Multinational supermarket chains in developing countries:

Does local agriculture benefit?

– Separate appendix

Hildegunn E. Stokke, Norwegian University of Science and Technology,

hildegunnes@svt.ntnu.no

Content

Appendix A:
The mathematical documentation of the dynamic general equilibrium model

1. EQUATIONS

The following equations are the detailed description of the model. The numerical model is solved by the General Algebraic Modeling System (GAMS).

Sector subscripts:
a – traditional agriculture
c – commercial agriculture
m – rest of economy
s – supermarkets (modern retail)
tr – traditional retail

Time subscript: *t*

The consumer's decision

The representative household is forward looking and maximizes an intertemporal utility function subject to the intertemporal budget constraint:

$$Max \sum_{t=1}^{\infty}(1+\rho)^{-t}U(Q_t)$$

$$s.t. \sum_{t=1}^{\infty}(1+r)^{-t}\left(PQ_t \cdot Q_t + \sum_j P_{j,t}\overline{C}_j\right) = \sum_{t=1}^{\infty}(1+r)^{-t}\left(Y_t - SAV_t\right) \qquad j = m,s,tr$$

Assuming constant intertemporal elasticity of substitution (σ), the isoelastic utility function is given as:

$$U(Q_t) = \frac{Q_t^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}}$$

where Q_t is aggregate household consumption beyond minimum consumption in period *t*, defined as:

$$Q_t = cs \cdot \prod_j (C_{j,t} - \bar{C}_j)^{\alpha c_j} \qquad j = m, s, tr$$

where $C_{j,t}$ is consumption of each final good and $\bar{C}_j$ is the minimum consumption level. Consumption goods are produced by the retail sectors and the rest of economy.

The household income is given as:

$$Y_t = w_t \cdot L_t + Rk_t \cdot K_t + wd_t \cdot LD + wu_t \cdot Lu_t + ws_t \cdot Ls_t + \sum_j tm \cdot PWM_c \cdot NM_{c,j,t} - (r - g - n) DEBT_t$$

where $j = s, tr$.

The first-order condition for the household's problem (the Euler equation) is:

$$\frac{Q_{t+1}}{Q_t} \frac{PQ_{t+1}}{PQ_t} = \left(\frac{1+r}{1+\rho} \right)^{\sigma}$$

Consumption growth depends on the interest rate, the time preference rate, the intertemporal elasticity of substitution, and the price path.

The household demand for each commodity is given by:

$$P_{j,t} \cdot (C_{j,t} - \bar{C}_j) = \alpha c_j \cdot PQ_t \cdot Q_t \qquad j = m, s, tr$$

Production decision

The value-added production functions for the five sectors:

$$X_{a,t} = A_{a,t}^{\alpha_1} AD_{a,t}^{\alpha_2} Lu_{a,t}^{\alpha_1} LD_{a,t}^{\alpha_2} K_{a,t}^{\alpha_3}$$
$$X_{c,t} = A_{c,t}^{\beta_1+\beta_2} AD_{c,t}^{\beta_3} Lu_{c,t}^{\beta_1} Ls_t^{\beta_2} LD_{c,t}^{\beta_3} K_{c,t}^{\beta_4}$$
$$X_{j,t} = A_{j,t}^{\gamma_j} L_{j,t}^{\gamma_j} K_{j,t}^{1-\gamma_j} \qquad j = m, tr$$
$$X_{s,t} = cst_t A_{s,t}^{\gamma_s} L_{s,t}^{\gamma_s} K_{s,t}^{1-\gamma_s}$$

The production function for supermarkets takes into account the potential costs related to supply chain development. We apply a reduced form specification, where the share of supermarket production value remaining after costs to supply chain development are paid (cst_t) depends on growth of rural skilled workers ($\hat{Ls}_t$) relative to the long run growth rate (n):

$$cst_t = \left(\frac{n}{\hat{Ls}_t} \right)^{v}$$

where v is a constant parameter. We do not consider the case of skill downgrading, so $cst_t \le 1$. If supermarkets invest in supply chain development, the value of their production decreases ($cst_t < 1$). The lower cst_t is, the higher are the skill upgrading costs.

Productivity growth in commercial agriculture ($\hat{A}_{c,t}$) is endogenously determined, and is related to the gap with the agricultural technology frontier, the farmers' degree of interaction with supermarkets as suppliers, and the commercial agriculture sector's level of human capital:[1]

$$\hat{A}_{c,t} = \lambda H_t^{\theta_1} \left(\frac{ND_{c,s,t}}{N_{c,s,t}} \right)^{\theta_2} \left(1 - \frac{A_{c,t}}{A_t^*} \right)$$

The human capital level (H_t) is measured by the skill share in commercial agriculture:

$$H_t = \frac{Ls_t}{Lu_{c,t} + Ls_t}$$

In all other sectors productivity grows exogenously at the long-run rate (g).

First order conditions:

$$\alpha_1 PV_{a,t} X_{a,t} = wu_t \cdot Lu_{a,t}$$
$$\alpha_2 PV_{a,t} X_{a,t} = wd_t \cdot LD_{a,t}$$
$$\alpha_3 PV_{a,t} X_{a,t} = Rk_t \cdot K_{a,t}$$

$$\beta_1 PV_{c,t} X_{c,t} = wu_t \cdot Lu_{c,t}$$
$$\beta_2 PV_{c,t} X_{c,t} = ws_t \cdot Ls_t$$
$$\beta_3 PV_{c,t} X_{c,t} = wd_t \cdot LD_{c,t}$$
$$\beta_4 PV_{c,t} X_{c,t} = Rk_t \cdot K_{c,t}$$

$$\gamma_i PV_{i,t} X_{i,t} = w_t \cdot L_{i,t} \qquad i = m, s, tr$$
$$(1-\gamma_i) PV_{i,t} X_{i,t} = Rk_t \cdot K_{i,t} \qquad i = m, s, tr$$

The agricultural sectors produce goods for the retail sectors. Traditional retail is supplied by both traditional and commercial farmers, while supermarkets are only supplied by commercial farmers. The input demand for agricultural goods is proportional to the retail sector production.

Total demand for agricultural good i from the retail sectors is given as:

$$N_{i,t} = \sum_j IO_{i,j} \cdot X_{j,t} \qquad i = a, c \qquad j = s, tr$$

Since traditional farmers only supply traditional retail, total demand for traditional agricultural goods is given as:

$$N_{a,t} = IO_{a,tr} \cdot X_{tr,t}$$

Total demand (including imports) for the commercial agricultural good from retail sector j is given as:

$$N_{c,j,t} = IO_{c,j} \cdot X_{j,t} \qquad j = s, tr$$

The value-added price for each sector is given by[2]:

[1] Note that in the paper deliveries from domestic commercial farmers to supermarkets are denoted ND_t, and total demand for agricultural goods by supermarkets is called N_t. This is to simplify the notation in the paper.

$$PV_{a,t} = PX_{a,t}$$
$$PV_{c,t} = PD_{c,t}$$
$$PV_{m,t} = PD_{m,t}$$
$$PV_{tr,t} = P_{tr,t} - PX_{a,t}IO_{a,tr} - PN_{c,tr,t}IO_{c,tr}$$
$$PV_{s,t} = P_{s,t} - PN_{c,s,t}IO_{c,s}$$

GDP at factor price:

$$GDP_t = \sum_i PV_{i,t} \cdot X_{i,t} \qquad i = a, c, m, s, tr$$

Investment decision

The investment decision is made according to intertemporal profit maximization, subject to the accumulation of the capital stock over time:

$$\underset{I,K}{Max} \sum_{t=1}^{\infty} (1+r)^{-t} \left[Rk_t \cdot K_t - (P_{m,t} \cdot I_t + ADJ_t) \right]$$
$$s.t.\ \ K_{t+1} = K_t \cdot (1-\delta) + I_t$$

Following the common practice in the literature, unit adjustment costs are specified as a positive function of the investment-capital ratio. Hence, total adjustment costs are given as:

$$ADJ_t = \mu \cdot P_{m,t} \cdot \frac{I_t^2}{K_t}$$

The first order conditions:

$$q_t = P_{m,t} + 2 \cdot P_{m,t} \cdot \mu \cdot \frac{I_t}{K_t}$$
$$rq_{t-1} = Rk_t + P_{m,t} \cdot \mu \cdot \left(\frac{I_t}{K_t} \right)^2 - \delta \cdot q_t + \dot{q}$$

The no-arbitrage condition states that the marginal return to capital must equal the interest payments on a perfectly substitutable asset with a value of q_{t-1}, where q is the shadow price of capital. The first term on the right-hand side is the capital rental rate, while the second term is the partial derivative of the adjustment cost function with respect to capital. The marginal return to capital must be adjusted by the depreciation rate and by the capital gain or loss, $\dot{q}$.

The investment good consists of goods from the rest of economy sector alone. Total investment demand includes the adjustment cost:

$$TI_t = I_t + \mu \cdot \frac{I_t^2}{K_t}$$

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[2] Sales taxes are ignored.

Exports

All exports are done by the rest of economy sector. Sales are endogenously determined through a CET function with imperfect substitution between sales to domestic markets and export markets. The supply functions are derived from maximizing current sales income, subject to the CET function:

$$Max \quad PD_{m,t} \cdot D_t + PE \cdot E_t$$

$$s.t. \quad X_{m,t} = ac[mc \cdot E_t^{-exc} + (1-mc)D_t^{-exc}]^{1/exc}$$

The first order conditions:

$$\frac{D_t}{X_{m,t}} = ac^{\frac{exc}{1-exc}} \cdot \left((1-mc) \cdot \frac{PX_{m,t}}{PD_{m,t}} \right)^{\frac{1}{1-exc}}$$

$$\frac{E_t}{X_{m,t}} = ac^{\frac{exc}{1-exc}} \cdot \left(mc \cdot \frac{PX_{m,t}}{PE} \right)^{\frac{1}{1-exc}}$$

where $exc = \frac{1}{\sigma_e} + 1$.

Imports

Imports of 'rest of economy' goods

Domestic and imported 'rest of economy' goods are imperfect substitutes, and demand is determined endogenously from minimizing current expenditure subject to the Armington function[3].

$$Min \quad PM_m \cdot M_t + PD_{m,t} \cdot D_t$$

$$s.t. \quad CC_t = aa[ma \cdot M_t^{-exa} + (1-ma)D_t^{-exa}]^{-1/exa}$$

The first order conditions:

$$\frac{M_t}{CC_t} = aa^{\frac{-exa}{exa+1}} \left(ma \cdot \frac{P_{m,t}}{PM_m} \right)^{\frac{1}{exa+1}}$$

$$\frac{D_t}{CC_t} = aa^{\frac{-exa}{exa+1}} \left((1-ma) \cdot \frac{P_{m,t}}{PD_{m,t}} \right)^{\frac{1}{exa+1}}$$

where $exa = \frac{1}{\sigma_m} - 1$.

[3] Import tariffs on the 'rest of economy' good is ignored, so $PM_m = PWM_m$.

Imports of commercial agriculture goods:

Traditional agriculture is non-traded, but commercial farmers face competition from abroad. Domestic and imported commercial goods are imperfect substitutes, and demand is determined endogenously from minimizing current expenditure subject to the Armington function.

$$Min \;\; PM_c \cdot NM_{c,j,t} + PD_{c,t} \cdot ND_{c,j,t}$$
$$s.t. \;\; N_{c,j,t} = a_{N_{c,j}} [b_{N_{c,j}} \cdot NM_{c,j,t}^{-exa\_N} + (1-b_{N_{c,j}}) ND_{c,j,t}^{-exa\_N}]^{-1/exa\_N}$$

where $j = tr, s$ since the commercial agricultural good is demanded by traditional retail and supermarkets.

The price of imported commercial goods is given as $PM_c = PWM_c(1+tm)$.

The first order conditions:

$$\frac{NM_{c,j,t}}{N_{c,j,t}} = a_{N_{c,j}}^{\frac{-exa\_N}{exa\_N+1}} \cdot \left(b_{N_{c,j}} \frac{PN_{c,j,t}}{PM_c} \right)^{\frac{1}{exa\_N+1}}$$

$$\frac{ND_{c,j,t}}{N_{c,j,t}} = a_{N_{c,j}}^{\frac{-exa\_N}{exa\_N+1}} \cdot \left((1-b_{N_{c,j}}) \cdot \frac{PN_{c,j,t}}{PD_{c,t}} \right)^{\frac{1}{exa\_N+1}}$$

where $exa\_N = \frac{1}{\sigma_N} - 1$.

Clearing of commodity markets

$$X_{a,t} = N_{a,t}$$
$$X_{c,t} = \sum_j ND_{c,j,t} \qquad j = s, tr$$
$$CC_t = C_{m,t} + TI_t$$
$$X_{j,t} = C_{j,t} \qquad j = s, tr$$

Clearing of factor markets

$$Lu_t = \sum_i Lu_{i,t} \qquad i = a, c$$
$$LD = \sum_i LD_{i,t} \qquad i = a, c$$
$$L_t = \sum_i L_{i,t} \qquad i = m, s, tr$$
$$K_t = \sum_i K_{i,t} \qquad i = a, c, m, s, tr$$

Foreign borrowing and foreign debt

$$FSAV_t = PM_m \cdot M_t + \sum_j (PM_c \cdot NM_{c,j,t}) - PE \cdot E_t$$

$$DEBT_{t+1} = DEBT_t \cdot (1+r) + FSAV_t$$

Foreign debt is accumulated over time from trade deficits and interest payments on outstanding debt.

Terminal conditions (long run constraints)

$$FSAV_T = (g+n-r) \cdot DEBT_T$$

$$I_T = (\delta + g + n) \cdot K_T$$

$$Rk_T + \mu \cdot P_{m,T} \cdot \left(\frac{I_T}{K_T}\right)^2 = (r+\delta) \cdot q_T$$

where T represents the steady state periods. These conditions state that the foreign debt and the capital stock grow at a constant rate given by $g+n$, and that marginal return to capital becomes constant.

2. GLOSSARY

Parameters

ρ	Consumer's time preference rate
σ	Intertemporal elasticity of substitution
cs	Shift parameter in total consumption function
αc_j	Share of consumer's demand for commodity j, $j = m, s, tr$
α_1	Share parameter for unskilled rural labor in production function for traditional agriculture
α_2	Share parameter for land in production function for traditional agriculture
α_3	Share parameter for capital in production function for traditional agriculture
β_1	Share parameter for unskilled rural labor in production function for commercial agriculture
β_2	Share parameter for skilled rural labor in production function for commercial agriculture
β_3	Share parameter for land in production function for commercial agriculture
β_4	Share parameter for capital in production function for commercial agriculture
γ_i	Share parameter for urban labor in production function for sector i, $i = m, s, tr$
v	Parameter in the cost function for supply chain development
θ_1	Elasticity of productivity growth in commercial agriculture with respect to the level of human capital
θ_2	Elasticity of productivity growth in commercial agriculture with respect to farmers' degree of interaction with supermarkets
λ	Parameter in the productivity specification in commercial agriculture

$IO_{i,j}$	Input demand for agricultural good i ($i = a, c$) from retail sector j ($j = s, tr$) relative to production in retail sector j (constant coefficient).
δ	Capital depreciation rate
μ	Coefficient in adjustment cost function for investments
exc	Exponent in CET function for commodity *m* (the good produced by the rest of the economy)
σ_e	Elasticity of substitution between sales of commodity *m* to domestic market vs. export market
mc	Share parameter for the export good in CET function for commodity *m*
ac	Shift parameter in CET function for commodity *m*
exa	Exponent in Armington function for commodity *m*
σ_m	Elasticity of substitution between imported and domestic 'rest of economy' goods
ma	Share parameter for imported good in Armington function for commodity *m*
aa	Shift parameter in Armington function for commodity *m*
exa_N	Exponent in Armington function for commodity *c* (commercial good)
σ_N	Elasticity of substitution between imported and domestic commercial agricultural goods
$b_{N_{c,j}}$	Share parameter for imported good in Armington function for agricultural commodity *c* in sector *j* ($j = s, tr$)
$a_{N_{c,j}}$	Shift parameter in Armington function for agricultural commodity *c* in sector *j* ($j = s, tr$)

Exogenous variables

$\bar{C}_j$	Minimum consumption good *j* ($j = m, s, tr$)
Lu_t	Supply rural unskilled labor
Ls_t	Supply rural skilled labor
$\hat{L}s_t$	Growth rate of rural skilled labor supply
LD	Land supply (constant over time)
L_t	Supply urban labor
PWM_i	World import price for commodity i ($i = c, m$)
PM_i	World import price included tariffs for commodity *i* ($i = c, m$)
PE	World export price for commodity *m* (rest of economy good)
tm	Tariff rate for commodity *c* (commercial agricultural good)
n	Exogenous labor supply growth rate (rural and urban labor)
g	Exogenous rate of technical progress
r	World market interest rate
$AD_{i,t}$	Land augmenting technical progress sector *i* ($i = a, c$)
$A_{i,t}$	Labor augmenting technical progress sector *i* ($i = a, m, s, tr$)
A_t^*	Agricultural frontier technology level

Endogenous variables

$X_{i,t}$	Output of commodity i ($i = a, c, m, s, tr$)
$K_{i,t}$	Capital demand sector i ($i = a, c, m, s, tr$)
$LD_{i,t}$	Land demand sector i ($i = a, c$)
$Lu_{i,t}$	Rural unskilled labor demand sector i ($i = a, c$)
$L_{i,t}$	Urban labor demand sector i ($i = m, s, tr$)
$A_{c,t}$	Labor augmenting technical progress in commercial agriculture
$\hat{A}_{c,t}$	Labor augmenting technical progress rate in commercial agriculture
GDP_t	Gross domestic product
$(1-cst_t)$	Share of production value in supermarkets going to payments of supply chain development
K_t	Aggregate capital stock
I_t	Investment of capital good in quantity
TI_t	Total investment demand including adjustment costs
ADJ_t	Investment adjustment costs
D_t	'Rest of economy' good produced and consumed domestically
M_t	Imports of commodity *m* (rest of economy good)
CC_t	Total absorption of composite good *m* (rest of economy good)
E_t	Exports of commodity *m* (equals total exports)
$C_{j,t}$	Consumption demand for good *j* ($j = m, s, tr$)
$N_{i,t}$	Total demand for good *i* ($i = a, c$)
$N_{c,j,t}$	Demand for commercial agricultural good from sector *j* ($j = s, tr$)
$NM_{c,j,t}$	Demand for foreign commercial agricultural good from sector *j* ($j = s, tr$)
$ND_{c,j,t}$	Demand for domestic commercial agricultural good from sector *j* ($j = s, tr$)
Q_t	Aggregate consumption
Y_t	Household income
SAV_t	Household savings
$FSAV_t$	Trade deficit (foreign savings)
$DEBT_t$	Foreign debt
H_t	Human capital level (measured by the skill share in commercial agriculture)
$PV_{i,t}$	Value added price for commodity i ($i = a, c, m, s, tr$)
w_t	Wage rate urban labor
wu_t	Wage rate rural unskilled labor
ws_t	Wage rate rural skilled labor
wd_t	Land rental rate
Rk_t	Rate of return to capital
$PX_{i,t}$	Producer price for commodity i ($i = a, m$)

PQ_t	Aggregate consumption price
$P_{m,t}$	Armington composite price for commodity m (rest of economy good)
$P_{i,t}$	Producer and consumer price for commodity i ($i = s, tr$)
$PN_{c,j,t}$	Armington composite price for the commercial agricultural good demanded by sector j ($j = s, tr$)
$PD_{i,t}$	Price for domestic good i ($i = c, m$)
q_t	Shadow price of capital

Appendix B: Data and calibration

The model calibration is based on a prototype Social Accounting Matrix (SAM) for a developing economy. The SAM is illustrated in Appendix Table 1 below.

Appendix Table 1: Prototype SAM for a developing economy

	Act_a	Act_c	Act_m	Act_s	Act_tr	Comd_a	Comd_c	Comd_m	Comd_s	Comd_tr
Act_a						5				
Act_c							16			
Act_m								80		
Act_s									60	
Act_tr										18.2
Comd_a					5					
Comd_c				20	3.2					
- dom				15	1					
- imp				5	2.2					
Comd_m										
Comd_s										
Comd_tr										
U_lab			65	14	7					
R_lab_u	2.5	2.5								
R_lab_s		6								
Cap	2	5.5	35	26	3					
Land	0.5	2								
S-I										
HH							1			
RoW							6.2	12		
Total	5	16	100	60	18.2	5	23.2	92	60	18.2

Appendix Table 1 continues

	U_lab	R_lab_u	R_lab_s	Cap	Land	S-I	HH	RoW	Total
Act_a									5
Act_c									16
Act_m								20	100
Act_s									60
Act_tr									18.2
Comd_a									5
Comd_c									23.2
- dom									16
- imp									7.2
Comd_m						38.6	53.4		92
Comd_s							60		60
Comd_tr							18.2		18.2
U_lab									86
R_lab_u									5
R_lab_s									6
Cap									71.5
Land									2.5
S-I							38.6		38.6
HH	86	5	6	71.5	2.5			-1.8	170.2
RoW									18.2
Total	86	5	6	71.5	2.5	38.6	170.2	18.2	

Note: Act_i = Activity sector i, Comd_i = Commodity i, U_lab = Urban labor, R_lab_u = Unskilled rural labor, R_lab_s = Skilled rural labor, Cap = Capital, S-I = Savings/Investments, HH = Household, RoW = Rest of world.

The level of the variables in the SAM has no meaning in itself. The important is relative magnitudes, like value added shares, consumption shares, capital intensity etc. The SAM represents the long-run equilibrium, and the market share of supermarkets is therefore set consistent with the current share in many Western European countries. Following data in Roe and Diao (2004), the supermarket sector is assumed to be more capital intensive than the traditional retail sector. The constant coefficients ($IO_{i,j}$) representing the demand for agricultural good i ($i = a, c$) from retail sector j relative to production in retail sector j ($j = s, tr$) can be calculated from the SAM and are broadly consistent with available data (Roe and Diao, 2004). Appendix Tables 2-4 give an overview of the long-run steady state values for a range of variables based on the given SAM.

Appendix Table 2: Steady state values for sectoral value added shares and market shares

	VA-shares	Market share food retail sector	Market share agricultural sector
Trad. agriculture	3 %		24 %
Com. agriculture	9.5 %		76 %
Rest of economy	58.5 %		
Supermarkets	23 %	80 %	
Trad. retail	6 %	20 %	

Appendix Table 3: Steady state values for sectoral factor cost intensity

	Trad. agriculture	Com. agriculture	Rest of economy	Supermarkets	Trad. retail
Urban labor			65 %	35 %	70 %
Capital	40 %	34.5 %	35 %	65 %	30 %
Rural unsk. labor	50 %	15.5 %			
Rural skilled labor		37.5 %			
Land	10 %	12.5 %			

Appendix Table 4: Steady state values for consumption shares

	Consumption shares
Rest of economy goods	40 %
Supermarket goods	46 %
Traditional retail goods	14 %

The model parameters are calibrated consistent with long run equilibrium, where the structure of the economy is stable, the trade surplus with interest payments balances the projected development of foreign debt, and the growth rate equals 4% (2% technological progress rate and 2% labor growth). The long run growth path must be consistent with the macroeconomic equilibrium as represented by the Euler equation: $r = (1+\rho)(1+g+n)^{1/\sigma} - 1$, where $g + n$ is the exogenous long-run growth rate. With a time preference rate of 5% and the intertemporal elasticity of substitution set equal to 2/3, the world market interest rate equals 11%. The parameters in the production, demand, and trade functions are calibrated based on the social accounting matrix (SAM) given in Appendix Table 1. Most parameters and initial values of variables related to the investment dynamics follow from the long run assumptions of the model. The capital depreciation rate is set to 6%. The value of total investments (including adjustment costs) and capital income are given from the SAM. With the calibrated interest rate and the exogenous long-run growth rate, the firm value follows. The capital stock can then be calibrated from the rate of depreciation, the long-run growth rate, the interest rate, the firm value, the value of total investments, and the capital income (an expression deduced from the long-run constraint on capital accumulation). Given the level of capital, the marginal product of capital is calculated from capital income. The shadow price of capital equals the firm value relative to the capital stock. The coefficient μ in the adjustment cost function is calibrated based on the no-arbitrage condition. With the calibrated value of μ, the initial value of adjustment costs follows. Investment is calibrated as the value of total investments minus adjustment costs. The initial level of foreign debt is set by the long-run constraint on debt accumulation, given data about trade deficit/surplus together with the long-run growth rate and the interest rate.

The trade elasticities represent substitution possibilities between domestic and foreign goods (Armington), and between sales to domestic markets versus export markets (CET). The elasticity of substitution in the Armington and CET functions for the rest of economy good is assumed to equal 2, and the elasticity of substitution between domestic and foreign commercial agricultural goods is set to 3. These assumptions are broadly consistent with the estimates in the GTAP database (Dimaranan and McDougall, 2002). The substitution possibilities between domestic and foreign commercial goods are important for the numerical results, and the robustness is investigated through sensitivity analyses of alternative elasticity values in the range 1.5-4.5.

The parameters of the productivity specification affect the numerical results, and are set according to available econometric estimates. The elasticity of productivity growth with respect to the share of skilled workers in commercial agriculture (θ_1) is set equal to 0.5. If the skill share increases by 1%, the productivity growth rate increases by 0.5%. This implies that if the skill share increases by 10% points, the productivity growth rate increases by 0.1-1% point when starting from the long-run growth rate, which corresponds to an increase in the TFP growth rate of 0.05-0.5% point[4]. The increase in the growth rate is higher, the lower the skill share is initially. In an analysis of 19 OECD countries during 1960-2000 Vandenbussche et al. (2006) find that human capital (measured by the share of the adult population with some tertiary education) stimulates TFP growth. Evaluated at the average technology gap among the OECD countries in the analysis ($A/A^* = 0.74$) their results imply that 10% points higher skill share generates about 1% point higher TFP growth rate[5]. The smaller magnitude of the effect assumed in our analysis seems reasonable since developing countries are further from the technological frontier. The elasticity of productivity growth with respect to supermarket interaction (θ_2) is set equal to 0.2. If the share of supermarket supply coming from domestic farmers increases by 1%, the productivity growth rate in commercial agriculture increases by 0.2%. For instance, if the domestic share increases by 10%-points, the productivity growth rate increases by 0.1-0.3%-point when starting from the long-run growth rate of 2%. The increase in the growth rate is higher, the weaker the link to the supermarket sector is initially. The magnitude of the effect seems conservative, so the quantitative results in the paper are not likely to exaggerate the productivity effect of delivering agricultural goods to supermarkets. Sensitivity analyses to check the robustness of the numerical results in the paper apply θ_1 values in the range 0.3-0.7 and θ_2 values in the range 0.05-0.4.

We assume a long-run technology gap equal to 0.6. This is just for calibration purposes, since the technology gap develops endogenously in the numerical simulations. Based on the long run technical progress rate, initial values of the sectoral skill share and the share of

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[4] The relationship between the rate of labor augmenting technical progress and TFP growth (*gTFP*) is defined as $gTFP_{c,t} = (\beta_1 + \beta_2)\hat{A}_{c,t}$, where $\beta_1 + \beta_2 = 0.53$ is the aggregate labor share in commercial agriculture. The steady state TFP growth rate therefore equals about 1%.

[5] The calculation is based on estimated coefficients in regression 5 of Table 4 in Vandenbussche et al. (2006). The average technology gap is given in their Table 1.

supermarket supply by local farmers, the long-run technology gap, and the elasticities in the productivity specification, the parameter λ follows as a residual.

The negative value of the parameter v equals the elasticity of cst_t with respect to the growth rate of rural skilled labor, where cst_t is the share of supermarket production value remaining after costs to supply chain development are paid. The lower cst_t is, the higher are the costs to skill upgrading. The parameter v is set equal to 0.2, which means that if the growth rate of rural skilled labor increases by 1%, cst_t falls by 0.2%. For instance, if the growth rate increases by 1%-point from 2% to 3% (50% increase), cst_t falls by 10% (from 1 to 0.9). This corresponds to skill upgrading costs accounting for 10% of the production value of supermarkets.

References

Dimaranan, B., McDougall, R., 2002. Global Trade, Assistance, and Production: The GTAP 5 Data Base, Ch. 20. Center for Global Trade Analysis, Purdue University.

Roe, T., Diao, X., 2004. Capital accumulation and economic growth: The case of the retail food industry in developing countries. Am. J. Agric. Econ. 86, 788-794.

Vandenbussche, J., Aghion, P., Meghir, C., 2006. Growth, distance to frontier and composition of human capital. J. Econ. Growth 11, 97-127.