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Agriculture and economic growth in Ethiopia: growth multipliers from a four-sector simulation model

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Abstract

Agriculture accounts for over half of Ethiopian GDP, yet the case for agriculture as a focus of economic growth strategies must rely on identifying a set of intersectoral linkages through which agricultural growth contributes to the growth of non-agriculture in the Ethiopian economy. This article develops a four-sector numerical simulation model of economic growth in Ethiopia which permits the calculation of macroeconomic growth multipliers resulting from income shocks to agriculture, services, modern industry, and traditional industry. The resulting growth multipliers are 1.54 for agriculture, 1.80 for services, 1.34 for modern industry, and 1.22 for traditional industry. These results depict an economy in which intersectoral linkages operate on a highly uneven basis. These limits are reflected in the wide disparity between sectoral growth multipliers and by substantial differences in the patterns of their decomposition. The policy relevance of these findings relate, in part, to the distributional implications of growth in particular sectors. Poverty in Ethiopia is disproportionately rural. An income shock to agriculture is clearly the most progressive choice, indicating the need to highlight agricultural development in growth strategies for Ethiopia. Yet, the simulation results further indicate that doing so imposes relatively little trade off against total benefit. While a \$1 service sector income shock generates \$0.80 in indirect benefits, a \$1 agricultural income shock still generates \$0.54 in indirect gains – a somewhat smaller benefit, but one likely to make the greatest possible impact on poverty reduction.

1. Introduction

No other country in sub-Saharan Africa, and only two other countries in the world, derive a higher share of gross domestic product from agriculture than Ethiopia. Agriculture accounted for 57% of Ethiopian GDP in 1994, employed 86% of the labor force (1990), and comprised 69% of total exports (1993).[1] In comparison, the World Bank (1996) reports that agriculture accounted for only 28% of GDP in a typical 'low-income' country, and employed 69% of the labor force. Given these broad indicators, there can be little doubt about the importance of agriculture in the Ethiopian economy.

Several further steps are required, however, to make the case that agriculture is an appropriate focus for realistic economic growth strategies in Ethiopia. It is well-known that as an economy grows, agriculture accounts for a decreasing share of both GDP and employment. Thus, the case for agriculture as a focus of economic growth strategies must rely on identifying a set of intersectoral linkages through which agricul-

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[1] World Bank (1996), and Government of Ethiopia (1995).

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tural growth contributes to the growth of *non-agriculture* in the Ethiopian economy. The fact that agriculture comprises over half of the Ethiopian GDP suggests that agriculture's *direct* impact on economic growth (or the lack of economic growth) is substantial. In the long run, however, agriculture's *indirect* contributions to economic growth through its catalytic effect on non-agricultural growth may be of even greater importance.

One approach to quantifying these indirect contributions to growth is to calculate macroeconomic growth multipliers for agriculture and other sectors. The literature on growth linkages has focused almost exclusively on regional-level linkages, using household-level data to measure the forward and backward resource flows arising from both production and consumption in the agricultural sector.[2] This paper describes the application of a four-sector numerical simulation model of economic growth in Ethiopia, yielding macroeconomic growth multipliers which complement the regional growth linkage literature.

The model distinguishes among four sectoral sources of GDP in the Ethiopian economy: agriculture, services, and two industrial sectors (traditional and modern). The 'traditional' industrial sector corresponds to small scale manufacturing and handicrafts in the national accounts, and includes such activities as agricultural processing (small-scale flour mills, oil presses, bakeries), handloom and leather production, and carpentry. Khan and Thorbecke (1988) provide a theoretical foundation for distinguishing small-scale manufacturing and handicrafts from large and medium scale manufacturing (which includes firms employing over 10 persons), which for the present purposes are aggregated with mining, electricity, and construction into the 'modern' industrial sector.[3]

In order to calculate the macroeconomic growth multipliers resulting from exogenous income shocks in each of the four sectors, the model specifies a set of intersectoral linkages through which the output of one sector can contribute, either through direct forward and backward linkages or indirectly (through effects on prices and investment) to output in other sectors. Simulations of income shocks in the four sectors indicate that intersectoral linkages in the Ethiopian economy operate unevenly. In particular, linkages operate robustly between the agricultural and service sectors, and to some extent from agriculture to traditional industry. The service sector provides important stimulus to modern industry. Yet, the industrial sectors are relatively limited in their impact on either services or agriculture. This conclusion is reflected in the sectoral growth multipliers which result from the simulated income shocks in the four sectors, which are 1.54, 1.80, 1.34, and 1.22 for agriculture, services, modern industry, and traditional industry, respectively. These results provide one step towards developing a growth strategy for the Ethiopian economy.

The outline of this study is as follows: Section 2 describes the specification of the simulation model, the nature of the intersectoral linkages it seeks to measure, and the model's base run; Section 3 presents the main results of the simulation experiments; and, Section 4 briefly summarizes the results and some of their implications for an economic growth strategy for Ethiopia.

2. Model specification

The model is designed to simulate Ethiopia's economic growth as a function of growth in four sectors (agriculture, services, modern industry and traditional industry) and their interactions with one another. Total GDP is the sum of value added in each sector. Thus, increments to income in any sector add directly to GDP. In addition, intersectoral linkages specified in the model permit income growth in a given sector to contribute indirectly to GDP by stimulating growth in other sectors. It is this indirect contribution that raises a sectoral growth multiplier above 1.0.

In keeping with both a goal of simplicity and the constraints imposed by the data, the model is specified at a level of aggregation which can barely begin to capture the full complexity and richness of the underlying processes. The model is thus, presented primarily as a tool for measuring aggregate sectoral growth multipliers rather than as a tool for detailed policy analysis.

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[2]Examples include: Hazell and Röell (1983), Haggblade (1989), Haggblade et al. (1989), Lewis and Thorbecke (1992) and Delgado (1994).

[3]Khan and Thorbecke (1988) employ such relevant criteria in distinguishing between traditional and modern industrial sectors as the degree of capital and labor intensity, value-added per worker, and returns to factors, in addition to firm size.

Table 1
Ethiopia simulation model equations

Equation number	Identities	Variable list
(1)	$YFACP = YA + YN$	COFFEE: coffee production (tons)
(2)	$YMKTP = YFACP + \overline{INDTXSUB}$	CONP: private consumption
(3)	$CONP = YMKTP - GI - TDBAL - \overline{GOV}$	EXPORT: value of exports
(4)	$YN = YS + YIMOD + YITAD$	GI: gross capital formation
(5)	$GI = GIN + \overline{GIA}$	GIA: gross capital formation in agriculture
(6)	$TDBAL = EXPORT - IMPORT$	GIN: gross capital formation in non-agriculture
	Stochastic equations	GOV: government consumption
(7)	$YA = f(YS_{t-1}\ \overline{DROUGHT}, \overline{RAIN})$	IMPORT: value of imports
(8)	$YIMOD = f(YS, GIN)^{***}$	INDTXSUB: indirect taxes and subsidies
(9)	$YITRAD = f(YS, YIMOD, YA_{t-1}, IMPORT)^{**}$	INSTAB: a proxy for macroeconomic instability
(10)	$YS = f(YA, GIN_{t-1}, RUTT)^{**}$	RER: real exchange rate
(11)	$GIN = f(YN_{t-1}, YA_{t-1}, IMPORT_{t-1}, RUTT, \overline{INSTAB})$	RUTT: rural-urban terms of trade
(12)	$RUTT = f(YA_{t-1}, YS_{t-1}, \overline{RER})$	TDBAL: exports - imports
(13)	$EXPORT = f(YN, \overline{COFFEE})^{**}$	YA: agricultural GDP
(14)	$IMPORT = f(YA, YS, \overline{RER})^{**}$	YFACP: GDP at factor prices
		YIMOD: modern industrial GDP
		YITRAD: traditional industrial GDP
		YMKTP: GDP at market prices
		YN: non-agricultural GDP
		YS: service sector GDP

[*] Estimated with AR(1) correction for serial correlation; [**] estimated by two-stage least squares; [***] both TSLS and AR(1).

The model consists of 14 endogenous variables and hence 14 equations – six identities and eight stochastic equations. Table 1 summarizes the model's structural equations. There are two aspects of these equations to be described: the specification and estimation of the individual equations, and the manner in which those individual equations interact with one another in creating the simulations.

2.1. Identities

Eq. (1) through (6) are identities and definitions which ensure that the simulations conform to basic conventions of national income accounting. The model's main emphasis is on the supply side. Eq. (1) defines GDP at factor prices as the sum of output in the four production sectors. Eq. (3) ensures macroeconomic equilibrium between supply and demand by specifying private consumption as a residual account – the approach actually taken by the Government of Ethiopia in creating the national income accounts. The remaining identities are definitions used for sectoral aggregation.

2.2. Stochastic equations

Specifications for the remaining eight endogenous variables are estimated econometrically and presented in Table 2. Eq. (7) through (10) describe output in the model's four supply sectors.

The intersectoral linkages which drive the growth multipliers result primarily from the specification of the output equations. Specification of direct linkages across sectoral outputs followed from both the characteristics of production and consumption in Ethiopia and the statistical credibility of the individual output equations. Agricultural output is specified in Eq. (7) as a function of (lagged) output in services, but is not directly a function of output in either of the industrial sectors (neither of which were statistically significant in this specification). The absence of statistically detectable linkages from the industrial sectors to agriculture reflects the fact that the smallholder peasant farmers who produce 95% of Ethiopia's agricultural output consume few if any purchased inputs. Fertilizer adoption rates are estimated to be 20% (International Fertilizer Development Corporation, 1993), and McCann (1990) confirms that agricultural

Table 2
Econometric estimates of stochastic equations

	R^2	D.W.
$YA = 2163.3_{3.56} + 0.403_{3.19} \times YS_{t-1} - 315.9_{1.65} \times DROUGHT + 0.577_{1.53} \times RAIN + 0.525_{2.53} \times AR(1)$ Instruments: YA_{t-1}, YS_{t-2}, $YIMOD_{t-1}$, $RAIN_{\text{Debre Markos}}$, $RAIN_{\text{Addis Ababa}}$, $RAIN_{\text{Combolcha}}$, $RUTT_{t-1}$	0.57	1.86
$YIMOD = 106_{0.73} + 0.19_{4.09} \times YS + 0.276_{2.56} \times GIN + 0.67_{2.86} \times AR(1)$ Instuments: $YIMOD_{t-1}$, YS_{t-1}, GIN_{t-1}, $RUTT_{t-1}$, $YITRAD_{t-1}$	0.98	1.93
$YITRAD = -49.1_{1.03} + 0.08_{4.51} \times YS + 0.09_{2.22} \times YIMOD + 0.04_{2.66} \times YA_{t-1} - 0.78_{4.50} \times IMPORT$ Instruments: $YITRAD_{t-1}$, DROUGHT, YS_{t-1}, $RAIN_{\text{avg. of Debre Markos, Addis Ababa, Combolcha}}$, GIN_{t-1}, $YIMOD_{t-1}$, YA_{t-2}	0.97	1.50
$YS = 3524.7_{2.99} + 0.14_{1.48} \times YA + 0.53_{3.61} \times GIN_{t-1} - 772.6_{2.22} \times RUTT + 0.95_{41.6} \times AR(1)$	0.99	1.60
$GIN = 864.1_{0.95} + 0.12_{1.08} \times YA_{t-1} + 0.17_{0.86} YN_{t-1} + 0.12_{0.65} \times IMPORT_{t-1} - 11564.5_{1.74} \times INSTAB - 1088.7_{2.50} \times RUTT + 0.89_{6.57} \times AR(1)$	0.93	0.79
$RUTT = 1.14_{4.79} - 0.00004_{0.65} \times YA_{t-1} - 0.22_{2.30} \times RER + 0.0002_{3.51} \times YS_{t-1}$	0.55	0.60
$EXPORT = -359.9_{1.14} + 0.154_{5.28} \times YN + 4.24_{1.86} \times COFFEE$	0.81	1.57
$IMPORT = 791.5_{1.32} - 0.61_{3.91} \times YA + 596.6_{2.64} \times RER + 0.65_{5.93} \times YS$ Instruments: $IMPORT_{t-1}$, YA_{t-1}, RER_{t-1}, RER_{t-2}, YS_{t-1}, ER, ER_{t-1}, RUTT	0.96	1.39

Absolute value of *t*-statistics are in subscript.

production techniques for the vast majority of Ethiopia's peasant framers have changed little since premodern times. The lack of effective demand for industrially produced inputs results in a situation where industrial output is essentially unrelated to agricultural output. As Ethiopian agriculture is almost entirely rain-fed, additional determinants of agricultural output include average rainfall (measured in Debre Markos) and a dummy variable equal to one in drought years.

It is also notable that neither agricultural investment nor the urban-rural terms of trade enters into Eq. (7). The highly labor-intensive (and relatively unchanged) production techniques practiced by the large majority of Ethiopian peasant farmers may also explain the lack of explanatory power of gross investment in agriculture in predicting agricultural output. Virtually all *documented* investment in agriculture during the period of estimation was public investment. The Derg regime channeled virtually all such investment into the state farms and collective farms. Chole and Manzewal (1992) estimate that this investment thus affected no more than 2% of total agricultural output and only 5% of farmers. There are no data describing private-sector farm-level investment in agriculture (e.g. by peasant farmers).

It is striking, as well, that there is no statistical relationship between agricultural output and the rural-urban terms of trade. Ethiopia perhaps more than any other country, remains a subsistence agricultural economy. One potential explanation for the lack of explanatory power of prices in Ethiopian agriculture is thus that approximately 80–85% of total agricultural output is consumed on-farm.[4] The lack of physical and economic infrastructure in rural areas may simply leave most farmers disconnected from markets. Brune (1992) describes that nearly 75% of Ethiopia's farms are at least a half-day's walk to the nearest all-weather road. An alternative explanation for the lack of statistical relationship between the rural-urban terms of trade and agricultural output is simply that the official prices for cereals and several other food crops remained fixed (in nominal terms) for 7 years during the 1980s, and thus, lack identifying variation.

[4]This estimate was suggested in interviews at the Ethiopian Ministry of Economic Development and Cooperation, 19 August 1996.

Eq. (8) determines modern industrial output as a function of output in services and gross investment in non-agriculture. Ethiopia's modern industrial sector is essentially unrelated to the agricultural sector, which neither supplies inputs to modern industry nor provides substantial demand for its output. Terfassa (1992) documents the heavy import dependence of Ethiopian industry, particularly those branches requiring significant capital goods, such as metals, chemical, paper and printing. This import dependence of Ethiopian industry does, however, point to an important indirect link from agriculture to industry: agriculture is a major source of the foreign exchange necessary to import industrial inputs (though this relationship is not statistically detectable at the aggregate level).

The linkages from services to industry are more direct. An increase in output in the services sector would lead to an increase in factor demand by the services sector for certain modern industrial outputs, such as electricity and construction. This type of backward linkage from services to industry likely explains most of the positive association found in Eq. (8). This perspective is in keeping with the characterization of Ethiopian modern industry operates largely as an enclave, with its inputs consisting primarily of mineral resources and imported capital, and its outputs consisting primarily of intermediate goods. There is, however, a positive association between gross investment in non-agriculture and industrial output, which is captured in Eq. (8). Under the Derg administration, much of this investment originated in the public sector. It is thus, reasonable to expect a positive correlation between such investment and output in what were largely state-owned industrial enterprises. Given the command nature of many industrial activities during the period of estimation, it is also not surprising that prices (represented by the rural-urban terms of trade) also fail to explain any significant share of the variation in modern industrial output.

Output in traditional industries is determined in Eq. (9) by output in each of the other sectors. Increased output in services largely reflects a consumption linkage, through which service sector workers increase their consumption of the output of traditional industries (i.e. processed foods, consumer goods). The connection between modern and traditional industry lies more in the backward linkage of increased demand for modern inputs (electricity, construction) by producers in traditional industries when their output grows. Similarly, agricultural output provides essential inputs to many traditional industries, most particularly food processing establishments and tanneries. Food processing activities account for approximately 32% of total output among handicrafts and small-scale industries.[5] Note that Eq. (8) and (9) allocate all industrial investment to modern industry, a stylized fact that is supported by the lack of statistical significance of gross investment in non-agriculture when included in Eq. (9).

Eq. (10) describes output in the services. This equation complements the agricultural output Eq. (7) in specifying a reciprocal relationship between agriculture and services. There is a potentially strong forward linkage on the consumption level, as food is the primary wage good for service sector employees. Increased agricultural income also stimulates rural demand for services.

Service sector output is also specified as a function of gross investment in non-agriculture and the rural-urban terms of trade. The rural–urban terms of trade broadly measure the incentives shaping trade between the service and agricultural sectors. As expected, an increase in the ratio of agricultural to non-agricultural prices leads to reduced output in the service sector.[6] Just as there was found to be no substantial backward linkage from modern industry to agriculture, neither are there measurable backward linkages from either industrial sector to services. In addition, as industry (in 1990) employed only 2% of the labor force, there is also not likely to be a substantial consumption linkage to the service sector.[7]

[5]Government of Ethiopia, background document to revised national income accounts. It is also interesting to note that if one includes textile and leather production, then nearly 80% of value added in handicrafts and small-scale industry depends directly on agriculture for the majority of its raw inputs.

[6]As indicated by the superscripts in Table 1, service sector output is not estimated with two-stage least squares, despite the contemporaneous specification of prices and output. Two-stage least squares, with the limited available instruments, proved unsuccessful in yielding a plausible specification for service sector output. The potential for simultaneity bias is mitigated, however, by the fact that the government administratively set many agricultural commodity prices during most of the time period of estimation.

[7]UNDP (1998), Human Development Indicators, Table 16.

The general picture to emerge from the four sectoral output equations is one of an economy in which there is substantial two-way interaction between the service and agricultural sectors, limited interaction between services and industry, and important interaction between agriculture and industry limited to agriculture's central role as a supplier of inputs to traditional industry.

Closer examination of the output equations reveals a secondary set of linkages via investment in non-agriculture (the data did not permit disaggregation of non-agricultural investment into services, and traditional and modern industry). Eq. (11) demonstrates that some agricultural income moves across sectors and is invested in non-agriculture. Thus, a secondary aspect of agriculture's indirect contributions comes from its stimulation of investment in non-agriculture, which ultimately contributes to GDP via its positive effect on output in services and modern industry. Similarly, increased industrial output has a roundabout positive effect on agricultural output: increased industrial output contributes to non-agricultural investment, which increases output in services. This increased service sector output, in turn, stimulates agricultural output growth.

The model's remaining equations determine prices (the rural–urban terms of trade), sectoral receipts of capital investment, and the trade balance (exports minus imports).[8]

2.3. Base run of the model

The equation by equation relationships described in the previous section are estimated in levels (in most cases by two-stage least squares, as indicated in Table 1). The resulting coefficients measure the impact of each explanatory variable on the relevant endogenous variables. Cointegration was established for each equation through application of the Engle–Granger method. Augmented Dickey–Fuller tests indicate that each series (with the exception of the drought dummy variable) is I(1), and that the residuals from each equation are stationary in levels, establishing cointegration.[9] Given starting values for the endogenous variables and the historical paths for the exogenous variables, the system of equations is solved to predict time paths for each endogenous series. The simulation is dynamic in that the values predicted for the endogenous variables in a given year depend on previous predictions for relevant endogenous variables.

Prior to using the model to measure counterfactual simulations, it is essential to determine the accuracy with which the model recreates the actual historical time paths of the endogenous variables. In general, this model does a reasonable (though not uniformly outstanding) job of recreating Ethiopia's recent economic history. The most accurately predicted series in the base run is also arguably the most important – GDP at market prices. The root mean squared percentage error in the prediction of that series is less than 5%. The model also does an excellent job of predicting output in the specific productive sectors: the root mean squared percentage errors in the base run for agriculture, services, and modern and traditional industries are 6.4%, 6.4%, 10.1%, and 8.1%, respectively. The model has greater difficulty, however, in predicting gross investment in non-agriculture, which has an RMSPE of 21.4%.[10]

3. Simulation results

This section describes the results of five counterfactual experiments. The first four experiments simulate the effect of exogenous income shocks to each of the model's four productive sectors. These simulations permit the calculation of macroeconomic growth multi-

[8] An explicit equation for gross investment in agriculture proved unnecessary because there is so little investment in peasant agriculture that aggregate agricultural investment failed to explain the variation in agricultural output. Under the Derg administration, virtually all agricultural investment was channeled directly into highly inefficient state farms, which produced approximately 5% of total agricultural output. Gross investment in agriculture is thus taken as exogenous.

[9] Cointegration tests results are available upon request from the author.

[10] Theil inequality statistics also suggest a reasonably good fit for the base run predictions. In all but two cases (GIA and TDBAL) the Theil inequality statistic is less than 0.1 (on a scale where 0 indicates a perfect fit and 1 indicates the worst possible fit). Decomposition of the Theil inequality statistics suggests a somewhat elevated degree of bias in several of the predictions for sector output. Full results for the goodness-of-fit statistics for the base run are available upon request from the author.)

Table 3
Simulation results for sectoral income shocks

Experiment	Growth multiplier	Change in YA	Change in YS	Change in YIMOD	Change in YITRAD
(1) Shock to YA	1.54[a]	1.09[b] (71%)[c][18%][d]	0.24 (16%)[44%]	0.09 (6%)[16%]	0.12 (7%)[21%]
(2) Shock to YS	1.80	0.42 (23%)[52%]	1.04 (58%)[5%]	0.25 (14%)[31%]	0.09 (5%)[12%]
(3) Shock to YIMOD	1.34	0.04 (3%)[13%]	0.11 (8%)[32%]	1.08 (81%)[23%]	0.11 (8%)[32%]
(4) Shock to YITRAD	1.22	0.04 (3%)[18%]	0.10 (8%)[44%]	0.07 (6%)[32%]	1.01 (83%)[6%]

[a] Growth multipliers are the undiscounted sum of the increment to GDP at factor cost resulting from an exogenous income shock in each sector.
[b] Gross increase in sectoral income resulting from a $1 shock to income in a given sector.
[c] Figures in parentheses are the sectoral shares of the benefit of the shock, gross of the initial $1 shock.
[d] Figures in square brackets are the sectoral shares of the benefit of the shock, net of the initial $1 shock.

pliers for each sector. A fifth experiment simulates the macroeconomic impact of a 1-year drought on Ethiopia.

3.1. Experiment 1: agricultural income shock

The agricultural income growth multiplier is 1.54. This result implies that an incremental $1 of income in the agricultural sector generates an additional $0.54 of income in other sectors. Table 3 summarizes the results of each sectoral income experiment, decomposing the gross addition to GDP into the induced income growth in each sector. The multipliers reported in Table 3 are the undiscounted sums of the difference between the experiment and the path predicted in the model's base run.

A $1 shock to agricultural income generates $0.24 of income in the services sector, as compared with $0.11 in the traditional industrial sector (largely the effect of increased inputs to food processors and tanneries), and only $.09 of income to the modern industrial sector (through agriculture's contributions to non-agricultural investment and service sector output). In addition, the initial shock to agriculture feeds back into the agricultural sector (via the positive effect of increments to service sector income on agriculture) to create an additional $0.10 income in agriculture. Thus, 44% of agriculture's *indirect* contribution to GDP (e.g. net of the initial $1 increase in agriculture itself) comes through its effect on income in the service sector, while 21% of agriculture's indirect contribution comes through its impact on traditional industry and only 6% comes through agriculture's impact on modern industry.

Fig. 1 illustrates this decomposition, as well as the shock's incremental contribution to GDP, over the life

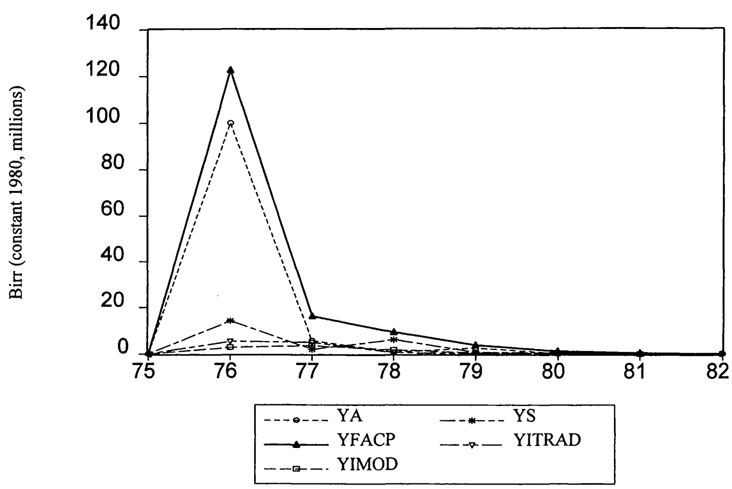

Fig. 1. Decomposition of agricultural income shock.

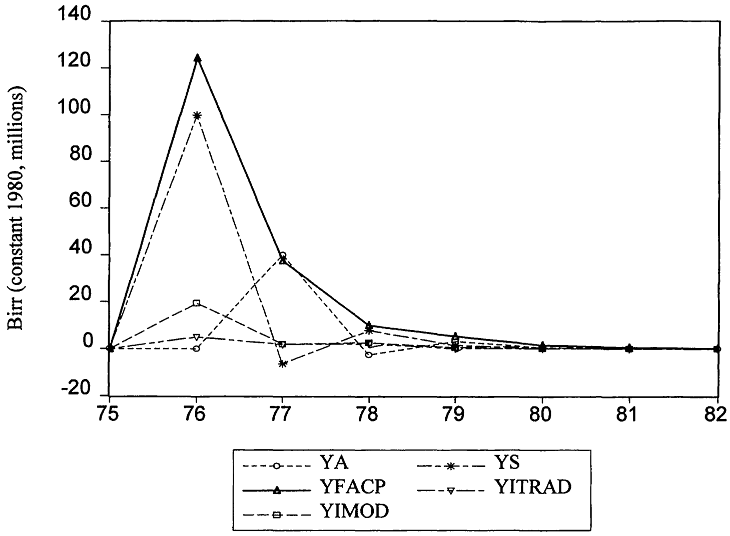

Fig. 2. Decomposition of services income shock.

of the shock.[11] The dynamic structure of the model is such that a shock to agricultural income decays over a period of 5–6 years after the initial shock, though the impact after the first 3 years is minimal.

3.2. Experiment 2: service sector income shock

Performing a similar experiment by shocking income in the service sector yields a growth multiplier of 1.80. This figure implies that a $1 shock to service sector income generates an additional $0.80 of GDP. Decomposing service's indirect contribution to GDP sheds further light on the nature of intersectoral linkages in Ethiopia's economy. Experiment 2 is consistent with Experiment 1 in demonstrating the relatively strong linkages between the service and agricultural sectors. As Table 3 illustrates, a $1 increase in service sector income spills over to increase agricultural sector income by $0.42, equivalent to 52% of the service sector shock's *net* contribution to GDP. Herein also lies the economy's strongest link to modern industry: the $1 increase in service sector income leads (largely through investment) to a $0.25 increase in modern industrial sector income (31% of service's net contribution). Table 3 further shows that a $1 shock to service sector income results in a $0.09 income increase in traditional industry (12% of the net impact), and $0.04 feeds back into the service sector itself through the second round effects resulting from increased output in the other sectors as well as changes in investment and prices. Fig. 2 illustrates this decomposition of the results of Experiment 2. As in the previous experiment, the aftereffects of the initial shock die out over a period of 5–6 years.

3.3. Experiment 3: modern industrial income shock

An exogenous $1 shock to income in the modern industrial sector leads to a total increase $0.34 in the income of the other three sectors, resulting in a macroeconomic growth multiplier of 1.34. Of this net increase, Table 3 illustrates that the largest shares are captured by the service sector and by traditional industry. Both sectors realize an income increase of $0.11, or 32% each of the shock's net effects. The next largest impact is on the modern industrial sector itself, which retains $0.08, or 23% of the net benefit (and 81% of the gross benefit) of the shock. In this sense, modern industry is by the most 'selfish' of Ethiopia's sectors, each other sector retains a far smaller share of the net benefits of an own-sector income shock.

[11]The year in which the shock is simulated is chosen arbitrarily and is immaterial to the results. All figures illustrate a shock in 1976.

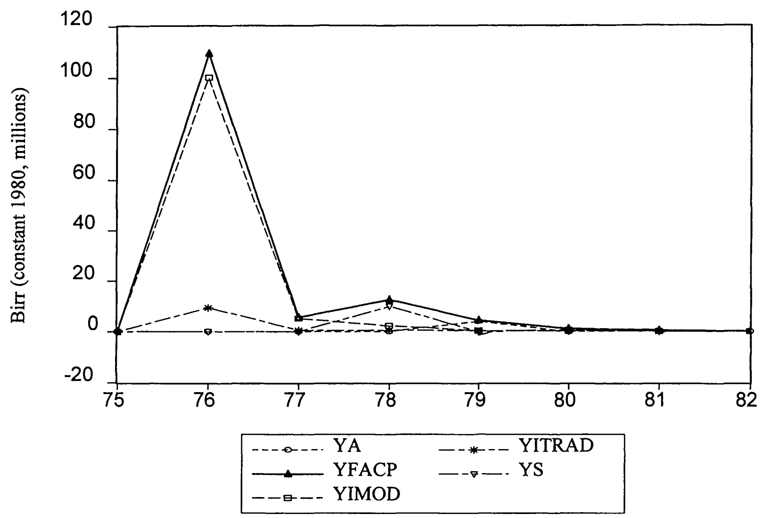

Fig. 3. Decomposition of modern industry income shock.

Agriculture is the sector which benefits the least from the income shock to modern industry, gaining only $0.04, or 13% of the net benefit (and only 3% of the gross benefit).

As discussed below, this decomposition has striking implications for income distribution, and hence for the policy implications of these findings. Also, in contrast to the previous experiments, in which the initial shock reverberates through the economy for 5 years, Fig. 3 shows that the shock to modern industry income dies out within 4 years after the original shock.

3.4. *Experiment 4: traditional industry income shock*

The growth multiplier for traditional industry is 1.22, the smallest of the four sectors. This results, in part, from the lack of forward linkages through which the output of traditional industry becomes the input for another sector. The macroeconomic impact of traditional industry is limited largely to consumption effects of laborers in this sector, as well as to the increased factor demand for certain modern sector outputs such as electricity and construction. Table 3 illustrates that of the $0.22 net income resulting from a $1 shock to traditional industry, the largest share is the $0.10 captured by the service sector (44% of the net impact, but only 8% of the gross impact). The second largest beneficiary is modern industry, which realizes an income increase of $0.07 per $1 increase in traditional industry income (equivalent to 32% of the net impact). Agriculture captures only $0.04 (18%) of the indirect impact of a shock to traditional sector income (and only 3% of the total economic benefit). The traditional sector itself retains $0.014 (6%) net of the original shock. Fig. 4 illustrates that the shock dies out largely within 4 years.

3.5. *Experiment 5: drought*

It is essential to recognize that growth multipliers also work in reverse. Recent history has made clear that Ethiopia's heavy dependence on rain-fed agriculture leaves the economy particularly vulnerable to drought. A final experiment undertaken with the model is to simulate the impact of a 1-year drought of average magnitude. [12]Drought enters directly only in determining agricultural output (Eq. (7)). Yet, the negative impact of a drought on agricultural income is transmitted throughout the economy in exactly the same manner as a positive shock to agricultural income. Ninety percent of the total loss to agriculture

[12]The simulated drought was created by changing a zero to a one in the drought dummy variable, which enters into the agricultural output equation. It is an 'average' drought in the sense that the magnitude of its impact on agricultural income is determined by the conditional impact of all other droughts during the period of estimation.

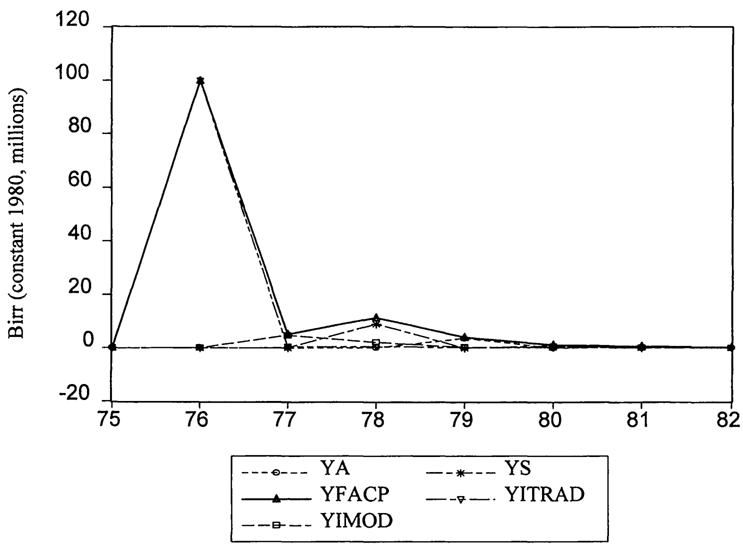

Fig. 4. Decomposition of traditional industry income shock.

occurs during the drought year itself; yet, as Fig. 5 illustrates, the aftershocks ripple through the economy for 5 additional years.

The simulated drought results in a 9.5% decrease in agricultural income in the drought year (based on the sample mean agricultural sector income). The transmission of the shock to other sectors, however, compounds the losses which comprise 7% of total GDP in the drought year itself (while the direct loss to agriculture is only 5% of GDP). The intersectoral linkages are such that of the total Birr 487 million loss to GDP (in constant 1980 prices), only 71% of the losses are within the agricultural sector itself, the remaining 29% reflecting the drought's indirect effects. Over half of the drought's indirect effects are concentrated on service sector income.

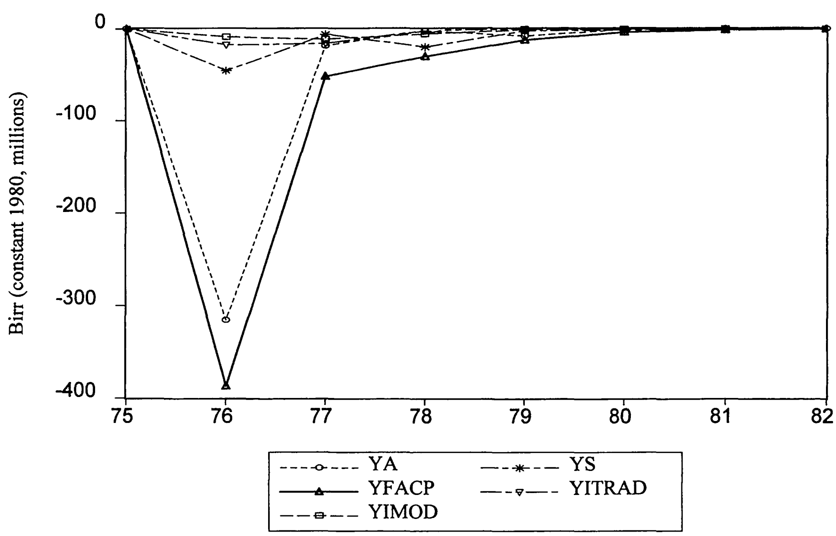

Fig. 5. Decomposition of drought shock.

4. Conclusions

This study describes the construction and application of a simple numerical simulation model of Ethiopia's economy. The goal of this exercise is to measure the linkages between the economy's major productive sectors as reflected in macroeconomic growth multipliers.

The questionable quality of the data used in estimation caution a conservative interpretation of these results. The growth multipliers to emerge from this analysis may not be precise in absolute terms; yet, their relative magnitudes are plausible and provide several insights into the functioning of the Ethiopian economy.

These results paint a picture of an economy in which intersectoral linkages operate on a highly uneven basis. These limits are reflected in the wide disparity between sectoral growth multipliers, and by substantial differences in the patterns of their decomposition. The most robust linkages to emerge from the simulation experiments described above are between the agriculture and service sectors: these two sectors have the two largest multipliers in absolute terms, and of the net impacts of income shocks, agriculture and services share the largest portions with each other. In contrast, the two industrial sectors have the two smallest multipliers in absolute terms, and modern industry retains within itself a much larger share of the net impact of an own-sector income shock than do any of the other sectors.

The policy relevance of these findings relate, in part, to the distributional implications of growth in particular sectors. UNDP (1998) estimates that agriculture accounts for 86% of Ethiopia's labor force, compared with 12% in services and 2% in industry (the data do not distinguish between modern and traditional industries, though the Government of Ethiopia (1995) suggests that approximately 80% of the labor force in manufacturing is in traditional industries). It is necessary to consider the distribution of both the direct and indirect benefits generated by sectoral income hocks in this context. For example, a $1 increase n modern industrial income generates an additional $0.08 of income (23% of the indirect impact) for its own work force, which comprises well under 2% of he total labor force. Including the initial shock, $1.08 r 81% of the total benefit) of the $1.34 addition to DP generated by a shock to modern industry income would be concentrated on 2% of the labor force. That same shock generates only $0.043 income to be shared among the 86% of the labor force employed in agriculture. Sixteen percent of the total benefit of a shock to modern industrial income would be shared evenly by the roughly 13% of the labor force employed in services and traditional industry. Such an allocation is particularly regressive, considering the disproportionately high incidence of poverty in rural Ethiopia.[13]

Similarly, a $1 shock to traditional industry generates only $0.04 income (3% of the total benefit) for the 86% of Ethiopia's labor force in agriculture. Eighty-nine percent of the total benefit of a shock to traditional industry income is concentrated on the 2% of Ethiopia's labor force in the industrial sectors.

In contrast, a $1 shock to service sector income generates $0.42 for the agricultural sector, retaining $1.04 (58% of the total benefit) for the 12% of the labor force in services. This reflects a substantially more progressive allocation of benefits. If one continues to consider the value of the original shock along with its indirect benefits, a shock to the agricultural sector generates $1.10 (equivalent to 71% of the total benefit) for the agricultural labor force, reserving $0.24 (or 16% of the total benefit) for the 12% of the labor force in services. This is clearly the most progressive of the possible allocations of benefits. Yet, what is most important in these results is that the most progressive result imposes relatively little trade off against the total benefit. While the service sector shock generates $0.80 in indirect benefits to GDP, an agricultural income shock still generates $0.54 in indirect gains, a somewhat smaller benefit, but one likely to make a substantially greater impact on reducing poverty.

Growth multipliers also work in reverse. A simulated drought costs Ethiopia 7% of the total GDP during the drought year; yet, only 5% of that loss is directly in agriculture. Over the 5-year life of the drought's impact on the economy, 29% of the total cost lies outside the agricultural sector.

[13] The disproportionate incidence of poverty in rural Ethiopia is broadly reflected by the fact that (in 1995) the 86% of the labor force in agriculture received only 57% of national income, as compared with the 33% of national income received by the 12% of the labor force in services and the 10% of GDP received by the 2% of the labor force in industry (UNDP, 1998).

It is also important to recognize that the results derived from this analysis are conditioned by the constraints currently facing the Ethiopian economy. They take no account of the possibility that improved rural infrastructure might dramatically increase the agriculture multiplier.[14] There is thus, the possibility that the increased rural income could eventually increase the growth multiplier of Ethiopian agriculture relative to the growth multiplier for other sectors.

An explicit concern for poverty alleviation would place substantial weight on the generation of rural income. The present analysis suggests that a strategy emphasizing growth in Ethiopia's rural economy would contribute substantially to income in non-agriculture, as well as make the greatest progress toward poverty alleviation.

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[14]Recent results of similar models for Zimbabwe and Kenya, where rural infrastructure and standards of living exceed those of Ethiopia, indicate that the agricultural growth multiplier can be 1.5–2.5 the net magnitude of the non-agricultural multiplier. Block and Timmer (1997).