqq \mathbf{F}' - \mathbf{S}'(1+r)$, so erkennen wir, dass für $r \in \Phi$ die Kegel $U(r)$ und $V(r)$ als Dimension die Anzahl der Sektoren des ökonomischen Systems $(\mathbf{F}', \mathbf{S}')$, $\dim(V(r)) = \dim(U(r)) = n$ aufweist.

Manara definiert den Vektor der *Sektor Löhne* $\mathbf{w} \coloneqq w \cdot \mathbf{L}$, wobei die Gesamtlohnsumme gleich $W = \mathbf{e}'\mathbf{w}$ ist. Er berechnet dann mit Hilfe des Preismodelles

$$\mathbf{w} \coloneqq w \cdot \mathbf{L} = (\mathbf{F}' - \mathbf{S}'(1+r))\mathbf{p} = \mathbf{J}(r)\mathbf{p}. \tag{19}$$

Manara beobachtet, dass Gleichung (19*) "keinen Preisvektor als Lösung enthält, der für jeden beliebigen Arbeitsvektor* $\mathbf{L}$ *positiv ist und*[3] *der die Menge der durch die Industrien des Systems absorbierte Arbeit angibt."* Aus diesem Grund ist es notwendig, eine weitere Bedingung zu postulieren (in Pasinetti (Ed.) [3], p. 8) die einen positiven Preisvektor $\mathbf{p} \in V(r)$ für $r \in \Phi$ garantiert. Man berechnet den Vektor $\mathbf{w}$ (19) der Sektor Löhne, und Manara folgend definieren man $V'(r)$ als Bild von $V(r)$ wie folgt,

$$V'(r) = \{\mathbf{w} | \mathbf{w} = \mathbf{J}(r)\mathbf{p} \wedge \mathbf{p} \in V(r)\}. \tag{20}$$

Wir erinnern daran, dass die nicht-leere Menge $V(r)$ positive potentielle Preisvektoren $\mathbf{p}$ enthält, dass die Lohnvektoren $\mathbf{w} = \mathbf{J}(r)\mathbf{p} > o$ also positiv sind! Die Matrix $\mathbf{J}(r)$ ist wegen (18) regulär, ihre inverse Matrix existiert. Wir erhalten die Äquivalenz

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[3] Manara formulierte im Original : $r \in \Phi \Rightarrow \mathbf{w} \in V'(r)$.

$$\mathbf{w} = \mathbf{J}(r)\mathbf{p} > \mathbf{o} \Leftrightarrow \mathbf{p} = \mathbf{J}(r)^{-1}\mathbf{w} > \mathbf{o}, \tag{21}$$

welche zu folgender Bedingung führt:

Annahme *(B4)*: *(Positive Vektoren von Sektor Löhnen, assoziiert zu positiven Preisvektoren)*. Wir formulieren diese Bedingung als Inklusion, die von einer Zugehörigkeitsaussage (binäre Relation) zu einer Äquivalenzaussage führt:

$$r \in \Phi \Rightarrow (\mathbf{p} \in V(r) \wedge \mathbf{w} = \mathbf{J}(r)\mathbf{p} \Leftrightarrow \mathbf{w} \in V'(r) \wedge \mathbf{p} = \mathbf{J}(r)^{-1}\mathbf{w}) . \tag{22}$$

Beispiel. Man betrachte ein Produktionssystem $(\mathbf{S}', \mathbf{F}')$ von $n = 2$ Sektoren und einer Profitrate $r \geq 0$, beschrieben durch folgende Matrizen

$$\mathbf{S} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}, \qquad \mathbf{F} = \begin{bmatrix} 0 & 3 \\ 5 & 1 \end{bmatrix}. \tag{23}$$

Das Produkt 2 ist der *numéraire*. Man verifiziere die Manara Annahmen *(B1)* bis *(B4)*. Man definiere die quadratische Matrix $\mathbf{J}(r) = \mathbf{F}' - \mathbf{S}'(1 + r)$, welche den konvexen polyedrischen Kegel definiert,

$$V(r) = \{\mathbf{y} \mid \mathbf{J}(r)\mathbf{y} \geq \mathbf{o} \wedge \mathbf{y} \in P\}, \tag{24}$$

und transformiere ihn in die Form gewichteter Summen. Man wähle $r = 0.5$ und stelle die Kegel (hier Dreiecke) $V(0.5)$ und $V'(r)$ in der euklidischen Ebene dar. Bestimme das Polynom $f(r) = \det(J(r))$, das Intervall Φ (18) und diskutiere die Positivität der Preisvektoren $\mathbf{p}$ und der Sektor Löhne $\mathbf{w}$. Berechne die Ergiebigkeit $R > 0$, falls dies möglich ist.

Lösung des Beispiels:

Der Überschussvektor $\mathbf{d} = (\mathbf{F} - \mathbf{S})\mathbf{e} = [1 \;\; 4] > 0$ (7) ist positiv *(B1).* Die Matrix $\mathbf{F}' - \mathbf{S}'$ ist regulär, $\det(\mathbf{F}' - \mathbf{S}') = -8 \neq 0$ *(B2).* Wir wählen dann einen beliebigen positiven Preisvektor $\bar{\mathbf{p}} = [1{,}2]'$ und berechnen den zugehörigen Vektor der Sektor Löhne (19) zur Profitrate $r = 0$, *(B3),*

$$\mathbf{w}_0 = (\mathbf{F}' - \mathbf{S}')\bar{\mathbf{p}} = \begin{bmatrix} -1 & 4 \\ 2 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \end{bmatrix} = \begin{bmatrix} 7 \\ 2 \end{bmatrix} > \mathbf{o} \Rightarrow \bar{\mathbf{p}} \in V(0). \tag{25}$$

Damit sind die Bedingungen *(B1), (B2), B(3)* schon verifiziert. Nun erstellen wir für einen beliebigen Vektor $\mathbf{y} > \mathbf{o}$ den konvexen polyedrischen Kegel

$$\begin{aligned} \mathbf{J}(r)\mathbf{y} &:= \left(\mathbf{F}' - \mathbf{S}'(1 + r)\right)\mathbf{y} = \left(\begin{bmatrix} 0 & 5 \\ 3 & 1 \end{bmatrix} - (1 + r)\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}\right)\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \\ &= \begin{bmatrix} -1 - r & 4 - r \\ 2 - r & -r \end{bmatrix}\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{Bmatrix} (-1 - r)y_1 + (4 - r)y_2 \geq 0 \\ (2 - r)y_1 - ry_2 \geq 0 \end{Bmatrix}. \end{aligned} \tag{26}$$

Wir wählen nun $r = 0.5$ und werten (26) mit dieser Profitrate aus,

$$\mathbf{J}(0.5)\mathbf{y} = \begin{bmatrix} -\frac{3}{2} & +\frac{7}{2} \\ +\frac{3}{2} & -\frac{1}{2} \end{bmatrix}\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{Bmatrix} \left(-\frac{3}{2}\right)y_1 + \frac{7}{2}y_2 \geq 0 \\ \frac{3}{2}y_1 - \frac{1}{2}y_2 \geq 0 \end{Bmatrix}, \tag{27}$$

und bestimmen dann die Geraden $-1.5y_1 + 3.5y_2 = 0$ sowie $1.5y_1 - 0.5y_2 = 0$, die die Punktmenge des polyedrischen Kegels definieren, welcher durch die Richtungsvektoren dieser Geraden eingefasst ist und den Kegel $V(0.5)$ ergibt,

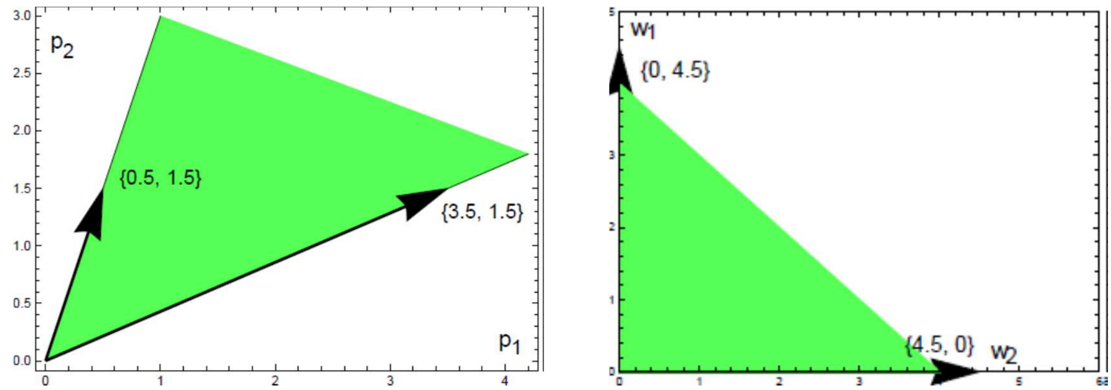
$$V(0.5) = \{p \mid p = \alpha_1 \begin{bmatrix} 3.5 \\ 1.5 \end{bmatrix} + \alpha_2 \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix}, \alpha_1 \geq 0, \alpha_2 \geq 0\}. \tag{28}$$

Wir bestimmen nun den *konvexen polyedrischen Kegel* $V'(0.5)$, das Abbild von $V(0.5)$. Zu diesem Zweck bestimmen wir die Bilder der Erzeugenden $\mathbf{v}_1(0.5)$ und $\mathbf{v}_2(0.5)$ des konvexen polyedrischen Kegels $V(0.5)$. Es sind dies die Vektoren $\mathbf{w}_k = \mathbf{J}(0.5)\mathbf{v}_k,\ k = 1{,}2$,

$$\mathbf{w}_1 = \begin{bmatrix} -\frac{3}{2} & +\frac{7}{2} \\ +\frac{3}{2} & -\frac{1}{2} \end{bmatrix} \begin{bmatrix} \frac{7}{2} \\ \frac{3}{2} \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{9}{2} \end{bmatrix}, \qquad \mathbf{w}_2 = \begin{bmatrix} -\frac{3}{2} & +\frac{7}{2} \\ +\frac{3}{2} & -\frac{1}{2} \end{bmatrix} \begin{bmatrix} \frac{1}{2} \\ \frac{3}{2} \end{bmatrix} = \begin{bmatrix} \frac{9}{2} \\ 0 \end{bmatrix}. \tag{29}$$

Wir haben nun das System der Erzeugenden $\{\mathbf{w}_1, \mathbf{w}_2\}$ des konvexen polyedrischen Kegels $V'(0.5) = \{\mathbf{w}\ |\mathbf{w} = \beta_1\mathbf{w}_1 + \beta_2\mathbf{w}_2, \beta_1 \geq 0, \beta_2 \geq 0\}$ gefunden. Die beiden konvexen polyedrischen Kegel sind in der Figur 1 dargestellt.

Wir führen einige exploratorische Berechnungen durch und wählen dazu die positiven Preisvektor $\mathbf{p}_1 = [4{,}1]' \notin V(0.5)$ und $\mathbf{p}_2 = [1{,}1] \in V(0.5)$ aus. Man erhält damit den *unzulässigen* Vektor $\mathbf{w}_1 = \mathbf{J}(0.5)\mathbf{p}_1 = [-2.5\ \ 5.5]' \notin V'(0.5)$ und den *zulässigen* Vektor der *Sektor Löhne* $\mathbf{w}_2 = \mathbf{J}(0.5)\mathbf{p}_2 = [2\ \ 1]' \in V'(0.5)$. Es ist das Ergebnis, das wir erwarteten.

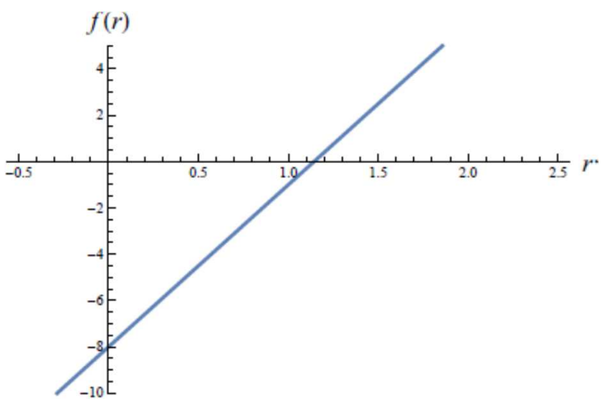


Figur 1: Konvexe polyedrische Kegel $V(0.5)$ (links) und $V'(0.5)$ (rechts) dieses Beispiel

Dann bestimmen wir die Wurzeln des Polynom $f(r)$, das in diesem Beispiel die Ordnung 1 aufweist,

$$f(r) = \det\big(\mathbf{F}' - \mathbf{S}'(1 + r)\big)\, 0 - 8 + 7r = 0 \Rightarrow\ r_1 = \frac{8}{7} > 0. \tag{30}$$

Überdies haben wir in diesem Beispiel ein System von *brutto-integrierten Industrien*, da die Matrix $\mathbf{F}$ regulär ist, $\det(\mathbf{F}) = -15 \neq 0$, so dass die nicht-negative Input-Output Koeffizienten Matrix $\mathbf{C}' = \mathbf{F}'^{-1}\mathbf{S}'$ berechnet werden kann.



Figur 2. Das Polynom $f(r)$ (30)

$$\mathbf{C}' = \mathbf{F}'^{-1}\mathbf{S}' = \begin{bmatrix} -\frac{1}{15} & \frac{1}{3} \\ +\frac{1}{5} & 0 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} = \frac{1}{15}\begin{bmatrix} 4 & 4 \\ 3 & 3 \end{bmatrix}, \tag{31}$$
$$\mathbf{C}'\mathbf{p}(1+R) = \mathbf{p} \quad \Rightarrow \quad \mathbf{C}'\mathbf{p} = \frac{1}{15}\begin{bmatrix} 4 & 4 \\ 3 & 3 \end{bmatrix}\mathbf{p} = \lambda_C \mathbf{p},\ \lambda_C = \frac{1}{1+R},$$

Man erhält die Frobeniuszahl $\lambda_C = (7/15)$ der Matrix $\mathbf{C}$ und den zugehörigen Preiseigenvektor $\mathbf{p} = [(4/3)\ \ 1]'$. Die Ergiebigkeit der Ökonomie ist $R = (1/\lambda_C) - 1 = (8/7) = r_1$, die auch die Nullstelle des Polynoms $f(r)$ (30) ist. Damit erhalten wir das offene Intervall $\Phi =]\ 0,\ (8/7)\ [$ der zulässigen Profitraten. Wir überprüfen noch (19),

$$\begin{bmatrix} L_1 \\ L_2 \end{bmatrix} \cdot w = \left(\begin{bmatrix} 0 & 5 \\ 3 & 1 \end{bmatrix} - \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} \left(1 + \frac{8}{7}\right) \right) \begin{bmatrix} \frac{4}{3} \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix},$$

wie erwartet, da das Modell (31) keinen Arbeitsvektor enthält.

Nun muss die allgemeine Gleichung (19) überprüft werden. Für jedes $r \in \Phi$ ist die Matrix regulär, $\det(\mathbf{J}(r)) \neq 0$. Somit hat man die Dimensionen, $\dim(V(r)) = \dim(V'(r)) = 2$, der konvexen polyedrischen Kegel $V(r), V'(r)$ Wir wollen nun zeigen, dass für alle $r \in \Phi$ der *Preisvektor* und der zugehörige *Vektor der Sektor Löhne* positive sind.

Zum konvexen polyedrischen Kegel $V(r) = \{\mathbf{y}\ |\mathbf{J}(r)\mathbf{y} \geq o \wedge \mathbf{y}\ \in P\}\}$ (24) berechnen wir die erste Begrenzungsgerade $(-1-r)y_1 + (4-r)y_2 = 0$, sowie die zweite Begrenzungsgerade $(-1-r)y_1 + (4-r)y_2 = 0$ (26). Damit können wir die Richtungsvektoren $\mathbf{v}_1 = [4-r, 1+r]'$ und $\mathbf{v}_2 = [r, 2-r]'$ bestimmen, die den konvexen polyedrischen Kegel $V(r)$ erzeugen. Die Tangensbedingung zwischen den Steigungswinkeln α und β der Vektoren $\mathbf{v}_1(r)$ und $\mathbf{v}_2(r)$ im ersten Quadranten der euklidischen Ebene $\mathbb{R}^2$ muss erfüllt sein:

$$\tan(\alpha) = \frac{1+r}{4-r} \leq \tan(\beta) = \frac{2-r}{r}. \tag{33}$$

Im Grenzfall führt dies zur Gleichung $(1+r)/(4-r) = (2-r)/r$ oder zu $r_1 = (8/7)$. Dies ist die dritte Berechnungsart der Ergiebigkeit $R = r_1 = (8/7)$ dieser Ökonomie. Schließlich berechnen wir noch die erzeugenden Vektoren des allgemeinen konvexen polyedrischen Kegels $V'(r)$, die da sind: $\mathbf{w}_k = \mathbf{J}(r)\mathbf{v}_k,\ \ k = 1{,}2$,

$$\mathbf{w}_1 = \begin{bmatrix} -1-r & 4-r \\ +2-r & -r \end{bmatrix} \begin{bmatrix} 4-r \\ 1+r \end{bmatrix} = \begin{bmatrix} 0 \\ 8-7r \end{bmatrix},\ \mathbf{w}_2 = \begin{bmatrix} -1-r & 4-r \\ +2-r & -r \end{bmatrix} \begin{bmatrix} r \\ 2-r \end{bmatrix} = \begin{bmatrix} 8-7r \\ 0 \end{bmatrix}. \tag{34}$$

Wir erkennen, dass $\mathbf{w}_1$ und $\mathbf{w}_2$ senkrecht aufeinander stehen und sogar für jedes $r \in \Phi$ eine *euklidische Basis* bilden. Damit ist die Manara-Bedingung *(B4)* erfüllt.

$$r \in \Phi \Rightarrow (\mathbf{p}\ \in V(r)\ \wedge\ \mathbf{w} = \mathbf{J}(r)\mathbf{p} > \mathbf{o}\ \Leftrightarrow\ \mathbf{w}\ \in V'(r) \wedge\ \mathbf{p} =\ \mathbf{J}(r)^{-1}\mathbf{w} > \mathbf{o}). \tag{35}$$

Für jedes $r \in \Phi =]\ 0, (8/7)\ [$ ist also der konvexe polyedrische Kegel $V'(r)$ der erste Quadrant der *euklidischen Ebene*. Zu jedem positiven Sektor Lohnvektor $\mathbf{w} > \mathbf{o}$ in $V'(r)$, $\mathbf{w} \in V'(r)$, ist der zugehörige Preisvektor $\mathbf{p} = \mathbf{J}(r)^{-1}\mathbf{w} > \mathbf{o}$ positiv und berechenbar. So ergibt sich etwa:

$$\mathbf{w} = \begin{bmatrix} 1 \\ \frac{3}{2} \end{bmatrix} > \mathbf{o} \quad \Rightarrow \quad \mathbf{p} = \mathbf{J}(0.5)^{-1}\mathbf{w} = \begin{bmatrix} \frac{23}{18} \\ \frac{5}{6} \end{bmatrix} \in V(0.5). \tag{36}$$

Die Bestimmung der polyedrischen Kegel $V(r)$ und $V'(r)$ ermöglicht also auf übersichtliche Weise die Berechnung von positiven Preisvektoren $\mathbf{p} > \mathbf{o}$ aus positiven Vektoren der Sektor Löhne $\mathbf{w} > \mathbf{o}$. Nach Definition gehört zur rechten Intervallgrenze r_1 von $\Phi =]0, r_1[$ der Nullvektor $\mathbf{L} = [0 \;\; 0]'$ der Sektor Löhne. Falls eine *brutto-integrierte Industrie* vorliegt, $\det(\mathbf{F}) \neq 0$, ist $R = r_1$ die Ergiebigkeit der vorliegenden Ökonomie, die auch aus der Frobeniuszahl λ_C der Matrix $\mathbf{C}' = \mathbf{F}'^{-1}\mathbf{S}'$ berechnet wird, $R = (1/\lambda_C) - 1$.

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Taxes and Subsidies in Input-Output Modelling: Lloyd Metzler Revisited

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Abstract: More than half a century ago Lloyd Metzler (1951) claimed that the outcomes of a tax and subsidization policy aimed at influencing product prices might surprise us. Suppose a certain group of commodities is taxed and another group subsidized: might there be surprises such as a decrease in the prices of taxed goods and an increase in the prices of subsidized goods? If so, one reason might be that taxed and subsidized goods can be used as inputs in the same or in related processes. For example, in producing cars steel is being used, and in producing steel cars are used. Now let us suppose that policy makers wish to tax the use of cars and subsidize the production of steel. Because steel and cars are inputs in each other's production processes, it is not a-priori clear what might happen. This led to the question if we can prove that prices, in the context of a tax/subsidy policy, always move in the expected direction.

The first formulation of an answer dates back to a study by Metzler (1944), which looked at the problem in the context of the international transfer of funds. However, the problem could not be satisfactorily solved at the time, and it was postponed for a later occasion. Metzler came back to the issue in his 1951 paper, in which he formulated it as a problem in input-output (IO) economics. However, also in this new context the problem proved hard to solve, and Metzler was only able to provide a solution if the coefficients matrix had a very particular form. Later on the topic was picked up by other scholars such as Allen (1972), Atsumi (1981) and Kimura (1983). However, also these contributions only succeeded in addressing certain partial problems and did not offer a general solution.

Actually, the matter is still open, with only some partial results having been obtained in later years. In this paper we would like to return to Metzler's question, because it concerns more than just a problem of an isolated nature. Taxation and subsidization problems play an important role in many policy areas and there should be a good theoretical foundation in place for addressing such problems.

In this contribution we first outline our interpretation of the problem. What the tax/subsidy scheme is supposed to do is to change certain commodity prices in a specific direction. IO, of course, has an established price theory that is based on the notion of so-called 'embodied' or 'imputed' quantities of primary factors such as labour or capital. It therefore seems evident, as attempted by earlier contributors, to look for a theoretical foundation for a tax/subsidy theory first in that direction. However, as we shall show, this approach does not work, the main reason being the lack of distinctive features of the multiplier matrix.

Against this background, this paper explores possibilities for finding a different foundation for a price theory for IO modeling, a foundation that, preferably, then could also serve as a basis for a tax/subsidy theory. We show in a number of steps that such a foundation can indeed be found. We thereby focus, as a core concept, on the role of the real wage and the distribution of this real wage over the various sectors. On this basis a consistent framework can be built that allows statements both of a quantitative nature (what is the new price?) and a qualitative nature (is a certain price going up or down?) in a tax/subsidy policy context.

We show in particular that quantitative statements are always possible. That is, we can always calculate the post tax/subsidy price changes. However, qualitative statements (as asked for by Metzler) can only be obtained

in a specific setting which requires close attention from modelers and policy makers. Throughout we have included a number of numerical illustrations.

Deindustrialization: New Measures and Policy Implications

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MOTIVATION

In recent years, there has been a clear evidence for the presence of deindustrialization in many countries. Not only has it been an issue for advanced economies, but developing countries started to suffer from this problem as well. Even more intriguing is the fact that in these countries, this has been happening at an even faster pace and at much lower levels of income compared to the early industrializers. Consequently, developing countries are running out of industrialization opportunities earlier and in most cases they experience the so-called premature deindustrialization (Rodrik, 2016). This could be harmful to them, since manufacturing has been always an important driver of growth and of the key sectors for job creation. In addition, unlike whole economies, manufacturing industries exhibit a strong unconditional convergence in labor productivity (Rodrik, 2013). It means that industries starting further away from the labor productivity frontier experience significantly faster productivity growth irrespective of institutional quality, domestic policies, geography or other country-specific features. Therefore, many researches have been intrigued by this topic and they are trying to find out the accurate measures of deindustrialization and its possible policy implications.

There are several studies (Dasgupta and Singh, 2006; Felipe, Mehta and Rhee, 2014; Rodrik, 2016) that document the so-called deindustrialization trend over the last decades but they focus mostly on the direct measures of its relative importance. However, outsourcing and the rising fragmentation of global value chains decrease the relevance of the direct employment and value added effects of manufacturing for overall economic performance. Many activities, once a part of manufacturing, are now supplied by businesses in the service sector and many high value added activities are being outsourced to companies outside the manufacturing industry (Bernard et al., 2016). Thus, the analysis of deindustrialization processes calls for an approach that considers complex linkages among industries. Input-output analysis is a useful tool for capturing these indirect effects, which are not visible in simple statistics. Therefore, our analysis has been closely related to the work of the Italian

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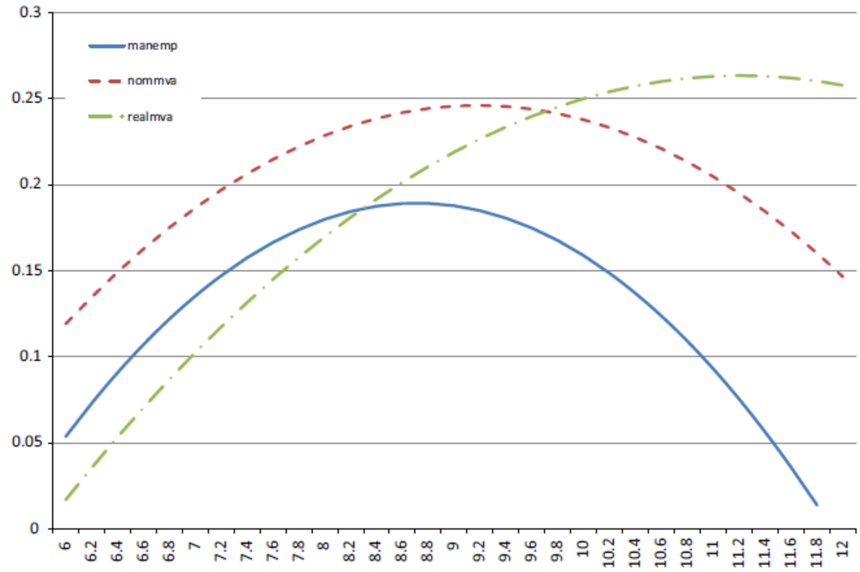
authors Montresor and Vittucci (2009), who dealt with the so called ‘Deindustrialization/Tertiarization (DT) hypothesis’. In order to reveal the real extent of the DT process, they used a subsystem analysis and used it on the artificial world consisting of the OECD7 countries covering the time period of 1980s and 1990s. Their results strongly support the DT hypothesis. They claim that although the weight of market services in the manufacturing subsystem increases (providing a counterbalance to manufacturing decline), subsystem shares decrease significantly, thus confirming DT as a more fundamental trend of the investigated period. Also, Peneder and Streicher (2017) used the input-output approach in order to reveal the importance of manufacturing and (de)industrialization. Moreover, they included the global value chain perspective as well. More precisely, they investigated the causes of deindustrialization using the trade-linked input-output data from the World Input-Output Database. Their method identifies the declining share of manufacturing value added in domestic final expenditures to be the main cause of deindustrialization. Their findings also point to the „paradox“ of industrial policy: when it is successful in raising competitiveness and hence productivity growth of manufacturing, it also furthers the global decline of relative prices in manufacturing. In contrast to the national objectives of reindustrialization, effective industrial policies accelerate deindustrialization in the global economy.

As mentioned before, in most of the developing countries, manufacturing has begun to shrink earlier and at levels of income that are just a fraction of those in advanced economies (Figure 1 and 2). This trend has been pointed out by many authors, for instance Rodrik (2016), Bernard et al. (2016) or even earlier by Dasgupta and Singh (2006). A special term for this paradox has been developed and it is called premature deindustrialization. As can be seen in Figure 1, the share of manufacturing for a ‘representative’ country first tends to rise and then fall as the country is developing. However, there is a significant difference in the turning points. In particular, manufacturing employment (*manemp*) peaks much earlier than the real manufacturing value added, which peaks very late in the development process (*realmva*). As shown by Rodrik (2016), industrialization in Western European countries such as Britain, Sweden or Italy peaked at income levels of around USD 14,000 (in 1990 dollars), while in India or many Sub-Saharan African countries, the manufacturing appeared to have reached its peak at income levels of only USD 700.

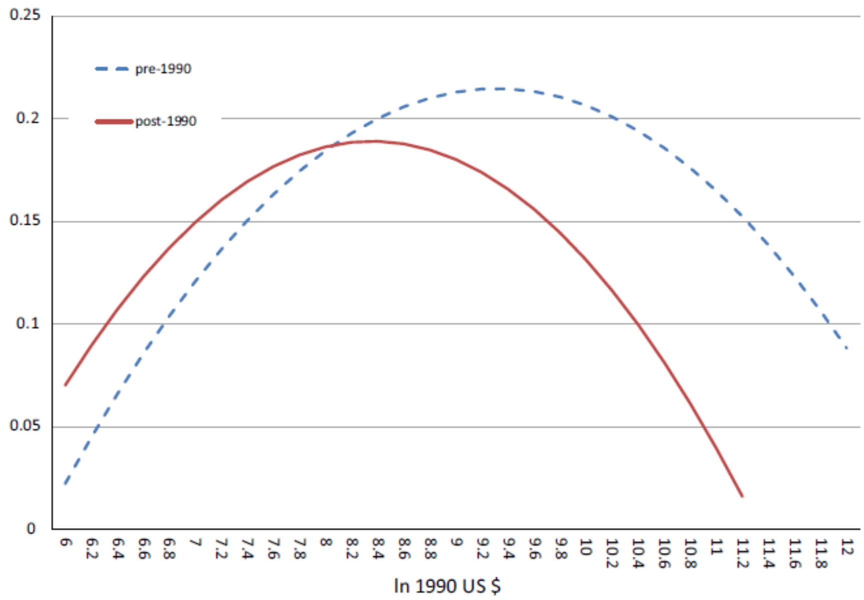
Figure 1: Simulated manufacturing shares as a function of income (In GDP per capita in 1990 international dollars)



Source: Rodrik 2016

This has been also documented by Amirapu and Subramanian (2015). They claim that the relationship between employment share in industry and GDP per capita has been changing dramatically over time. First, at any given stage of development, countries are specializing less in manufacturing and simultaneously devoting fewer labor resources to it. Second, the point of time at which industry peaks and deindustrialization begins is happening earlier in the development process (also shown in Figure 2 by Rodrik). This pattern has been also confirmed by Felipe, Mehta and Rhee (2014) who show that this downward trend applies whether taking manufacturing shares in terms of employment or output. They also document that the trend is stronger for employment shares. This implies that developing countries are not able to build as large manufacturing sectors and are turning into service economies without having gone through a proper industrialization. Undoubtedly, technological progress plays a great role in the story behind employment deindustrialization. However, this is mostly true for advanced economies; in the developing countries, trade and globalization likely played a comparatively bigger role. There are also many other factors to blame depending on the character of an individual country.

Figure 2: Simulated manufacturing employment shares



Source: Rodrik 2016

In this paper, we are going to examine, whether the peak of industrialization in manufacturing subsystems is present at lower levels of income in comparison with direct measures and what is the speed of deindustrialization over time in subsystem approach compared to the direct measures. Furthermore, we would like to find out what the differences in deindustrialization measured by value added and employment shares are using these two approaches. In order to test these hypotheses, we use the data from multiple datasets: WIOD 2013 Release, WIOD 2016 Release, OECD/WTO Trade in Value Added Database and EORA multi-region input-output table (EORA26).

METHODOLOGY

In the Leontief model, the final demand vector $\mathbf{y}$ translates to overall production vector $\mathbf{x}$ in the following way

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y},$$

where $(\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse matrix calculated from the identity matrix $\mathbf{I}$ and the matrix of domestic flow-based input coefficients $\mathbf{A}$. The Leontief matrix plays a key role in a subsystem analysis because it allows us to reclassify any variable from the sector base into the subsystem base (Montresor and Vittucci, 2009). We calculate this matrix using the diagonalized vector of gross production $\hat{\mathbf{x}}$ and the diagonalized final demand vector $\hat{\mathbf{y}}$

$$\mathbf{B} = \hat{\mathbf{x}}^{-1}(\mathbf{I} - \mathbf{A})^{-1}\hat{\mathbf{y}}.$$

Matrix $\mathbf{B}$ shows the proportion of the activity of industry *i* which comes under

subsystem *j*. The sum of each row of $\mathbf{B}$ adds up to 1. This matrix can be used to reclassify value-added data by industries in vector $\mathbf{v}$ from the industrial base into the subsystem base by multiplying it by the diagonalized vector $\hat{\mathbf{v}}$

$$\mathbf{N} = \hat{\mathbf{v}}\mathbf{B}.$$

The elements of matrix $\mathbf{N}$ show the amount of value added generated directly and indirectly in industry *i* in order to satisfy the final demand for commodities of industry *j.* In a similar way, we can reclassify employment data.

We measure the importance of manufacturing by four different indicators:

1. Direct **value added share** of manufacturing on the total value added
$$vas_{it} = \frac{va_{it}^{man}}{va_{it}^{tot}}$$
2. Share of domestic **value added induced** by the final demand for manufacturing on the total domestic value added
$$ivasd_{it} = \frac{ivad_{it}^{man}}{va_{it}^{tot}}$$
3. Direct **employment share** of manufacturing on the total employment
$$emps_{it} = \frac{emp_{it}^{man}}{emp_{it}^{tot}}$$
4. Share of domestic **employment induced** by the final demand for manufacturing on total employment
$$iemps_{it} = \frac{iemp_{it}^{man}}{emp_{it}^{tot}}$$

To analyze the deindustrialization trends over time, we estimate the following “Deindustrialization model” proposed by Rodrik (2016):

$$manshare_{it} = \beta_0 + \beta_1(\ln pop_{it}) + \beta_2(\ln pop_{it})^2 + \beta_3(\ln y_{it}) + \beta_4(\ln y_{it})^2 + a_i + p_t + \varepsilon_{it},$$

where $manshare_{it}$ represents the importance of manufacturing in country *i* and period *t* measured by indicators 1 to 4 defined above, pop_{it} is the population of country *i* in period *t*, y_{it} is GDP per capita in country *i* and period *t*, a_i are country fixed effects, and p_t are time dummies. Data on population and GDP per capita were obtained from Penn World Table 9.0 Database.

RESULTS

Using the direct and also the indirect approach, the process of output deindustrialization is visible among all regions (Table 1). However, it is even faster when considering the indirect effects. The biggest difference is observable in the group of G7 countries (-4.6 pp and -3.5

pp), which implies that the process of deindustrialization is most visible among the major developed regions. However, this is not a new phenomenon. What is intriguing is that this has been happening in the developing countries as well. In 2014, the share of value added in manufacturing decreased to 90% of the value of 2000 with the average rate of decline of 0.81% (direct effects). From the perspective of indirect effects, the picture looks somewhat better for this group of countries, however the relative importance of manufacturing is decreasing there as well.

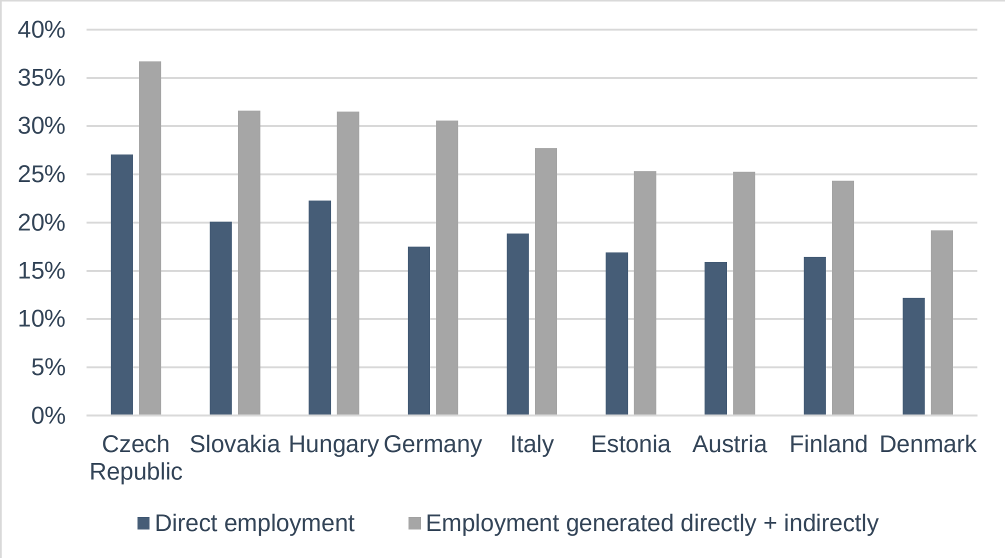
Table 1: The ‘speed‘ of deindustrialization: direct vs. subsystem approach

	G7	Developed	Developing
2000	23.2%	24.2%	30.5%
2014	18.7%	20.7%	28.3%
Difference (direct + indirect)	**-4.6 pp**	**-3.5 pp**	**-2.2 pp**
2000	18.1%	18.6%	23.3%
2014	14.6%	15.6%	20.8%
Difference (direct)	**-3.5 pp**	**-3.0 pp**	**-2.5 pp**

Note: Data in the table represent the shares of direct and direct + indirect value added in manufacturing on the total value added (%) and the differences between 2000 and 2014 (percentage points).
Source: Authors’ calculations based on WIOD 2016

As mentioned in the Motivation section, deindustrialization tends to be strongest when looking at employment. This is closely related to a continuous increase in labour productivity in manufacturing. In this case, we also adopted the subsystem approach in order to identify the real importance of manufacturing for job creation in various countries. As shown in Figure 3, while the direct employment in manufacturing, except for the Czech Republic and Hungary, is well below 20%, the complex employment generated by manufacturing is much higher. It is above 30% in the Czech Republic, Slovakia, Hungary and Germany, which implies that approximately every third employee is in some way (directly or indirectly) working for manufacturing. Even when looking at Denmark, where the direct employment in manufacturing is very low, almost every fifth job is created by the final use of manufacturing products. Thus, the importance of manufacturing for creating new jobs is definitely not negligible. Simple statistics cannot reveal such linkages; however, they are really important from the national economic point of view. A significant part of the services sector would not be created if it was not for a well-functioning manufacturing. This should be considered when talking about deindustrialization and a decreasing importance of manufacturing for the development of economies.

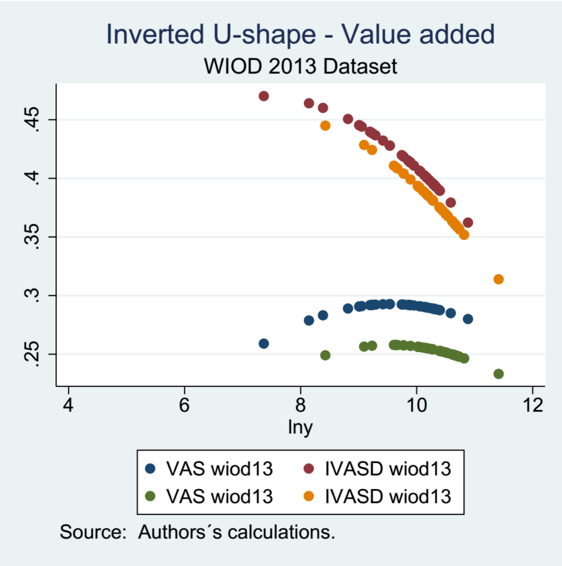
Figure 3: Direct and complex employment generated by manufacturing, % of total employment, 2011

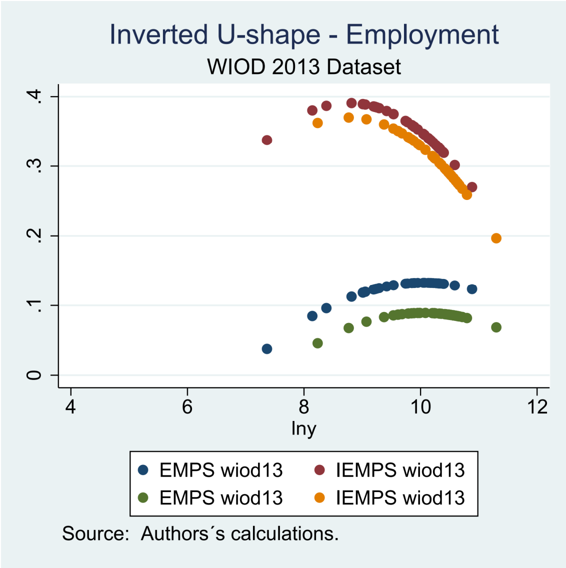


Source: Authors' calculations based on WIOD 2013

To get some more insights into the deindustrialization trends over time measured by direct measures and by the sub-system approach, in Figure 4, we present the projections from "Deindustrialization model" based on data from WIOD 2013. Estimates for value added are drawn on the figure to the left, estimates based on the employment data are drawn on the figure to the right. Horizontal axis indicates the logarithm of GDP per capita. Different measures of the importance of manufacturing are drawn on the vertical axis. We can identify an inverted U-shaped curve for all four deindustrialization measures. Direct measures are plotted in blue and green. Indirect measures are plotted in red and orange. Projections are based on the time dummies for the first period (blue and red) and the last period (green and orange).

Figure 4: Estimated inverted U-shape curve for value added and employment, WIOD 2013, 1995–2001, 40 countries





Several facts can be learned from the figures:

- The importance of manufacturing for national economies is higher, once we focus on direct and indirect linkages of the final use of manufacturing products. Orange and red curves are above the green and blue ones in both pictures.
- The industrialization peak appears to be achieved at lower levels of economic development in the sub-system approach in comparison to direct measures. The peak in orange and red curves is shifted to the left.
- The deindustrialization trend over time is faster in terms of direct measures and it is very slow in the sub-system approach. The green curve is shifted down from the blue one quite significantly, while orange and red curves are very close to each other.
- Economic development (measured by an increase in GDP per capita) is linked with faster deindustrialization in terms of the sub-system approach in comparison with direct measures. This fact is suggested by steeper red and orange curves. The same increase in GDP per capita leads to stronger decline in manufacturing in the sub-system approach.

These findings have to be taken with caution. Several robustness checks are necessary in further research. This includes utilization of other datasets as well as model specifications.

SUMMARY

In the aftermath of the Great Recession in 2008–2009, the declining importance of manufacturing for direct employment and value added creation attracted new interests in the causes and consequences of deindustrialization. We show that deindustrialization is present in the direct value added and employment shares as well as in manufacturing subsystems, which take into account the direct and indirect linkages of the final use of manufacturing products. Our results suggest that the peak of industrialization in manufacturing subsystems is present at even lower income levels in comparison with direct measures. On the other side, the speed of deindustrialization over time in the subsystem approach is slower than in direct measures. An increase in income after the industrialization peak is connected with higher speed of deindustrialization in the subsystem approach. These are preliminary results which should provoke discussions but require further research and robustness checks.

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Optimisation Problems for Planning Structural and Technological Changes

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Abstract: In the 90-th, the years of the Transition Economy in Ukraine, Professor Mikhail Vladimirovich Mikhalevich developed a planning instrument to optimize the use of the means of production of an economy. He started from the core of an official input-output table, the flow commodity matrix $Z = \{z_{ij}\}_{i,j=\overline{1,n}}$ in monetary terms, describing the inter-industrial market. He operated with the vector of total output $x = Z\ e = [x_1, \dots, x_n]^T$ (T means transposition) and the technology matrix $A = Z\hat{x}^{-1} = \{a_{ij}\}_{i,j=\overline{1,n}}$, also called the input-output coefficients matrix, and formulated two optimisation problems to find the desirable characteristics of economic process. It was proposed to apply Shor's r-algorithm that calculates modifications ΔA of matrix $A \rightarrow A + \Delta A$, by appropriated variation of its elements $a_{ij} \rightarrow a_{ij} + \Delta a_{ij}$, in application of an optimization process operated on a weighted mean of the outputs x_i of each branch i, namely $D = \sum_{i=1}^{n} q_i x_i$, which is the total income of households, where q_i is the share of income of households to the cost of production for every branch i, and is also subject to modifications $q_i \rightarrow q_i + \Delta q_i$, $i = \overline{1,n}$.

1 INTRODUCTION

Some results of the project "Analysis of Institutional and Technological Changes in Market and Transition Economies on the Background of the Present Financial Crisis" are reported in this paper.[5]

Input-output tables of Leontief, based on the principle of circularity, proved to be an essential tool to analyse the structural properties of economies. In the Leontief-type models the input-output coefficients matrix (technology matrix) is supposed to be known and is calculated from official input-output tables.

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M.V. Mikhalevich formulated an inverse problem: how to determine the structural and technological changes that would reduce the production costs and thus would increase the incomes of households and make the economy more dynamic. Or, in other words, how to select and adjust the input coefficients to improve properties of the economic process. These models of M.V. Mikhalevich ([1]-[3]) can be called inverse models of the Leontief type.

Inverse models of the Leontief type form a family of multiextremal problems, where the elements of the technology matrix are modified during the optimization process. These models are formulated in terms of nonlinear maximization problems and include two objective functions: the income of households (wages, social transfers, and profit) and the coefficient "increase of incomes - increase of production".

Constraints included to the models describe the conditions of non-inflationary growth of incomes and some other aspects (for example, scarcity of natural resources, available to establish structural and technological transformations, condition of non-negativity of updated input coefficients etc.).

The developed models belong to the class of non-convex non-differentiable optimisation problems. Recommended numerical optimization procedures are based on Shor's *r*-algorithm ([4]-[5]) and up-to-date realizations providing a tool to analyse input-output tables. This procedure is integrated into a program designed as open menu-driven software available for Windows.

The MiSTC system is designed to solve these optimization problems of intersectoral planning of structural and technological changes in the analysis of macroeconomic processes. Professor M.V. Mikhalevich, whose name is mentioned in the title (MiSTC – Michalevich Structural and Technological Changes), was the initiator of its creation and developed the theoretical foundations of this system as a tool to study possible ways of economic development and to indicate the most promising directions for structural and technological transformations of the industry in the context of scarcity of natural resources for carrying out these transformations. System developers are also P.I. Stetsyuk, L.B. Koshlai, O.V. Pylypovskyi and A.Yu. Vidil.

More detailed information about these optimisation problems for planning structural and technological changes can be found in [3], [6]. A description of Shor's r-algorithm is based on the paper [7].

2 MODEL FORMULATION

Let an economy contain n pure industries manufacturing only one type of products; $i, j = \overline{1, n}$ be the numbers of these branches. Denote by a_{ij} the input coefficient which gives the value of direct production costs of the branch i for manufacturing a unit of production of the branch j. We assume that this quantity is expressed in monetary terms. The matrix $A = \{a_{ij}\}_{i,j=\overline{1,n}}$ is the technology matrix. Denote by q_i the share of income of households (wages, social transfers, and profit) to the cost of production for every branch i, and constitute the vector $q = \{q_i\}_{i=\overline{1,n}}$ of these shares. Possible changes of existing components of matrix A and vector q are denoted by $\Delta A = \{\Delta a_{ij}\}_{i,j=\overline{1,n}}$ and by $\Delta q = \{\Delta q_i\}_{i=\overline{1,n}}$, respectively.

Following [3] let us describe assumptions related to the model. Denote by f_i the final consumption (also called final demand) and by x_i the total output of industry i at constant prices. These quantities are linked by the relationship

$$x_i = \sum_{j=1}^{n} a_{ij}x_j + f_i, \quad i = \overline{1,n}. \tag{1}$$

Let $x = (x_1, \dots, x_n)$, $f = (f_1, \dots, f_n)$. Then (1) can be rewritten as

$$f = (I - A)x \text{ or } x = (I - A)^{-1}f,$$

where I is the identity $(n \times n)$-matrix.

We assume that the total income D of households is a linear function of the total output x_i of each branch i and is given by

$$D = \sum_{i=1}^{n} q_i x_i.$$

It is also assumed that the final consumption f_i consists of two parts: a part that depends on D and a part dependent on a h_i determined from the export/import balance of branches and the structure of public consumption. Assuming linear dependence, we obtain for the final consumption of households:

$$f_i = \alpha_i D + h_i, \quad i = \overline{1,n}, \tag{2}$$

where the coefficients α_i reflect mainly the structure of individual consumption and internal investments.

We use these relations to express D in terms of A and q. From (1), $x = (I - A)^{-1}f$, where I is the identity $(n \times n)$-matrix, $x = (x_1, \dots, x_n)$, $f = (f_1, \dots, f_n)$. Therefore $D = (q, x) = (q, (I - A)^{-1}f)$. From the last equality and (2) we obtain

$$D = \frac{q^T(I-A)^{-1}h}{1-q^T(I-A)^{-1}\alpha},$$

where $h = (h_1, \dots, h_n)$, $\alpha = (\alpha_1, \dots, \alpha_n)$. The coefficient $k = q^T(I - A)^{-1}\alpha$ can be used to characterise dependence "increase of incomes - increase of production".

We have to find such changes ΔA for the matrix A and such changes Δq for the vector q that maximize the final incomes of households and a coefficient "increase of incomes - increase of production". So, two optimization problems are considered:

$$F_1(\Delta A, \Delta q) = \frac{(q+\Delta q)^T(I-(A+\Delta A))^{-1}h}{1-(q+\Delta q)^T(I-(A+\Delta A))^{-1}\alpha} \to \max \tag{3}$$

$$F_2(\Delta A, \Delta q) = (q + \Delta q)^T(I - (A + \Delta A))^{-1}\alpha \to \max \tag{4}$$

where T means transposition.

The goal function $F_1(\Delta A, \Delta q)$ corresponds to the final incomes of households, and the goal function $F_2(\Delta A, \Delta q)$ is a coefficient "increase of incomes - increase of production". Elements of the vectors α and h are defined by the structure of individual and public consumption and the export-import balance of the branches.

One more assumption of the model is a linear relationship between the share of value added $\tilde{q}_i$ in the price of the product of the branch i and the share of the incomes of households in the price of this product

$$\tilde{q}_i = l_i \, q_i + d_i, \; i = \overline{1,n} \; ,$$

where l_i is a fiscal multiplier for incomes of households, and d_i is the share of other components of value added in the price of the product of the i-th branch.

Possible constraints included into the model:

- the constraints that exclude the intensification of the inflation of costs:

$$\sum_{i=1, i \neq j}^{n} \frac{a_{ij} + \Delta \, a_{ij}}{1-(a_{jj} + \Delta \, a_{jj}) - l_j \, (q_j + \Delta \, q_j) - d_j} \leq \beta, \qquad (5)$$

  where $0 < \beta < 1$ is a confidential parameter (see [2, 3]);

- the relationships that follow from the physical meaning of the coefficients Δa_{ij} and Δq_j:

$$0 \leq q_j + \Delta \, q_j \leq 1, \quad 0 \leq a_{ij} + \Delta \, a_{ij} \leq 1, \;\; i,j = \overline{1,n}; \qquad (6)$$

- the balance of the expenses and added cost:

$$\left(a_{jj} + \Delta \, a_{jj}\right) + l_j \left(q_j + \Delta \, q_j\right) + d_j \leq 1, \;\; j = \overline{1,n}; \qquad (7)$$

- constraints for the possible ranges of variation of the coefficients due to specific features of the technologies available:

$$\underline{\gamma_{ij}} \leq \Delta a_{ij} \leq \overline{\gamma_{ij}}, \;\; i,j = \overline{1,n}, \qquad \underline{q_i} \leq \Delta q_i \leq \overline{q_i}\,, \;\; i = \overline{1,n}, \qquad (8)$$

  where $\underline{\gamma_{ij}}$, $\overline{\gamma_{ij}}$ are the lower and upper bounds of the possible variation in the technical coefficients, and $\underline{q_i}$, $\overline{q_i}$ are the lower and upper bounds of the possible variation in the share of the final incomes of households;

- the resource constraints:

$$\sum_{j=1}^{n} \sum_{i=1}^{n} b_{ijk} \; \max \; (0, -\Delta a_{ij}) \leq B_k \,, \;\; k = \overline{1,K}, \qquad (9)$$

where K is the number of resources, B_k is the volume of k-th resource intended to carry out structural and technological changes, b_{ijk} is the expenditure of this resourse in taking measures that provide a unitary decrease in the expences of the production of the branch i to produce a unit of production of the branch j.

When we start to study the formulated problems (3), (5)-(9) and (4), (5)-(9) from the point of view of optimisation, we have to accept, that they are rather difficult. First of all, the objective functions $F_1(\Delta A, \Delta q)$ and $F_2(\Delta A, \Delta q)$ are nonconvex. So, they may be multiextreme.

Moreover, to make the formulations correct, some additional constraints are needed. The function $F_2(\Delta A, \Delta q)$ is well-defined only when the matrix $I - (A + \Delta A)$ is nonsingular. For the function $F_1(\Delta A, \Delta q)$ it is additionally required that the condition $(q + \Delta q)^T (I - (A + \Delta A))^{-1} \alpha \neq 1$ be satisfied. Analogous precautions should be taken for the constraint (5).

Sure, one can try to find the solutions to these problems by any algorithm of non-differentiable optimization. Based on great experience of the use of the *r*-algorithm and a lot of applied problems solved with its use, it was taken as optimisation core in the MiSTC system. Basic information about *r*-algorithm and short description of the MiSTC system needed for analysis of input-output data will be given in the next sections.

More detailed description of the model, substantiation of objective functions and constraints, possible extensions to study economic and ecological problems can be found in [1-3].

3 SHOR'S *R*-ALGORITHM

The *r*-algorithm is one of the Shor's subgradient-type methods with the transformation of the space of variables (the space dilation) for minimization of nonsmooth convex functions [4] or [5, pp.100–112]. Shor's *r*-algorithms are based on two related ideas. The first idea lies in the use of the steepest descent method in the direction of anti subgradient of nonsmooth convex functions in the transformed space of variables. It ensures a monotonicity of a nonsmooth convex function for the minimizing sequence which is constructed by *r*-algorithm. The second idea employs the operation of the space dilation in the direction of the difference of two subsequent subgradients in order to transform the space of variables; this permits to improve properties of ravine-like functions in the transformed space. Combination of the ideas provides the accelerated convergence of *r*-algorithms for ravine-like functions ensuring their monotonicity (or almost monotonicity) under the certain regulation of the step and the space dilation coefficients.

Let $f(x)$ be a convex function, x be a vector in n variables. We assume that the space dilation coefficients $\{\alpha_k\}_{k=0}^{\infty}$ have to be greater than unity. The *r*-algorithm for minimization of $f(x)$ is an iterative procedure for finding a sequence of vectors $\{x_k\}_{k=0}^{\infty}$ and matrices $\{B_k\}_{k=0}^{\infty}$ by the following rule:

$$x_{k+1} = x_k - h_k B_k \xi_k , \quad B_{k+1} = B_k R_{\beta_k}(\eta_k), \quad k = 0, 1, 2, \dots, \tag{10}$$

where

$$\xi_k = \frac{B_k^T g_f(x_k)}{\|B_k^T g_f(x_k)\|}, \quad h_k = \arg\min_{h \ge 0} f(x_k - hB_k\xi_k), \tag{11}$$

$$\eta_k = \frac{B_k^T r_k}{\|B_k^T r_k\|}, \quad r_k = g_f(x_{k+1}) - g_f(x_k), \quad \beta_k = \frac{1}{\alpha_k} < 1. \tag{12}$$

Here, x_0 is a starting point; $B_0 = I$ is the identity $(n \times n)$-matrix (B_0 is often taken to be diagonal matrix D_n with positive entries on a diagonal to make the scaling of variables); h_k is a step multiplier (found from a condition of minimum of function $f(x)$ in the direction of normed subgradient in the transformed space of variables); α is a coefficient of the space dilation; $R_\beta(\eta) = I + (\beta - 1)\eta\eta^T$ is an operator of contraction of space of subgradients in the normed direction η with a coefficient $\beta = \frac{1}{\alpha} < 1$; $g_f(x_k)$ and $g_f(x_{k+1})$ are subgradients of function $f(x)$ at points x_k and x_{k+1}. If $g_f(x_k) = 0$, then x_k is a point of the minimum of function $f(x)$, and the process (10)–(12) stops.

Among r-algorithms the most efficient is $r(\alpha)$ algorithm with $\alpha_k \equiv \alpha$ and adaptive regulation of step h_k. Value of h_k is related with the one-dimensional descent procedure in the direction of the normed antigradient in the transformed space of variables. The procedure involves parameters h_0, q_1, n_h, q_2. Here, h_0 is the value of initial step (it is used on the first iteration, and this value is sequentially refined on each iteration); q_1 is a step decrease factor ($q_1 \leq 1$), if the descent stopping criterion is satisfied in one step; q_2 is a step increase factor ($q_2 \geq 1$); natural number n_h specifies the number of steps in one-dimensional descent ($n_h > 1$) - after this number of steps the step size will be taken q_2 times greater. Guidance to choose the values of the space dilation coefficient, as well as, parameters of the adaptive regulation of step is discussed in [5, pp. 104–105]. The values are chosen to better approximate the minimum of the convex function $f(x)$, provided that the number of steps should not be too large (2–3 per one iteration). Stopping criteria in $r(\alpha)$-algorithm are described by parameters ε_x and ε_g : calculations come to the end at point x_{k+1} , if $\|x_{k+1} - x_k\| \leq \varepsilon_x$ (stopping criterion by argument) or if $\|g_f(x_{k+1})\| \leq \varepsilon_g$ (stopping criterion by normed gradient, which is used for smooth functions). Abnormal program termination can happen if either function $f(x)$ is not bounded below, or initial step h_0 is too small and should be increased. The following values of parameters are recommended for minimization of nonsmooth functions: $\alpha = 2 \div 3$, $h_0 = 1.0$, $q_1 = 1.0$, $q_2 = 1.1 \div 1.2$, $n_h = 2 \div 3$. If the priory bound of the distance from starting point x_0 to the minimum point x^* is given, then it is reasonable to choose initial step h_0 to be approximately equal to $\|x_0 - x^*\|$.

For minimization of smooth functions the same parameters are recommended, except q_1, that should be taken $q_1 = 0.8 \div 0.95$. This can be explained in such a way: further step decreasing would provide finding a more accurate approximation to the minimum point of the function in the direction, and in the case of minimization of smooth functions this gives good rate of convergence. Under these parameters the number of descents is usually not greater than two, and after n steps the accuracy by function will be three-five times better. Stopping parameters ε_x , $\varepsilon_g \sim 10^{-6} \div 10^{-5}$ for minimization of a convex function (even the strongly ravine-like one) provide finding x_r^* which is a fairly good approximation to the minimum point of the function. Usually the condition $\frac{f(x_r^*) - f(x^*)}{|f(x^*)| + 1} \sim 10^{-6} \div 10^{-5}$ for nonsmooth functions ($\sim 10^{-12} \div 10^{-10}$ for smooth functions) is satisfied. It is confirmed by the results of numerous tests and applied calculations in linear and nonlinear programming problems, block problems with different schemes of decompositions, minimax and matrix optimization problems, as well as, for calculation of Lagrangian dual bounds in multiextremal and combinatorial optimization problems [5].

4 SHORT INFORMATION ABOUT THE MISTC SYSTEM

Programs for solving the formulated above problems are written in Qt (being the extension of the C ++ language) using the Lapack ++ library to perform mathematical operations. This library provides a convenient user interface to enter large numerical matrices and to analyse the results of mathematical calculations in the problems (3), (5)-(9) and (4), (5)-(9). Other important features of the system - modularity and extensibility - facilitates quick adaptation to special user's requirements.

The program interface provides a set of tabs (Figure 1), which group interface elements according to their meaning and tables to input and display matrices. The optimal value of the chosen objective function is searched using the *r*-algorithm [4, 5] and the multi-start procedure (sequential start of the subgradient algorithm from different starting points and subsequent analysis of the results).

When the MiSTC system is started, the user is asked to specify the main scalar parameters: the size of the problem (the number of branches), the inflation parameter β, the number of start points for the multi-start, and the objective function of the optimization process (Figure 1).

Before starting the optimization process, it is recommended to check the consistency of the system of constraints. Depending on the number of analysed industries, the user can choose other values of penalties and *r*-algorithm parameters than standard ones.

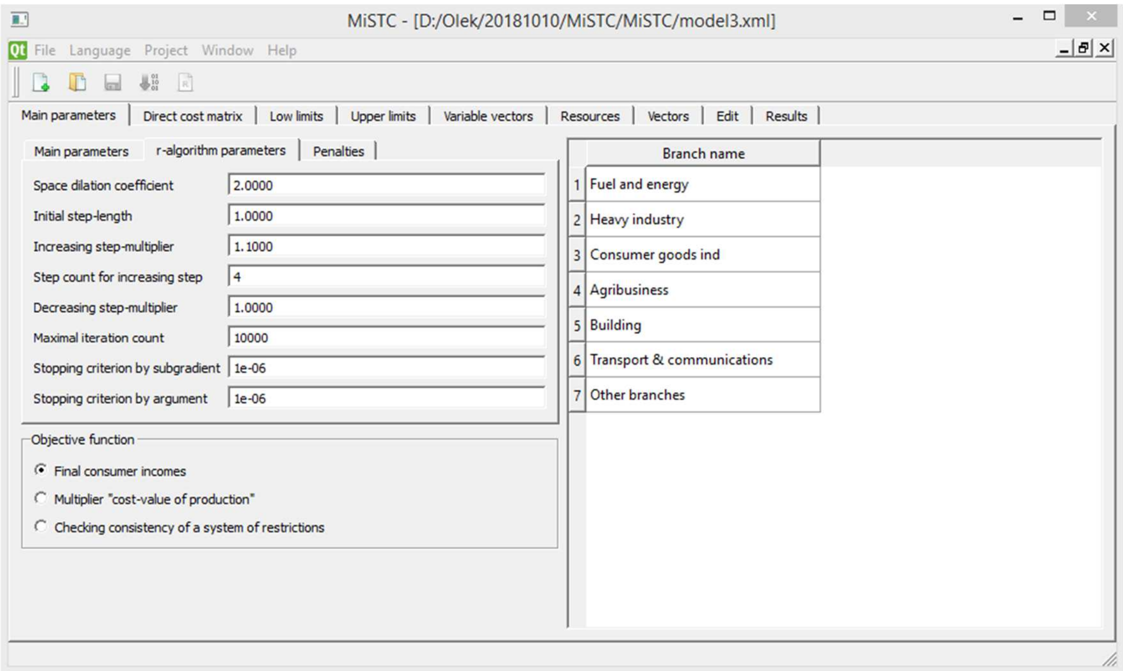

Fig. 1. The MiSTC program window opened on the tab with the main parameters. The problem for seven branches is considered.

Given value of the number of industries, the input-output coefficients matrix A (Figure 2) and the vectors used are generated (Figure 3). A separate tab is provided for input of resource constraints (Figure 4). It is possible to automatically fill the boundaries of the matrix, which makes it easier to work with a large number of industries.

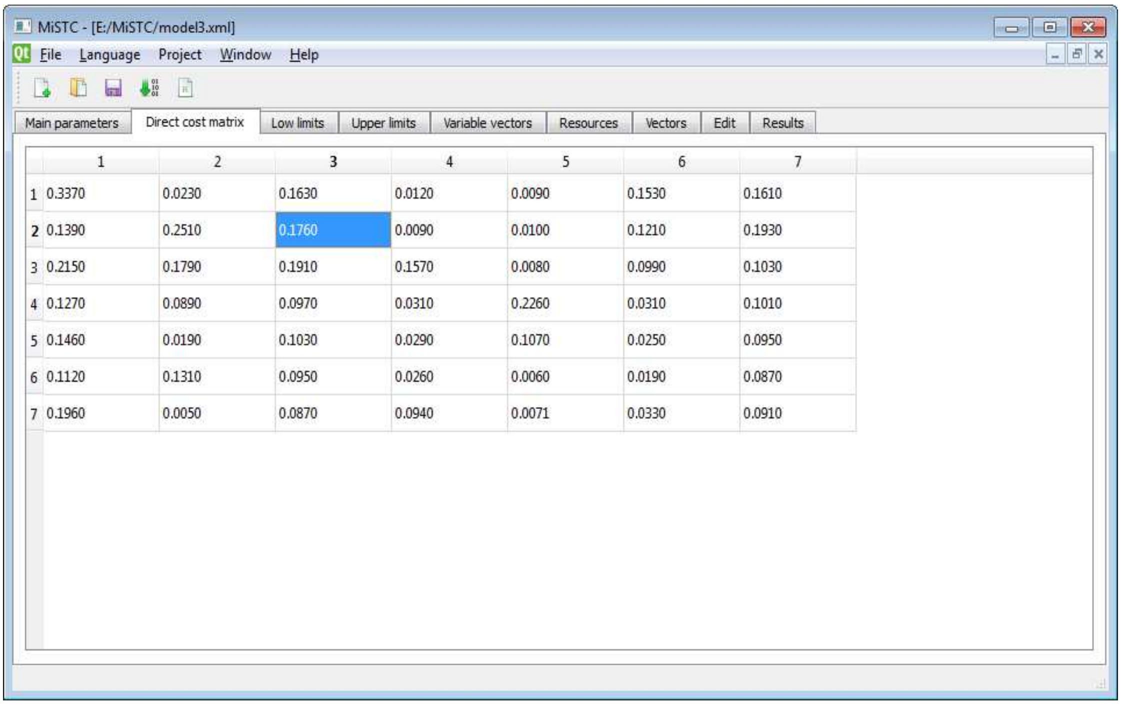

Fig. 2. Enter the input-output coefficients matrix.

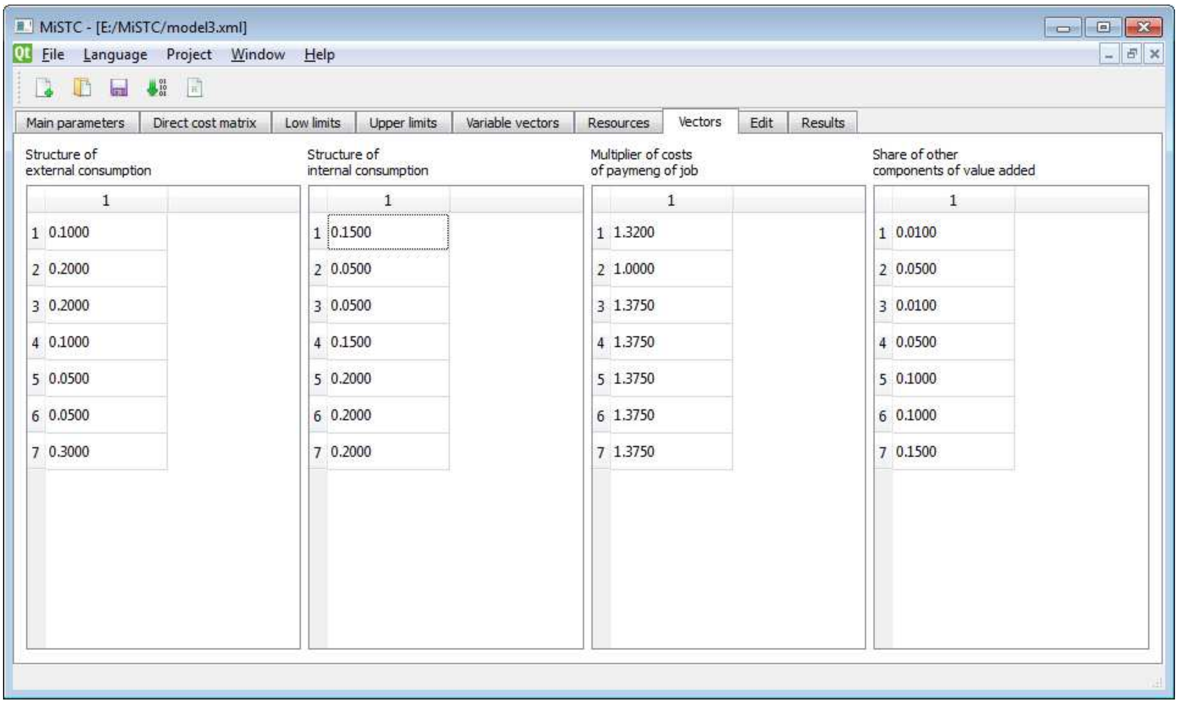

Fig. 3. Vectors of the structure of public and individual consumption, the multiplier of labour costs and the share of other components in the cost of production.

It is possible to put the specified values for the boundaries of all elements of matrix, and also only for a given number of largest or smallest elements (Figure 5). Simultaneous setting of the upper and lower bounds to zero allows you to regulate the actual number of variables in the problem. Before running calculations, the variables are automatically checked to ensure that all elements satisfy the condition $0 \leq a_{ij} + \Delta a_{ij} \leq 1$.

The result of the calculations is a set of final input-output coefficients matrices and the vectors needed for analysis of optimization process (Figure 6). Their number corresponds to the number of given starting points. The selected solution is displayed in the form of a table combining the input-output coefficients matrix and vectors of labour costs with indication of industries corresponding to the lines. Moreover, the values and residuals of the objective function in the record and the last points of the subgradient process are indicated, as well as information on the progress of the calculations (the number of iterations, the number of calculations of the function and the subgradient, the stopping criterion and the computation time). An user has an ability to eliminate solutions that coincide with a specified accuracy and to view separately the values ΔA and Δq. For the convenience of analysing the proposed changes by industries, a special illumination of the elements, which became greater or smaller than the original input-output coefficients matrix is used. A report can be generated in HTML format; it contains information about the problem input data and the results of calculations.

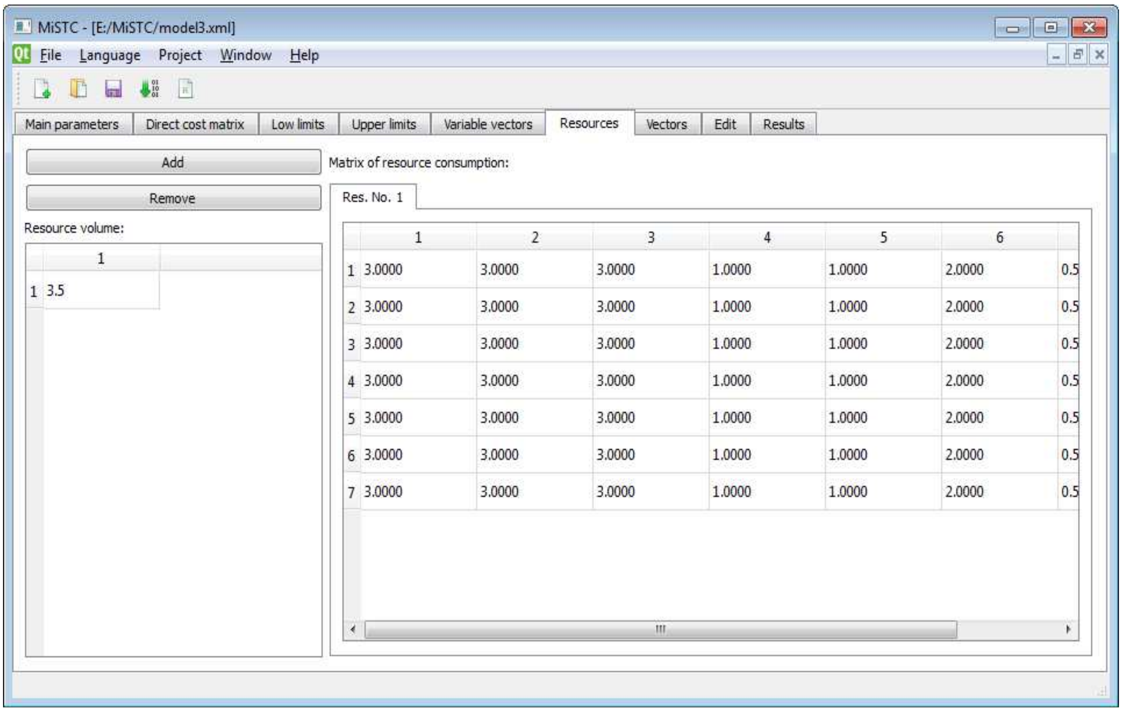

Fig. 4. The interface to enter resource constraints. The values B_k are entered to the left, and the values of the matrix b_k are entered to the central area of the matrix.

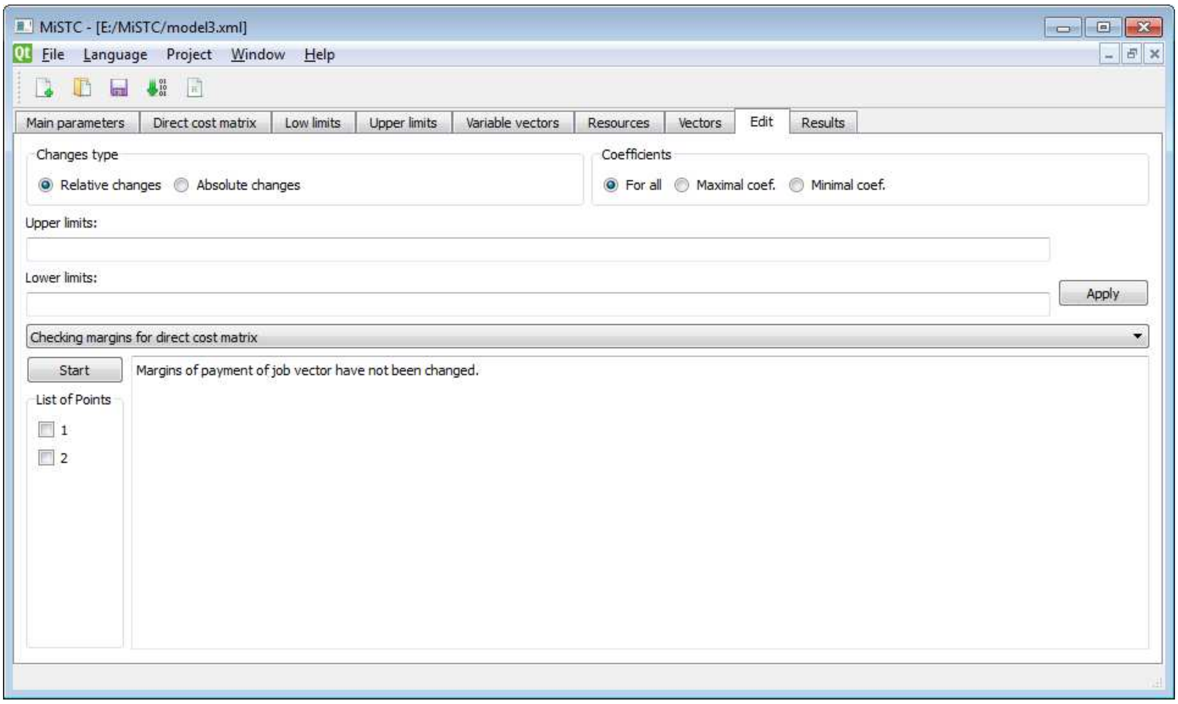

Fig. 5. The tab to analyse the properties of the input-output coefficients matrix and changes in its boundaries.

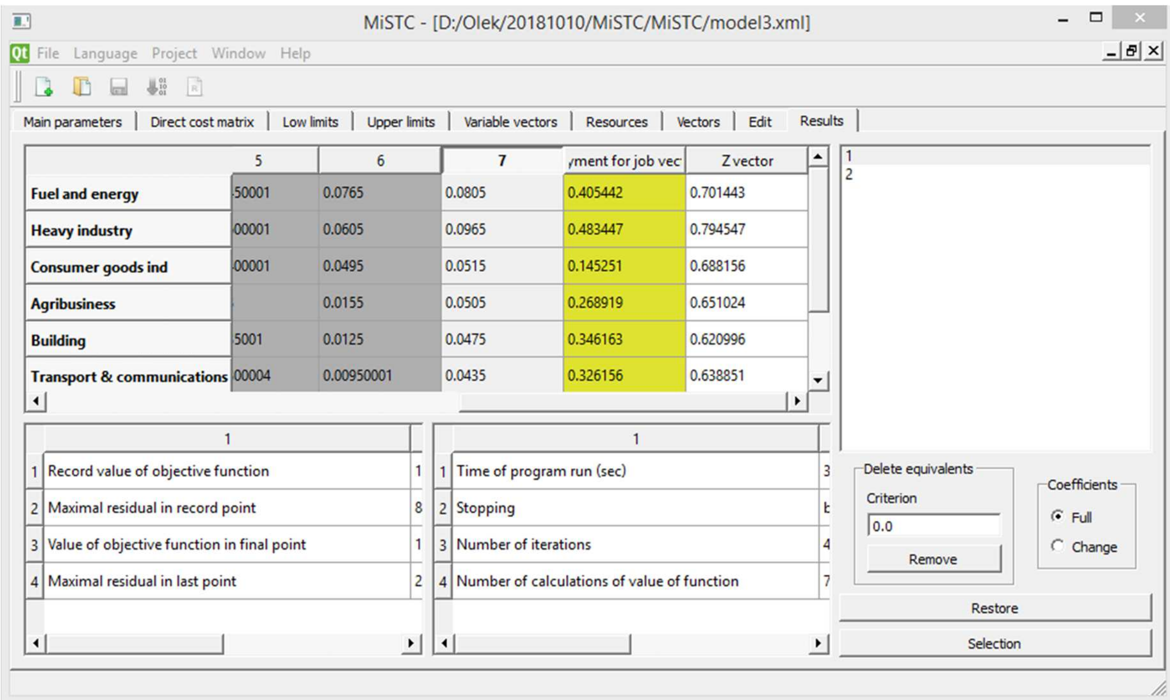

Fig. 6. Results of calculations: the input-output coefficients matrix. The colour indicates changes in its components to a larger (yellow) or smaller (gray) side compared to the initial one.

Example. Let us consider the problem for seven industries with the following values of the input-output coefficients matrix A and the vector q:

$$A = \begin{bmatrix} 0.337 & 0.139 & 0.2150.127 & 0.146 & 0.1120.1960 \\ 0.023 & 0.251 & 0.1790.089 & 0.019 & 0.1310.0050 \\ 0.163 & 0.176 & 0.1910.097 & 0.103 & 0.0950.0870 \\ 0.012 & 0.009 & 0.1570.031 & 0.029 & 0.0260.0940 \\ 0.009 & 0.010 & 0.0080.226 & 0.107 & 0.0060.0071 \\ 0.153 & 0.121 & 0.0990.031 & 0.025 & 0.0190.0330 \\ 0.161 & 0.193 & 0.1030.101 & 0.095 & 0.0870.0910 \end{bmatrix}, \quad q = \begin{bmatrix} 0.05 \\ 0.02 \\ 0.01 \\ 0.08 \\ 0.09 \\ 0.12 \\ 0.14 \end{bmatrix}.$$

It is assumed that there is one resource in the amount $B_1 = 3.5$ described by the matrix

$$\{b_{ij1}\}_{ij}^{nn} = \begin{bmatrix} 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \\ 3.00 & 3.00 & 3.001.00 & 1.00 & 2.000.50 \end{bmatrix}.$$

The multiplier $l = (1.320, 1.000,\ 1.375,\ 1.375,\ 1.375,\ 1.375,\ 1.375)^T$, and some of the other components of the value added were assumed to be equal $d = (0.01,\ 0.05,\ 0.01,\ 0.05,\ 0.10,\ 0.10\ 0.15)^T$. At the same time, the structure of individual consumption is characterized by a vector $\alpha = (0.15,\ 0.05,\ 0.05,\ 0.15,\ 0.20,\ 0.20,\ 0.20)^T$, and the structure of public consumption by a vector $h = (0.1,\ 0.2,\ 0.2,\ 0.1,\ 0.05,\ 0.05,\ 0.3)^T$. Changes in the coefficients of the input-output coefficients matrix were considered in the range up to 50% of the initial value, and the change in the wage vector in the direction of increase to the maximum value.

Table 1. *Optimal values of objective functions (3) and (4) depending on the boundaries of changes in the input-output coefficients matrix and the coefficient β.*

	$\beta = 1$		$\beta = 0.95$		$\beta = 0.90$	
%	F_1^*	F_2^*	F_1^*	F_2^*	F_1^*	F_2^*
50	2.16188	0.6751	1.88599	0 .64637	1.67095	0.62027
40	2.03471	0.66316	1.78670	0.63521	1.57472	0.60788
30	1.90212	0.64954	1.65749	0.61939	1.43671	0.5874
20	1.75540	0.63315	1.47255	0.59417	1.21586	0.55085
10	1.57512	0.61044	1.23925	0.55654	0.95043	0.49664

The results of calculations showed that a decrease in the coefficient β and boundaries of changes in the input-output coefficients matrix negatively affect on the macroeconomic indicators described by the functions (3) and (4), see Table 1.

The developed system does not need a special installation. Requirements for software and hardware: Windows XP, Windows 7, processor at least 1.5 GHz, RAM is not less than 1.0 GB. The system is equipped with helps.

CONCLUSIONS

The models described in this paper reflect one of the possible aspects of planning structural and technological transformations. They were created as an instrument to study the processes of transitional periods. Despite the fact that they do not describe these processes in all the aspects, they may serve as a tool to study possible consequences of transformations and to describe the most reasonable ways of development. As it was indicated in [3], „… the results of computations based on the described above models cannot be directive under conditions of transitive economy. They can be used to obtain desirable structure of industrial technologies that intensify the social and economic development of the country, to reveal the ways of reducing the existing structure to the desirable one, to evaluate the necessary resources etc.“

There are several ways to continue researches in this direction. It may be calculations for customer-supplied data. New services and new optimisation models could be included to the MiSTC system.

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Exploring the evolution of India's economic structure: the case of manufacturing-services interlinkages

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Abstract: The Indian economy has seen a rapid increase of the service sector share in its GDP since the early 1990s or during the post-reforms period. The manufacturing sector share in output stagnated during the same period. Moreover, the period did not see a commensurate increase in the employment share of the service sector and the manufacturing employment share also remained largely stagnant. With this backdrop this paper makes an attempt to understand the growth process associated with the evolution of India's economic structure during the post-reforms period. This is done specifically by analyzing the production and demand linkages between the manufacturing and service sectors using the Input-Output tables for India. The paper finds that manufacturing sector has been much more integrated within India's production structure both, in terms of input cost and as a stimulator of output and employment for other sectors, as compared to services. Service sector in this rapid growth phase saw a larger share of value added being generated in modern producer services like financial, Information and Communication Technology (ICT), real estate and business services, which contributed much less to the service sector employment. The dependence of manufacturing on these service inputs has not been found to have increased as opposed to the internationally established patterns of such dependence which tends to increase over the course of economic development. The role of final demand as a source of service sector demand was much more than intermediate demand. Within final demand private consumption has been the major source of service sector demand. At the same time service sector share in India's private consumption has risen steeply over this period, and was much higher than that of manufacturing. This finding is also incompatible with India's stage of economic development when compared to international experiences. The findings of this paper are consistent with the suggestions in the existing literature on the Indian economy that point towards a co-evolutionary process between income inequality and the production structure of the Indian economy.

1 INTRODUCTION

Economic progress is considered to be fundamentally dependent on rapid output growth in an economy. According to Rodrik (2013), two traditions related to output growth can be identified in economic theory. The one based on development economics identifies an economy as an amalgam of heterogeneous sectors[6] which differ in their logic of production. Economic growth in this set-up depends on the interdependence among the various sectors of the economy. On the other hand the neoclassical theory of economic growth focuses on output growth irrespective of sectoral distinctions.

The present paper considers inter-sector heterogeneity and their interactions to be important in understanding the evolution of output growth. It is in this context that the seminal works of Hirschman (1958) and Kaldor (1967) provide bases for identification of growth-inducing sectors in an economy. Industrialization through manufacturing sector growth has been central to a Kaldorian economic growth paradigm. In it, manufacturing sector exhibits economies of scale, manufacturing output growth leads to increased productivity growth, and overall productivity growth can be increased by shifting resources to the manufacturing sector due to diminishing returns to factors in the agricultural sector (Targetti, 2005; Bagchi, 2005). The Hirschmanian arguments rest on the idea of backward and forward linkages of sectors in ascertaining their growth stimulating potential on the economy. Backward linkages depict the demand stimulus a sector creates on the other sectors by using inputs from other sectors in the economy. Forward linkages capture the stimulating impact a sector creates on the others through its use as inputs in other sectors. The role of forward linkages as an inducement mechanism is argued to be dependent on the existence of backward linkages. Therefore, backward linkages assume central importance here[7]. Hirschman suggested the use of input-output tables in assessing inter-sectoral linkages. Although he has not been as explicit as Kaldor, in his analysis on economic and industrial development, manufacturing activities have implicitly assumed particular significance.

The evolution of India’s economic structure depicted by the sectoral composition of GDP and employment during the post liberalization period i.e. after 1991, suggests that the role of manufacturing has been rather muted in driving the economic growth of the Indian economy. The GDP share of manufacturing has stagnated around 15-16 percent from 1991-92 to 2012-13 as compared to an increase from 9 percent to 15 percent from 1950-51 to 1990-91. The manufacturing employment share between 1993-94 and 2011-12 hovered around 10-12 percent (Mehrotra et al., 2014). The GDP share of services on the other hand has grown rapidly from 38 percent to 53 percent from 1991-92 to 2012-13 as compared to 27 percent to 36 percent from1950-51 to 1990-91[8]. Mehrotra et al. (2014) show that services employment share increased from 21 percent to 27 percent during 1993-94 to 2011-12. Clearly, employment contribution of the service sector has not been commensurate with its GDP contribution during this period. These findings suggest that the gap in the average

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[6] The paper refers to the Lewis (1954) dual economy approach which divides the economy into traditional and modern sectors. In brief, the movement of labor from less productive traditional sector to more productive modern sector leads to economic growth in this approach.

[7] See Hirschman (1958). pp. 116-117.

[8] National account statistics, 2004-05 prices, EPWRF.

value added between those employed in manufacturing and service sector has been persistently high during the post-reform period.

The well-established patterns of structural change observed across the world indicate that during the initial stages of development, with increase in per-capita income, the share of agriculture in terms of employment and output tends to fall and the share of the secondary sector (of which manufacturing is the most important) goes up. It is at more advanced levels of per capita income that the service sector takes over as the dominant sector of the economy.

Kochar et al. (2006), Papola (2006) and Ghose (2016) discuss the distinctness of India's structural change in relation to its per capita income. The former using cross country regressions shows that India's service sector during the post-reforms period was a positive outlier in terms of its GDP share and a negative outlier in its employment share. On the other hand the manufacturing sector contribution to employment and output remained comparably low. Papola (2006) compares the experience of India's structural change from 1960 to 2002 with Asian economies like China, Indonesia, Malaysia, South Korea, Philippines and Thailand. He finds India's pattern of structural change distinct in three aspects. The relatively lower role of industry (manufacturing plus non-manufacturing industries) in output and employment over the course of structural change, the shift of labour force from agriculture to non-agricultural sectors has been much slower in India and its service sector share in GDP was the largest among compared economies but service sector employment share was the lowest. Similarly, Ghose (2016) points out that in comparison to selected Asian economies like China, Indonesia, Malaysia and Thailand which had higher per capita income than India in the reference year 2012, India exhibited a significantly smaller employment and output share in manufacturing. India's service sector output share was the highest and its employment share was the lowest among the countries compared.

Recent works like Dasgupta & Singh (2006), Ghani & O'Connel (2014) and Kucera & Roncolato (2016) have seriously investigated if there is a role of service sector as a driver of economic growth. Kucera & Roncolato (2016) identify three important views from the literature on this issue. These views include services as a substitute to manufacturing as an engine of growth, service sector as a leading or lagging complement to manufacturing sector in the growth process and co-evolutionary movement of services and manufacturing in the growth process. In the context of India, Dasgupta and Singh (2006) based on their analysis in the Kaldorian framework suggest Information and Communication technology (ICT) services to be crucial as an engine of growth. These services in the Indian context have been regarded as complementary/additional engine of growth to manufacturing. Ghani & O'Connel (2014) discuss the possibility of services as a substitute to manufacturing for rapid economic growth for less developed regions. Their analysis focuses on the African region where various low-income economies have witnessed premature de-industrialisation i.e. decline in manufacturing employment and output shares at low levels of per capita income. They attempt to assess if in such a scenario service sector could lift these economies to higher levels of economic development. Guerrieri & Meliciani (2005) discuss the co-evolutionary processes of manufacturing and service growth in advanced economies. They suggest that growth and international competitiveness of modern producer services like finance, real estate and business services hinge on their linkages with knowledge intensive manufacturing industries and in this context there is a possibility of combined growth in the two sectors taking advantage of these linkages.

The recognition of manufacturing and services as potential drivers of economic growth has also led to inquiries into production and demand linkages between the two sectors. Park (1987), Park & Chan (1989) and Tregenna (2008) have used Input-Output transactions tables (IOTTS) to assess the manufacturing-service interactions on Hischarmanian lines. The production and demand linkages of sectors in an economy not only enable us to assess the sectoral integration within the production structure but also growth and employment inducement potential of different sectors. Park (1987) and Park & Chan (1989) in their cross-country analysis find manufacturing-services input dependency on each other for production and identify patterns of these dependencies across countries according to their per-capita income classifications. For example, the latter work shows evidence for increased input dependence of manufacturing on producer services as an economy moves from low per capita income to advanced stages of development. Tregenna (2008) analyses manufacturing-services input-output linkages with each other and the rest of the economy for South Africa. The study finds that even with a decline in manufacturing share in GDP and a larger service-GDP share, manufacturing remained more "growth pulling" in terms of its backward linkages with the rest of the economy.

There have been important works that have used IOTTS to analyze inter-sectoral linkages in India as well. This includes Sastry et al. (2003), Saikia (2011), Das (2015), Hansda (2001) and Bhowmik (2003). The first three studies look at the production and demand structure of the Indian economy at the aggregate level of agriculture, industry (manufacturing plus non-manufacturing industries) and service sectors. They discuss the inter-dependence between any two sectors based on their dependence on each other for inputs in the production of their respective outputs. Also, on the demand side they look at the importance of a sector for the others in terms of the demand it generated for other sectors. The period of analysis in these three studies includes IOTTS ranging from 1968-69 to 2003-04 (Saikia; 2011), 1968-69 to 1993-94 (Sastry et al.; 2003) and 1979-80 to 1998-99 (Das; 2015). A common finding in these studies is increased agriculture dependence on industrial inputs over time but reduced industry dependence on agricultural inputs, reflecting broad-based growth of industry. Services tended to be more strongly related to industry than agriculture over time. The other two articles i.e. Hansda (2001) and Bhowmik (2003) focus on the importance of service sector in the inter-sectoral production and demand. Bhowmik (2003) analyzes the IOTTS for the period ranging1968-69 to 1993-94 and Hansda (2001) only studies the 1993-94 IOTT. The first shows that service intensity of production increased during the pre-reform period and metal products, machineries, trade and banking had been the key sectors in terms of service intensity during this period. The latter argues service sector to be an important sector in the Indian economy based on its intensive usage in production of output of various sectors. There is no available study that analyzes manufacturing-services production and demand linkages in India, for an extended period since the economic reforms. This paper fills this gap by analyzing five IOTTS of the Indian economy from 1993-94 to

2013-14 and explores some important aspects of India's post-reform structural transformation. Based on its findings it suggests areas for further research.

The following part of the paper is divided into five sections. Section two discusses the recent research on post-reform rapid service sector growth and manufacturing-services interaction in India. Section three provides an analysis of the production and demand linkages of the manufacturing and service sector based on the IOTTS. Section four delves into a closer analysis of the services at the level of sub-sectors. Finally, section five provides a brief summary and discussion on the findings with suggestions for further research.

2. RECENT RESEARCH ON SERVICE SECTOR GROWTH AND SERVICE-MANUFACTURING INTERACTION IN INDIA

The increasing share of service output in the Indian economy during the post-reform period has drawn attention of various researchers. This is because the growth in service sector output superseded the other major sectors of the economy during this period. Ghose (2015) points out that the share of services at 30 percent of India's GDP was already large relative to other sectors at the beginning of 1980s. Its contribution to GDP growth which surpassed all the other sectors put together that makes the structure of GDP growth distinct from the pre-1980s period. This tendency has strengthened in the post-reforms period. Table 1 below depicts the average annual growth rates of the sectors in the Indian economy. It can be seen that during 1990-91 to 1999-2000 and 2010 to 2015-16 the average annual service sector growth superseded that of all the other sectors and the Indian economy. Even during the decade between 2000-01 and 2009-10 it was only marginally lower than and second to the construction sector, which witnessed the fastest average annual growth during this period. Service sector growth in 1980s was relatively faster than many sectors but remained behind mining & quarrying and electricity, gas & water supply. Also, it can be seen that the gap between average annual growth rates of services and manufacturing widened in the post 1990 era as compared to the 1980s when the gap was much lower.

Table 1

Average annual growth rate of sectors (at 2004-05 prices)

	1980-81 to 1989-90	1990-91 to 1999-2000	2000-01 to 2009-10	2010-11 to 2015-16
Agriculture, forestry and fishing	3.3	3.1	2.6	2.5
Mining and Quarrying	8.2	4.2	4.6	4.5
Manufacturing	6.4	5.8	8.1	4.0
Electricity, Gas and Water Supply	8.8	7.3	6.0	5.4
Construction	3.8	4.9	9.6	4.6
Services	6.8	8.0	9.3	9.0
GDP	5.4	5.9	7.5	6.7

Source: Author's calculations of Compound Annual growth rates (CAGRs) at 2004-05 prices based on back series, NAS 2011 and NAS 2017, Central Statistics Office, Government of India.

It has already been mentioned that from an international perspective India's employment and output structure in the backdrop of rapid service sector growth has been distinct during the post-reform period. In explaining the growth success of the service sector during the post-reforms three factors have been highlighted by researchers. On the supply side, first, India heavily focused on tertiary education with substantial public investment which was exceptional at its level of development. This as a result led to creation of relatively cheap skilled workforce to be employed in skill intensive sectors (Kocchar et al.; 2006, Nayyar; 2012). Second, after economic liberalization, government policies in terms of taxes andFDI rules were relatively less restrictive for the service sectors as compared to the manufacturing sector (Nayyar, 2012). Thirdly, demand side growth accounting of the service sector using IOTTS between 1979 and 2008 shows that major part of the service sector growth can be explained by domestic final demand and exports (Eichengreen & Gupta, 2011a; Nayyar, 2012; Ghose, 2015). Inter-industry demand contributed much less to this growth. It has been argued that the limited role of intermediate demand in service sector growth shows lack of splintering i.e. outsourcing of various industrial activities to the service sector. While the role of exports has grown in explaining service sector expansion post reforms, domestic final demand has remained dominant since the pre-reform years.

Datta (2015) challenges the consensus on rapid service sector growth in contemporary India and argues that a decline in relative price of manufacturing due to rapid productivity improvements in this sector vis-à-vis services, especially education, health and public administration & defence (EHPAD) is responsible for the value added share increase in favour of service sectorin the post-reforms period. Since this argument is restricted only to EHPAD services, it is unable to explain the rise in value added share of the service sector as a whole[9]. Another distinct view in the context of post-reform service sector growth is that of Nagaraj (2009). According to him the service sector output since 1991 is overestimated due to underestimation of price deflators for this sector. However, the paper does not quantify the extent of this overestimation.

There are also studies that have discussed the different aspects of the combined growth process in the service and manufacturing sectors without analyzing their production and demand linkages explicitly. The implications of a relatively large service sector in the economy based on its relationship with the commodity producing sectors (manufacturing and agriculture) have been discussed in Bhattacharya and Mitra (1990). The paper argues that service sector growth between 1950-51 and 1986-87 as compared to the real output of the commodity sectors, may not reflect a real output growth as service output does not reflect tangible physical output. The income generated in the service sector during this period as opposed to increase in service sector output may have been reflected in service sector growth. This is because the increment in the employment share of the service sector was relatively low, rising only by 3 percent from 15 percent to 18 percent from 1960 to 1981 whereas output share grew by 7 percent from 30 percent to 37 percent. They point out that income growth[10] and shift of non-market services to the market might have contributed to the sector's output growth. They also argue that this gap between relative output and employment shares for the service sector had been much narrower in other developing countries[11], while the bulk of employment in the advanced economies was absorbed in the service sector by that time. Based on an econometric exercise estimating elasticity of service sector value added with the commodity producing sectors, they do not find statistical support in favour of induced growth (spillover of growth from other sectors to service sector) in the sector. In such a scenario, they predict that disproportional service sector growth could be inflationary and may increase import demand because of increased demand for the goods from commodity producing sectors through rise in the relative incomes of those associated in service production. These observations were made for the pre-liberalization period when Indian economy was relatively closed. Recently, Ghose (2016) also argued on similar lines suggesting that rapid growth of service sector incomes has contributed to an import-intensive manufacturing growth in India during the last decade.

Banga and Goldar (2004) looked at organized manufacturing and service sector linkage to analyse the productivity of the manufacturing sector during 1980-81 to 1999-2000. They find that the importance of services as an input in manufacturing increased during the first decade of the post-reforms period. They also find a favourable role of services in manufacturing productivity during the 1990s. This study uses KLEMS methodology (KLEMS-Capital,

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[9] Nayyar (2012) argues that India's service sector growth in the post reforms period is real and not notional. This means that it's not the greater relative prices of services vis-a-vis industry that reflects its higher share in output. This is based on his assessment of the movement implicit price deflators of agriculture, industry and services in the post-reforms period.

[10] Incomes of those associated with service production.

[11] Economies not explicitly mentioned.

Labour, Energy, Material and Services inputs) to analyse the productivity of inputs used in producing organized manufacturing gross output. In this supply side analysis service inputs have been calculated as a residual of total inputs minus the KLEM inputs assuming the residual inputs to be from the service sector.

Ghani et al. (2016) studies the spatial pattern of manufacturing and service sector growth in India during 2001-2010. They use Annual Survey of Industries (ASI) and National Sample Survey Organisation (NSSO) establishment level data to track manufacturing and service activity across Indian states and between rural and urban areas. They find service activities to be more urbanized as compared to manufacturing. According to them, there is evidence of spatial correlation between manufacturing and services, both being concentrated in a few states. They also find manufacturing to be more dependent on infrastructure for its development while human capital being important for services on the other hand. Additionally, they show that manufacturing and services do not appear to crowd out each other, which is the only finding that discusses interaction between manufacturing and service sector. They find limited statistical support for employment growth to be correlated between the two sectors. They suggest this evidence for weak complementarity may be understood as evidence against crowding-out between the two sectors.

Dehejiya and Panagariya (2014) attempt to provide a framework to understand India's manufacturing and services growth experience in recent years through a symbiotic relationship between the two sectors. The primary aim of the study was to understand the accelerated service sector growth in India in the post-liberalization era. They use NSSO data from 57th (2001-02) and 63rdround (2006-07) for service sector enterprises. They suggest that service sector growth took place due to both, direct demand as an input in manufacturing and indirect income induced demand through accelerated growth in manufacturing, leading to a downward shift in the latter's relative prices. They support this claim by regressions showing a statistically significant relationship between services and manufacturing growth. They use only 1998-99 IOTT in their regression framework to provide some basis of manufacturing sector use of service inputs but the study does not attempt to understand the input-output linkages between manufacturing and services exhaustively across the post-reform period. Importantly, they also provide econometric evidence of growth in capital-intensive services to be associated with use of imported inputs enabled by trade liberalization.

These are important contributions towards understanding post-reform manufacturing-service co-evolution in India. But none of these studies analyses the interaction between manufacturing and services for post-reform period comprehensively from a structuralist perspective. In particular, the extent of integration of these two sectors through their production and demand linkages and their relative contribution to India's production structure have not been adequately investigated for the entire post –reform period. This analysis is carried out in the following sections using the five available IOTTS for the Indian economy since the early 1990s.

3. MANUFACTURING AND SERVICE SECTORS IN INDIA'S PRODUCTION STRUCTURE

The Central Statistics Office (CSO), Ministry of Statistics and Programme Implementation (MOSPI), Government of India publishes IOTTS for the Indian economy. There are four IOTTS published by CSO since the economic reforms. These are for the years 1993-94, 1998-99, 2003-04 and 2007-08. CSO published Supply and Use Tables (SUTs) in 2011-12 and 2012-13. IOTTS are square matrices with equal number of sectors in the rows and columns, but SUTs have been published as rectangular matrices with unequal number of rows and columns. Kanhaiya and Saluja (2016) have modified the 2012-13 SUT to obtain the IOTT for 2013-14 which has been used for this study[12] as the most recent data point along with the four IOTTS published by the CSO. The 1993-94 and 1998-99 IOTTS contain 115 sectors and for the later three i.e. 2003-04, 2007-08 and 2013-14 there are 130 sectors of the Indian economy. The SUTs have been published with 140 rows and 66 columns. For the purpose of analysis at the aggregate/broad sectoral level the five IOTTS have been collapsed into 6 sectors. These include agriculture and allied activities, mining and quarrying, manufacturing, construction, electricity & water supply (CEW), services and public administration and defence. These broad sectors contain various sub-sectors. These sub-sectors have been collapsed into these 6 broad sectors following the sector classification provided with IOTTS by CSO. The CSO has also provided information regarding concordance of sectors across IOTT years where the sector numbers vary as discussed above, which has been followed while aggregating the sub-sectors.

The sectors in an IOTT are embedded in a way that each sector's output can be traced as an input in other sectors. All the sectors can be visualised as input providing upstream sectors and input using downstream sectors in the same table. The rows of an IOTT depict all the sectors as upstream sectors and the columns depict them as downstream sectors. The importance of the input providing upstream sector in the production of output of a downstream sector reflects the production linkage between the two sectors. The demand for an upstream sector's output as an input in all the sectors constitutes its intermediate demand. The importance of a downstream sector as a source of intermediate demand for the upstream sector reflects demand linkages[13]. This set-up of input-output linkages between sectors reflects the production structure of an economy in the IOTT context. The IOTTS also provide information on use of a sector's output outside the production structure i.e. final use/demand. The final demand includes private final consumption expenditure (PFCE), government final consumption expenditure (GFCE), gross fixed capital formation (GFCF), change in stocks (CIS), valuables and net exports. This reflects the final demand composition/structure of each sector. An IOTT allows us to analyse both, the production and demand

[12] Since the IOTT for the year 2013-14 prepared by Kanhaiya and Saluja (2016) is not the official IOTT but derived from official SUTs, its results need to be read with care.

[13] See Appendix B for a mathematical representation of production and demand linkages calculated through IOTTS.

structure of an economy. The linkages between sectors within the production structure enable identification of important sectors on Hirschmanian lines, both in terms of their use as inputs and due to the intermediate demand they generate for other sectors. The most important tool of analysis, based on the theoretical understanding provided by Hirschman, is that of backward linkages. In a crude sense, it is the demand stimulus a downstream sector generates on the other/upstream sectors of an economy while using their outputs as inputs in its production process[14].

We begin the analysis by looking at the share of all the sectors in the total input cost incurred to produce the output of the Indian economy for the available time points.

Table 2

Share of different sectors in total input cost of the Indian economy

S No.	*Year*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
	*Sectors**					
1	Agriculture and Allied activities	15	14	13	12	11
2	Mining and quarrying	7	6	8	9	13
3	Manufacturing	38	39	42	43	41
4	CEW#	9	9	8	8	11
5	Services	30	31	29	29	23
6	Total Input Cost	100	100	100	100	100

Source: Author's calculations based on IOTTS, CSO for the years 1993-94 to 2007-08 and IOTT prepared by Kanhaiya and Saluja (2016) for the year 2013-14

#Construction, Electricity and Water Supply

*Public administration and defence contained "0" entry in all the cases as it only enters IOTTS as a Final expenditure under the head of Government Final Consumption Expenditure. It is therefore not shown in the table.

We can notice from Table 2 that in terms of the input cost share, manufacturing and services have been the most important sectors of the Indian economy during the post-reforms period. The importance of manufacturing in terms of input costin production of Indian economy's output has not only been much larger than services butwitnessed an increase over the post-reforms period. The importance of services in India's production structure as depicted by its input cost share witnessed a decline after 1998-99. This finding is striking given that service sector has grown rapidly in terms of value added share and manufacturing share in value added[15] remained stagnant during the post-reforms period.

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[14] See Appendix C for a detailed exposition of the methodology.

[15] The decline in service input cost share does not seem to be due to fall in relative prices of services vis-a-vis manufacturing. Baumol (1967) and on similar lines Datta (2015) have argued that relative prices of services tend to rise.In such a situation the rise in service value added share and fall in its input cost share is peculiar. This may be due to evolving production structure and technological progress but we are unable to separate the reasons of such an outcome. Also, see Appendix A, Table A1 and Figure A1 for the ratio of implicit deflators of manufacturing and service sectors which show that this ratio has hovered around 1 during the entire post reform period.

In Table 3, Hirschman-type backward linkages of manufacturing and services on the Indian economy have been calculated for the post-reform period.

Table 3

Manufacturing and service sector backward linkages

SNo.	*Year*	*1993-94*		*1998-99*		*2003-04*		*2007-08*		*2013-14*	
	Sectors	*M*	*S*	*M*	*S*	*M*	*S*	*M*	*S*	*M*	*S*
1	Agriculture, Forestry and Fishing	0.18	0.06	0.21	0.06	0.17	0.06	0.16	0.06	0.20	0.05
2	Mining and Quarrying	0.11	0.03	0.11	0.02	0.16	0.03	0.21	0.03	0.30	0.06
3	Manufacturing	1.60	0.23	1.58	0.24	1.67	0.26	1.74	0.26	1.65	0.29
4	CEW	0.10	0.07	0.10	0.07	0.10	0.05	0.08	0.04	0.13	0.15
5	Services	0.39	1.23	0.38	1.26	0.39	1.24	0.41	1.24	0.31	1.24
6	Bj(Total Backward Linkage=Sum of 1 to 6)	2.37	1.62	2.37	1.65	2.49	1.64	2.60	1.64	2.58	1.79

Source: Same as Table 2
M: Manufacturing; S: Services

Each cell in Table 3 reflects the total demand (intermediate demand plus final demand) generated for the sector placed in the row, in response to a unit of final demand generated in the sector depicted in the column, expressed as a fraction/multiple of this one unit of final demand. These entries have been extracted from the Leontief inverse matrix calculated from the IOTTS (See Appendix C). Following Jones (1976), row 6 can be interpreted as the total demand generated in the economy in response to a unit of final demand generated in the sector represented in the column, expressed as a multiple of this unit of final demand. This indicates the demand stimulating potential of a sector on the economy due to its interconnectedness with the other sectors in the economy. It can be clearly seen here that backward linkages of both manufacturing and services increased during the post-reforms period, but manufacturing persistently remained more integrated within the production structure as compared to services. In Kaldorian and Hirschmanian terms, manufacturing sector performed as a key sector in stimulating output and employment (employment to the extent to which each unit of output production generated employment in the concerned sector- an issue we are not engaging with in this paper) in other sectors of the economy. Although, service sector grew rapidly, it remained behind manufacturing in stimulating production in the other sectors. This finding is similar to that observed by Tregenna (2008) in the context of South Africa in 2005.

The fact that services have been relatively less integrated than manufacturing in India's production structure is corroborated by Table 4 where we decompose the total demand for these two sectors into intermediate and final demands.

Table 4
Distribution of Sector Total Demand (as percentage)

Sector	*Manufacturing sector*			*Service Sector*		
Year	*Intermediate demand*	*Final Demand*	*Total Demand*	*Intermediate demand*	*Final Demand*	*Total Demand*
1993-94	49	51	100	41	59	100
1998-99	47	53	100	39	61	100
2003-04	51	49	100	40	60	100
2007-08	51	49	100	41	59	100
2013-14	49	51	100	36	64	100

Source: Same as Table 2

We notice that intermediate and final demands were equally important for the manufacturing sector during this period, but the contribution of final demand to total demand in case of services was much more than intermediate/inter-industry demand. In the more recent period, the relative importance of final demand has only increased for services. This is a reflection of service sector being relatively less integrated in India's production structure as compared to the manufacturing sector. Being the largest sector in terms of value added share during the post-reforms period, service sector contributed relatively much less to the Indian production structure as a demand stimulant and also depended much less on it (i.e. intermediate demand) in deriving its own demand.

The previous analysis shows that the demand that services generated for other sectors has been weaker relative to manufacturing. The latter has been much more integrated within India's production structure both in as an input and the distribution of its demand between intermediate and final demand. Given the relative importance of manufacturing and services in India's production structure the subsequent analyses investigates the interaction between the two sectors through their production and demand linkages. As previously stated, an analysis of the production and demand linkages would enable us to know the nature of manufacturing-service interaction in the period of rapid service sector growth. This shall further help us to understand the process underlying the resultant employment and output structure of the Indian economy during the post-reforms period.

Production linkages involve the dependence of manufacturing and services on all the upstream sectors for their inputs as also depicted for the Indian economy in Table 1. Demand linkages would show the importance of all downstream sectors for services and manufacturing as a source of intermediate demand, based on their use as inputs in downstream sectors. Earlier, Table 3 discussed backward linkages i.e. direct plus indirect demand stimulus that services and manufacturing created on other sectors by using them as inputs.

Table 5 and Table 6 below depict input cost share of all the sectors in manufacturing and service production, respectively. For the purpose of this paper our focus will be rows 3 and 5 in both the tables.

Table 5

Manufacturing sector production linkages with different sectors (as % of its total input cost)

S No.	*Year*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
	Sectors					
1	Agriculture and Allied activities	13.1	15.5	10.7	9.1	14.5
2	Mining and quarrying	9.0	8.6	12.9	15.9	24.1
3	Manufacturing	45.9	44.6	47.0	48.2	43.0
4	CEW	5.5	6.0	5.3	3.5	5.2
5	Services	26.6	25.4	24.2	23.4	13.3
6	Total input cost of manufacturing sector	100	100	100	100	100

Source: Same as Table 2

Table 6

Service sector production linkages with different sectors (as % of its total input cost)

S No.	*Year*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
	Sectors					
1	Agriculture and Allied activities	7.0	6.1	6.4	7.5	3.1
2	Mining and quarrying	1.1	0.9	0.1	0.1	0.3
3	Manufacturing	34.2	34.1	39.3	38.5	32.1
4	CEW	14.4	12.1	8.7	7.5	28.2
5	Services	43.3	46.8	45.5	46.3	36.3
6	Total input cost of service sector	100	100	100	100	100

Source: Same as Table 2

It can be noticed that manufacturing and service occupied much larger input cost shares in each other's production compared to all other sectors. At the same time service sector input cost share in manufacturing witnessed a consistent decline during the post reform period (See Table 5). This is a different pattern as compared to what Park (1987), Park & Chan (1989), Guerrieri & Meliciani (2005) and more recently Driemeier and Nayyar (2018) show in their research. They find greater production integration between the two sectors over the course of economic development i.e. with higher per capita income levels. According to Driemeier and Nayyar (2018) the share of embodied services i.e. the value added share of services in value of gross manufactures' exports has globally seen a marginal increase of one percent between 1995 and 2011, with this increase being more pronounced in the European region. The fall in share of embodied services in India's manufacturing seems to be a peculiar development in this light. Table 6 shows that service sector input cost share was persistently higher than manufacturing input cost share in service production. Park (1987) based on his research of East Asian and Pacific Basin economies shows that at relatively lower levels of economic development service sector tends to be much more dependent on manufacturing for production than it does on services[16]. The importance of services in service sector production tends to be greater than manufacturing at higher levels of economic development as depicted by the case of Japan and USA in Park's (ibid) analysis. India seems to have graduated to this stage rather uncharacteristically for its level of development.

There is an important asymmetry between tables 5 and 6. Manufacturing sector dependence on services has been lower throughout than service sector dependence on manufacturing. This asymmetry has been also noted in Park (1987) for all the economies at various levels of development. What stands out for India is the greater dependence of service sector on services vis-à-vis manufacturing, a pattern shown to be occurring at more advanced stages of economic development.

While the dependence between manufacturing and services have declined from both ends during the entire period (except for the period between 1998-99 and 2003-04 when service sector dependence on manufacturing increased), the fall has been sharper in the manufacturing sector dependence on services than vice versa. Appendix A shows that the relative price ratio of manufacturing and services hovered around one during the entire post-reforms period with moderate fluctuations. The decline in dependence of manufacturing on services and recently of services on manufacturing in this situation does not seem to be purely a reflection of relative price fluctuations but an actual weakening of physical linkages. This seems to be a peculiar change in India's production structure in a period of relatively high economic growth in India's post-independence period.

Next we look at the intermediate demand linkages between the two sectors in Table 7 and Table 8. These tables respectively depict manufacturing and service sector dependence on all the sectors as a source of intermediate demand.

[16] See Park (1987) p. 366.

Table 7

Manufacturing sector demand linkages with different sectors (as a % of total intermediate demand for manufacturing)

S No.	Year / Sectors	1993-94	1998-99	2003-04	2007-08	2013-14
1	Agriculture and Allied activities	7.2	7.3	5.3	3.4	4.3
2	Mining and quarrying	1.3	0.8	1	0.8	1
3	Manufacturing	57.4	56	56.9	60.6	53.1
4	CEW	13.3	12.9	15.6	16.7	24.4
5	Services	20.8	23.1	21.2	18.5	16.6
6	Total intermediate demand for manufacturing sector	100	100	100	100	100

Source: Same as Table 2.

Table 8

Servicesector demand linkages with different sectors (as a % of total intermediate demand for services)

S No.	Year / Sectors	1993-94	1998-99	2003-04	2007-08	2013-14
1	Agriculture and Allied activities	9.5	6.8	7.7	7.2	5
2	Mining and quarrying	0.9	0.7	0.9	1	4.5
3	Manufacturing	41.6	39.4	41.7	43.9	28.9
4	CEW	15.1	14.1	14.7	14.7	26.3
5	Services	32.9	39.1	35	33.3	33.1
6	Total intermediate demand for service sector	100	100	100	100	100

Source: Same as Table 2.

It can be seen from Table 7 and Table 8 that manufacturing sector was the most important source of intermediate demand for itself and the service sector (except in 2013-14 for services) during the post-reforms period. We already know that intermediate demand has played a muted role in propelling service sector growth, but within this segment manufacturing has been more important in stimulating the service sector. On the other hand manufacturing dependence on service sector as a source of demand was not only much lower, but also declined during the larger part of this period i.e. since 1998-99. This asymmetry in demand dependence between manufacturing and services in India is in agreement with the findings of Park (1987) and Treganna (2008). For the South African economy, Treganna (2008) also shows that service sector has depended more on manufacturing than vice versa in terms of intermediate demand.

The analysis of production and demand linkages points out two important things about manufacturing and service sector. In terms of production linkages, manufacturing and service sector did not witness an intensified integration alongside rapid service sector growth contrary to what works like Park (1987), Park & Chan (1989), Guerrieri & Meliciani (2005) and Driemeier & Nayyar (2018) on various economies suggest. This is particularly the case for services share in total manufacturing input cost. Intermediate demand linkages suggest that manufacturing has been crucial as a source of intermediate demand for service sector thereby being important in stimulating its output and employment although its share in India's output remained stagnant during the post-reform period. It is important at the same time to realize that though manufacturing has been an important source of intermediate demand for services, but intermediate demand itself contributed in the range of 36-40 percent of total services demand in the Indian economy during the post-reform period (See Table 4).

This exploration so far indicates that manufacturing sector was much more broad-based in terms of its inter-industry linkages within the production structure as compared to services. On the other hand, service sector linkages in India have been comparably weaker with the rest of the economy. The greater impact of manufacturing on output and employment of the Indian economy through its backward linkages, in comparison to services, is consistent with the findings of Tregenna (2008) in the context of South Africa. The acceleration of service sector growth has drawn attention in terms of its importance for economic development of late-comers to industrialization as already discussed through the works of Dasgupta and Singh (2006) and Ghani & O'Connel (2014). The analyses in this section has clearly established that service sector integration with the overall production structure has not been commensurate with its rapid growth and sharp increase in its value added share during the post-liberalisation period. The finding adds an important dimension to the debate on economic growth and structural change particularly for India and other developing economies in general. It is therefore, important to explore the service sector more at more detail in terms of its sub-sectors to understand the exact dynamics of sector. This task is taken up in the next section.

4. A DISAGGREGATED INVESTIGATION OF SERVICES

This section first takes a look at the distribution of various service sub-sectors in service value added and employment at single-digit classification of the National Industrial Classification (NIC; 1987, 1998, 2004). This is to understand the broad distributions of value and employment within the service sector across its sub-sectors. In the subsequent analyses of this section the paper also looks at double-digit classification for analyzing their linkages within the economy and their sources of demand. The analysis here begins looking at value added and employment distribution across various service sub-sectors in Table 9 and Table 10[17], respectively, spanning two decades of the post-reforms period.

Table 9

Value added distribution within service sector(as a percentage of total service sector value added)

S No.	*Service Sub-Sectors*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
1	Wholesale and Retail Trade	29.6	32.1	30.3	32.6	23.4
2	Hotels and restaurants	3.5	2.2	2.9	3.6	3.7
3	Transport and Communication	26.6	17.2	18.9	16.7	14.2
4	Financial Services (Banking and Insurance)	10.2	14.6	13.2	11.4	13.4
5	Real estate, Renting and Business Services (RRB)*	-	-	17.5	20.1	29.4
6	Education and research	5.9	10.2	8	7.6	7.2
7	Medical and health	3.6	2.9	3.9	3.3	3.4
8	Other Services excluding 5 (9-5)#	-	-	5.3	4.6	5.1
9	Other Services plus RRB (8+5)	20.6	20.8	22.8	24.7	34.6
10	Services (sum of 1 to 8)	100	100	100	100	100

Source: Same as Table 2.

*Includes real estate services related to commercial and residential buildings, legal services, computer-related services like software publishing, hardware consultancy etc., architectural and engineering services, business and management consultancy, advertising etc.

#Includes community social and personal services like laundry services, hair dressing, television broadcasting and services not elsewhere classified etc.

Note: Data on "5" and "8" is separately unavailable in 1993-94 and 1998-99 but data on "8+5" is available.

[17] The value-added shares and employment shares in Table 9 and Table 10 respectively, do not have exact concordance in terms of years. This is because employment data sourced from studies has been extracted from NSSO which is for specific NSSO rounds and the value added data for the same disaggregation is provided in IOTTS which differs from exact years in NSSO rounds. This does not seem to distort the broader trends in value added shares and employment shares across service sub-sectors as the corresponding years for both the shares differ only slightly.

Table 10

Employment distribution within service sector (as percentage of total service sector employment)

S No.	*Service Sub-Sectors*	*1993-94*	*1999-00*	*2004-05*	*2009-10*	*2011-12*
1	Wholesale and Retail Trade	42.1	43.5	41.6	40.7	37.0
2	Hotels and restaurants	4.5	5.5	5.9	5.7	6.5
3	Transport and Communication	14.7	17.5	17.8	18.7	19.2
4	Financial Services (Banking and Insurance)	3.6	2.6	2.9	3.6	3.6
5	Real estate, Renting and Business Services (RRB)*	2.3	3.1	4.3	5.4	5.6
6	Education and research	11.5	10.3	11.2	11.0	11.8
7	Medical and health	4.2	3.4	3.5	3.4	3.7
8	Other Services excluding 5 (9-5)#	16.9	14.2	12.9	11.5	12.6
9	Other Services + RRB (8+5)	19.2	17.3	17.2	16.9	18.2
10	Services (sum of 1 to 8)	100	100	100	100	100

Source: Author's calculation using Employment data from Nayyar (2012) and Mehrotra et al. (2014)

*Includes real estate services related to commercial and residential buildings, legal services, computer-related services like software publishing, hardware consultancy etc., architectural and engineering services, business and management consultancy, advertising, legal services, renting of machinery and equipment etc.

#Includes community social and personal services like laundry services, hair dressing, television broadcasting and services not elsewhere classified etc.

On observing the evolution of value added shares and corresponding employment shares across service sub-sectors, some important patterns emerge. Wholesale and retail trade remained the single largest sector in terms of value added (except 2013-14) and employment shares during the post-reforms period. But the sector witnessed a continuous decline in its employment share since 1999-2000 and a steep fall in its value added share between 2007-08 and 2013-14. It continued to dominate in terms of employment share but it lost its importance in value added share. In case of hotels and restaurants the value added share was largely stable with moderate fluctuations, but saw moderate increase in employment share over the years.

A perverse pattern can be noticed for transport and communications where the value added share saw a decline over the entire period (except between 1998-99 and 2003-04), but witnessed a consistent rise in its employment share. Financial services saw moderate fluctuations in its value added share but was larger than 1993-94 in all subsequent periods. Its employment share continued to remain extremely low in comparison to its value added share during the entire period. RRB services saw steep rise in value added share and gradual increase in employment share, but the gap between its value added and employment shares broadened during this period. Its share in employment continued to remain relatively small. Education and research and medical and health services saw stable value added and employment shares. Other services (row 8) saw a stable value added share but a decline in its employment share. Its value added share continued to remain much smaller than its employment share over the period. The larger dynamics of the service sector depict a perverse pattern of employment and value added shares over the post-reform period, as services like finance and RRB which gained in terms of value added shares contributed relatively much less to employment and at the same time services like wholesale & retail trade and transport & communications contributed relatively more to employment as compared to their value added shares.

Eichengreen and Gupta (2011b) in their analysis of advanced economies consisting of 15 European Union countries along with United States, Japan, South Korea and Australia between 1970 and 2005, suggest that service sector growth could be divided into two waves over time. The first wave involves growth of traditional services like wholesale and retail trade, storage and transportation and public administration and defence thereby increasing service sector share in the economy's GDP. The second wave post 1990 marks domination of service sector growth through modern sectors like banking & finance, Information and communication technology, business, legal and technical services and a hybrid of modern and traditional sectors like education, health, hotel & restaurants and community, personal and social services. Countries have moved from the first to the second wave in conjunction with increase in levels of per capita income. Also, according to them the second wave of service sector growth which occurs at higher levels of per capita income has witnessed a lowering of its threshold in terms of per capita income. They show evidence that this is subject to factors like democracy, urbanization, openness to trade and proximity with major global financial centres. Looking at the shares of RRB and financial services on one hand wholesale & retail trade and transport and communication on the other hand in Table 9, it seems that the pattern of service sub-sector GDP shares in agreement with the two wave pattern of service sector growth argument put forth by Eichengreen and Gupta (2011b). But the employment share data, as already discussed shows that direct employment generated by the modern services has not been consistent with the income growth of these services. The analysis of value added shares and direct employment shares of finance and RRB services hints towards a lack of a broad-based character in the growth of these services.

To verify this, Table 11 looks at a comparison of all the available service-sub sectors in terms of their total backward linkages or demand stimulating potential on the economy, similar to Table 3.

Table 11

Ranks of service sub-sectors in terms of their total backward linkages

S No.	*Sector*	*1993-94*	*1998-99*		*2003-04*	*2007-08*	*2013-14*
		Total No. of Ranks-12			Total No. of Ranks-21		
1	Air transport	-	-		4	3	1
2	Water transport	-	-		7	7	2
3	Legal services	-	-		18	18	3
4	Communication	8	10		12	11	4
5	Supporting and auxiliary transport activities	-	-		5	5	5
6	Land transport including via pipeline	-	-		3	2	6
7	Storage and warehousing	6	6		6	8	7
8	Other services not elsewhere classified (n.e.c) {S No. 23 minus 3, 9, 10, 11, 13 &15)}	-	-		11	10	8
9	Real estate activities	-	-		16	16	9
10	Renting of machinery & equipment	-	-		21	12	9
11	Other community, social & personal services	-	-		13	15	10
12	Hotels and restaurants	2	2		2	1	12
13	Business services				8	4	13
14	Railway transport services	4	3		1	6	14
15	Computer & related activities	-	-		14	13	15
16	Medical and health	1	1		9	9	16
17	Insurance	9	7		10	14	17
18	Wholesale and retail trade	7	8		15	17	18
19	Banking	11	9		17	19	19
20	Education and research	10	11		19	20	20
21	Ownership of dwellings	12	12		20	21	21
22	Other Transport	3	4		-	-	-
23	Composite Other services (Includes services S No. 3, 8, 9, 10, 11, 13 & 15)	5	5		-	-	-

Source: Same as Table 2

Note: The serial numbers of sectors follow the rank sequence of the year 2013-14 starting from the top ranked sector.

In Table 11 services have been ranked according to their total backward linkage on the rest of the economy. The backward linkages of the sectors on themselves have been subtracted from the total backward linkages to assess the demand stimulating impact on the rest of the economy which includes all the other sectors of the economy. The disaggregated data for services in rows 1 to 3, 5, 6, 8 to 11, 13 and 15 is only available from the year 2003 onwards in the IOTTS.

If we look at the finance and RRB services, we see that although these are leading subsectors in terms of value added shares, their growth inducing potential for the rest of the economy is much more modest. For example, the rank of banking remained among the bottom few in the entire post-liberalization period with respect to backward linkage. The two of the largest components of RRB in terms of value added shares have been ownership of dwellings and computer & related activities. They together constituted around 2/3rd of RRB value added during the period since 2003 when the disaggregated data is available. It can be seen that the indirect output and employment stimulating impact of these services have been relatively limited. Legal services, real estate and business services and renting of machinery & equipment generated more demand for each unit of their final demands than the two major components of RRB, but as compared to other service subsectors their contribution during the decade between 2003-04 and 2013-14 was lagging. Although a massive jump in the rank of legal services can be seen in 2013-14, its value added share within RRB remained around 3.3 per cent. Simply put, the modern services including finance and RRB did not lead in stimulating the other sectors of the economy as they continued to grow rapidly during the post-liberalization era.

Guerrieri & Meliciani (2005) suggest that the ability of an economy to develop an efficient and dynamic service sector is associated with its linkages with the manufacturing sector. Their focus in this context is on producer services like financial services and real estate & business services (RRB) for economies like Canada, France, Germany, Finland, Spain, Italy, Japan, Netherlands, UK and USA for the period between 1992 and 1999. They argue that greater intensity of manufacturing sector's usage of these services tends to be associated with higher growth and export competitiveness of these services.

Table 12

Percentage share of service sub-sectors in manufacturing input cost

S No.	*Sector*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
1	Railway transport services	1.6	1.4	1.4	1.0	0.7
2	Other transport services	7.4	4.9	5.4	5.9	2.1
3	Storage and warehousing	0.0	0.0	0.0	0.0	0.0
4	Communication	0.7	0.6	1.2	0.8	0.2
5	Wholesale and retail trade	10.2	9.9	9.3	9.7	7.4
6	Hotels and restaurants	0.0	0.0	0.0	0.0	0.1
7	Banking	3.1	5.2	3.7	2.8	1.6
8	Insurance	0.8	0.6	1.1	0.7	0.1
9	Ownership of dwellings	0.0	0.0	0.0	0.0	0.0
10	Education and research	0.0	0.0	0.0	0.0	0.0
11	Medical and health	0.0	0.0	0.0	0.0	0.0
12	Business services	-	-	0.5	0.8	1.1
13	Computer & related activities	-	-	0.3	0.4	0.0
14	Legal services	-	-	0.0	0.1	0.0
15	Real estate activities	-	-	0.0	0.0	0.0
16	Renting of machinery & equipment	-	-	0.0	0.0	0.1
17	Other community, social & personal services	-	-	0.9	1.0	0.0
18	Other services not elsewhere classified (n.e.c) {19-(12 to 17)}	-	-	0.2	0.2	0.0
19	Other services (Sum of 12 to 18)	2.7	2.8	2.1	2.4	1.2
20	All Services	26.6	25.4	24.2	23.4	13.3

Source: Same as Table 2.

Note: Distributive services: 1 to 5; Producer services- Financial services: 7+8 and RRB: 9 and 12 to 16; Residual services: 6, 10, 11, 17 and 18

For India, we have already noted the consistent decline of aggregate sector service input cost share in manufacturing production earlier. But we see (Table 12) that the share of producer services remained lower than distributive services. The producer services have not integrated with the manufacturing sector production during the post-reform period in India as opposed to the pattern observed by Guerrieri & Meliciani (2005) for the set of advanced economies mentioned previously. For example, banking services input cost share in manufacturing decreased consistently after 1998-99, and the share of insurance services also saw a steep and consistent decline after 2003-04. In case of RRB services we see that important services like computer and related activities, real estate and legal services did not witness greater dependency from the manufacturing sector in terms of their share in input cost. Business service share increased consistently, but continued to remain small. Therefore, manufacturing dependency on finance and RRB services did not witness intensification during the post-liberalization period.

In the previous section, we found that a much larger share of service sector demand came from final demand vis-à-vis intermediate demand. To gain more insight at the sub-sector level Table 13 presents a disaggregation of the components of final demand as sources of service sector demand.

Table 13

Major components of service sub-sector final demands (as percentage of final demand)

S No.	*Component of Demand*	*Private Final Consumption Expenditure*					*Exports*				
	Sector/Year	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*	*1993-94*	*1998-99*	*2003-04*	*2007-08*	*2013-14*
1	Railway transport services	82	74.0	51.5	59.9	70.4	10	10.6	19.6	17.0	0.0
2	Other transport services	71	77.1	77.5	67.7	86.9	16	14.2	11.9	20.7	10.6
3	Storage and warehousing	0	0	0	0.2	0	0	0	0	0	0
4	Communication	63	69.5	78.1	52.9	89.7	1	1.4	0.5	25.9	10.3
5	Trade	73	71.2	77.5	69.0	70.0	15	15.7	13.4	19.0	17.4
6	Hotels and restaurants	80	86.6	87.5	96.8	100	17	10.7	11.1	0	0
7	Banking	63	90.8	80.9	87.5	84.2	0	0	3.2	0	15.8
8	Insurance	56	87.0	74.5	67.5	86.0	44	13.0	15.2	24.7	14.0
9	Ownership of dwellings	99	100	100	100	100	0	0	0	0	0
10	Education and research	51	53.7	64.8	63.8	43.9	0	0	0	0	0.8
11	Medical and health	66	79.6	83.2	83.6	67.7	0	0	0	0	0
12	Business services	-	-	23.7	4.9	24.9	-	-	54.8	82.0	75.1
13	Computer & related activities	-	-	0	4.7	0	-	-	83.9	90.7	86.6
14	Legal services	-	-	86.2	63.7	100	-	-	0	26.6	0
15	Real estate activities	-	-	100	100	100	-	-	0	0	0

16	Renting of machinery & equipment	-	-	33.5	78.9	100	-	-	0	0	0
17	Other community, social & personal services	-	-	64.3	73.6	93.7	-	-	0	0	0
18	Other services not elsewhere classified (n.e.c) {19-(12 to 17)}	-	-	24.4	10.8	25.8	-	-	54.1	78.8	51.8
19	Other services (Sum of 12 to 18)	75	52.8	26.4	21.9	32.4	18	30.9	50.5	66.9	57.1
20	All Services	74.7	74.3	72.8	65.2	68.2	14.0	10.4	13.5	22.2	20.0

Source: Same as Table 2.

Note: Distributive services: 1 to 5; Producer services- Financial services: 7+8 and RRB: 9 and 12 to 16; Residual services: 6, 10, 11, 17 and 18

Table 13 only presents the shares of private final consumption expenditure (PFCE or private consumption) and exports as a percentage of final demand. This is because other components of final expenditure which are Government final consumption expenditure (GFCE), Gross fixed capital formation (GFCF) and Change in stocks remained minor through the entire period. Most of the service sector final demand share has been composed of PFCE and exports (see Table 13, row 20) during the entire post-reforms period. Therefore, this suggests that private consumption and exports have been important drivers of service sector growth during the post-reform period. Producer services like business services and computer & related activities (includes the ICT- services) have been highly export-oriented.

In terms of the aggregate service sector, these findings can be further corroborated by Table 14 and Table 15 below.

Table 14

Share of different sectors in PFCE of the Indian Economy

Sector	1993-94	1998-99	2003-04	2007-08	2013-14
Agriculture, Forestry and Fishing	38	31	26	24	17
Manufacturing	22	25	26	26	29
Services	39	42	47	49	51

Source: Same as Table 2.

Table 15
Share of different sectors in Total Exports of the Indian economy

Sector	1993-93	1998-99	2003-04	2007-08	2013-14
Agriculture, Forestry and Fishing	6.5	8.4	4.5	2.9	5.7
Manufacturing	57.2	56.8	53.7	42.7	55.3
Services	34.1	34.0	35.4	48.1	37.8

Source: Same as Table 2.

It can be seen from the two tables above that the share of services in aggregate private consumption of the Indian economy has increased rapidly during the reforms period. The share in exports also rose but less rapidly than private consumption over this entire period.

Park (1987) in his study showed that the share of services in private consumption tends to increase more during advanced stages of economic development. At less developed stages it is the private consumption of manufactured goods that increases more than other commodities in the aggregate private consumption share of an economy. In the Indian context, however, private consumption share of services has been not only larger than manufacturing but has also increased much more rapidly.

The analysis in this section suggests some important characteristics of India's service sector growth in the post-reform period that have not been looked at in the literature. The distribution of value added share within services across service sub-sectors shows that modern services like finance and RRB became more important compared to other service sectors. These sectors classified as modern services by Eichengreen and Gupta (2011b) conform to their finding of increased growth in finance and RRB services observed internationally after 1990. But at the same time their direct employment contribution in India remained extremely low. As stated previously, by 2013-14 financial and RRB services together stood at 42.8 percent of service value added but just employed 9.2 percent (2011-12) of service sector workforce. Even in terms of the indirect growth inducing impact on the rest of the economy, observed through their backward linkages, these services remained less important.

Additionally, unlike Guerrieri & Meliciani's (2005) findings, in the Indian context, increased export orientation doesn't seem to have been a result of greater production linkages of modern services with the manufacturing sector. Computer and related activities which reflect the ICT services were highly export oriented with limited manufacturing sector dependence on these services in terms of input cost.

The service sector saw a rapid rise in private consumption share of the Indian economy, exceeding that of major sectors like agriculture, forestry & fishing and manufacturing sectors. This has been a distinct feature of post-reform growth as compared to India's level of development. As mentioned earlier, according to Park (1987) the share of services in private consumption exceeds manufacturing only at advanced stages of economic development and it is the manufactured goods that dominate the private consumption share of an economy up to a higher threshold of per capita income. For example, the study shows that in 1975 the share of manufactured goods in private consumption for economies like Indonesia and South Korea was 48 per cent and 52 per cent respectively and the corresponding figures for Japan and USA were 30 per cent and 29 percent. The shares of services in private consumption for the former two were 18 per cent and 17 per cent respectively and that of the latter two were 41 per cent and 46 per cent respectively.

These are crucial findings on the nature of India's service sector growth, its linkages with manufacturing and the rest of the economy, which depict various important features associated with the post-reform evolution of the country's output and employment structure. The analysis clearly depicts limited inter-sector integration of service sector as an input in manufacturing and the Indian economy as a whole. The absence of broad-based character (in terms of output and employment stimulating impact on the economy and the disproportional distribution of value added and employment between modern services and traditional services) of the service sector alongside its rapid growth adds a crucial dimension to the debate on economic growth and structural change for India and other developing economies.

SUMMARY AND DISCUSSION

This paper has analysed the production and demand linkages of the manufacturing and service sector using the available IOTTS in the post reforms period in India. It was found that in terms of input cost share the contribution of manufacturing to the production of India's output was much more important than the service sector and the importance of service sector during this period declined by this measure. In terms of Hirschman-type demand inducement, manufacturing sector has been much more integrated with India's production structure as compared to services. For each unit of final demand generated for manufacturing it created much larger stimulus on output and employment of the sectors in the Indian economy as compared to services. This suggests that though service sector grew more rapidly than manufacturing during this period, its ability to stimulate growth and employment in other sectors remained limited. It was also found that manufacturing dependence on services for production in terms of its input cost share in manufacturing did not witness intensification over this period. At the same time manufacturing remained an important source of intermediate demand for services. Another finding of the paper is that modern/technology-intensive producer services rapidly increased their share of service value added but contributed much less in terms of employment. Therefore, the distribution of value added within the service sector was highly uneven across its sub-sectors and gains of technological progress seem to have been unequally distributed within the sector. These dynamic services also did not witness a greater integration with manufacturing. Some of these producer services like computer and related activities (ICT-related) and business services have been highly export oriented during this period. The larger part of service sector demand during this period came from the final demand segment. Within final demand it was private consumption and exports that were the main sources of service sector demand. Also, service sector share in total private consumption grew rapidly and was much higher than all the other sectors of the Indian economy. This finding is particularly striking in comparison to the level of India's development.

Given the larger role of final demand as a source of service sector demand, it has been argued by Rakshit (2007), Nayyar (2012), Guha (2013), and Ghose (2015) that income inequality has contributed to rapid service sector growth. Nayyar (2012) and Guha (2013) have attempted to analyse the household expenditure on services in this context and find some evidence for an unequal pattern in India, but the channels through which income inequality fits into explaining the post-reform growth process in India have not been adequately analysed in the literature. In a recent study, Basu and Das (2017) analyse the household expenditure data to find a link between demand pattern and service sector growth in India. They suggest that the rise in share of service expenditure for the bottom 75 percent of the expenditure distribution during the post-reform period could be explained by increased dependence on private provisioning of various services which were publically provided previously. In absence of extensive empirical evidence in this area they suggest further research on this link between post-reform service-led growth in India and consumption demand pattern.

The findings of this paper also indicate a complex process through which income inequality may be connected to the production structure underlying the recent growth pattern in India. First, the distribution of value added between aggregate manufacturing and service sectors remained highly uneven as compared to their employment shares in the economy. At the same time the economic gains from technologically-intensive sectors within services have been found to be much higher than the rest of the sub-sectors indicating high distributional inequality within services itself. These advanced services neither witnessed an increased manufacturing dependence on them nor were they leading services in stimulating output and employment indirectly in other sectors. Second, a rapid rise in share of services in private consumption expenditure seems to be a reflection of an evolving consumption pattern possibly linked with income inequality as such a rise does not seem to be commensurate with the level of India's per-capita income. This inequality in income and consumption in turn possibly feeds back into the production structure to create a self-reinforcing pattern. The results from this paper are strongly suggestive of such a process at work but a definitive demonstration of the same with adequate understanding of the causal channels will require further research.

5. APPENDIX

1. Appendix A

Table A1

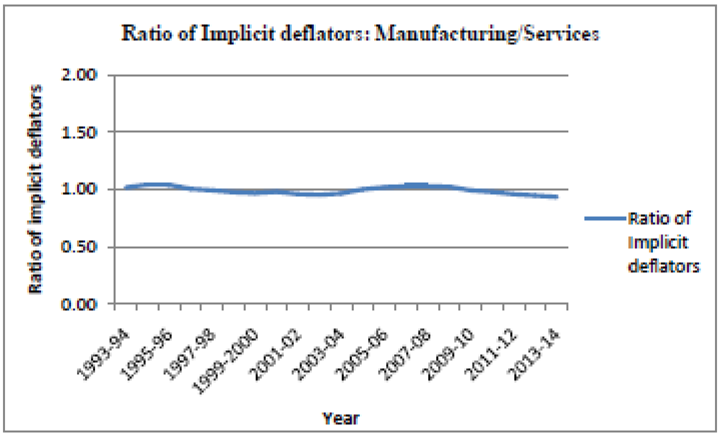
Ratio of Implicit deflators

(Manufacturing/Services) at 2004-05 prices

Year	*Ratio of Implicit deflators(Manufacturing/Services)*
1993-94	1.02
1994-95	1.04
1995-96	1.04
1996-97	1.00
1997-98	0.99
1998-99	0.97
1999-2000	0.97
2000-01	0.98
2001-02	0.96
2002-03	0.95
2003-04	0.96
2004-05	1.00
2005-06	1.02
2006-07	1.03
2007-08	1.03
2008-09	1.02
2009-10	0.99
2010-11	0.98
2011-12	0.96
2012-13	0.95
2013-14	0.93

Source: Author's calculation using NAS back series 2011, and NAS 2017, CSO, GOI

Figure A1



Source: Same as Table A1

2. Appendix B

Production and demand linkages:

Park (1987) defines the dependence of a sector (downstream sector) on other sectors (upstream sectors) based on the input cost share of upstream sectors in the total input cost of the downstream sector. This can be obtained from the following mathematical expression:

$$P_{ij} = \frac{A_{ij}}{\sum_{i=1}^{n} A_{ij}}$$

Where Pij represents production linkage/dependence of jth sector on the ith sector; Aij is the value of ith sector output used as input in jth sector and $\sum_{i=1}^{n} A_{ij}$ represents the sum of values of inputs used in the production of jth sector's output in an economy with n number of sectors. Since dependence here is based on dependence on inputs for production, we can call it production linkage/dependence.

A sector is not only dependent on other sectors in terms of production but also in terms of demand for its output. Therefore, similarly we can also compute intermediate demand linkage/dependence as follows:

$$D_{ij} = \frac{A_{ij}}{\sum_{j=1}^{n} A_{ij}}$$

Where Dij represents linkage/dependence of ith sector on the jth sector for intermediate demand; Aij is the value of ith sector output used as input in jth sector and $\sum_{j=1}^{n} A_{ij}$ represents the sum of value of total intermediate demand of ith sector.

3. Appendix C

Backward linkages:

Mathematically in an Input-Output framework backward linkages (direct plus indirect backward linkages between sectors i.e. total intermediate demand and final demand generated for an upstream sector- input producing sector in response to a unit of final demand generated in the downstream sector-input using sector) are expressed in the following manner[18]:

$AX + F = X \rightarrow (1)$

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}; F = \begin{matrix} F_1 \\ \vdots \\ F_n \end{matrix}; X = \begin{matrix} X_1 \\ \vdots \\ X_n \end{matrix}; \; a_{ij} = \frac{A_{ij}}{X_j}$$

$F = (I - A)X \rightarrow (2)$

$(I - A)^{-1}F = X \rightarrow (3)$

[18] For a discussion on the methodology of computing backward linkages see Jones (1976) and Miller &Blair (2009).

$$B = (I - A)^{-1}; B = \begin{pmatrix} b_{12} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nn} \end{pmatrix}$$

Here X is the column vector of gross outputs of n sectors in an economy and column vector F represents the final demand for each sector in the economy. Matrix A is also known as the coefficient matrix, where each aij represents the ith sector output used as input in the jth sector as a fraction of jth sector gross output. Matrix A is the basic matrix to understand inter-sectoral relationships in an economy in the Input-Output framework. The matrix of our concern at the moment is matrix B also known as the Leontief inverse, where each bij represents the demand generated for the ith sector output as a fraction of Fj or a unit of final demand in the jth sector. Higher values of bij represent stronger backward linkage of jth sector with the ith sector. The relative integration of a sector within the economy based on its backward linkages with all the sectors in the economy is computed as follows:

$$B_j = \sum_{i=1}^{n} b_{ij}$$

Where, Bj represents the column sum of jth column in matrix B. This is nothing but the total backward linkage of jth sector with all the other sectors in the economy. Using this technique, we try to find out the inter-sectoral integration of manufacturing and service sectors with the other sectors in the economy.

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Deutschlands "Basar-Ökonomie" nach der Finanz- und Wirtschaftskrise

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Abstract: Mit dem Wandel der internationalen Arbeitsteilung hin zur vertikalen Spezialisierung der Produktion wird die nationale Produktion von Exportgütern zunehmend von Importen durchdrungen und die einheimische Wertschöpfung ausgedünnt. So erhöhte sich der Importgehalt der deutschen Exporte seit den Neunzigerjahren von gut einem Viertel auf über 40 % im Vorfeld der Finanz- und Wirtschaftskrise 2008/2009. Dieser Anstieg wurde zwar von einer überaus kräftigen Dynamik der Wiederausfuhr importierter Güter (Re-Exporte) überzeichnet, er signalisierte aber auch den zunehmenden Einsatz von importierten Vorleistungsgütern in der nationalen Exportgüterproduktion. Der so abgegrenzte Importgehalt erhöhte sich allerdings weniger dramatisch, von reichlich einem Fünftel auf knapp 30 % der heimischen Exportgüter bis zum Jahr 2008.

Der zunehmende Importgehalt der Exporte wurde in Deutschland zu Beginn des 21. Jahrhunderts in einer öffentlichen Debatte als Weg in eine "Basar-Ökonomie" gedeutet: Der Exportweltmeister verlöre seine Bedeutung als Produktionsstandort und konzentriere sich zunehmend auf die Distribution von Gütern, also den Handel, Transport und die Kommunikation (Sinn 2003). In einer kontrovers geführten Debatte wurde die "Basar-These" verworfen und die steigende Importdurchdringung als Nutzung der Vorteile der internationalen Arbeitsteilung durch die deutschen Unternehmen interpretiert (Sachverständigenrat 2004 u. a.).

Die Finanz- und Wirtschaftskrise 2008/2009 traf die deutsche Wirtschaft infolge ihrer beträchtlichen Abhängigkeit von den Weltmärkten besonders stark über den Außenhandelskanal. Hier stellte sich die Frage, inwieweit der Exportschock und seine Überwindung Einfluss auf den Importgehalt der deutschen Exporte ausgeübt haben. Wir untersuchen das Problem mit dem offenen statischen Leontief Input-Output-Mengenmodell und verwenden die deutschen Input-Output-Tabellen für die Jahre 2008 bis 2013 als Datenbasis. Wir präsentieren den Einfluss des Exportschocks über den Güter- und den Einkommenskreislauf auf die Wertschöpfung und die Beschäftigung in Deutschland, saldiert mit dem veränderten Importgehalt der Exporte.

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Inter-country comparison of carbon footprint with purchasing price index adjustment

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Abstract: Measuring the impact of economic activities in units of carbon dioxide emissions (carbon footprint) is essential information to frame policies addressing the responsibility and behaviour of economic agents towards global warming. Recent analyses based on the OECD's Inter-Country Input-Output (ICIO) database have contributed to provide estimates of country and sector-specific CO2 emissions embodied in domestic and foreign final demand for numerous economies. Such estimations have already improved our understanding on the distribution of CO2 emissions along global value chains. However, these CO2 analyses based on input-output tables in nominal monetary value are heavily biased due to considerable price differences across countries on the one hand, and differences in the electricity generation mix of countries on the other hand. In this paper, we compute CO2 emissions intensity of the final demand adjusted by consumption price differences for the 35 OECD members and major non-OECD economies. Our results show that adjusting CO2 intensity by purchasing price parity (PPP) substantially affects the countries' ranking according to their demand-driven CO2 intensity. Taking a closer look at sectoral results, we observe a particularly high difference in the ranking for the food, construction and transportation sectors. High differences between adjusted and non-adjusted final demand prices for the above-mentioned sectors may be attributable to labour-intensive production structures.