Chapter 4
Importance of Industrial Clusters and Inter-industry Linkages for Regional Policy in the Gauteng City-Region

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4.1 Introduction

Economic clusters are groups of strongly interdependent firms and/or organizations that are spatially concentrated, are somehow related, and impact one another as a result of their complementarities or similarities. Due to the nature of their interdependent relationships within their respective clusters, growth (or decline) in one firm creates a better (or worse) business environment for the others in the group, meaning that, the whole is greater than the sum of its parts (Porter 2000; Economics Center 2004). Cortright, notes that clusters encompass:

> linked industries and other entities, such as suppliers of specialized inputs, machinery services, and specialized infrastructure; distribution channels and customers, manufacturers of complementary products, and companies related to skills, technologies, or common inputs; and related institutions such as research organizations, universities, standard-setting organizations, training entities, and others. (2006, p. 3, citing Porter (1998), a leading mind in global cluster phenomena. See also Rosenfeld 1997; Martin and Sunley 2003)

The spatial interdependence and proximity of firms and/or organizations ensures the achievement of agglomeration economies. Firms benefit from agglomeration economies by being able to depend on shared knowledge of technology and other strategies 'in the air'; a certain type of economic infrastructure or environment with information and knowledge; accessible technology; adequate financing; or an acceptable business climate (Marshall 1890; Economics Center 2004). With

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inherent critical mass, clusters of firms create economic efficiencies (such as costs reduction, and creation of better products) and reduce the risk for startups. In turn, this enhances growth and expertise in the cluster, ultimately leading to higher rates of technological change and innovation (Porter 2000; Pisa et al. 2015).

The wider Gauteng City-Region (GCR) is South Africa's largest economic agglomeration and its economic footprint extends beyond the borders of Gauteng into the neighbouring provinces of Free State, Mpumalanga and North West. Its core, Gauteng province, which consists of three metropolitan and seven local municipalities (see Fig. 1.2), alone contributes 34.73% of national gross value added (GVA), while the wider GCR accounts for 43.25% of national GVA (EasyData 2016). With a specialized economy that is focused on the manufacturing (contributing 16% to regional GVA) and services sectors (contributing 75% to regional GVA) (EasyData 2016), identifying the clusters that are the building blocks of the regional economy is crucial. Understanding the prevailing structure of the regional economy, through the identification of forward and backward linkages inherent in the different clusters, is important for several reasons including the need to diversify economic activity, sustainably enhance competitiveness in the city-region (Pisa et al. 2015), and provide a background to regional economic growth discussions and/or theorizing (Robinson 2002; Economics Center 2004).

After this Introduction (Sect. 4.1), Sect. 4.2 of this chapter explores the industrial cluster phenomenon, specifically its antecedents and its role in development policy. Section 4.3 reviews government industrial cluster policies that are relevant to Gauteng province, and Sect. 4.4 focuses on methodology and data frameworks. Section 4.5 focuses on the identification and structural path analysis of the key industrial clusters in Gauteng, and Sect. 4.6 draws conclusions and suggests policy options.

4.2 The Industrial Cluster Phenomenon

4.2.1 The Antecedents of the Industrial Cluster Phenomenon

The study of the industrial cluster phenomenon can be traced back to Marshall's (1890) work relating to industrial districts in nineteenth-century England. Vom Hofe and Chen (2006) provide a comprehensive review of the cluster phenomenon in terms of theory, concepts, analytical methods, and empirical cluster studies. While acknowledging the prominence of the industrial cluster phenomenon, Vom Hofe and Chen decry, however, the lack of consensus "among ED practitioners and academicians alike on proper cluster definitions, appropriate cluster identification methodologies, and their translation into cluster-based economic development policies" (2006, p. 3). They cite Doeringer and Terkla (1995), Rosenfeld (1997) and others to show that prevailing methods are insufficient individually or in combination to help in the actual identification of clusters.

From his extensive work in the industrial districts of England during the 1890s, Marshall (1890) identified three agglomeration economies: knowledge spillovers among firms; labour market pooling; and sharing of industry-specific non-traded inputs. Later, Hoover (1948) introduced three types of agglomeration economies: economies of localization, economies of urbanization, and internal returns to scale. Economies of localization, that is, benefits accruing to a firm from the presence of other firms in the same industry, in the same area, are synonymous with Marshall's three external sources of agglomeration. Economies of urbanization accrue to a firm from to its mere geographical proximity to several other industries, often in a large, diverse metropolitan economy. Unlike the two previous agglomeration economies that are external to firms, the third type, internal returns to scale, are internal, location-specific and accrue to a firm from the existence of large and specialized factors of production (Vom Hofe and Chen 2006; Jofre-Monseny et al. 2012, 2014; Glaeser et al. 1991; Hoover 1948; Krugman 1991).

From the theoretical foundations described above, Vom Hofe and Chen (2006) observe that economic development theories that focused on the spatial co-location of firms mushroomed in the 1950s and 1960s. The full list of such theories is too long to review here, but some of the most important are: Perroux's (1950) growth pole/development pole theory, which focused on innovations and investments that are the driving forces behind industrial development; Myrdal's (1957) core–periphery model, which addressed spatial concentrations of economic activities, and how sustained economic growth may lead to geographic dualism in economic activities; and Vernon's (1966) product-cycle theory, which argued that the location of firms is influenced by a combination of market demand, technology change, and labour costs. Also worth mentioning is the work of Isard et al. (1956), who fused locational analysis with input–output analysis and showed the possibility of "quantifying the cost advantage of combining a region's industrial activities characterized by intensive forward and backward input–output linkages" (Vom Hofe and Chen 2006, pp. 6–7). Overall, there are distinguishable cluster concepts/definitions that are used in development discourse (Vom Hofe and Chen 2006, pp. 8–9):

- Industrial clusters, following the theoretical principles of localization economies based on Marshall's (1890) work (related to the work of Rosenfeld 1995; Swann and Prevezer 1996; Schmitz and Nadvi 1999).
- Industrial cluster definitions, derived mainly from inter-industry relationships found in input–output tables (related to the work of Czamanski (1974); Czamanski and Ablas (1979), Roepke et al. (1974), O'Huallachain (1984), Redman (1994), Bergman and Feser (1999), Feser and Bergman 2000).
- Industrial cluster concepts, encompassing the widest spectrum of arguments explaining why establishments group in geographic proximity, including economies of localization and urbanization, internal returns to scale, value chain linkage, and technology innovation, among others (related mainly to the work of Porter 1990, 1998).

More recently, the mid-1980s saw a resurgence of the phenomenon following several studies of networks of globally competitive small businesses in Italy, and studies of the industrial structure of developed nations and the world's leading industries, with the latter being published in Porter's (1990) *Competitive Advantage of Nations.* This was followed by an avalanche of other cluster studies (see Cortright 2006; Vom Hofe and Chen 2006).

4.2.2 Industrial Clusters in Development Policy

Despite the confusion prevailing in the cluster concepts and methods discourses, it is widely agreed in policy-making that the role of industrial cluster analysis in economic development strategies is indispensable. Cluster analysis is useful for guiding economic growth and development as it helps economic development specialists monitor and understand structural economic change and take appropriate new approaches and actions for the benefit of their communities, with competitive advantage in mind (Porter 1990). In market-oriented economies, where clusters are supposedly expected to grow organically, empirical analysis of local/regional economies through cluster analysis is still helpful to development specialists in providing proactive, appropriate actions, such as in identifying targets where there is a need for workforce development (e.g., recruitment and retention) and for investment in business supportive strategies (such as infrastructures, etc.). Cluster analysis also provides a background to regional economic growth discussions and/or theorizing (Robinson 2002; Economics Center 2004).

With evident disagreement about the definition of what a cluster is and how that translates to policy prescription (see, for example, Martin and Sunley 2003), Feser states that specific "policies differ based on varying definitions of clusters, possible levels of analysis, and degree to which clustering constitutes the central focus" (1998, p. 2). He uses the definitional typologies of Boekholt (1997) and Roelandt et al. (1997), and his own adaptation of the work of DeBresson and Hu (1997) and Kirkpatrick and Gavaghan (1996) on environmental technologies, to show that different definitions of clusters imply different development strategies. Feser (1998, p. 3) notes that Boekholt's (1997) typology of clusters is based on how such policies define:

> 1) the types of collaborative links among cluster firms (e.g., simple buyer–supplier relations versus knowledge/technology transfer); 2) the types of constituent firms and actors included in the cluster (e.g., firms only or firms and supporting institutions); 3) the appropriate level of aggregation (e.g., micro versus macro); 4) the position of firms in the value chain (i.e., horizontal, vertical, or lateral); 5) the appropriate spatial level of intervention (local, regional, national, international); and 6) the specific policy mechanisms employed (general business assistance, network brokering, technology transfer, information provision, and so on).

The typology of Roelandt et al. (1997), according to Feser (1998), is a value-chain approach based on the level of analysis. Depending on whether it is national (macro), branch or industry (meso), or firm (micro), the cluster concept and focus of analysis differs accordingly. Feser (1998) also notes that, beyond the typologies of Boekholt (1997) and Roelandt, et al. (1997), industrial cluster-related policy applications can be seen in terms of cluster-specific strategies and cluster-informed strategies. He differentiates between the two types of strategies, stating that under a cluster-specific policy approach, the objective is to encourage the emergence or development of a distinct, identified cluster, while the main policy objective of cluster-informed strategies is the improved implementation of individual (or isolated) development initiatives.

An important conclusion is that cluster initiatives aim for the improvement of the business environment as a pre-requisite for collective benefits by all cluster-related industries, whereas industrial policy initiatives, often sectoral, posit that some industries are more beneficial, thus the role of the government should be in fostering these industries through subsidies and other policies that, by design, distort competition in their favour (Porter 2001).

4.3 Government Industrial Cluster Policy in Gauteng

On its website, the national Department of Trade and Industry (DTI) indicates several policies that aim to enhance industrial development in South Africa. These incentives focus on specific sectors and programmes (SMME development, trade export and investment, industrial development across several sectors) as well as specific population groups (i.e., women empowerment and black entrepreneurs) (DTI 2017).

A few policies focus specifically on cluster development: the Clothing and Textile Competitiveness Programme (CTCP) and the Cluster Development Programme (CDP). The CTCIP (divided into the Improvement Programme (CTCIP) and the Production Incentive (PI))—administered by the Industrial Development Corporation (IDC) on behalf of the DTI—aims to "improve the global competitiveness of South African-based clothing, textile, footwear, leather and leather goods manufacturers and designers in the related sectors" (DTI 2013). In the process, South African clothing and related sectors build capacity to compete and afford access to both local and international value chains.

The CTCIP provides 65% grants to individual companies and 75% grants to company clusters. The PI provides grants pegged at 7.5% of individual company manufacturing value addition. The CTCP identifies four elements necessary for ensuring cluster development:

- A network of different types of member companies and/or organisations. These member companies and/or organisations should preferably include private companies, public organisations and academic/research institutions.
- An independent cluster organisation (CO) with a separate office and identity, cluster administrator/facilitator/manager, a website, etc.

- Governance of the initiative (e.g., the formation of a cluster board/management committee).
- Financing of the initiative (international/national/regional/local public funding, member fees, consulting fees) (DTI 2013, p. 7).

The CDP is intended to promote industrialization, sustainable economic growth and job creation in South Africa through cluster development and industrial parks. The DTI (2017) notes that an eligible cluster should have five or more businesses that are registered tax-paying entities or non-profit organizations. In addition, in the first year (i.e., the pilot stage), at least 20% of the membership of the cluster should be entities with 51% black-ownership. In the case of industrial parks, the majority of tenants must be supply-based firms or involved in manufacturing. Such industrial parks should be located in areas where there are high levels of unemployment (e.g., townships or rural areas). The CDP's incentives include a shared-infrastructure grant, business development grant, and cluster management organization funding.

Table 4.1 gives a summary of most of the other policies and/or programmes in terms of sector or population group covered, kinds of conditional incentives, and implementing agency. Apart from the CTCP and CDP discussed above, the end game of many of these policies is to improve productivity, to create and/or sustain employment, encourage spatial development, and broaden participation of all population groups, among other objectives, rather than cluster development per se. The review focuses mainly on industrial development incentives. However, it is worth noting that most of these policies serve broader purposes, for example, some policies that are primarily industrial development incentives, also focus on black and women empowerment.[1]

Since Gauteng is the economic heartland of the country, most of these policies apply to this region. It is worth mentioning, though, that these policies are insufficient in fostering any meaningful cluster-related competitiveness. As is evident below, the clusters (see Sect. 4.5) that are the key building blocks of the regional economy have no cluster policies specifically targeting them. Industrial development in Gauteng is the responsibility of the Gauteng Department of Economic Development (GDED), which, in its 2014–2019 strategic plan, stated its intention to radically transform, modernize, and re-industrialize the economy of Gauteng (Gauteng Province 2015; see Chap. 5 in this volume). Under the GDED, the Gauteng Growth and Development Agency (GGDA) and the Gauteng Enterprise Propeller (GEP) are among the key agencies mandated to foster the economic development potential and competitiveness of Gauteng. The GGDA expects to "create an enabling environment for growth-targeted investment facilitation, strategic infrastructure development and social transformation, thus positioning Gauteng as a leading Global City Region" (GGDA, n.d.). The GEP provides "financial and non-financial support to Small, Medium and Micro-Enterprises (SMMEs) and Co-operatives" (GEP, n.d.).

[1]For a complete review of current DTI financial incentives, see https://www.thedti.gov.za/financial_assistance/financial_assistance.

Table 4.1 Summary of cluster-related policies and/or programmes in Gauteng

Policy/program type	Objectives and sectors/population group	Year started	Kind of incentive/s	Implementing agency
Aquaculture Development and Enhancement Programme (ADEP)	To stimulate investments, increase production, and broaden participation, etc. in the aquaculture development as classified under SIC code 132, 301, and 3012	2013	Reimbursable cost-sharing grant of up to a maximum of Rs 40 million on qualifying costs, including machinery and equipment and bulk infrastructure	National DTI
Business Process Services (BPS)	To support business process services firms to widen their activities beyond South African borders	2011	A two-tier incentive, based on fully-loaded cost of an offshore job created, is paid for a maximum 60 months as estimated from the day the job is created	National DTI
Manufacturing Competitiveness Enhancement Programme (MCEP)	To provide financial assistance to clusters and partnerships of companies, engineering services and conformity assessment services in the manufacturing industry	2014	Incentive amounting to 80% of the costs of the cluster up to a maximum grant of Rs 50 million per cluster. The relevant costs include *inter alia* product development costs, local and international marketing and advertising costs	National DTI/IDC
Seda Technology Programme (STP)	To provide technology transfer services to small enterprises and women-owned enterprises		Financial assistance in the form of a non-repayable grant up to a maximum of Rs 600, 000 per project	DTI

(continued)

Table 4.1 (continued)

Policy/program type	Objectives and sectors/population group	Year started	Kind of incentive/s	Implementing agency
Sector Specific Assistance Scheme (SSAS)	To support export councils, joint action groups, industry associations, etc. through reimbursable cost-sharing incentive scheme		A reimbursable cost-sharing (80:20) scheme	DTI
People-carrier Automotive Incentive Scheme (P-AIS), part of AIS	To stimulate growth of people-carrier vehicle assemblers		Non-taxable cash grant of between 20% and 35% of the value of qualifying investment in productive assets	DTI
Medium and Heavy Commercial Vehicles Automotive Investment Scheme (MHCV-AIS), part of AIS	To provide grants to medium and heavy commercial vehicle manufactures		Non-taxable cash grants of 20–25% of the value of qualifying investment in productive assets, component, and tooling by MHCV manufactures	DTI
Critical Infrastructure Programme (CIP)	To leverage investment by supporting infrastructure that is deemed to be critical, thus lowering the cost of doing business		Cost-sharing incentive (grants of 10–30%) upon completion of infrastructures deemed critical	DTI
Capital Projects Feasibility Programme (CPFP)	To support feasibility studies that are likely to lead to high-impact projects that will stimulate value-adding economic activities		Grants capped at Rs 8 million, with maximum 50 and 55% of total costs of projects done, domestic and internationally, respectively	DTI

(continued)

Table 4.1 (continued)

Policy/program type	Objectives and sectors/population group	Year started	Kind of incentive/s	Implementing agency
Support Programme for Industrial Innovation (SPII)	To provide financial assistance for the development of innovative products and/or processes		Limited to Rs 2 million, funds qualifying costs incurred depending on level of BEE ownership: 0–25% gets 50%, 25.1–50% gets 75%, and >50% gets 85% of qualifying costs	DTI

Source https://www.thedti.gov.za/financial_assistance/financial_incentives)

4.4 Methodology and Data Framework

4.4.1 The Social Accounting Framework

The approach we propose in this chapter involves identifying inter-industry linkages, based on the work of Pyatt and Round (1979), Defourny and Thorbecke (1984), and Stone (1985). Building a multiplicative decomposition model from a social accounting matrix (SAM) for the Gauteng region allows evaluation of the strength of inter-industry linkages, which is then the basis for grouping those industries that have strong buying and selling relationships together. The Gauteng SAM maps all economic transactions for the Gauteng region for a specific period of time. It is well suited for our purposes as it represents a snapshot of the Gauteng economy for one year. Like an input–output table, the rows in a SAM depict inflows of money (i.e., income) and the columns depict outflows of money (i.e., expenditure). The major advantage of SAMs over input–output tables is the inclusion of socio-economic transactions, making them a more complete circular process of economic interdependencies. A simplified schematic of the organization of the Gauteng SAM used for this study is shown below in Table 4.2 (see Keuning and Ruuter 1988; See also Annexure 4.5 for a more detailed conceptualized SAM).

The conceptual SAM shown in Table 4.2 is a comprehensive and complete dataset including all actors and markets within a socio-economic system. It is a square balanced regional accounting framework, meaning that the corresponding row and column totals are equal, a feature similar to double-entry bookkeeping systems (Adelman and Robinson 1986). Reading down the columns identifies the outlays being made by various accounts (i.e., purchases), while reading across the rows follows the flow of receipts being generated (i.e., sales). For all transactions occurring within a region, for one specific year, we can thus see which account pays what to whom. The SAM provides a complete picture of a regional economy as it

Table 4.2 Conceptual algebraic schematic of the Gauteng social accounting matrix SAM)

	Endogenous account			Exogenous account			Totals
	Production	Factors	Private institutions	Government	Capital	Rest of the world	
Endogenous							
Production	T_{11}	0	T_{13}	X_{14}	X_{15}	X_{16}	Y_1
Factors	T_{21}	0	0	X_{24}	X_{25}	X_{26}	Y_2
Private institution	0	T_{32}	T_{33}	X_{34}	X_{35}	X_{36}	Y_3
Exogenous							
Government	L_{41}	L_{42}	L_{43}	t_{44}	t_{45}	t_{46}	Y_4
Capital	L_{51}	L_{52}	L_{53}	t_{54}	t_{55}	t_{56}	Y_5
Rest of the world	L_{61}	L_{62}	L_{63}	t_{64}	t_{65}	t_{66}	Y_6
Totals	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	

Notes T_{ij} refers to a matrix, while t_{ij} refers to single, highly aggregated exogenous accounts, that is, government, capital, and Rest of world

includes inter-industry transactions (T_{11}), the core of every input–output table. The endogenous accounts further map the accruement of value added by the production accounts (T_{21}), and the distribution of these value added payments among the private institutions (T_{32}), namely households and enterprises, the owners of the factors of production. Following the flow of income and expenditures through the system, the SAM also maps how private institutions spend their received income buying goods and services (T_{13}), and the private inter-institutional transfers (T_{33}) (Thorbecke and Jung 1996).[2] A simplified graph of the main interrelationships among the principal SAM accounts is shown in Fig. 4.1.

Traditional input–output analysis focus mainly on production activities (T_{11}) (Fig. 4.1). Accordingly, the input–output multiplier analysis evaluates direct and indirect changes in the economic system stemming from exogenous injections originating in the final demand sector. Usually, the exogenous final demand sector in input–output analysis consists of institutions, including households, governments, and enterprises, as well as capital and trade accounts. Alternatively, some input–output analyses also treat households endogenously, which is sometimes labelled a Type II multiplier framework, where the additional impact resulting from the inclusion of households is termed 'induced effects' (Wang and Vom Hofe 2007). One important consideration when working with social accounting frameworks is defining which individual accounts are treated endogenously and as such are included in the derivation of social accounting matrix multipliers. Here, Thorbecke and Jung (2000) recommends treating the producing sectors, the factors

[2]Adjusted to reflect the organization of the 2006 Gauteng Social Accounting Matrix. Source: Thorbecke and Jung (1996).

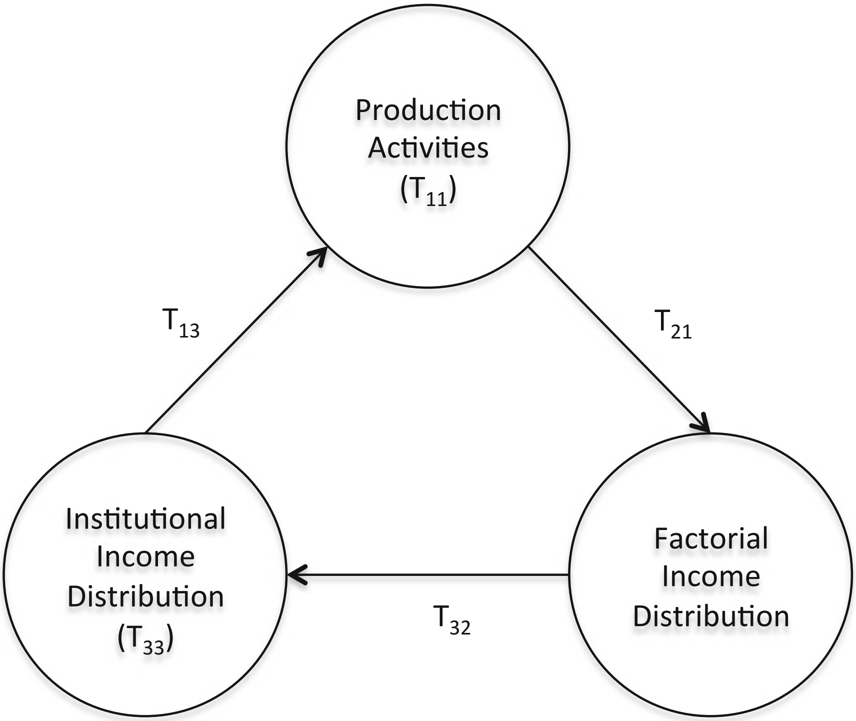

Fig. 4.1 Simplified interrelationships among SAM accounts

of production (land, labour, and capital), as well as all private institutions (household and enterprises) as endogenous, as is shown in Table 4.2. It is a common practice in SAM-based multiplier analysis to treat the government, the capital account, and the rest of the world, exogenously.

In Table 4.2, transactions within the endogenous accounts are labelled T_{11} to T_{33}. The policy variables, X_{14} to X_{36} are the exogenous injections from government, capital, and exports account, into production, factors of production, and households respectively. These exogenous injections through final demand constitute the potential policies that can be evaluated in a SAM-based multiplier framework, such as government spending and transfer (welfare and poverty alleviation) policies, industrial policies, and others. Leakages, and moneys leaving the region, from industries, factors, and private institutions, are accordingly denoted by L_{41} to L_{63}. Inter-institutional transactions among the exogenous accounts are labelled t_{44} to t_{66}, and finally, Y_1 to Y_6 refer to both total expenditures (the column totals) and total incomes (the row totals). As with any economic model, its strengths and weaknesses are embedded in its main assumptions, which are: (1) the economy is totally demand-driven and there exist no supply constraints for firms and businesses, meaning that each industry has enough excess production capacity to meet any increase in final demand; (2) prices are constant, not subject to change, making the SAM-based multiplier model a 'fixed price' model; and (3) the underlying production function is linear, based on fixed input coefficients, and exhibits constant returns to scale. The direct implication of fixed input coefficients is the absence of substitutability between inputs of production, implying that an industry's input requirements always change proportionally with an increase in output (Wang and Vom Hofe 2007).

4.4.2 The 2006 Gauteng Social Accounting Framework

We must emphasize that, given their heavy data requirements, social accounting matrices are not produced on a regular basis. This study uses the 2006 SAM for Gauteng province, the most recent version available, although we recognize that it is more than 10 years old. Importantly, the structure of the provincial Gauteng economy has remained relatively unchanged since 2006. The 2006 Gauteng SAM (Conningarth Economists 2006) provides a detailed socioeconomic picture of the province. It includes 37 activities (read industries) as well as an equal number of commodities. The factor payments account distinguishes between 44 different types of labour payments (i.e. 11 Africans, 11 Coloureds, 11 Asians/Indians, and 11 Whites) and 4 different capital payments. The private institutions account is subdivided into 4 enterprise sectors and 48 separate household groups. The exogenous account in the Gauteng SAM has 7 government sectors, 2 capital sectors, 4 sectors for Gauteng's trade with the rest of South Africa and another 4 for its trade activities with the rest of the world. It is worth noting that the production account distinguishes explicitly between activities and commodities. Originally introduced by the United Nations in its 1968 *System of National Accounts* (United Nations 1968), the so-called make–use framework provides a better description of real-world economies as one industry can produce more than one commodity.[3] Regardless, for analytical purposes, the symmetric Leontief model, in which each industry only produces one homogenous commodity, is preferred for analyzing structural changes or industrial linkages (Guo et al. 2002).

4.4.3 The Social Accounting Multipliers

As in Leontief input–output analysis, the social accounting framework lends itself to economic impact analysis aimed at examining exogenous stimuli to the regional economic system. It is one way of measuring economy-wide changes in selected

[3]The 'use' matrix represents intermediate parts—commodity inputs by industries. The 'make' matrix maps industries producing commodities—industries by commodities.

endogenous variables, such as output, and household income, following an exogenous impulse in a selected sector. It can be the case that final demand for a sector's products increases as a result of increases in government spending or exports. An advantage of the SAM framework is that it includes the factorial income distribution and its translation to the distribution of incomes across the endogenous institutions, namely households and enterprises. Accordingly, following an exogenous injection, as mentioned, SAM multipliers are well suited for mapping detailed changes in factorial income and institutional incomes. More specifically, exogenous changes (the x_i's in Table 4.3) determine, through their interaction with the endogenous accounts in the SAM matrix, the incomes of the production activities (vector y_1), the factor incomes (y_2), and the household and enterprise incomes (y_3) (Thorbecke and Jung 2000).

Based on the aforementioned logic, we prepared the SAM by aggregating all exogenous accounts (i.e., government, capital, and rest of the world) into one aggregated exogenous account. In the next step, we follow Thorbecke and Jung (2000) and define the total receipts of all endogenous accounts as a set of linear equations:

$$y_1 = T_{11} + T_{13} + x_1 \tag{4.1}$$

$$y_2 = T_{21} + x_2 \tag{4.2}$$

$$y_3 = T_{32} + T_{33} + x_3 \tag{4.3}$$

Replacing the endogenous transactions T_{ij} by their corresponding average expenditure propensities, where $A_{ij} = T_{ij}\left(y_j\right)^{-1}$, we rewrite the linear system as:

$$y_1 = A_{11}y_1 + A_{13}y_3 + x_1 \tag{4.4}$$

$$y_2 = A_{21}y_1 + x_2 \tag{4.5}$$

$$y_3 = A_{32}y_2 + A_{33}y_3 + x_3 \tag{4.6}$$

Table 4.3 Simplified conceptual algebraic schematic of the Gauteng SAM

	Endogenous account			Exogenous account	Totals
	Production	Factors	Private istitutions		
Endogenous account					
Production	T_{11}	0	T_{13}	X_1	Y_1
Factors	T_{21}	0	0	X_2	Y_2
Private institutions	0	T_{32}	T_{33}	X_3	Y_3
Exogenous account	l'_1	l'_2	l'_3	X_4	Y_4
Totals	Y'_1	Y'_2	Y'_3	Y'_4	

In the last step, solving the linear system for y, we obtain:

$$y_1 = (I - A_{11})^{-1}x_1 + (I - A_{11})^{-1}A_{13}y_3 \quad (4.7)$$

$$y_2 = x_2 + A_{21}y_1 \quad (4.8)$$

$$y_3 = (I - A_{33})^{-1}x_3 + (I - A_{33})^{-1}A_{32}y_2 \quad (4.9)$$

Equations 4.7 to 4.9 explain the operation of the multiplier process and the interactions between the production account, the factor incomes, and the endogenous institutional incomes, namely, households and enterprises. Assuming an increase in government, capital, or export demand (x_1) due to an exogenous shock, output of the corresponding production activities change by $(I - A_{11})^{-1}x_1$. In turn, an increase in production activities requires new additional value added, $A_{21}y_1$, constituting new factor income. Potential exogenous factor income received either from the government or from the rest of the world is included in x_2.

Equation 4.9 maps the distribution of newly generated factorial income (y_2) among the endogenous institutions, $(I - A_{33})^{-1}A_{32}$, according to their resource endowment (A_{32}) and inter-institutional transfers (A_{33}). Newly generated government subsidies and transfer payments and remittances from other regions and abroad, that is, $(I - A_{33})^{-1}x_3$, are the second source of new household and enterprise income. Lastly, we close the loop of interrelated endogenous SAM transactions by mapping how newly generated household and enterprise income (y_3) translates into new production activities, that is, $(I - A_{11})^{-1}A_{13}$.

Modifying Fig. 4.1, the multiplier effects among all endogenous accounts is represented in Fig. 4.2.

Summarizing Eqs. 4.7 to 4.9, the SAM multiplier model can be expressed as:

$$y = (I - A_n)^{-1}x = M_a x \quad (4.10)$$

where $M_a = (I - A_n)^{-1}$ represents the matrix with the SAM multipliers, also referred to as the accounting multiplier matrix. Despite its computational simplicity, Defourny and Thorbecke (1984) emphasize that the accounting multiplier matrix, M_a, implies unitary income elasticities and consequently, the average expenditure propensities apply to any exogenous injection. To address this shortcoming, scholars (Defourny and Thorbecke (1984) and Kahn (1999), among others) propose the use of a matrix of marginal expenditure propensities, C_n, where the C_n matrix is partitioned in the same way as the A_n matrix. Changes in income (dy) resulting from changes in exogenous shocks (dx) are then derived as:

$$dy = (I - C_n)^{-1}dx = M_c dx \quad (4.11)$$

where M_c is now called the fixed price multiplier matrix. The advantage here is that it avoids the somewhat unrealistic assumption of exploring the macro-economic

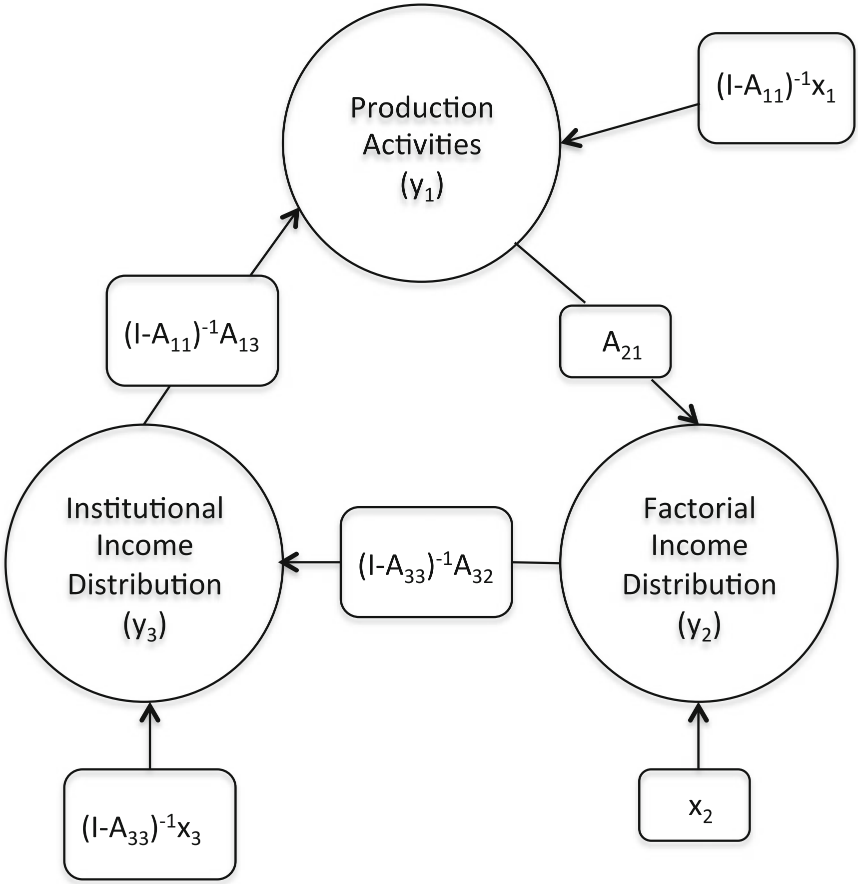

Fig. 4.2 Multiplier process among endogenous SAM accounts. *Source* Modified from Thorbecke and Jung (2000)

effects of exogenous changes when consumers react to any given proportional change in their incomes by increasing expenditure on the different commodities by exactly the same proportion (Kahn 1999). In other words, new consumer spending is not bound by average expenditure propensities (AEP_i), allowing for a wide range of marginal expenditure propensities (MEP_i).

Decomposing the multiplier matrix M_a into three multiplicative components M_1, M_2, M_3, following Pyatt and Round (1979), Defourny and Thorbecke (1984), and Round(2003a, b), adds some additional and useful insights to the socio-economic linkages on how exogenous shocks are transmitted through national or regional economies. For a better interpretation, this multiplicative decomposition can be expressed as four additive components:

$$M_a = I + (M_1 - I) + (M_2 - I)M_1 + (M_3 - I)M_2M_1 \tag{4.12a}$$

$$M_a = I + T + O + C \tag{4.12b}$$

where:

I Initial injections
T Net contribution of the transfer multiplier effects
O Net contribution of the open-loop or cross-multiplier effects
C Net contribution of the circular closed-loop multiplier effects.

The transfer multiplier effects, T, result from direct endogenous transfer within the corresponding accounts. In the SAM this includes the multiplier effects of inter-industry transfers, (A_{11}), and inter-institutional transfers among households and enterprises, (A_{33}), where the multiplier effects of inter-industry transfers are the well-known Leontief input–output multipliers. The open-loop effects capture the interactions among and between the endogenous accounts (A_{13}, A_{21}, A_{32}). Accounting for the interconnectivity of the endogenous accounts, it is the part of the global-multiplier effects that shows how an exogenous injection into one sector (i) of one account is transmitted to the other endogenous accounts via the flow of incomes. The closed-loop effects complete the circular flow of income among the endogenous accounts. This accounts for the feedback effect from production activities, to factors, to institutions, and then back to activities, in the form of consumption demand (Defourny and Thorbecke 1984). This represents the consequences of an exogenous injection travelling around the entire triangular system to reinforce the initial injection (Pyatt and Round 2006).

4.4.4 Structural Path Analysis (SPA)—The SAM Multiplier Decomposition Process

To increase the amount of information on how influence is transmitted within an economic system such as a social accounting matrix, Defourny and Thorbecke (1984) propose a more sophisticated approach of breaking down SAM-based multipliers (m_{ij}). The decomposition explained in the previous section is limited to explaining the total effects from exogenous injections within and between accounts. In their seminal work, Defourny and Thorbecke (1984) showed by means of structural path analysis (SPA), how to identify the network of paths along which influence is carried among and between production activities, factors and households. More specifically, they decompose the multiplier matrix (either M_a or M_c) defining three types of 'influences': (1) direct influence, I^D; (2) total influence, I^T; and (3) global influence, I^G. Multiplier decomposition and the SPA are intended to shed light upon the structural and behavioural mechanism within the economy.

They aim to identify a particular path along which an exogenous shock is transmitted.

The ***direct influence*** $I^D_{(i \to j)}$ of i on j along arc (i, j) is measured between the two poles i and j, without considering adjacent circuits. It refers to the change in income (or production activity) in j as a direct result of a unitary change in i, other poles remaining constant. Consequently, the direct influence $I^D_{(i \to j)}$ is equal to a_{ji} from the matrix of average expenditure propensities, A_n. A second case of direct influence $I^D_{(i \to j)}$ along an elementary path takes on the form $(i, \ldots, j)$. As shown in the direct influence $I^D_{(i \to j)}$ transmitted from pole i to pole j can take on the elementary path (i, m, n, j). The direct influence $I^D_{(i \to j)}$ along the elementary path (i, m, n, j) is simply the product of its individual intensities:

$$I^D_{(i \to j)} = a_{mi} a_{nm} a_{jn}, \tag{4.13}$$

the product of three average expenditure propensities constituting the elementary path Fig. 4.3 (i, m, n, j).

The ***total influence*** $I^T_{(i \to j)}$ is made up of the direct influence $I^D_{(i \to j)}$ amplified by the indirect effects, or the adjacent circuits. Adjacent circuits are formed by linking poles along an elementary path $(i, \ldots, j)$ to other poles and other paths, for instance, as shown in the paths $(y, x) or\ (y, z, x)$. While the direct influence $I^D_{(i \to j)}$ (shown in Fig. 4.3) transmits any influence in a direct and one-directional manner, adjacent circuits transmit the influence back, that is, in the opposite direction, which explains the indirect effects (i.e. the multiplier effects). The creation of loops sends the

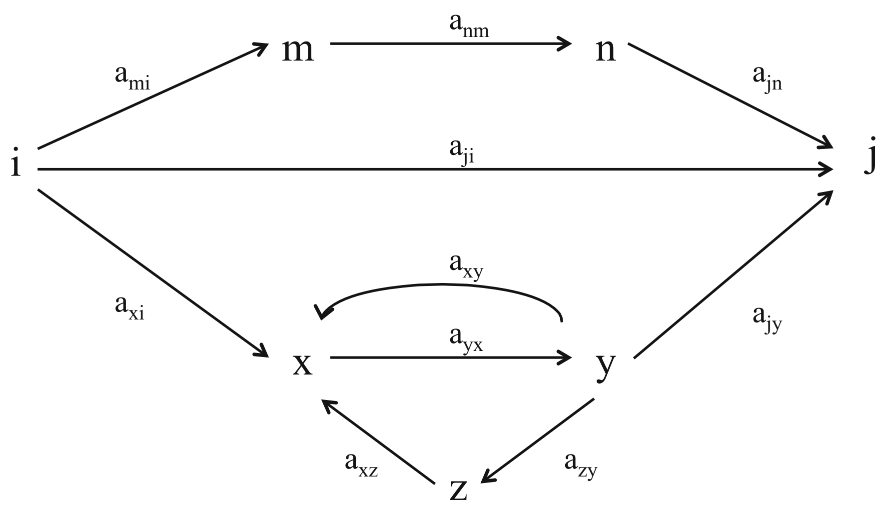

Fig. 4.3 Network of elementary paths and adjacent circuits based on Defourny and Thorbecke (1984)

transmitted influence forward and backward. The more of these loops that exist along the path $(i, \ldots, j)$, the larger the multiplier effect and therefore the larger the ***total influence*** $I^T_{(i \to j)}$ will be. Mathematically, the loop between x and y is expressed as $a_{yx}\left(a_{xy} + a_{zy}a_{xz}\right)$, where $\left(a_{xy} + a_{zy}a_{xz}\right)$ expresses the influence transmitted back from y to x via the two loops. Allowing for a series of dampened impulses between x and y, the combined multiplier effect of these two loops becomes $\left[I - \left(a_{xy} + a_{zy}a_{xz}\right)\right]^{-1}$. Finally, the total influence $I^T_{(i \to j)}$ is defined as:

$$I^T_{(i \to j)} = a_{xi}a_{yx}a_{jy}\left[I - \left(a_{xy} + a_{zy}a_{xz}\right)\right]^{-1} \tag{4.14a}$$

$$I^T_{(i \to j)} = I^D_{(i \to j)}\boldsymbol{M}_p \tag{4.14b}$$

where $\boldsymbol{M}_p$ resembles the multiplier effect along path p.

The ***global influence*** $I^G_{(i \to j)}$ is the sum of all total influences $I^T_{(i \to j)}$ from pole i to pole j. It measures the full change in income or output of pole j as a result of a unitary change in pole i. The global influence between pole i and pole j is thus equivalent to the $(j, i)^{th}$ element of the matrix of accounting multipliers $\boldsymbol{M}_a$, where $\boldsymbol{M}_a = [I - A_n]^{-1}$.

Having defined matrix $\boldsymbol{M}_a$ as the matrix of global influences, we can establish that:

$$I^G_{(i \to j)} = m_{a_{ji}} \tag{4.15}$$

And bringing everything together, we define the global influence $I^G_{(i \to j)}$ between pole i and pole j (shown in Fig. 4.3) as:

$$\begin{aligned} I^G_{(i \to j)} &= m_{a_{ji}} = I^T_{(i,m,n,j)} + I^T_{(i,j)} + I^T_{(i,x,y,j)} \\ &= a_{mi}a_{nm}a_{jn} + a_{ji} + I^D_{(i \to j)_3}\boldsymbol{M}_p \\ &= I^D_{(i \to j)_1} + I^D_{(i \to j)_2} + I^D_{(i \to j)_3}\boldsymbol{M}_p \end{aligned} \tag{4.16}$$

consisting of two direct influences $I^D_{(i \to j)_1}$ and $I^D_{(i \to j)_2}$ and one total influence $I^D_{(i \to j)_3}\boldsymbol{M}_p$.

We carried out the structural path analysis using SimSIP SAM, a Microsoft Excel-based application with MATLAB running in the background, which facilitates analyzing input–output (I-O) tables and social accounting matrices (SAM). SimSIP SAM was developed by Parra and Wodon (2009) as part of the Development Dialogue on Values and Ethics (DDVE) initiative in the Human Development Network at the World Bank.

4.4.5 Principal Component Analysis (PCA)—Identifying Potential Industrial Clusters

The use of principal component factor analysis (PCA) to identify industrial clusters has a long history in the input–output analysis literature (Czamanski 1974; Bergman and Feser 1999; Feser and Bergman 2000). As a data reduction method, PCA reduces the number of correlated variables in the dataset to a smaller number of meaningful dimensions or factors (Tinsley and Tinsley 1987). Applying PCA to an input–output matrix means reducing the number of industries to a smaller number of industrial clusters using the maximum common variance criteria between industries and clusters. Applying PCA to the original inter-industry transaction matrix identifies industrial clusters based on similarities in their buying patterns (R-mode analysis) (Roepke et al. (1974). Analogously, applying PCA to the transposed transaction table, groups industries together that have similar selling patterns (Q-mode analysis). Czamanski and Ablas (1979) introduced a method that focuses on sales and purchase linkages between industry pairs rather than on similarities in sales and purchase patterns. To capture these value-chain linkages, they proposed performing a PCA on a new matrix ***S*** that captures the correlations of input–output tables between pairs of industries. To derive this symmetric correlation matrix ***S***, we calculated the following correlations as a first step:

$Corr(\mathbf{a}_i, \mathbf{a}_j)$ Correlation between industries i and j in terms of purchase patterns
$Corr(\mathbf{b}_i, \mathbf{b}_j)$ Correlation between industries i and j in terms of sales patterns
$Corr(\mathbf{a}_i, \mathbf{b}_j)$ Correlation between the purchase pattern of i and sales pattern of j
$Corr(\mathbf{b}_i, \mathbf{a}_j)$ Correlation between the sales pattern of i and purchase pattern of j.

where:

$A = \left[a_{ij}\right] = \frac{T_{ij}}{\sum_i T_{ij}}$ The matrix of technical input coefficients: the proportions of total inputs bought by industry j from industry i

$B = \left[b_{ij}\right] = \frac{T_{ij}}{\sum_j T_{ij}}$ The matrix of output ('sales') coefficients: the proportions of industry i's sales going to industry j

In the second step, we constructed the symmetric correlation matrix ***S*** by selecting the largest of the above four correlation coefficients for each industry pair. Then we performed the PCA with Varimax rotation on this matrix ***S***. We applied the Kaiser criterion to identify the final set of industrial clusters. The Kaiser criterion, which is based on the eigenvalues of each factor, explains how much each factor contributes to the common variance. It is calculated as the sum of all squared factor loadings for a factor. We selected all factors with eigenvalues greater than 1.0 as candidate clusters. If, however, a selected factor with an eigenvalue close to 1.0 is composed of seemingly unrelated industry sectors, then it is dropped from the final pool of clusters. For better interpretability of the PCA solution, without changing the underlying mathematical principles, the initial factors are rotated using an orthogonal Varimax rotation. Once we had identified the final set of industrial clusters, we identified the individual industry sectors affiliated to each cluster, based on each industry sector's factor loading. The factor loadings represent the correlation of each sector with the cluster it belongs to. For the present study, we used a factor loading value of 0.50 as the cut-off value for identifying cluster affiliation. Strong cluster affiliation is indicated by loadings of 0.7–1.0 and median cluster affiliation by loadings of 0.5–0.7.

We chose principal component analysis on the symmetric matrix ***S*** as a suitable method for identifying and ranking/prioritizing industrial clusters over other methods such as Chenery and Watanabe's (1958) linkage measures, Beyers' (1976) key sector identification method, and the Power-of-Pull (PoP) method applied by Pisa et al. (2015), which conceptually all evaluate backwards and/or forwards linkages in the input–output matrix. However, we need to acknowledge some of the shortcomings of our chosen method. First, the received factors may vary slightly with a selected rotation method. Second, using factor loadings as the sole cluster affiliation criteria does not say anything about the importance of cluster members for regional economies. And third, while higher eigenvalues usually correspond to larger numbers of cluster members, this does not imply that clusters with higher eigenvalues are more important to regional economies.

4.5 Gauteng's Industrial Clusters

4.5.1 Principal Component Analysis (PCA)—Selected Industrial Clusters

In this section we present results and findings from the principal component analysis (PCA). As an overview, based on the PCA results, we can assign 33 of the 36 initial industry sectors to one of the six distinctive industrial clusters: Service and Trade; Food Products; Metal Products; Chemical Products and Petroleum; Building and Metal Products; and Light Manufacturing Products. Of the 36 initial industry sectors, three sectors cannot be associated with any of the six identified clusters because of factor loadings of less than 0.5. These are Gold Mining; Communication, Medical and other Electronic Equipment; and Water, which have factor loadings of 0.231, 0.266, and 0.412, respectively. A fourth industry sector, Community, Social and Personal Services has a factor loading of 0.724 with the Building and Metal Products Cluster, and a factor loading of 0.488 with the Service and Trade Cluster. Because Community, Social and Personal Services is a service sector, we decided to assign it to the Service and Trade Cluster, instead of assigning it to the Building and Metal Products Cluster.

The 33 industrial sectors that were placed in the six identified clusters (combined) contributed 4,600,900 jobs and 761,305 million Rand of GVA (Table 4.4).[4] The Service and Trade cluster with its eight industry sectors (i.e. Trade; Transport; Business Services; Real Estate; Communication; Accommodation; Insurance; Community Social and Personal Services) is the predominant industry cluster in the Gauteng region. The cluster's dominance and importance is emphasized by the fact that this cluster alone provides employment to 3,592,475 people, amounting to a total of 68.5% of the employment in the Gauteng region. Of the total employment in the identified clusters, however, 1,113,498 jobs are classified as 'informal employment' and, as such, are jobs without job and social security.[5] The combined Gross Value Added (GVA) for these eight service industries totals 538,455.7 million Rand, or 55.9% of the Gauteng region's GVA. With respect to employment, the three main industry sectors are Trade; Business Services and Real Estate; and Community, Social, and Personal Services, with 1,142,756 (21.8%), 893,364 (17%), and 846,430 (16.1%) employees respectively.[6] Note that, as indicated in Table 4.4, employment and GVA for Real Estate is included in Business Services.

Though Trade has the highest employment of any industry sector, the Business Services and Real Estate sectors are major contributors to regional economic development when considering their contribution to regional GVA. While constituting 17% of regional employment, they contribute 16.6% (159,968.1 million Rand) of the region's total GVA. In contrast, the Community, Social, and Personal Services sector, while accounting for as much as 16.1% of the region's employment, only contributes 5.3% (50,728.9 million Rand) to the region's total GVA. This can be explained partly by the fact that 28.4% (240,442) of the jobs in Community, Social, and Personal Services fall into the informal sector, compared to only 16.6% (148,348) of Business Services and Real Estate jobs. The other four service industries (i.e. Transport, Communication, Accommodation, and Insurance) account for 709,925 employees (13.5%), while contributing 202,680 million Rand (21%) annually to the Gauteng region's GVA.

Compared to the Service and Trade cluster, the remaining five industry clusters: Food Products; Metal Products; Chemical Products and Petroleum; Building and Metal Products; and Light Manufacturing Products, only play a minor role individually. Together, they account for the remaining regional employment of 1,008,425 (19.2%) and 222,849.6 of regional GVA (23.1%). Among these five industry clusters, the Building and Metal Products cluster is the second most important cluster in the Gauteng region, contributing 471,960 (9.0%) jobs and 59,522.0 million Rand (6.2%) to the region's economy. Within the Building and

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[4]The government sector and the three industrial sectors mentioned above that did not belong to any cluster contributed the difference to the regional employment of 5,248,019 jobs and regional GVA of 964,018 million Rand.

[5]Regional formal and informal employment not placed in any cluster, including in government and the three industrial sectors, is 3,832,611 and 1,415,408 jobs, respectively.

[6]Percentages in parentheses represent employment in percent of total regional employment, including formal and informal employment.

Table 4.4 Gauteng selected industrial clusters

1: Service and trade cluster	Employment (no.)	Formal /informal employment	GVA	Formal /informal compensation
Trade	1,142,756	612,463	125,078.4	61,374.0
		530,293		4601.0
Transport	279,646	149,834	57,572.4	22,331.1
		129,812		1601.4
Business Services	893,364	745,016	159,968.1	74,239.5
		148,348		4560.3
Real Estate (incl. in Business Services)	Incl. in Bus. Serv.		Incl. in Bus. Serv.	
Communication	81,302	52,428	40,208.8	15,427.6
		28,874		812.2
Accommodation	118,362	82,633	7332.7	3696.3
		35,729		316.6
Insurance	230,615	230,615	97,566.4	60,678.7
Community, social and personal services	846,430	605,988	50,728.9	38,135.2
		240,442		1216.9
Total	3,592,475	3,592,475	538,455.7	288,990.8
II: Food products sluster				
Other food products	77,056	63,873	16,185.7	13,654.3
		13,183		844.4
Dairy products	Incl. in Oth Food Pdts		Part of Other Food Pdts	
Grain mill, bakery and animal feed products	Incl. in Oth Food Pdts		Part of Other Food Pdts	

(continued)

Table 4.4 (continued)

1: Service and trade cluster	Employment (no.)	Formal /informal employment	GVA	Formal /informal compensation
Meat, fish, fruit, vegetables products	Incl. in Oth Food Pdts		Part of Other Food Pdts	
Beverages and tobacco products	Incl. in Oth Food Pdts		10,710.1	
Agriculture	70,498	62,833	3520.9	1979.9
		7665		60.8
Total	147,554	147,554	30,416.7	16,539.4
III: Metal products cluster				
Other fabricated metal products	140,965	123,338	598.4	30,166.4
		17,627		1237.7
Machinery and equipment	Incl. in Oth Met Pdts		10,918.1	
Basic metal products	Incl. in Oth Met Pdts		11,229,5	
Electrical machinery and apparatus	26,710	25,939	5598.2	7254.4
		771		648.1
Other manufacturing and recycling	26,281	14,955	10,364.0	2362.9
		11,326		251.8
Other mining	9554	9467	7224.2	4014.5
		87		376.7

(continued)

Table 4.4 (continued)

1: Service and trade cluster	Employment (no.)	Formal /informal employment	GVA	Formal /informal compensation
Structural metal products	Incl. in Oth Met Pdts		4842.9	
Total	203,510	203,510	50,775.3	46,312.5
IV: Chemical products and petroleum cluster				
Petroleum	63,762	63,304	37,771.3	25,222.9
Chemicals and Chem. Prod, (incl Plastic Prod.)	Incl. in Petroleum	458	17,503.0	364.6
Rubber products	Incl. in Petroleum		980.7	
Total	63,762	63,762	56,255.1	25,587
V: Building and metal products cluster				
Building and other construction	414,870	190,142	35,859.7	18,086.2
		224,728		1711.6
Wood and wood products	12,958	10,096	2485.8	1255.7
		2862		108.1
Non-metallic mineral products	26,794	20,721	5540.9	3372.6
		6073		249.1
Structural metal products	–	–	–	–
Electricity	17,338	15,876	15,635.7	5300.0
		1462		219.9

(continued)

Table 4.4 (continued)

1: Service and trade cluster	Employment (no.)	Formal /informal employment	GVA	Formal /informal compensation
Total	471,960	471,960	59,522.0	30,303.2
VI: Light manufacturing products cluster				
Paper and paper products	12,089	12,089	3495.9	1739.1
Publishing and printing	22,626	21,592	4881.4	4694.8
		1034		327.6
Textiles, clothing, leather products	33,254	21,201	2712.1	2281.5
		12,053		199.9
Furniture	13,560	11,517	1890.0	1495.5
		2043		129.1
Manufacturing of transport equipment	40,110	40,110	12,901.1	13,520.4
Rubber products		–		
Total	121,639	121,639	25,880.5	24,387.9

Source Authors' calculations based on 2015 data from EasyData (2016)
Note GVA (at basics prices) and employee compensation are both in Rand millions, and at 2010 constant prices

Metal Products cluster, the Building and Other Construction industry sector stands out as the cluster's driving force with 414,870 jobs (7.9%) and 35,859.7 million Rand of regional GVA (3.7%). The Building and Other Construction industry is also the only industry sector in the region that has a majority of employment (224,728) in the informal sector. Despite its large number of informal jobs, the construction industry is an important contributor to Gauteng's regional economy.

Another regional economic driver is the Metal Products cluster. With a total of 203,510 jobs (4.4%) and 50,775.3 million Rand (6.7%) of GVA, it is the third largest contributor to the Gauteng region's economy. It is important to note that the employment numbers for Machinery and Equipment; Basic Metal Products; and Structural Metal Products; are combined with Other Fabricated Metal Products, adding up to a total of 140,965 (2.7%), while the corresponding GVA numbers are listed individually. In comparison, the combined GVA for these four sectors equals 27,589.0 million Rand (2.8%). We also emphasize that in order to avoid double-counting of Structural Metal Products GVA, this sector's GVA is included in the total GVA of the Metal Products cluster and not in the Building and Metal Products cluster. The same holds for the Rubber Products industry, whose GVA is included in the total GVA of the Chemical Products and Petroleum cluster, and excluded from the total GVA of the Light Manufacturing Products cluster.

The Food Products cluster, including Agriculture, as well as several food- and beverage-producing industries, employs 147,554 people (2.8%), while adding 30,416.7 million Rand (3.2%) to the region's GVA. Though the employment is fairly evenly split between Agriculture and the food- and beverage-producing industries—70,498 versus 77,056 respectively—Agriculture adds very little (i.e., 3,520.9 million Rand or 0.4%) to the region's GVA, which can be explained by the usually lower wages paid in Agriculture.

We derived two manufacturing clusters, the Light Manufacturing Products cluster and the Chemical Products and Petroleum cluster, with employment numbers of 121,639 (2.3%) and 63,762 (1.2%) respectively. Though these two clusters are somewhat smaller in size with respect to employment, and their composition is interesting in that light manufacturing activities—for example, Paper and Paper Products, Publishing and Printing, Textile, Clothing, Leather Products, and Furniture—have very similar requirements for intermediate inputs and outputs. The Chemical Products and Petroleum cluster encompasses the Petroleum industry as well as those industries that rely on petroleum as an input to their production, that is, Chemicals and Chemical Products and Rubber Products.

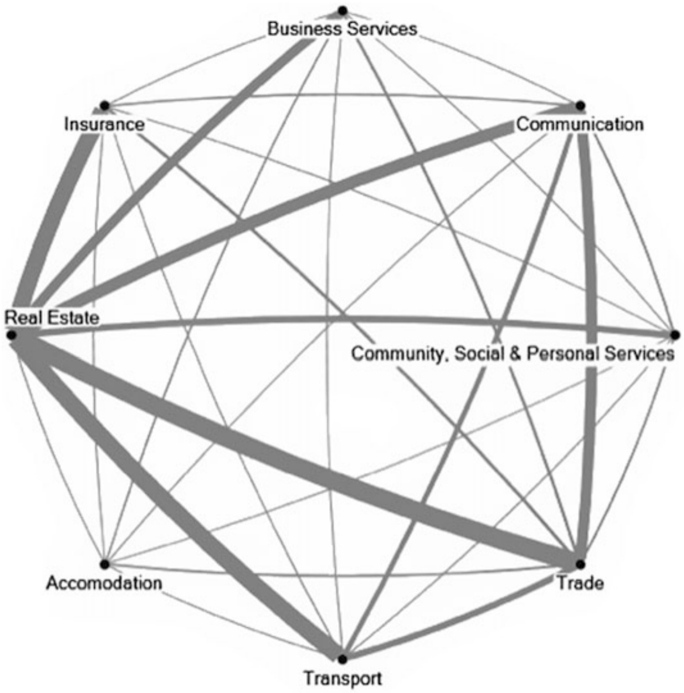

Fig. 4.4 Service cluster—structural paths among all eight service sectors

4.5.2 Gauteng's Service Cluster—A Graphical Presentation of Industry Linkages

Figure 4.4 is a graphical presentation of our findings from the structural path analysis (SPA) for Gauteng's service cluster.[7] The links shown between any pair of industries are based on the sum of the combined global influences, that is, $I^G_{(ij)} = I^G_{(i \to j)} + I^G_{(j \to i)}$, which includes all adjacent circuits and their path multipliers. Using combined influences in this context, we can see how strongly two industry sectors in the service cluster are connected to one another, while ignoring the direction of the influence. The thicker the line in Fig. 4.4, the stronger the influence

[7]Figures 4.4, 4.5, and 4.6 were created with NodeXL (http://nodexl.codeplex.com).

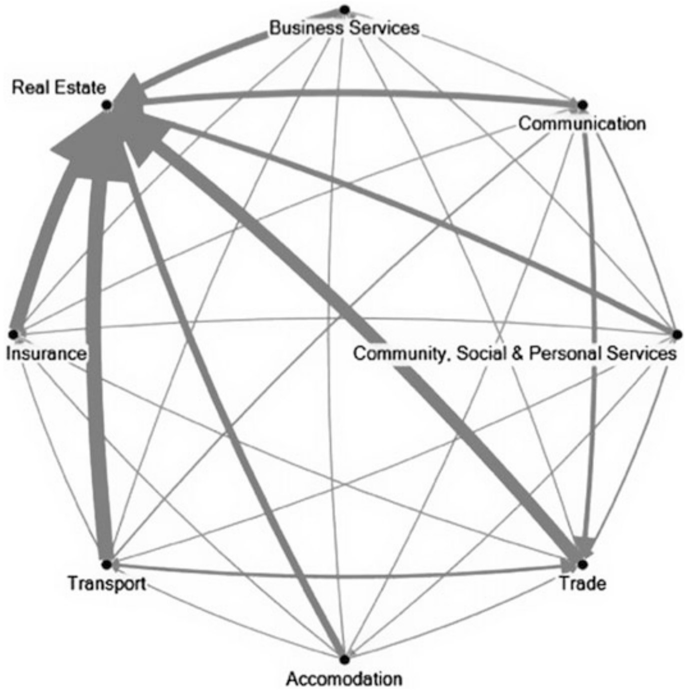

Fig. 4.5 Service cluster—structural paths among all seven service sectors (strongest influences)

is between the two corresponding service sectors. In Fig. 4.4, we categorise three inter-industry connections as *very strong*, three as *strong*, and three as *significant*. The three *very strong* inter-industry influences in the service cluster are between Insurance and Real Estate, Trade and Real Estate, and Transport and Real Estate. The *strong* influences are between Business Services and Real Estate, Communication and Real Estate, and Communication and Trade. It is interesting that of the six strongest influences found in the service cluster, Real Estate is included in five of them. The influences between Communication and Transport, between Community, Social, and Personal Services and Real Estate, and between Trade and Transport are *significant* in that they stand out, but as per the thickness of their lines in the diagram, we do not classify them as *very strong* or *strong*. In addition, we find that Accommodation shows very weak associations with any of the other industries in the service cluster, while Community, Social, and Personal Services only connects *significantly* with Real Estate. Insurance and Business Services at least have a *strong* connection with one other service industry. Trade, Communication, and Transport have three connections each. Real Estate clearly

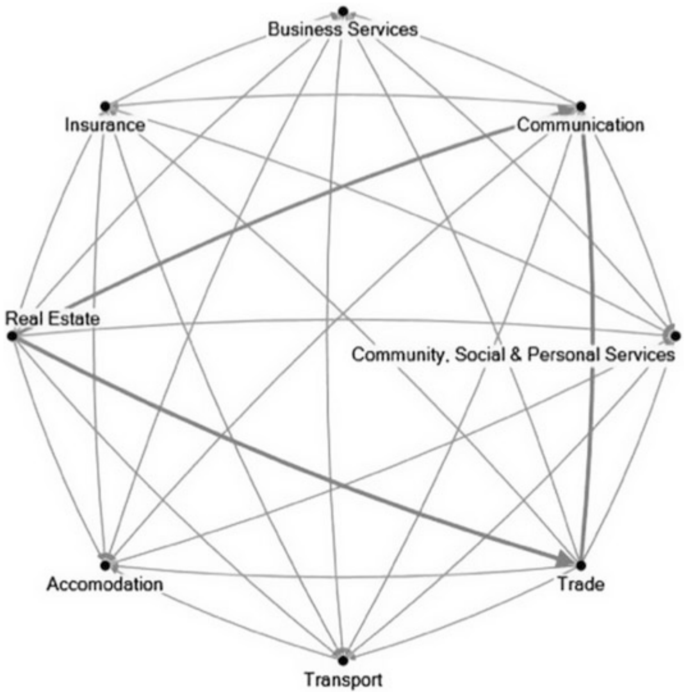

Fig. 4.6 Service cluster—structural paths among all seven service sectors (weakest influences)

stands out as it connects to all other service sectors with the exemption of Accommodation.

So far, we have ignored the direction of the influences between industry sectors in the service cluster. In Figs. 4.5 and 4.6, we distinguish between *strongest* and *weakest* influences. The idea here is that an industry i influences industry j, while at the same time, there is an influence in the opposite direction from industry j to industry i. Breaking down the combined global influences (shown in Fig. 4.4) into two individual directional influences $I^G_{(i \to j)}$ and $I^G_{(j \to i)}$ allows us to identify which of the two industry sectors exerts a stronger influence on the other. In Fig. 4.5, we show all the *stronges*t influences, while in Fig. 4.6, we display all the *weakest* influences.

While we identified Real Estate as an important service cluster industry in Fig. 4.4, from Fig. 4.5 we see that all the *strongest* influences are being exerted on Real Estate. For policy makers this implies that money spent on Real Estate does not stimulate many other industries in the service cluster. On the other hand, Insurance, Transport, and Trade, for instance, have a strong potential to stimulate the Real Estate industry. Real Estate, however, does influence Communication and

Trade to a lesser extent, as indicated in Fig. 4.6. Somewhat expected is the finding that Transport and Communication have a stronger influence on Trade that vice versa.

4.6 Conclusions

At the beginning of this chapter, we laid out the rationale for industrial cluster theories. This was followed by a discussion of the antecedents of the industrial cluster phenomenon, as well as an overview of industrial cluster policies in the Gauteng region. There is strong evidence that the Gauteng region is embracing industrial cluster policies, as discussed in Sect. 4.3, so a more detailed industrial cluster analysis appears to be an appropriate step for developing further cluster-specific economic development policies.

The basis for all analytical work presented in this chapter is the 2006 Gauteng social accounting matrix (SAM), which has two major shortcomings. First, it is somewhat outdated as it includes data that are over 10 years old. To justify the use of an older accounting framework, we emphasize that all analysis presented in this chapter uses either normalized data and/or multipliers. Consequently, an older data framework is still appropriate as long as the structure of the regional economy—in this case the Gauteng economy—has not changed significantly over the intervening years. There is no evidence that the regional economy has changed structurally in a fundamental way. Second, and more limiting for identifying industrial clusters, the 2006 Gauteng SAM only includes 37 activities (industry sectors). Considering that General Government Services sector does not contain any data, this means that only 36 industry sectors can be assigned to one of the identified industrial clusters. A more detailed Gauteng SAM would thus provide a better framework for identifying individual industrial cluster compositions. Being limited to, in this case, a highly aggregated SAM, prevented us from identifying more detailed industrial clusters as presented, for instance, by Vom Hofe and Bhatta (2007), who used a regional SAM with as many as 223 individual industry sectors.

Section 4.4 provides a detailed and coherent description of the analytical techniques addressed in the chapter. This includes a description of the 2006 Gauteng province social accounting framework, the derivation of social accounting multipliers, and a detailed description on how to conduct a structural path analysis (SPA) as well as a principal component analysis (PCA) to identify industrial clusters. The emphasis on the presented analytical approach is to identify industrial clusters based on inter-industry linkages as shown by Czamanski (1974) and Bergman and Feser (1999). Although these techniques were introduced more than 40 years ago, we preferred the SPA techniques to the widely used linkage measures (including Power-of-Pull (PoP) method), as shown in the work of Pisa et al. (2015), for instance.

Using a principal component analysis, we identified six distinctive industrial clusters in the Gauteng regional economy. As might have been expected, the Service and Trade cluster, which consists of eight industry sectors, is the predominant cluster with 68.5% of total regional employment and 55.9% of regional GVA. The strong emphasis on services in the Gauteng regional economy is reflected in the composition of the identified industrial clusters. The remaining five clusters are: Food Products; Metal Products; Chemical Products and Petroleum Cluster; Building and Metal Products; and Light Manufacturing Products. Three industry sectors–Gold Mining; Communication, Medical and other Electronic Equipment; and Water—could not be associated with any of the six identified clusters.

As a second step, we conducted a structural path analysis (SPA) to highlight linkages within the predominant Service and Trade cluster. Based on the sum of the combined global influences, we identified three inter-industry connections as *very strong*, three as *strong*, and three as *significant*. Against all expectations, Real Estate emerged as the industry that benefits the most from the Service and Trade cluster, as it is included in five of the six strongest influences shown in the graph. Communication and Trade, and Transport and Trade, are two significant linkages that stand out, confirming expectations (see Fig. 4.4).

A comparison of the discussion in Sect. 4.3, where a review of the existing cluster-related policies was undertaken, with the key clusters that were identified in Sect. 4.4, shows that the existing cluster policies in the regional economy are insufficient for government to claim that there is a serious effort to bolster the competitiveness of the regional economy through cluster development. The need to develop cluster policies that specifically target the identified clusters cannot be overemphasized.

Given the dominance of the Service and Trade cluster in terms of regional employment and regional GVA, policy wise, it is of great concern what the effects for the regional economy would be should the key sectors experience crisis or decline, such as happened during the 2008 global financial crisis, for instance. In that crisis, of the 102,906 jobs lost in the regional economy, the Service and Trade cluster suffered about half (46%) of those losses. These results suggest the need to strengthen and diversify the regional economy to avoid susceptibility to external shocks. It is also necessary to ensure that the Service cluster remains competitive with respect to other similar clusters in up-and-coming locations such as Nairobi in the East African economic hub, so that the Gauteng City-Region remains a "gateway" or "launching pad" for global financial flows to the rest of the African continent (see Chap. 3 in this volume). This can be achieved by government focusing on cluster initiatives rather than industrial policy per se. Cluster initiatives, including improving education systems, investing in communication infrastructures, implementing anti-trust rules, promoting investment incentives, and protecting intellectual property rights, could improve the business environment, affecting all cluster-related industries. Across the world, there are examples of successful cluster initiatives that have heralded new working relationships between business and government. Industrial policy initiatives, however, posit that some industries are more beneficial, thus the role of the government should be in fostering these industries through subsidies and other policies that, by design, distort competition in their favour (Porter 2001).

It can be argued, with evidence showing that, as expected, the Service cluster provides more formal employment (2,478,977 jobs) than informal employment (1,113,498 jobs), that this cluster is elitist. It is disappointing that informal workers, who represent about a third of the employment in this cluster, earn a paltry 13 billion Rand, compared to the formal workers in the cluster, who earn disproportionately more—275 billion Rand. This means that, on average, a formal worker earns R111,288 per year, while an informal worker earns R3,645 per year. The high 'informalised' aspect of the Service cluster, a major regional employer, and its low redistributive character, should be of serious concern to all spheres of government that strive to radically transform, modernize, and re-industrialize national, regional, and local economies. Follow-up research is necessary to examine the redistributive component of potential shocks to the Service and other identified clusters, to ascertain the *real* effects of such shocks on household and other institutional incomes.

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Annexure

Table 4.5 A conceptual Social Accounting Matrix (SAM)

	Endogenous Accounts				Exogenous Accounts				
N. Expenditures	Production	Factors of Production		Households	Governments (3b)	Firms	Capital Account (3d)	Trade Account	Totals
Incomes n.	(1)	Labor (2a)	Capital (2b)	(3a)		(3c)		(4)	Receipts
Production (1)	Intermediate Demand			Household Consumption	Government Consumption		Investment	Exports	Production Income
Factors of Production CL aa ib ait or	Payments to Labor (wages) Payments to Capital (rent)							Labor Incomes from Abroad Capital Incomes from Abroad	Factor Income
Households (3a)		Allocation of Labor Income to Households	Allocation of Capital Income to Households	Intrahousehold Transfers	Transfers i.e. Welfare & Unemployment Payments	Dividends		Transfers	Household Income
Government (3b)	Indirect Business Taxes	Social Security Tax	Taxes on Profits	Personal Taxes	Intragovernment Transfers	Dividends, Taxes		Transfers	Government Income
Firms (3c)			Nondistributed Profits		Transfers				Firms Income
Capital Account (3d)			Capital Consumption Allowance	Household Savings	Government Savings	Firm Savings			Total Savings
Trade Account (4)	Imports	Labor Payments Abroad	Capital Payments Abroad	Commodity Trade, Transfers	Commodity Trade, Transfers		Capital Purchases		Total Imports
Totals	Total Production Outlays	Factor Outlays		Household Expenditures	Government Expenditures	Firm Expenditures	Total Investment	Total Exports	

Source Wang and Vom Hofe (2007)

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