Assessing the Economic Impact of an Agricultural Project in a Petroleum-Exporting Country
The Case of Palm Oil in the Republic of Congo

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**Paper prepared for presentation at the EAAE 2011 Congress
Change and Uncertainty**
Challenges for Agriculture,
Food and Natural Resources

August 30 to September 2, 2011
ETH Zurich, Zurich, Switzerland

1. Introduction[1]

The international institutions dealing with major challenges of current economic underdevelopment (FAO, 2010; UNCTAD, 2010) have recently confirmed that agricultural development is one of key driving forces on the road to a sustainable and lasting growth for developing and least developed countries. Not only agricultural investments help peasants, households and whole agricultural sector itself to escape from poverty; these investments have also important economy-wide impacts at both local and national levels. The quantification of these economy-wide impacts, however, is also controversial since others are the sectors (construction, infrastructure, manufacturing) often considered to be those with the large multipliers on the rest of the economy. Assessing and quantifying the economy-wide impact of agricultural development project in these countries is, therefore, of crucial importance. Nonetheless, such an assessment depends on three orders of critical aspects. On the one hand, the economy–wide impact is substantially influenced by how the economy itself is structured, in particular by the presence and the role of some strategic and predominant sector. On the other hand, the impact largely depends on how the agricultural project itself is designed and implemented. It may focus on intensive small-scale agriculture or on extensive large-scale agriculture; it may be oriented to production of agricultural products for local and national consumption or may be export-oriented. Finally, the assessment depends on the methodology used to estimate the impact as the choice of the methodological approach is in no case neutral and may substantially affect the eventual results.

The present paper presents an assessment of the economic impact of an agricultural pilot project in the Republic of Congo. This country is not actually considered among the African least developed countries as it achieved a relatively higher (compared to bordering countries) income levels and living standard particularly for the strong relevance assumed within the national economy by crude oil extraction and exportation. For this reason, UNCTAD classifies the Republic of Congo among the major petroleum exporting developing countries (UNCTAD, 2010). As matter of fact, this strong specialization of the national economy leaves the agricultural sector, its current potentials and limits relatively in the background. Nonetheless, the development of the agricultural sector and production remains among the crucial objective of the country strategic development plans for the forthcoming years and decades (Comite National de Lutte Contre la Pauvrete, 2007).

The agricultural investment under consideration is carried by an Italian multinational company that signed in August 2008 a memorandum of agreement with the Government of the Republic of Congo for carrying out a large agricultural project. The latter consists in cultivating oil palms in specific areas of the Republic of Congo. The oil extracted by palms will be used as food (both direct human consumption and food

processing), thus contributing to reduce to currently strong dependency on vegetable oil imports.

The choice of oil palms amongst oil plants is motivated by the fact that it is considered as the only really viable option taking account several factors: proven experience on an industrial scale, high productivity, low seasonality, significant amount of residual organic material that can be used to improve soil fertility. Three areas were identified for the location of Palm plantations, in the regions of Niari, Pool and Djambala, respectively. Despite the choice of the palm, which guarantees the highest production of oil per hectare, the amount of land that the project plans to cultivate to achieve the production target is remarkable (several tens of thousands of hectares). However, before starting with the whole agricultural project, a pilot project applied to a much more limited area is carried out. This aims at testing the feasibility of the project idea and at obtaining useful information to improve the effectiveness of the entire project. Even more important, here, this pilot project should allow a tentative quantification of the positive effects of the whole project on the economy of the Republic of Congo.

This paper deals with these latter issues, that is, the assessment of the wider economic impact that such agricultural project can produce. This assessment is noticeably different in developing countries as data needed for such assessment exercises are often lacking. This paper presents a study finalised to assess economic-wide repercussions deriving from the pilot project. It describes the modelling framework and some of the most significant results of this study. In particular, the assessment has been carried out by constructing and applying a multi-regional I-O model of the Republic of Congo that represents a first attempt to describe the economic structure of the country within this kind of models.

The paper is articulated as follows. Section 2 describes the main characteristics of the pilot project and provides a short economic overview on the regions involved in the project. Section 3 illustrates the methodology adopted. Section 4 summarizes the results, that is, the economic impacts of the pilot project. The final section concludes.

2. Description of the project

The objective areas of the project are in the Republic of Congo. This country (also known as Congo-Brazzaville) is a former French colony located in the central-western part of sub-Saharan Africa. In 2009 there were 3.7 million inhabitants, of whom about 97% were under 65 years old. 85% of total population lives in few urban areas, namely in Brazzaville, Pointe-Noire, or one of the small cities or villages along the railway which connects the two cities. For this, Congo is one of the most urbanized countries in Africa. In rural areas, industrial and commercial activities have rapidly declined in recent years, leaving rural economies dependent on government support and subsistence. The country has serious infrastructural deficits and a weak agricultural tradition despite its favourable environmental conditions. Its economy is largely based on petroleum extraction and export and on those industries and services somehow linked to this activity. Currently (2009 data), the per capita annual GDP in the country is about to 2,600 US dollars, a relatively high value compared to many other sub-Saharan countries such as, for instance, the bordering Democratic Republic of Congo. The oil (petroleum) sector accounts for 65% of the GDP, 85% of government revenue, and 92% of exports.

The pilot project of oil palms cultivation is based on two demonstration units (or modules) each one consisting of:

- a oil palm cultivation plant of 2,500 ha, corresponding to about 357,500 palm trees;
- a complete nursery area of about 70 ha (2 pre-nursery, 68 main nursery);
- plants for pumping and distributing irrigation water;
- an agro-industrial centre for storing products, raw materials and chemicals and for enhancing agricultural production with a section for oil extraction, food processing and final packaging for national or international markets;
- a unit for producing electricity and steam from wasted biomass and industrial production water to satisfy energy requirements of modular units;
- means of transportation for products and raw materials and operative means for agricultural production.

These two demonstration units are located in the regions of Pool and Niari, respectively (Figure 1). These two regions share some general characteristics. Due to a very limited industrial development and with tertiary activities concentrated in urban centres, agriculture remains the prevalent activity in the rural areas, though often based on subsistence productions (staple food) and with a poor development of the downstream food industry. The infrastructure endowment is poor. Nonetheless, compared to other internal regions of the country, both regions are not so far from both the seaside and the capital town, therefore from the core of the petroleum-based national economy. This, by itself, provides more opportunities of development.

Both demonstration units are far from residential areas and therefore the investment has to provide all infrastructure, facilities and buildings that are necessary to their management, such as, sheds for storing machinery and tools, workshops, warehouses, buildings for storing products, canteen, offices, nursing, a structure dedicated to training courses and seminars and other civilian buildings. Adequate internal circulation and access to major roads has also to be provided. The two production modules are expected to become fully operative starting from the eighth year since their implementation. The total investment (of more than 40 million US dollars) is made of 73% of machinery and transport means and the remaining 27% of buildings and roads. The 64% of the investment concerns the demonstration unit in Niari region whereas the remaining 36% the unit in the Pool region.

3. Methodology

The approach used to estimate the economic impacts generated by the pilot project over its various stakeholders (i.e., suppliers, employees, government, etc.) is based on a multiregional demand-driven I-O model of the Republic of Congo. Despite some criticism that its restrictive assumptions can arise (Gerking *et al.*, 2001), the Input-Output (I-O) model is still being considered as a valid tool to quantify the economy-wide impacts generated by a final demand variation over a given time period in terms of output and, by simple extensions, of value added and employment (Doyle et al., 1997). In particular, it can be effectively used to estimate impacts that a new activity (or a new sector) generates in a given economy (Miller and Blair, 2009). For this, it is been often

used in assessing the economy-wide impacts generated by single investments or projects. Some examples of studies based on I-O models and applied to agricultural and food-processing investments in Africa are Bureau for Economic Research and Quantec Research for the South African Breweries Ltd. (2008), Kapstein et al., (2009), Econex and Quantec Research for the South African Breweries Ltd. (2010).

An I-O analysis considers the inter-industry relationships in an economy, depicting how the output of one industry flows toward another industry where it is used as an input. As a consequence, it is possible to trace economic interdependencies among producers of goods and services, or how one industry depends upon another one as both a customer of output and a supplier of inputs. Due to the possibility of taking into account relationships among sectors and, through apposite extensions, between these latter and social sectors like households, an I-O model is able to capture three types of effects: direct, indirect and induced effects. Direct effects are strictly related to the activities carried out within the project (i.e. direct increase in output, employment, income, investments in plants and equipment and taxes paid). Indirect effects derive from the existence of linkages among sectors, which induce input providers to increase their production to satisfy requirements of upward sectors activated by the initial final demand variation. Finally, induced effects are those variations which are generated by increases in household consumption due to increases in income produced by the initial final demand change.

A multiregional I-O model has further advantages in comparison with single-country or single-region models. Firstly, it allows the capture of those effects that are produced by spatial linkages among industries (interregional feedback and spillover effects). Secondly, it is consistent with the objective of measuring overall effects produced by projects whose impact is likely to go beyond the local context. Third, it allows the analyst to assess the distribution of the impact across space. Finally, a multiregional approach table ensures more internal consistency than a single-region table since the sum of flows and components must equal the aggregate (national) ones.

Though based on stronger assumptions and, in fact, capable of providing more limited information, an I-O approach is a feasible tool compared with the more demanding SAM-based CGE models. It represents the best compromise between a consistent assessment of economy-wide impacts of an investment and the scarce data availability on the regional economic structure that characterises most developing countries and, in particular, the Republic of Congo.

The rest of this section is articulated as follows. Section 3.1 describes analytical foundations of the multiregional I-O model here used to estimate impacts. Section 3.2 illustrates the data used and the procedure adopted to update and regionalise the I-O model. Section 3.3 illustrates how project's impacts have been modelled and computed. Finally, section 3.4 describes the sensitivity analysis carried out to test the robustness of results.

3.1. The multiregional I-O model

A multiregional I-O model is based on an I-O table that describes both inter-industry relationships and interregional trade of the regions involved. Here, the multiregional I-O table involves three regions: the Niari region, the Pool region and the rest of the country.

The project is modelled within this I-O framework as a new sector or activity adding a row and a column (one for each region involved by the project) to the multiregional I-O table. The column describes the purchases made within the project. It is assumed that

the new sector purchases all the necessary inputs from sectors of the region of the investment and, therefore, it does not import any input from other regions. The row is left entirely blank except for the fraction of palm oil private consumption thus behaving as an exogenous variable. The column sum equals the row sum and corresponds to the project's planned output. The hypothesis is that all output is consumed. Therefore, output (supply) always equals consumption (demand).

The augmented multiregional I-O model takes the following form:

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\begin{bmatrix} x_p^N \\ \mathbf{x}^N \\ x_p^P \\ \mathbf{x}^P \\ \mathbf{x}^C \end{bmatrix} = \left(\mathbf{I} - \begin{bmatrix} 0 & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{a}_p^{NN} & \mathbf{A}^{NN} & \mathbf{0} & \mathbf{A}^{NP} & \mathbf{A}^{NC} \\ 0 & \mathbf{0} & 0 & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{A}^{PN} & \mathbf{a}_p^{PP} & \mathbf{A}^{PP} & \mathbf{A}^{PC} \\ \mathbf{0} & \mathbf{A}^{CN} & \mathbf{0} & \mathbf{A}^{CP} & \mathbf{A}^{CC} \end{bmatrix} \right)^{-1} \times \begin{bmatrix} fd_p^N \\ \mathbf{fd}^N \\ fd_p^P \\ \mathbf{fd}^P \\ \mathbf{fd}^C \end{bmatrix} \qquad (1)
$$

where: subscript p indicates the project; superscripts N, P and C indicate the Niari, the Pool and the "rest of the country" regions, respectively. $\mathbf{x}$ is output vector; $\mathbf{I}$ is the identity matrix; $\mathbf{a}_p$ is the vector of purchases of the project's sector from other sectors. $\mathbf{A}^{ii}$ is the intraregional input coefficients matrix of region, $i = \{N, P, C\}$; $\mathbf{A}^{ij}$ is the interregional trade coefficients matrix between region i and region $j = \{N, P, C\}$ (exports from region i to region j, or imports of region j from region i) and $\mathbf{fd}$ is the final demand vector.

The sum of each column of the inverse matrix reported in model (1), the so-called Leontief inverse, represents a sector output multiplier that measures the overall output variation (direct and indirect) in the Congo economy produced by a change in final demand of one monetary unit. In the case of multiregional models, the variation also takes account of spillover and feedback effects deriving from spatial linkages. One of the advantages of this kind of models is to allow the analyst to distinguish variations occurred in a given region from those occurred in the rest of the country.

To assess the impact also in terms of employment, the inverse matrix has to be transformed into an employment inverse matrix as follows: $\mathbf{em} = \hat{\mathbf{e}}(\mathbf{I} - \mathbf{A}^*)^{-1}\mathbf{fd}^*$, where $\mathbf{em}$ is a vector of employment, $\mathbf{e}$ is a vector of employment coefficients, $\mathbf{A}^*$ and $\mathbf{fd}^*$ are the coefficient matrix and the final demand vector shown in equation (1), respectively. Similarly, to capture the effects in terms of value added (labour income, profits, taxes, total value added) generated by final demand variation, the I-O model has to be modified converting goods and services flows into value added flows, i.e.: $\mathbf{in} = \hat{\mathbf{h}}(\mathbf{I} - \mathbf{A}^*)^{-1}\mathbf{fd}^*$, where $\mathbf{in}$ is a vector of value added, whilst $\mathbf{h}$ is a vector of value added coefficients obtained as ratios between sector value added and outputs.

In order to compute induced effects, the I-O model has to be closed with respect to household sector. In other words, household sector is made endogenous to the I-O model. Technically, this means adding a row and a column to the input and trade coefficient matrix and to calculate the Leontief inverse. The row is made up of labour income coefficients, obtained as ratios between labour income and outputs, and the column is given by consumption coefficients obtained by dividing private consumption of each sector by total consumption.

3.2. Data and regionalization procedure

The starting I-O table of the present study is a 2007 18-sector I-O table of the Republic of Congo. In turn, it derives from a 1967 18-sector I-O table evaluated at purchaser's prices (Coordination générale des services de planification, 1967).[2]

This old table was first converted to producer's prices by removing trade margins and moving them to the trade sector. Then, it was updated to 2007, the year of the most recent available data. Updating has been made in two steps. In the first step, the well-known RAS (or bi-proportional) adjustment technique (Stone and Leicester, 1966) has been applied to the full I-O table using as row and column totals 2007 data on sectoral outputs, primary inputs and final demand sector.[3] The RAS technique is adopted since the respective multiplier-based adjustments should potentially capture technological changes through the measurement of fabrication effects, by varying the ratio between primary inputs and intermediate inputs, and substitution effects caused by price differences. As in Bonfiglio (2006a), sectoral outputs have been estimated supposing that they varied from 1967 to 2007 at the same rate as sectoral value added, this latter taken from official statistics (CNSEE, 2009). Also data on total imports and final demand come from official statistics. Distribution of the total value added among its main components has been initially estimated using information from the old I-O table.

The application of RAS technique produced a first estimates of the updated I-O flows then used as a starting point of the second step of the updating procedure. In this second step, a cross-entropy optimization procedure (Golan et al., 1994) was applied to embed into the I-O table all the superior data available and to balance the table. In comparison with other constrained techniques like RAS the cross entropy approach has the advantage of higher flexibility allowing inclusion of additional information and making estimation possible even with lack of data (information) (Robinson et al., 2000). Therefore, the joint use of RAS and cross-entropy optimization techniques should guarantee a satisfactory level of reliability of the updated table. The result of this updating procedure is a 2007 I-O table describing all economic transactions occurring within the national economy.

This updated national I-O table was then regionalized to derive the multiregional I-O model. The choice of regionalising the national table is due to the lack of data on intraregional and interregional sectoral flows. This is a frequent problem in regional studies commonly faced by introducing over time indirect techniques reducing the need for primary data (Chenery, 1953; Moses, 1955; Leontief and Strout, 1963; Polenske, 1970). In the case of a bi-regional I-O model, the Round's interregional approach (Round, 1972; 1978; 1983) can be a straightforward solution. This approach derives

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[2] The choice of an old table as a starting point is motivated by the lack of most recent data. In a study concerning the distributional impact of oil subsidies in the Republic of Congo (Bessaha A. and Karpowicz I., 2008), a mention is made to a 2005 national 18-sector I-O table that would have been used to carry out the analysis. However, in interpellating the authors, it was replied that the data used come from a household survey conducted by the Centre National de la Statistique et des Études Économiques in 2005. In any case, there is no evidence about the existence of a more recent official I-O table of the Republic of Congo.

[3] The 1967 Congo I-O table reports many null intermediate flows reflecting an underdeveloped economic structure. Since from 1967 to 2007 economic structure can be changed significantly, to take account of possible strong changes, zeroes have been replaced with small quantities. This allows RAS technique to adjust also null values, obtaining a picture that better reflects the changed inter-industry relationships. Moreover, it avoids convergence problems.

both interregional imports and exports and offers a higher degree of internal consistency than single region applications. A problem associated with this technique is that there is no obvious extension of the approach to multiregional input-output tables, that is, involving three or more regions (Hewings and Janson, 1980). For this reason, we adopted the Bonfiglio's (2006b) approach which extends Round's idea to constructing multiregional models. This approach is based on the application of a three-stage estimation method. Stage 1 consists in the application of a location quotient technique to estimate the intersectoral flows within a given region (the input coefficient matrices, $\mathbf{A}^{ii}$) and imports of the region from the rest of the country (total trade coefficient matrix,

$\sum_{j \neq i} \mathbf{A}^{ji}$). In particular, the Augmented Flegg *et al*. Location Quotient (AFLQ) (Flegg and Webber, 2000) was used in this study. The choice of this method is motivated by recent empirical evidence indicating that it produces more reliable multipliers in comparison with other regionalisation techniques (Bonfiglio and Chelli, 2008; Bonfiglio, 2009).[4]

In stage 2, a gravity model is used to allocate total imports of a given region among the other regions (trade coefficients matrices, $\mathbf{A}^{ij}$). The hypothesis is that the probability of attraction of import flows exerted by a region is an indirect function of its distance from the import region and a direct function of its ability to attract import flows, approximated by sector outputs.

The two stages described above are repeated recursively as many times as the number of regions under study. The result of this iterative process is an 18-sector-by-3-region I-O matrix that has been successively converted into intermediate flows multiplying coefficients by output data.[5]

Finally, stage 3 consists in the application of a non-linear optimization technique (here a cross-entropy-based technique is used) to reconcile discrepancies within the multiregional I-O table and inconsistencies with respect to the national I-O table. In this phase, all the available superior data can be used in order to increase the reliability of the table.

The very final stage of the adopted approach includes the project within the multiregional model by deriving the relevant vectors of input purchases. Detailed information about project's intermediate purchases and output over eight years was used. These data include capital expenses, operative expenses and revenues. As there is not a direct correspondence with sectors of the I-O table, for any expense a typology

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[4] The AFLQ is based on a parameter δ, which allows greater modification for regional imports. A value of $\delta = 0.36$ was chosen since Bonfiglio (2009) showed that it has the highest probability to be the best value at different regional levels.

[5] Regional outputs have been first estimated by applying regional and national employment ratios to national outputs and further adjusted using the simple location quotient. Outputs of the rest of the country (region C) have been calculated by difference. Then, regional sectoral outputs have been constrained to the relevant national outputs. Employment data are officially available at a national level at a lower sector detail than that of the I-O table. Therefore, these available national employment data were disaggregated using sector output ratios. Then, regional employment data were derived from the national ones on the basis of economic and social indicators (particularly, population and agricultural workers ratios) and expert judgment. Final demands and primary inputs have been first derived in the same way as outputs and then constrained to the difference between outputs and a sum of intermediate sales and purchases, respectively. Final demands and primary inputs of the rest of the country (region C) have been obtained by difference.

(intermediate cost, investment or primary input) and a respective I-O sector were identified.

The output of the project corresponds to its revenues from palm oil. The project starts producing revenues (thus output) from the fourth year onwards. Therefore, the new sector related to the project can be added to the multiregional I-O table only starting from the fourth year. By dividing project's intermediate flows by output, project's input coefficients can be derived. Evidently, as both intermediate costs and planned output vary over years, the structure of project's input coefficients changes, as well, and stabilises from the eighth year onwards.

To estimate other impacts, in addition to project's output, and to calculate induced effects, value added, labour unit and consumption coefficients for the project's sector have been calculated using relevant and detailed information (expected value added, labour use and final consumption, which equals output by assumption).

3.3. Modelling project's impacts within the I-O model

As mentioned, the pilot project enters the I-O model as a new sector producing palm oil for food consumption and processing. Before the production sites become operative, however, the project carries out several preliminary operations such as construction of buildings and roads, land preparation for cultivation, creation of nursery areas, irrigation plants and oil processing centres, purchases of inputs (agricultural inputs, fuel, mechanical services, maintenance and training). All these operations, in addition to output production, are expected to generate positive effects in the economy. Therefore, the study models all these impacts within the I-O framework used for a complete assessment.

Construction of buildings and roads is modelled as an increase in consumption of goods produced by the construction sector of the local (regional) economy. Investments in machinery, plants and transport means are modelled as increase in investment demand related to the corresponding I-O sectors. These final demand changes, however, only occur if capital goods come from local (regional) industries. In other words, if machinery, transport means and equipment are imported no variation of local final demand and, therefore, of output occurs. In this regard, according to the available information, the pilot project requires imports for about 17% of investments whereas the remaining 83% will be purchased locally leading to an increase in local final demand. Input purchases enter the I-O model as increases in consumption of goods produced by the relevant sectors. This is the same as treating the subjects involved in the project and responsible for purchases as final consumers.

Starting from the fourth year since their implementation, the sites begin producing palm oil then becoming fully operative at the eighth year. Assuming that all production is purchased by final demand sector, the impact generated by palm oil production is modelled as an increase in palm oil consumption, which equals the expected revenues.

3.4. Sensitivity analysis

As mentioned, due to the lack of more recent data, the I-O table here used for impact analysis has been derived updating a quite old I-O table. Even though the procedure of updating took account of possible structural changes and embedded all available superior (and more recent) data, it might have generated a table that is not fully representing the real regional economic structure, thus influencing the reliability of the

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impacts estimated. In order to test the plausibility of results, a sensitivity analysis has been carried out by adopting an alternative starting I-O table.

The objective of this kind of analysis is twofold. Firstly, it aims at studying whether and to what extent the impacts generated by the adopted I-O approach are robust and thus reliable (that is, the extent to which they do not depend on the starting data used). Secondly, it compares impacts generated by the same agricultural investment within an economy strongly depending on crude oil extraction and exportation (Republic of Congo) and within an economy with a pretty different internal sectoral structure.

The alternative I-O table adopted is a 2001 I-O table of the Democratic Republic of Congo evaluated at producer prices[6]. This table is relatively recent but concerns an economy that substantially differs from the Republic of Congo, though they are bordering countries. The Democratic Republic of Congo is located in the central part of Africa and it is much bigger (the third largest African country counting about 70 million people). It is included among the African least development countries in the last UNCTAD report (UNCTAD, 2010). In 2009 per capita GDP was 160 US dollars. However, much economic activity occurs in the informal sector and is not reflected in GDP data. It is not a major petroleum producing and exporting country but the economy still heavily relies on mining. Given the strong differences between the two countries, the corresponding results of the present impact assessment can differ considerably. Nevertheless, the use of an alternative table related to a much less petroleum-dependent economy can provide a valid comparison to assess robustness and plausibility of results.

4. Results

This section reports a selection of the estimated impacts of the palm oil pilot project according to the multiregional demand-driven I-O model described in previous sections. The main interest, here, is on distinguishing direct, indirect and induced effects, as well as to analyze how these effects distribute across space and sectors. Impacts that are reported concern value added, its components (household income, profits and savings, and taxes) and employment.[7] This section, in particular, reports the impacts generated over the first eight years of the investment, corresponding to the period that is needed to implement the project and make it fully operative (starting from the eighth year).

Results show that the project generates 88.5 million US dollars in value added for the whole national economy in eight years, corresponding to an average annual increase of 1.2% of GDP with respect to the observed 2007 level (Table 1). Of this, 50% comes from direct effects, 27% from indirect effects and 23% from induced effects. In other words, the direct effects of the project and the remaining effects due to sector linkages and induced purchases both corresponds to about 50% of total impact. Each component of value added (household income, profits and savings, taxes) roughly shows the same distribution across these three effects. Of the three components, "profits and savings" is

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[6] The 2001 I-O table of the Democratic Republic of Congo has been extracted from the GTAP African database (*Global Trade, Assistance, and Production: The GTAP 6 Data Base*, Center for Global Trade Analysis, Purdue University).

[7] Impacts can be quantified both partially and totally. In other words, they can be evaluated by assuming, respectively, that only one module (either the Niari module or the Pool module) or both modules are operative. In this way, it is possible to separate the effects generated by each module from overall effects generated by the whole project. In this paper, for lack of space, we only report overall impacts.

the largest (almost 50%) corresponding to an average yearly increase of 1.1% in total profits and savings of the national economy.

The impact on household income is generated through the payment of wages and salaries to both the directly involved workers and employees of input. The overall impact of the project amounts to a yearly average increase of 1.3% of the national household income.

Finally, the project provides a direct contribution to the national government through the taxes paid on incomes generated by the project both directly and indirectly. In particular, taxes show an annual average increase of 1.3%.

In terms of employment, the project generates over the 8-year period more than two thousand labour units directly. Since the project activates production in other sectors due to indirect and induced effects, further labour units are generated. This additional increase amounts to 1,224 labour units (659 attributable to indirect effects, 565 to induced impacts), which are equivalent to 153 units averagely. The total impact on employment is, therefore, of about 3.3 thousand labour units in eight years, of which 63% are due to direct effects. Average labour units, amounting to 415, provide an estimate of new jobs created. If compared to the national total employment in 2007, the project generates, therefore, a small increase of 0.3%.

A synthetic measure of the effects generated by the project on the overall economy is obtained by dividing impacts by total final demand changes. This ratio can be referred as a conversion index of the project, i.e. the extent to which one US dollar deriving from the project as investment, input demand or final consumption is converted in economy-wide benefits. This index can be useful for policy makers to make comparisons with alternative but similar projects and to evaluate the corresponding economic profitability for the whole country. It turns out that for every 100 US dollars of direct expenditure, the project generates further 99 US dollars of value added (31$ of household income, 49$ of profits and savings, and 17$ of taxes).

Analysing the distribution of the impact by sector, it turns out that most impacts, and especially employment, are produced, as expected, in the new sector related to the project (the palm oil sector) (Table 2). Further sectors benefiting from the project, are, in particular, the mining sector, consistently with its importance within the national economy, and those sectors involved in the implementation of the project, such as construction and machinery sectors. In terms of employment, in addition to the new sector, tertiary sectors such as other services and financial sectors are also interested by significant impacts.

Although the project directly involves only two regions, the existence of interregional linkages with the rest of the country spread part of the effects outside these regions (Figure 2). In fact, about 70% of total impact in terms of value added and of its components remains within the Niari and Pool regions, whilst about 30% spills over the rest of the country. The share of impact retained by the regions is even higher (80%), in terms of employment.

As mentioned in the previous section, in order to carry out a sensitivity analysis, the project's impacts have been also computed using an alternative starting table, the 2001 Democratic Republic of Congo (DRC) I-O table. The corresponding results were compared to the previous ones by computing the respective % variation (the row *Total DRC (Var. %)* in Table 1). Results indicate that, as expected, impacts significantly differ since the two starting tables (i.e., economies) are quite different. Nonetheless, they are not too far and this can be an evidence of robustness of results. In particular,

value added (except for taxes) and employment impacts generated in the case of the DRC table are higher, particularly in the case of induced effects. This can be attributed to a markedly higher weight of intermediate purchases (sales) in relation to output, characterising the Republic of Congo and to the strong presence of petroleum sector in the economy. The consequence is lower value added (except for taxes) and employment coefficients in the case of the Republic of Congo. A higher weight of intermediate inputs with respect to output can be an artifact of the adopted updating procedure which could have caused an overestimation of output and relevant sector multipliers. If, on one hand, this can influence the reliability of results, on the other hand, it suggests that impacts here measured in terms of value added and employment can be considered as prudential estimates of the real effects induced by the project that would be, in fact, higher.

5. Concluding remarks

The analysis carried in this paper suggests that the agricultural project here considered, consisting in producing palm oil for food consumption and processing, is expected to produce significant economic effects in regional and national contexts well beyond the initial and direct impacts. This occurs because there are sectoral and spatial linkages that amplify the first round effects. In particular, the economy-wide impacts of the project in terms of value added are double of the direct effects, whereas the multiplicative effect in terms of employment is a little lower (i.e., 1.6).

From a methodological point of view, the paper aims at illustrating how an agricultural project, and its effects can be modelled using an I-O model. A project does not produce impacts only when it becomes operative (i.e. when its output and the relevant sector appears in the economy) but also during its phase of implementation. Therefore, it becomes important to capture also those effects that are produced during this initial phase for a complete assessment.

A further interesting result of this study is the derivation of a multi-regional I-O model for the Republic of Congo, which can be used by policy makers and analysts to assess overall impacts of single projects, policy interventions or programmes or various shocks, by also taking into account sectoral and spatial linkages. This result is particularly valuable if one considers the actual scarcity of data. The sensitivity analysis carried out to assess robustness of results supported the plausibility of the key results and, therefore, the overall reliability of the I-O model used.

Nevertheless, results are still affected by model and data limitations and should be therefore taken with caution. One of these methodological limitations is, for instance, the implicit assumption that prices are constant. Even though the underlying justification is that the market-level impact of the project on prices is negligible due to its limited size, it remains true that, on some specific markets, this impact can be, in fact, significant and may affect results.

Beside these limitations, some possible developments can be suggested to improve the reliability of results. First of all, better data could be helpful and, in particular, updated (even regional) and more disaggregated I-O tables, as well as additional and more detailed superior data. Secondly, as the objective is to assess the impacts of projects that develop over time, the analysis could be refined by adopting a dynamic and, preferably, variable I-O model. However, this latter and, in general, more demanding

models (like SAM-based CGE models) are particularly data-intensive and thus unsuited to situations characterised by severe data limitations.

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Figure 1 – The Republic of Congo, regional administrative borders: the two regions involved in the project, Niari and Pool
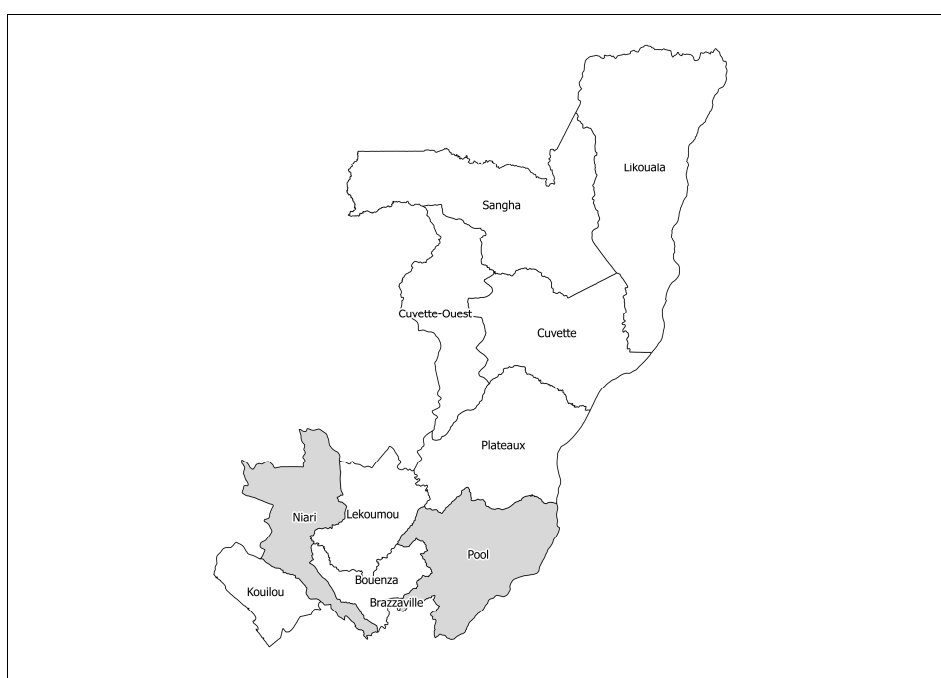
Table 1 – Impacts generated by the pilot project and sensitivity analysis, Republic of Congo

Impact	Value added (US thousand dollars)				Employment (units)
	Household income	Profits and savings	Taxes	Total	
Direct					
Total	14,109.2	21,170.8	7,245.6	44,249.8	2099.5
% of Economy-wide impacts	50.7	48.5	47.3	50.0	63.2
8-year Average	1,763.7	2,646.4	905.7	5,531.2	262.4
Total DRC (Var. %)[a]	*32.3*	*31.2*	*-26.7*	*20.9*	*5.5*
Indirect					
Total	7,957.5	12,066.4	4,342.9	24,366.9	658.8
% of Economy-wide impacts	28.6	27.6	28.3	27.5	19.8
8-year Average	994.7	1,508.3	542.9	3,045.9	82.4
Total DRC (Var. %)[a]	*13.5*	*32.9*	*-87.0*	*5.2*	*19.9*
Induced					
Total	5,740.5	10,409.1	3,734.5	19,884.1	564.9
% of Economy-wide impacts	20.6	23.8	24.4	22.5	17.0
8-year Average	717.6	1,301.1	466.8	2,485.5	70.6
Total DRC (Var. %)[a]	*210.3*	*116.1*	*-75.6*	*107.3*	*104.7*
Total (economy-wide)					
Total	27,807.3	43,646.3	15,323.1	88,500.8	3323.1
Var. % 2007	1.3	1.1	1.3	1.2	0.34
8-year Average	3,475.9	5,455.8	1,915.4	11,062.6	415.4
Conversion index	31.0	48.6	17.1	98.6	3.7
Total DRC (Var. %)[a]	*63.7*	*51.9*	*-55.7*	*36.0*	*25.2*

[a] Total DRC refers to total impacts estimated by using the 2001 I-O table of the Democratic Republic of Congo. Variations are obtained as: (Total DRC – Total) / Total.

Table 2 – Sectoral impacts (in %) generated by the project , Republic of Congo

	Value added				Employment
	Households	Profits	Taxes	Total	
Palm Oil Project	**27.6**	**39.2**	**31.5**	**35.4**	**60.4**
Agriculture	1.5	8.6	1.3	4.9	2.0
Forestry	0.8	0.1	0.5	0.4	0.0
Mining & Quarrying	17.5	26.3	19.6	21.9	0.0
Energy & Water	0.8	0.4	0.9	0.6	0.7
Food Industry	1.9	0.7	3.9	1.6	0.0
Beverages &Tobacco	0.5	0.4	3.6	1.0	0.0
Footwear &Textiles	0.2	0.2	0.4	0.2	0.0
Wood	0.3	0.0	0.2	0.2	0.1
Rubber, Paper, Fuel, Chemicals	2.3	0.3	4.5	1.6	0.4
Mineral & Non Mineral	0.1	0.0	0.0	0.0	0.0
Metal Products	0.4	0.1	0.8	0.3	0.1
Machinery and transport Equipment	10.7	2.4	8.0	5.9	1.2
Other manufacturing	0.0	0.0	0.0	0.0	0.0
Construction	15.5	6.4	8.5	9.5	1.1
Trade	8.2	3.4	7.1	5.5	0.1
Transport and communication	5.2	1.2	3.6	2.8	1.2
Finance and intermediation	3.0	0.6	2.6	1.7	14.8
Other services	3.6	9.7	3.0	6.4	17.8
TOTAL	100.0	100.0	100.0	100.0	100.0

Figure 2 – Regional and extra-regional economy-wide impacts induced by the project (in %), Republic of Congo