Family size, human capital and growth: structural path analysis of Rwanda

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Abstract

This paper analyzes the role that different household groups play in human capital formation, sectoral growth and income distribution in Rwanda. Using the 2006 SAM of Rwanda, the paper calculates accounting multipliers to characterize the transmission of economic influences stimulated by an exogenous income injection. The paper further explores macroeconomic implications of family size for human capital, sectoral growth and income distribution, drawing on the pathways identified by structual path analysis. The following two findings are noted. First, the smaller the number of children in an average family, the higher the investment in human capital of the children in that family, demonstrating the presence of quantity-quality trade-off. In particular, the household group with 1-3 children tends to spend more for the improvement of education and health status of children than those household groups with more than 3 children. Second, an improvement in human capital leads to a significant increase in agricultural production and that households with 1-3 children act as an important intermediate pole transmitting the influence of human capital investment on agricultural production. In conclusion, promoting family planning programs in Rwanda thus seems to be a viable strategy for economic growth and poverty reduction, considering the current average family size of 5 children.

1 Background and Introduction

The role of human capital in economic growth and development has been well documented in the literature.[1] The debates about the relationship between human capital and economic development evolve around three main assertions (Rosenzweig, 1988; Bloom, Canning and Sevilla, 2001). First, large families directly contribute to lowering human capital; for given resources, high fertility impedes human capital formation. Dissemination of information to families about the negative consequences of high fertility for their children and providing the means for controlling fertility should be high priorities for public agencies. Second, human capital investment reflects the economic circumstances of a country; the observed mix of large families and low levels of education, health, and nutrition are symptoms, not causes, of a lack of economic development. Governments and international development agencies should therefore focus on removing impediments to economic development and not on families' decisions about their family size. Third, the inability to control fertility is an important deterrent to human capital investment. These assertions clearly demonstrate that fertility and poverty are interlinked through investment in human capital not only at the household but also at the national level. Considerable evidence from the development literature suggests that lowering fertility - in part through family planning programs - is essential to reduce population growth, increase per capita income through investment in human capital and hence reduce poverty through good policies.

The Rwandan government has formally acknowledged the link between fertility and poverty (MINECOFIN, 2007) and embarked on various large-scale, donor-funded family planning programs (Solo, 2008).[2] The contribution of these programs and supportive policies to the smooth transition to stability and development cannot be overlooked. Demographic programs during the period of 1995-2006 have led to an average fertility rate of about five, while economic policy has led to an average GDP growth of 7.3 percent per year. The sectoral contribution to this high economic growth during the period concerned has been researched by a large number of studies in the literature (see Diao, Fan, Kanyarukiga and Yu, 2010); however, the extent to which different household groups transmit the economic influence of an exogenous income injection onto the economy-wide human capital formation, employment, output and income distribution remains largely unexplored. This paper aims to shed light on the

[1] Human capital theory focuses on education and health as inputs to economic growth and development. Human capital is a broad concept, which includes peoples' knowledge, skills, strength and vitality, acquired partly by education and partly by health and nutrition. Schütt (2003) presents a comprehensive review of selected theoretical models of human capital and economic growth, discussing the empirical findings and their policy implications from a large number of studies.

[2] Rwanda has a young population, with a mean age of 21 years, and children under 15 comprise 43% of the population. The average household has 5 members. Nationally, every working person supports 1.2 persons; for the poorest households this is 1.5 and for the richest it is 1. Increasing GDP offers a window of opportunity for investing in education, health and nutrition of the children and paves the way for healthy and more skilled labor to increase productivity.

role of family size in the transmission of economic influences during the period 1995-2006. In order to facilitate the analysis of the linkages between family size and human capital formation, the 2006 Social Accounting Matrix (SAM) of Rwanda has been adjusted. The first adjustment is the disaggregation of household account into 4 groups: household group 1 includes those households without children; group 2, with 1-3 children; group 3, with 4-5 children; and group 4, with more than 5 children. The second adjustment is the disaggregation of both production and commodity accounts into 5 sectors: agriculture, manufacturing, service, education and health sectors. In the context of the current paper, the education and health sectors together are assumed to reflect the developments concerning human capital formation.

In the literature, analysis of the economic effects of fertility usually focuses on an assessment of the rate of return to investment in human capital because high fertility puts mothers at risk, rises the dependency ratio and lowers per child investment in human capital, which in turn at the macro level reduces productivity and income. A large number of micro-econometric and demographic studies show that family size is negatively correlated with children's educational and health attainment (see, for example, Rosenzweig and Wolpin, 1986; Rosenzweig, 1988; Angrist, Lavy and Schlosser, 2005; Schultz, 2005; Rosenzweig and Zhang, 2009). Many studies also suggest that providing family planning services is the most direct and effective way to reduce fertility, making other interventions more effective in improving overall welfare (for example, World Bank, 1990; Ross, Parker, Green and Cooke, 1992; Schultz, 1997). Complementing micro studies are macroeconomic analyses which integrate household fertility behavior with the consumption/saving decision. The models presented by Becker and Barro (1988) and Barro and Becker (1989), for example, demonstrate that fertility is inversely related to growth. At low levels of education, a combination of low productivity and high fertility point to a Malthusian equilibrium. With a general equilibrium model, Becker, Murphy and Tamura (1990) derives the conditions under which a country may switch from the Malthusian to the "development" equilibrium in which high levels of human capital stock lead to high productivity and low fertility. Their analysis highlights that a country may reach a reasonably high development level if it has good policies that favor human capital investment. More recently, the focus switched towards models that discuss demographic transition and offer diverse explanations (e.g., Galor and Weil 1996, 2000). Azarnert (2004) introduced an analysis of interactions between income redistribution, fertility and growth in an open economy. The list can be extended at will.

The literature has not been so generous in the analysis of economy-wide effects of households or family size within SAM framework, although such analysis may provide critical information on effective targeting of specific household groups. So far, only a few studies have been carried out.[3] For example, Defourny

[3]On the contrary, there is a large number of studies applying the SAM multiplier method to analyze: growth strategies in developing economies (Pyatt and Round, 1985), income distribution and redistribution (Pyatt and Thorbecke, 1976; Roland-Holst and Sancho, 1992), fiscal policies (Whalley and Hillaire, 1987), intersectoral linkages and poverty (Thorbecke,

and Thorbecke (1984) characterize the interactions among production, factors of production and households in the context of South Korea. They demonstrate that when production activities are poorly linked, households facilitate the transmission of economic influence across production activities. Likewise, Roberts (1996) finds out that households play an important role in the establishment and strengthening of structural linkages between agriculture and the rest of the economy as well as in the rural-urban spillover. Examining the role of different household groups in the transmission of exogenous shocks within rural economies, Roberts (2005) further demonstrates that households with children are the most important transmitters of economic influence within the local economy examined and that large differences exist with respect to the dependence of different sectors on particular types of households. Another original study follows from Osorio, Carlos and Quentine (2010), adopting the SAM framework, explores the transmission channels through which sectoral growth patterns of Tanzania imply different effects on the incomes of women and men. The findings obtained are illustrative in nature rather than informing policies. The current paper intends to provide a case study of Rwanda, applying the structural path analysis (SPA) to identify critical pathways from households to human capital formation (i.e., education and health) and from human capital production to other production sectors.[4] This would not only uncover the actual sources of the multiplier effects but also demonstrate the welfare-improving sequence of policy interventions.

The following findings seem to emerge from our analysis. First, there is a trade-off between family size and human capital formation: the higher the number of children, the less the investment in human capital of the children. More specifically, the evidence reveals that household groups with up-to three children tend to spend more for the improvement of the education and health status of their children than those household groups with more than three children. Secondly, the path analysis reveals that an improvement in human capital promises a significant growth of agricultural production and that households with upto 3 children act as an important intermediate pole transmitting the influence of human capital investment on agricultural growth in particular and on the rest of the economy in general. These two findings together suggest that promoting family planning programs and policies in Rwanda seems to be a viable strategy for economic growth and poverty reduction, considering the current average family size of 5 children.

The scenario analysis provides additional evidence that investing in education and health is the first best policy in terms of net aggregate income gain. Regarding the sectoral income and employment effects, a relatively higher investment in education paves the way for: (i) the H_0, the H_{13} and P_a to absorb a significant portion of the income gains made and (ii) a higher level of labor and capital employment relative to the employment from an equivalent invest-

1995) among many others.

[4] The reader is referred to the following methodology papers: Defourny and Thorbecke (1984), Khan and Thorbecke (1989), Round (2003), Thorbecke (1995) and Thorbecke and Jung (1996).

ment in the health sector. Furthermore, a comparison of Scenario [1] with [17] demonstrates a striking result that investing in education and health is welfare improving over investing in the agricultural and manufacturing sectors and that investing in education and health leads to higher household income. Finally, the backward-forward linkage analysis reveals that the health and education sectors are the key sectors of the economy, promoting growth in the rest of the economy.

The rest of the paper is organized as follows. Section 2 presents the SAM multiplier and structural path analysis of Defourny and Thorbecke (1984). Section 3 describes how the original SAM has been adjusted to facilitate the analysis of the linkages between four household groups and the rest of the economy. The key empirical findings and their policy implications are discussed in Section 4. Section 5 concludes the paper, with a summary of the main results.

2 Methodology

2.1 Multiplier analysis

SAM is a matrix representation of the system of national accounts. In a SAM, column sums (i.e., expenditures) are equal to row sums (i.e., incomes). To analyze a policy change, some accounts in the SAM must be manipulable exogenously; therefore, in a modeling framework, the SAM is partitioned as endogenous and exogenous accounts. Production activities, commodities, factors, households and firms represent endogenous accounts, while the government, savings-investment and the rest of the world accounts are assumed to be exogenous.

Let $T_{(d,d)} = [t_{ij}]_{i=j=1,...,d}$ denote a SAM with $d = (n + x)$ where n and x denote the number of endogenous and exogenous accounts, respectively. An element, t_{ij}, represents account j's expenditure on the output from account i. Let $T_{(d,d)}$ be partitioned as:

$$T_{(d,d)} = \begin{bmatrix} T_{nn} & T_{nx} \\ T_{xn} & T_{xx} \end{bmatrix}$$

where T_{nn} = transactions among endogenous accounts
T_{nx} = injections from exogenous into endogenous accounts
T_{xn} = leakeges from endogenous into exogenous accounts
T_{xx} = residuals arising from interactions among exogenous accounts
(N, X, L, R) = vectors of row sums of $(T_{nn}, T_{nx}, T_{xn}, T_{xx})$, respectively
y = $(y_1, ..., y_d) \equiv ((y_n), (y_x))$ = vector of row sums of $T_{(d,d)}$
y' = $(y'_1, ..., y'_d) \equiv ((y'_n), (y'_x))$ = vector of column sums of $T_{(d,d)}$

Let $A_{(d,d)} = [a_{ij}]_{i=j=1,...d}$ denote a matrix of average expenditure propensities (AEPs) where $a_{ij} = (t_{ij}/y'_j)$ and $\sum_{i=1}^{d} a_{ij} = \sum_{i=1}^{d} (t_{ij}/y'_j) = 1$ for $\forall_{j=1,2,...,d}$.

Let $A_{(d,d)}$ be partitioned as:

$$A_{(d,d)} = \begin{bmatrix} A_{nn} & A_{nx} \\ A_{xn} & A_{xx} \end{bmatrix} \quad (2)$$

where A_{nn} is a square matrix of AEPs across n endogenous accounts; A_{xn} is a matrix of leakages; that is, the proportions of n endogenous accounts that leak out as expenditure into x exogenous accounts; A_{nx} is a matrix of injections; that is, the proportions of expenditures of x exogenous accounts injected into n endogenous accounts; and A_{xx} is a matrix of residuals; that is, the proportions of expenditures circulated only among x exogenous accounts.

SAM accounting multiplier matrix, M_{nn}, follows from:

$$\begin{aligned} y_n &= N + X = A_{nn} y_n + X \\ &= (I - A_{nn})^{-1} X \\ &= M_{nn} X. \end{aligned} \quad (3)$$

For notational convenience, from now on, we drop the subscript n from M_{nn}. The multiplier matrix $M = (dy_n/dX) = (I - A_{nn})^{-1}$ measures the impact of unit change in aggregate demand, X, on the incomes of endogenous accounts, y_n.[5]

There are two ways to conduct scenario analysis. The simplest and most commonly applied way is to deal with only one target ("sink": point of final effect) and one instrument ("source": point of injection). Eq. (3) represents the model used for the analysis of a single, aggregate injection. A more complex model given in Eq. (4) is used to deal with multiple targets and multiple instruments. Replacing X in Eq. (3) with T_{nx} allows us to disentagle the individual impacts of multiple injections originating from several exogenous accounts:

$$y_{nx} = M T_{nx} \quad (4)$$

where y_{nx} is a matrix of n rows and x columns. Each column in y_{nx} represents the vector of endogenous incomes associated with a single exogenous account such as the government.

2.2 Structural path analysis

The SPA is based on two types of paths. The first type is a *direct-binary path* given in Eq. (5), linking two accounts without any intermediate account. $A'_{(n,n)}$ is a matrix of direct-binary paths and the expenditure propensities in it correspond to economic influences.[6] Take, for example, the direct-binary path,

[5] See Defourny and Thorbecke (1984) for the implication of unitary income elasticity and for the linkages between accounting and fixed-price multipliers. The lack of data on expenditure (income) elasticities does not allow us to compute marginal expenditure propensities associated with the SAM of Rwanda.

[6] It should be noted that the path analysis is carried out using $A'_{(n,n)}$, which is the transpose of $A_{(n,n)}$. With this convention, the elements in a row in $A'_{(n,n)}$ represent the expenses of the corresponding account, while the elements in the corresponding column represents the income. Therefore, a_{ij} in $A'_{(n,n)}$ would define the influence from account i to j.

$I^D(i \to j)$, indicating the actual influence, $a_{ij} \in A'_{(n,n)}$, transmitted from row i to column j:

$$I^D(i \to j) = \underbrace{a_{ij}}_{\text{influence of } i \text{ on } j} \tag{5}$$

The second type is a *direct pathway* p given in Eq. (6), linking two accounts (i and j) through one or more intermediate accounts. The direct influence, $I^D(i \to j)_p$, transmitted through this pathway p with intermediate accounts $k, z,$and u is defined:

$$I^D(i \to j)_p = I^D(i,k,z,u,j) = \underbrace{a_{ik}a_{kz}a_{zu}a_{uj}}_{\text{influence of } i \text{ on } j \text{ through } k,\ z \text{ and } u} \tag{6}$$

For illustrative purposes, let (i,k,z,u,j) represent the direct pathway $p = 1$ between i and j. The level of influence actually transmitted through $p = 1$ is estimated as the multiplication of direct, binary path expenditure propensities: $(a_{ik}a_{kz}a_{zu}a_{uj})$.

It should be noted that the direct influences explained above do not cover the influences implied by possible adjacent feedback circuits. The measure of *total influence* from i to j in Eq. (7) does the job, encompassing all of the possible indirect effects implied by these feedback curcuits. Suppose that there are two feedback curcuits associated with the direct pathway (i,k,z,u,j): one from u back to k denoted by $(u \to k)$ and another from k back to i through a new account r denoted by $(k \to r \to i)$. In this case, the total influence of $p = 1$ is computed as:

$$\begin{aligned} I^T(i \quad \to \quad j)_1 &= I^T(i,k,z,u,j) \\ &= I^D(i,k,z,u,j)M_1 = (a_{ik}a_{kz}a_{zu}a_{uj})M_1 \end{aligned} \tag{7}$$

where the path multiplier M_1 estimates the degree to which the direct influence along the direct pathway (i,k,z,u,j) is amplified through the effects of the two feedback curcuits $\{(u \to k), (k \to r \to i)\}$. M_1 is calculated as $(\triangle_1/\triangle)$ where $\triangle$ is the determinant $\mid I - A_{nn} \mid$ of the structure represented by T_{nn} and $\triangle_1$is the determinant of the structure excluding the accounts (i,k,z,u,j) constituting the pathway $p = 1$.

It is very likely to have more than one pathway spanning from i to $\dot{j}$. Suppose that two other pathways exist between i and $j : (i,s,j)$ and (i,v,j) with a loop around v. The total influences of these additional pathways are, respectively, calculated as:

$$I^T(i \quad \to \quad j)_2 = I^T(i,s,j) = I^D(i,s,j)M_2 = (a_{is}a_{sj})M_2$$
$$I^T(i \quad \to \quad j)_3 = I^T(i,v,j) = I^D(i,v,j)M_3 = (a_{iv}a_{vj})M_3$$

Finally, *global influence* from i to j is defined as:

$$\begin{aligned} I^G(i \rightarrow j) = m_{ij} &= \sum_{p=1}^{3} I_p^T(i \rightarrow j) = \sum_{p=1}^{3} I_p^D(i \rightarrow j) M_p \\ &= I^T(i \rightarrow j)_1 + I^T(i \rightarrow j)_2 + I^T(i \rightarrow j)_3 \\ &= I^D(i \rightarrow j)_1 M_1 + I^D(i \rightarrow j)_2 M_2 + I^D(i \rightarrow j)_3 M_3 \\ &= I^D(i,k,z,u,j) M_1 + I^D(i,s,j) M_2 + I^D(i,v,j) M_3 \\ &= (a_{ik}a_{kz}a_{zu}a_{uj}) M_1 + (a_{is}a_{sj}) M_2 + (a_{iv}a_{vj}) M_3 \end{aligned} \quad (8)$$

For notational convenience, in the SPA we use $m_{ij} \in M'$ where M' is the transpose of M.

2.3 Data

Emini (2007) has compiled the only available SAM for Rwanda, using the 2006 data. This SAM with 197 accounts has been revised by reducing its dimension to 24 accounts: 2 factors of production, 4 household groups plus 1 household transfer account, the firms account, 5 production activities, 5 commodities plus 1 trade margin account, 2 exportable commodities, the savings account, the government account and the rest of the world account (Table 1). For the purpose of our analysis, the household account has been adjusted to create 4 household groups based on the number of children (15 years old or younger). Household group 1 includes those households with no children; group 2, with 1-3 children; group 3, with 4-5 children; and group 4, with more than 5 children. Considering the observation that the current average fertility rate in Rwanda is about 5 children, the grouping concerned allows us to compare the human capital formation behaviour of households in Groups 1 and 2 with those in Groups 4 and 5. Such a grouping also allows us to characterize the behavior of a specific household group with respect to its human capital formation in particular and the role of households in the transmission of economic influence in the Rwandan economy in general. The production account has been aggregated into 5 activities, including agriculture, manufacturing, services, education and health.

The revision of Emini's original SAM has required a substantial amount of data compilation using the 2005-2006 household living conditions survey (EICV2) (MINECOFIN, 2007). In the construction of 4 household groups, using all the variables listed in Table 8 of Emini (2007), we have organized the EICV2 data to construct household-group specific incomes and expenditures across the 24 accounts of the SAM. Expectedly, the row and column sums in the revised SAM were not consistent (i.e., row sums were not equal to column sums) due to the fact that the EICV2 survey data were obtained from a sample of 6900 households only. In order to construct a consistent SAM, the household-group specific percentages calculated from the EICV2 data were repeatedly applied to the aggregate figures given in Emini's original SAM.

An important issue to note is that the survey does not provide child-specific health and education data but rather provides the desired data at the household level. This means that, given a household group, the health and education expenses in the SAM should be read as that household group's gross health and education expenses, not necessaily as the expenses on the children falling under that household group.

3 Key findings

This section presents the key findings from the multiplier and path analyses, with a special focus on the role that different household groups play in the human capital formation, sectoral growth and income distribution in Rwanda.

3.1 Multiplier analysis

M is constructed by using six blocks of endogenous accounts: factors (F), households (H), firms (Fr), production (P), commodity (C) and exports (X). Each block ($i = j = F, H, Fr, P, C, X$) has several sub-accounts: F has 2 sub-accounts (F_L, F_C); H has 5 sub-accounts ($H_0, H_{13}, H_{45}, H_6, H_{tr}$); Fr, 1 account; P, 5 sub-accounts (P_a, P_m, P_s, P_e, P_h); C, 6 sub-accounts ($C_a, C_m, C_s, C_e, C_h, T_m$); and X, 2 sub-accounts (X_a, X_m). A sub-matrix $M^{ij}_{s_i,s_j}$ in M represents the interaction between block i and j.

$$M = \begin{bmatrix} M^{FF}_{2,2} & M^{FH}_{2,5} & M^{FFr}_{2,1} & M^{FP}_{2,5} & M^{FC}_{2,6} & M^{FX}_{2,2} \\ M^{HF}_{5,2} & M^{HH}_{5,5} & M^{HFr}_{5,1} & M^{HP}_{5,5} & M^{HC}_{5,6} & M^{HX}_{5,2} \\ M^{FrF}_{1,2} & M^{FrH}_{1,5} & M^{FrFr}_{1,1} & M^{FrP}_{1,5} & M^{FrC}_{1,6} & M^{FrX}_{1,2} \\ M^{PF}_{5,2} & M^{PH}_{5,5} & M^{PFr}_{5,1} & M^{PP}_{5,5} & M^{PC}_{5,6} & M^{PX}_{5,2} \\ M^{CF}_{6,2} & M^{CH}_{6,5} & M^{CFr}_{6,1} & M^{CP}_{6,5} & M^{CC}_{6,6} & M^{CX}_{6,2} \\ M^{XF}_{2,2} & M^{XH}_{2,5} & M^{XFr}_{2,1} & M^{XP}_{2,5} & M^{XC}_{2,6} & M^{XX}_{2,2} \end{bmatrix}$$

Income Transfers across Households — $M^{HH}_{5,5}$ in Table 2 maps the multipliers within the household block. A diagonal element of $M^{HH}_{5,5}$ measures the relative *degree of internal integration* of the corresponding household group. For example, the diagonal element associated with the H_{13}, which is equal to 2.2. $= m_{H_{13},H_{13}} = \max\{m_{H_0,H_0},\ m_{H_{13},H_{13}},\ m_{H_{45},H_{45}},\ m_{H_6,H_6}\}$, implies that the H_{13} is internally the most integrated household group. Unit increase in the income of the H_{13} is expected to generate 1.2 units of additional income for itself after accounting for all the direct and indirect influences within the household block. The H_0 occupies the second place, with the diagonal entry $m_{H_0,H_0} = 1.7$ and 0.7 unit of additional income for itself. The H_{13} occupies the first place with respect to its integration with other household groups, too. This is implied by its relatively high transfer multiplier 3.7 (which is the sum of the multipliers in the 2nd column of $M^{HH}_{5,5}$), followed by the H_{45} with 3.6 and by the H_0 with 3.5. These findings demonstrate that economically the H_{13} is the most active household group because it generates the maximum income gain not only for itself but also for the entire household block. The (column-sum, row-sum)-coordinates of $M^{HH}_{5,5}$ further show that the income the H_{13} has received from other 3 household groups is much higher than its transfers to them, which is implied by the coordinate (3.7, 7). The H_0 follows the H_{13} with a coordinate of (3.5, 5).

Production Effects of Intermediate Consumption — $M^{PP}_{5,5}$ maps the input-output multipliers. Three important observations are noted. First, the demand for agricultural, service and manufacturing production accounts for 89% of the total intersectoral demand within the production block.[7] The demand for education and health explains the remaining 11%. Second, in the order of importance, of one unit injection into the production block, agriculture benefits 37% (i.e. 8.5/22.7), followed by services with 31% (i.e., 7.1/22.7) and manufacturing with 21% (i.e., 4.8/22.7). Education and health benefit 6% and 5%, respectively. Third, agriculture is internally the most integrated sector (implied by its diagonal multiplier of 2.5), followed by services (2.2) and manufacturing (1.8). Education and health productions show weak internal integration.

Production Effects of Family Size — $M^{PH}_{5,5}$ shows the multipliers associated with the influence of an exogenous increase in household income on production. The H_{13} has the maximum economic influence on production, implied by the multipliers in the 2^{nd} column of $M^{PH}_{5,5}$. One unit increase in the income of the H_{13} is estimated to generate, through a network of influences in the economy, 1.61 unit increase in the agricultural, 1.15 unit in the services, and 0.78 unit in the manufacturing output. In other words, 97% of the total influence generated by one unit increase in the income of the H_{13} goes to agricultural, service and manufacturing production (i.e., (3.54/3.66) = 0.97). The remaining 3% goes to education and health production. The second largest production effect comes from the H_{45}, implied by the multipliers in the 3^{rd} column of $M^{PH}_{5,5}$.

Human Capital Effects of Family Size — $M^{CH}_{6,5}$ shows the multipliers associated with the commodity demand effect of an exogenous increase in household income. The multipliers in the 2^{nd} column suggest that unit exogenous increase in the H_{13}'s income would yield the largest rise in the commodity demand. The H_{45} causes the second largest rise, followed by the H_0. With respect to the type of commodity demand, we observe that household income increase leads to the largest rise in the agricultural commodity demand, followed by the manufacturing, the services, the education and the health commodity demands. In terms of the contribution to the aggregate demand, agriculture takes the 1^{st} place with 38%. Of this, 26% originates from the H_{13}, 25% from the H_{45} and 24% from H_0. Likewise, manufacturing takes the second place with 34%, of which 27% originates from the H_{13}, 26% from the H_{45} and 24% from the H_0. What happens to the household demand for education and health? The demand for the two public goods explains only 3% of the economy-wide commodity demand. Of this, 29% comes from the H_{13} and about 24% from each one of the other

[7] The sum of the multipliers in the 1^{st} row of $M^{PP}_{5,5}$, which is equal to 8.5, is a measure of the extent of the demand for agricultural outputs by 5 production sectors. This demand also includes agricultural sector's demand for its own outputs. Likewise, the sums of the multipliers in the 2^{nd} (4.8) and and the 3^{rd} (7.1) rows, respectively, approximate the demand for manufacturing and service outputs. Then, the ratio, $(8.5 + 4.8 + 7.1)/22.7 = 0.89$, would measure the extent of the total demand multiplier for the outputs of the three sectors where 22.7 is the sum of all the individual multipliers in $M^{PP}_{5,5}$.

three groups. Clearly observed is that the H_{13} plays the leading role in generating demand for public goods, followed by the H_{45} and the H_0. All in all, the above findings lend support to two related hypotheses: (i) there is a trade-off between family size and human capital investment, implying that households with 1-3 children invest relatively more in the human capital of their children; and (ii) given an income stimulus, households with the less-than-average number of children account for the largest share of spending for their children's human capital.

Income Distribution Effects of Production — $M_{5,5}^{HP}$ shows the multipliers associated with the influence on households of an exogenous increase in the production demand. The multipliers in the 2^{nd} row of $M_{5,5}^{HP}$ demonstrate that, irrespective of production activities, the H_{13} benefits the most from unit increase in the demand, followed by the H_0 and the H_{45}. It is important to note that unit increase in the education and health demand respectively yields 1.49 unit and 1.48 unit additional income for the H_{13}. This is higher than the effect of an equal increase in the service (1.46) and manufacturing (1.40) production demand. Similar patterns of influence are also observed for the H_0 and the H_{45}, with a bit less income gain relative to that of the H_{13}. All in all, we can safely claim that the H_0 and the H_{13} are likely to benefit the most from an exogenous increase in the education and health demand. Interestingly, in the case of a rise in export demand, these two household groups again receive the largest income gain, implied by the multipliers in $M_{5,2}^{HX}$.

Employment and Income Distribution Effects — Sector-specific ratios of capital and labor demand multipliers in $M_{2,5}^{FP}$ indicate that, relatively speaking, capital would be employed at a higher rate in the agriculture, manufacturing and service sectors, while labor be employed at a higher rate in the education and health sectors. These multipliers further indicate that increasing demand for education and health creates the largest labor employment, while increasing demand for agricultural, service and manufacturing creates the largest capital employment. (The multipliers in $M_{2,6}^{FC}$ imply similar employment patterns when the commodity demand rises.) Regarding the distribution of the factor income generated, household group-specific capital and labor income multiplier ratios computed from $M_{5,2}^{HF}$ suggest that households with 0-3 children receive a larger share of their income from labor employment, whereas households with 4 or more children earn most of their income from capital employment.[8] To sum up, capital (labor) demand is triggered at a higher rate by the agricultural, manufacturing and service (education and health) sectors and is accomodated

[8] The (K/L) multiplier ratios computed from $M_{2,5}^{FP}$ are: 1.20 for agriculture, 1.25 for manufacturing, 1.09 for services and 0.95 for both education and health sectors. The ratios computed from $M_{2,6}^{FC}$ results in the same figures. Household group-specific capital and labor income multiplier ratios computed from $M_{5,2}^{HF}$: 0.85 for the H_0, 0.99 for the H_{13}, 1.06 for the H_{45} and 1.05 for the H_6. These figures imply that households with 0-3 children obtain a larger share of their income from labor employment, whereas households with 4 or more children earn the largest part of their income from capital employment. To sum up, capital demand is triggered at a higher rate by the agricultural, manufacturing and service sectors and is accomodated at a higher rate by the H_{45} and the H_6, while labor demand is promoted at a higher rate by public sectors and is accomodated at a higher rate by the H_0 and the H_{13}.

at a higher rate by the H_{45} and the H_6 (the H_0 and the H_{13}).

3.2 Scenario analysis

Using the model in Eq. (3), we have computed net aggregate and net sector-specific income effects under 19 scenarios given in **Table 3**. It should be noted that the aggregate injection made under all these scenarios remains bounded by 10% of the $RoW's$ transfers to four household groups. That is, in absolute terms, the aggregate injection is equal to 1148 million Rwf. This would allow us to contrast the net effects of the $RoW's$ direct transfers to households with the effects implied by alternative policy interventions.

Scenario [1], which represents the first best policy among the 19 scenarios, reveals that investing in education and health generates the largest national income gain. Assuming an exogenous investment in the education ($C_e = 765$) and health ($C_h = 383$) commodity sectors, this scenario leads to the maximum net aggregate income gain of 19,545 mil Rwf. A comparison of net income gains across Scenarios [1], [2] and [4] demonstrate that a relatively higher investment in education is welfare improving. Net aggregate income gain under Scenarios [2] and [4], which are respectively associated with the exogenous investment policies of $\{C_e = C_h = 574\}$ and $\{C_e = 383 < C_h = 765\}$, is smaller than that implied by Scenario [1]. Regarding the sectoral income effects, we find that a relatively higher investment in education paves the way for: (i) the H_0, the H_{13} and P_a to absorb a significant portion of the income gains made and (ii) a higher level of labor and capital employment relative to the employment from an equivalent investment in health.

A comparison of Scenario [1] with [17] further demonstrates that investing in education and health is not only welfare improving but also yields a higher level of household income over the investment in the agricultural and manufacturing commodity sectors.

Under Scenario [2] and [3], an equal investment, $C_e = C_h = 574$, is made to the education and health sectors separately through the savings-investment and the government accounts. The investment made through the savings-investment account is found to be more efficient than the government investment. The differences between the two scenarios are reflected in terms of higher capital demand (F_C), income received by the H_{45} and demand for health production (P_h).

When the whole amount of 1148 mil Rwf is invested only in the health sector, as assumed under Scenario [5], net aggregate income gain becomes smaller than that under Scenarios [1]-[4]. This reveals that Scenario [5] is welfare reducing over Scenarios [1]-[4]. However, Scenario [5] is welfare improving over the investment in either the agricultural or the manufacturing commodity sectors assumed under Scenarios [6]-[19]. This evidence lends a strong support for policies prioritizing higher investment in health relative to investment in the agricultural and the manufacturing sectors. The comparison of Scenario [5] with [6] also suggests that: (i) investing in health (agriculture) leads to higher growth of labor (capital) income relative to the investment in agriculture (health) and

(ii) investing in agriculture yields higher household income compared to the investment in health, and households with more than 3 children (i.e., the H_{45} and the H_6) receive a larger proportion of this income. Consequently, agricultural (health) growth benefits large (small) families more.

Do small families spend proportionally more on the education and health of their children than large families? Scenarios [13] and [16] have been designed to answer this question. Under Scenario [13], only small families (i.e., the H_0 and the H_{13}) experience an exogenous increase in their income, whereas under Scenario [16], only large families (i.e., the H_{45} and the H_6) experience the same increase. The estimations show that small families' demand for education and health commodities $\{C_e = 0.108, C_h = 0.094\}$ under Scenario [13] is higher than the demand by large families $\{C_e = 0.101, C_h = 0.090\}$ under Scenario [16]. This finding proves that households with a small number of children invest proportionally more on the education and health of their children than those with a large number of children.

3.3 Structural pathways and backward-forward linkages

Four types of structural pathways are discussed using M'.[9] Type I pathways characterize income transfers within the household block; Type II, the input-output multipliers within the production block; Type III, the multipliers of economic influence of households on commodities; Type IV, the multipliers of economic influence of production on factors; and Type V, the multipliers of economic influence of exports on household income.

Table 4 lists Type I pathways characterizing the effect of an exogenous income transfer from one household group to another. For example, the global influence of $I^G(H_0 \rightarrow H_{13}) = m_{H_0,H_{13}} = 1.118$ under Column 3 in Type I-1 represents the multiplier effect on the H_{13} of an injection into the H_0. That is, an injection of 100 Rwf into the H_0 is expected to generate an additional income of 111.8 Rwf for the H_{13}. Under Type I-1, five significant pathways account for 68 % of the global influence.[10] The most influential pathway from H_0 to H_{13}, $\{H_0 \rightarrow C_a \rightarrow P_a \rightarrow F_C \rightarrow H_{13}\}$, accounts for 27.1 % of 111.8 Rwf. The other pathways within the household block reveal that the global influence from H_0 to H_{13} is exercised indirectly through intermediate accounts: $\{H_0 \rightarrow C_a \rightarrow P_a \rightarrow F_L \rightarrow H_{13}\}$ accounts for 19.8 % of the global influence; $\{H_0 \rightarrow C_s \rightarrow P_s \rightarrow F_L \rightarrow H_{13}\}$, 7.3 % and so on. Likewise, under Column 3 in Type I-2, the global influence of $I^G(H_0 \rightarrow H_{45}) = m_{H_0,H_{45}} = 0.482$ represents the multiplier effect on the H_{45} of an injection into the H_0. Again, five significant pathways from H_0 to H_{45} explain 65 % of the global influence: $\{H_0 \rightarrow C_a \rightarrow P_a \rightarrow F_C \rightarrow H_{45}\}$ accounts for 28.6 % of the global influence; $\{H_0 \rightarrow C_a \rightarrow P_a \rightarrow F_L \rightarrow H_{45}\}$, 16.7 %; $\{H_0 \rightarrow C_s \rightarrow P_s \rightarrow F_C \rightarrow H_{45}\}$, 7.2 % and so on. Type I further shows

[9] Note that for notational convenience in this section we use M' (i.e., the transpose of M) and thus define m_{ij} as the multiplier effect from account i to account j.

[10] A pathway is assumed to be significant if it transmits at least 5 % of the global influence given in Column 8. Therefore, those pathways with less-than-five percent influence are not reported in tables.

that indirect income transfers between any two household groups always take place through commodity, production and factors of production. In particular, agriculture plays the key role in facilitating significant income transfers between households. The main intermediate poles of income transfers include $C_a,\ P_a,\ F_L$ and F_C, which clearly demonstrate the vitality of agriculture for promoting rural development in Rwanda.

Table 5 lists Type II pathways characterizing the interactions within the production block. Feeding a very large number of people in Rwanda, agriculture and its linkages with the education and health sectors warrant a thorough examination because of the expected positive contribution to production of improved skill and health. Under Type II-3, only six pathways from agriculture to education account for 84 % of the global influence of $m_{P_a,P_e} = 0.078$. The most important pathway, $\{P_a \rightarrow F_C \rightarrow H_{13} \rightarrow C_e \rightarrow P_e\}$, accounts for 25 % of the global influence. This demonstrates that households with 1-3 children sell their capital to the agricultural sector, and the factor income earned is spent on education, which in turn triggers the demand for the education services. The second important pathway, $\{P_a \rightarrow F_L \rightarrow H_{13} \rightarrow C_e \rightarrow P_e\}$, accounting for 18,5 % of the global influence confirms the key role of the H_{13} in promoting education activities through labor income earned. In conclusion, 44 % of the global influence is determined by H_{13} as the key intermediate pole.

Under Type II-4, again only six pathways from agricultural to health account for 86 % of the global influence of $m_{P_a,P_h} = 0.023$. Of these, the most influential pathways include $\{P_a \rightarrow F_C \rightarrow H_{13} \rightarrow C_h \rightarrow P_h\}$ and $\{P_a \rightarrow F_L \rightarrow H_{13} \rightarrow C_h \rightarrow P_h\}$ which respectively account for 27 % and 20 % of the global influence. Again, the H_{13} is the the most critical intermediate pole transmitting significant amount of economic influence from agriculture to health.

Type II-13 shows the significant pathways from education to agriculture, with a global influence of $m_{P_e,P_a} = 1.49$. Only five pathways explain 56 % of the global influence. The critical pathways, $\{P_e \rightarrow F_L \rightarrow H_{13} \rightarrow C_a \rightarrow P_a\}$ and $\{P_e \rightarrow F_L \rightarrow H_0 \rightarrow C_a \rightarrow P_a\}$, respectively account for 19 % and 13 % of the global influence. It should be noted that here households without children H_0 appears to be an important intermediate pole as well. Both H_0 and H_{13} supply labor (F_L) and both spend the labor income earned on agricultural commodities, which then stimulate agricultural production. This chain of interactions demonstrate that increasing demand for education boosts labor employment especially among households with upto 3 children. Demand for capital appears to play a limited role in agricultural production as well as employment creation, with a 9 % global influence.

Type II-17 illustrates five significant pathways from health to agriculture, explaing 53 % of the global influence $m_{P_h,P_a} = 1.47$. Two of these pathways, including $\{P_h \rightarrow F_L \rightarrow H_{13} \rightarrow C_a \rightarrow P_a\}$ and $\{P_h \rightarrow F_L \rightarrow H_0 \rightarrow C_a \rightarrow P_a\}$, respectively account for 19 % and 13 % of the global influence. H_0 and H_{13} play an identical role as in Type II-13. It should be noted that about half of the global influence is explained by the pathways with less than 5 % explanatory power. This shows that long-chain indirect effects are as important as the shorter pathways.

Three important findings evolve from a comparison of Type II-13 with Type II-17. First of all, households up to 3 children play the key role in the transmission of economic influence. Secondly, investment in the education and health sectors boosts substantial employment of labor. Lastly, the promotion of education and health production is likely to give a momentum not only to agricultural but also to manufacturing and service sectors, which is implied by very large income multipliers of an injection into the health and education sectors.

The significant pathways listed under Type II-16 and II-20 help understand the nature of interaction between the two public services. Type II-16 declares four important pathways from education to health, explaining almost half of the global influence $m_{P_e,P_h} = 0.022$. The pathways, $\{P_e \rightarrow F_L \rightarrow H_{13} \rightarrow C_h \rightarrow P_h\}$ and $\{P_e \rightarrow F_L \rightarrow H_0 \rightarrow C_h \rightarrow P_h\}$, respectively explain 22 % and 11 % of the global influence. With a 10 % explanatory power, the pathway $\{P_e \rightarrow F_C \rightarrow H_{13} \rightarrow C_h \rightarrow P_h\}$ occupies the third place in ranking. H_0 and H_{13} play a role comparable the pathways discussed in the previous paragraph. Type II-20 also declare four critical pathways from health to education, explaining about half of the global influence $m_{P_h,P_e} = 0.076$. Again, households with up to three children play a dominant role in the transmission of the influence from health to education. Interestingly, $m_{P_h,P_e} = 0.076 > m_{P_e,P_h} = 0.022$ reveals that the influence of health on education is about four times stronger than that of the education on health.

Table 6 lists Type III pathways characterizing the impact of an exogenous increase in household income on commodity demand. The focus is in particular on the impact on the demand for the education and health commodities, which concern the pathways under Type III-4, III-5, III-10, III-11, III-16, III-17, III-22, III-23, III-28 and III-29. With respect to the effect on education, H_{13} occupies the first place with a global influence of $m_{H_{13},C_e} = 0.087$ under Type III-10. Sixty-four percent of this global influence is accounted for only by a single, direct path from H_{13} to C_e. Next comes H_0 with $m_{H_0,C_e} = 0.081$ under Type III-4, which accounts for 53 % of the global influence. It is also important to note that, under Type III-28, H_{13} acts as the key intermediate pole effectively transmitting income from H_{tr} to C_e, explaining 25 % of $m_{H_{tr},C_e} = 0.083$. H_0 occupies the second place, accounting for 21 % of $m_{H_{tr},C_e} = 0.083$. Concerning the health effects under Type III-5, III-11, III-17, III-23 and III-29, household groups are ranked in the same order as above but the multipliers associated with them are much smaller than those in the case of education. A common observation among the education and health pathways discussed so far is that longer chain pathways with less than 5 % explanatory power also play a critical role in promoting the demand for human capital.

Table 7 shows Type IV pathways characterizing the impact on factor demand of an exogenous increase in production. A comparison of the production multipliers across labor and capital inputs given in $(M_{2,5}^{FP})'$ (i.e., compare the figures in the1*st* with those in the 2*nd* column of $(M_{2,5}^{FP})'$) demonstrates that the agricultural, manufacturing and service sectors (the education and health sectors) promote higher capital (labor) employment than labor (capital) employment when the demand equally rises for these production activities. Direct, binary paths in Table 7 explain a very large share of the global influence, including $\{P_a \rightarrow F_C$ explains 85 % of the global influence; $P_s \rightarrow F_C$, 65 %; $P_m \rightarrow F_C$, 44 %; $P_e \rightarrow F_L$, 63 % and $P_h \rightarrow F_L$, 63 %$\}$. The corresponding path multipliers given in Column (6) further imply that these one-edge paths are substantially influenced by loops around the path origin. To sum up, increasing demand for human capital would create proportionally higher labor employment.

Table 8 shows Type V pathways characterizing the impact on household income of an exogenous increase in the export demand. The exports of Rwanda include agricultural and manufacturing goods only. Regarding the impact of agricultural exports, H_{13} obtains the largest income gain with an income multiplier of 1.542: one unit increase in agricultural exports generates 1.542 units of income for households with 1-3 children. Fifty-one percent of 1.542 is explained by capital demand from H_{13}, whereas 38 percent is explained by labor demand from H_{13}. With an income multiplier of 0.966, H_0 follows H_{13}. Labor supply of H_0 explains 47 % of the income multiplier, while capital supply explains 38 %. These findings confirm that, in absolute terms, H_{13} dominates over H_0 in terms of labor as well as capital income multiplier effects created by unit rise in export demand. (The same result also holds for the manufacturing export sector.) In conclusion, increasing exports would benefit households with 1-3 children the most, followed by households with no children.

Backward (or diffusion) and forward (or absorption) linkage analysis helps us identify the "key" sectors of the Rwandan economy. A sector is called "key" if it leads to an over-average impact on the whole economy either through an exogenous change in its own demand structure or through a change in its demand structure induced by the rest of the economy. To identify the key sectors, the Multiplier Product Matrix (MPM) and the backward and forward linkage indices are calculated as follows:

$$
\begin{aligned}
MPM &= [mpm_{ij}]_{i,j=1,\dots,n} = \frac{|\, m_{i\cdot}\ m_{\cdot j} \,|}{m} \\
b_j &= \frac{m_{\cdot j}}{(m/n)},\ j = 1, 2, ..., n \quad \text{"backward linkages"} \\
f_i &= \frac{m_{i\cdot}}{(m/n)},\ i = 1, 2, ..., n \quad \text{"forward linkages"} \\
\text{where } m &= \sum_{i=1}^{n=21} \sum_{j=1}^{n=21} m_{ij} = \text{sum of all the multipliers in } M \\
m_{i\cdot} &= \text{sum of the multipliers in row } i \text{ of } M \\
m_{\cdot j} &= \text{sum of the multipliers in column } j \text{ of } M \\
| & \ m_{i\cdot}\ m_{\cdot j} \,|= \text{absolute value of the product } m_{i\cdot} \text{ and } m_{\cdot j}
\end{aligned}
$$

Table 9 shows that, with $f_{C_a} = 219$ %, the agricultural commodity sector has the highest forward linkage. This means that a unit change in the demand of the rest of the economy affects agriculture the most, with a 119 % higher than the economy-wide average multiplier. Other sectors significantly affected by changes in the rest of the economic system include capital and agricultural output with a 117 % higher than the economy-wide average multiplier implied by f_{F_C}, f_{P_a} = 217 %, the manufacturing commodity sector with a 104 % higher multiplier from f_{C_m} = 204 %, labor with a 95 % higher multiplier from f_{F_L} = 195 % and the H_{13} with a 94 % higher multiplier from $f_{H_{13}}$ = 194 % and so on.

On the other hand, with b_{T_m} = 117 %, trade margin has the highest backward linkage. This means that a unit exogenous increase in trade margin would yield 17 % higher economic activity in the rest of the economy than that implied by the economy-wide average multiplier. With b_{C_e} = 115 %, the education commodity sector occupies the 2^{nd} place; that is, a unit exogenous increase in the demand of education would yield a 15 % higher activity level than that implied by the average multiplier. The health commodity sector as well as the agricultural and manufacturing export sectors all together take the 3^{rd} place; that is, a unit increase in the demand of these sectors would separately promote 14 % more economic activity than that implied by the average multiplier.

Three important findings are in order. First, implied by their significant backward linkages, C_e and C_h tend to transmit their growth to the rest of the economy more effectively than others. Second, H_{13} is able to internalize more effectively the growth that other sectors of the economy experience. Lastly, C_e, C_h, P_e, P_h, and X_a and X_m seem to perform poorly in absorbing the growth effects taking place in the rest of the economy.

4 Discussion

MULTIPLIER ANALYSIS confirms that family size is an important factor in the formation of human capital. In the context of Rwanda, households with 1-3 children, which is less than the national average family size of 5, tend to invest in the education and health of their children significantly more than households with 4 or more children. This suggests that the 2006 SAM of Rwanda represents an economy in which family size is inversly related to human capital investment. Implementing family planning programs thus seems to be a viable option for the promotion of human capital-based economic development.

With respect to poverty reduction, the results further confirm that households with small family size perform a leading role in the economy-wide income generation and experience the largest income gain from an investment in human capital. Given an income stimulus for the education and health production, households with upto 3 children experience the highest income gain. Export growth also favors the same households in terms of income growth.

As to household income transfers, the results demonstrate that households with 1-3 children tend to receive more indirect transfers than the transfers it actually makes to others. Due to the absence of direct income transfers across households, all the transfers represented by the multipliers within the household block stand for the rate of indirect household transfers resulting from the economic interactions between households. Income distribution pattern show that increasing demand for human capital rises labor demand accomodated at a higher rate by the labor supply of households with 1-3 children. On the other hand, higher employment of capital takes place in agriculture, manufacture and services, which benefits households with 4-5 children the most.

SCENARIO ANALYSIS reveals that, in terms of net aggregate income gain, human capital investment is the first-best policy in Rwanda relative to investment in agriculture, manufacturing and service sectors. Specifically, with a large employment multiplier effect, education and health investment benefits small-size families the most. Within the SAM framework, such an investment can be channeled through either the S-I account or the government account. The scenarios carried out support the hypothesis that investment funds released from the S-I account do the job more efficiently than those from the government account. These findings suggest that in the context of Rwanda policies should give priority to human capital investment because small families contribute directly to increasing the human capital of children; higher fertility impedes human capital formation, for given resources. Dissemination of information to families about the negative consequences of high fertility for their children and providing the means for controlling fertility should be high priorities for public agencies.

In terms of net aggregate income gain, large families benefit more from agricultural growth, while small families benefit more from human capital growth. Furthermore, small families demand human capital commodities more than large families. Together, These findings confirm the assertion that households with a smaller number of children tend to invest marginally more on the education and health of their children than those with a larger number of children.

PATH ANALYSIS shows that households interact with each other only through elementary pathways from commodities, to production activities and to factors. There is no direct binary path among household groups. Regarding the intersectoral influence, the most important pathway, $\{P_a \rightarrow F_C \rightarrow H_{13} \rightarrow C_e \rightarrow P_e\}$, clearly shows that the H_{13} finances its demand for education commodity through its capital income from the agricultural sector. The secondary source of H_{13}'s education expenditure is its labor income. Together, the capital and labor income of H_{13} accounts for about half of the global influence on education of a unite increase in agricultural production. Regarding the health commodity demand, we observe the same pattern in which H_{13} is the most critical intermediate pole. To sum up, H_{13} has more savings (or capital) than other households and invests more in the education and health of their children.

An improvement in human capital (i.e., education and health) is expected to have an important impact on agricultural production through the enhancement of allocative efficiency. The path analysis suggests that there is ample scope for increasing investment in human capital to promote agricultural production. One could easily see that if the government of Rwanda aims to promote agricultural sector, the investment in education and health should occupy the top of its policy agenda. Agaian, the H_{13} seems to be the key intermediate pole in transmitting the influence of such an investment to agriculture in particular and to the rest of the economy in general.

The linkage analysis shows that the agricultural commodity sector is the key sector in the Rwandan economy, followed by the education and health commodity sectors. Furthermore, the education and health sectors promote significant growth in other sectors of the economy and act as the engine of growth in the agriculture, manufacturing and service sectors. The household group with the highest allocative efficiency remains to be the H_{13} as it is the group which can effectively internalize economic growth.

5 Summary and Conclusions

The main purpose of this paper is to explore the role of different household groups in the formation of human capital, employment, sectoral growth and income distribution in Rwanda. The 2006 SAM used in the analysis represents a general equilibrium data system of the Rwandan economy. The multiplier and structural path analyses are applied to examine the transmission of economic influences across institutions. The paper first computes income multipliers to characterize the macroeconomic transmission of economic influences stimulated by an exogenous increase in demand. Then, applying the SPA, it identifies the critical, individual transmission pathways behind these computed income multipliers and explores macroeconomic effects of different groups of households on human capital formation, employment, sectoral growth and income distribution.

The following two findings are noted. First, the smaller the number of children in an average family, the higher the investment in human capital of the children in that family, demonstrating the presence of quantity-quality trade-off. In particular, the household group with 1-3 children tends to spend more for the improvement of education and health status of children than those household groups with more than 3 children. Second, an improvement in human capital leads to a significant increase in agricultural production and that households with 1-3 children act as an important intermediate pole transmitting the influence of human capital investment on agricultural production. In conclusion, promoting family planning programs in Rwanda thus seems to be a viable strategy for economic growth and poverty reduction, considering the current average family size of 5 children.

Some final remarks should be made on the limitation of the current study. First, the SAM data framework assumes that expenditure of an account represents the influece of that account on other accounts. In reality, the actual influence of one account on other accounts can be better approximated through a more detailed econometric causality estimation between the relevant accounts. Second, the multiplier analysis draws on average expenditure propensities obtained from the SAM, while marginal propensities are more reliable to depict non-linear structural relations. In other words, the implicit assumption of unitary expenditure elasticities may not reflect the actual behaviour of an institution and hence the SAM multiplier analysis may deviate from the realities on the ground. Third, disaggregation of the SAM accounts is arbitrary. For example, that agriculture is represented as a single account in the SAM implicitly assumes that all farm types produce an identical output mix using the same technology. This makes the estimated results conditional on the type and nature of policies analysed. Given the issues analyzed in this work, the highly disaggregated representation of health and education accounts would not add much to the analysis of economy-wide effects of human capital investment. Fourth, the SAM multiplier method is limited in its ability to provide a picture of the feedback interactions between the sectors of an economy because a SAM gives only a snopshot picture of the transactions in a given year. The feedback analysis obviously demands for a time-series of SAMs but the construction of such a time series is very rare in practice. CGE models have largely overcome this limitation, allowing to investigate the economy-wide growth and distributive outcomes of exogenous changes in market conditions or policies simultaneously implemented. Last but not least, the SAM multiplier method cannot be applied if income changes follow a stochastic process. Methodological advancement is needed to analyze stochastic income multiplier effects.

All together, these limitations may justify the development of two modeling frameworks. The CGE modelling framework is generally considered as a natural extension of a SAM-based multiplier model. Even if referring to different theoretical frameworks, studies in the literature generally agree that these two models yield complementary results to policy analysis. Finally, a more significant improvement in modelling the economy-wide effects of households could probably be obtained by developing an integrated micro–macro approach. The availability of a suitable database would allow researchers to build a micro-simulation model of households, and to link it to the macro-economic framework through the SAM.

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Table 1: Social Accounting Matrix for Rwanda, 2006

	Endogenous Accounts																					Exogenous Accounts		
	F_L	F_C	H_0	H_{13}	H_{45}	H_6	H_{tr}	F_r	P_a	P_m	P_s	P_e	P_h	C_a	C_m	C_s	C_e	C_h	T_m	X_a	X_m	G	SI	RoW
F_L	0	0	0	0	0	0	0	0	287755	67320	285603	43449	14118	0	0	0	0	0	0	0	0	0	0	0
F_C	0	0	0	0	0	0	0	0	367715	144915	252057	18607	6046	0	0	0	0	0	0	0	0	0	0	0
H_0	241788	170769	0	0	0	0	7502	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5937
H_{13}	299924	358471	0	0	0	0	7090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3783
H_{45}	113472	170493	0	0	0	0	2827	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1271
H_6	28461	42483	0	0	0	0	1698	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	477
H_{tr}	0	0	7145	7931	3062	978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F_r	0	47124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8569	0	30839
P_a	0	0	0	0	0	0	0	0	0	0	0	0	0	697883	0	0	0	0	0	1485	0	0	0	0
P_m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	468471	0	0	0	0	0	74340	0	0	0
P_s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	763470	0	0	0	0	0	0	0	0
P_e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88812	0	0	0	0	0	0	0
P_h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28857	0	0	0	0	0	0
C_a	0	0	164586	282874	107673	32295	0	0	17599	121740	19216	5089	1029	0	0	0	0	0	0	0	0	0	0	0
C_m	0	0	136554	237483	109199	18242	0	0	18089	95007	86944	6511	2396	0	0	0	0	0	0	0	0	0	233582	0
C_s	0	0	55433	95050	43902	6807	0	0	8210	113830	119650	15155	5268	0	0	0	0	0	150020	0	0	168479	0	0
C_e	0	0	10442	16482	5589	1650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54649	0	0
C_h	0	0	2504	5379	1985	187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18818	0	0
T_m	0	0	0	0	0	0	0	0	0	0	0	0	0	52682	97338	0	0	0	0	0	0	0	0	0
X_a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1485
X_m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	74340
G	0	0	19405	11652	4054	539	0	28766	0	0	0	0	0	105	110412	18334	0	17	0	0	0	193283	0	168673
SI	0	0	27909	10088	11981	12319	0	38699	0	0	0	0	0	0	0	0	0	0	0	0	0	-2258	0	134844
RoW	14600	0	2019	2328	617	103	0	19068	0	0	0	0	0	1431	267786	0	0	0	0	0	0	113699	0	0

Table 2: Global Multiplier Matrix M

	F_L	F_C	H_0	H_{13}	H_{45}	H_6	H_{tr}	F_r	P_a	P_m	P_s	P_e	P_h	C_a	C_m	C_s	C_e	C_h	T_m	X_a	X_m
F_L	2,17	1,13	1,14	1,24	1,19	1,10	1,18	0,00	1,57	1,39	1,56	1,71	1,70	1,56	0,85	1,52	1,71	1,70	1,52	1,57	1,39
F_C	1,37	2,32	1,34	1,46	1,40	1,29	1,39	0,00	1,88	1,74	1,71	1,62	1,61	1,86	1,03	1,67	1,62	1,61	1,67	1,88	1,74
H_0	1,07	0,91	1,70	0,77	0,73	0,68	1,12	0,00	0,97	0,87	0,93	0,96	0,96	0,96	0,53	0,90	0,96	0,95	0,90	0,97	0,87
H_{13}	1,57	1,56	1,12	2,21	1,16	1,08	1,53	0,00	1,54	1,40	1,46	1,49	1,48	1,53	0,84	1,43	1,49	1,48	1,43	1,54	1,40
H_{45}	0,66	0,69	0,48	0,52	1,50	0,46	0,65	0,00	0,67	0,61	0,63	0,63	0,63	0,66	0,36	0,61	0,63	0,63	0,61	0,67	0,61
H_6	0,17	0,18	0,12	0,13	0,13	1,12	0,22	0,00	0,17	0,15	0,16	0,16	0,16	0,17	0,09	0,16	0,16	0,16	0,16	0,17	0,15
H_{tr}	0,05	0,04	0,05	0,05	0,04	0,04	1,05	0,00	0,04	0,04	0,04	0,04	0,04	0,04	0,02	0,04	0,04	0,04	0,04	0,04	0,04
F_r	0,08	0,14	0,08	0,09	0,08	0,08	0,08	1,00	0,11	0,10	0,10	0,10	0,10	0,11	0,06	0,10	0,10	0,10	0,10	0,11	0,10
P_a	1,51	1,46	1,48	1,61	1,52	1,48	1,54	0,00	2,49	1,57	1,43	1,49	1,46	2,41	0,93	1,40	1,49	1,46	1,40	2,49	1,57
P_m	0,74	0,71	0,72	0,78	0,77	0,66	0,75	0,00	0,73	1,77	0,75	0,75	0,75	0,73	0,95	0,74	0,75	0,75	0,74	0,73	1,77
P_s	1,08	1,04	1,05	1,15	1,12	0,96	1,09	0,00	1,07	1,27	2,21	1,24	1,25	1,14	0,85	2,16	1,24	1,25	2,16	1,07	1,27
P_e	0,08	0,08	0,08	0,09	0,08	0,08	0,08	0,00	0,08	0,07	0,07	1,08	0,08	0,08	0,04	0,07	1,08	0,08	0,07	0,08	0,07
P_h	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,00	0,02	0,02	0,02	0,02	1,02	0,02	0,01	0,02	0,02	1,02	0,02	0,02	0,02
C_a	1,63	1,57	1,60	1,74	1,64	1,60	1,66	0,00	1,61	1,70	1,55	1,61	1,58	2,60	1,00	1,51	1,61	1,58	1,51	1,61	1,70
C_m	1,49	1,44	1,45	1,58	1,56	1,33	1,50	0,00	1,47	1,55	1,52	1,51	1,51	1,47	1,92	1,48	1,51	1,51	1,48	1,47	1,55
C_s	1,10	1,07	1,08	1,17	1,15	0,99	1,12	0,00	1,09	1,30	1,24	1,27	1,28	1,17	0,87	2,21	1,27	1,28	2,21	1,09	1,30
C_e	0,08	0,08	0,08	0,09	0,08	0,08	0,08	0,00	0,08	0,07	0,07	0,08	0,08	0,08	0,04	0,07	1,08	0,08	0,07	0,08	0,07
C_h	0,02	0,02	0,02	0,03	0,02	0,02	0,02	0,00	0,02	0,02	0,02	0,02	0,02	0,02	0,01	0,02	0,02	1,02	0,02	0,02	0,02
T_m	0,27	0,26	0,26	0,28	0,28	0,25	0,27	0,00	0,26	0,28	0,27	0,27	0,27	0,33	0,27	0,26	0,27	0,27	1,26	0,26	0,28
X_a	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00
X_m	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00

Table 3: Scenario Analysis - 10% of ROW transfer to HH is alternatively used as an injection into different accounts

Scenarios	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]
Injection by	SI	SI	G	SI	SI	SI	RoW	G	G	G	G	G RoW	RoW	RoW	G	RoW	SI	G	SI
Injection into	C_e=765 C_h=383	C_e=574 C_h=574	C_e=574 C_h=574	C_e=383 C_h=765	C_h=1148	C_a=1148	X_a=23 X_m=1125	P_a=574 C_e=287 C_h=287	P_e=574 P_h=574	P_m=1148	P_a=1148	P_a=287 H_0=295 C_e=145 H_{13}=189 C_h=145 H_{45}=64 H_6=24	H_0=701 H_{13}=447	H_0=594 H_{13}=378 H_{45}=127 H_6=48	H_0=594 H_{13}=378 H_{45}=127 H_6=48	H_{45}=835 H_6=313	C_a=574 C_m=574	C_a=574 C_m=574	C_m=1148
Net aggregate income gain	19545	19535	19532	19517	19489	19461	19425	18878	18387	18274	18227	17674	16450	16406	16404	16269	15868	15867	12273
Endog accounts	% change in net income gain																		
F_L	0,2804	0,2803	0,2803	0,2800	0,2796	0,2564	0,2287	0,2688	0,2804	0,2281	0,2574	0,2319	0,1945	0,1939	0,1939	0,1919	0,1976	0,1976	0,1389
F_C	0,2358	0,2355	0,2354	0,2351	0,2346	0,2706	0,2532	0,2544	0,2355	0,2529	0,2733	0,2282	0,2017	0,2012	0,2011	0,1994	0,2106	0,2106	0,1505
H_0	0,2582	0,2580	0,2580	0,2577	0,2573	0,2587	0,2354	0,2592	0,2580	0,2350	0,2603	0,2972	0,3608	0,3352	0,3350	0,1934	0,2002	0,2002	0,1418
H_{13}	0,2546	0,2545	0,2545	0,2542	0,2537	0,2625	0,2407	0,2594	0,2545	0,2401	0,2645	0,2573	0,2651	0,2542	0,2540	0,1956	0,2035	0,2035	0,1443
H_{45}	0,2524	0,2524	0,2520	0,2520	0,2513	0,2638	0,2423	0,2590	0,2520	0,2416	0,2656	0,2510	0,1989	0,2423	0,2420	0,4860	0,2045	0,2045	0,1451
H_6	0,2516	0,2516	0,2516	0,2503	0,2503	0,2626	0,2407	0,2585	0,2516	0,2407	0,2639	0,2612	0,1997	0,2639	0,2639	0,6236	0,2038	0,2038	0,1436
H_{tr}	0,2563	0,2563	0,2511	0,2563	0,2563	0,2616	0,2406	0,2563	0,2511	0,2354	0,2616	0,2720	0,2877	0,2825	0,2825	0,2616	0,2040	0,2040	0,1465
F_r	0,1283	0,1283	0,1283	0,1283	0,1283	0,1479	0,1375	0,1375	0,1283	0,1375	0,1479	0,1237	0,1098	0,1086	0,1086	0,1075	0,1144	0,1144	0,0820
P_a	0,2432	0,2425	0,2425	0,2418	0,2402	0,3956	0,2614	0,3257	0,2425	0,2582	0,4089	0,2885	0,2515	0,2508	0,2507	0,2479	0,2737	0,2738	0,1519
P_m	0,1584	0,1584	0,1584	0,1586	0,1586	0,1544	0,3694	0,1566	0,1584	0,3738	0,1546	0,1571	0,1575	0,1573	0,1571	0,1570	0,1780	0,1780	0,2015
P_s	0,1873	0,1876	0,1876	0,1877	0,1882	0,1718	0,1906	0,1741	0,1876	0,1911	0,1607	0,1691	0,1639	0,1635	0,1635	0,1625	0,1501	0,1501	0,1282
P_e	0,9593	0,7443	0,7443	0,5292	0,0980	0,1002	0,0923	0,4222	0,7443	0,0912	0,1013	0,2669	0,1081	0,1070	0,1070	0,1013	0,0777	0,0777	0,0552
P_h	1,4173	2,0792	2,0758	2,7411	4,0649	0,0936	0,0832	1,0847	2,0792	0,0832	0,0936	0,5926	0,0936	0,0936	0,0970	0,0901	0,0728	0,0693	0,0520
C_a	0,2439	0,2432	0,2432	0,2424	0,2409	0,3965	0,2586	0,2442	0,2432	0,2590	0,2454	0,2481	0,2520	0,2512	0,2513	0,2484	0,2744	0,2743	0,1522
C_m	0,1836	0,1837	0,1837	0,1837	0,1839	0,1789	0,1878	0,1815	0,1837	0,1881	0,1792	0,1820	0,1824	0,1821	0,1822	0,1819	0,2062	0,2062	0,2336
C_s	0,1873	0,1875	0,1876	0,1878	0,1882	0,1718	0,1906	0,1742	0,1876	0,1911	0,1607	0,1692	0,1639	0,1635	0,1635	0,1626	0,1500	0,1502	0,1283
C_e	0,9593	0,7443	0,7443	0,5292	0,0980	0,1002	0,0923	0,4222	0,0980	0,0912	0,1013	0,2669	0,1081	0,1070	0,1070	0,1013	0,0777	0,0777	0,0552
C_h	1,4165	2,0780	2,0780	2,7395	4,0659	0,0935	0,0831	1,0840	0,0900	0,0831	0,0935	0,5922	0,0935	0,0935	0,0970	0,0900	0,0727	0,0693	0,0519
T_m	0,2046	0,2046	0,2046	0,2040	0,2040	0,2553	0,2133	0,2033	0,2046	0,2126	0,2026	0,2053	0,2073	0,2066	0,2066	0,2053	0,2300	0,2300	0,2046
X_a	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	1,5488	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
X_m	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	1,5133	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000

Table 4: Type I pathways within the household block

	(1) Path origin (i)	(2) Path destination (j)	(3) Global influence $I^G_{(i\to j)}$	(4) Elementary paths $(i \to j)_p$					(5) Direct influence $I^D_{(i\to j)p}$	(6) * Path multiplier * M_p	(7) = Total influence = $I^T_{(i\to j)p}$	(8) $[I^T_{(i\to j)p}/I^G_{(i\to j)}]$ (in %)
1	H_0	H_{13}	1,118	H_0	C_a	P_a	F_L	H_{13}	0,063	3,495	0,222	19,8
				H_0	C_a	P_a	F_C	H_{13}	0,086	3,540	0,303	27,1
				H_0	C_m	P_m	F_C	H_{13}	0,019	3,808	0,074	6,6
				H_0	C_s	P_s	F_L	H_{13}	0,020	3,996	0,082	7,3
				H_0	C_s	P_s	F_C	H_{13}	0,019	4,135	0,079	7,1
2	H_0	H_{45}	0,482	H_0	C_a	P_a	F_L	H_{45}	0,024	3,358	0,081	16,7
				H_0	C_a	P_a	F_C	H_{45}	0,041	3,392	0,138	28,6
				H_0	C_m	P_m	F_C	H_{45}	0,009	3,501	0,032	6,7
				H_0	C_s	P_s	F_L	H_{45}	0,008	3,660	0,028	5,9
				H_0	C_s	P_s	F_C	H_{45}	0,009	3,850	0,035	7,2
3	H_0	H_6	0,123	H_0	C_a	P_a	F_L	H_6	0,006	3,251	0,020	15,9
				H_0	C_a	P_a	F_C	H_6	0,010	3,317	0,034	27,4
				H_0	C_m	P_m	F_C	H_6	0,002	3,381	0,008	6,3
				H_0	C_s	P_s	F_L	H_6	0,002	3,468	0,007	5,5
				H_0	C_s	P_s	F_C	H_6	0,002	3,742	0,008	6,9
4	H_0	H_{tr}	0,049	H_0	H_{tr}				0,017	1,730	0,029	59,8
5	H_{13}	H_0	0,765	H_{13}	C_a	P_a	F_L	H_0	0,056	3,495	0,195	25,5
				H_{13}	C_a	P_a	F_C	H_0	0,045	3,540	0,158	20,6
				H_{13}	C_m	P_m	F_C	H_0	0,010	3,808	0,039	5,1
				H_{13}	C_s	P_s	F_L	H_0	0,018	3,996	0,072	9,4
				H_{13}	C_s	P_s	F_C	H_0	0,010	4,135	0,041	5,4
6	H_{13}	H_{45}	0,524	H_{13}	C_a	P_a	F_L	H_{45}	0,026	3,494	0,092	17,5
				H_{13}	C_a	P_a	F_C	H_{45}	0,045	3,444	0,153	29,3
				H_{13}	C_m	P_m	F_C	H_{45}	0,010	3,611	0,037	7,0
				H_{13}	C_s	P_s	F_L	H_{45}	0,008	3,978	0,034	6,4
				H_{13}	C_s	P_s	F_C	H_{45}	0,010	3,950	0,039	7,5
7	H_{13}	H_6	0,133	H_{13}	C_a	P_a	F_L	H_6	0,007	3,387	0,022	16,7
				H_{13}	C_a	P_a	F_C	H_6	0,011	3,369	0,037	28,0
				H_{13}	C_m	P_m	F_C	H_6	0,003	3,491	0,009	6,6
				H_{13}	C_s	P_s	F_L	H_6	0,002	3,787	0,008	6,0
				H_{13}	C_s	P_s	F_C	H_6	0,003	3,843	0,010	7,1
8	H_{13}	H_{tr}	0,046	H_{13}	H_{tr}				0,012	2,247	0,027	57,6
9	H_{45}	H_0	0,733	H_{45}	C_a	P_a	F_L	H_0	0,049	3,358	0,166	22,7
				H_{45}	C_a	P_a	F_C	H_0	0,039	3,392	0,134	18,3
				H_{45}	C_m	P_m	F_C	H_0	0,011	3,501	0,038	5,2
				H_{45}	C_s	P_s	F_L	H_0	0,019	3,660	0,071	9,6
				H_{45}	C_s	P_s	F_C	H_0	0,011	3,850	0,041	5,6
10	H_{45}	H_{13}	1,164	H_{45}	C_a	P_a	F_L	H_{13}	0,061	3,494	0,214	18,4
				H_{45}	C_a	P_a	F_C	H_{13}	0,083	3,444	0,285	24,5
				H_{45}	C_m	P_m	F_C	H_{13}	0,023	3,611	0,082	7,1
				H_{45}	C_s	P_s	F_L	H_{13}	0,024	3,978	0,095	8,2
				H_{45}	C_s	P_s	F_C	H_{13}	0,022	3,950	0,088	7,6
11	H_{45}	H_6	0,128	H_{45}	C_a	P_a	F_L	H_6	0,006	3,250	0,019	14,8
				H_{45}	C_a	P_a	F_C	H_6	0,010	3,221	0,032	24,7
				H_{45}	C_m	P_m	F_C	H_6	0,003	3,185	0,009	6,7
				H_{45}	C_s	P_s	F_L	H_6	0,002	3,451	0,008	6,1
				H_{45}	C_s	P_s	F_C	H_6	0,003	3,557	0,009	7,4
12	H_{45}	H_{tr}	0,044	H_{45}	H_{tr}				0,011	1,544	0,016	37,4
13	H_6	H_0	0,678	H_6	C_a	P_a	F_L	H_0	0,058	3,251	0,190	28,0
				H_6	C_a	P_a	F_C	H_0	0,047	3,317	0,155	22,8
				H_6	C_s	P_s	F_L	H_0	0,012	3,468	0,041	6,0
14	H_6	H_{13}	1,077	H_6	C_a	P_a	F_L	H_{13}	0,072	3,387	0,245	22,8
				H_6	C_a	P_a	F_C	H_{13}	0,098	3,369	0,330	30,6
				H_6	C_m	P_m	F_C	H_{13}	0,015	3,491	0,052	4,9
				H_6	C_s	P_s	F_L	H_{13}	0,015	3,787	0,055	5,1
				H_6	C_s	P_s	F_C	H_{13}	0,014	3,843	0,052	4,9
15	H_6	H_{45}	0,465	H_6	C_a	P_a	F_L	H_{45}	0,027	3,250	0,089	19,2
				H_6	C_a	P_a	F_C	H_{45}	0,047	3,221	0,150	32,3
				H_6	C_m	P_m	F_C	H_{45}	0,007	3,185	0,023	4,9
				H_6	C_s	P_s	F_C	H_{45}	0,007	3,557	0,023	5,0
16	H_6	H_{tr}	0,044	H_6	H_{tr}				0,013	1,161	0,016	35,3
17	H_{tr}	H_0	1,121	H_{tr}	H_0				0,392	1,730	0,679	60,5
18	H_{tr}	H_{13}	1,528	H_{tr}	H_{13}				0,371	2,247	0,834	54,6
19	H_{tr}	H_{45}	0,647	H_{tr}	H_{45}				0,148	1,544	0,228	35,3
20	H_{tr}	H_6	0,216	H_{tr}	H_6				0,089	1,161	0,103	47,7

Source: Author's own calculations based on a Mathematica Code developed by himself. The Mathematica Code used will be made available upon request.

Table 5: Type II pathways within the production block

	(1) Path origin (i)	(2) Path destination (j)	(3) Global influence $I^G_{(i-->j)}$	(4) Element paths $(i --> j)_p$					(5) Direct influence $I^D_{(i-->j)p}$ *	(6) Path multiplier M_p =	(7) Total influence $I^T_{(i-->j)p}$	(8) $[I^T_{(i-->j)p}/I^G_{(i-->j)}]$ (in %)
1	P_a	P_m	0,731	P_a	C_m	P_m			0,013	3,422	0,044	6,0
				P_a	F_L	H_0	C_m	P_m	0,023	3,867	0,088	12,0
				P_a	F_L	H_{13}	C_m	P_m	0,031	3,937	0,123	16,8
				P_a	F_L	H_{45}	C_m	P_m	0,013	3,853	0,049	6,6
				P_a	F_C	H_0	C_m	P_m	0,018	3,849	0,070	9,5
				P_a	F_C	H_{13}	C_m	P_m	0,042	3,883	0,163	22,3
				P_a	F_C	H_{45}	C_m	P_m	0,021	3,769	0,081	11,0
2	P_a	P_s	1,069	P_a	F_L	H_0	C_s	P_s	0,018	4,227	0,077	7,2
				P_a	F_L	H_{13}	C_s	P_s	0,025	4,285	0,105	9,8
				P_a	F_C	H_0	C_s	P_s	0,014	4,304	0,062	5,8
				P_a	F_C	H_{13}	C_s	P_s	0,033	4,315	0,143	13,4
				P_a	F_C	H_{45}	C_s	P_s	0,017	4,254	0,072	6,7
3	P_a	P_e	0,078	P_a	F_L	H_0	C_e	P_e	0,004	3,198	0,011	14,2
				P_a	F_L	H_{13}	C_e	P_e	0,004	3,340	0,015	18,5
				P_a	F_L	H_{45}	C_e	P_e	0,001	3,198	0,004	5,3
				P_a	F_C	H_0	C_e	P_e	0,003	3,284	0,009	11,7
				P_a	F_C	H_{13}	C_e	P_e	0,006	3,338	0,020	25,0
				P_a	F_C	H_{45}	C_e	P_e	0,002	3,191	0,007	9,0
4	P_a	P_h	0,023	P_a	F_L	H_0	C_h	P_h	0,001	3,186	0,003	11,6
				P_a	F_L	H_{13}	C_h	P_h	0,001	3,331	0,005	20,4
				P_a	F_L	H_{45}	C_h	P_h	0,001	3,184	0,002	6,4
				P_a	F_C	H_0	C_h	P_h	0,001	3,263	0,002	9,5
				P_a	F_C	H_{13}	C_h	P_h	0,002	3,318	0,006	27,4
				P_a	F_C	H_{45}	C_h	P_h	0,001	3,160	0,003	10,7
5	P_m	P_a	1,574	P_m	C_a	P_a			0,208	3,352	0,698	44,3
				P_m	F_L	H_{13}	C_a	P_a	0,021	3,884	0,081	5,2
				P_m	F_C	H_0	C_a	P_a	0,021	3,794	0,079	5,0
				P_m	F_C	H_{13}	C_a	P_a	0,048	3,829	0,182	11,6
				P_m	F_C	H_{45}	C_a	P_a	0,020	3,714	0,074	4,7
6	P_m	P_s	1,271	P_m	C_s	P_s			0,205	2,951	0,604	47,6
				P_m	F_C	H_{13}	C_s	P_s	0,017	4,277	0,072	5,7
				P_m	C_a	T_m	C_s	P_s	0,015	4,702	0,072	5,7
7	P_m	P_e	0,071	P_m	F_L	H_0	C_e	P_e	0,001	3,096	0,003	4,6
				P_m	F_L	H_{13}	C_e	P_e	0,001	3,393	0,004	6,3
				P_m	F_C	H_0	C_e	P_e	0,001	3,280	0,005	6,5
				P_m	F_C	H_{13}	C_e	P_e	0,003	3,392	0,010	14,2
				P_m	F_C	H_{45}	C_e	P_e	0,001	3,088	0,004	4,9
8	P_m	P_h	0,021	P_m	F_L	H_{13}	C_h	P_h	0,000	3,383	0,001	6,9
				P_m	F_C	H_0	C_h	P_h	0,000	3,256	0,001	5,3
				P_m	F_C	H_{13}	C_h	P_h	0,001	3,370	0,003	15,6
				P_m	F_C	H_{45}	C_h	P_h	0,000	3,054	0,001	5,8
9	P_s	P_a	1,434	P_s	C_a	P_a			0,023	3,981	0,093	6,5
				P_s	F_L	H_0	C_a	P_a	0,046	4,227	0,196	13,7
				P_s	F_L	H_{13}	C_a	P_a	0,063	4,285	0,270	18,8
				P_s	F_L	H_{45}	C_a	P_a	0,021	4,212	0,089	6,2
				P_s	F_C	H_0	C_a	P_a	0,026	4,304	0,110	7,7
				P_s	F_C	H_{13}	C_a	P_a	0,059	4,315	0,254	17,7
				P_s	F_C	H_{45}	C_a	P_a	0,025	4,254	0,105	7,3
10	P_s	P_m	0,755	P_s	C_m	P_m			0,057	2,951	0,167	22,1
				P_s	F_L	H_0	C_m	P_m	0,021	3,992	0,082	10,9
				P_s	F_L	H_{13}	C_m	P_m	0,028	4,249	0,120	15,9
				P_s	F_L	H_{45}	C_m	P_m	0,011	3,961	0,045	6,0
				P_s	F_C	H_0	C_m	P_m	0,011	4,190	0,048	6,3
				P_s	F_C	H_{13}	C_m	P_m	0,026	4,277	0,113	15,0
				P_s	F_C	H_{45}	C_m	P_m	0,013	4,016	0,054	7,1
11	P_s	P_e	0,074	P_s	F_L	H_0	C_e	P_e	0,003	3,416	0,011	14,6
				P_s	F_L	H_{13}	C_e	P_e	0,004	3,728	0,015	19,8
				P_s	F_L	H_{45}	C_e	P_e	0,001	3,400	0,004	5,4
				P_s	F_C	H_0	C_e	P_e	0,002	3,732	0,007	8,8
				P_s	F_C	H_{13}	C_e	P_e	0,004	3,828	0,014	19,0
				P_s	F_C	H_{45}	C_e	P_e	0,001	3,559	0,005	6,6
12	P_s	P_h	0,022	P_s	F_L	H_0	C_h	P_h	0,001	3,403	0,003	11,9
				P_s	F_L	H_{13}	C_h	P_h	0,001	3,719	0,005	21,8
				P_s	F_L	H_{45}	C_h	P_h	0,000	3,386	0,001	6,5
				P_s	F_C	H_0	C_h	P_h	0,000	3,709	0,002	7,1
				P_s	F_C	H_{13}	C_h	P_h	0,001	3,807	0,005	20,8
				P_s	F_C	H_{45}	C_h	P_h	0,001	3,527	0,002	7,9
13	P_e	P_a	1,491	P_e	C_a	P_a			0,053	2,670	0,142	9,5
				P_e	F_L	H_0	C_a	P_a	0,061	3,244	0,197	13,2
				P_e	F_L	H_{13}	C_a	P_a	0,082	3,373	0,278	18,6
				P_e	F_L	H_{45}	C_a	P_a	0,028	3,244	0,089	6,0
				P_e	F_C	H_{13}	C_a	P_a	0,037	3,376	0,126	8,5
14	P_e	P_m	0,749	P_e	C_m	P_m			0,036	2,002	0,073	9,7
				P_e	F_L	H_0	C_m	P_m	0,027	3,185	0,086	11,5
				P_e	F_L	H_{13}	C_m	P_m	0,037	3,469	0,128	17,2
				P_e	F_L	H_{45}	C_m	P_m	0,015	3,168	0,047	6,3
				P_e	F_C	H_{13}	C_m	P_m	0,017	3,476	0,058	7,8
15	P_e	P_s	1,243	P_e	C_s	P_s			0,167	2,289	0,381	30,7
				P_e	F_L	H_0	C_s	P_s	0,022	3,416	0,074	5,9
				P_e	F_L	H_{13}	C_s	P_s	0,029	3,728	0,109	8,7
16	P_e	P_h	0,022	P_e	F_L	H_0	C_h	P_h	0,001	2,506	0,003	11,2
				P_e	F_L	H_{13}	C_h	P_h	0,002	2,864	0,005	21,5
				P_e	F_L	H_{45}	C_h	P_h	0,001	2,505	0,001	6,1
				P_e	F_C	H_{13}	C_h	P_h	0,001	2,910	0,002	9,9
17	P_h	P_a	1,465	P_h	C_a	P_a			0,033	2,619	0,087	5,9
				P_h	F_L	H_0	C_a	P_a	0,061	3,231	0,196	13,4
				P_h	F_L	H_{13}	C_a	P_a	0,082	3,365	0,277	18,9
				P_h	F_L	H_{45}	C_a	P_a	0,028	3,230	0,089	6,1
				P_h	F_C	H_{13}	C_a	P_a	0,037	3,357	0,125	8,6
18	P_h	P_m	0,751	P_h	C_m	P_m			0,041	1,944	0,080	10,7
				P_h	F_L	H_0	C_m	P_m	0,027	3,171	0,086	11,4
				P_h	F_L	H_{13}	C_m	P_m	0,037	3,460	0,128	17,1
				P_h	F_L	H_{45}	C_m	P_m	0,015	3,152	0,047	6,3
				P_h	F_C	H_{13}	C_m	P_m	0,017	3,454	0,058	7,7
19	P_h	P_s	1,253	P_h	C_s	P_s			0,178	2,234	0,398	31,8
				P_h	F_L	H_0	C_s	P_s	0,022	3,403	0,073	5,9
				P_h	F_L	H_{13}	C_s	P_s	0,029	3,719	0,108	8,7
20	P_h	P_e	0,076	P_h	F_L	H_0	C_e	P_e	0,004	2,506	0,010	13,7
				P_h	F_L	H_{13}	C_e	P_e	0,005	2,864	0,015	19,6
				P_h	F_L	H_{45}	C_e	P_e	0,002	2,505	0,004	5,1
				P_h	F_C	H_{13}	C_e	P_e	0,002	2,910	0,007	9,0

Source: Author's own calculations based on a Mathematica Code developed by himself. The Mathematica Code will be made available upon request.

Table 6: Type III pathways from households to commodities

	(1) Path origin (*i*)	(2) Path destinatio (*j*)	(3) Global influence $I^G_{(i\text{-->}j)}$	(4) Element paths $(i \text{-->} j)_p$					(5) Direct influence $I^D_{(i\text{-->}j)p}$ ×	(6) Path multiplier × M_p	(7) Total influence $= I^T_{(i\text{-->}j)p}$	(8) $[I^T_{(i\text{-->}j)p} / I^G_{(i\text{-->}j)}]$ (in %)
1	H_0	C_a	1,596	H_0	C_a				0,386	2,897	1,119	70,1
				H_0	C_m	P_m	C_a		0,036	3,704	0,132	8,3
2	H_0	C_m	1,448	H_0	C_m				0,321	2,512	0,806	55,6
3	H_0	C_s	1,078	H_0	C_s				0,130	2,798	0,364	33,8
				H_0	C_a	T_m	C_s		0,027	4,118	0,111	10,3
				H_0	C_m	P_m	C_s		0,033	3,462	0,116	10,7
				H_0	C_m	T_m	C_s		0,033	3,462	0,114	10,6
4	H_0	C_e	0,081	H_0	C_e				0,025	1,756	0,043	52,8
5	H_0	C_h	0,023	H_0	C_h				0,006	1,721	0,010	44,9
6	H_0	T_m	0,261	H_0	C_a	T_m			0,027	3,035	0,082	31,4
				H_0	C_m	T_m			0,033	2,586	0,086	32,7
7	H_{13}	C_a	1,738	H_{13}	C_a				0,423	3,092	1,307	75,2
				H_{13}	C_m	P_m	C_a		0,040	3,798	0,150	8,6
8	H_{13}	C_m	1,581	H_{13}	C_m				0,355	2,922	1,037	65,6
9	H_{13}	C_s	1,174	H_{13}	C_s				0,142	3,227	0,458	39,0
				H_{13}	C_a	T_m	C_s		0,030	4,195	0,124	10,6
				H_{13}	C_m	P_m	C_s		0,037	3,815	0,141	12,0
				H_{13}	C_m	T_m	C_s		0,037	3,815	0,140	11,9
10	H_{13}	C_e	0,087	H_{13}	C_e				0,025	2,255	0,056	64,1
11	H_{13}	C_h	0,026	H_{13}	C_h				0,008	2,225	0,018	67,8
12	H_{13}	T_m	0,285	H_{13}	C_a	T_m			0,030	3,208	0,095	33,3
				H_{13}	C_m	T_m			0,037	2,978	0,109	38,3
13	H_{45}	C_a	1,639	H_{45}	C_a				0,374	2,818	1,054	64,3
				H_{45}	C_m	P_m	C_a		0,042	3,640	0,154	9,4
14	H_{45}	C_m	1,560	H_{45}	C_m				0,379	2,317	0,878	56,3
15	H_{45}	C_s	1,151	H_{45}	C_s				0,152	2,618	0,399	34,7
				H_{45}	C_a	T_m	C_s		0,026	4,074	0,107	9,3
				H_{45}	C_m	P_m	C_s		0,040	3,280	0,129	11,2
				H_{45}	C_m	T_m	C_s		0,039	3,280	0,128	11,1
16	H_{45}	C_e	0,079	H_{45}	C_e				0,019	1,567	0,030	38,6
17	H_{45}	C_h	0,024	H_{45}	C_h				0,007	1,521	0,011	43,1
18	H_{45}	T_m	0,276	H_{45}	C_a	T_m			0,026	2,963	0,078	28,1
				H_{45}	C_m	T_m			0,039	2,400	0,094	34,0
19	H_6	C_a	1,599	H_6	C_a				0,442	2,637	1,165	72,9
				H_6	C_m	P_m	C_a		0,028	3,545	0,098	6,2
20	H_6	C_m	1,325	H_6	C_m				0,250	2,026	0,505	38,1
21	H_6	C_s	0,988	H_6	C_s				0,093	2,321	0,216	21,9
				H_6	C_a	T_m	C_s		0,031	4,002	0,124	12,5
				H_6	C_m	P_m	C_s		0,026	3,051	0,079	8,0
				H_6	C_m	T_m	C_s		0,026	3,051	0,079	7,9
22	H_6	C_e	0,077	H_6	C_e				0,023	1,191	0,027	34,8
23	H_6	C_h	0,019	H_6	C_h				0,003	1,140	0,003	15,9
24	H_6	T_m	0,249	H_6	C_a	T_m			0,031	2,802	0,087	34,8
				H_6	C_m	T_m			0,026	2,120	0,055	21,9
25	H_{tr}	C_a	1,655	H_{tr}	H_0	C_a			0,152	2,923	0,443	26,8
				H_{tr}	H_{13}	C_a			0,157	3,126	0,490	29,6
				H_{tr}	H_{45}	C_a			0,055	2,862	0,158	9,6
				H_{tr}	H_6	C_a			0,039	2,682	0,105	6,4
26	H_{tr}	C_m	1,503	H_{tr}	H_0	C_m			0,126	2,541	0,320	21,3
				H_{tr}	H_{13}	C_m			0,132	2,960	0,390	25,9
				H_{tr}	H_{45}	C_m			0,056	2,365	0,133	8,8
27	H_{tr}	C_s	1,116	H_{tr}	H_0	C_s			0,051	2,829	0,144	12,9
				H_{tr}	H_{13}	C_s			0,053	3,267	0,172	15,4
				H_{tr}	H_{45}	C_s			0,023	2,670	0,060	5,4
				H_{tr}	H_{13}	C_m	P_m	C_s	0,014	3,860	0,053	4,7
				H_{tr}	H_{13}	C_m	T_m	C_s	0,014	3,860	0,052	4,7
28	H_{tr}	C_e	0,083	H_{tr}	H_0	C_e			0,010	1,781	0,017	20,8
				H_{tr}	H_{13}	C_e			0,009	2,287	0,021	25,3
				H_{tr}	H_{45}	C_e			0,003	1,609	0,005	5,6
29	H_{tr}	C_h	0,024	H_{tr}	H_0	C_h			0,002	1,746	0,004	16,9
				H_{tr}	H_{13}	C_h			0,003	2,258	0,007	28,1
				H_{tr}	H_{45}	C_h			0,001	1,562	0,002	6,7
30	H_{tr}	T_m	0,271	H_{tr}	H_0	C_a	T_m		0,011	3,061	0,033	12,0
				H_{tr}	H_0	C_m	T_m		0,013	2,615	0,034	12,5
				H_{tr}	H_{13}	C_a	T_m		0,011	3,242	0,036	13,1
				H_{tr}	H_{13}	C_m	T_m		0,014	3,015	0,041	15,1
				H_{tr}	H_{45}	C_m	T_m		0,006	2,448	0,014	5,2

Source: Author's own calculations based on a Mathematica Code developed by himself. The Mathematica Code used will be made available upon request.

Table 7: Type IV pathways from production to factors

	(1) Path origin *(i)*	(2) Path destination *(j)*	(3) Global influence $I^G_{(i-->j)}$	(4) Elementary paths $(i --> j)_p$				(5) Direct influence * $I^D_{(i-->j)p}$ *	(6) Path multiplier = M_p =	(7) Total influence $I^T_{(i-->j)p}$	(8) $[I^T_{(i-->j)p} / I^G_{(i-->j)}]$ (in %)
1	P_a	F_L	1,5653	P_a	F_L			0,412	3,037	1,250	79,8
2	P_a	F_C	1,8794	P_a	F_C			0,526	3,046	1,602	85,2
3	P_e	F_L	1,7089	P_e	F_L			0,489	2,195	1,074	62,9
				P_e	C_s	P_s	F_L	0,062	3,142	0,196	11,5
4	P_e	F_C	1,6245	P_e	F_C			0,210	2,375	0,498	30,6
				P_e	C_a	P_a	F_C	0,028	3,157	0,088	5,4
				P_e	C_s	P_s	F_C	0,055	3,416	0,188	11,6
5	P_m	F_L	1,3873	P_m	F_L			0,124	2,809	0,348	25,1
				P_m	C_a	P_a	F_L	0,086	3,722	0,319	23,0
				P_m	C_s	P_s	F_L	0,077	3,756	0,319	20,7
6	P_m	F_C	1,7383	P_m	F_C			0,267	2,866	0,765	44,0
				P_m	C_a	P_a	F_C	0,109	3,642	0,399	22,9
				P_m	C_s	P_s	F_C	0,068	3,885	0,263	15,1
7	P_h	F_L	1,7015	P_h	F_L			0,489	2,177	1,065	62,6
				P_h	C_s	P_s	F_L	0,067	3,125	0,209	12,3
8	P_h	F_C	1,6141	P_h	F_C			0,210	2,339	0,490	30,4
				P_h	C_s	P_s	F_C	0,059	3,378	0,199	12,3
9	P_s	F_L	1,5584	P_s	F_L			0,374	3,118	1,167	74,9
10	P_s	F_C	1,706	P_s	F_C			0,330	3,364	1,110	65,1

Source: Author's own calculations based on a Mathematica Code developed by himself. The Mathematica Code used will be made available upon request.

Table 8: Type V pathways from exports to households

	(1) Path origin *(i)*	(2) Path destination *(j)*	(3) Global influence $I^G_{(i\to j)}$	(4) Eleme paths $(i \to j)_p$					(5) Direct influence $I^D_{(i\to j)p}$	* (6) Path multiplier M_p	= (7) Total influence $I^T_{(i\to j)p}$	(8) $[I^T_{(i\to j)p}/I^G_{(i\to j)}]$ (in %)
1	X_a	H_0	0,966	X_a	P_a	F_L	H_0		0,143	3,180	0,453	46,9
				X_a	P_a	F_C	H_0		0,114	3,253	0,370	38,3
2	X_a	H_{13}	1,542	X_a	P_a	F_L	H_{13}		0,177	3,328	0,588	38,1
				X_a	P_a	F_C	H_{13}		0,239	3,311	0,791	51,3
3	X_a	H_{45}	0,667	X_a	P_a	F_L	H_{45}		0,067	3,179	0,213	31,9
				X_a	P_a	F_C	H_{45}		0,114	3,148	0,358	53,6
4	X_a	H_6	0,169	X_a	P_a	F_L	H_6		0,017	3,064	0,051	30,5
				X_a	P_a	F_C	H_6		0,028	3,068	0,087	51,4
5	X_a	H_{tr}	0,044	X_a	P_a	F_L	H_0	H_{tr}	0,002	3,206	0,008	17,5
				X_a	P_a	F_L	H_{13}	H_{tr}	0,002	3,362	0,007	16,1
				X_a	P_a	F_L	H_{45}	H_{tr}	0,001	3,223	0,002	5,2
				X_a	P_a	F_C	H_0	H_{tr}	0,002	3,279	0,006	14,3
				X_a	P_a	F_C	H_{13}	H_{tr}	0,003	3,345	0,010	21,7
				X_a	P_a	F_C	H_{45}	H_{tr}	0,001	3,192	0,004	8,8
6	X_m	H_0	0,872	X_m	P_m	F_L	H_0		0,043	3,075	0,132	15,1
				X_m	P_m	F_C	H_0		0,058	3,245	0,187	21,5
7	X_m	H_{13}	1,400	X_m	P_m	F_L	H_{13}		0,053	3,379	0,180	12,9
				X_m	P_m	F_C	H_{13}		0,121	3,362	0,408	29,1
8	X_m	H_{45}	0,607	X_m	P_m	F_L	H_{45}		0,020	3,059	0,062	10,2
				X_m	P_m	F_C	H_{45}		0,058	3,041	0,175	28,9
9	X_m	H_6	0,154	X_m	P_m	F_L	H_6		0,005	2,876	0,015	9,5
				X_m	P_m	F_C	H_6		0,014	2,913	0,042	27,2
10	X_m	H_{tr}	0,040	X_m	P_m	F_L	H_0	H_{tr}	0,001	3,104	0,002	5,6
				X_m	P_m	F_L	H_{13}	H_{tr}	0,001	3,416	0,002	5,5
				X_m	P_m	F_C	H_0	H_{tr}	0,001	3,274	0,003	8,0
				X_m	P_m	F_C	H_{13}	H_{tr}	0,001	3,399	0,005	12,4
				X_m	P_m	F_C	H_{45}	H_{tr}	0,001	3,089	0,002	4,8

Source: Author's own calculations based on a Mathematica Code developed by himself. The Mathematica Code used will be made available upon request

Table 9: Backward and forward linkages

	Column Total Backward linkages		Row Total Forward linkages	
	%	Rank	%	Rank
F_L	102	9	195	4
F_C	99	11	217	2
H_0	94	13	126	8
H_{13}	101	10	194	5
H_{45}	98	12	87	10
H_6	90	14	27	12
H_{tr}	103	8	12	17
F_r	7	16	20	14
P_a	107	6	217	2
P_m	107	6	115	9
P_s	106	7	173	6
P_e	108	5	24	13
P_h	108	5	16	16
C_a	114	3	219	1
C_m	72	15	204	3
C_s	110	4	170	7
C_e	115	2	17	15
C_h	114	3	10	18
T_m	117	1	43	11
X_a	114	3	7	19
X_m	114	3	7	20