Intersectoral labor mobility and deforestation in Ghana

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ONLINE APPENDIX

Appendix A1. *Details of description of variables and sources of data*

The data employed in this paper cover the period from 1970 to 2008. They are annual time series data on Ghana. In what follows, the definition and measurement of each variable are provided. The sources of all the data are also indicated.

Labor Mobility

Where agriculture is the largest sector and the residual employer in an economy, labor mobility rate is measured as the magnitude of labor contributed by the agricultural sector to the rest of the economy. As noted by Johnston and Kilby (1975) and Fosu (1989), the absolute increase in the non-agriculture labor force per annum is computed as $M_t^A = (\dot{L}_t^N - \dot{L}_t)(L_{t-1}^N / L_t)$, where M_t^A is the labor mobility rate in period t and $(\dot{L}^N - \dot{L})$, $\dot{L}^N$ and $\dot{L}$ are the coefficient of differential growth (namely, the Folke Dovring Coefficient), the growth rate of labor force in non-agricultural sector in period t and the growth rate of the total labor force respectively. Total labor force represents all persons aged 15 years and above engaged in or seeking employment in the agricultural sector or the non-agricultural sector. The time series data on labor employed in agriculture and the whole economy (proxied by the respective economically active population) were obtained from various issues of the *UN Food and Agriculture Organization (FAO) Production Yearbook* and the *Quarterly Digest of Statistics* published by the Ghana Statistical Service, Accra.

Deforestation Rate

The deforestation rate used in the present paper is based on deforestation due to agricultural land expansion. The variable is computed as the difference between the total area under agricultural cultivation for consecutive years. Notably, FAO defines deforestation as the conversion of forestland to arable land, permanent crops and permanent pastures. As Scrieciu

(2007) pointed out, changes in agricultural land area are used as indicators of tropical forest depletion because land clearing for agriculture is viewed generally as the main source of deforestation in the tropics. Ready availability of data suggested the deforestation measure employed in the present study. These data were obtained from various issues of the *FAO Production Yearbook.*

Income

Due to data availability, total Gross Domestic Product (GDP) is used to proxy national income. Notably complete data on sectoral wages for the period under study were not readily available. Total GDP is made up of GDP in agriculture and GDP in non-agriculture. Non-agricultural GDP is the difference between total GDP and GDP in agriculture. Agricultural and non-agricultural GDP are used to proxy agricultural and non-agricultural incomes respectively. The income variables used in the estimations are income per capita. Agricultural income per capita is the ratio of agricultural income to agricultural population. Non-agricultural income per capita is the ratio of non-agricultural income to non-agricultural population. The income in agriculture relative to that in non-agriculture was derived as the ratio of agricultural income per capita to non-agricultural income per capita. Both GDP in current and constant 1985 prices were obtained. Dividing the nominal GDP (current) by the real GDP (constant) yields the relevant GDP deflator (1985=100). The agricultural population and non-agricultural population data were obtained from the various issues of the *FAO Production Yearbook.* The time series data on gross domestic product originating in the agricultural and non-agricultural sectors were obtained from the Ghana Statistical Service and the various issues of the *International Financial Statistics (IFS*) published by the *International Monetary Fund (IMF*).

Rural Population Pressure

Rural population pressure is defined as the ratio of rural population (millions) to area cultivated (ha). Data on rural population are obtained from various issues of the *FAO Production Yearbook*. Time series data on annual arable (cultivated) land are also obtained from this source.

Rate of Unemployment in the Non-Agricultural Sector

The rate of non-agricultural unemployment is computed as unity minus the employment rate in non-agricultural sector. The non-agricultural employment rate is the ratio of employment in the non-agricultural sector to the total labor force in non-agricultural sector. Complete data on labor force in the non-agricultural sector for the period of study were not readily available so economically active population in the non-agricultural sector was used as a proxy for the labor force in the non-agricultural sector. Data on economically active population were obtained from various issues of the *FAO Production Yearbook*. The sources of the employment data were the *ILO Yearbook of Labor Statistics*.

Real Price of Insecticides

Annual time series data on the real price of cocoa insecticides measured in Ghana cedis per liter are employed. The real prices of insecticides are obtained by deflating the nominal price of insecticides by the rural CPI (1997=100). The relevant data are obtained from the Ghana COCOBOD and the Ghana Statistical Service.

Real Price of Fertilizer

Annual time series data on the real price of fertilizer measured in Ghana cedis per kg of NPK or 15-15-15 are employed. The real prices of fertilizer are obtained by deflating the nominal price of fertilizer by the rural CPI (1997=100). The relevant fertilizer data were obtained from the Ministry of Food and Agriculture.

Real Producer Price of Cocoa

The data on the real producer price of cocoa are obtained by deflating the nominal producer price of cocoa by the rural CPI (1997=100). Annual time series data on the producer price of cocoa in Ghana cedis per kg and the rural CPI were obtained from the Ghana COCOBOD and various issues of the *Quarterly Digest of Statistics (QDS*) published by the Ghana Statistical Service.

Real Producer Price of Maize

The real producer price of maize was obtained by deflating the nominal producer price of maize (Ghana cedis per 50 kg) by the rural CPI (1997=100). Data on nominal producer price of maize were obtained from the Ministry of Food and Agriculture, Ghana.

Mean Annual Rainfall

The mean annual rainfall data covering Ghana measured in millimeters (mm) were obtained from the Ghana Meteorological Service in Accra, Ghana.

Irrigation Infrastructure

The proportion of arable land under irrigation was used to proxy access to irrigation infrastructure. It was computed as the ratio of agricultural land under irrigation (ha) to the total arable land (ha) in Ghana. Annual time series data on arable land under irrigation and total arable land in the whole economy were obtained from the various issues of the *FAO Production Yearbook.*

Appendix A2. *Definitions of the variables and their descriptive statistics*

Variable	Definition	Mean	Standard deviation	Maximum	Minimum
Dependent variables					
M_t^A	Labor mobility from the agricultural sector to the non-agricultural sector.	2.360	4.761	23.492	0.078
A_t^C	Area deforested ('000 hectares).	4.604	4.950	19.831	0.338
Independent variables					
R_t^{PP}	Population pressure in rural areas (millions per hectare).	3.508	0.452	4.035	2.636
W_t^A	Income in the agricultural sector relative to the non-agricultural sector.	0.606	0.163	0.999	0.422
U_t^{NA}	Unemployment rate in the non-agricultural sector.	0.762	0.246	0.991	0.065
P_t^{INS}	Price of insecticides (Ghana cedis per liter).	19.760	54.720	254.885	0.036
P_t^{FT}	Price of fertilizer (Ghana cedis per kg of NPK 15-15-15).	622.200	968.830	3099.671	11.809
P_t^{CO}	Real producer price of cocoa (Ghana cedis per kg).	42.616	58.466	196.580	0.285
P_t^{MZ}	Real producer price of maize (Ghana cedis per 50 kg).	25.582	47.626	158.660	0.056
RF_t	Mean annual national rainfall (mm)	1.317	0.139	1.646	1.000
IR_t	Access to irrigation infrastructure (proportion of arable land irrigated)	0.009	0.001	0.011	0.007
S_t^D	Structural adjustment program dummy ($S_t^D = 1$ for 1983 – 99, 0 = otherwise).	0.205	0.409	1.000	0.000

Source: Authors' computations

Appendix A3. *Results of unit root test*

Series	Level			Difference			Conclusions
	ADF	MCV	Lag-Length	ADF	MCV	Lag-Length	
M_t^A	-2.7028	-3.5386	2	-5.313	-3.5426	2	$M_t^A \sim$ I(1)
A_t^C	-3.39648	-3.5348	1	-5.274	-3.5386	1	$A_t^C \sim$ I(1)
R_t^{PP}	-2.1325	-3.5348	1	-4.0731	-3.5386	1	$R_t^{PP} \sim$ I(1)
W_t^A	-3.2889	-3.5348	1	-6.4368	-3.5386	1	$W_t^A \sim$ I(1)
U_t^{NA}	1.8393	-3.5426	3	-4.0724	-3.5514	3	$U_t^{NA} \sim$ I(1)
P_t^{INS}	-1.8077	-3.5348	1	-7.8743	-3.5386	1	$P_t^{INS} \sim$ I(1)
P_t^{FT}	-2.31874	-3.5348	1	-4.06350	-3.5386	1	$P_t^{FT} \sim$ I(1)
P_t^{CO}	-1.2034	-3.5348	1	-5.8743	-3.5386	1	$P_t^{CO} \sim$ I(1)
P_t^{MZ}	-2.1737	-3.5348	1	-4.9498	-3.5386	1	$P_t^{MZ} \sim$ I(1)
RF_t	-3.47051	-3.5348	1	-6.9281	-3.5386	1	$RF_t \sim$ I(1)
IR_t	-2.27686	-3.5348	1	-4.6610	-3.5386	1	$IR_t \sim$ I(1)

Notes: All variables are in their raw form. The ADF technique tests $H_0 : X_1 \sim I(1)$ against $H_1 : X_0 \sim I(0)$. MCV are the asymptotic critical values or the Mackinnon critical values for rejection of hypothesis of a unit root and they are at the 5 per cent level of significance. Each ADF equation includes a drift and a trend term.

Source: Authors' computations

Appendix A4. *Empirical cointegration results of the long-run relationships*

Dependent Variable: $\ln M_t^A$				
Variable	Coefficient	Std. Error	t-Statistic	Probability
CONSTANT	2.3269	2.8838	0.8069	0.4247
$\ln W_t^A$	-1.8431	0.7814	-2.3587	0.0236
$\ln R_t^{PP}$	1.5275	2.0657	0.7395	0.4642
$\ln U_t^{NA}$	-2.3989	0.6003	-3.9963	0.0003
S_t^D	0.4939	0.3286	1.5030	0.1411
$\Delta \ln W_t^A$	-1.8820	1.0648	-1.7674	0.0852
$\Delta \ln R_t^{PP}$	-2.5738	3.5290	-0.7293	0.4703
$\Delta \ln U_t^{NA}$	6.3793	1.5235	4.1871	0.0002
$\Delta \ln W_{t-1}^A$	0.2175	1.0554	0.2061	0.8378
$\Delta \ln R_{t-1}^{PP}$	-5.1737	3.6281	-1.4260	0.1620
$\Delta \ln U_{t-1}^{NA}$	1.3107	1.7807	0.7361	0.4662
R^2	0.4897		Mean	0.0263
Adjusted R^2	0.2855		S.D.	1.0812
S.E.R	0.9139		RSS	20.8802
Observations	36		BG(2)	1.1841(0.2765)
Dependent Variable: $\ln A_t^C$				
CONSTANT	-46.3912	24.7604	-1.8736	0.0687
$\ln M_t^A$	-0.7970	0.1370	-5.8171	0.0000
$\ln R_t^{PP}$	10.4541	5.6213	1.8597	0.0707
$\ln P_t^{CO}$	0.0612	0.9919	0.0617	0.9512
$\ln P_t^{MZ}$	0.0370	0.6191	0.0597	0.9527
$\ln P_t^{INS}$	-0.2414	0.2382	-1.0133	0.3173
$\ln P_t^{FT}$	0.7639	0.3995	1.9124	0.0634
$\ln RF_t$	4.7292	2.6071	1.8140	0.0776
$\ln IR_t$	-6.6244	3.7207	-1.7804	0.0830
$\Delta \ln R_t^{PP}$	-18.5762	5.9595	-3.1171	0.0035
$\Delta \ln P_t^{CO}$	-0.4560	0.7194	-0.6339	0.5299
$\Delta \ln P_t^{MZ}$	0.2643	0.5595	0.4723	0.6394
$\Delta \ln P_t^{INS}$	-0.2200	0.3648	-0.6030	0.5501
$\Delta \ln P_t^{FT}$	0.2533	0.5800	0.4367	0.6648
$\Delta \ln RF_t$	2.9785	2.1810	1.3657	0.1801
$\Delta \ln IR_t$	3.9811	3.1416	1.2672	0.2128
$\Delta \ln R_{t-1}^{PP}$	-5.4772	5.1990	-1.0535	0.2988
$\Delta \ln P_{t-1}^{CO}$	0.4234	0.4318	0.9806	0.3330
$\Delta \ln P_{t-1}^{MZ}$	-0.4273	0.3883	-1.1003	0.2781

$\Delta \ln P_{t-1}^{INS}$	-0.3341	0.2934	-1.1386	0.2620
$\Delta \ln P_{t-1}^{FT}$	0.4060	0.4004	1.0140	0.3170
$\Delta \ln RF_{t-1}$	-0.5758	1.6868	-0.3414	0.7347
$\Delta \ln IR_{t-1}$	0.8175	2.5374	0.3222	0.7491
R^2	0.6931		Mean	0.9827
Adjusted R^2	0.1738		S.D.	1.1840
S.E.R	1.0762		RSS	15.0577
Observations	36		BG(2)	0.8969(0.3436)

Notes: With the exception of the structural adjustment dummy, all the variables are in natural logarithms. Δ denotes difference of the respective variable. The instruments used in the relevant equations are $\ln R_t^{PP}$, $\ln U_t^{NA}$, $\ln P_t^{CO}$, $\ln P_t^{FT}$, $\Delta \ln U_t^{NA}$, $\Delta \ln W_t^{A}$, $\Delta \ln P_t^{MZ}$, $\Delta \ln P_t^{CO}$, $\Delta \ln P_t^{INS}$, $\Delta \ln IR_t$, $\Delta \ln RF_t$, $\Delta \ln R_{t-1}^{PP}$, $\Delta \ln U_{t-1}^{NA}$, $\Delta \ln W_{t-1}^{A}$, $\Delta \ln P_{t-1}^{MZ}$, $\Delta \ln P_{t-1}^{CO}$, $\Delta \ln P_{t-1}^{FT}$, $\Delta \ln P_{t-1}^{INS}$, $\Delta \ln IR_{t-1}$, $\Delta \ln RF_{t-1}$, $\Delta \ln R_{t-2}^{PP}$, $\Delta \ln U_{t-2}^{NA}$, $\Delta \ln W_{t-2}^{A}$, $\Delta \ln P_{t-2}^{MZ}$, $\Delta \ln P_{t-2}^{CO}$, $\Delta \ln P_{t-2}^{FT}$, $\Delta \ln P_{t-2}^{INS}$, $\Delta \ln IR_{t-2}$, $\Delta \ln RF_{t-2}$. See Appendix A2 for the definitions of the variables.

Source: Authors' computations

Appendix A5. *Empirical error correction modeling results of the short-run relationships*

Dependent Variable: $\Delta \ln M_t^A$				
Variable	Coefficient	Std. Error	t-Statistic	Probability
CONSTANT	-0.0881	0.1365	-0.6451	0.5221
$\Delta \ln W_t^A$	-1.2062	1.1197	-1.0773	0.2871
$\Delta \ln R_t^{PP}$	4.6256	3.2745	1.4126	0.1646
$\Delta \ln U_t^{NA}$	-3.1734	1.0867	-2.9202	0.0054
ΔS_t^D	0.9082	0.7887	1.1515	0.2556
$\Delta \ln W_{t-1}^A$	1.1357	1.0607	1.0707	0.2900
$\Delta \ln R_{t-1}^{PP}$	-1.4158	3.4465	-0.4108	0.6832
$\Delta \ln U_{t-1}^{NA}$	-4.9767	1.6604	-2.9973	0.0044
$ect_{1,t-1}$	-1.2571	0.1793	-7.0115	0.0000
R^2	0.7379		Mean	-0.05862
Adjusted R^2	0.6602		S.D	1.4689
S.E.R.	0.8563		RSS	19.7964
Observations	36		BG (2)	1.9217(0.1656)

Dependent Variable : $\Delta \ln A_t^C$				
Variable	Coefficient	Std. Error	t-Statistic	Probability
CONSTANT	-0.0321	0.1934	-0.1661	0.8688
$\Delta \ln M_t^A$	-0.3872	0.1970	-1.9650	0.0543
$\Delta \ln R_t^{PP}$	0.7985	5.7116	0.1398	0.8894
$\Delta \ln P_t^{CO}$	1.0495	0.3703	2.8340	0.0069
$\Delta \ln P_t^{MZ}$	0.5709	0.2746	2.0792	0.0433
$\Delta \ln P_t^{INS}$	-0.0488	0.3054	-0.1597	0.8739
$\Delta \ln P_t^{FT}$	0.4124	0.4049	1.0186	0.3138
$\Delta \ln RF_t$	1.1734	1.0963	1.0703	0.2902
$\Delta \ln IR_t$	-4.3698	2.6125	-1.6727	0.1003
$\Delta \ln R_{t-1}^{PP}$	6.8995	3.7437	1.8430	0.0719
$\Delta \ln P_{t-1}^{CO}$	0.0120	0.4785	0.0250	0.9801
$\Delta \ln P_{t-1}^{MZ}$	-0.0122	0.3648	-0.0334	0.9735
$\Delta \ln P_{t-1}^{INS}$	-0.2285	0.2713	-0.8425	0.4040
$\Delta \ln P_{t-1}^{FT}$	0.6737	0.4085	1.6492	0.1061
$\Delta \ln RF_{t-1}$	-2.2789	1.4356	-1.5874	0.1194
$\Delta \ln IR_{t-1}$	-1.3026	1.8040	-0.7221	0.4740
$\Delta \ln A_{t-1}^C$	-0.1094	0.1542	-0.7094	0.4817
$ect_{2,t-1}$	-0.9273	0.2463	-3.7646	0.0005
R^2	0.5937		Mean	0.0552
Adj. R^2	0.2101		S.D	0.9374
S.E.R.	0.8331		RSS	12.4930

Observations	36	BG (2)	2.6244(0.1226)

Notes: With the exception of the structural adjustment dummy, all variables are in natural logarithm. Δ denotes difference of the respective variable and *ect* denotes error correction term. The instruments used in the equations are $\ln R_t^{PP}$, $\ln P_t^{MZ}$, $\ln IR_t$, $\Delta \ln P_t^{FT}$, $\Delta \ln R_{t-1}^{PP}$, $\Delta \ln U_{t-1}^{NA}$, $\Delta \ln W_{t-1}^{A}$, $\Delta \ln P_{t-1}^{MZ}$, $\Delta \ln P_{t-1}^{INS}$, $\Delta \ln IR_{t-1}$, $\Delta \ln RF_{t-1}$, $\Delta \ln U_{t-2}^{NA}$, $\Delta \ln RF_{t-2}$, ΔP_t^{INS}, P_t^{INS}, RF_t, P_{t-1}^{MZ}, P_{t-1}^{CO}, R_{t-1}^{PP}, S_{t-1}^{D} $ect_{1,t-1}$ $ect_{2,t-1}$ $\Delta \ln A_{t-2}^{C}$. See Appendix A2 for the definitions of the variables.

Source: Authors' computations

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