How Does Growth Affect Labor Income by Gender? A Structural Path Analysis for Tanzania

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Chapter 7

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Introduction

Social accounting matrices (SAMs) have been used fairly extensively to model the effects of shocks on a nation's economy. A brief literature review on SAMs and examples of their use for simple simulations were provided by Parra and Wodon (2009b) in chapter 6 of this volume. That chapter highlighted the strengths and weaknesses of SAMs and emphasized the need to be careful before using SAM-based simulation results in order to inform policy. It is worthwhile to start here by summarizing briefly some of the key features of SAMs from that chapter.

A social accounting matrix is a database with information on cross-purchases between different agents and sectors in the economy. But it can also be used as a simple, static yet comprehensive model of an economy. As such model, the SAM assumes that all agents and accounts behave according to their expenditure propensities, which represent what one agent or account in the economy buys from other agents or accounts. It is also assumed that these propensities are unaffected by the shocks simulated in the model; that is, there are no behavioral responses or changes following a shock. This means, among other things, that when a SAM is used for quantity shocks, prices are held constant, and when it is used for simulating price shocks, quantities used or consumed are also held constant.

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The general equilibrium nature of the SAM model comes from the fact that the model takes into account multiplier effects. If production in one account or sector is increased, that sector by assumption must buy inputs from other accounts, which in turn must purchase additional inputs, and so on. All these spillover effects from an initial shock are taken into account in the SAM model, which gives us the overall impact of a shock on the economy or on households after the economy has reached a new equilibrium following the shock.

The core of the SAM model is the technical coefficients matrix containing the expenditure propensities for every account in the matrix. The equilibrium character of the model is given by the fact that, at a solution, there are no forces suggesting additional changes. In the simplest form of the model, no resource constraint is specified because it is assumed that any additional production required is feasible, so that all resources (factors) required to undertake additional production are available (this assumption can be relaxed).

SAMs have been used to measure the impact, or multiplier effects, of a wide variety of shocks in an economy, such as those discussed in Chapter 6, to assess how sectoral growth patterns may affect household labor income by gender. This type of analysis is feasible when the labor income accounts in the SAM are disaggregated by gender.

Beyond measurement of multipliers, SAMs can also be used to better understand exactly how an initial shock affects the economy and ends up in an overall final impact that is larger than the initial shock. These shock effects are what this chapter focuses on; specifically, structural path analysis (SPA) is used to examine the transmission channels through which an initial shock travels through the economy to affect all the other accounts of the SAM, with a focus here on the impact of shocks on labor income by gender. This analysis is used to characterize what we call the concentration, strength, and speed of various transmission channels. Concentration refers to the share of the total impact of a shock that travels through one or more paths linking various accounts in the SAM. Strength, by contrast, depends on the size of the contribution of a path to the total multiplier effect estimated through the SAM. Finally, speed relates to the share of the contribution of the path that travels directly from the origin to the destination, without going through any account more than once, with paths of higher lengths typically taking more time to materialize because a higher number of transactions need to take place.

This chapter builds on several previous papers that have relied on SPA in the literature on SAMs. The SPA methodology was initially proposed by Lantner (1974) who applied it to an input-output table (Lantner 1972). Defourny and Thorbecke (1984) applied SPA to a SAM for the first time using a 1968 SAM for the Republic of Korea. Their analysis concentrated on the effects of production activities on other production activities, on factors of production, on households, and finally the influence of households on production activities. Xie (2000) illustrates the use of SPA to an environmentally extended SAM in China.

Using economic links, fields of influence, and SPA on a 1995 SAM for Australia, Lanzen (2003) concludes that considerable environmental and resource pressure is exerted along paths that lead to exports. Beef cattle for exported meat products, exports of non-ferrous metal products, and exported sheep and wool were found to be the sectors exerting most of the pressure. The environmental effects are measured through emission of greenhouse gases, and measures of energy consumption, water use, and land disturbance are also used.

Ferri and Uriel (2002) use SPA on a 2000 SAM for Spain to study the distributive effects of exogenous shocks to public spending and exports. They conclude that Other Services is the key sector to increase labor income of qualified workers. More than 80 percent of the total effect of Other Services on labor income of qualified workers is explained by direct payments, with no other account as intermediary.

Roberts (2005) uses SPA to analyze the role of different types of households in the rural Western Isles region of Scotland in 1997. Quantifying the importance of all paths that include household accounts, she concludes that households with children, compared to households without children and retired households, play a key role in connecting production and consumption, accounting for more than half of the total household-related multiplier effects for every economic sector. The study was motivated by the observation that, because of limited inter-industry links in rural areas, households have a high influence on multiplier effects.

Khan and Thorbecke (1989) analyze the gradual substitution of traditional technologies using a highly disaggregated 1975 SAM for Indonesia. In particular, the authors compare the structures of hand-pounded rice with that of rice milling, and the structures of brown and refined sugars. They conclude that the higher multiplier effect of hand-pounded rice on agricultural employees is explained by higher backward links between hand-pounded rice and farm food crops, as compared to milled rice and farm food crops. In the case of sugar, the links to the factors of production in the rural areas are much larger for brown than for refined sugar.

This chapter uses a recent SAM for Tanzania to show how SPA can be used to better understand the transmission channels through which sectoral growth patterns are likely to have different effects on the incomes of women and men. To our knowledge, this is the first time that structural path analysis has been used to study gender issues. As mentioned, one must be careful in using results from SAM simulations for policy direction. Our goal here is not to inform policy in Tanzania, but simply to illustrate the type of gender and labor analysis that can be performed with a SAM, especially using SPA.

The next section provides a brief description of the Tanzania SAM with a focus on the gender disaggregation (for a more generic description of the basic structure of a standard SAM, see Chapter 6 on Guinea). The third and fourth sections present the results of basic simulations and the structural path analysis, respectively, followed by a brief conclusion.

Main Features of the 2001 Tanzania SAM

This section presents a description of the structure of the SAM used for our analysis, as well as some descriptive statistics on indicators like production, value-added, exports, and imports. A more detailed description is provided for the labor disaggregation in the SAM (by gender and education level), including the labor intensity, and female labor intensity and share for every sector in the SAM.

Description of the Accounts in the Tanzania SAM

The 2001 Tanzania SAM was constructed by Thurlow and Wobst (2003) at the International Food Policy Research Institute.[1] It includes 43 activities and commodities, 10 categories of labor, 2 types of capital as a production factor, 1 account for land, 1 for enterprises, 12 types of households, 7 accounts for government, 1 account for investment, and 1 account for the rest of the world. The labor income accounts are disaggregated according to gender and education (with the following categories: individuals with no formal education, individuals not having completed primary school, individuals with primary school but not having completed secondary school, and individuals with secondary or higher education). Child labor is also included as a separate account. Capital is divided into agricultural and non-agricultural capital accounts. Household accounts are based on the area of residence, poverty status, and education of the head of household.

Table 7.1 provides basic data on the sectors included in the SAM. The table shows that Real Estate, Public Administration, Trade, and Maize are the largest contributors to value-added, with shares of total value-added of, respectively, 14.4 percent, 11.3 percent, 7.2 percent, and 6.1 percent.

In terms of international trade, imports are mainly for Transport and Communications, Equipment, and Petroleum Refineries sectors, which together account for 60 percent of total imports in CIF (cost, insurance, and freight) value. For the following goods, the imports exceed domestic production (the imports as a share of domestic production is provided in parenthesis): Wheat (72 percent), Chemicals (170 percent), Fertilizers and Pesticides (110 percent), Petroleum Refineries (880 percent), Rubber and Plastic (112 percent), Metal Products (94 percent), Equipment (484 percent), and Transport and Communications (57 percent). The Transport and Communications sector represents 44 percent of total exports in FOB value, while the Cashew Nuts and Coffee sectors account for 7 percent each of total exports. In terms of export propensity, almost the entire domestic production of coffee and cashew nuts is exported.

Gender Disaggregation for Labor Income

The impact of exogenous shocks on labor income shares by gender can be analyzed in this chapter because those accounts are disaggregated by gender in the SAM. Basic descriptive statistics are displayed in table 7.2. Overall, the Beans sector

Table 7.1 Sectoral Analysis for Tanzania SAM, 2001 (T Sh million)

	Production (Q)		Value added at factor cost		Imports (M)		Exports (X)			
	Value	Share (%)	Value	Share (%)	Value	Share (%)	Value	Share (%)	M/Q	X/XS
Maize	851.9	6.1	750.0	9.9	16.2	0.8	1.0	0.1	1.9	0.1
Paddy	406.3	2.9	283.0	3.7	21.7	1.1	2.6	0.2	5.3	0.6
Sorghum	126.1	0.9	100.1	1.3	0	0	0.1	0	0	0.1
Wheat	26.3	0.2	17.5	0.2	19.0	0.9	0.1	0	72.4	0.2
Beans	211.3	1.5	178.2	2.3	0	0	1.1	0.1	0	0.5
Cassava	155.8	1.1	152.0	2.0	0	0	0	0	0	0
Other Cereals	34.4	0.2	25.7	0.3	0	0	0.1	0	0	0.4
Oil Seeds	125.0	0.9	113.1	1.5	0.2	0	4.5	0.3	0.2	3.6
Other Roots and Tubers	131.0	0.9	122.7	1.6	0	0	0	0	0	0
Cotton	96.1	0.7	47.7	0.6	0	0	41.5	3.2	0	43.2
Coffee	87.3	0.6	57.6	0.8	0	0	94.9	7.3	0	108.8
Tobacco	74.7	0.5	40.8	0.5	0.2	0	48.1	3.7	0.2	64.4
Tea	38.8	0.3	20.9	0.3	0.2	0	26.4	2.0	0.5	68.1
Cashew Nuts	87.2	0.6	78.2	1.0	0	0	93.6	7.2	0	107.3
Sisal Fiber	16.5	0.1	7.1	0.1	0	0	0	0	0	0
Sugar	160.6	1.1	120.3	1.6	50.3	2.5	12.8	1.0	31.3	7.9
Fruits and Vegetables	527.7	3.8	499.0	6.6	7.9	0.4	27.5	2.1	1.5	5.2
Other Crops	67.1	0.5	60.5	0.8	0.1	0	4.5	0.3	0.2	6.7
Poultry and Livestock	294.9	2.1	248.8	3.3	2.8	0.1	6.4	0.5	1.0	2.2
Fishing	334.2	2.4	302.2	4.0	0.1	0	65.1	5.0	0	19.5
Hunting and Forestry	302.0	2.1	278.7	3.7	0.5	0	5.5	0.4	0.2	1.8
Mining	128.2	0.9	110.4	1.5	13.3	0.7	19.9	1.5	10.4	15.5

continued

Table 7.1 Sectoral Analysis for Tanzania SAM, 2001 (T Sh million) ***continued***

	Production (Q)		Value added at factor cost		Imports (M)		Exports (X)			
	Value	**Share (%)**	**Value**	**Share (%)**	**Value**	**Share (%)**	**Value**	**Share (%)**	**M/Q**	**X/XS**
Meat and Dairy	327.9	2.3	176.2	2.3	3.9	0.2	0.6	0	1.2	0.2
Grain Milling	647.6	4.6	50.5	0.7	15.5	0.8	6.8	0.5	2.4	1.0
Processed Food	421.9	3.0	150.4	2.0	73.6	3.7	7.0	0.5	17.4	1.7
Beverages and Tobacco Products	173.1	1.2	65.6	0.9	16.5	0.8	1.2	0.1	9.5	0.7
Textiles and Leather Products	412.3	2.9	229.3	3.0	76.3	3.8	16.9	1.3	18.5	4.1
Wood, Paper, Printing	147.3	1.0	71.8	0.9	67.9	3.4	5.6	0.4	46.1	3.8
Chemicals	65.8	0.5	16.2	0.2	111.7	5.6	3.2	0.2	169.9	4.8
Fertilizers and Pesticides	11.2	0.1	3.0	0	12.4	0.6	0.1	0	110.4	0.5
Petroleum Refineries	27.5	0.2	13.6	0.2	241.8	12.0	0.1	0	880.0	0.4
Rubber, Plastic	54.4	0.4	17.5	0.2	60.9	3.0	1.3	0.1	111.9	2.4
Glass and Cement	89.2	0.6	30.0	0.4	6.4	0.3	6.7	0.5	7.2	7.5
Metal Products	133.1	0.9	41.7	0.6	125.3	6.2	1.1	0.1	94.1	0.8
Equipment	115.0	0.8	47.1	0.6	557.1	27.7	7.8	0.6	484.2	6.8
Utilities	216.4	1.5	132.2	1.7	0	0	0	0	0	0
Construction	769.6	5.5	342.3	4.5	2.4	0.1	0	0	0.3	0
Trade	1,013.4	7.2	792.9	10.5	0	0	0	0	0	0
Hotels and Restaurants	453.8	3.2	198.5	2.6	0	0	00	0	0	0
Transport and Communications	684.6	4.9	438.4	5.8	392.6	19.5	578.6	44.3	57.4	84.5
Real Estate	2,032.6	14.4	452.8	6.0	0	0	0	0	0	0
Public Administration	1,585.1	11.3	470.3	6.2	17.4	0.9	71.3	5.5	1.1	4.5
Business and Other Services	401.9	2.9	227.9	3.0	94.5	4.7	142.1	10.9	23.5	35.4
All	**14,066.9**	**100.0**	**7,582.4**	**100.0**	**2,009.0**	**100.0**	**1,306.0**	**100.0**	**2,160.3**	**615.2**

Source: Authors.
Note: M/Q = Import share within sector production; X/XS = Export share of production; M = Imports.

Table 7.2 Summary Data on Labor Income Shares in Tanzania SAM

Activity	Labor intensity (percent)	Female labor income intensity (percent)	Female labor income share (percent)	Activity	Labor intensity (percent)	Female labor income intensity (percent)	Female labor income share (percent)
Maize	16.7	66.1	9.8	Grain Milling	76.7	38.6	1.8
Paddy	39.6	57.9	7.7	Processed Food	14.0	36.5	0.9
Sorghum	16.9	58.3	1.1	Beverages and Tobacco Products	17.6	3.0	0
Wheat	47.4			Textiles and Leather Products	52.5	39.9	5.7
Beans	35.3	75.6	5.7	Wood, Paper, Printing	23.3	3.8	0.1
Cassava	9.5	54.1	0.9	Chemicals	81.5	0	0
Other Cereals	44.0	62.5	0.8	Fertilizers and Pesticides	70.7	0	0
Oil Seeds	36.7	60.7	3.0	Petroleum Refineries	27.5	0	0
Other Roots and Tubers	23.6	64.7	2.2	Rubber, Plastic	21.8	29.2	0.1
Cotton	50.3	36.5	0.9	Glass and Cement	22.9	0.8	0
Coffee	46.1	40.7	1.3	Metal Products	23.3	2.0	0
Tobacco	50.2	40.2	1.0	Equipment	9.1	8.2	0
Tea	49.2	0	0	Utilities	20.3	4.3	0.1
Cashew Nuts	50.2	28.9	1.3	Construction	67.9	1.6	0.4
Sisal Fiber	50.0	10.8	0.0	Trade	7.9	25.9	1.9
Sugar	50.2	54.6	3.9	Hotels and Restaurants	23.5	54.4	3.0
Fruits and Vegetables	30.8	62.9	11.3	Transport and Communications	12.7	14.0	0.9
Other Crops	27.9	49.0	0.9	Real Estate	5.7	10.7	0.3
Poultry and Livestock	41.5	58.4	6.5	Public Administration	95.9	33.8	18.2
Fishing	47.3	11.3	1.9	Business and Other Services	32.1	24.5	2.1
Hunting and Forestry	20.6	53.8	3.7				
Mining	1.8	13.1	0.0				
Meat and Dairy	1.0	30.0	0.1				

Source: Authors.

is the most female-intensive labor activity, with 75.6 percent of total payments to labor going to female workers. The Maize sector, Fruits and Vegetables sector, as well as the Other Cereals sector, follow with shares of labor income allocated to women of, respectively, 66.1 percent, 62.9 percent, and 62.5 percent. Other sectors with high female labor intensities (exceeding 50 percent) are Paddy, Sorghum, Cassava, Oil Seeds, Other Roots and Tubers, Sugar, Poultry and Livestock, Hunting and Forestry, and Hotels and Restaurants.

However, these female-labor-intensive sectors (as defined by the share of total income allocated to female workers) differ widely in terms of their labor intensity (as measured through the share of labor income in the total value-added of the sector). While labor income represents 50 percent of the value-added in the Sugar sector, it represents only between 10 and 20 percent of value-added in the Cassava, Maize, and Sorghum sectors.

Sectoral Growth and Impact on Labor Income Shares by Gender

All the computations in this section were performed using SimSIP SAM, a powerful and easy-to-use Microsoft® Excel based application, with MATLAB® running in the background, which can be used to conduct policy analysis under a SAM framework. The tool was developed by Parra and Wodon (2009a) and is distributed free of charge,[2] together with the necessary MATLAB components. The accompanying user's manual describes the theory behind the computations. The application can be used to perform various types of analysis and decompositions, as well as to obtain detailed and graphical results for experiments.

In table 7.3, using an approach similar to that of Parra and Wodon (2009b) in chapter 6, we start by showing the effect of an exogenous demand shock equal to 100 million Tanzanian shillings (T Sh) (1.3 percent of GDP) on labor income by gender, as well as on the labor incomes obtained by different subgroups defined according to the education level of the workers. This is done for six sectors: Maize, Beans, Sorghum, Trade, Transport and Communications, and Real Estate. The size of the shock is arbitrary—it was picked to make the results of our simulations easier to interpret as a proportion of the initial shock. However, because the SAM model is linear, the results obtained with larger or smaller shocks would be proportionately identical (a shock twice as large would have an impact twice as large).

Simulations were conducted on sectors with both high and low female labor intensities. The first three of the six sectors considered (Maize, Beans, and Sorghum) have high female labor intensities (66.1 percent, 75.6 percent, and 58.3 percent, respectively), while the last three (Trade, Transport and Communications, and Real Estate) have relatively low female labor intensities (25.9 percent,

Table 7.3 Effect on Labor of Exogenous Demand Shock of T Sh 100 million
(percentage changes in parentheses)

Destination/Origin	Maize	Beans	Sorghum	Trade	Transport and Communications	Real Estate
Female workers						
No formal education	4.4	6.4	5.7	2.3	2.2	2.4
	(6.3)	(9.1)	(8.2)	(3.3)	(3.1)	(3.4)
Unfinished primary school	4.2	5.4	3.4	2.8	2.6	2.7
	(5.1)	(6.7)	(4.2)	(3.5)	(3.2)	(3.4)
Unfinished secondary school	26.6	38.7	22.6	17.5	16.4	17.6
	(5.0)	(7.3)	(4.3)	(3.3)	(3.1)	(3.3)
Secondary or higher education	2.2	2.3	2.2	2.7	3.3	3.6
	(1.4)	(1.5)	(1.4)	(1.7)	(2.1)	(2.3)
Male workers						
No formal education	3.5	3.7	4.1	2.5	2.3	2.6
	(4.3)	(4.5)	(5.0)	(3.0)	(2.8)	(3.1)
Unfinished primary school	10.5	12.3	9.8	7.7	7.2	8.2
	(3.9)	(4.6)	(3.7)	(2.9)	(2.7)	(3.1)
Unfinished secondary school	19.4	20.2	19.3	18.1	18.4	21.0
	(2.9)	(3.0)	(2.9)	(2.7)	(2.7)	(2.1)
Secondary or higher education	6.8	6.7	6.7	8.8	11.5	12.2
	(1.6)	(1.6)	(1.6)	(2.1)	(2.7)	(2.9)

continued

Table 7.3 Effect on Labor of Exogenous Demand Shock of T Sh 100 million
(percentage changes in parentheses) ***continued***

Destination/Origin	Maize	Beans	Sorghum	Trade	Transport and Communications	Real Estate
Gender						
Female	37.4 (4.5)	52.7 (6.3)	33.9 (4.1)	25.4 (3.0)	24.4 (2.9)	26.3 (3.1)
Male	40.2 (2.8)	43.0 (3.0)	39.8 (2.8)	37.1 (2.6)	39.4 (2.7)	44.0 (3.0)
Education						
No formal education	7.9 (5.2)	10.1 (6.6)	9.8 (6.4)	4.8 (3.2)	4.5 (2.9)	5.0 (3.3)
Unfinished primary school	14.7 (4.2)	17.7 (5.1)	13.1 (3.8)	10.6 (3.0)	9.8 (2.8)	11.0 (3.2)
Unfinished secondary school	46.1 (3.8)	58.9 (4.9)	42.0 (3.5)	35.6 (2.9)	34.8 (2.9)	38.6 (3.2)
Secondary or higher education	9.0 (1.6)	9.0 (1.6)	8.9 (1.5)	11.5 (2.0)	14.7 (2.6)	15.8 (2.7)

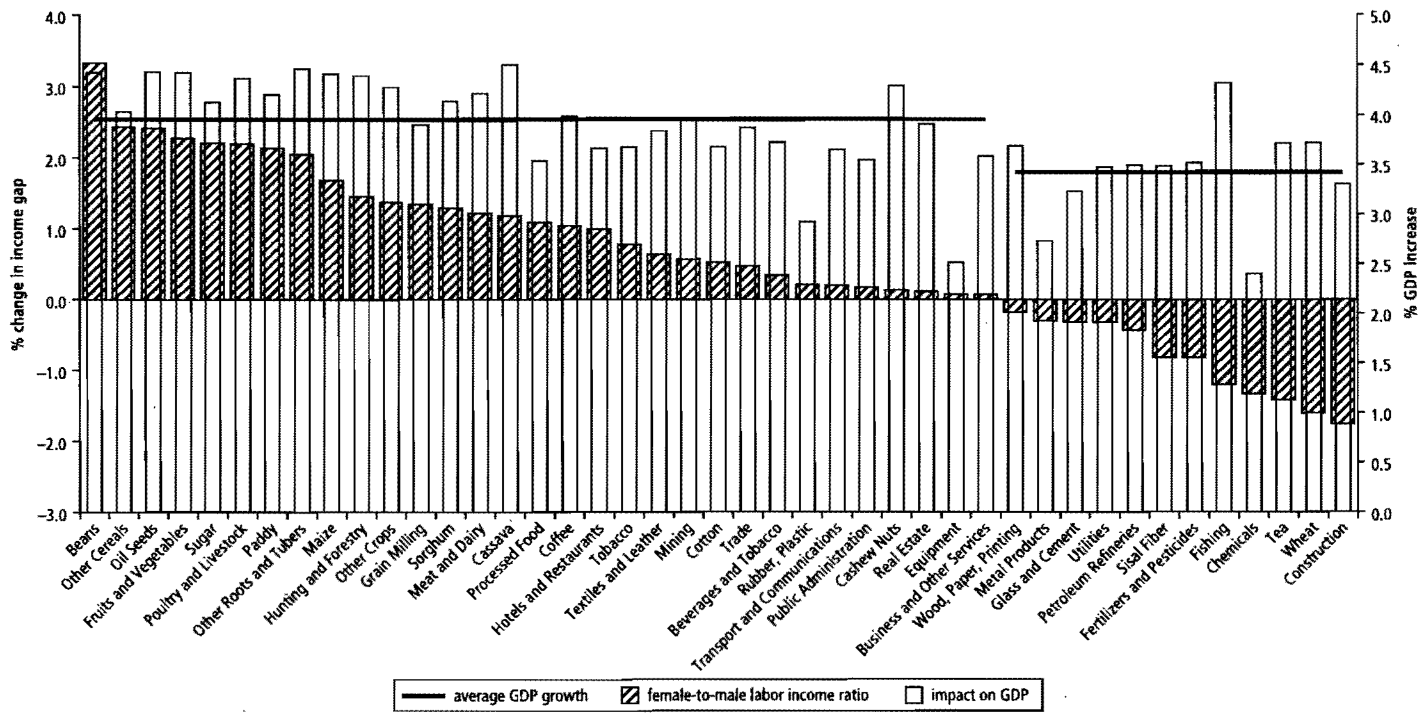
Source: Authors using SimSIP SAM.

14.0 percent, and 10.7 percent, respectively). In conducting the analysis, it is best to express many of the changes in percentage terms to correct for the size effect that is present when reporting changes in levels (that is, large accounts tend to have bigger changes as results of exogenous shocks, but not necessarily bigger percentage changes.) After the initial shock, it turns out that, in percentage terms, payments to female workers increase more than payments to male workers for all six sectors; the same is true for workers without formal education compared to workers with higher levels of education. This means that an exogenous increase in the demand for any of the six sectors would help (at the margin) to close the gap between total pay for male and female workers, and between total pay for educated and non-educated workers. The exogenous demand shock in the Beans sector has the highest impact on female labor income (in percentage terms) among the six sectors, as well as on total labor income in levels, and on the labor income of workers with less than finished secondary education.

For comparison of the percentage increases in labor income by gender in the six sectors with other sectors, a demand shock of T Sh100 million was applied to each sector in the economy, one at a time, and compared with the resulting percentage changes in labor income. Figure 7.1 presents two computations that result from applying this demand shock. On the left vertical axis are the differences in the percentage increases in labor income for male and female workers, and on the right vertical axis is the impact on aggregate GDP caused by the shock. For example, the first shaded bar on the left indicates that a demand shock of T Sh100 million to the Beans sector would result in a percentage increase for female labor income 3.2 percent higher than the percentage change for male labor income (thereby closing at the margin the gap between female and male labor income); the hollow bar indicates that the same shock would generate a percentage change in GDP of about 4.5 percent (as measured on the right vertical axis). Beans, Other Cereals, Oil Seeds, and Fruits and Vegetables are the sectors with the largest difference between the percentage increase in female labor income and the increase in male labor income, and they all lead to larger proportional gains for female workers. Only 12 of the 43 sectors favor male over female workers, with Chemicals, Tea, Wheat, and Construction being the most favorable to male workers.

Another finding regards the direct relationship between how much a sector benefits female more than male workers, and the impact it has on aggregate GDP. The thick horizontal lines in figure 7.1 represent the average impact on GDP. For sectors that favor female workers, the average impact on GDP is a 3.96 percent increase, while this figure is only an increase of 3.42 percent for sector that favor male workers. Nine of the 10 sectors with the highest impact on GDP favor female workers over male workers. These two results would suggest that promoting value added growth in Tanzania could help close the gap between female and male labor income.

Figure 7.1 **Difference Between Sectoral Impact on Female and Male Labor Income, and Impact on Aggregate GDP (Shock of T Sh 100 million)**



Source: Authors using SimSIP SAM.

At the same time, care must be taken about what is actually measured here. We are simulating shocks of the same magnitude to different sectors, but because women tend to work in lower-productivity sectors, achieving an initial shock of T Sh 100 million in sectors with a higher female intensity of labor would normally require the creation of more jobs than achieving the same initial shock in sectors with a higher male intensity of labor. Also, while governments are under pressure to help create jobs, if only to cope with demographic pressure, they also aim to create higher-quality jobs that on a per-job basis contribute more to growth than low-skilled jobs. Thus, the simple analysis presented here should not be used to argue that Tanzania's growth strategy should be oriented to the sectors with a high female intensity of labor. Designing appropriate policies for job creation is much more complex than that and requires more detailed analysis of the growth and employment potential of various sectors of the economy.

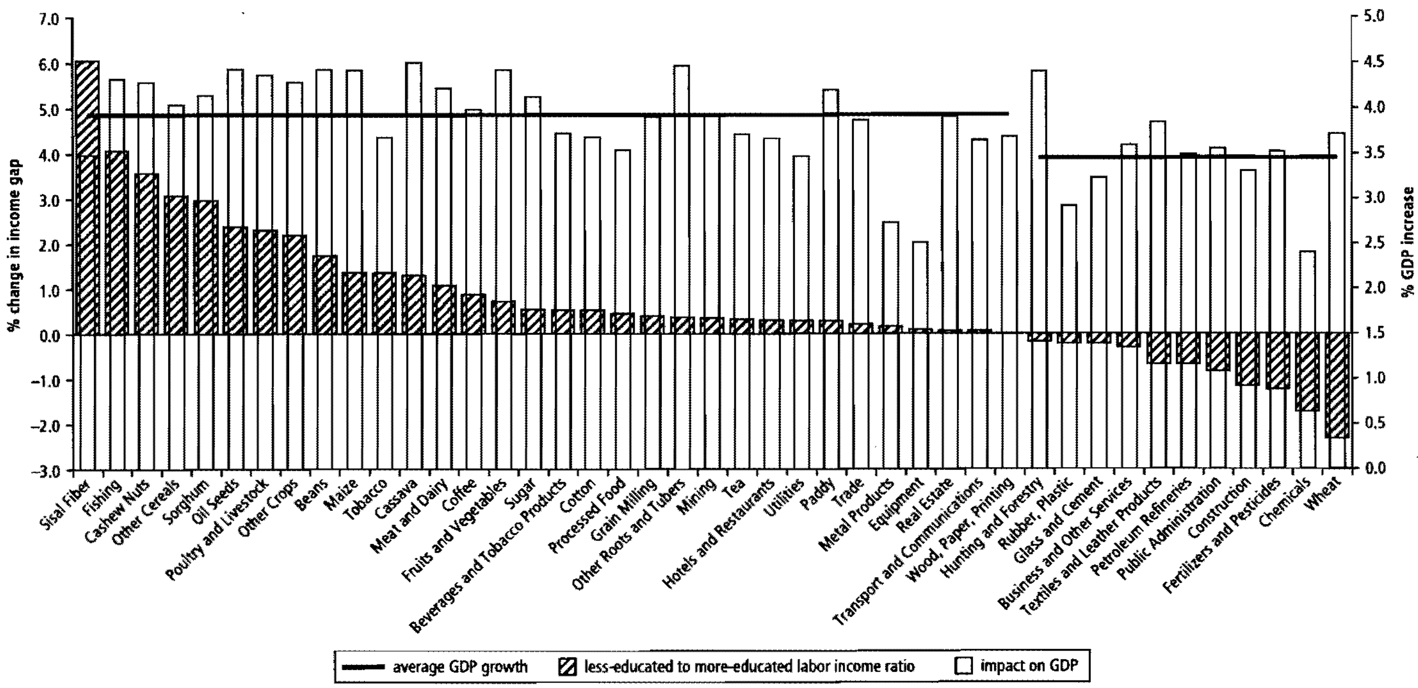
Figure 7.2 shows estimates of the differences in the percentage increases in labor income for workers with no formal education and workers with unfinished secondary, resulting from the same aggregate shock (T Sh 100 million) applied to all sectors, one at a time. The results are very similar to the ones shown in figure 7.1, with 26 of the 31 sectors that favor female workers favoring workers with no formal education. As was the case in figure 7.1, the sectors that favor workers with no formal education exhibit a higher average impact on GDP (3.93 percent) than the sectors favoring workers with unfinished secondary (3.45 percent). But the same caveats mentioned earlier for the proper interpretation of the results apply.

Structural Path Analysis

In many cases, knowing the total potential impact of an exogenous shock on GDP growth and labor income is not sufficient to discuss options for policy. The multiplier analysis provided in the SAM model is useful to get an order of magnitude for the potential of shocks, but if no further analysis is conducted, this functions essentially as a black box that does not help in understanding how the economy functions. One of the key advantages of SAMs, versus more complex Computable General Equilibrium (CGE) models, may be the fact that because the SAM model relies on much simpler assumptions, it is possible to trace how a shock propagates itself through the economy, and thereby to better understand the mechanism at work in the multiplier effect.

With structural path analysis (SPA), it is possible to decompose the final effect of the shock along the different paths through which it unfolds as it travels in the economy, starting from the account that receives the initial shock. To put it another way, the SPA decomposition provides information about the economic structure of a country by fully describing the (most important) paths used by a shock to travel from an origin account (the one that receives the initial shock) to any account labeled as "final destination." A full description of SPA consists of a

Figure 7.2 Difference Between Sectoral Impact on Workers with No Formal Education and Unfinished Secondary (Shock of T Sh 100 million)



Source: Authors using SimSIP SAM.

list of the accounts involved along a given path, together with different measures of the influence traveling along that path.

A description of the SPA principles is provided in the annex. If account *i* and account *j* are directly connected along a path, in that order, it means that account *j* makes payments to account *i*, or in other words, account *j* uses what account *i* produces. The intensity of the connection is measured by the respective element a_{ij} of the technical coefficients matrix. (The matrix of technical coefficients is the result of dividing every cell T_{ij} in a SAM by the respective column sum T_{j}.) Note that if account *i* is connected with account *j* (again, the order is important), meaning that account *j* makes payments to account *i*, then it is not necessarily the case that account *i* is connected with account *j*. In most cases presented in Annex table 7.A (which provides examples of results obtained from the SPA), a sector is directly connected to a labor account. This means that the sector pays for the use of the corresponding type of labor.

Suppose that we want to analyze how, in structural terms, an exogenous demand shock of T Sh 100 million[3] on the Maize sector affects female workers with nonformal education (Fem Nonformal—see the first row of table 7.4). The size of the final effect is given by the cell $m_{FemNonformal, Maize}$ of the inverse matrix M times the size of the shock (100 in this case), and is equal to T Sh 4.4 million. The most important elementary path (a path that does not go through any account on the path more than once) connecting these two accounts is the one that connects the accounts without using any other intermediate account, and it carries a total influence of T Sh 2.3 million, or 53.3 percent of the final effect. Out of the T Sh 2.3 million that travel along this path, 1.6 million (68.4 percent, according to the last column in table 7.4) would travel in a single step; this is known as "direct influence."

For a longer path, consider the second row for Transport and Communications (Trans-A) in table 7.4. The path connects Transport and Communications and female workers with nonformal education. The full path reads "Trans-A → Non Agr Capital → Firms → Rural Non Poor Unf Secondary → Maize-A → Fem Nonformal," which means that Transport and Communications (Trans-A) pays for using non-agricultural capital (Non Agr Capital); these funds are then

Table 7.4 Example of Structural Path Results

Origin	Destination	Global influence	Elementary paths	Direct influence	Total influence	Total/ Global (%)
Maize-A	Fem Nonformal	4.4	Maize-A → Fem Nonformal	1.6	2.3	53.3
Trans-A	Fem Nonformal	2.2	Trans-A → Non Agr Capital → Firms → Rural Non Poor Unf Secondary → Maize-A → Fem Nonformal	0.0	0.1	2.6

Source: Authors using SimSIP SAM.

transferred to the firms (Firms) that own the capital in this SAM, and then Firms pay dividends to some of their owners, in this case rural non-poor households with unfinished secondary education (Rural Non Poor Unf Secondary), who auto-consume Maize (Maize-A) produced in the household, and who finally hire female workers with nonformal education (Fem Nonformal) for their home production. Hence, even though the initial shock was applied to Transport and Communications, it was through Maize production that the shock finally reached female workers with nonformal education. Only T Sh 2.2 million would reach the female workers with nonformal education as a result of the initial demand shock of T Sh 100 million to Transport and Communications (third column of table 7.5), once all multiplier effects are taken into account. Of those T Sh 2.2 million, merely 0.1 million would travel along the path described in this paragraph (2.6 percent).

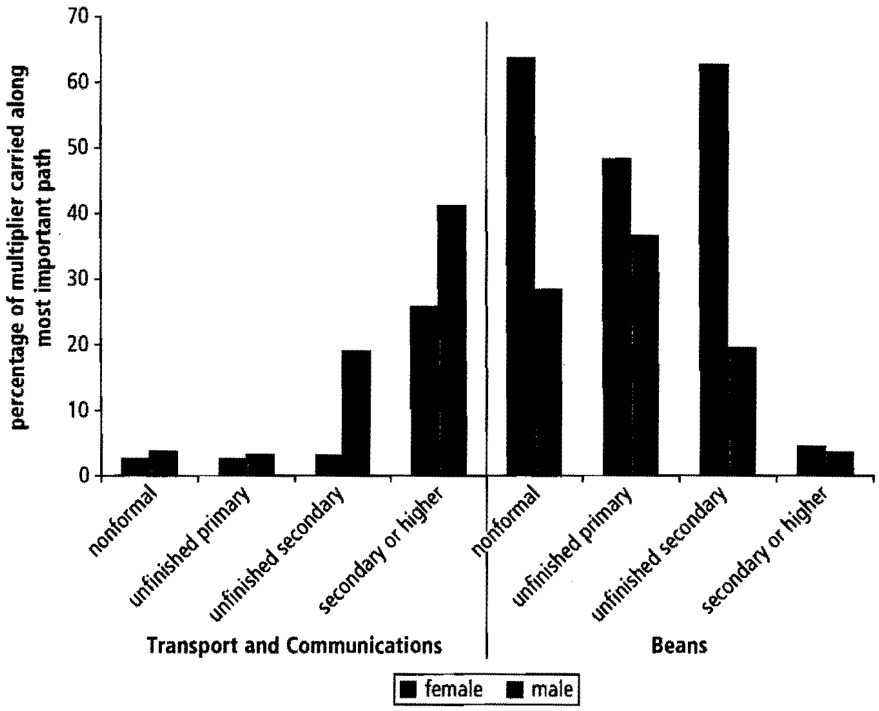
Detailed results for the path analysis for the same six sectors studied above as origin accounts (each of these accounts would receive an exogenous demand shock of T Sh 100 million) and the six categories of labor as destination accounts can be found in Annex table 7.A1. Only the most important path connecting any pair of accounts is shown. More detailed results can be obtained from the authors upon request.

We now highlight what we consider the three main results of the path analysis. First, the strength of a path can simply be associated with its contribution to the total multiplier effect of a shock. Second, the percentage of the multiplier carried along the most important path, or what we refer to as the concentration of transmission channels, is higher for female workers and workers with nonformal education in the three agricultural sectors, and higher for male workers and workers with completed secondary education or higher in the three services sectors. Figure 7.3 compares the most important paths for the Transport and Communications and Beans sectors.

Third, Transport and Communications, and especially Real Estate, display a structure with longer (more indirect) paths that are more important than in the other four sectors. For all categories of labor, except highly educated males, it takes at least three steps (transactions) for a shock in Real Estate to reach the workers, while it takes only one step for most labor categories in Maize, Beans, Sorghum, and Trade. Construction serves as the sector linking Real Estate and male workers, with Public Administration linking the sector and female workers of medium qualification. Figure 7.4 presents the paths connecting both Maize and Real Estate to female workers with unfinished primary. Sorghum would be the sector where the effects of a demand shock would be transmitted "the soonest," while Real Estate would be the "slowest" in transmitting the full effects of the shock.

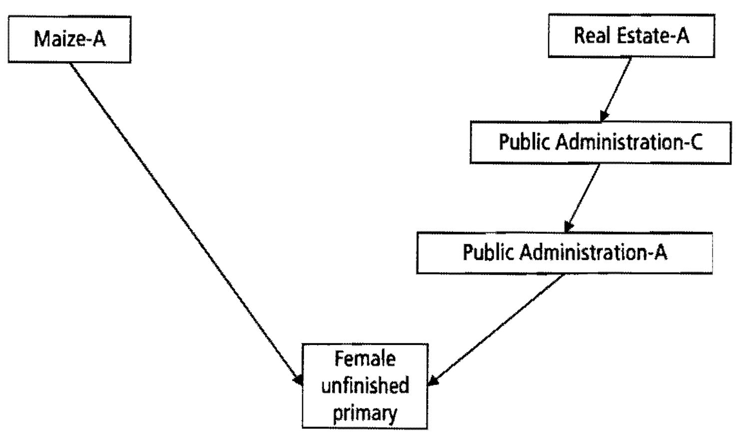
References to length of time are in quotations because the SAM model is a comparative statics exercise and therefore lacks a temporal dimension. The time concept alluded to here is based on the distinction between the direct and

Figure 7.3 Concentration of Selected Transmission Channels from Growth to Labor Income



Source: Authors using SimSIP SAM.

Figure 7.4 Example of Paths to a Category of Labor

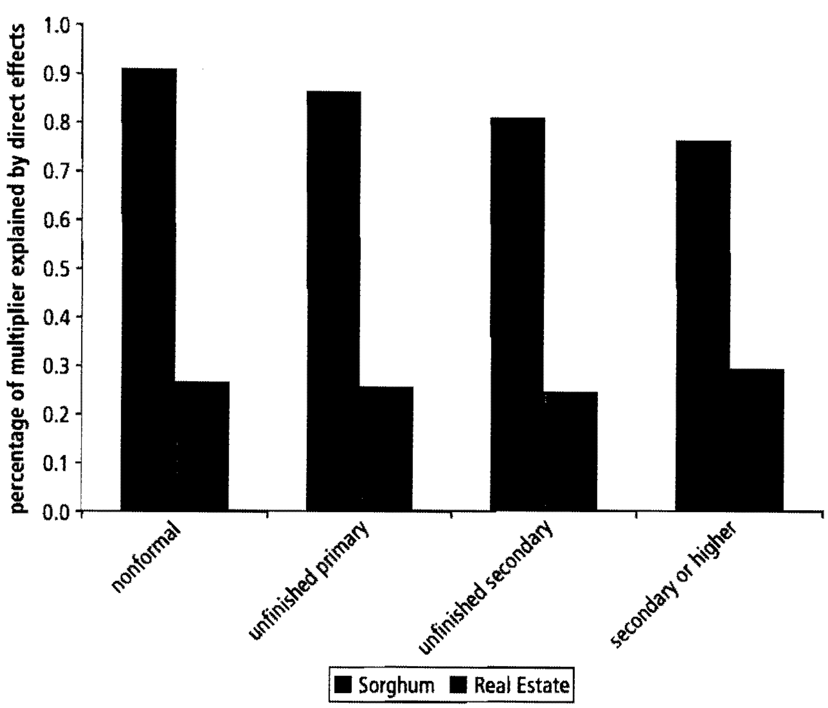


Source: Authors using SimSIP SAM.

indirect components of the influence. As its name indicates, the direct influence is made up of direct connections between accounts; on the other hand, the indirect influence is the set of circuits and all possible indirect paths connecting two accounts. Intuitively, the circuits and indirect connections take more time than a direct connection. Hence, if most of the total influence is direct, we could say that it might take less time to unfold. Along these lines, the last column in annex table 7.A1 contains the fraction of the total influence traveling along a path that is accounted for by direct links between accounts on that path.

The first three sectors—Maize, Beans, and Sorghum—with high female labor intensities, and Trade, with a low female labor intensity, have a relatively high percentage of the total influence being explained by direct connections, with percentages ranging from 60 to 90 percent. Real Estate has, by far, the lowest importance of direct connections, with no direct to total ratio exceeding 30 percent. This implies that for Maize, Beans, Sorghum, and Trade, the effects on labor income would probably unfold more quickly than effects initiated at Transport and Communications or at Real Estate. Figure 7.5 presents the "transmission speeds" for male workers in Sorghum (fastest) and Real Estate (slowest).

Figure 7.5 Speed of Selected Transmission Channels of Shocks from Growth to Labor Income



Source: Authors using SimSIP SAM.

Conclusions

As discussed by Parra and Wodon (2009b) in Chapter 6, SAMs have both strengths and weaknesses. The simplicity of the SAM model is an advantage, first, because it relies on less data than a typical CGE. And in some sub-Saharan countries, good data are not easy to get, for example, to estimate the parameters of a CGE. A second strength of the SAM-based model is that it is relatively straightforward, and thus easier to understand as well as to manipulate to conduct simulations. This is again an advantage for use in countries where capacity is limited. But at the same time, the SAM model also has weaknesses. It cannot easily be adapted to factor in behavioral effects, and it has other very strong assumptions embedded in it.

However, there are some useful analyses that can be conducted with SAMs and cannot be conducted (or at least not as easily) with more complex models such as CGEs. One such unique feature of the SAM model is structural path analysis, which is made feasible by the linear structure of the SAM. This type of analysis helps the analyst understand the transmission channels through which an initial shock travels through an economy. The analysis can be used to characterize the concentration, strength, and "speed" of various transmission channels; those concepts were illustrated in this chapter using a SAM for Tanzania.

Concentration relates to the share of the total impact of a shock that travels through one or more specific paths linking accounts in the SAM. Strength simply relates to the contribution of a path to the total effect at play, in absolute value as opposed to percentage terms. Speed relates to the share of the contribution to the multiplier that travels directly from the origin to the destination account, without going through any account more than once, with paths of higher lengths typically taking more time to materialize because of the higher number of transactions that need to take place. By providing detailed analysis of the ways through which shocks affect an economy, structural path analysis thus can enable analysts to better understand the economy itself, which in turn can be useful in the design of development policies.

Annex 7A Structural Path Analysis[4]

The SAM multiplier framework can be used to quantify the effect of an increase in the exogenous component of an endogenous account into another endogenous account. But this framework is unable to show how this effect is conducted through the economic system. That is exactly what the structural path analysis does. Some basic definitions are as follows.

We associate the notion of expenditure with that of influence. Take the matrix of technical coefficients A_{nxn}. Any endogenous account can be considered a *pole*. Any two poles, i, j, are connected by an arc starting from i and ending at j – $arc(i, j)$ –. The cell, a_{ji} of A, is the *intensity* of $arc(i, j)$. A sequence of consecutive arcs defines a *path*. The *length* of a path is equal to its number of arcs. An *elementary path* is one that does not visit any pole more than once. A *circuit* is a path that starts and ends in the same pole.

Three kinds of influence between accounts can be distinguished: direct influence, total influence, and global influence. Let $(i \rightarrow j)_p$ denote the path p from i to j. See figure 7A.1 below from Shantong, Ying, and Jianwu (2004).

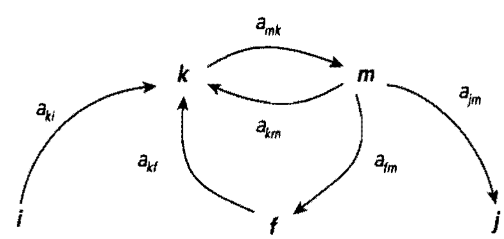
Direct Influence

The direct influence of i on j, through an elementary path, is the change in the income of j caused by a unitary injection in i, where the only incomes that are allowed to change are those of the poles in the elementary path. The direct influence from i to j through the elementary path p is given by the product of the intensities of all arcs constituting the path. For example, the direct influence caused by the elementary path is given by $I^D_{(i \rightarrow j)} = a_{ki}a_{mk}a_{jm}$.

Total Influence

Given an elementary path from i to j, the total influence of i on j is the influence transmitted along the elementary path, including all indirect effects imputable to that path. This definition can be better understood through an example.

Figure 7A.1 Sketch Map for Calculation of Total Influence



Source: Shantong, Ying, and Jianwu (2004).

Consider the structure described in figure 7A.1. In order to compute the total influence, we need to include all possible ways of going from i to j in the structure. First, influence from i to k, and from m to j is given by the respective direct influences. The total influence from k to m requires further explanation. One way to go from k to m is to travel along the elementary path; the influence attributed to that path is the direct influence a_{mk}. Another way to go involves the circuit between k and m and the circuit that connects k and m through f. After one round of feedback, the influence from k to m is given by $a^2_{mk}a_{km} + a_{fm}a_{kf}a^2_{mk}(a_{km}+a_{fm}a_{kf})$. After t rounds of feedback, the influence is given by $a_{mk}[a_{mk}(a_{km}+a_{fm}a_{kf})]^t a_{mk}[a_{mk}+ a_{fm}a_{kf}]^t$. Finally, any influence has to be transmitted from m to j with an influence of . Using a geometric series argument, we finally get that the total influence is given by:

$$I^T(i \rightarrow j)_p = a_{ki}a_{mk}a_{jm}\,[1-a_{mk}\,(a_{km}+a_{fm}a_{kf})]^{-1} \tag{7.1}$$

Note that the first product is just the direct influence along the path p, and the second term is called the *path multiplier* M_p. Then equation (7.1) can be rewritten as: $I^T(i \rightarrow j)_p = I^D_{(i \rightarrow j)p}M_p$

Global Influence

The global influence from i to j is simply given by the accounting multiplier m_{ji} from the inverse matrix. Annex table 7A.1 presents the structural path analysis for all types of labor in each of the six sectors studied in this chapter. The global influence is just the multiplier for the accounts in the first two columns. For each row, the next column describes the nodes of the elementary path connecting the two accounts. The next four columns present the direct and total influence (see definitions above) in levels and as percentages of the global influence, for the elementary path described on that row.

Table 7A.1 Structural Path Analysis for Tanzania, 2001

Origin	Destination	Global influence	Elementary paths	Direct influence	Total influence	Total/Global (%)	Direct/Total (%)
Maize-A	Fem Nonformal	4.4	Maize-A → Fem Nonformal	1.6	2.3	53.3	68.4
	Fem Unf Primary	4.2	Maize-A → Fem Unf Primary	1.1	1.6	37.4	68.1
	Fem Unf Secondary	26.6	Maize-A → Fem Unf Secondary	7.0	11.2	42.1	62.2
	Fem Sec or Higher	2.2	Maize-A → Subsistence → Rural Non Poor Unf Sec → Cloth-C → Cloth-A → Fem Sec or Higher	0.0	0.1	2.4	36.5
	Male Nonformal	3.5	Maize-A → Male Nonformal	0.7	1.0	29.0	68.1
	Male Unf Primary	10.5	Maize-A → Male Unf Primary	1.9	2.9	28.0	65.6
	Male Unf Secondary	19.4	Maize-A → Male Unf Secondary	2.2	3.5	17.9	62.3
	Male Sec or Higher	6.8	Maize-A → Male Sec or Higher	0.2	0.2	3.5	66.3
Beans-A	Fem Nonformal	6.4	Beans-A → Fem Nonformal	3.2	4.0	63.7	79.7
	Fem Unf Primary	5.4	Beans-A → Fem Unf Primary	2.1	2.6	48.3	79.5
	Fem Unf Secondary	38.7	Beans-A → Fem Unf Secondary	17.1	24.3	62.7	70.7
	Fem Sec or Higher	2.3	Beans-A → Fem Sec or Higher	0.1	0.1	4.5	80.0
	Male Nonformal	3.7	Beans-A → Male Nonformal	0.8	1.1	28.4	79.5
	Male Unf Primary	12.3	Beans-A → Male Unf Primary	3.4	4.5	36.6	75.7
	Male Unf Secondary	20.2	Beans-A → Male Unf Secondary	2.8	4.0	19.5	71.0
	Male Sec or Higher	6.7	Beans-A → Male Sec or Higher	0.2	0.2	3.6	77.3
Sorghum-A	Fem Nonformal	5.7	Sorghum-A → Fem Nonformal	3.1	3.4	59.7	91.0
	Fem Unf Primary	3.4	Sorghum-A → Fem Unf Primary	0.5	0.5	15.7	90.6
	Fem Unf Secondary	22.6	Sorghum-A → Fem Unf Secondary	4.1	5.1	22.6	79.6
	Fem Sec or Higher	2.2	Sorghum-A → Cloth-C → Cloth-A → Fem Sec or Higher	0.1	0.2	6.8	78.3
	Male Nonformal	4.1	Sorghum-A → Male Nonformal	1.4	1.6	38.5	90.8
	Male Unf Primary	9.7	Sorghum-A → Male Unf Primary	1.6	1.9	19.2	86.1
	Male Unf Secondary	19.3	Sorghum-A → Male Unf Secondary	2.3	2.9	14.9	80.7
	Male Sec or Higher	6.7	Sorghum-A → Cloth-C → Cloth-A → Male Sec or Higher	0.1	0.2	2.6	76.0
Trade-A	Fem Nonformal	2.3	Trade-A → Fem Nonformal	0.1	0.1	5.0	79.0
	Fem Unf Primary	2.8	Trade-A → Fem Unf Primary	0.2	0.2	8.4	78.9

	Fem Unf Secondary	17.5	Trade-A → Fem Unf Secondary	1.0	1.4	8.2	70.5
	Fem Sec or Higher	2.7	Trade-A → Fem Sec or Higher	0.3	0.4	14.2	79.6
	Male Nonformal	2.5	Trade-A → Male Nonformal	0.1	0.2	6.7	79.0
	Male Unf Primary	7.7	Trade-A → Male Unf Primary	0.4	0.5	6.8	75.5
	Male Unf Secondary	18.1	Trade-A → Male Unf Secondary	2.3	3.2	17.8	71.7
	Male Sec or Higher	8.8	Trade-A → Male Sec or Higher	1.7	2.3	25.6	77.5
Trans-A	Fem Nonformal	2.2	Trans-A → Non Agr Capital → Firms → Rural Non Poor Unf Secondary → Maize-A → Fem Nonformal	0.0	0.1	2.6	39.5
	Fem Unf Primary	2.6	Trans-A → Hotel-C → Hotel-A → Fem Unf Primary	0.1	0.1	2.6	77.3
	Fem Unf Secondary	16.4	Trans-A → Fem Unf Secondary	0.4	0.5	3.1	76.9
	Fem Sec or Higher	3.3	Trans-A → Fem Sec or Higher	0.7	0.8	25.8	88.3
	Male Nonformal	2.3	Trans-A → Non Agric Capital → Firms → Rural Non Poor Unf Secondary → Fish-C → Fish-A → Male Nonformal	0.0	0.1	3.8	45.1
	Male Unf Primary	7.2	Trans-A → Male Unf Primary	0.2	0.2	3.2	83.1
	Male Unf Secondary	18.4	Trans-A → Male Unf Secondary	2.7	3.5	19.0	78.2
	Male Sec or Higher	11.5	Trans-A → Male Sec or Higher	4.0	4.7	41.1	85.6
Estate-A	Fem Nonformal	2.4	Estate-A → Subsistence → Rural Non Poor Unf Secondary → Maize-A → Fem Nonformal	0.0	0.0	1.6	14.4
	Fem Unf Primary	17.6	Estate-A → Pub Admin-C → Pub Admin-A → Fem Unf Primary	0.1	0.6	3.3	12.0
	Fem Unf Secondary	3.6	Estate-A → Pub Admin-C → Pub Admin-A → Fem Unf Secondary	0.2	1.4	37.7	13.6
	Male Nonformal	2.6	Estate-A → Const-C → Const-A → Male Nonformal	0.0	0.1	5.5	26.5
	Male Unf Primary	8.2	Estate-A → Const-C → Const-A → Male Unf Primary	0.2	0.8	10.0	25.4
	Male Unf Secondary	21.0	Estate-A → Const-C → Const-A → Male Unf Secondary	1.3	5.4	25.6	24.4
	Male Sec or Higher	12.2	Estate-A → Male Sec or Higher	1.0	3.4	27.6	29.1

Source: Authors, using SimSIP SAM.

Notes

1. Tanzania Social Accounting Matrix, 1998–2001; 2003 datasets. Washington, D.C.: International Food Policy Research Institute (IFPRI) http://www.ifpri.org/data/Tanzania02.htm
2. The latest version can be obtained from www.simsip.org.
3. The size of the shock is arbitrary and was chosen to make results easier to interpret.
4. This section is based on Defourny and Thorbecke (1984) and Shantong, Ying, and Jianwu (2004).

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