



Université de Montréal  
Faculté des arts et des sciences  
Département de sciences économiques

CAHIER 9626

**PRODUCTION LINKAGES BETWEEN INFORMAL AND FORMAL ACTIVITIES  
CONSIDERING DOMESTIC AND IMPORTED INPUTS : AN APPLICATION OF THE  
MINIMAL-FLOW-ANALYSIS METHOD TO SENEGAL**

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November 1996

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Our research could not have been undertaken without the material support of PARADI, a cooperative research program between the C.R.D.E., Université de Montréal and CRÉFA, Université Laval. PARADI is financed by the Canadian International Development Agency. Comments should be addressed to : [martensa@ere.umontreal.ca](mailto:martensa@ere.umontreal.ca).

Ce cahier a également été publié au Centre de recherche et développement en économique (C.R.D.E.) (publication no 2996).

Dépôt légal - 1996  
Bibliothèque nationale du Québec  
Bibliothèque nationale du Canada

ISSN 0709-9231

## RÉSUMÉ

Nous appliquons à la matrice intrants-extrants du Sénégal de 1990, désagrégée en activités formelles et informelles, une méthode d'analyse structurelle récente (Minimal-Flow-Analysis) permettant de représenter les liens directs et indirects de production unissant ces activités. Nos résultats montrent que, dans le cas du Sénégal, des liens significatifs couvrent plus des deux tiers de la production brute, les liens indirects ne peuvent pas être ignorés, activités formelles et informelles sont interreliées, les activités informelles qui comptent en termes de liens appartiennent aux secteurs primaire et tertiaire (alors que pour les activités formelles le secteur secondaire a aussi des liaisons importantes avec le reste de l'économie), la prise en compte des intrants importés, en plus des intrants produits localement, affecte la structure des liens au sein du secteur formel mais peu au niveau du secteur informel.

Mots clés : Sénégal, secteur informel, liens de production, analyse interindustrielle

## ABSTRACT

We apply to the Senegalese input-output matrix of 1990, disaggregated into formal and informal activities, a recently designed structural analytical method (Minimal-Flow-Analysis) which permits to depict the direct and indirect production linkages existing between activities. Our results show that, in the case of Senegal, interconnectedness covers more than two thirds of the country's output, indirect connections cannot be ignored, backward and forward linkages exist between formal and informal activities as well as between informal activities themselves, and interconnectedness mainly affects primary and tertiary informal activities whereas secondary formal activities are also affected. The inclusion or exclusion from the analysis of imported inputs modifies the nature of interconnectedness in the case of the formal sector but leaves largely unaffected the informal one.

Key words : Senegal, informal sector, production linkages, input-output analysis



## I. INTRODUCTION

The identification of production linkages between informal and formal activities has been of interest to development economists for a long time [for a survey of the literature of the 70s and 80s, see Harriss (1990) and, for more recent studies, see United Nations (1991), Nanjundan (1992), Tambunan (1993) and Roubaud (1994)]. Several reasons have been given for such a concern. Among them, we find the usual justifications for the study of production linkages in general. If such linkages exist, trade opportunities are already present [Hirschman (1977)]. Changes in linkages reflect changes in the production structure which can be related to macroeconomic indicators such as per capita income and the degree of openness to trade in an effort to understand the growth process [Kubo, de Melo, Robinson and Syrquin (1986)]. If the informal-formal dimension is introduced, additional reasons immediately come forward. Production linkages form a possible basis for the subcontracting of small firms by large ones and are a likely support for the diffusion of technical progress from modern to traditional activities [Watanabe (1983)]. Moreover, in certain countries, and particularly in developing countries, factor markets are segmented. As such, production linkages between informal and formal activities cannot be ignored if the impact of macroeconomic policies affecting labor or credit markets has to be correctly assessed [Ginsburgh and Schioppa (1985); Fortin, Marceau and Savard (1994)].

There are two kinds of production linkages : backward and forward. In the case of backward linkages, one considers the purchases of inputs by a given activity from other activities. In the case of forward linkages, one looks at the sales of the activity's output to other activities. Both linkages can be studied in a partial-equilibrium framework, where only direct purchases and sales are taken into account. They can also be studied in a general-equilibrium framework, in which case indirect purchases and sales are included in the analysis. Our study falls in the second category.

The general-equilibrium framework, which has traditionally been used for the study of production linkages, is the well-known Leontief input-output (IO) system where activities are precisely interrelated through the purchases and sales of intermediate products. There is a long history of attempts to identify production linkages on the basis of the IO matrix of intermediate flows. The most frequently used methods have been : the triangulation of the matrix [initiated by Chenery and Watanabe (1958) and improved by Simpson and Tsukui (1965)]; the computation of indices of (backward) power of dispersion and (forward) sensitivity of dispersion [Rasmussen (1958)]; the search for industrial clusters [Czamanski (1974)]. These methods suffered, however, at least in their initial formulation, from a common shortcoming : they lacked a well-defined criterion for assessing whether a given production linkage had to be considered important (relevant, essential) or unimportant (irrelevant, unessential) for the economic structure under study. A new method was recently developed to address this issue of relevance or irrelevance of the production linkages identified on the basis of the IO matrix. It is known as the *minimal-flow-analysis method* or MFA [Schnabl (1991 and 1994)].<sup>1</sup> Like other structurizing methods, the MFA has to make a decision as to which flows to include and which to neglect in order to obtain a representative and "complete" structure. (More details on how to reach such a decision are given in the Appendix.) The result is then translated into a structural graph. In other words, the MFA shows the "important" linkages of an economy like a road map shows the network of freeways in a country, given the definition of a freeway, whilst omitting all other, i.e., smaller roads.

In this paper, we apply the MFA to the Senegalese IO matrix of 1990, the format of which is given in Section II, with special attention given to the production linkages between informal and formal activities. More precisely, the MFA is first applied to the aggregate version of the matrix, i.e., where there is no breakdown between informal and formal activities (Section III). It is then applied to a disaggregate version, where such a breakdown exists (Section IV). At both stages, results are derived under two variants. In the first one, only domestic purchases and sales are considered, while in the second, imports of intermediate inputs are also included in the corresponding flows. Our study is,

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<sup>1</sup> For other attempts, see Cabrer, Contreras and Miravete (1991) and Cassetti (1995).

at least to our knowledge, the first serious attempt at taking a systematic look at the place held by the Senegalese informal sector in Senegal's overall economy. In the past, only survey analyses were conducted, and they were generally limited to urban areas : Dakar, the country's capital [van Dijk (1986); Zarour (1989); Lubell and Zarour (1990)], and Kaolack, a major town of the central Sine-Saloum region [Morice (1981)].

## II. THE SENEGALESE 1990 IO MATRIX

In 1990, Senegal GNP per head was US\$720, making it a middle-income developing country. The relative contribution of agriculture (mainly groundnut production), forestry, fishing and livestock was 19.9 %, that of industry 18.7 %, whereas services contributed for the remainder, i.e., 61.4 %. Manufacturing, that is, industry excluding minerals, energy and construction, amounted, however, to only 13.1 % of GDP, the main subsector being foodprocessing followed by textile, clothing and leather [World Bank (1995)]. Transactions on intermediate inputs, whether domestically produced or imported, were equal to 42.8 % of the country's gross output. The 1990 aggregate matrix we used for Senegal contains 25 activities which are listed in Table 2.1 [for details on the construction of the Senegalese IO table, see Ndiaye (1995)]. When the breakdown between informal and formal activities was introduced, the IO matrix disaggregation brought the total number of activities from 25 to 40. This disaggregation (see Table 2.1) obeyed the following rules : agriculture, forestry and livestock were considered solely as *informal* activities; fish preparations, paper and printing, petroleum industry, chemicals, energy, postal and telecommunication services, and financial services were considered only as *formal* activities; all other activities were divided into informal and formal ones. The criterion retained for distinguishing between informal and formal activities was : if a given production unit happened to be registered with the Directorate of Statistics, the Social Security Fund, the Retirement Fund or the Division for Human Resources of Senegal, it was included in the formal sector. If it was not registered with any of these public bodies,

**Table 2.1**  
**Symbols Associated to the Activities in the Aggregate and Disaggregate IO Matrices**

| Name of the Activity                               | Aggregate Matrix | Disaggregate Matrix <sup>1</sup> |
|--|------------------|----------------------------------|
| 1. Agriculture                                     | Agr              | AgI                              |
| 2. Forestry  | For              | FrI                              |
| 3. Fishing   | Fis              | FsF, FsI                         |
| 4. Livestock                                       | Liv              | LvI                              |
| 5. Minerals  | Min              | MnF, MnI                         |
| 6. Meat and preserves                              | Mea              | MeF, MeI                         |
| 7. Fish preparations                               | Fip              | FpF                              |
| 8. Fats and vegetable oils                         | Fat              | FaF, FaI                         |
| 9. Grain and flour                                 | Grn              | GrF, GrI                         |
| 10. Miscellaneous food industries                  | Foo              | FoF, FoI                         |
| 11. Textile, clothing and leather                  | Tex              | TxF, TxI                         |
| 12. Wood industry                                  | Woo              | WoF, WoI                         |
| 13. Paper and printing                             | Pap              | PpF                              |
| 14. Petroleum industry                             | Pet              | PmF                              |
| 15. Chemicals                                      | Chm              | ChF                              |
| 16. Construction materials                         | Con              | CnF, CnI                         |
| 17. Metallurgy and mechanical industries           | Met              | MtF, MtI                         |
| 18. Energy   | Enr              | EnF                              |
| 19. Construction and public works                  | Cpw              | CpF, CpI                         |
| 20. Hotels, bars and restaurants                   | Hbr              | HbF, HbI                         |
| 21. Transportation                                 | Tsp              | TrF, TrI                         |
| 22. Postal and telecommunication services          | Pst              | PtF                              |
| 23. Financial services                             | Fns              | FnF                              |
| 24. Trade  | Trd              | TdF, TdI                         |
| 25. Other services (including government services) | Srv              | SvF, SvI                         |

<sup>1</sup> The third letter of the symbol denotes formal (F) or informal (I).



it was considered as part of the informal sector [for additional details on the disaggregation procedures, see Camara, Ciré, Dansereau and Fall (1996, forthcoming)].<sup>2</sup>

On the basis of the above disaggregation, the value added by the informal sector in 1990 was equal to 57 % of Senegal's GDP at factor cost. This confirms previous results according to which the corresponding percentage oscillated over the 1982-1986 period between 55 and 58 [Farell, Panhuys and Seck (1989)].

### III. AGGREGATED LINKAGES

The aggregated linkages, i.e., with no distinction between informal and formal activities, are depicted by the structural graphs of Figures 3.1 and 3.2. In Figure 3.1, only domestic intermediate inputs are considered. Figure 3.2 also includes imported inputs.

The connections found in the structural graphs are ordered according to a *coefficient of centrality (CC)*. The CC-values are computed for every activity and comprise the input-output ratio of the linkages (direct and indirect) of the individual activities as obtained at the graph theoretical level. More precisely, a CC-value of *one* means that the activity has roughly as many "inflow" relationships as "outflow" relationships, denoting the *centre* of the structure. In our analysis, activities with CC-values between the arbitrarily chosen cut-off points of 0.7 and 1.3 were marked as "central" in the graphs by a *bold circle* (e.g., *Agr* in Figure 3.1). The coefficients of centrality are given in Table 3.1 for Figure 3.1 and in Table 3.2 for Figure 3.2.

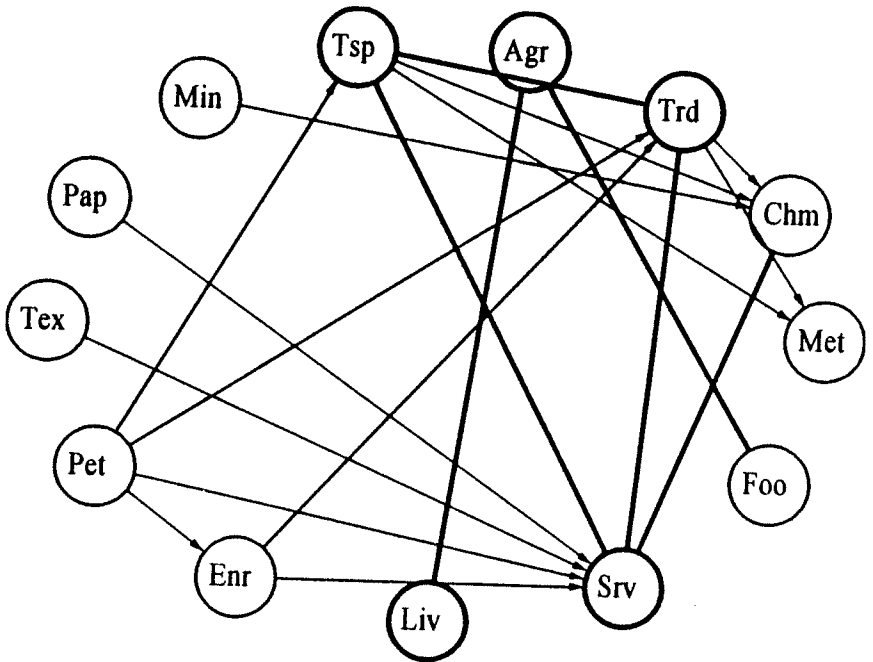
<sup>2</sup> The criterion of registration or the lack of it as a basis for including production units in the formal or informal sector, though straightforward, remains rather rough, since it does not explicitly take into account the numerous micro features which seem to characterize informal activities as opposed to formal ones [see, e.g., Pearson (1992)]: ease of market entry, reliance on indigenous resources, family ownership, labor-intensive technology, skills acquired outside formal education and training, limited access to bank credit, unregulated and competitive market environment, etc. It is beyond the scope of our study to elaborate further on the issue for the simple reason that, given the state of the information we were provided, it would hardly change or improve our data base. The interested reader is, however, referred to Tokman (1978), Thomas (1992, chap. 4) and Lautier (1994, chap. 3 and 4).

Activities which are not central can be divided into *source* activities and *sink* activities. Source activities are more output-oriented and consequently have a CC-value smaller than 0.7 and appear on the left side of the graph (e.g., *Min* in Figure 3.1), whereas sink activities are more input-oriented and have a CC-value greater than 1.3 and appear on the right (e.g., *Met* in Figure 3.1). A *single line arrow* (e.g., as from *Min* to *Chm* in Figure 3.1) denotes a supplying flow equal to or greater than an *endogenous* filter value or MFA value (see Appendix). *Thick lines* (without arrow heads) indicate mutual supply with at least the MFA value (as between *Agr* and *Liv* in Figure 3.1). *Dashed equivalents* of both lines denote that the assumed connection is weaker, since it exists at a filter value *one level lower* than the MFA value (as between *Pap* and *Srv* in Figure 3.2). Finally, the graphs only show the activities which are interconnected as opposed to those which are not, the so-called isolated activities. In the latter case, *all* their connections are smaller than the filter value one level lower than the MFA value.

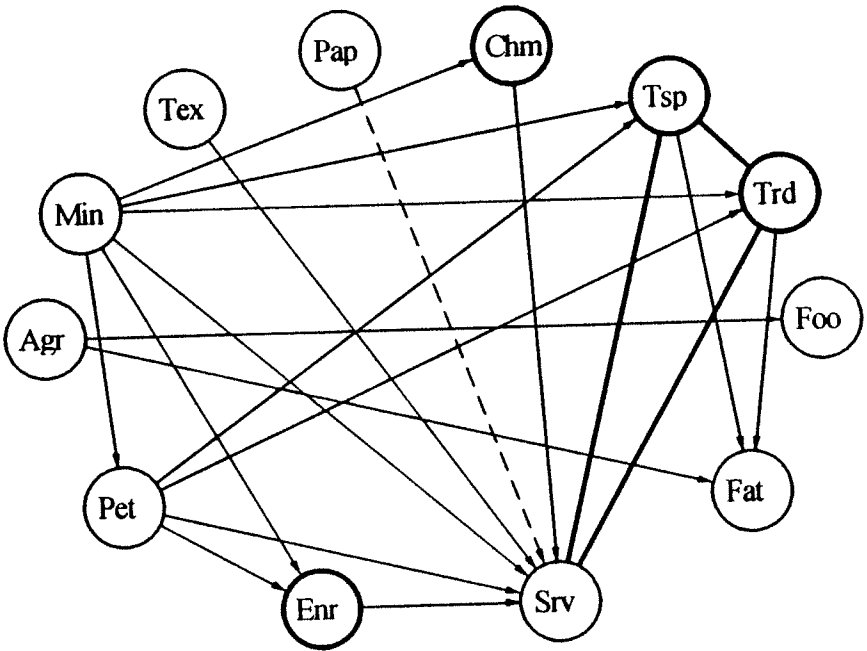
We are now equipped to analyze Figures 3.1 and 3.2. If only domestic input linkages are considered, the following observations can be made at the aggregate level (Figure 3.1) :

- there are 13 interconnected (i.e. important) activities in the Senegalese economy, the 12 remaining ones being isolated;
- the gross output of the interconnected activities is equal to 70.3 % of the country's total output [as computed on the basis of the IO matrix]. The corresponding ratio varies between sectors : 78.7 % for the agricultural sector (agriculture, forestry, fishing, livestock), 43.7 % for the manufacturing sector, 43.4 % for the rest of the industrial sector (minerals, energy, construction) and 90 % for the services sector,

Figure 3.1 : Aggregated Linkages with Only Domestic Inputs



**Figure 3.2 : Aggregate Linkages with Domestic and Imported Inputs**



**Table 3.1**  
**Coefficients of Centrality of the Aggregate IO Matrix**  
**[Only Domestic Inputs]**

| Activities                                 | CC-Value | Type of Activity |
|--|----------|------------------|
| Agriculture [Agr]                          | 0.870    | central          |
| Livestock [Liv]                            | 1.200    | central          |
| Minerals [Min]                             | 0.476    | source           |
| Miscellaneous food industries [Foo]        | 1.489    | sink             |
| Textiles, clothing and leather [Tex]       | 0        | source           |
| Paper and printing [Pap]                   | 0        | source           |
| Petroleum industry [Pet]                   | 0        | source           |
| Chemicals [Chm]                            | 1.613    | sink             |
| Metallurgy and mechanical industries [Met] | 1.764    | sink             |
| Energy [Enr]                               | 0.509    | source           |
| Transportation [Tsp]                       | 0.801    | central          |
| Trade [Trd]                                | 0.903    | central          |
| Other services [Srv]                       | 1.237    | central          |

Note: The isolated (i.e., excluded) activities are: forestry, fishing, meat and preserves, fish preparations, fats and vegetable oils, grain and flour, wood industry, construction materials, construction and public works, hotels, bars and restaurants, postal and telecommunication services, financial services.

**Table 3.2**  
**Coefficients of Centrality of the Aggregate IO Matrix**  
**[Domestic and Imported Inputs]**

| Activities                           | CC-Value | Type of Activity |
|--------------------------------------|----------|------------------|
| Agriculture [Agr]                    | 0        | source           |
| Minerals [Min]                       | 0        | source           |
| Fats and vegetable oils [Fat]        | 2        | sink             |
| Miscellaneous food industries [Foo]  | 2        | sink             |
| Textiles, clothing and leather [Tex] | 0        | source           |
| Paper and printing [Pap]             | 0        | source           |
| Petroleum industry [Pet]             | 0.444    | source           |
| Chemicals [Chm]                      | 0.727    | central          |
| Energy [Enr]                         | 0.981    | central          |
| Transportation [Trp]                 | 0.930    | central          |
| Trade [Trd]                          | 1.088    | central          |
| Other services [Srv]                 | 1.384    | sink             |

Note: The isolated (i.e., excluded) activities are: forestry, fishing, livestock, meat and preserves, fish preparations, grain and flour, wood industry, construction materials, metallurgy and mechanical industries, construction, hotels, bars and restaurants, postal and telecommunication services, financial services.

- interconnectedness, in Senegal, reflects not only direct linkages but also indirect ones. If indeed we compute for each of the 25 activities the weighted index of the ratio of direct intermediate sales to total direct sales (i.e., including sales to final demand) and of the ratio of direct intermediate purchases to total direct purchases (i.e., including purchases of primary inputs), seven activities with an index lower than the 0.35 median value, that is, with weak direct links with the rest of the economy, are nevertheless interconnected on the basis of our criterion (agriculture, minerals, miscellaneous food industries, chemicals, metallurgy and mechanical industries, trade, other services);

- among the 13 interconnected activities, five are central activities (agriculture, livestock, transportation, trade, other services), five are source activities (minerals, textiles, clothing and leather, paper and printing, petroleum industry, energy) and three are sink activities (miscellaneous food industries, chemicals, metallurgy and metallic industries). The fact that manufacturing activities can either be source or sink activities reflects the heterogeneity of the sector itself: e.g., the presence of textile, clothing and leather, and paper and printing among the source activities, i.e., the more output-oriented ones, may suggest that their products are relatively unprocessed or unsophisticated. The reverse argument applies to miscellaneous food industries, chemicals, and metallurgy and mechanical industries which are more input-oriented;

- finally, there are six cases of mutual supply (agriculture with miscellaneous food industries and livestock; trade with transportation; other services with chemicals, transportation and trade). Other services encompass such different subactivities as equipment leasing, mechanical repairs and laundry services. Thus, the growing relevance of services with emphasis on business-oriented services is proven once again, as could already be shown for developed countries like Germany [Schnabl (1991)].

Let us now extend the analysis to the situation where *imported* intermediate inputs are also incorporated in the study of linkages (Figure 3.2), and let us compare the new situation with the previous one :

- if imported intermediate inputs are included, the new set of interconnected activities covers a smaller share of the country's gross output : 67.8 % (versus 70.3 %). It is due to the fact that livestock as well as metallurgy and metallic industries become isolated activities, this being less than compensated by the appearance of fats and vegetable oils as an interconnected activity. The disappearance of livestock can easily be explained : the importance of imported livestock products is small in relation to the augmented weight of other deliveries now including imports. Thus, the activity, when compared to other activities, has become a "small" supplier of intermediate inputs. In the case of metallurgy and metallic industries, the corresponding imported products are, on the contrary, much bigger. However, they go mainly to final demand (e.g., finished equipment goods entering capital formation). Consequently, it is not surprising that metallurgy and metallic industries also become a "small" supplier. The departure of fats and vegetable oils from isolation - it becomes a sink activity - is mainly explained by the existence of a significant amount of imported agricultural inputs that it will process;
- the number of central activities is reduced from five to four. As we just saw, livestock, a former central activity, has disappeared altogether. Moreover, agriculture has become a source activity, and other services a sink one. In the case of agriculture, the presence of imported agricultural products has decreased its input-output ratio of linkages (the CC-value is now 0 as compared to 0.870), which means that it has become more output-oriented, considering that the Senegalese agriculture uses few imported inputs due to the prevalence of traditional cultivation techniques. In the case of other services, the reverse applies. The output of that activity is essentially made of nontradables. The denominator of the CC-ratio is thus hardly affected. However, the incorporation of imported inputs at all stages of the production system increases the numerator. As such, the input orientation of the activity also increases, the CC-value now being 1.384 instead of 1.237. Meanwhile, both energy and chemicals have become central activities, respectively from source and sink activities. For the former, imports of energy inputs, such as fuel, are responsible and, for the latter, imports of processed chemical products are the explanation;

- from the previously existing six cases of mutual supply, only three remain (other services with transportation and trade, and transportation with trade). In other words, in the case of the incorporation of imported inputs, mutual supply has only been preserved between nontradable activities, whereas it has been destroyed when tradable activities are involved (agriculture, livestock, miscellaneous food industries, chemicals), a result which is intuitively acceptable. Contrary to this, the *bilateral triangle*  $Tsp=Trd=Srv$  is stable, as, by definition of the bilateral (= mutual) supply of two activities above the MFA-threshold, each bilateral link represents a growth dipol (since enhancing the demand of one partner would cause some important "boomerang-demand"). A triangle of those dipol-connections, like the triangle  $Tsp=Trd=Srv$ , by the synergistic effects of all three links, forms what might be considered a growth-center of the Senegalese economy, whether we look at domestic production or at the more technically defined total production system. We need not emphasize here that all three activities involved belong to the category of services.

#### IV. DISAGGREGATED LINKAGES

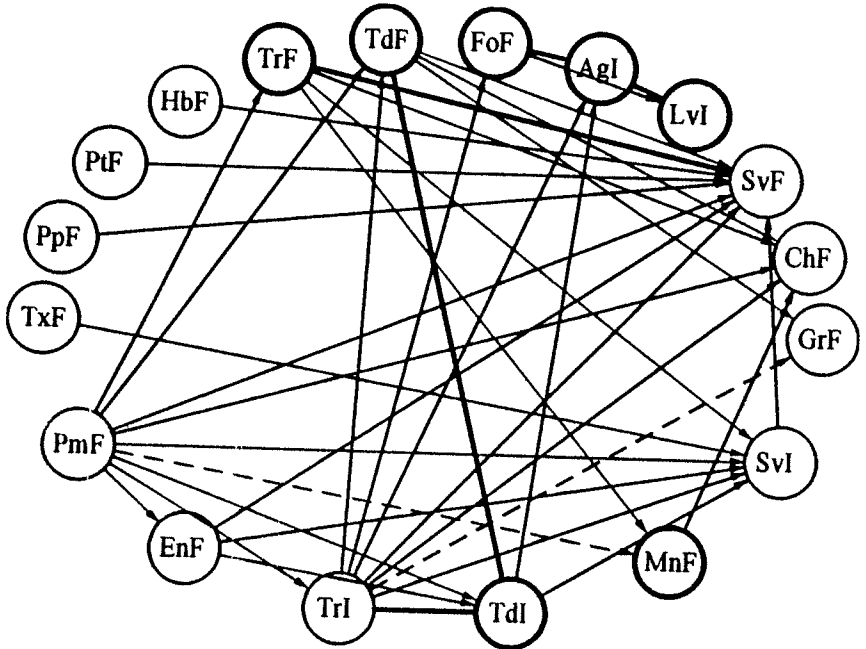
The disaggregated linkages, i.e., where there exists a distinction between *informal* and *formal* activities, are depicted by the structural graphs of Figures 4.1 and 4.2. In Figure 4.1, like in Fig. 3.1, only domestic intermediate inputs are taken into account. Figure 4.2, again, also incorporates imported inputs. The coefficients of centrality or CC-values are given in Table 4.1 for Figure 4.1 and in Table 4.2 for Figure 4.2.

Let us first look at Figure 4.1 :

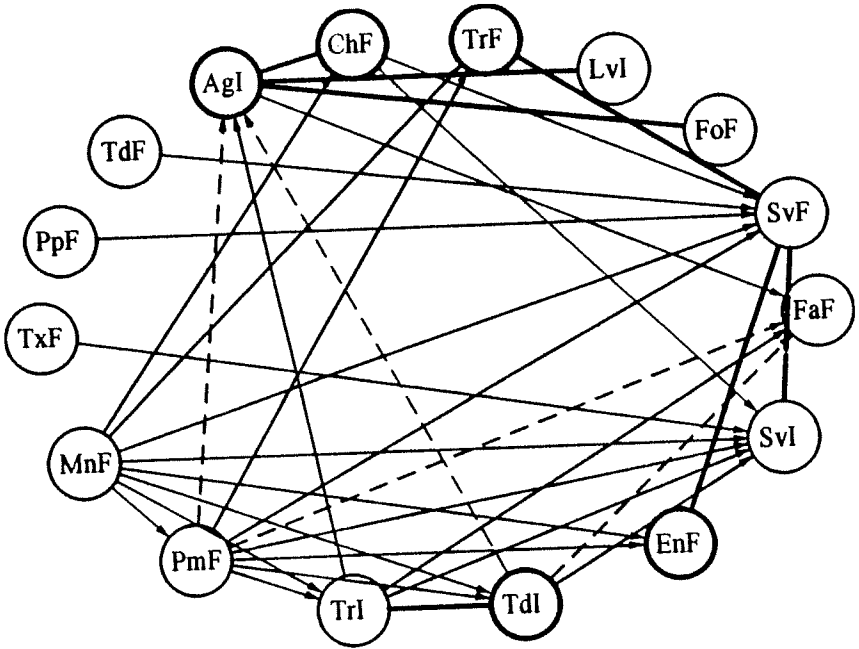
- among the 40 activities of the disaggregate IO matrix, 18 are interconnected. Thirteen of them belong to the formal sector and five to the informal one;



**Figure 4.1 : Disaggregated Linkages with Only Domestic Inputs**



**Figure 4.2 : Disaggregated Linkages with Domestic and Imported Inputs**



**Table 4.1**  
**Coefficients of Centrality of the Disaggregate IO Matrix**  
**[Only Domestic Inputs]**

| Activities                                    | CC-Value | Type of Activity |
|---|----------|------------------|
| <i>Formal activities</i>                      |          |                  |
| - Minerals [MnF]                              | 1.037    | central          |
| - Grain and flour [GrF]                       | 2        | sink             |
| - Miscellaneous food industries [FoF]         | 0.944    | central          |
| - Textile, clothing and leather [TxF]         | 0        | source           |
| - Paper and printing [PpF]                    | 0        | source           |
| - Petroleum industry [PmF]                    | 0        | source           |
| - Chemicals [ChF]                             | 1.898    | sink             |
| - Energy [EnF]                                | 0.421    | source           |
| - Hotels, bars and restaurants [HbF]          | 0.285    | source           |
| - Transportation [TrF]                        | 0.726    | central          |
| - Postal and telecommunication services [PtF] | 0        | source           |
| - Trade [TdF]                                 | 0.878    | central          |
| - Other services [SvF]                        | 1.658    | sink             |
| <i>Informal activities</i>                    |          |                  |
| - Agriculture [AgI]                           | 1.066    | central          |
| - Livestock [LvI]                             | 1.155    | central          |
| - Transportation [TrI]                        | 0.674    | source           |
| - Trade [TdI]                                 | 0.972    | central          |
| - Other services [SvI]                        | 1.588    | sink             |

Note : The isolated (i.e., excluded) *formal* activities are : fishing, meat and preserves, fish preparations, fats and vegetable oils, wood industry, construction materials, metallurgy and mechanical industries, construction, financial services. The isolated *informal* activities are : forestry, fishing, minerals, meat and preserves, fats and vegetable oils, grain and flour, miscellaneous food industries, textile, clothing and leather, wood industry, construction materials, metallurgy and mechanical industries, construction, hotels, bars and restaurants.

**Table 4.2**  
**Coefficients of Centrality of the Disaggregate IO Matrix**  
**[Domestic and Imported Inputs]**

| Activities                            | CC-Value | Type of Activity |
|---------------------------------------|----------|------------------|
| <i>Formal activities</i>              |          |                  |
| - Minerals [MnF]                      | 0        | source           |
| - Fats and vegetable oils [FaF]       | 1.902    | sink             |
| - Miscellaneous food industries [FoF] | 1.319    | sink             |
| - Textile, clothing and leather [TxF] | 0        | source           |
| - Paper and printing [PpF]            | 0        | source           |
| - Petroleum industry [PmF]            | 0.347    | source           |
| - Chemicals [ChF]                     | 0.986    | central          |
| - Energy [EnF]                        | 1.189    | central          |
| - Transportation [TrF]                | 1.250    | central          |
| - Trade [TdF]                         | 0        | source           |
| - Other services [SvF]                | 1.469    | sink             |
| <i>Informal activities</i>            |          |                  |
| - Agriculture [AgI]                   | 0.811    | central          |
| - Livestock [LvI]                     | 1.302    | sink             |
| - Transportation [TrI]                | 0.690    | source           |
| - Trade [TdI]                         | 1.111    | central          |
| - Other services [SvI]                | 1.416    | sink             |

Note : The isolated (i.e., excluded) *formal* activities are : fishing, meat and preserves, fish preparations, grain and flour, wood industry, construction materials, metallurgy and mechanical industries, construction, hotels, bars and restaurants, postal and telecommunication services, financial services. The isolated *informal* activities are : forestry, fishing, minerals, meat and preserves, fats and vegetable oils, grain and flour, miscellaneous food industries, textile, clothing and leather, wood industry, construction materials, metallurgy and mechanical industries, construction, hotels, bars and restaurants.

- the 18 interconnected activities cover 71.6 % of the country's gross output, which is slightly larger than in the case of the aggregated analysis where this percentage was 70.3. The informal interconnected activities cover, on their part, 71.3 % of the informal sector's total output, whereas the formal interconnected activities have an output equal to 71.8 % of the formal sector's total output;
- if we compare the aggregated set of interconnected activities (Figure 3.1) with the disaggregated one, the following emerges : agriculture and livestock which are solely informal activities remain in the new set; transportation, trade and other services also remain in both their formal and informal components; in the case of three activities, only their formal component now belongs to the set (minerals; miscellaneous food industries; textile, clothing and leather); four activities which are only formal and which were interconnected activities at the aggregate level remain so (paper and printing; petroleum industry; chemicals; energy); three new activities appear, two in their formal component (grain and flour; hotels, bars and restaurants), and one which is only formal (postal and telecommunication services); moreover, both components of metallurgy and metallic industries join the group of isolated activities;
- centrality is slightly affected by disaggregation, except in the cases where formal minerals and informal transportation become respectively central and source activities, whereas both components of other services are now sink activities.

More important to us are the types of linkages that the five informal interconnected activities have either with the other formal activities or between themselves, directly and indirectly :

- informal agriculture,  $AgI$ , has linkages of mutual supply with informal livestock,  $LvI$ , and formal miscellaneous food industries,  $FoF$ ; informal livestock has no other linkage than that of mutual supply with agriculture, thus forming a "bilateral chain" :  $FoF=AgI=LvI$ , a kind of domestic "technical paradigm";

- informal transportation, *TrI*, is a supplier to formal activities (grain and flour, miscellaneous food industries, chemicals, trade, other services) and informal ones (agriculture, *AgI*, and other services, *SvI*). It has a linkage of mutual supply with informal trade, *TdI*, and only buys from one formal activity; namely, petroleum industry, *PmF*;

- informal trade, *TdI*, is a supplier to two informal activities (agriculture and other services) having, moreover, as mentioned, a linkage of mutual supply with informal transportation. It also buys from formal activities (petroleum industry, *PmF*, and energy, *EnF*);

- informal other services, *SvI*, buy from formal activities (textile, clothing and leather, *TxF*, petroleum industry, *PmF*, energy, *EnF*, and transportation, *TrF*) as well as from informal ones (transportation, *TrI*, and trade, *TdI*). It supplies formal other services, *SvF*.

The linkage between formal transportation and informal other services may look surprising at first since, according to the IO table, transport used by informal other services is strictly informal. But these services consume textiles, petroleum and energy products that make intensive use of formal transport. The connection is thus indirect.

In a nutshell, informal activities that matter, at least in terms of production linkages, are either primary activities (agriculture, livestock) or tertiary activities (transportation, trade and other services). No informal industrial activity counts, they are all isolated. Linkages between informal and formal activities exist, the informal ones being either suppliers (transportation, trade) or buyers (other services). In two cases, even these linkages are between activities which produce the "same" product (informal and formal trade, informal and formal other services). Finally, linkages also exist between informal activities themselves (agriculture and livestock, transportation, trade and other services).

This general picture is hardly modified when imported inputs are included (Figure 4.2). Worth mentioning, however, in this new situation is that the appearance of

a new activity, formal fats and vegetable oils - and this for reasons already given in Section III - creates new linkages with the informal sector; namely, with agriculture, transportation and trade. This last connection comes from the direct use of informal transport and indirectly through agricultural products, mainly groundnuts which use informal transport and constitute essential inputs in the production of fats and vegetable oil. Another feature is the connection emerging between formal chemicals and informal other services. This results from the fact that informal services to enterprises and households buy imported chemical inputs such as paints, varnishes and rubber products. Finally, livestock does not become isolated as it did in Figure 3.2.

#### IV. CONCLUSIONS

The following main conclusions can be derived from the above analysis : 1) interconnectedness covers a considerable share of the Senegalese production sector (more than two thirds of the country's gross output), the informal sector having a share more or less equal when measured with respect to its total output; 2) indirect connections cannot be ignored when it comes to the interpretation of the linkage structure; 3) supply- and purchase-type linkages exist between informal and formal activities as between informal activities themselves; 4) in the case of the informal sector, interconnectedness, however, only takes part in primary and tertiary activities, whereas, in the case of the formal sector, industrial activities are also part of the picture; 5) the inclusion or exclusion from the analysis of imported inputs modifies the nature of interconnectedness in the case of the formal sector but leaves the informal one largely unaffected.

To these purely descriptive conclusions, one can add a more normative one : the existence of linkages between informal and formal activities producing the "same product" as for trade and other services suggests, following Watanabe (1983), that there might be room for subcontracting of traditional firms by modern ones as for the diffusion of technical progress from the latter to the former. This should, however, be substantiated by studies of a more micro nature.

The reader should also take our conclusions with some caution. First, there are the limitations of the data base. It covers only one year, 1990. The criterion of registration used to classify formal and informal units, as previously mentioned, remains rather rough, since it ignores several micro features. There is also undoubtedly an important part of the informal production which originates in the household sector and, as such, is obviously not covered by the IO matrix of intermediate transactions, the inputs for household production being part of final and not intermediate demand. Second, production linkages give only a partial picture of the existing interrelationships between activities. There may be credit linkages, marketing arrangements as well as labor movements which by definition are not reflected in intermediate transactions. Finally, a cross-section picture such as ours is also the product of a given institutional, social and economic environment. In particular, the observed transactions are influenced by the degree of tariff and nontariff protection, the foreign exchange value, the distortions introduced by the corporate taxation system and the labor laws which prevailed in the year under study. Indeed, the IO transactions are not, as it is too often assumed, only subject to technical determinants. For example, to what extent have the structural adjustment policies, pursued since 1990 by the Senegalese government, including a 50 % devaluation in January 1994 of the national currency (the CFA Franc), affected what we found for 1990? This remains an open question in the absence of a more recent data base.<sup>3</sup>

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<sup>3</sup>

For further discussion of the limitations of production linkage analysis for development and policy analysis, see McGilvray (1977) and Pack (1993), as well as Cella (1996) who introduced the distinction between "virtuous" and "vicious" interindustry linkages, depending on whether the price competitiveness of the activities is above or below a given threshold.



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**APPENDIX**  
**The MFA-method**

Contrary to conventional Qualitative Input-Output Analysis (QIOA) where the entries  $t_{ij}$  are directly taken from the intermediary transaction table T, the MFA does not use the transaction matrix T, but rather "layers" derived from it, which represent its respective *intermediary stages*. The splitting of the transaction matrix into several layers is based on the Eulerian row development of the inverse, in order to understand the indirect links more precisely. If we rewrite the transaction matrix T as :

$$T = A \langle x \rangle \quad (a.1)$$

where A represents the matrix of input coefficients and  $\langle x \rangle$  the diagonal matrix of the output vector x, we can further replace x by

$$x = R y \quad (a.2)$$

The Leontief inverse R is obtained with the usual conditions valid as :

$$R = I + A + A^2 + A^3 + \dots \quad (a.3)$$

Given these assumptions, the transaction matrix T can be divided into *layers* according to the Eulerian row development, where the first three layers are given here as an example :

$$T_0 = A \langle y \rangle \quad (a.4)$$

$$T_1 = A \langle A y \rangle \quad (a.5)$$

$$T_2 = A \langle A^2 y \rangle, \text{ etc.} \quad (a.6)$$

Finally, the filter value limits this extension because the creation of layers has to be continued until no more entry satisfies the minimal flow condition :

$$t_{ij}^k \geq \text{filter} \quad (\text{a.7})$$

for any  $ij$  with  $ij = 1 \dots n$  and  $k < n$ .

After the creation of layers  $T_k$ ,  $k = 1, 2, 3, \dots$ , the individual layers are worked through by entries. For each entry  $t_{ij}^k$  in the  $k^{\text{th}}$  layer, the entry value is tested whether or not the given filter value is surpassed, i.e., whether there is any information relevant for structure. Thus, the corresponding adjacency matrices  $W_k$  are obtained from the matrices  $T_k$  by the process of *binarisation* (i.e., setting  $w_{ij}^k$  to 1, if the entry surpasses the threshold; 0 otherwise). These adjacency matrices are then used in a graph-theoretical design in order to determine the links within the structure according to equation (a.8), where the matrix multiplications are done in a Boolean manner (i.e.,  $1+\#1 = 1$ ).

$$W^k = W_k W^{k-1} \quad (\text{a.8})$$

$W^k$  is reflecting the connections of sectors of the length of  $k$  steps. Once the single power matrices  $W^k$ ,  $k = 1, 2, 3, \dots$ , have been determined, *condensation* of these power matrices  $W^k$  to the dependency matrix  $D$  is done again by Boolean summation. Thus, an individual entry  $d_{ij} = 1$  if and only if there exist direct *or* indirect links between sectors  $i$  and  $j$  (of any path length  $< n$ ) which, altogether, sum up to a value greater than (or equal to) the chosen filter value. Thus, the minimal flow condition is assessed continuously through the intermediary stages of backward linkages, because of the compound flows being subject to that condition.

The aim of this graph-theoretical derivation is to calculate the so-called *connexity matrix*  $H$ , whose general term is :

$$h_{ij} = d_{ij} + d_j \quad (\text{a.9})$$

The connexity matrix  $H$  *qualifies* all connections by three indices, i.e., 0, 1, 2. This is an efficient standard graph-theoretical procedure in order to automatically label each sector with respect to its place within the total structural plot and degree of interconnectivity with others [cf. Harary et al. (1965)]. Individual values of  $h_{ij}$  denote the following :

- $h_{ij} = 0$ ,      sectors  $i$  and  $j$  are *isolated*,
- 1,      a *unidirectional* link exists between sectors  $i$  and  $j$ ;
- 2,      a *bilateral* (mutual) link exists between sectors  $i$  and  $j$ , i.e., the delivery flows between sectors  $i$  and  $j$  have at least the defined minimum.

The procedure described is done *about* 50 times for 50 equidistant scan levels. The resulting single  $H$  matrices of *each scan level* are then cumulated to the so-called  $H_{cum}$  matrix, which is the starting point of extracting an "average" overall structure defined as the characteristic structure of the table under study [for details, see Schnabl (1994)].

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